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INDUSTRY AND DEVELOPMENT

GLOBAL REPORT 1990/91

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
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Preface

During 1989 the world industrial economy slowed down and there is little prospect that the inaugural year of the 1990s will reverse this deceleration. Inflationary expectations, renewed uncertainty about the price of raw materials, especially oil*, the financial hangover from rapid deregulation and globalization are all creating conditions hostile to industrial growth. At the same time, scepticism persists about the benefits of economic and especially industrial growth. It is argued that the level of income of a country often correlates poorly with its achievements in social areas such as life expectancy, education and health. Such disparities between aggregate income levels and indicators of social development are no doubt present, but it would be false to conclude from them that income growth (as against the level of income) is superfluous as a factor in social development. *Global Report 1990/91* argues that trends in income and in social dimensions of well-being move together. It is not income but the use to which it is put by citizens and Governments of the different countries that explains the lack of correlation between income levels and the measure of well-being. Sustained growth in income, achievable, on the evidence so far, only through industrial growth, remains a necessary though by no means a sufficient condition for enhanced well-being.

Another school of critics of industrial growth points to the environmental damage that could result from such growth. As a United Nations agency principally concerned with industrial growth, UNIDO takes this criticism seriously. *Global Report 1990/91* therefore has as its special theme the relationship between industry and the environment. In line with established UNIDO practice, it takes a hard and detailed factual look at the technical and economic aspects of pollution and explores recent pollution abatement policies. Industrial stagnation would be a costly medicine for dealing with environmental problems, and it is doubtful whether it would be effective. The truth in this matter, as elsewhere, is far more complex than simple sloganeering would suggest. Some industrial processes pollute more than others, as do some industrial products. It is by choosing better processes and devising better products that pollution will be controlled, and even the monitoring and control of pollution requires sophisticated industrial technology.

Following the pattern set in previous *Global Reports*, forecasts are presented for the world economy as a whole and for its principal regions. UNIDO takes a cautiously optimistic view of the prospects for industrial growth in the coming year. Nevertheless, the industrial growth rate of developing countries is unlikely to reach the levels of the 1960s or 1970s. The lack of success in meeting technical, material and human requirements inhibits many countries from achieving sustained industrialization. *Global Report 1990/91* examines these requirements in an attempt to help policy-makers better assess their strengths and their shortcomings.

The context of industrialization is changing. Development planning is being replaced by market-oriented liberalization. Globalization of financial markets and the international division of labour have created an environment of cut-throat competition rather than co-operation or integration. In these circumstances, industrial growth in developed as well as developing countries looks to the innovative stimulus provided by foreign investors who bring money, technology and a dynamic competitive spirit. This theme is followed up in *Global Report 1990/91*. Besides providing a detailed account of industrial performance in 10 regions of the world, it charts the evolution of foreign direct investment in each of those regions and includes a survey of 13 selected manufacturing industries.

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*This year's forecasts were prepared before the outbreak of the political crisis in Western Asia in August 1990. As a result, some of the assumptions underlying the forecasts now seem unrealistic. High oil prices, if they persist into 1991, will change the level and pattern of growth in the world economy.

The 1980s were a lost decade for developing countries, especially the poorest ones of Africa. If the 1990s are to offer anything better, they will only do so as developing economies learn to weather the rigours of global competition and accelerate their learning process. Recent momentous changes in Eastern Europe have shown that this has now become the fate of economies thoughout the world. The best tools for progress will be information, know-how and the willingness to be competitive. *Global Report 1990/91* is offered as an aid in charting the unfamiliar terrain of industrialization in the 1990s, in the hope that rapid industrial growth may yet again become a familiar and welcome phenomenon.

DOMINGO L. SIAZON, Jr.

Director-General

تصدير

تباطأ مسار الاقتصاد الصناعي في العالم أثناء سنة ١٩٨٩ ، ولا يحتمل كثيرا أن ينقلب هذا التباطؤ تسارعا في السنة الاولى من التسعينات . فتوقعات التضخم ، وتجدد الشكوك بشأن أسعار المواد الخام ، ولا سيما النفط* ، والمخلفات المالية لرعة الغاء القيود الاقتصادية ، وتطبع الاقتصاد بالطابع العالمي ، هي كلها عوامل تخلق ظروفا مناوئة للنمو الصناعي . وفي الوقت نفسه ، يستمر التشكك في منافع النمو الاقتصادي ، ولا سيما النمو الصناعي . ومما يتذرع به أن مستوى دخل البلدان ليس له ، في أحيان كثيرة ، ارتباط وثيق بمنجزاتها في مجالات اجتماعية مثل التوقع العمري والتعليم والصحة . وهذا التباين بين مستويات الدخل الاجمالية ومؤشرات التنمية الاجتماعية موجود ولا شك ، ولكن لا يصح أن يستنتج منه أن نمو الدخل هو (في موازاة مستوى الدخل) غير ذي أهمية بين عوامل التنمية الاجتماعية . وكما يرد في التقرير العالمي لعام ١٩٩٠/١٩٩١ ، فان اتجاهات الدخل واتجاهات الأبعاد الاجتماعية للرفاه تسير يدا بيد . وليس الدخل هو الذي يفسر انعدام الارتباط بين مستويات الدخل وتدابير الرفاه ، بل الطريقة التي يستخدمه بها مواطنو مختلف البلدان وحكوماتها . ويظل النمو المستمر في الدخل ، الذي تفيد الادلة المتيسرة حتى الآن أنه لا يتحقق الا بالنمو الصناعي ، شرطا ضروريا ، وإن لم يكن كافيا اطلاقا ، لتعزيز الرفاه .

وتشير مدرسة أخرى من منتقدي النمو الصناعي الى التلف البيئي الذي يمكن أن ينجم عن هذا النمو . واليونيدو ، باعتبارها وكالة من وكالات الامم المتحدة معنية ، أساسا ، بالنمو الصناعي ، تحمل هذا الانتقاد على محمل الجد . ولذلك اتخذت العلاقة بين الصناعة والتنمية موضوعا خاصا ل التقرير العالمي لعام ١٩٩٠/١٩٩١ . وتبعا للممارسة الراسخة في اليونيدو ، يلقي التقرير نظرة وقائية فاحصة وتفصيلية على الجوانب التقنية والاقتصادية للتلوث ، ويبحث السياسات التي اتبعت في الآونة الأخيرة في مجال تخفيفه . ومن ذلك أن الركود الصناعي قد يكون دواء باهظ التكلفة لمعالجة المشاكل البيئية ، ومن المشكوك فيه أن يكون ناجعا . والحقيقة في هذا الامر ، كما هي في غيره ، أكثر تعقيدا بكثير مما يوحي به اطلاق الشعارات المبسطة . فبعض العمليات الصناعية أكثر تلويثا من البعض الآخر ، وكذلك بعض المنتجات الصناعية .

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* أعدت تنبؤات هذا العام قبل نشوب الأزمة السياسية في غربي آسيا آب/ أغسطس ١٩٩٠ . ونتيجة لذلك تبدو الآن بعض الافتراضات التي أسندت اليها التنبؤات غير واقعية . واذا استمرت أسعار النفط مرتفعة طوال عام ١٩٩١ فستغير مستوى ونمط النمو في الاقتصاد العالمي .

ومكافحة التلوث تكون باختيار عمليات أفضل وابتكار منتجات أفضل . بل ان رصد التلوث ومكافحته تقتضيان تكنولوجيا صناعية معقدة .

وعملا بالنمط المتبع في الأعداد السابقة من التقرير العالمي ، تقدم تنبؤات عن الاقتصاد العالمي ، في جملته ، وعن مناطقه الرئيسية . ونظرة اليونيدو الى احتمالات النمو الصناعي في السنة القادمة هي نظرة تتسم بالتفاؤل الحذر . غير أن معدل النمو الصناعي للبلدان النامية لا يحتمل له أن يصل الى المستويات التي بلغها في الستينات أو السبعينات . والاخفاق في تلبية المتطلبات التقنية والمادية والبشرية يمنع بلدانا كثيرة من تحقيق تصنيع مستمر . ويبحث التقرير العالمي لعام ١٩٩١/١٩٩٠ هذه المتطلبات ، في اطار محاولة لمساعدة مقرري السياسات على اجراء تقدير أفضل لمواطن قوتهم ومواطن قصورهم .

ان سياق التصنيع آخذ في التغير . ففي الوقت الحاضر يستعاض عن التخطيط الانمائي برفع القيود عن الاقتصاد على نحو يتجه وجهة الاقتصاد السوقي وقد أدى اضفاء الصبغة العالمية على الأسواق المالية والتقسيم الدولي للعمل الى نشوء بيئة تقاتل ، لا بيئة تعاون أو تكامل . وفي هذه الظروف ، يتطلع النمو الصناعي في البلدان المتقدمة النمو ، وكذلك في البلدان النامية ، الى الحافز الابتكاري الذي يهيؤه المستثمرون الأجانب ، جالبو المال والتكنولوجيا والروح التنافسية الدينامية . وهذا الموضوع متابع في التقرير العالمي لعام ١٩٩١/١٩٩٠ . فالى جانب تقديم عرض تفصيلي للأداء الصناعي في عشر مناطق من العالم ، يرصد التقرير تطور الاستثمار الأجنبي المباشر في كل من تلك المناطق ، ويتضمن دراسة استقصائية لثلاث عشرة صناعة تحويلية مختارة .

لقد كانت الثمانينات عقدا مهدورا في البلدان النامية ، ولا سيما أفقرها في افريقيا . واذا كان للتسعينات أن تأتي بخير منه ، فلن يحدث ذلك الا عندما تتعلم الاقتصادات النامية الصمود لأنواء المنافسة العالمية ، وتعجل عملية تعلمها . والتغيرات الضخمة التي حصلت مؤخرا في أوروبا الشرقية تثبت أن هذا قد أصبح الآن قدر الاقتصادات في جميع أنحاء العالم . وستكون أفضل أدوات التقدم هي المعلومات ، والدراية ، والاستعداد لاكتساب القدرة على المنافسة . وها هو التقرير العالمي لعام ١٩٩١/١٩٩٠ ، يقدم للمساعدة في كشف مجاهل التصنيع في التسعينات ، أملا في أن يصبح النمو الصناعي السريع من جديد ، ظاهرة معتادة جديرة بالترحيب .

دومينغو ل . سيازون ، الابن

المدير العام

序　言

世界工业的发展在１９８９年减慢了，１９９０年代第一年也难望扭转这一减速趋势。预期的通货膨胀，原材料特别是石油＊价格重新捉摸不定，以及由于各国迅速放宽管制和走向全球化而带来的财政困难，这一切都对工业增长造成极为不利的条件。与此同时，对于经济增长特别是工业增长的利益，仍有一些人抱将信将疑态度。有人认为，一国的收入水平常常与其社会领域的成就，例如与平均寿命、教育和保健等领域取得的成就并无多大的联系。总的收入水平和社会发展指标之间的这种距离无疑是存在的，但如果因此断言收入增长（相对于收入水平）作为社会发展因素来说是多余的，那就错了。《１９９０／９１年全球报告》认为，收入的增长与社会福利的增长息息相关。收入水平之所以与福利高低相互脱节，其原因不在于收入，而在于各国公民和政府如何使用这些收入。根据迄今为止的事实来看，只有通过工业增长才能实现的收入持续增长，依然是提高福利的必要条件，尽管不是唯一的条件。

另一学派的批评家指出，工业增长会使环境受到破坏。对于这一批评，工发组织作为主要关心工业增长的一个联合国机构，给予了认真的处理。因此，《1990／９１年全球报告》将工业与环境的关系作为报告的一个特别主题。按照工发组织的一贯做法，《全球报告》客观而细致地考核了污染所涉的技术和经济问题，并分析了近年来采取的污染防治政策。工业停滞也许会缓解环境方面的问题，但这种办法代价高昂，而且是否奏效令人怀疑。这个问题也与别的问题一样，实际上极为复杂，远非空喊口号那么简单。有些工业在生产作业上，污染程度比另一些工艺来得严重，同样，某些工业产品造成的污染又比另一些工业产品来得严重。如果选用较好的工艺或设计出较好的产品，就可以控制污染，反过来说，监测和控制污染也需要精湛的工业技术。

＊　本年度的预测是在１９９０年８月西亚爆发政治危机前作出的。因此，作为预测根据的一些设想现在看来已经不符合实际。石油价格的高涨如果持续到１９９１年，势必改变整个世界经济的增长水平和格局。

《全球报告》参照以往的格式，对整个世界及其主要区域作了经济预测。工发组织对来年的工业增长前景持谨慎的乐观态度。不过，发展中国家的工业增长率不可能达到１９６０年代或１９７０年代的水平。许多国家面临的难题是在技术、物质和人力条件方面达不到实现持续工业化的要求。《１９９０／９１年全球报告》认真审查了这些需求，以期帮助各国决策者更好地评估本国具有的优势和缺陷。

工业化的气候正在发生变化。发展规划日渐淡化，代之而起的是以市场为导向的自由化。金融市场全球化和国际分工并没有造成相互合作或一体化气氛，而是造成了你死我活的竞争环境。在这种情况下，发达国家以及发展中国家的工业增长只能企望于外国投资者提供新的刺激，仰赖外国投资者带来金钱、技术和积极的竞争精神。《１９９０／９１年全球报告》对这一主题作了进一步的讨论。它不但详细介绍了世界１０个区域的工业发展情况，而且综述了外国直接投资在其中每个区域内的变化趋势，同时还对１３个选定的制造业进行了调查分析。

对发展中国家，特别是对非洲最贫穷的国家来说，１９８０年代是毫无起色的十年。如果要使１９９０年代呈现任何转机，那么发展中国家必须学会如何经受住全球竞争的严峻考验，而且要加快这一学习过程。东欧最近的重大变化表明，现在这已成为世界各国经济的唯一出路。信息、专门知识和加强竞争能力，这些将是取得进步的良方。《１９９０／９１年全球报告》的出版正是为了引导人们在１９９０年代在工业化的一些陌生领域探索道路，希望迅速的工业增长再度成为热门话题，受到人们的欢迎。

总干事

小多明哥．L．夏松

Préface

En 1989, la progression de l'industrie mondiale s'est ralentie et on ne peut guère compter que la première des années 90 renversera cette décélération. La crainte de l'inflation, l'incertitude accrue quant au prix des matières premières et plus spécialement du pétrole*, les séquelles financières d'une déréglementation et d'une globalisation rapides, tous ces facteurs créent des conditions défavorables à la croissance industrielle. Par ailleurs, le scepticisme persiste quant aux avantages de la croissance économique et en particulier de la croissance industrielle. Certains soutiennent que souvent, dans un pays, le niveau des revenus n'est guère en rapport avec les réalisations sociales dans des domaines tels que l'espérance de vie, l'éducation et la santé. De tels écarts entre les revenus globaux et les indicateurs du développement social existent sans aucun doute, mais il serait faux d'en conclure que la croissance des revenus (par opposition à leur niveau) n'intervient pas en tant que facteur du développement social. D'après le *Rapport 1990/91*, les revenus et les dimensions sociales du bien-être évoluent dans le même sens. Ce ne sont pas les revenus mais l'usage qu'en font les habitants et les gouvernements des différents pays qui explique le manque de corrélation entre le taux des revenus et le niveau du bien-être. La croissance soutenue des revenus, qui jusqu'à preuve du contraire ne peut être obtenue que grâce à la croissance industrielle, reste une condition nécessaire, encore que nullement suffisante, d'un bien-être accru.

D'autres critiques de la croissance industrielle soulignent les dommages à l'environnement que cette croissance pourrait causer. En tant qu'institution des Nations Unies s'occupant principalement de la croissance industrielle, l'ONUDI prend cette critique très au sérieux. Aussi le *Rapport 1990/91* est-il spécialement consacré à la relation entre l'industrie et l'environnement. Conformément à sa pratique établie, l'ONUDI y examine de façon rigoureuse et détaillée, en s'en tenant aux faits, les aspects techniques et économiques de la pollution, et y étudie des politiques récentes de lutte contre la pollution. Pour faire face aux problèmes écologiques, la stagnation industrielle serait un remède coûteux dont l'efficacité est d'ailleurs douteuse. Comme toujours, la vérité est ici beaucoup plus complexe que de simples slogans ne donnent à penser. Certains procédés industriels, comme certains produits industriels, polluent plus que d'autres. C'est en choisissant de meilleurs procédés et en concevant de meilleurs produits que l'on maîtrisera la pollution, et la lutte contre la pollution exige elle-même des techniques industrielles perfectionnées.

Comme dans les *Rapports* précédents, les prévisions sont présentées pour l'ensemble de l'économie mondiale et pour les principales régions. L'ONUDI considère avec un optimisme prudent les perspectives de croissance industrielle pour l'année qui vient. Il est néanmoins improbable que le taux de croissance industrielle des pays en développement atteigne les niveaux des années 60 ou 70. Faute de pouvoir satisfaire à des exigences techniques, matérielles et humaines, de nombreux pays ne parviennent pas à atteindre une industrialisation soutenue. Le *Rapport 1990/91* examine ces exigences afin d'aider les responsables à mieux évaluer leurs points forts et leurs points faibles.

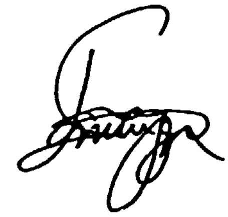
Le contexte de l'industrialisation évolue. La planification du développement fait place à une libéralisation orientée vers le marché. Au lieu de favoriser la coopération ou l'intégration, la globalisation des marchés financiers et la division internationale du travail ont créé une situation de concurrence féroce. Cela étant, dans les pays développés comme dans les pays en développement, la croissance industrielle a besoin du stimulant novateur offert par les investisseurs étrangers, qui apportent des capitaux, de la technologie et un esprit de concurrence dynamique. Ce thème est

*Les prévisions de cette année ont été préparées avant la crise politique qui a éclaté en Asie occidentale en août 1990. En conséquence, certaines des hypothèses sur lesquelles reposent ces prévisions semblent maintenant manquer de réalisme. Les prix élevés du pétrole, s'ils persistent en 1991, modifieront le taux et la structure de la croissance de l'économie mondiale.

développé dans le *Rapport 1990/91* qui, outre un exposé détaillé des réalisations industrielles dans 10 régions du monde, trace l'évolution des investissements directs étrangers dans chacune de ces régions et comprend une étude de 13 industries manufacturières.

Les années 80 ont été une décennie perdue pour les pays en développement, en particulier pour les pays les plus pauvres d'Afrique. Pour que les années 90 soient plus bénéfiques, il faudra que les économies en développement apprennent à résister aux rigueurs de la compétition mondiale et à accélérer leur apprentissage. Les changements importants survenus récemment en Europe orientale ont montré que tel est désormais le lot des économies du monde entier. Pour progresser, les meilleurs outils seront l'information, le savoir-faire et la volonté d'être compétitif. Dans le *Rapport 1990/91*, on s'est proposé d'aider à reconnaître le terrain peu familier de l'industrialisation dans les années 90, en espérant que la croissance industrielle rapide redeviendra un phénomène familier et bienvenu.

Le Directeur général,



DOMINGO L. SIAZON Jr

Предисловие

В 1989 году темпы роста мирового промышленного производства замедлились, и вероятность того, что в первый год наступившего десятилетия эта тенденция изменится, невелика. Ожидание инфляции, вновь возникшая неопределенность в отношении цен на сырье, особенно на нефть*, финансовые трудности, вызванные стремительным сокращением государственного регулирования и растущей глобализацией, — все это создает неблагоприятные условия для промышленного роста. В то же время сохраняется скептицизм в отношении выгод экономического и особенно промышленного развития. Утверждается, что изменение уровня доходов в стране часто не зависит от достижений в социальной области, например, от увеличения продолжительности жизни, развития систем образования и здравоохранения. Подобное несоответствие между совокупными показателями уровня доходов и показателями социального развития, несомненно, существует, однако было бы ошибочно на основании этого делать вывод о том, что рост доходов (в отличие от уровня доходов) не является существенным фактором социального развития. В **Глобальном докладе за 1990/91 год** указывается, что тенденции изменения показателей доходов и социальных параметров благосостояния имеют одинаковую направленность. Отсутствие взаимосвязи между уровнем доходов и уровнем благосостояния обусловлено не показателями самих доходов, а тем, как они используются гражданами и правительствами различных стран. Устойчивый рост доходов, который может быть достигнут, судя по опыту, лишь на основе развития промышленности, по-прежнему является обязательным, хотя вовсе и недостаточным условием роста благосостояния.

Другая группа критиков промышленного роста указывает на то, что в результате этого процесса может быть нанесен ущерб окружающей среде. ЮНИДО как учреждение Организации Объединенных Наций, занимающееся в основном проблемами промышленного развития, воспринимает эту критику серьезно. Поэтому взаимосвязь между промышленностью и окружающей средой является специальной темой **Глобального доклада за 1990/91 год.** В соответствии с установившейся в ЮНИДО практикой в нем на основе конкретных фактов объективно и подробно рассматриваются технико-экономические аспекты проблемы загрязнения и анализируются принятые в последнее время программы борьбы с загрязнением окружающей среды. Замедление промышленного развития может оказаться весьма дорогостоящим и отнюдь не эффективным решением экологических проблем. Истина как в этом, так и в других случаях гораздо сложнее рецептов упрощенных лозунгов. Одни промышленные процессы, как и некоторые виды промышленной продукции, вызывают большее загрязнение, чем другие. Поэтому именно выбор более совершенных технологий и разработка более совершенных видов продукции позволят предотвратить загрязнение окружающей среды, причем даже мониторинг и борьба с загрязнением окружающей среды требуют высокоразвитой промышленной технологии.

Как и в предыдущих **Глобальных докладах,** в настоящем докладе представлены прогнозы развития мировой экономики в целом и по основным регионам. ЮНИДО смотрит на перспективы роста промышленного производства в предстоящий год с определенным оптимизмом. Тем не менее темпы роста промышленного производства развивающихся стран вряд ли достигнут уровня 60-х или 70-х годов. Достижению многими странами устойчивого процесса индустриализации препятствует неспособность мобилизовать технические, материальные и людские ресурсы. Поэтому потребности в таких ресурсах рассматриваются в **Глобальном докладе за 1990/91 год,** с тем чтобы помочь директивным органам лучше оценить их преимущества и недостатки.

В настоящее время процесс индустриализации протекает несколько в иных условиях. На смену планированию развития приходит либерализация рыночной ориентации. Глобализация финансовых рынков и международное разделение труда создают обстановку острой конкуренции, а не сотрудничества или интеграции. В этих условиях для обеспечения промышленного роста в развитых и развивающихся странах требуются новые стимулы со стороны иностранных инвесторов, которые предоставляют деньги, технологию и привносят дух активной конкуренции. Эта тема рассматривается в **Глобальном докладе за 1990/91 год.** Помимо подробного рассмотрения результатов развития промышленности в 10 регионах мира, в докладе прослеживается динамика прямых иностранных инвестиций в каждом из этих регионов и приводится обзор 13 отдельных отраслей обрабатывающей промышленности.

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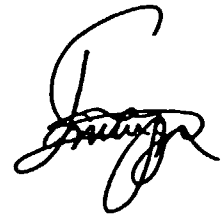
* Прогнозы на этот год составлялись до возникновения в августе 1990 года в Западной Азии политического кризиса. Поэтому некоторые исходные положения таких прогнозов в настоящее время представляются нереалистичными. Высокие цены на нефть, если они сохранятся в 1991 году, повлияют на темпы и структурные параметры развития мировой экономики.

Для развивающихся стран, особенно для наиболее бедных стран Африки, 80-е годы оказались потерянным десятилетием. В 90-е годы более благоприятные условия могут быть обеспечены лишь в том случае, если развивающимся странам удастся выдержать жесткие условия глобальной конкуренции и ускорить процесс подготовки кадров. Последние изменения в Восточной Европе свидетельствуют о том, что такая задача стоит перед экономикой и других стран мира. Наиболее эффективными рычагами прогресса в будущем будут информация, ноу-хау и стремление к достижению конкурентоспособности. **Глобальный доклад за 1990/91 год** предлагается в качестве своего рода пособия, позволяющего лучше разобраться в необычных условиях индустриализации в 90-е годы, в надежде на то, что стремительный рост промышленного производства вновь станет привычным и желанным явлением.



ДОМИНГО Л. СИАЗОН, мл.
Генеральный директор

Prefacio

En 1989 se registró una disminución de la actividad económica industrial mundial, y ha_ pocas esperanzas de que el año inaugural del decenio de 1990 cambie de signo este proceso de desaceleración. Las expectativas inflacionistas, la renovada incertidumbre con respecto al precio de las materias primas, y especialmente del petróleo*, la resaca financiera producida por la rápida desregulación o eliminación de restricciones, y por la mundialización, están creando —todas ellas— condiciones hostiles al crecimiento industrial. Al mismo tiempo, persiste el escepticismo acerca de los beneficios del crecimiento económico y, especialmente, del crecimiento industrial. Se sostiene que el nivel de ingresos de un pais tiene a menudo escasa correlación con sus logros en aspectos sociales como la esperanza de vida, la educación y la salud. Es indudable que se dan tales diferencias entre los niveles de ingresos globales y los indicadores de desarrollo social, pero sería erróneo deducir de ello que el crecimiento del ingreso (comparado con el nivel de ingresos) resulta superfluo como factor de desarrollo social. El *Informe Mundial 1990/91* sostiene que las tendencias del ingreso y de las dimensiones sociales del bienestar avanzan juntas. No es el ingreso, sino la utilización que de él hagan los ciudadanos y los gobiernos de los diferentes países, lo que explica la falta de correlación entre los niveles de ingresos y el grado de bienestar. Un crecimiento sostenido del ingreso, factible, como se ha demostrado hasta ahora, únicamente mediante el crecimiento industrial, sigue siendo una condición necesaria, pero en modo alguno suficiente, para un bienestar mayor.

Otra corriente crítica del crecimiento industrial apunta al daño que tal crecimiento podría ocasionar al medio ambiente. Como organismo de las Naciones Unidas principalmente interesado en el crecimiento industrial, la ONUDI toma esta crítica en serio. Por ello, el *Informe Mundial 1990/91* tiene como tema especial la relación entre la industria y el medio ambiente. En el *Informe*, y de acuerdo con la práctica normalmente seguida por la ONUDI, se examinan a fondo y con gran objetividad los aspectos técnicos y económicos de la contaminación, y se estudian políticas recientemente adoptadas para su reducción. El estancamiento industrial sería una medicina costosa, y de dudosa eficacia, para tratar los problemas del medio ambiente. Como suele suceder, la verdad es también en este caso mucho más compleja de lo que llevaría a creer un eslogan simplista. Algunos procesos industriales contaminan más que otros, y lo mismo cabe decir de algunos productos industriales. Como podrá controlarse la contaminación será eligiendo mejores procesos e ideando mejores productos, e incluso la vigilancia y el control de aquélla requieren tecnología industrial sofisticada. De conformidad con la pauta establecida en anteriores *Informes Mundiales*, se hacen previsiones para la economía mundial en su conjunto y para sus principales regiones.

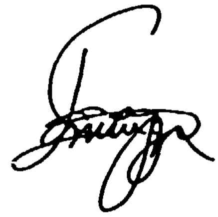
La ONUDI se muestra cautamente optimista con respecto a las perspectivas de crecimiento industrial para el año próximo. Con todo, la tasa de crecimiento industrial de los países en desarrollo no es probable que alcance los niveles de los decenios de 1960 ó 1970. El hecho de que muchos países no consigan satisfacer sus necesidades técnicas, materiales y humanas les impide lograr una industrialización sostenida. En el *Informe Mundial 1990/91* se examinan esas necesidades en un intento por ayudar a los encargados de formular políticas a que determinen con mayor precisión los puntos fuertes y las insuficiencias de esos países.

El contexto de la industrialización está cambiando. La planificación del desarrollo está siendo sustituida por la liberalización orientada al mercado. La mundialización de los mercados financieros y la división internacional del trabajo han creado un ambiente de competencia despiadada, en lugar de fomentar la cooperación o la integración. En estas circunstancias, el crecimiento industrial, tanto en

*Las previsiones de este año se hicieron antes de que estallara, en agosto de 1990, la crisis política en Asia occidental. Como resultado de ello, algunos de los supuestos en que se basan tales previsiones parecen ahora poco realistas. Los elevados precios del petróleo, si persisten en 1991, determinarán variaciones en el nivel y en la estructura del crecimiento de la economía mundial.

los paises desarrollados como en los países en desarrollo, depende del estímulo innovador proporcionado por los inversionistas extranjeros, que aportan dinero, tecnología y un espíritu competitivo dinámico. Este tema se reconsidera en el *Informe Mundial 1990/91*. En éste, además de exponerse detalladamente los rendimientos industriales de 10 regiones del mundo, se traza la evolución de la inversión directa extranjera en cada una de esas regiones y se incluye un estudio de 13 industrias manufactureras seleccionadas.

Los años 80 fueron un decenio perdido para los países en desarrollo, y especialmente para los más pobres de África. Si se quiere que el decenio de 1990 ofrezca algo mejor, ello sólo será posible si las economías en desarrollo aprenden a enfrentarse a la reñida competencia mundial y aceleran su proceso de aprendizaje. Los cambios decisivos recientemente registrados en Europa oriental han demostrado que éste es el destino de todas las economías del mundo. Los mejores instrumentos para el progreso serán la información, los conocimientos técnicos y el deseo de ser competitivos. El *Informe Mundial 1990/91* se ofrece como una ayuda para explorar el desconocido terreno de la industrialización en el decenio de 1990, con la esperanza de que el crecimiento industrial rápido pueda nuevamente convertirse en un fenómeno familiar y bien acogido.



DOMINGO L. SIAZON, Jr.

Director General

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EXPLANATORY NOTES

Reference to dollars ($) are to United States dollars, unless otherwise stated.

References to tonnes are to metric tonnes, unless otherwise specified.

A slash (1980/1981) indicates a crop year or a financial year.

Industry categories referred to in this publication are based on Revision 2 of the International Standard Industrial Classification (ISIC).

References to ISIC codes are accompanied by a descriptive title (for example, ISIC 323—"Manufacturing of leather and products of leather, leather substitutes and fur, except footwear and wearing apparel"). Considerations of space, however, require a shortening of this description (for example, ISIC 323 may be referred to simply as "Leather and fur products"). In some cases, ISIC categories have been aggregated and the descriptive titles adjusted accordingly.

The term "billion" signifies a thousand million.

Figures in square brackets [ ] refer to source material listed after chapter IV.

The following symbols have been used in tables:

Two dots (..) indicate that data are not available or are not separately reported.

A dash (-) indicates that the amount is nil or negligible.

Totals may not add precisely because of rounding.

The following abbreviations and acronyms appear in this publication.

ABS	acrilonitrile-butadiene-styrene
ASEAN	Association of South-East Asian Nations
B.t.u.	British thermal units
CAD	computer-aided design
CAM	computer-aided manufacture
CARICOM	Caribbean Community
CFC	chlorofluorocarbon
CIM	computer-integrated manufacture
CIMACO	Association of Tanning Machinery Constructors
CMEA	Council for Mutual Economic Assistance
COCUM	Co-ordinating Committee for Multilateral Export Controls
ECU	European currency unit
EEC	European Economic Community
EFTA	European Free Trade Association
FAO	Food and Agriculture Organization of the United Nations
GATT	General Agreement on Tariffs and Trade
GCC	Gulf Co-operation Council
GDP	gross domestic product
GNP	gross national product
GSP	generalized system of preferences
IFC	International Finance Corporation
IMF	International Monetary Fund
ISIC	International Standard Industrial Classification of all Economic Activities
LME	London Metal Exchange
MITI	Ministry of International Trade and Industry
MTBE	methyl tertiary butyl ether
MVA	manufacturing value added
NIC	newly industrializing country
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of Petroleum Exporting Countries
PVC	polyvinyl chloride
R+D	research and development
RMS	reference material system
SABIC	Saudi Basic Industries Corporation
TCI	technology complexity index
TFP	total factor productivity
TRI	Toxics Release Inventory
WHO	World Health Organization

This report is based on information available as of March 1990.

Introduction: The structure of this *Report*

The beginning of the last decade of the twentieth century has surprised everyone by the variety and rapidity of the changes it has set in motion. The dynamics of an already globalizing economy have been enhanced by the momentous events in Eastern Europe that have led to a process of irreversible change from a planned to a market economy and the end of the cold war, with the prospect of an enlarged European Economic Community beyond the horizons of the original plans for 1992, and the emergence of other large economic and trading blocs in North America and the Asia-Pacific region. At the same time, the 1980s were a severe decade for many developing countries, especially in Africa. The challenge of enabling these countries to benefit from the dynamic global growth process by removing the many obstacles facing them remains urgent.

The global growth process, after decelerating in 1989 from its high level of 1988, will remain steady during 1990. In chapter I, the immediate economic outlook is assessed as in previous years. UNIDO takes the view that despite the many uncertainties in the financial and raw-materials areas, there are clear signs that growth will pick up in 1991. At the same time, however, a scepticism about the desirability of pursuing growth has been rekindled. In Chapter I the benefits of economic growth over the past three decades are examined in terms of social indicators of human well-being—health, education, nutrition—as well as in terms of the greater sophistication and availability of material industrial products. Growth is clearly a necessary ingredient for improving well-being, although it may not be sufficient.

There are, however, obstacles to achieving industrial growth in developing countries. These obstacles—technical, material and human—are also surveyed in chapter I in an assessment of the scope for industrialization. In the new global context, they will involve flows of trade and of direct investment, as well as the availability of opportunities to borrow much-needed capital.

Foreign direct investment is crucial for industrial growth in both developed and developing countries. In chapter II, which provides a survey of the industrial performance in the 10 different regions, the evolution of foreign direct investment and the structural role it plays are highlighted. In a competitive environment, to survive is to change, and foreign investment everywhere entails new and different approaches that encourage innovation. Of the 10 regions surveyed in chapter II, none is confronting the challenge of adapting to a new environment more boldly than the Eastern European region. Macro-economic stabilization and institutional reform are the major themes, and the overall prospects, though uncertain, are hopeful. Problems persist, however, in the Latin American and African regions, while the fragility of the recent recovery in China and the continuing trade tension between the United States and Japan cannot be lightly dismissed.

One of the strong grounds for scepticism about growth has been the environmental impact of economic, and specifically industrial, growth. There has recently been much heated debate on the issue, as global awareness of ecological problems increases. What has been lacking is a comprehensive and detailed, factual account of the environmental impact of industrial processes and products. In chapter III of *Global Report 1990/91* an attempt has been made to fill this lacuna by offering a balanced and sober account of the environmental impact of industrial activity. While industrial activity pollutes, there is scope for reducing such pollution by using new processes that are clean and waste-reducing. It is demonstrated that the installation of new processes can be profitable, and thus there need not be a zero- or negative-sum game between growth and environment. Unfortunately, the use of the new technologies has not yet become sufficiently widespread. Their dissemination and adoption in both developed and especially developing countries offers a challenge and a hope for reconciling growth and environmental protection. The detailed treatment of environmental problems in chapter III should provide much-needed information for industrial decision-makers.

In *Global Report 1989/90* it was decided to restrict the industrial survey to a small number of selected manufacturing industries, an innovation maintained in *Global Report 1990/91*, with surveys of 13 manufacturing industries contributed by experts. It is hoped that this survey, contained in chapter IV, will continue to be a useful source of information for policy-makers everywhere.

I. The immediate outlook for the world economy and industrialization of developing countries in retrospect

A. The world economy in 1989

While 1989 was a year of surprises in terms of political change, world economic developments were pretty much as expected, which is to say it was a good year for forecasters. *Global Report 1989/90* was very close in forecasting 1989 world economic growth at 3.4 per cent versus the 3.3 per cent actually registered. As shown in table I.1 the regional and country-level forecasts were also generally quite accurate.

In Latin America and Africa, performance remained sluggish. Growth in Latin America in 1989 was only 1.6 per cent, which was only a slight improvement over the 1988 rate of 1.1 per cent. Tropical Africa registered 2.8 per cent growth in 1989, which while nearly a full percentage above the 1988 rate was still not high enough to raise per capita incomes in the region. Lack of substantial progress toward resolving the debt crisis in these two regions is the main factor responsible for their poor economic performance.

There was a widespread fall in growth throughout much of developing Asia. In China growth fell from 11.4 per cent in 1988 to 3.9 per cent in 1989. This slow-down occurred in response both to economic sanctions, which were imposed by a number of countries following the events of June 1989, and to China's own economic restructuring and austerity programme.

In East and South-East Asia growth fell from the 1988 rate of 8.3 per cent to 6.7 per cent in 1989. However, there was a considerable variety in performance at the subregional or country level. The newly industrializing countries* (NICs) of Indonesia, Malaysia, Philippines and Thailand, the "new NICs", generally continued to perform strongly, while the "old NICs" experienced a decline. In particular, Hong Kong and the Republic of Korea both registered a nearly 50 per cent fall-off in growth.

On the Indian Subcontinent, growth fell from 8.6 per cent in 1988 to 4.3 per cent in 1989. In India it fell from 10 per cent in 1988 to 4.5 per cent in 1989. One factor that may have accounted for the slow-down was a set of new restrictions on imports, which could have delayed some investment decisions and curtailed the availability of inputs in a number of industries. A growing deficit in the federal budget may also have been a contributing factor, as was perhaps the need to take measures to control the climbing inflation rate ([1], p. 135). In Nepal, growth was down from 9.7 per cent in 1988 to 1.5 per cent in 1989. The main factor was the collapse of its economic relations with India, which resulted in the severing of Nepal's transport and trade links with the rest of the world. In Pakistan, growth in 1989 of 5.6 per cent was about the same as in 1988.

For developed countries the main factor affecting economic performance in 1989 was the re-emergence of inflation as one of the main concerns of policy-makers. In Western Europe growth remained strong at 3.4 per cent, which about matched the 1988 figure of 3.5 per cent. Developments in Eastern Europe and increased investment activity in preparation for the unification of the European Economic Community (EEC) market in 1992 were probably the main factors contributing to this strong performance. At 4 per cent, growth in the Federal Republic of Germany reached a 10-year high. The large inflow of workers from the German Democratic Republic was one factor contributing to higher growth there.

The 3.1 per cent growth which North America registered in 1989 was the lowest rate posted in the region since the trough of the last recession in 1982. The final estimates of the United States Department of Commerce put fourth-quarter 1989 growth at only 1.1 per cent. The Canadian economy turned in a similar growth trajectory. In both countries tighter monetary policies prompted by fears of higher inflation were responsible for the slower growth. Japan's 1989 growth led by very strong investment demand and continued strength in exports remained substantial in 1989 at 4.9 per cent. However, it did not match the 1988 rate of 5.7 per cent.

The European centrally planned economies experienced a nearly 50 per cent fall-off in growth from 4 per cent in 1988 to 2.1 per cent in 1989. In 1989 the countries of the region, in differing degrees, faced a variety of economic problems, including high State budget deficits, high levels of international debt and the inevitable disruptions that have been encountered as many of these economies make the transition to market economies. Slower growth, high inflation and growing unemployment have been the result in various degrees depending on the country.

Within the context of overall economic performance the special interest of UNIDO is the performance of

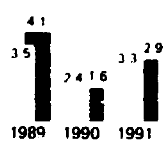
*The term "NICs" is used extensively to describe developing economies, be they countries, provinces or areas, where there has been particularly rapid industrial growth. It does not imply any political division within the ranks of developing countries and is not officially endorsed by UNIDO.

Table I.1. Regional and country estimates of GDP and MVA

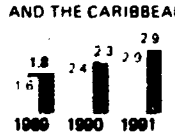
Regions, countries and areas	GDP growth rates percentage 1989	1990	1991	MVA growth rates percentage 1989	1990	1991
World	3.3	3.1	3.7	4.0	3.3	[illegible]
Developing countries excluding China	3.0	3.9	4.1	3.8	5.3	5.5
Developed countries	3.3	2.8	3.5	4.0	3.0	3.9
China	3.9	5.2	5.2			
North America	3.1	2.5	3.2	3.6	1.7	3.6
Bermuda	1.2	1.3	2.5	2.7	2.8	2.9
Canada	3.9	2.8	3.7	0.4	1.1	3.2
United States	3.0	2.5	3.2	3.8	1.7	3.6
Western Europe	3.4	3.3	3.8	4.5	3.6	4.6
Austria	4.0	3.7	5.0	6.2	4.1	6.3
Belgium	4.5	3.1	3.7	4.0	3.9	4.7
Denmark	1.2	1.6	3.4	1.5	2.5	3.8
Finland	5.0	2.9	3.1	4.2	4.6	3.3
France	3.1	3.0	3.3	4.7	2.9	3.5
Germany, Fed. Rep. of	4.0	4.4	5.0	5.6	4.5	5.8
Greece	2.3	2.3	3.7	1.3	1.8	3.8
Iceland	3.0	2.1	3.0	3.9	1.1	2.6
Ireland	5.7	5.9	4.8	12.9	7.5	7.5
Israel	0.9	1.2	1.6	1.4	0.4	0.6
Italy	3.1	3.0	5.4	3.7	3.8	8.6
Luxembourg	3.1	2.9	2.8	10.3	5.2	3.9
Malta	6.0	6.4	4.9	5.5	5.9	5.0
Netherlands	4.1	2.8	4.0	3.9	2.9	3.8
Norway	3.6	2.5	4.7	2.3	1.0	0.3
Portugal	4.8	3.7	4.3	2.0	3.6	4.6
Spain	4.9	4.5	4.7	5.2	6.1	5.9
Sweden	1.7	2.0	2.6	2.9	1.8	2.9
Switzerland	3.0	2.3	1.9	1.8	2.2	2.0
United Kingdom	2.8	2.9	1.7	4.8	2.0	0.2
Yugoslavia	0.8	0.0	1.1	1.9	2.1	2.3
Eastern Europe incl. USSR	2.1	0.4	0.6	2.2	0.9	0.3
Albania	1.0	2.7	2.2	4.2	1.9	3.7
Bulgaria	0.4	1.0	1.2			
Czechoslovakia	1.3	1.3	1.4	2.1	1.2	1.7
German Dem. Rep.	2.0	2.5	3.3	3.4	3.3	3.7
Hungary	2.0	3.0	3.5	1.2	2.8	3.1
Poland	0.0	0.1	0.6	2.8	0.2	0.8
Romania	2.4	1.0	2.0	4.3	3.0	2.8
USSR	2.4	0.0	0.0	2.2	0.3	1.5
Japan	4.9	5.0	6.1	6.1	6.8	8.4
Other developed countries	3.5	2.4	3.3	4.1	1.6	2.9
Australia	4.2	2.7	3.5	6.4	1.3	2.6
New Zealand	2.4	1.6	3.4	2.7	2.4	4.4
South Africa	2.1	2.1	2.5	0.1	2.1	3.0
Latin America and the Caribbean	1.6	2.4	2.9	1.8	2.3	2.9
Argentina	5.0	0.0	2.0	9.9	1.2	2.3
Bahamas	1.5	4.6	5.0			
Barbados	3.1	1.6	2.1	3.8	1.5	1.8
Belize	2.8	3.9	2.7	1.9	2.6	2.6
Bolivia	2.6	4.2	3.7	2.0	4.5	3.8
Brazil	3.0	2.0	2.3	1.7	0.5	0.8
Chile	10.0	5.2	4.1	12.4	5.0	4.2
Colombia	3.0	2.5	2.5	2.3	1.3	1.2
Costa Rica	5.6	2.9	2.4	7.4	3.7	3.0
Cuba	1.0	1.6	0.2	1.1	1.8	0.2
Dominican Republic	3.8	6.0	5.7	3.0	8.3	6.4
Ecuador	0.5	2.5	7.3	2.3	8.1	4.4
El Salvador	2.0	1.6	0.1	2.6	2.1	0.3
French Guiana	1.4	0.8	1.2	2.5	2.8	2.9
Guadeloupe	1.1	3.3	2.8	1.5	1.6	3.2
Guatemala	4.0	3.8	3.8	4.5	4.2	4.3
Guyana	1.3	2.7	1.5	1.7	3.5	1.2
Haiti*	0.5	1.0	1.6	0.5	0.8	1.7
Honduras	2.1	3.0	3.4	2.2	3.2	3.7
Jamaica	0.8	1.8	0.3	0.7	1.7	0.2
Martinique	2.0	3.2	4.1	3.0	2.9	2.8
Mexico	2.4	4.0	3.7	5.8	5.7	4.7
Montserrat	2.1	1.0	1.5	7.8	4.8	4.6
Netherlands Antilles	3.5	5.0	0.8	2.6	2.6	2.8
Nicaragua	1.1	1.0	0.5	0.6	2.7	2.2
Panama	0.0	2.8	4.4	0.0	1.9	3.0
Paraguay	5.7	6.0	6.0	5.4	5.5	5.8
Peru	14.2	[illegible]	5.0	24.0	3.0	6.2
Puerto Rico	3.7	2.1	6.5	6.9	4.6	8.8
Suriname	0.0	0.8	0.5	5.5	4.6	4.7
Trinidad and Tobago	3.4	1.1	1.5	1.2	0.8	0.8
Uruguay	1.2	3.5	1.2	5.2	3.4	0.7
Venezuela	0.5	1.5	2.3	2.8	3.5	4.1
Tropical Africa (Sub-Sahara)	2.8	3.5	3.1	0.5	3.9	4.2
Benin*	0.5	2.0	0.5	1.5	2.7	1.6
Botswana*	8.5	2.5	2.4			
Burkina Faso*	12.0	5.0	2.3	6.3	4.0	2.6
Burundi*	2.1	0.9	6.3	3.2	3.0	4.3
Cameroon	5.5	1.5	8.1	14.5	4.0	9.2
Cape Verde*	5.0	5.3	4.2			
Central African Republic*	2.1	2.3	1.8	1.6	1.6	1.6
Chad*	5.0	3.5	2.8	4.9	3.5	2.8
Comoros*	3.4	4.1	2.5	3.3	4.4	3.7
Congo	3.3	3.1	2.5	3.7	0.4	4.3

NORTH AMERICA

OTHER DEVELOPED COUNTRIES



LATIN AMERICA AND THE CARIBBEAN



growth for 1989 and projections for 1990 and 1991

Regions, countries and areas	GDP growth rates (percentage) 1989	1990	1991	MVA growth rates (percentage) 1989	1990	1991
Cote d'Ivoire	2 0	2 3	2 0	6 0	2 1	2 0
Djibouti*	1 7	1 1	1 1	8 2	5 2	4 1
Equatorial Guinea*	3 8	3 9	3 4	2 7	2 7	2 4
Ethiopia*	4 5	5 8	3 1	4 0	6 9	4 1
Gabon	4 7	8 9	4 0			
Gambia*	6 3	5 0	3 9	0 8	0 8	1 1
Ghana	6 1	4 8	2 4	13 4	10 1	4 0
Guinea*	4 1	1 0	1 1	3 7	0 3	0 4
Guinea-Bissau*	5 1	6 9	2 3	0 1	0 7	0 1
Kenya	3 5	6 1	6 2	6 0	8 6	8 7
Lesotho*	3 0	6 2	7 0			
Liberia	1 5	0 5	1 5	3 9	2 7	4 2
Madagascar	1 9	1 5	0 9	2 6	2 6	3 0
Malawi*	4 3	6 0	5 2	5 5	6 8	7 2
Mali*	9 9	4 0	3 7	5 2	4 3	5 0
Mauritania*	3 5	3 0	2 0	6 6	6 8	6 6
Mauritius	5 0	4 0	3 2	8 5	7 4	6 5
Mozambique*	4 4	1 5	4 1	7 8	2 9	6 5
Namibia	3 0	0 9	0 2			
Niger*	4 3	2 5	3 2	3 6	2 8	3 2
Nigeria	4 0	3 3	4 0	1 6	3 5	4 1
Reunion	3 0	3 6	4 6	3 0	2 9	2 8

Regions, countries and areas	GDP growth rates (percentage) 1989	1990	1991	MVA growth rates (percentage) 1989	1990	1991
Rwanda*	1 7	4 5	3 5			
Sao Tome and Principe*	2 3	4 8	1 5	1 9	3 7	1 3
Senegal	0 5	3 9	3 0	18 6	5 9	0 6
Seychelles	4 3	2 5	3 3	9 1	8 4	8 7
Sierra Leone*	2 5	0 9	0 1	5 5	3 3	2 2
Somalia*	8 2	3 6	0 6			
Swaziland	5 0	3 2	7 2	5 1	4 9	6 5
Togo*	4 0	1 4	1 7	4 0	1 3	1 6
United Rep of Tanzania*	4 0	3 8	3 9	5 2	5 1	5 2
Uganda*	2 0	0 4	2 4	1 5	1 1	5 3
Zaire	2 2	3 0	4 0	0 0	0 9	2 1
Zambia	0 1	4 5	0 4	1 3	7 4	0 7
Zimbabwe	5 5	4 6	4 0	7 0	6 0	5 3
North Africa	2 3	3 8	3 6	3 6	5 1	5 2
Algeria	2 8	3 5	1 9	1 4	4 8	4 2
Egypt	2 5	5 4	5 0	3 3	4 8	4 6
Libyan Arab Jamahiriya	1 6	2 1	3 4	9 9	10 6	11 1
Morocco	3 0	4 7	5 8	5 2	4 6	4 9
Sudan*	2 0	1 3	0 9	3 0	1 4	0 6
Tunisia	3 1	3 4	4 9	6 2	6 6	8 3

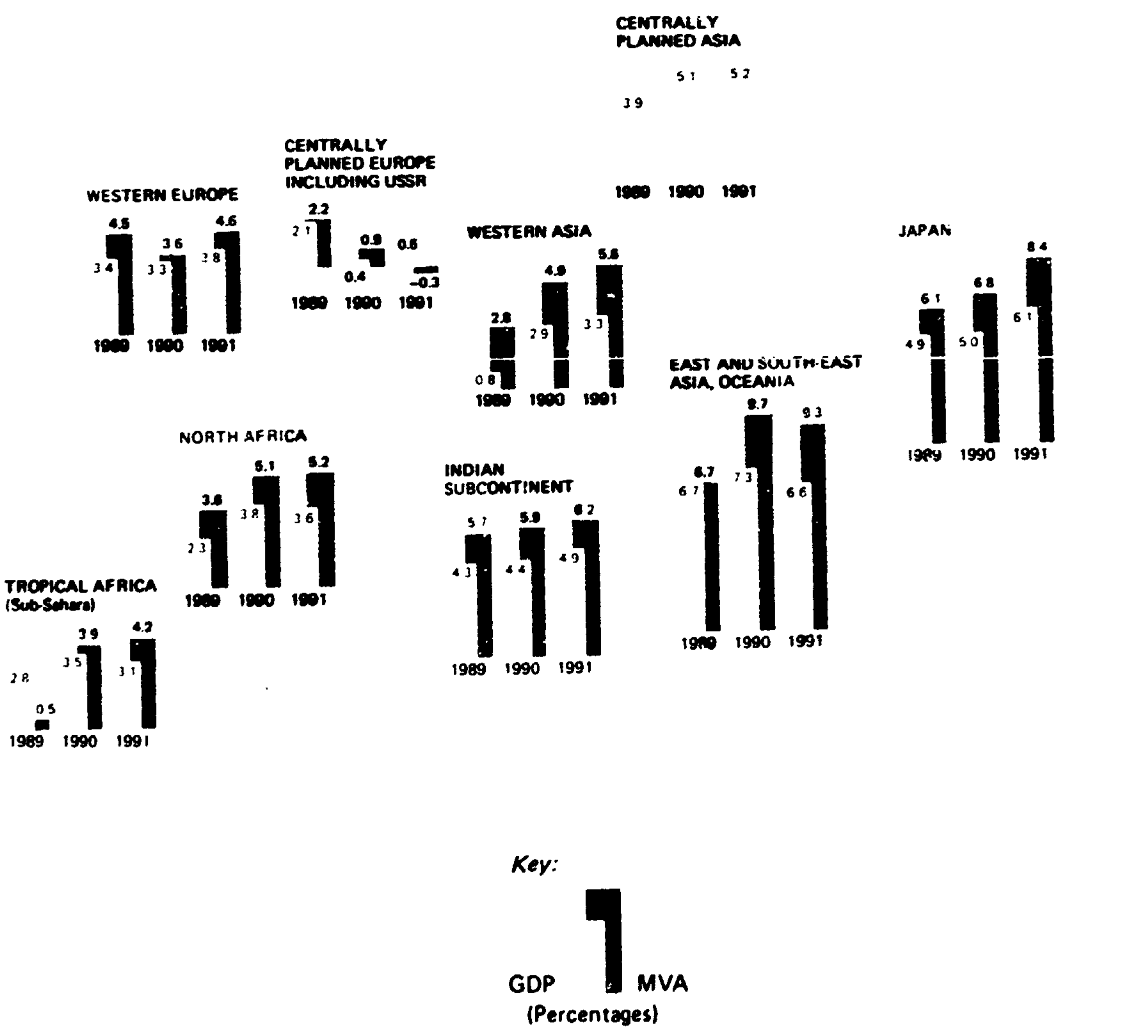


Table I.1. Regional and country estimates of GDP and MVA growth for 1989 and projections for 1990 and 1991 *(continued)*

Regions, countries and areas	GDP growth rates (percentage) 1989	1990	1991	MVA growth rates (percentage) 1989	1990	1991
Western Asia	0.8	2.9	3.3	2.8	4.9	5.6
Cyprus	6.0	4.8	6.1	6.2	5.1	6.8
Democratic Yemen*	2.0	1.5	4.5	4.1	4.1	4.2
Iran (Islamic Rep. of)	1.0	3.0	3.5	2.4	5.8	6.2
Iraq	2.0	2.0	2.3	6.3	6.2	6.1
Jordan	0.0	3.1	3.3	0.5	2.0	3.5
Kuwait	7.5	2.0	1.0	2.3	0.7	0.3
Oman	4.2	4.7	6.3			
Qatar	0.9	3.5	3.5	8.3	9.2	9.1
Saudi Arabia	0.7	3.3	3.5	3.7	5.6	5.8
Syrian Arab Republic	2.0	2.8	6.0			
Turkey	1.1	2.7	3.4	1.2	3.4	4.4
United Arab Emirates	1.0	2.2	2.5	8.0	7.2	7.8
Yemen*	6.0	4.0	6.0	11.1	12.3	11.6
Indian Subcontinent	4.3	4.4	4.9	5.7	5.9	6.2
Afghanistan*	1.2	5.6	5.0	1.3	3.8	4.7
Bangladesh*	1.9	3.2	3.7	2.5		
Bhutan*	6.7	10.0	12.5	12.6	14.4	17.0
India	4.5	4.4	4.9	6.6	5.9	6.2
Myanmar*	3.4	3.9	3.4	3.2	3.7	3.2
Nepal*	1.5	3.8	5.6	5.2	11.4	0.8
Pakistan	5.6	5.3	5.5	2.2	5.7	6.7
Sri Lanka	2.1	0.3	1.9	8.4	7.3	5.9
East and South-East Asia, Oceania	6.7	7.3	6.6	6.7	9.7	9.3
Brunei Darussalam	2.5	4.4	2.3	0.3	2.3	0.1
Fiji	12.1	3.0	8.9	24.7	3.8	14.4
French Polynesia	6.4	7.0	7.4	9.5	9.5	10.1
Hong Kong	3.7	7.5	6.0	2.7	5.9	4.7
Indonesia	6.5	7.5	7.2	12.2	13.7	13.2
Malaysia	7.6	8.3	7.0	11.6	11.8	10.2
New Caledonia	1.0	1.0	0.3	1.9	1.4	2.3
Papua New Guinea	0.1	2.5	2.1	1.1	1.1	1.1
Philippines	6.0	5.6	4.7	6.6	6.1	5.0
Republic of Korea	5.9	8.8	6.7	3.6	10.7	11.4
Samoa*	1.0	9.0	9.0	1.6	0.6	1.5
Singapore	9.2	9.0	9.0	9.8	10.2	10.7
Taiwan Province	7.7	7.0	6.1	4.2	7.5	5.4
Thailand	10.5	7.5	7.7	13.1	9.3	9.5
Tonga	2.5	6.2	4.7	10.4	18.5	11.5
Tuvalu*	0.0	0.0	0.0			
Vanuatu*	2.0	2.5	3.0	25.1	25.3	25.1
Centrally planned Asia	3.9	5.1	5.2			
China	3.9	5.2	5.2			
Democratic People's Republic of Korea	4.9	4.7	5.1			
Lao People's Democratic Republic*	4.0	3.3	3.0	2.6	3.3	1.5
Mongolia	6.4	4.5	4.0	8.9	6.7	2.9
Viet Nam	3.2	2.3	4.1			

*Least developed country

Table I.2. Share of industrial output of developing countries in world total in 1975, projected shares for 1990 and 1991, and growth rates 1975-1991

(Percentage)

		Share of developing countries in world total			*Average annual growth rates*			
			Projected		*Developed countries*		*Developing countries*	
ISIC code	*Industry*	*1975*	*1990*	*1991*	*1975-1985*	*1985-1990*	*1975-1985*	*1985-1990*
3	Manufacturing	11.6	13.8	14.0	2.4	3.3	4.3	4.8
311	Food manufacturing	14.6	17.4	17.9	1.8	2.5	3.0	4.3
313	Beverages	19.3	23.9	24.1	0.8	2.0	3.1	3.4
314	Tobacco manufactures	32.1	36.3	36.8	2.1	1.4	4.3	3.2
321	Textiles	18.7	25.2	25.9	0.2	1.6	2.4	3.7
322	Wearing apparel	11.9	17.4	18.0	0.8	1.3	3.7	4.3
323	Leather and fur products	18.2	30.6	31.4	0.3	0.1	3.3	5.3
324	Footwear, excluding rubber or plastic	18.8	24.1	24.5	0.6	0.1	2.8	1.5
331	Wood and cork products	12.6	12.5	12.6	0.2	3.2	1.7	2.2
332	Furniture and fixtures	10.2	8.6	8.4	1.7	4.0	1.9	2.4
341	Paper and paper products	10.1	11.0	11.1	1.7	4.1	4.1	4.5
342	Printing and publishing	8.8	6.2	6.2	4.0	5.5	2.8	4.2
351	Industrial chemicals	8.8	12.4	12.7	1.6	4.3	5.1	6.6
352	Other chemical products	15.8	17.5	17.8	3.6	4.3	4.9	7.0
353	Petroleum refineries	30.5	44.6	45.4	0.7	1.3	6.2	3.7
354	Miscellaneous petroleum and coal products	6.9	16.7	17.5	2.0	2.1	9.6	4.3
355	Rubber products	13.0	18.9	19.2	1.2	3.0	4.6	6.3
356	Plastic products n.e.c.	14.6	14.4	14.0	5.8	5.4	7.0	5.7
361	Pottery, china and earthenware	14.1	16.0	16.0	1.0	3.9	1.6	5.7
362	Glass and glass products	11.4	15.0	15.1	1.5	3.9	4.4	5.9
369	Other non-metallic mineral products	13.9	20.7	21.2	1.0	2.6	5.0	4.5
371	Iron and steel	9.9	19.0	19.5	1.5	1.7	5.6	4.2
372	Non-ferrous metals	9.6	16.0	16.7	0.9	3.3	6.1	6.7
381	Metal products excluding machinery	9.6	10.7	10.8	1.6	3.4	3.8	4.1
382	Non-electrical machinery	5.0	4.4	4.4	3.7	4.5	3.7	4.0
383	Electrical machinery	7.9	10.7	10.8	5.0	3.2	6.4	9.6
384	Transport equipment	7.7	8.3	8.2	3.2	2.4	4.5	3.9
385	Professional and scientific goods	2.6	4.2	4.3	3.7	3.3	6.8	9.8
390	Other manufactures	10.4	15.7	16.1	2.7	3.8	6.7	7.7

Source: UNIDO statistical data base, estimates and forecasts by UNIDO/PPD/IPP/GLO.

Notes: Calculations are based on deflated 1985 dollar figures. Growth rates are derived from 117 sample countries, 32 developed and 85 developing (United Nations Industrial Statistics consolidated by UNIDO). China and other centrally planned Asian countries are not included.

industry. Industrial performance is measured by manufacturing value added (MVA), which UNIDO forecasts each year along with gross domestic product (GDP). In *Global Report 1989/90*, UNIDO forecast a slow-down in the rate of growth of manufacturing, but the slow-down that occurred turned out to be more pronounced than expected. At the world level, MVA growth in 1989 was 4 per cent, while the *Global Report 1989/90* had forecast 4.6 per cent. Furthermore, UNIDO had expected that the slow-down would occur in developed countries, but developing countries also experienced a decline, from 4.1 to 3.8 per cent. Certainly the rate of MVA growth in developing countries has been disappointing, although MVA growth in 1989 for developing countries as a whole did not fall by as much as did GDP growth. Countries with debt servicing problems, while needing additional industrial production for export purposes, have often found their manufacturing sector operating at far below capacity because of shortages of imported raw materials and spare parts.

MVA in Western Asia grew at 2.8 per cent, which was down from its 3.4 per cent 1988 growth rate and below its average over the past 12 years. Inflation and debt overhang have become problems in some countries, but there are indications that after years of declining GDP the region may have turned the corner in 1988 and is now poised for a resumption of growth. Positive GDP growth in 1989 marked the first time since 1977 that the region as a whole has experienced three consecutive years of positive GDP growth.

MVA growth in the Indian Subcontinent fell somewhat less sharply in 1989 than GDP, but at 5.7 per cent was the lowest figure recorded for several years in the region. Manufacturing in India has benefited from export promotion activities including favourable treatment for exporters in obtaining imported raw materials and capital equipment. Despite the generally high rate of growth in exports, the balance of payments has deteriorated as a result of the liberalization of import restrictions. In 1989 concern about the mounting balance-of-payments deficit led to the imposition of some temporary restrictions on imports. This may have occasioned some part of the reduction in manufacturing growth as firms had difficulty obtaining imported inputs and some expansion plans have been scrapped.

In Latin America, MVA for the region as a whole declined by 0.3 per cent in 1988 and grew by a meagre 1.8 per cent in 1989. Only Chile experienced average MVA growth exceeding 10 per cent during the past two years. In Brazil MVA grew by 1.7 per cent in 1989, which was a marked improvement over 1988 when it fell by 3.4 per cent. In Argentina MVA fell by nearly 10 per cent after a 7 per cent fall in 1988. The fall in MVA growth in Argentina was nearly twice that of the fall in GDP growth as the effects of the debt service crisis nearly paralysed the industrial sector.

MVA growth in Tropical Africa was a meagre 0.7 per cent in 1988 and fell to 0.5 per cent in 1989. In North Africa, it was somewhat better at 3.1 per cent in 1988 and 3.6 per cent in 1989, although still under the world average. But some countries in the region have performed quite well over the past two years. Ghana experienced strong MVA growth for the second straight year, at 13.7 per cent in 1988 and 13.4 per cent in 1989. In fact, the simple average growth rate of MVA in Ghana over the past six years has been over 13 per cent. In 1989 total MVA in the country again reached the level which had been achieved in 1970. Three other African countries experienced MVA growth rates averaging 10 per cent or more over the past two years, namely, Botswana, Chad and Lesotho. Cameroon, where MVA fell by nearly 30 per cent over the past two years, is joined by a number of other African countries that have experienced declining MVA, including Congo, Côte d'Ivoire, Djibouti and Sierra Leone.

The sharp fall in MVA growth in South-East Asia, from 10.5 per cent in 1988 to 6.7 per cent in 1989, was mainly the result of developments in the NICs. The Republic of Korea experienced a fall in MVA growth from 14.5 per cent in 1988 to 3.6 per cent in 1989. This decline greatly outweighed the simultaneous decline in the rate of GDP growth from 11.3 per cent to 5.9 per cent. On the other hand MVA growth in 1989 was close to or over 12 per cent in Indonesia, Malaysia and Thailand, which was in each case about the same as in 1988.

B. UNIDO forecasts for 1990-1991: a summary

UNIDO GDP and MVA growth rate projections for 1990 and 1991 for individual countries and groups of countries are shown in tables I.1 and I.2 and figures I.1, I.2 and I.3. A detailed discussion of country and regional industrial development trends is presented in chapter II. The short-term forecast is discussed in the present section.

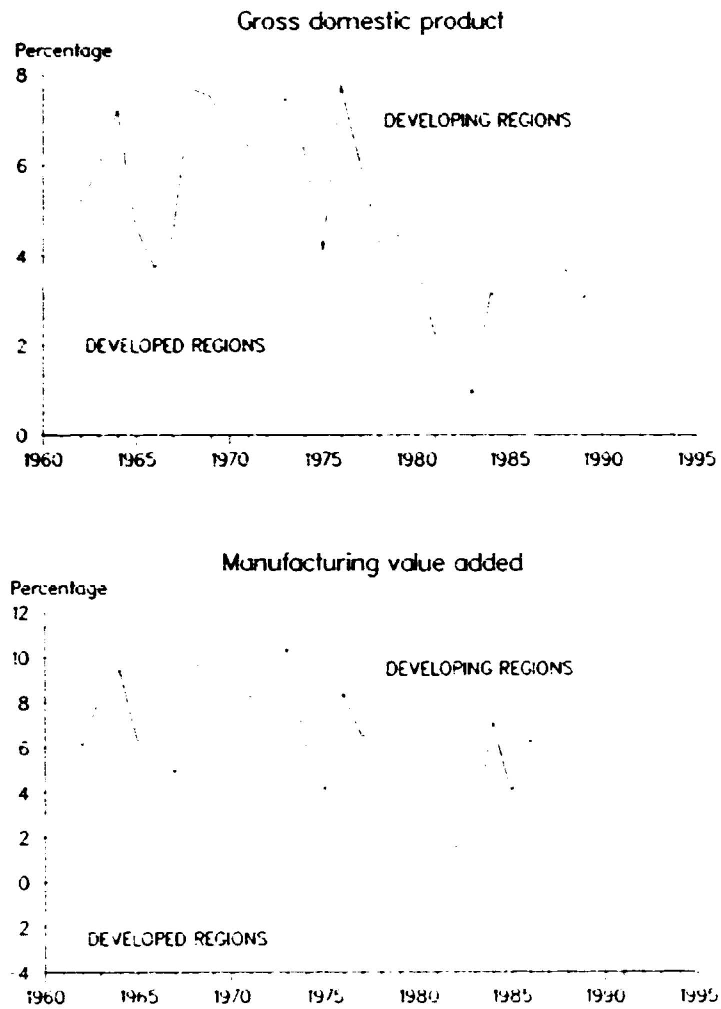
In preparing its forecasts UNIDO took into account a number of important recent economic developments and made a few key assumptions about the behaviour of certain major economic variables. The most important of these, particularly as they relate to developing countries, are listed below:

(a) The trade and budget deficits of the United States are not believed to pose a risk to global economic stability, or to presage a recession in the United States;

(b) Almost all developing countries have greatly liberalized their international trade policies during the 1980s. While the total trade of developing countries fell in 1987, it has been increasing since then, and UNIDO believes it will continue to increase in the short and medium term. Further, as a result of liberalization, UNIDO believes that this growth in trade will be a stronger positive factor in promoting development than it has been in the past;

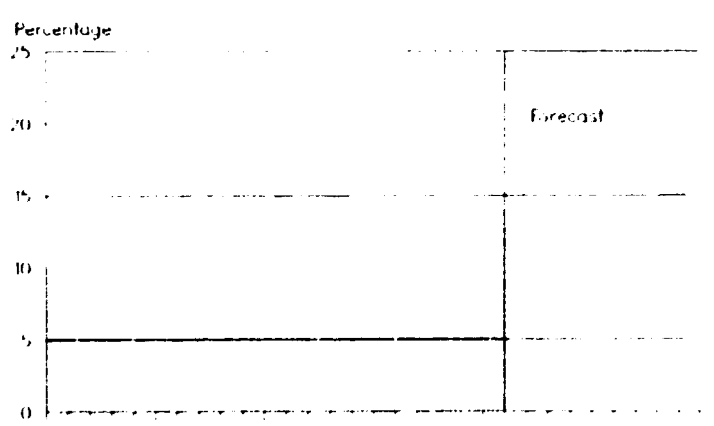
(c) Tight monetary policies in developed countries will result in continued high interest rates. UNIDO believes that this will continue to have a negative effect on growth in developing countries. Nevertheless, it is now apparent that direct investment opportunities in many developing countries are once again beginning to attract foreign investors. Thus despite continued slow progress in finding solutions to the debt problem, UNIDO believes that there will be an improvement in growth in developing countries over the next two years;

Figure I.1. Growth rates of GDP and MVA in developed and developing regions, 1962-1991



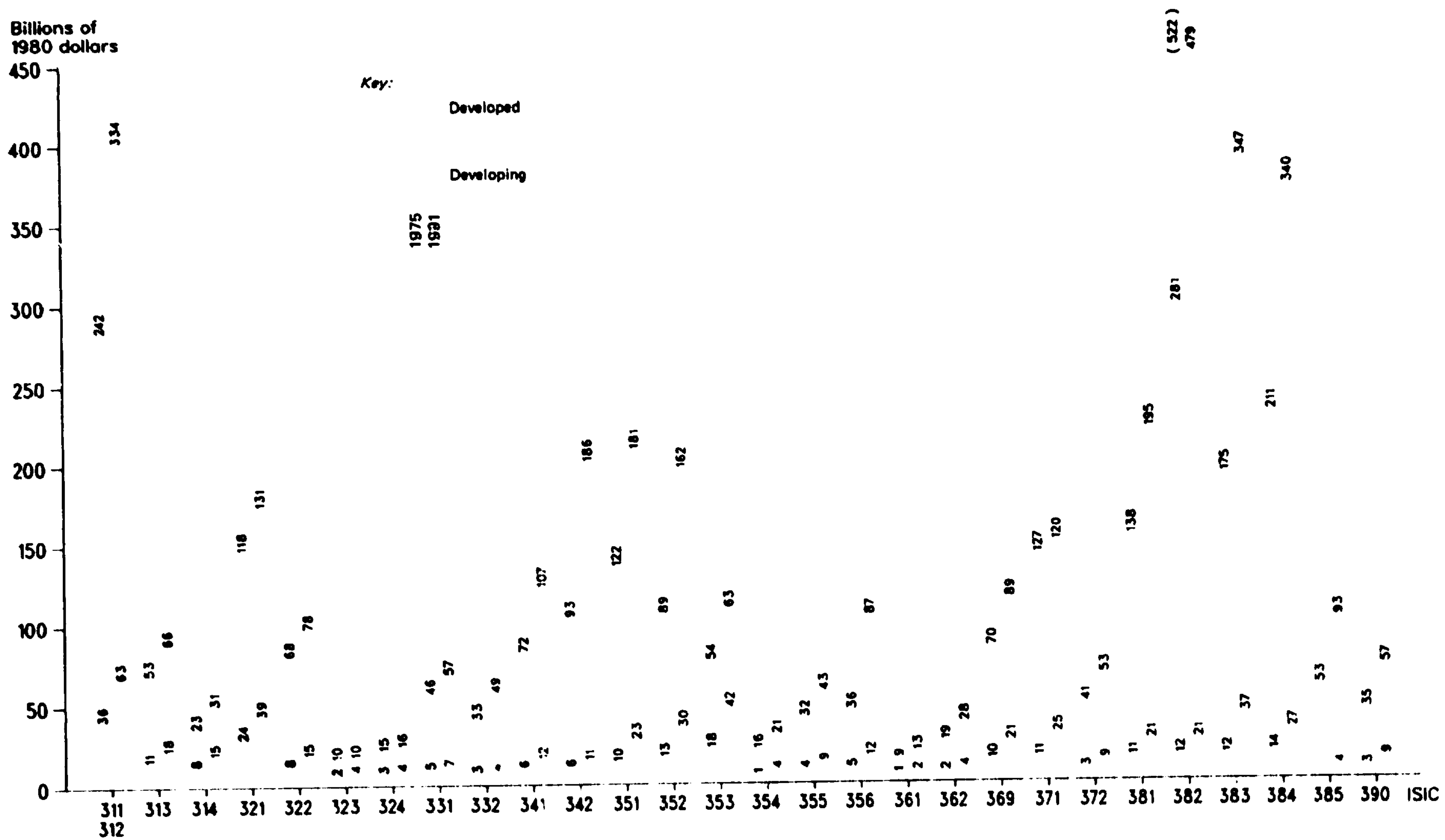
Sources: United Nations National Accounts Statistics and forecasts by UNIDO/PPD/IPP/GLO.

Figure I.2. Manufacturing share of developing countries in world industrial output, 1970-1991 and 2000



Sources: [illegible]

Figure I.3. Manufacturing value added of North and South, 1975 and 1991



Sources: United Nations Industrial Statistics and forecasts by UNIDO PPD IPP GLO

(d) The aggregate level of primary commodity prices including oil is expected to remain roughly unchanged throughout 1990-1991. Barring an unforeseen disruption in oil supply, UNIDO does not foresee a significant increase in energy prices in the short-run. It is, however, expected that energy prices will turn sharply higher around 1996;

(e) Eastern European countries will increase their trade with the rest of the world. But their main interest will be in capital goods, and they will not be a significant factor in boosting the exports of developing countries. Exporters of manufactures, including the NICs, will participate in this market to some extent;

(f) The high-growth countries of South-East Asia, the NICs, are being joined as the world growth leaders by the new NICs, namely Indonesia, Malaysia, Philippines and Thailand;

(g) UNIDO believes the globalization of production will continue to be a major economic force in the 1990s. Even in the short-run, globalization will gather a new impetus in part from economic development in Eastern Europe, but more importantly from the new spirit of international co-operation resulting from the end of the cold war.

The UNIDO 1990/91 forecast is that the slowdown, which began in 1989, will continue through 1990 before growth again picks up in 1991. From 4.4 per cent growth in 1988, growth fell to 3.3 per cent in 1989 and is forecast to fall to 3.1 in 1990, before climbing back to 3.7 in 1991. Developing countries are forecast to grow by 3.9 per cent in 1990 and 4.1 per cent in 1991, which is slightly faster than the expected growth in developed countries.

For developed countries, UNIDO forecasts slower growth for 1990 at 2.8 per cent, followed by 3.5 per cent growth in 1991. Western Europe and Japan are expected to outperform North America substantially in both periods, and Japan is forecast to maintain its growth lead over Western Europe. These projections take into account the dynamic conditions in Europe as the EEC approaches the goal of achieving a unified market in 1992, as rapid progress is made towards the unification of Germany, as the countries of Eastern Europe, including the USSR, restructure their economic systems to a greater or lesser degree along the lines of traditional market economies, and as the cold war comes to an end. Such conditions, however, do increase the uncertainty surrounding this year's forecast.

The monetary authorities in the United States have at least so far succeeded in their attempt to slow economic growth without bringing on a recession. Interest rates have remained fairly high, the dollar stands higher than most forecasters had predicted, and unemployment is low, at least by recent standards. Inflation has not been beaten back much, but it has not increased either. Wage gains in real terms remain low, a testimony perhaps to the successes over 10 years in eroding structural impediments to labour market competition. In forecasting 2.5 per cent growth for 1990 and 3.2 per cent for 1991 in the United States, UNIDO is not assuming that the twin budget and trade deficit problems will be corrected, but that they no longer carry a significant threat to short-term economic stability. It assumes that a "soft landing" has been achieved and the conditions have been established for a gradual renewal of economic growth.

In Western Europe, GDP growth, after slowing a tenth of a percentage point to 3.3 in 1990, is forecast to reach 3.8 per cent in 1991, the highest rate in over 15 years. The main factors will be an acceleration of final preparations for the unification of the European market in 1992 and developments in Eastern Europe. In the Federal Republic of Germany a continuing influx of workers from the German Democratic Republic will help to hold down wage pressures and allow the economy to achieve the very high growth rates that UNIDO is forecasting without unacceptably increasing inflation. UNIDO is in effect forecasting that the rapid growth experienced in North America and Japan following recovery from the 1982-1983 recession is at last coming to Europe.

Japan will continue rapid growth at 5 per cent in 1990, but is forecast to spurt to 6.1 per cent in 1991. This is the highest growth rate in Japan since 1973. As GDP growth continues throughout 1991, the boom which will already be nearly 50 months old at the beginning of the year will exceed the previous record of 57 months by the third quarter of 1991. UNIDO believes the present high investment levels, stronger domestic consumption and high exports will continue to fuel growth throughout 1991.

While UNIDO believes that in the medium term economic and political changes taking place in the centrally planned economies of Europe will result in a renewal of growth, the short-term forecast is not very optimistic. The far-reaching changes will disrupt economic activity in the short run and reduce growth to near zero levels during 1990-1991. The region as a whole is forecast to grow at 0.4 per cent in 1990 and 0.6 per cent in 1991. A decline in MVA of 0.3 per cent is forecast for 1991. The USSR is forecast to have zero growth in the next two years and the manufacturing sector is forecast to stagnate in 1990 and decline by 1.5 per cent in 1991. Growth in the neighbourhood of 3 per cent is foreseen only for the German Democratic Republic and Hungary. Unification of the economies of the Federal Republic of Germany and the German Democratic Republic, while it will lead eventually to rapid growth in the former, will also result in a disruption of existing production facilities. UNIDO has therefore taken a relatively pessimistic position on growth in the German Democratic Republic over the next 18 months; in 1990 the forecast is for growth of 2.5 per cent, increasing to 3.3 per cent in 1991. Wage differentials will lead to a significant amount of migration from East to West which will hold down growth in wages but will allow per capita GDP to increase. The forecast growth rate in the German Democratic Republic is slightly over half the growth rate that UNIDO is forecasting for the Federal Republic of Germany during the same period. The Hungarian economy has been in the process of decentralizing its economy longer than other economies in the region, and despite Hungary's serious debt problem, the UNIDO forecast puts Hungary as the growth leader in both 1990 and 1991. The willingness of the developed market economies to assist in the economic revitalization of these countries will be a factor in determining the extent and pace of their economic growth. Trade, direct investment and technology transfer are the main areas where assistance from the developed market economies could make the greatest contribution to economic growth.

The forecast for Latin America is for growth of 2.4 per cent in 1990, rising to 2.9 per cent in 1991. MVA is forecast to grow at about the same rate. Slow growth in the United States over the period and continued high interest rates will have a negative impact on the region. Brazil, having registered 3 per cent GDP growth in 1989, will experience a fall in growth over the next two years as efforts to reduce inflation continue. The manufacturing sector is forecast to remain torpid at growth rates of 0.5 and 0.8 per cent over 1990 and 1991, respectively. The sharpest fall is forecast for Chile, where it is expected that GDP growth will fall from 10 per cent in 1989 to 5.2 per cent in 1990, and slip further to 4.1 per cent in 1991. MVA growth is forecast to follow approximately the same declining trajectory.

Growth in Tropical Africa will pick up modestly to 3.5 per cent in 1990, before falling off slightly to 3.1 per cent in 1991. The economic fortunes of the region are still largely tied to commodity price developments, and UNIDO expects little improvement in commodity prices during 1990-1991. While for many countries debt overhang will continue to stand in the way of renewal of growth, even some of the highly indebted countries in the region will continue to maintain growth rates sufficient to lift per capita incomes significantly.

Growth in India is forecast to remain lower than it has been during the late 1980s, mainly as a result of the emergence of balance-of-payments problems, which have resulted in import restrictions, and the need to cope with a persistent government deficit.

UNIDO has not taken the short-term decline in the MVA growth rate of the NICs to presage a long-term trend. Countering the trend, Taiwan Province experienced a very slight increase in MVA growth in 1989 over the very low 1988 level, up from 3.6 per cent in 1988 to 4.2 per cent in 1989. However, low labour costs and a generally favourable treatment of foreign investors will result in a large increase in foreign investment in Indonesia, Malaysia and Thailand and propel them ahead of the NICs as growth leaders in the region.

Growth in China will continue over the next two years to be limited by government austerity measures. While the Government will lift some measures to allow the partial restoration of growth, it is not likely that the pace and form of economic change experienced during the 1980s will re-emerge. Economic sanctions imposed by some developed countries will continue to have a pronounced effect, but there are signs that they may soon be partially lifted. The UNIDO forecast of a recovery to 5.2 per cent growth over the 1990-1991 period is based on the assumption of a continuation of the government austerity measures and some form of sanctions.

UNIDO forecasts for 1990 and 1991 show the developing countries' share of world MVA at 13.8 per cent in 1990 increasing to 14 per cent in 1991. This 0.2 percentage point gain is just above the average over the past 15 years since the Lima Declaration and Plan of Action on Industrial Development and Co-operation, adopted by the Second General Conference of UNIDO, established as a goal that developing countries should produce 25 per cent of total world industrial output by the year 2000. It is none the less considerably below the approximately 0.5 percentage point yearly gain over 25 years that would be required in order to achieve the 25 per cent goal.

UNIDO forecasts that MVA in developing countries will grow at an annual rate of 5.4 per cent during 1990-1991, which will be about one half to one percentage point higher than the average for the five-year period 1985-1990, 4.8 per cent, or for the earlier 10-year period from 1975 to 1985, 4.3 per cent. While growth over the 1990-1991 period is thus somewhat high by recent standards, it does not approach the levels achieved in the 1960s and early 1970s, when it was often in the 7 to 10 per cent range.

On the basis of UNIDO forecasts for 1991, the industries in which developing countries will have a 25 per cent share of world MVA are tobacco manufactures (ISIC 314), leather and fur products (ISIC 323), textiles (ISIC 321) and petroleum refineries (ISIC 353). The share of developing countries will be over 20 per cent in beverages (ISIC 313), other non-metallic mineral products (ISIC 369) and footwear (ISIC 324). On the basis of UNIDO forecasts for 1990, the growth of MVA in developing countries between 1985 and 1990 will be 4.8 per cent. For the same period, it turns out that, except for the leather and fur products industry, all of the industries with larger shares will grow at less than the average rate. On the other hand, the industries that grow fastest over this period in the world as a whole turn out to be those in which developing countries account for less than 10 per cent of world MVA. These are furniture and fixtures (ISIC 332), printing and publishing (ISIC 342), non-electrical machinery (ISIC 382), transport equipment (ISIC 384) and professional and scientific goods (ISIC 385). Developing countries have lost their world share over the past 15 years in three of these industries, namely furniture and fixtures, printing and publishing and non-electrical machinery.

Over the long run, it would be expected that developing countries would tend to have a larger share of world MVA in industries that are more labour- or natural-resource-intensive. This in fact corresponds to what is generally observed in the share columns in table I.2. Developing countries have the largest shares in certain industries where natural resources play the most important role, as in petroleum refineries, or labour costs are most important, as in textiles, leather and fur products and beverages. It is likely that comparative advantage will play a larger role in the future if, as expected, trade liberalization in developing countries continues, and if pending a successful outcome of the Uruguay Round of negotiations within the framework of the General Agreement on Tariffs and Trade (GATT), trade barriers facing developing countries' exports to the North are reduced. UNIDO believes this will help to bring about a more efficient global division of labour and ultimately work to the advantage of the developing countries.

Developing countries are also expected to continue to gain a larger share of the older "smoke-stack" industries, which while contributing to industrialization are also a cause of environmental pollution. Environmental controls on these industries, which are becoming stronger particularly in Europe and Japan, are one of the factors that are giving a comparative advantage to developing countries where environmental controls are less strict. While this will contribute to industrialization, it also presents a challenge to the Governments of developing countries, which often lack the expertise to evaluate the costs and benefits of industrial pollution-control regulations. Industrial pollution in developing countries is the subject of a special chapter in the present *Global Report*.

C. Industrialization of developing countries: need for a long-term perspective

The 1980s have often been termed the lost decade for developing countries. To be sure, many countries in East and South-East Asia have made substantial progress, with some achieving a spectacular breakthrough during the decade to join the ranks of the so-called NICs (a label the countries themselves no longer welcome for fear of being singled out for trade restrictions). Progress has also been steady in the two larger countries in the Indian Subcontinent. To an overwhelming majority of developing countries, especially in Africa and Latin America, however, the decade represented a continuous economic crisis which has exacted an enormous toll in terms of both progress promised and progress forgone.

To most developing countries, the history of economic development is all but three decades old. The trials of the 1980s are therefore significant to many developing countries not so much because of the lost time, but because a damaging interlude might have occurred in their development process, forcing them to start the whole process anew. Unlike in the 1960s, however, the world has become more impatient with and less indulgent towards the apparently slow pace of progress being made by developing countries. More importantly, developing countries themselves seem to be rapidly losing the self-confidence they once possessed in initiating and managing their own development processes. The truth, often forgotten, is that economic development is a long-term process that has never been achieved in one generation. It is natural to be disheartened when progress seems so hopelessly stalled and mired down. It is, however, important not to lose the proper perspective, since historically at least, what developing countries have managed to accomplish since the early 1960s seems impressive enough, and at times they are more than comparable to similar achievements of the industrializing countries of the nineteenth century.

In the rest of the present chapter, therefore, the progress so far achieved by developing countries will be examined in some detail in order to place it in a proper perspective. Economic development is, however, a complicated process, and no single statistical indicator can adequately measure what has or has not been accomplished. The usual GDP-per-capita figure conveys only a rough macro-economic picture, and many international agencies, including UNIDO, have been compiling supplementary series of data to help convert the simplistic picture into a more holistic one. The help of the "other" development indicators as well as "non-conventional" economic indicators available to UNIDO will therefore be enlisted in the following analysis.

Economic development is only a means of achieving a higher living standard for the common people. The material aspect of progress achieved by developing countries in the past three decades is examined in section D below in terms of private consumption. The average living standard is undoubtedly still quite low in developing countries, yet the improvement has been significant. The end of the 1980s has, however, brought with it a revival of scepticism about the necessity for or desirability of economic, and especially industrial, growth. Some of this scepticism arises paradoxically from the adverse experience of many developing countries that failed to achieve sustained industrialization during the past decade. This is then more a problem of impatience than of doubt.

Others, however, argue that in many cases, per-capita income levels and achievement in some dimensions of human well-being—health, education, nutrition—are poorly correlated. Efforts to achieve a high level of income through industrialization are thus implicitly decreed as misguided or insufficient to achieve a high level of social development. The evidence once carefully examined establishes the opposite of this conclusion. In section E the evidence is briefly reviewed and it is found that not only do economic growth and improvements in human well-being move in parallel, but also that developing countries have achieved significant social development as well.

It is also a mistake to look at a small number of outcome indicators for human well-being. With industrialization comes the easy availability of a wide range of goods and services which are inputs leading to the achievement of some of the outcomes. Food has to be produced, processed and consumed to achieve the nutritional levels so often used as a critical indicator of social development. The scope of industrialization measured in terms of the variety of industrial products produced in developing countries since 1960 is therefore examined in section F. While the ability to manufacture even simple industrial products still remains beyond the resources of many small developing countries, the range of industrial products actually produced in the developing countries as a whole has, however, expanded tremendously during the past three decades. However, what is more important for the future is the accumulated material and human capital. Thus, section G, deals with the physical and human capital requirements for industrialization and the distance developing countries have yet to travel.

Finally, in the concluding section H, the focus is on the relative status achieved by developing countries in the rapidly changing world economy, on the roles they have come to play, and on the strength and conviction of their performance. Specifically, three crucial aspects of international co-operation are examined—trade, foreign direct investment and foreign borrowing. International co-operation in these areas is important if the industrial growth process in developing countries is to regain its former vitality. The nature as well as the substance of international co-operation have been undergoing a drastic overhaul and the sooner developing countries realize this, the better off they will be in their development efforts.

D. Industrialization and living standards

Humankind has always striven to improve the material aspects of its existence, expending energy in the quest for a better life and even deriving a kind of pleasure from the effort. Admittedly, human aspirations extend beyond material well-being to embrace spiritual values, which are often associated with a rejection of the mindless pursuit of material achievement for its own sake. In developing countries, the difficulty of the challenge has often outweighed any sense of pleasure derived from the endeavour itself, making the material gains thus achieved seem all the more precious. Table I.3 takes stock of the material progress achieved by developing countries through the provision of selected items such as food, clothing, shelter and other durable and non-durable consumer goods. It also includes statistics on civil air travel and cinema attendance, which may be taken as partial indicators of "leisure".

(a) Food and food products. According to the Food and Agriculture Organization of the United Nations (FAO), there were some 510 million undernourished people in the developing countries as late as between 1983 and 1985 ([2] p. 66). Famines, flood and drought still occur, claiming hundreds of thousands of lives and providing a grim reminder of the fragility of food security in developing countries. Nevertheless, one of the biggest achievements of developing countries in the past three decades is still that the average person in those countries is better fed today than he or she was three decades ago. For example, the nutrition level measured by daily calorie intake reached 2,509 units per day in developing countries in 1986, compared with 2,116 units per day in 1965. The nutritional level has also improved in terms of proteins, fats and calcium, although progress in terms of some vitamins and minerals is still lagging.

The improved calorie intake in developing countries has been achieved through a fairly balanced growth in major cereals and meat consumption. Table I.3 shows that combined per-capita consumption of wheat and rice (including that used for animal feed) increased by 31 per cent between 1968 and 1987, whereas the aggregate per-capita consumption of bovine, pork and poultry meat rose from 12 kilograms to 15.6 kilograms, or by 30 per cent, between 1970 and 1987. The grain and meat consumption figures for developing countries are still far too low compared with those found in developed countries. Measuring nutritional standards through the consumption of major grains and meat alone, however, ignores the fact that developing countries have a wider and more diverse dietary tradition in which cassava, maize and potatoes are some of the important staples. Moreover, although the low meat consumption level in developing countries largely reflects income status, the average figure includes 800 million people in India who consumed an average of only 0.6 kilograms of bovine meat in 1987, and the entire population of the Islamic world who do not consume pork at all for religious reasons.

Despite the fact that population in developing countries has more than doubled in the past 30 years, an increase in overall food production enabled them to increase their per-capita food consumption. Expansion of arable land and an increase in livestock were partly responsible, but the main reason for the production increase has been improved productivity achieved through the introduction of new high-yielding crop varieties, extensive use of fertilizers, improved irrigation systems, improved breeding of livestock, as well as a general improvement in farming technologies. For example, rice and wheat yields in developing countries rose by 41 per cent and 77 per cent, respectively, between 1969-1971 and 1983-1985. Food self-sufficiency ratios measured by cereal import requirements stood, however, at 79 per cent for Africa, 63 per cent for Western Asia, 99 per cent for Asia and 96 per cent for Latin America in 1983-1985.

A significant increase was observed not only in consumption of basic cereals and meats, but also of more processed foods in developing countries. For example, in North Africa and Western Asia, where consumption of coffee depends almost entirely on imports, the import bill increased tremendously between 1974 and 1986. In North Africa it rose from $67 million to $226 million and in Western Asia from $58 million to over $194 million in 1982, but declined to $102 million at the end of the period. It is interesting that coffee has become an important import item for some countries, especially in Asia, where in the mid-1970s coffee hardly figured on the import list. In 1974 the Republic of Korea and Malaysia imported coffee worth $3 million and $7 million, respectively, while in 1986, the figures were $79 million for the Republic of Korea and $33 million for Malaysia. Growth was even more spectacular in Singapore, where the increase was from $12 to $223 million.

(b) Shoes and clothing. If food consumption differs all over the world for dietary, culinary and other reasons, clothing and housing differ for cultural or more importantly for climatic reasons. It should be possible to obtain at least a notion of the quantitative improvement by checking the changes in the amount of basic materials that go into them. Thus, total textiles fibre consumption of all kinds in developing countries increased by 64 per cent over the 12-year period between 1975 and 1986. In per capita terms, this meant that the provision of clothing materials improved by 30 per cent. The 1986 total fibre consumption figure, 4.25 kilograms per person in developing countries, was, however, only one quarter the level achieved in developed countries. Furthermore, the figure for developing countries was heavily weighted by cotton (70 per cent), while that for developed countries consisted mainly (53 per cent) of synthetic fibres which are lighter in weight.

Shoes are an important item of clothing, yet no satisfactory statistics exist for international comparison, except for "shoes with leather uppers", meaning the shoe style characteristic of developed market economies. The apparent consumption figure (domestic production plus imports minus exports) for this particular type of shoe shows an average increase of more than 81 per cent from 1968-1971 to 1987. This means that on a per capita basis the average person in developing countries had 0.30 pairs in the 1960s and 0.33 pairs in the 1980s. For developing countries as a whole this is indeed a modest improvement. Among developing countries the highest shoe-consumer countries are, however, in Latin America and Western Asia, where the average was one pair per person,

Table I.3. Improvement in the standard of living: Indicators of per-capita

Country or area	Food: Wheat 1968 (kg per capita)	Wheat 1987	Rice 1968 (kg per capita)	Rice 1987	Bovine meat 1970 (kg per capita)	Bovine meat 1987	Pork meat 1970 (kg per capita)	Pork meat 1987	Poultry meat 1970 (kg per capita)	Poultry meat 1987	Clothing and shoes: Cotton fibre 1975 (kg per capita)	Cotton fibre 1982	All fibres 1975 (kg per capita)	All fibres 1982	Pairs of leather shoes per person 1968-71	Pairs of leather shoes 1987	Housing and sanitation: Thousands of new dwelling 1977-85	Δ Population / Δ Dwellings 1977-85	Access to safe drinking water 1970 (% of population)	Access to safe drinking water 1985
World	93.8	106.0	80.8	92.8	11.0	10.0	10.8	13.8	4.8	7.1	3.3	3.2	6.5	6.7	0.86	0.82	85,237.6	2.4	..	66
Total developing	48.2	73.6	106.2	126.0	4.7	4.2	5.3	7.9	2.0	3.5	2.2	2.2	3.1	3.5	0.30	0.33	13,308.0	9.7	29	55
Total developed	203.4	208.2	16.6	15.9	26.5	28.3	23.3	30.2	11.5	18.8	6.1	6.0	15.2	15.6	2.19	2.31	71,929.6	1.0	..	96
Developing countries:																				
Afghanistan	186.3	194.3	31.0	33.1	2.9	4.6	..	..	0.5	1.0	1.4	0.8	2.4	2.1	0.71	0.75	..	..	3	17
Algeria	172.7	176.3	0.6	1.1	1.8	3.1	..	..	2.2	2.4	1.5	1.9	3.2	4.8	0.37	0.38	..	..	77 (75)	68
American Samoa	22.8	64.1	35.8	25.6	9.5	25.6	1.5	3.1	27.0	43.6	2.6	2.7	2.6	2.7	..	..	..	..	..	..
Angola	19.0	14.3	6.1	11.5	6.9	6.5	1.6	1.8	1.1	2.5	1.1	0.9	1.6	1.6	0.14	0.05	..	..	26 (80)	33
Antigua	52.8	59.5	26.0	6.0	0.4	15.2	0.4	2.0	9.0	32.1	1.7	2.3	2.8	3.7	..	..	..	..	..	95 (83)
Argentina	141.9	152.4	9.7	11.0	94.8	85.8	8.7	7.1	6.1	7.0	4.5	2.8	8.1	5.3	1.49	1.27	..	..	56	56
Bahamas	54.6	70.7	28.9	24.8	21.6	19.9	11.5	16.0	5.3	45.9	..	..	..	..	..	..	6.7	4.9	65	100
Bahrain	57.8	56.6	89.2	53.8	..	12.9	..	..	4.5	27.4	8.7	10.2	19.2	23.1	..	..	..	..	99	100
Bangladesh	12.4	24.3	273.7	219.2	2.4	1.3	..	..	0.4	1.2	0.7	0.6	0.8	0.7	0.03	0.05	..	..	45	46
Barbados	72.7	96.5	30.9	35.2	5.9	8.2	4.4	22.2	16.3	40.6	2.5	3.0	5.8	7.5	..	..	8.1 (79-85)	0.6	95	99
Belize	76.7	50.9	30.7	34.6	8.4	11.7	..	6.1	6.9	23.7	6.3	4.9	7.4	5.6	..	..	..	..	68 (80)	64
Benin	3.0	8.4	2.3	11.5	3.0	3.5	2.2	1.6	0.7	6.6	2.7	2.6	3.4	2.9	..	..	..	..	29	50
Bermuda	64.3	56.9	5.4	5.5	26.9	27.8	5.6	16.4	40.7	35.9	..	..	..	..	..	..	3.6	0.8	..	..
Bhutan	1.9	19.0	..	66.9	..	3.5	..	0.7	..	..	..	..	..	..	..	..	..	..	7 (80)	..
Bolivia	54.1	47.5	16.0	25.3	11.3	18.6	3.7	5.6	0.9	2.8	1.3	1.2	2.7	2.4	0.77	1.01	14.8	91.0	33	43
Botswana	..	375.0	..	3.6	40.9	20.7	..	..	..	1.7	..	..	..	..	..	..	..	..	29	53
Brazil	38.3	62.6	72.2	74.4	18.2	16.5	8.0	7.2	3.7	13.1	3.1	3.5	4.8	5.3	0.52	0.74	1,328.9	18.8	55	77
Brunei	19.2	20.7	148.4	96.7	0.2	10.1	0.1	4.9	1.4	42.1	3.3	4.1	6.1	7.7	..	..	..	..	..	90 (84)
Burkina Faso	3.4	3.4	7.7	12.3	3.5	3.0	0.5	1.3	1.1	2.6	1.0	0.7	1.2	0.9	0.05	0.07	..	..	12	67
Burundi	4.8	5.2	1.8	4.9	2.6	1.2	0.3	1.0	0.6	0.6	0.2	0.2	0.4	0.4	..	..	..	..	23 (80)	25
Cambodia	2.7	..	488.4	251.8	3.6	3.4	4.9	3.1	2.0	2.6	..	..	..	..	..	..	..	..	..	..
Cameroon	8.2	19.4	3.9	18.8	3.7	7.5	1.6	1.7	1.0	1.7	1.1	1.3	1.8	1.9	0.49	0.45	12.1 (78-83)	114.8	32	32
Cape Verde	13.0	48.7	6.5	72.8	..	..	..	5.7	0.1	..	0.6	0.7	0.8	0.7	..	..	..	..	25 (80)	52
Central African Rep.	5.8	11.3	5.6	6.3	7.0	14.8	0.5	4.8	0.5	0.7	1.2	0.9	1.3	0.9	0.05	0.07	0.7 (79-84)	440.6	..	16 (80)
Chad	3.0	7.4	10.0	6.8	5.0	7.2	..	0.0	0.6	0.8	..	..	..	..	..	..	..	..	27	26 (75)
Chile	176.5	151.6	11.7	13.4	21.3	14.1	4.6	7.0	5.9	7.3	4.5	1.9	6.1	5.0	0.55	0.56	340.2	4.7	56	87
China	42.3	95.6	119.6	164.9	2.4	0.7	10.8	17.8	3.3	2.4	3.5	3.3	2.9	4.5	0.12	0.14	..	..	..	..
Colombia	17.7	25.0	39.8	62.3	25.8	19.1	2.6	4.1	3.3	6.3	1.4	1.3	3.1	3.4	0.64	0.71	527.5	9.6	63	86 (80)
Comoros	7.0	7.8	88.0	67.5	3.7	5.9	..	..	..	0.2	0.9	0.9	1.4	1.5	..	..	..	..	..	58 (82)
Congo	18.1	44.9	4.8	6.7	1.8	3.3	0.8	1.2	0.9	3.4	1.4	2.4	2.0	2.8	0.50	0.65	..	..	27	38 (75)
Cook Islands	6.4	89.5	6.8	10.5	..	5.0	..	52.6	..	14.2	..	..	..	..	..	..	..	..	..	92
Costa Rica	38.6	48.7	53.9	54.4	19.5	24.9	2.9	3.6	2.9	1.8	2.4	1.9	4.2	5.3	1.11	1.11	95.8	6.4	74	91
Côte d'Ivoire	12.7	23.6	81.2	88.0	7.4	6.0	0.7	1.7	1.7	2.9	2.4	2.2	2.9	2.7	0.33	0.21	..	..	44	20 (80)
Cuba	82.7	143.6	33.5	66.1	21.2	13.9	4.5	9.4	3.7	11.0	3.9	6.7	5.8	7.2	1.52	1.19	414.1	1.2	56	61 (82)
Cyprus	119.9	145.8	4.4	3.8	8.6	14.4	19.5	36.7	14.6	20.5	2.1	3.7	7.3	11.3	2.61	5.14	72.1	0.7	95	100
Democratic Yemen	73.6	80.3	16.0	17.5	0.7	1.3	..	..	0.1	4.4	..	..	..	..	..	..	..	..	57	52 (80)
Dem. Peop. Rep. Korea	18.1	65.9	162.7	279.3	1.4	1.9	4.8	7.5	1.3	2.0	..	..	..	..	..	..	..	..	..	100 (83)
Djibouti	32.9	44.8	20.2	51.7	..	6.4	..	0.2	..	0.9	5.8	9.7	6.6	15.8	..	..	2.4 (79-85)	35.7	43 (80)	45
Dominica	61.8	93.7	..	13.9	..	..	..	..	..	24.1	..	..	..	..	..	..	..	..	..	77 (80)
Dominican Republic	28.8	37.7	46.5	79.6	6.2	8.7	2.5	1.6	5.6	12.6	1.1	0.9	1.8	1.5	0.09	0.37	121.2 (79-84)	6.9	37	62
Ecuador	26.3	29.9	51.4	43.4	9.1	9.3	5.5	6.8	1.3	4.6	1.2	1.0	3.6	3.6	0.07	0.15	161.8	13.2	34	57
Egypt	120.4	195.4	63.9	42.9	6.5	10.2	0.0	0.1	2.3	8.3	4.7	5.1	5.6	6.8	0.50	1.17	1,202.1	8.7	93	84 (80)
El Salvador	15.1	20.2	18.3	13.4	5.3	3.4	2.0	3.0	1.7	0.1	2.4	0.7	3.5	1.8	0.45	0.75	51.4	11.4	40	51
Equatorial Guinea	..	6.8	..	12.2	..	0.3	..	..	..	1.0	..	..	..	..	..	..	..	..	..	..
Ethiopia	26.8	30.4	0.0	0.3	8.7	5.6	0.0	0.0	1.9	1.6	0.7	0.8	0.8	0.9	0.01	0.03	..	..	6	16
Fiji	88.6	107.2	44.7	55.1	7.7	6.7	2.2	2.4	2.5	5.6	3.2	2.8	9.1	6.1	..	..	8.6	12.1	37	77 (80)
French Guiana	76.4	86.2	24.8	119.5	5.8	7.7	1.5	14.0	10.0	30.0	3.5	4.2	6.6	7.3			3.9	5.9	..	..
French Polynesia	145.5	62.7	15.7	32.2	..	30.5	2.0	7.0	13.8	29.2	6.9	6.7	10.0	10.3	..	..	5.2	5.0	..	..
Gabon	19.2	38.6	5.0	14.2	2.2	10.4	0.1	2.2	0.2	6.8	6.1	5.3	8.3	6.8	..	..			..	50 (83)
Gambia	8.4	24.4	119.6	89.0	6.5	5.1	..	..	..	1.4	4.9	3.6	5.5	4.0	..	..	..	..	12	59
Ghana	10.1	10.2	11.6	11.8	2.5	1.3	0.6	1.2	1.1	0.9	3.6	2.1	4.9	2.9	0.09	0.18	..	..	35	56
Greenland	20.6	42.6	2.5	4.4	3.2	9.1	3.2	18.3	9.8	16.9	..	..	..	..	..	..	4.1	0.7	..	..
Grenada	78.7	69.0	10.0	18.0	0.5	0.3	0.3	0.5	2.5	25.0	..	..	..	..	..	..	..	..	60	83 (75)
Guadeloupe	83.5	106.5	37.2	31.0	9.8	14.0	3.5	11.2	5.2	27.2	3.5	4.6	4.2	5.5	..	..	10.4	0.5	..	..
Guam	..	10.8	58.4	53.8	15.5	10.8	8.3	23.8	11.3	20.8	..	..	..	..	..	..	..	..	..	..
Guatemala	21.0	26.2	4.9	6.3	8.8	4.5	2.5	1.9	1.5	5.9	1.7	0.6	3.3	1.6	0.25	0.36	..	..	38	37
Guinea	4.9	12.9	94.8	99.7	3.0	3.0	0.2	0.2	0.9	2.8	..	..	..	..	..	..	..	..	14 (75)	18
Guinea Bissau	6.2	9.2	110.6	177.1	2.6	2.2	9.5	9.7	..	1.1	1.1	1.3	1.4	1.6	..	..	..	..	10 (80)	21
Guyana	67.8	52.9	166.9	187.9	5.6	2.0	2.8	1.0	4.2	15.2	2.6	2.1	6.3	4.2	..	..	..	..	75	76
Haiti	6.7	24.1	17.8	21.0	3.7	5.5	4.7	2.6	0.4	2.6	0.3	0.4	0.7	1.3	0.07	0.13	1.1 (77-78)	163.9	12 (80)	38

consumption in developed and developing countries and areas

		Consumer durables						Others							
Access to sanitation facilities		Radio receivers [a] per 1000 persons		TV receivers [a] per 1000 persons		Passenger cars per 1000 persons		Telephones per 1000 persons		Daily newspaper circulation per 1000 persons		Annual cinema attendance per per person		Air travel per person	
1970 (% of population)	1985	1965	1987	1965	1987	1965	1985	1975	1985	1975	1986	1970	1987	1977	1987
..	46	166	370	57.7	137.2	42.8	79.8	98.4	132.2	136.4	100.0	5.7	3.8	2.3	2.6
28	33	41	173	7.7	40.6	3.3	12.3	10.6	23.9	26.9	36.6	4.3	1.4	0.6	0.6
..	77	461	996	171.0	441.7	137.6	282.7	322.6	451.5	327.1	328.3	8.4	5.9	8.5	7.9
21	21 (75)	75 (80)	105	2.8 (80)	8.2	1.2	3.5 (73)	1.8	2.0 (80)	4.3 (79)	4.9	1.4	..	0.3	0.3
9	57	40 n	227	31.2 (75)	69.6	6.3	30.8 (83)	15.6	37.9	17.8	36.3	2.3 (67)	0.9 (85)	1.6	1.2
..	..	1,000 (80)	1,154	66.7 (70)	230.8	..	..	..	..	133.3	236.8	10.0	..	..	..
20 (80)	19	15	49	3.9 (80)	5.4	8.2	20.9 (73)	..	5.2 (80)	2.1	11.5	0.5 (69)	0.4 (85)	0.6	1.3 (86)
..	100 (83)	149 (70)	298	33.3	238.1	..	..	..	..	55.6	72.3	2.1 (66)	..	..	96.4 (86)
85	69	296	658	71.8	216.8	41.0	123.5 (84)	76.3	105.3	106.4	85.7	2.2	1.7 (83)	2.7	2.5 (86)
66	100	286	498	137.8 (80)	211.2	142.9	232.6 (83)	303.0	476.2	151.2	137.9	..	..	28.6 (76)	20.2 (86)
	100	253 (70)	505	58.8 (70)	389.2	33.6	188.7	95.2	277.8	..	42.4	6.3	..	16.6	19.4
6	5	7 n(75)	40	0.3 (75)	3.3	0.3	0.5 (81)	1.0	..	4.6	6.9	..	0.1	0.1	0.1 (86)
100	100 (75)	169	875	25.4	194.6	56.2	129.9	172.4	303.0 (82)	97.2	156.9	5.4	..	8.1	7.8 (86)
69 (80)	66	275	585	..	166.2	18.6	54.9 (77)	38.2	..	30.3	49.0 (79)	..	..	..	..
14	33	14	75	1.4 (80)	3.9	3.0	5.5 (76)	..	3.7	0.3	0.2	0.4	..	0.6	0.5
..	..	704 (70)	1,293	314.8 (70)	862.1	163.9	285.7 (82)	..	833.3 (80)	203.7	310.3	..	..	..	..
..	..	2	15	..	..	..	..	..	..	..	..	0.2	..	..	..
12	21	93 (70)	527	9.2 (75)	77.3	2.6	12.0 (83)	..	..	40.7	35.3	0.9 (64)	..	1.9	1.8
..	36 (83)	7	130	..	6.9	3.8	13.4	9.3	18.3 (84)	18.5	16.1	..	..	..	1.7
58	63	123 (70)	368	63.6 (70)	190.9	13.5	69.9 (84)	28.6	90.1	45.3	47.2	2.6 (67)	0.7 (85)	1.6	1.8 (86)
..	80 (84)	94	227	89.2 (75)	165.3	52.9	333.3 (84)	64.1	163.9	..	..	18.3	..	..	21.5 (86)
4	9	10	24	1.1 (70)	4.8	0.8	2.3 (81)	1.0	2.2	0.3	0.4	0.2 (69)	0.7	0.3	0.2
35 (80)	58	19 (70)	56	..	0.2	0.7	2.0	1.1	1.7	0.5	0.4	0.0	..	..	..
..	..	14	106	1.1	7.5	2.9	2.6 (73)	..	..	..	..	3.1 (67)	..	0.1 (76)	..
..	43	19	125	..	11.5	3.0	9.0 (78)	..	5.1 (83)	3.3	3.5	..	..	0.8	0.5 (6)
11 (80)	10	17	152	..	..	3.9	9.4 (84)	7.2	6.4 (83)	..	..	1.1 (69)	..	3.5 (76)	2.9 (86)
72	100 (75)	17	60	0.4 (80)	2.2	2.1	16.8 (83)	2.2 (80)	2.8 (84)	..	..	0.3 (65)	..	0.9	0.7
1	1 (75)	120	237	..	0.9	1.0	1.5 (73)	..	1.0	..	0.2	0.4 (68)	..	0.5	0.4
29	84	147 (70)	335	52.6 (70)	163.5	11.3	51.5	42.0	65.8	89.0	115.0	7.3 (68)	1.1	2.0	2.3 (86)
..	..	16	187	0.1 n	16.8	0.1 (73)	0.2	3.7	6.8	..	35.9	6.2 (60)	..	0.0 (76)	0.1 (86)
47	61 (80)	88	167	19.3	108.5	6.7	26.4 (83)	52.1	80.6	53.8	40.0	4.7 (68)	1.7 (86)	2.0	2.2 (86)
..	..	21	112	..	0.2	..	..	..	..	..	..	0.4 (69)	..	..	..
6	9 (75)	44	120	1.7 (70)	3.3	7.7	20.7 (84)	10.5 (82)	9.6	0.7	4.5	..	..	1.4	1.1
..	99	..	579	..	..	..	..	..	..	52.6	105.3	17.6 (69)	..	..	..
52	95	75 (70)	258	33.7	78.8	15.2	42.6 (83)	62.1	137.0	88.4	91.2	..	0.1 (85)	3.4	2.5
5	17 (80)	13	130	1.3	53.8	7.1	18.5 (82)	..	10.6 (80)	5.2	8.4	..	..	0.4	0.3 (86)
..	31 (82)	155 (70)	335	63.8 (75)	194.2	20.7	20.4	49.8 (83)	53.8	5.7	107.4	..	7.7 (85)	1.3	3.0
95	100	223	250	24.0 n	130.7	52.4	188.7	117.6	370.4	127.9	123.1	9.9	..	11.4	22.0
35 (80)	45 (83)	58 (75)	154	9.6	21.1	9.6	12.0	..	..	6.6 (79)	5.4	0.2 (63)	2.0 (82)	1.8 (76)	1.8
..	100 (83)	..	110	..	12.2	..	..	..	..	..	47.9	..	9.2 (85)	..	0.1 (86)
39 (80)	64	54 (75)	88	6.0 (70)	48.3	49.0 (68)	54.1 (84)	16.7	22.8	..	..	1.3 (69)	..	..	2.8 (86)
..	86 (80)	82 (75)	456	..	..	..	..	42.4	90.9 (84)	..	..	..	..	..	..
58	23	152 (75)	164	13.1	78.9	7.9	15.8	21.4	29.0 (80)	39.0	42.0	1.6 (61)	..	1.1	0.8 (86)
43 (80)	65	105	292	8.1	80.6	3.3	11.4 (81)	25.8	37.6	50.7 (79)	76.9	3.7	1.0	0.9	1.0
..	70 (81)	92	309	11.0	82.8	3.3	19.2 (84)	13.6	29.3	30.2	48.8	1.8 (69)	0.7 (84)	0.6	0.9
37	58	132	406	11.6	83.2	8.7	18.1 (84)	14.7	27.0	57.3	60.3	5.9 (60)	..	1.6	1.2 (86)
..	..	244 (75)	251	3.1 (75)	4.9	..	..	..	..	..	2.5	1.8 (67)	..	..	..
14	14 (75)	29 (75)	194	0.1	1.6	0.9	1.0	2.0	3.1	1.3	1.0	..	..	0.4	0.5
91	70 (80)	476 (80)	573	..	14.0	15.7	46.5	50.3	82.6	34.7	96.6	1.3 (60)	..	6.8 (76)	8.4
..	..	71	747	46.8 n(70)	160.9 n	63.3	250.0 (81)	142.9	344.8	35.1	29.9 (79)	14.9 (68)	..	..	..
..	..	316	509	10.5	169.6	59.5	144.9 (72)	104.2	238.1	82.1	137.7	..	2.3	..	..
..	50 (83)	73	118	2.4 (70)	22.7	6.3	14.3 (75)	..	16.0 (82)	..	14.7	..	0.1	7.5 (76)	5.7
..	77 (83)	108 (70)	146	..	.	3.0	7.3 (84)	..	..	..	5.2	..	..	..	..
55	30	71	292	0.1	12.5	3.5	2.9 (83)	6.1	5.8	50.9	34.6	2.2 (69)	..	0.4	0.2
..	..	..	389	60.0 (75)	148.1	..	..	..	..	..	..	8.6 (68)	..	40.8	18.5 (86)
..	..	110	500	..	..	38.3 (70)	..	68.5 (80)	63.7 (84)	..	..	2.2 (65)	..	..	..
..	..	97 n(75)	251	3.3 n	213.0	55.2	270.3 (84)	73.0	322.6	72.7	95.0	..	..	..	..
..	..	..	1,385	..	638.5	..	..	..	..	176.5	150.0	5.6 (69)	..	..	..
30 (80)	24	47 (70)	65	12.0	37.3	6.3	13.8 (78)	..	16.5 (84)	41.3	24.8	0.9	1.1 (82)	0.6	0.2 (86)
13	11 (80)	19	33	1.1 (80)	1.6	2.2	5.2 (84)	..	..	1.0	2.1	..	0.4 (85)	0.2 (76)	0.5 (85)
15 (80)	21	6	38	..	..	..	..	..	..	9.5	6.6	0.6 (69)	..	..	..
93	86	124	303	..	15.7	27.0 (70)	38.3 (77)	28.7	41.8	79.0 (79)	80.2	12.3		1.3 (76)	2.1 (86)
19 (80)	21	16	41	2.4 (70)	4.2	1.1	4.0 (81)	..	..	18.8	7.5	0.4 (64)	..	0.2 (76)	0.2 (86)

Country or area	Food: Wheat 1968 (kg per capita)	Food: Wheat 1987 (kg per capita)	Food: Rice 1968 (kg per capita)	Food: Rice 1987 (kg per capita)	Food: Bovine meat 1970 (kg per capita)	Food: Bovine meat 1987 (kg per capita)	Food: Pork meat 1970 (kg per capita)	Food: Pork meat 1987 (kg per capita)	Food: Poultry meat 1970 (kg per capita)	Food: Poultry meat 1987 (kg per capita)	Clothing and shoes: Cotton fibre 1975 (kg per capita)	Clothing and shoes: Cotton fibre 1982 (kg per capita)	Clothing and shoes: All fibres 1975 (kg per capita)	Clothing and shoes: All fibres 1982 (kg per capita)	Clothing and shoes: Pairs of leather shoes per person 1968-71	Clothing and shoes: Pairs of leather shoes per person 1987	Housing and sanitation: Thousands of new dwelling 1977-85	Housing and sanitation: Δ Population / Δ Dwellings 1977-85	Housing and sanitation: Access to safe drinking water 1970 (% of population)	Housing and sanitation: Access to safe drinking water 1985 (% of population)
Honduras	18.7	25.9	4.9	11.8	7.1	7.7	4.6	2.3	1.5	3.5	1.1	0.9	2.3	1.4	9.39	0.21	18.5	64.6	36	49
Hong Kong	35.4	41.3	83.3	64.0	9.2	12.2	30.5	44.7	10.0	25.5	21.2	14.6	25.8	28.1	0.25	1.12	516.9	1.8	..	..
India	40.5	54.9	113.9	105.0	0.3	0.6	0.1	0.1	0.1	0.2	1.8	1.6	2.1	2.0	0.35	0.38	..	..	17	56
Indonesia	4.6	9.9	135.7	232.9	1.9	1.6	0.7	0.9	0.5	2.3	0.6	0.7	1.3	2.0	0.05	0.05	..	..	3	38
Iran (Islamic Rep.)	157.3	226.7	45.0	53.8	3.2	5.0	0.0	..	1.1	5.1	2.5	2.1	7.1	5.5	0.52	0.70	1,256.6	10.6	35	51 (75)
Iraq	198.6	226.6	40.2	42.2	5.3	6.3	0.0	..	0.9	14.8	3.5	2.8	7.0	7.1	0.07	0.29	535.5	7.4	51	86
Jamaica	96.9	85.4	13.6	22.6	8.6	6.0	4.0	2.6	11.4	27.2	1.9	1.2	3.8	2.8	1.34	0.29	..	.	62	96
Jordan	99.7	171.1	8.1	18.9	0.4	4.5	..	0.0	2.2	17.1	1.9	2.4	4.8	5.6	0.10	0.11	.	.	77	96
Kenya	15.4	20.6	1.8	3.1	11.6	7.4	0.4	0.2	1.2	1.9	0.8	0.5	1.5	1.0	0.15	0.06	13.9	437.1	15	26 (80)
Kiribati	47.1	51.5	21.1	52.1	3.0	0.2	..	..	..	1.4	..	..	..	..	..	..	..	..	..	..
Kuwait	109.0	70.3	59.1	41.4	..	8.1	..	..	6.4	32.0	14.6	13.9	33.3	40.6	..	..	..	..	51	89 (75)
Lao Peop. Dem. Rep.	1.6	3.7	320.5	318.8	5.6	10.3	9.6	14.3	4.1	5.6	..	..	..	..	0.07	0.13	..	..	48	41 (75)
Lebanon	135.6	106.5	7.3	11.9	6.5	8.7	0.4	0.4	8.1	21.4	..	..	..	..	0.41	0.29	..	..	..	98
Lesotho	68.9	38.2	..	1.5	7.5	7.4	1.9	1.8	0.9	0.6	..	..	..	..	..	..	..	..	3	36
Liberia	5.1	4.2	131.9	174.0	0.9	0.6	1.5	1.7	1.5	2.3	3.0	1.7	4.0	2.5	..	..	..	..	15	53
Libyan Arab Jam.	135.3	232.6	6.8	7.3	3.5	11.0	0.0	..	1.4	12.8	5.7	6.2	17.1	14.6	0.82	2.23	..	..	58	96 (80)
Macau	21.6	21.1	57.0	54.0	..	4.4	..	27.0	2.7	12.9	..	..	..	..	..	.	13.0 (81-84)	4.2	..	..
Madagascar	4.6	4.0	279.8	219.7	15.9	12.7	2.9	3.4	4.7	7.3	1.1	0.8	1.4	1.2	0.10	0.06	..	..	11	31
Malawi	3.2	1.7	0.4	3.7	1.8	1.8	1.3	1.0	1.3	1.2	1.2	0.5	1.7	0.9	0.04	0.04	..	..	41 (80)	56
Malaysia	35.4	37.3	169.6	117.0	1.6	2.4	6.3	8.8	3.3	16.4	1.5	1.1	3.4	4.4	0.07	0.12	..	.	29	84
Maldives	15.9	42.3	21.9	43.9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2 (80)	21
Mali	2.6	2.1	17.3	33.5	6.5	7.0	0.2	0.2	1.4	2.3	1.5	1.0	1.7	1.2	0.04	0.06	..	..	..	16
Malta	165.7	166.2	3.0	3.6	10.9	21.0	12.2	20.8	6.8	11.7	4.9	4.1	9.4	10.8	..	..	..	..	..	100 (83)
Martinique	99.4	102.1	9.3	16.1	15.5	16.7	3.8	9.2	3.9	32.6	3.7	3.2	6.3	6.0	..	..	12.7	..	..	..
Mauritania	14.3	62.0	12.0	53.6	13.1	7.0	..	..	1.6	2.2	..	..	..	..	..	..	..	..	17	84 (80)
Mauritius	60.9	80.9	74.3	78.6	2.7	5.6	1.2	1.0	0.1	6.8	2.3	1.5	5.6	3.7	..	.	47	3.3	61	100
Mexico	55.7	58.4	6.8	7.1	8.1	12.6	6.5	12.4	2.2	8.7	2.3	2.0	5.6	5.8	1.22	0.67	..	..	54	83
Mongolia	169.2	277.4	3.7	5.4	39.2	26.1	..	1.5	..	..	..	..	..	..	1.22	1.48	44.1	9.6	..	100 (83)
Morocco	234.9	108.8	2.4	3.0	5.7	6.0	0.1	0.0	1.8	6.4	0.7	0.4	3.0	2.7	0.66	0.66	368.5	12.0	51	59
Mozambique	7.8	6.3	11.1	8.5	3.3	2.7	1.1	0.7	0.4	1.4	1.0	0.9	1.2	1.2	0.11	0.06	..	..	..	15
Myanmar	2.0	4.9	296.6	338.2	3.0	2.6	2.3	2.2	0.6	2.9	0.7	0.7	0.7	0.8	0.22	0.13	..	..	18	27
Namibia	1.0	0.6	..	..	20.1	22.9	1.9	2.3	..	..	..	..	..	..	..	..	..	..	..	..
Nepal	17.3	39.9	184.6	169.1	1.7	5.2	0.3	0.4	1.2	0.3	0.3	0.5	0.6	0.9	0.02	0.03	..	..	2	28
Netherlands Antilles	74.7	51.9	27.0	59.1	16.3	6.6	6.9	13.6	10.8	51.9	..	..	..	..	..	..	..	..	..	..
New Caledonia	96.2	115.7	35.0	30.1	35.7	20.3	8.9	7.3	..	32.9	6.2	5.1	9.0	8.3	..	..	3.5	4.9	..	..
Nicaragua	21.6	18.6	57.8	39.2	15.4	10.4	3.9	4.3	1.5	3.4	3.4	1.9	4.5	2.6	0.69	0.31	5.7 (77-84)	120.2	35	48
Niger	1.2	6.2	9.9	13.9	6.2	5.4	0.2	0.2	1.2	2.8	0.8	1.7	0.8	1.8	0.05	0.08	..	..	20	47
Nigeria	2.2	2.5	6.6	18.2	3.7	2.5	0.5	0.5	0.8	3.0	1.1	0.9	1.9	1.3	0.09	0.08	83.4 (80-82)	99.5		38
Oman	..	70.7	..	..	..	4.5	..	..	..	18.4	4.3	5.7	8.4	12.2	..	..	..	..	52 (75)	53
Pakistan	126.4	111.6	44.9	42.8	3.0	5.1	..	..	0.2	1.2	3.2	1.5	3.7	2.1	0.51	0.40	..	..	21	44
Panama ex. Canal Zone	34.9	33.5	117.2	79.4	21.3	25.6	3.4	5.7	4.7	15.6	1.8	1.5	4.4	4.6	0.82	0.70	26.2	16.5	69	82
Papua New Guinea	11.3	22.1	16.6	25.9	0.7	4.0	0.2	7.2	0.5	1.6	1.5	1.1	1.9	1.5	..	..	8.7 (79-85)	67.9	70	26
Paraguay	55.4	72.8	9.4	26.8	46.1	21.2	10.2	27.5	3.0	5.4	1.8	1.9	2.5	3.1	0.95	1.22	..	..	11	28
Peru	59.5	58.5	26.8	66.6	8.1	6.6	4.4	4.0	3.6	13.7	1.5	1.0	3.6	2.9	1.06	0.91	..	..	35	55
Philippines	17.4	12.7	124.8	147.2	2.9	1.9	8.2	8.6	2.5	3.6	0.6	0.4	2.4	1.9	0.05	0.11	213.3	53.8	36	52
Puerto Rico	..	..	0.8	0.6	6.6	7.9	4.8	6.8	4.8	11.8	..	..	..	..	1.29	1.80	106.4	3.9	..	..
Qatar	159.6	112.8	26.6	61.2	.	3.1	..	..	..	52.0	..	..	..	..	..	..	8.1 (81-85)	8.6	95	97 (75)
Republic of Korea	40.4	97.9	153.4	180.4	1.2	5.6	2.5	8.9	1.2	3.4	2.3	3.3	6.5	9.7	0.10	0.26	1,982.8	2.6	58	75
Reunion	29.0	39.6	100.6	152.9	11.0	6.3	9.5	19.0	1.9	17.6	2.0	3.1	3.8	5.8	..	.	21.4	2.6	..	..
Rwanda	0.7	1.9	0.5	1.5	2.1	2.2	0.5	0.5	0.0	0.2	0.2	0.3	0.5	0.5	0.03	0.02	..	..	67	50
Saint Lucia	65.5	119.7	..	30.1	..	12.5	..	7.6	..	48.7	..	..	..	..	..	..	..	..	..	70 (79)
Samoa	39.0	35.9	8.6	7.2	13.9	9.4	13.9	6.0	..	8.7	2.1	1.6	3.1	2.2	..	..	..	..	17	43 (75)
Sao Tome and Principe	42.3	41.3	18.5	19.2	..	1.9	..	..	..	..	..	..	..	..	..	..	..	..	..	45
Saudi Arabia	59.7	176.1	23.9	30.2	1.6	5.1	..	..	1.8	31.0	3.5	7.6	10.6	31.1	0.18	0.05	..	..	69	94
Senegal	10.8	16.4	64.4	65.2	9.9	7.6	0.7	2.2	1.7	2.9	2.1	1.5	2.7	2.0	0.23	0.29	..	..	43 (80)	53
Seychelles	35.6	38.2	57.7	68.1	1.0	3.7		16.0	0.6	0.5	3.1	6.2	3.3	8.7	..	..	..	..	..	95
Sierra Leone	9.0	13.0	173.1	146.4	1.9	1.3	0.4	0.5	1.1	2.1	1.6	0.6	2.2	1.0	..			..	12	24
Singapore	126.6	56.9	107.1	79.8	3.0	3.8	11.4	31.9	11.0	37.2	24.8	13.9	43.6	23.9	0.58	1.34	335.1	0.8	..	100 (82)
Solomon Islands	20.4	23.9	45.2	53.4	0.6	3.5	..	3.4	0.2	0.4	2.3	1.2	3.1	3.2	..	..	..	..	..	..
Somalia	4.6	31.0	4.4	18.3	4.4	6.4	..	..	0.3	0.4	1.0	0.6	1.1	0.8	0.11	0.07		..	15	34
Sri Lanka	51.1	26.5	144.2	123.3	1.7	0.8	0.2	0.1	0.6	0.5	0.9	0.2	1.2	0.9	0.15	0.25	55.4 (78-85)	36.8	21	40
St. Kitts and Nevis	81.1	57.1	23.4	34.7	0.3	0.8	0.9	..	9.3	35.7	..	..	..	..	..	..	..	..	..	75 (83)
St. Vinct & the Grnd.	69.6	40.2	..	13.1	..	9.9	..	..	..	37.4	3.5	3.6	4.8	5.7	..	..	..	..	..	75 (81)
Sudan	19.9	36.2	0.6	0.9	12.9	8.2	..	..	0.7	0.7	2.9	1.0	3.5	1.4	0.50	0.37	..	..	19	50 (75)
Suriname	52.0	78.3	233.0	403.9	7.7	2.7	..	2.6	12.3	26.0	4.3	4.0	8.2	8.4	..	..	..	..	88 (80)	83

(continued)

Access to sanitation facilities 1970 (% of population)	1985	Consumer durables: Radio receivers [b] per 1000 persons 1965	1987	TV receivers [b] per 1000 persons 1965	1987	Passenger cars per 1000 persons 1965	1985	Others: Telephones per 1000 persons 1975	1985	Daily newspaper circulation per 1000 persons 1975	1986	Annual cinema attendance per per person 1970	1987	Air travel per person 1977	1987
26	30	41 (70)	376	0.9	67.3	4.5	7.8	6.5	11.9	32.1	64.7	0.1	..	2.1	1.1 (86)
..	..	143	632	13.5	240.5	15.2	29.5	238.1	454.5	..	649.3	20.1	12.2 (83)	7.1	..
18	9	11 n	77	0.0 n	6.9 n	0.9	1.8 (83)	2.8	5.3	15.1	27.8	4.0 (69)	..	0.1	0.1
12	37	12	165	0.4	39.5	1.6	6.6	2.3	4.4 (81)	16.2	16.1	2.9 (57)	..	0.5	0.7 (86)
70	78 (75)	63 (70)	234	4.6	52.6	5.6	1.6	20.6	42.6	..	..	0.6 (69)	0.6 (85)	1.3	0.7
47	76	99	199	21.4	64.5	6.8	26.2 (82)	16.8	57.8 (86)	17.4	34.7	1.0 (65)	..	1.3	0.9 (86)
96	91	199	408	14.2	107.9	26.1	44.4 (73)	50.5	54.6 (80)	64.1	40.0	..	..	7.6	5.5 (86)
70 (80)	90 (84)	137	237	20.0 (70)	68.6	3.2	43.3	..	..	22.3	42.5	0.9	..	5.2	7.6
50	30 (80)	29 (75)	90	1.0	5.6	7.4	6.2 (86)	8.9	14.3	9.8	13.3	0.8 (63)	..	0.6	0.5
..	..	44	209	..	..	..	..	..	..	..	..	4.0	..	..	15.2
..	100	141 (70)	322	134.2 (70)	257.9	125.0	263.9	128.2	101.8	..	202.4	5.1	0.5	13.9	14.0
3 (75)	..	18 (70)	123	..	1.6	2.6	4.7 (76)	..	2.3 (86)	1.7	3.5	0.4 (69)	..	0.3 (76)	0.3 (86)
..	75	263 (70)	778	62.7	306.0	45.9	81.3 (76)	..	..	102.2	86.4	1.9	..	18.8	4.4 (86)
11	15	5	67	..	0.6	3.0	4.1 (82)	..	9.3 (86)	0.8	29.7	..	..	..	0.6
19	21 (83)	126	224	2.5	18.1	6.3	5.7	.	..	8.2	10.2	0.7 (66)	..	0.6 (76)	..
67	88 (80)	31	220	0.5 (70)	62.4	26.0	151.5 (81)	..	..	16.8	10.2	2.7 (55)	..	3.7	3.7
..	..	22	239	..	4.7	7.2	45.7	65.4 (81)	153.8	190.3 (79)	..	23.0 (69)	..	..	..
..	..	80 (70)	193	0.6 (70)	5.5	5.3	4.6 (83)	4.1	4.3	2.7 (79)	6.4	0.7 (69)	0.3	0.9	0.6
83 (80)	55 (84)	20	197	..	..	1.6	1.8	3.8	6.1	..	2.0	..	..	0.7	0.3
59	75	44	435	5.6	140.2	16.8	88.5	23.8	87.7	84.7	97.7	9.6 (69)	1.2	2.4	3.0 (86)
3 (75)	22	9 (70)	107	6.4 (80)	20.4	..	1.6	..	..	..	10.5	0.9 (69)	..	..	10.5 (86)
8	19	4	37		0.2	0.9	2.0 (75)	..	..	..	0.5	0.5 (68)	..	0.3	0.1 (86)
..	100 (83)	236 n	353 n	86.1 n	307.3 n	69.0	238.1	217.6 (80)	400.0	..	156.5	10.7 (69)	1.7	16.5	52.0
..	..	128 n(70)	179 n	6.4 n	136.4 n	58.1	238.1 (79)	96.3	370.4	81.8	97.0	6.5 (68)	3.3	..	..
7	..	45 (70)	139		1.1	1.3	0.3 (75)	..	3.1 (82)	..	..	0.1 (63)	..	1.4	1.1
77	92	80 n	261 n	5.2 n	187.8 n	18.1	32.4 (86)	28.3	64.1 (86)	96.1	71.3	9.9 (69)	1.4	1.1	7.5
55 (80)	58	106 (70)	241	26.8	120.4	17.0	64.5 (83)	47.2	97.1	..	127.5	4.8		1.6	2.1
..	50 (83)	79 (75)	128	0.8 (70)	31.1					77.5	90.0	1.2	..	..	..
29	46 (84)	53	206	2.5 n	55.8 n	12.3	23.0	9.7	14.7	16.2	15.7	1.3 (67)	1.9 (83)	1.2 (76)	1.6
..	20	7	38	0.1 (75)	0.9	6.1	2.4	4.8	4.5	3.6 (79)	5.8	0.3 (68)	0.3	0.5	0.3
35	26	16	79	0.0 (80)	1.3	1.0	1.6	..	..	10.5	11.5	0.4 (68)	..	0.2 (76)	0.2 (86)
..	..	..	123	..	10.6	..	..	53.2	55.2 (80)	..	12.7	..	..	..	..
1	1 (80)	4	31	..	1.3	0.3	0.4 (68)	0.9	1.1 (83)	7.4	7.0	..	..	0.2 (76)	0.6 (86)
..	..	478	1,070	119.6	320.9	..	..	..	..	279.2	293.5	..	..	27.0	..
..	..	151	553	71.4 (70)	257.9	137.0	416.7 (77)	142.9	222.2 (82)	107.9 (79)	121.0	6.2	1.3	..	..
..	27	57	237	9.1	59.9	7.4	12.0	14.9	16.4 (83)	37.8	10.6	4.6 (63)	..	0.8 (76)	0.3 (86)
1	7 (80)	12	62	0.9 (80)	2.6	0.7	3.6 (84)	1.3	1.9 (84)	..	0.8	0.2	..	0.4	0.3
..	..	22 (70)	163	0.6	5.9	1.0	1.4 (78)	..	2.7 (84)	9.1	9.1	..	..	0.2	0.3
12 (75)	31	20 (75)	644	3.9 (75)	734.1	4.0 (70)	8.7 (78)	6.5	59.5	..	39.5	..	..	5.9	6.7
3	19	54 (75)	86	0.2	13.5	2.3	4.7	3.4	6.5	4.8	13.9	4.2	0.2	0.5	0.5
78	81	140 (70)	220	52.8	162.6	22.7	56.8 (84)	81.3	106.4	76.7	76.7	3.6 (68)	..	4.5	3.1 (86)
14	44	41 (75)	63	..	1.9	3.5	4.6	13.0	18.0	6.3 (79)	12.5	..	..	3.5	3.9 (86)
6	8.	67 (75)	164	20.1 (75)	23.4	2.4	22.7 (83)	13.8	25.2	27.2	41.5	..	..	1.1	2.6 (86)
36	49	132 (70)	241	18.3	86.4	13.5	19.4	26.3	31.6 (86)	90.8	70.6	..	..	1.5	1.3 (86)
57	67	19	134	3.7	36.2	4.3	6.4	10.4	15.1 (84)	16.1	34.8	.	..	1.0	0.9
..	..	561 (70)	675	150.8 (70)	267.5	98.0	312.5 (83)	161.3	196.1 (80)	150.4 (79)	170.9	3.5 (63)	..	..	..
83	100 (75)	223 (70)	505	116.3 (75)	409.8	147.1 (75)	357.1 (82)	123.5	384.6	..	191.1	4.9 (69)	1.6 (83)	25.6	27.5
25	100	69	907	1.6 n	196.7	0.6	13.6	39.7	227.3	173.0 (79)	208.0	5.3	1.2	1.3	2.0 (86)
..	..	117	230	7.6	162.5 n	42.7	250.0	57.8	238.1	55.7	88.1	2.8 (69)	..	..	..
53	56	8 (70)	54	..	..	0.5	1.2	0.7	1.5	0.0	0.0	..	..	..	..
..	62 (79)	625 (75)	705	19.6 (70)	22.7	25.0	41.0 (84)	62.5	102.0	..	30.5	..	..	..	..
84	99 (75)	109	437	19.2 (80)	35.9	5.5	11.2 (84)	..	..	..	..	3.5	..	..	..
..	15	29	269	..	..	11.7	20.4	..	..	..	..	1.4 (69)	..	..	..
21	82	131 (75)	271	224.0 (80)	266.6	12.0	17.9 (78)	47.2 (80)	123.5 (84)	..	54.9	..	..	7.8	8.8
36 (80)	..	60 (70)	103	0.2 (70)	32.4	7.1	9.3 (75)	..	..	5.2	8.0	1.5 (65)	..	0.4	0.3
12 (80)	99 (84)	125	641	..	44.1	15.7 (68)	52.9	50.8	166.7	66.7	44.8	2.0 (67)	..	..	29.9 (86)
..	24	11	216	0.4	8.6	5.6	6.6 (84)	..	..	10.2	2.7	0.0 (69)	..	0.7 (76)	0.3 (86)
..	85 (84)	132 n(70)	306	33.5 n	214.0 n	57.5	92.6	140.8	434.8	198.3	356.9	13.5	12.5 (83)	20.2	33.6 (86)
..	..	42	109	..	..	..	..	..	..	..	..	0.6 (68)	..	..	7.1 (86)
47 (75)	18	11	38	..	0.4	1.6	2.1 (75)	..	..	..	..	1.3	..	0.2 (76)	0.6
64	44	39 n	187	2.4 (80)	31.4	7.4	9.4	5.3	7.9	..	30.6	7.8	2.2	0.4	0.7 (86)
..	96	..	490	87.0 (80)	163.3	37.9 (70)	80.0 (84)	..	..	43.5	..	1.4 (66)	..	..	..
..	88 (81)	..	645	..	74.8	16.7	42.0	50.8	55.2 (80)	..	..	..	..	..	..
16	22 (75)	72 (75)	229	0.8	51.9	1.9	4.0	3.7	3.7 (84)	..	9.8	..	0.6 (83)	0.6	0.5
68	62	247 (70)	666	21.0	129.2	22.3	89.3 (83)	69.3	95.2	90.2	81.4	5.1 (65)	..	5.5 (76)	7.9 (86)

Country or area	Food: Wheat 1968 (kg per capita)	Wheat 1987 (kg per capita)	Rice 1968 (kg per capita)	Rice 1987 (kg per capita)	Bovine meat 1970 (kg per capita)	Bovine meat 1987 (kg per capita)	Pork meat 1970 (kg per capita)	Pork meat 1987 (kg per capita)	Poultry meat 1970 (kg per capita)	Poultry meat 1987 (kg per capita)	Clothing and shoes: Cotton fibre 1975 (kg per capita)	Cotton fibre 1982 (kg per capita)	All fibres 1975 (kg per capita)	All fibres 1982 (kg per capita)	Pairs of leather shoes per person 1968-71	Pairs of leather shoes per person 1987	Housing and sanitation: Thousands of new dwelling 1977-85	Δ Population / Δ Dwellings 1977-85	Access to safe drinking water 1970 (% of population)	Access to safe drinking water 1985 (% of population)
Swaziland	..	30.6	15.0	5.6	28.5	23.6	..	1.4	..	1.4	..	..	..	..	..	..	..	..	37 (75)	31
Syrian Arab Republic	154.0	244.1	8.9	10.2	1.6	2.9	..	..	1.3	6.8	4.2	4.2	7.1	6.9	0.06	0.17	438.3	6.3	71	76 (80)
Thailand	1.2	4.4	337.1	255.1	3.8	4.2	4.8	6.1	2.4	8.6	1.9	1.9	2.8	2.6	0.15	0.20	..	..	17	64
Togo	4.4	20.5	9.8	13.8	1.5	3.3	1.5	1.3	1.0	3.5	2.1	5.2	2.4	6.0	0.35	0.25	..	..	17	54
Tonga	58.6	59.1	0.4	2.2	3.1	1.7	11.6	8.7	..	3.2	..	..	..	..	..	..	..	..	63	99
Trinidad and Tobago	69.9	105.2	39.7	49.1	5.3	5.2	2.8	2.4	13.7	19.7	3.3	3.7	6.5	10.5	0.32	0.08	28.6	5.6	96	98
Tunisia	138.7	302.4	0.4	1.0	3.5	5.9	0.2	..	1.4	5.4	1.7	1.2	3.7	5.0	0.28	0.29	148.7 (77-82)	6.6	49	70
Turkey	206.0	357.5	6.1	8.2	5.5	5.4	..	..	0.9	5.3	5.7	3.8	8.7	6.9	0.76	1.19	1,126.8	8.4	52	67 (80)
Uganda	2.6	1.7	0.5	1.4	6.8	3.6	0.2	1.3	0.7	1.4	0.7	0.5	0.8	0.7	..	..	..	..	22	20
United Arab Emirates	..	150.9	..	145.0	..	5.8	..	..	..	27.4	..	..	..	..	..	..	..	..	92 (80)	100
United Rep. Tanzania	7.3	6.9	11.9	29.7	9.4	6.5	..	0.2	1.0	1.1	0.8	1.0	1.1	1.3	0.08	0.05	..	..	13	53
Uruguay	206.1	129.1	29.9	49.5	64.8	83.9	7.8	6.3	4.6	6.9	1.9	1.9	4.1	5.1	0.54	1.06	..	..	92	85
US Virgin Islands	76.0	..	26.7	..	31.7	9.2	6.2	..	46.2	..	..	..	..	..	..	..	..	..	..	..
Vanuatu	12.1	31.6	44.1	44.5	20.3	19.6	23.8	13.2	..	1.3	2.8	2.9	3.1	3.2	..	..	0.8	49.5	..	64
Venezuela	77.4	61.7	21.8	21.1	19.0	16.0	4.5	7.6	8.1	18.1	3.0	1.7	6.8	5.2	1.06	1.75	244.3	17.2	75	89
Viet Nam	11.9	3.2	269.2	247.4	2.1	2.4	8.2	8.7	1.7	2.8	..	..	..	..	..	..	..	..	..	45
Yemen	12.1	121.4	0.9	5.9	2.7	1.9	..	..	0.2	8.6	..	..	..	..	..	..	..	..	4	46
Yugoslavia	222.1	250.2	2.3	2.3	9.5	14.2	15.6	36.0	6.9	13.4	4.1	3.3	10.6	9.6	1.21	2.01	1,248.9	1.3	..	68 (81)
Zaire	3.7	9.7	8.0	11.9	0.9	1.3	1.0	0.9	0.4	1.1	1.0	0.7	1.2	0.9	0.03	0.03	..	..	11	32
Zambia	..	12.3	0.9	1.5	7.8	4.8	0.1	0.9	1.4	2.2	1.4	1.2	2.8	1.6	..	0.19	..	..	37	58
Zimbabwe	19.5	30.1	1.6	1.8	15.7	5.7	1.4	1.1	1.1	1.1	1.6	1.7	2.3	2.7	0.27	0.42	..	..	..	52 (84)
Developed countries:																				
Albania	108.6	183.6	6.4	4.2	7.9	9.1	2.8	2.9	1.4	5.2	3.0	3.1	3.8	3.9	..	..	..	..	..	92 (80)
Australia	666.1	668.2	10.0	32.5	57.9	58.5	14.1	17.2	9.1	23.6	7.0	7.7	17.6	20.3	3.17	1.28	1,077.2	1.6	..	99 (82)
Austria	143.8	130.1	4.8	9.4	22.0	22.5	34.6	51.7	8.1	13.4	4.2	5.5	15.7	15.2	1.59	2.96	416.8	-0.1	..	100 (80)
Belgium-Luxembourg	126.9	152.4	3.4	8.2	26.8	26.4	37.1	52.6	8.5	15.6	6.4	5.9	16.2	12.4	1.96	2.54	427.3	0.2	..	95 (84)
Bulgaria	292.2	461.5	8.2	9.6	10.2	13.8	16.7	41.0	8.0	16.2	7.8	5.8	15.1	14.1	0.97	1.11	627.4	0.3	..	96 (80)
Canada	373.8	128.9	2.1	5.2	41.5	38.5	27.3	28.1	26.5	25.9	6.6	6.1	18.9	14.5	2.16	1.48	1,665.0	1.4	..	97 (82)
Czechoslovakia	317.8	399.6	4.7	3.1	31.1	23.9	40.9	56.9	7.8	13.3	5.4	4.5	17.0	16.0	2.02	1.86	1,032.4	0.6	..	75 (83)
Denmark	99.2	359.4	1.4	3.0	25.1	25.8	134.6	146.7	6.0	12.3	6.1	6.8	14.5	13.2	1.89	2.64	265.7	0.2	..	100 (82)
Faeroe Islands	76.3	68.1	0.7	1.1	3.0	14.5	2.7	8.3	2.8	14.9	..	..	..	..	..	..	..	..	..	..
Finland	121.3	56.5	3.4	4.5	20.9	23.8	20.8	32.9	5.4	5.5	4.7	6.4	13.6	16.3	1.39	1.52	457.3	0.4	..	79 (84)
France	202.3	202.1	3.0	5.5	30.0	33.2	30.5	35.5	14.7	19.3	5.3	5.5	12.6	14.3	1.97	2.37	2,909.6 (77-84)	0.7	..	98 (83)
German Democratic Rep.	202.0	269.9	2.7	1.5	20.9	26.5	46.6	79.2	6.1	9.7	5.1	5.5	21.5	21.4	2.19	2.96	1,651.4	-0.1	..	90
Germany, Federal Rep.	120.5	169.0	2.1	2.8	23.9	26.6	37.8	61.4	8.1	9.9	6.6	6.8	19.9	19.2	2.62	3.17	3,287.5	-0.3	..	100 (84)
Greece	163.1	203.7	11.2	10.6	16.8	26.4	5.3	23.6	6.8	15.5	6.0	5.4	13.0	10.6	1.60	0.92	1,156.1	0.7	..	..
Hungary	364.8	425.7	5.7	5.4	10.1	9.2	33.3	85.7	15.9	26.1	5.0	5.5	11.6	12.7	2.26	3.04	714.0	0.1	..	86 (84)
Iceland	66.6	72.6	1.8	1.6	9.6	16.1	..	8.1	..	7.4	5.4	6.9	11.6	16.6	..	..	17.4	1.2	..	100 (84)
Ireland	230.9	186.2	3.8	1.2	25.7	41.9	43.1	34.8	10.7	18.1	4.5	6.2	9.2	17.9	1.97	3.26	229.4	1.3	..	97 (84)
Israel	190.3	222.5	9.9	14.9	18.5	10.1	1.7	2.7	30.8	35.3	5.2	3.8	10.0	9.7	1.70	1.67	288.7	2.4	..	98 (84)
Italy	203.1	220.2	8.8	16.7	25.4	26.7	12.9	29.5	11.6	18.0	4.0	5.0	9.2	10.5	1.78	1.58	1,383.2 (80-85)	0.6	..	99 (81)
Japan	68.6	68.6	186.9	109.1	2.9	6.4	7.2	15.3	3.8	13.7	6.0	7.4	12.1	16.9	0.65	0.52	11,677.7	0.7	..	..
Netherlands	90.6	119.9	3.9	5.9	21.6	20.2	38.8	56.6	8.3	14.9	6.0	5.8	14.6	17.9	2.08	2.13	981.2	0.7	..	100 (82)
New Zealand	178.7	198.2	2.4	3.3	76.4	79.7	13.6	16.1	4.9	14.7	7.7	7.4	18.6	19.6	1.89	1.63	157.0	0.9	..	100 (84)
Norway	87.9	119.9	1.5	2.6	13.7	18.8	17.9	21.5	1.6	4.0	5.1	6.4	15.5	18.3	1.79	2.75	314.4	0.4	..	99 (83)
Poland	175.4	272.5	1.8	2.4	15.2	18.3	40.9	46.4	3.6	8.1	4.2	3.5	13.6	10.9	1.69	1.44	1,999.7	1.4	..	67 (80)
Portugal	106.0	106.2	20.3	19.4	10.7	12.6	11.7	21.2	5.8	13.1	4.4	4.4	7.4	9.4	..	..	355.8	2.7	..	57 (80)
Romania	180.9	420.4	4.5	9.9	9.8	8.4	21.6	35.8	9.1	17.7	3.7	2.4	11.5	12.0	1.44	2.14	1,407.9	0.9	..	77 (80)
South Africa	59.4	93.3	3.7	6.4	18.5	19.7	4.6	3.7	1.8	11.5	2.6	2.2	6.5	7.0	1.39	0.91	258.9	22.0	..	..
Spain	137.5	150.0	8.1	10.2	12.0	12.2	14.6	39.4	9.3	21.6	2.6	1.3	8.7	7.3	1.27	2.38	2,248.7	1.2	..	95 (83)
Sweden	104.1	105.0	1.5	3.7	18.5	17.0	28.2	32.0	3.3	5.1	7.3	6.7	18.2	16.8	2.05	2.22	423.5	0.3	..	100 (83)
Switzerland	122.1	115.3	3.6	10.0	26.6	27.7	32.9	42.8	6.5	10.6	6.0	7.2	15.5	17.3	2.50	3.71	274.0 (77-83)	0.0	..	99 (84)
United Kingdom	138.1	166.1	2.2	3.6	21.6	20.3	16.4	17.7	10.5	18.0	4.4	4.2	15.7	14.9	1.97	2.07	2,093.7	0.2	..	100
United States	121.9	103.3	14.1	14.4	51.7	46.6	29.7	27.9	30.0	36.8	7.1	6.2	20.0	18.9	2.80	2.78	13,914.6	1.5	..	100 (84)
USSR	377.3	356.9	5.5	11.6	22.4	30.5	18.7	23.1	4.7	11.3	7.6	7.7	15.1	15.8	2.92	3.13	18,156.0	1.1	..	100 (83)

Sources: Social Indicators of Development data base (World Bank); *Production Yearbook* and *Trade Yearbook* (Rome, Food and Agriculture Organization of the United Nations, various issues); *World Apparel Fibre Consumption Survey 1985* (Rome, Food and Agriculture Organization of the United Nations, 1985); *World Statistical Compendium for Raw Hides and Skins, Leather and Leather Footwear 1968-1987* (Rome, Food and Agriculture Organization of the United Nations, 1989); *Construction Statistics Yearbook* (United Nations publication, (various issues); United Nations Environment Programme, *Environmental Data Report* (Oxford, Basil Blackwell, 1989); *Statistical Yearbook* (Paris, United Nations Educational, Scientific and Cultural Organization, various issues).

(continued)

		Consumer durables						Others							
Access to sanitation facilities		Radio receivers [a] per 1000 persons		TV receivers [a] per 1000 persons		Passenger cars per 1000 persons		Telephones per 1000 persons		Daily newspaper circulation per 1000 persons		Annual cinema attendance per person		Air travel per person	
1976 (% of population)	1985	1965	1987	1965	1987	1965	1985	1975	1985	1975	1986	1970	1987	1977	1987
36 (75)	45	22	147	1.8 (80)	12.6	10.3	27.6 (83)	21.3 (80)	30.0	16.5 (79)	11.6	0.2 (69)	..	..	1.5 (86)
50 (80)	..	187 (70)	232	12.2	57.9	5.1	11.5	26.0	61.0	12.2 (79)	15.0	..	1.1 (85)	1.4 (76)	0.9
17	52	71	173	6.5	103.2	2.2	13.6 (86)	7.5	19.3	42.5 (79)	45.5	..	..	0.7	1.3 (86)
1	14	18	178	3.9 (80)	5.4	1.8	0.8 (83)	3.9 (80)	4.4 (82)	3.1	3.3	0.2 (64)	..	0.8	0.6
100	52	53	435	..	..	4.9 (68)	9.3	..	42.0 (83)	..	..	..	..	..	0.7
..	99 (83)	106	458	22.3	290.0	61.7	206.1	66.2	96.2 (82)	99.0	146.1	8.9 (69)	..	14.4	14.7
62	55	76 (70)	170	14.0 (70)	68.2	11.1	18.3 (75)	23.0	40.0	33.9	36.5	1.6 (68)	..	2.7	2.9
..	10 (82)	78 n	160	0.1 n	171.4	2.8	19.5	25.3	86.0	89.3 (79)	65.6	2.1 (59)	0.5 (85)	0.7	0.7
76	30	22 (75)	96	0.7	6.3	3.8	2.5 (75)	4.1	4.0 (82)	1.6 (79)	1.6	0.2 (65)	..	0.3 (76)	0.1 (86)
80 (80)	86	103 (75)	309	49.4 (75)	163.1	156.3 (72)	169.5 (73)	87.8	263.2	4.0	196.6	..	..	7.1	6.2
17 (75)	66 (80)	10	16	0.3 (75)	0.6	2.7	2.3 (82)	4.0	5.3	4.4	4.3	0.5 (60)	0.1	0.1	0.2
82	59	336	595	76.2	173.3	42.4	106.2	88.5	135.1	225.1	109.1	..	..	1.4	1.6
..	..	556	864	138.5 (79)	559.6	..	..	..	..	177.1	196.4	6.2	..	..	..
..	40	119 (70)	206	..	6.6	14.9	16.8	20.8	21.9	..	..	2.4	..	..	..
52 (80)	50	377 (75)	396	72.5	142.3	29.7	131.6	51.3	90.9	86.2	111.4	3.7 (69)	0.8 (85)	3.4	2.5 (86)
26	30 (83)	..	99	..	36.2	..	..	1.8 (82)	1.9	9.5 (79)	8.9	6.6 (67)	5.9 (86)	..	0.0 (86)
..	12 (83)	16 (75)	36	0.8 (80)	7.5	..	..	..	..	..	15.5	0.4 (65)	..	0.9 (76)	1.1
..	58 (81)	143 n	196 n	29.7 n	176.6 n	9.7	122.0	61.0	156.3	88.8	107.8	4.2	3.0	1.5	2.8
5	22 (75)	32 (70)	98	0.4 (70)	0.6	2.1	3.5 (86)	2.1	1.3 (86)	1.8 (79)	1.4	0.1	..	0.5	0.2
16	55	12	73	2.5	14.5	12.1	10.9 (83)	10.9	12.7	21.9	13.7	..	..	1.7	0.8
..	26 (86)	28 (70)	85	9.5 (70)	21.8	26.8	30.9 (86)	29.3	30.5	18.8	23.8	..	0.7 (85)	..	1.1
..	..	69	167	0.5	82.8	..	..	..	..	47.4	44.7	4.0 (69)	..	..	..
..	99 (82)	578 (70)	1,268	171.6	402.6	256.4	436.8	370.4	555.6 (86)	391.5	263.9	2.6 (69)	..	13.4	15.1 (86)
..	85 (80)	270 n(70)	358 n	195.7 n	330.1 n	108.7	333.3	285.7	500.0	319.8	358.1	4.4	..	3.1	3.3
..	99 (82)	321 n	470 n	160.6 n	317.3 n	142.4	336.3	286.8	452.6	263.1	225.4	3.3 (69)	1.6	5.4	6.0
..	..	251 n	221 n	22.6 n	188.3 n	..	..	89.3	280.0 (82)	231.9	315.8	12.9	9.5	1.1 (76)	3.2 (86)
..	60 (82)	703 (70)	952	269.8	575.7	270.3	408.0	508.2	769.2	214.4	224.2	3.8 (69)	3.0 (86)	14.2	14.6 (86)
..	61 (83)	263 n	255 n	149.2 n	284.3 n	29.2	175.4	175.4	238.1	299.7	330.9	8.0	4.7	2.1	1.9
..	100 (82)	333 n	452 n	227.8 n	306.4 n	156.3	294.1	454.5	833.3	340.4	367.0	4.9	2.2	6.3	8.2 (86)
..	..	..	383 n	..	234.0	..	..	..	..	..	..	7.5	..	..	..
..	72 (86)	338 n	908	160.4 n	373.2 n	100.0	312.5	304.6	625.0 (86)	445.6	561.4	2.4	1.3	9.1	11.1
..	85 (80)	315 n	890	133.1 n	332.0 n	196.1	306.6	263.2	625.0 (86)	208.4	192.6	3.6	2.5	5.1	5.2 (86)
..	70	337 n	661	189.0 n	372.5 n	38.9	200.0	151.5	227.3	471.5	568.9	5.4	4.2	..	..
..	88 (80)	303 n	954	192.8 n	306.4 n	153.8	416.7	312.5	625.0	330.9 (79)	344.5	2.8	1.8	3.0	4.8
..	..	106	410	19.3 n(70)	175.1	12.2	128.2	222.2	400.0	101.8	..	16.1 (61)	..	4.3	5.3
..	60 (86)	265 n	584	81.9 n	275.7 n	10.0	135.1	100.0	144.9	232.9	261.4	7.7	5.3	1.3 (76)	1.7
..	100 (80)	269 n	617 n	260.0 n(70)	296.4 n	144.9	436.8	416.7	526.3 (82)	426.7	559.5 (79)	11.7 (66)	9.4 (82)	71.7	80.6
..	94 (84)	212	500	89.0 n	228.3 n	99.0	206.1	138.9	270.3 (84)	216.1	180.8	13.4 (61)	3.3 (85)	7.9	7.5
..	95 (84)	160 (70)	469	5.5 n	263.0	32.5	144.9	243.9	416.7	..	236.3	11.8	..	9.6	9.8
..	99 (81)	206 n	786	116.0 n	256.6 n	105.3	370.4	263.2	476.2	116.7	98.5	11.1	1.9	2.6	2.6
..	..	207	861	102.8 n	506.5	22.1	232.6	357.1	555.6 (86)	545.0	565.7	2.5	1.2	2.7	3.4 (86)
..	100 (81)	252 n	908	171.9 n	325.4 n	103.1	333.3 (86)	370.4	625.0	323.7 (79)	310.7	2.3	1.1	7.4	10.1
..	88 (84)	865 (75)	923	157.1 n	369.4	270.3	454.5	526.3	666.7	363.6 (79)	328.1	..	..	16.4	17.9
..	85 (83)	292 n	790	131.6 n	348.0 n	125.0	370.4	357.1	625.0 (83)	413.4	530.2	4.2 (60)	3.0	16.1	17.6 (86)
..	50 (80)	179 n	207 n	66.0 n	261.4 n	7.8	99.0	75.8	119.0	267.7	199.6	4.2	2.5	1.0	1.0
..	41 (80)	128 n	212	19.7 n	159.0 n	35.0	149.3 (83)	114.9	192.3	67.3	47.5	3.1	1.7	4.5	4.0
..	50 (80)	147 n	288	26.3 n	165.7 n	..	..	..	..	141.9	159.3	9.8	7.0	0.9	0.9 (86)
..	.	76	320	4.0 (75)	96.9	56.8	92.6	76.3	128.2	..	44.6	..	..	2.1	1.8 (86)
..	40 (84)	142	295	121.8 (70)	367.9	24.1	238.1	222.2	304.6	98.1	75.1	9.8	2.2	4.6	3.7
..	85 (80)	386 n	874	269.6 n	394.4 n	232.6	384.6	666.7	909.1 (82)	538.6	534.2	3.2	2.2	7.9	10.9 (86)
..	85 (80)	282 n	400 n	106.0 n	358.3 n	156.3	400.0	625.0	833.3	395.0 (79)	409.3	5.1	2.5	14.1	17.1
..	100	248 n	1,142	247.9 n	365.7 n	166.7	303.0	357.1	526.3 (83)	427.7	420.4	3.5	1.3	7.3	7.8 (86)
..	98 (80)	1,235	2,115	362.1	809.2	384.6	555.6	714.3	769.2 (81)	280.8	258.9	4.5	4.4	19.6	26.1 (86)
..	50 (80)	320	683	68.0	312.7	28.7 (78)	36.0 (81)	66.7	113.6 (84)	396.0	440.5	19.1	14.8 (85)	..	0.4 (86)

Note Figures in parentheses indicate years to which data refer

[a] n Number of licences issued or receivers declared. Other figures are estimated number of receivers in use. 0.0 means values less than 0.05

while in Africa only every tenth person purchased a pair of shoes per year during the period 1985-1987. The apparent consumption figure in developed countries has in the mean time surpassed the level of two pairs per person.

The low consumption figure for developing countries in shoes (with leather uppers) is in a sharp contrast to their prominence as producers of footwear. In 1987, 82 per cent of the world's industrially produced footwear was manufactured in developing countries. In that year, six developing countries produced more than 200 million pairs each, the bulk of them exported to other countries. In addition, 18 per cent of the world's wearing apparel was also produced by developing countries in 1989.

(c) Housing and sanitation. As with clothing, housing requirements differ widely among developing countries and between developed and developing countries as a whole. Not only are the majority of developing countries physically located in the tropical and subtropical belts of the earth, but the majority of the population in developing countries live in rural areas—a fact that makes evaluation doubly difficult, since improvements in rural housing often escape official statistics, because they are almost always privately and informally accomplished.

Governments of developing countries participate in improving the housing situation. For example, in 1987, public housing programmes along with community amenities and welfare absorbed 16.6 per cent of the total combined government budgets of developing countries, which was 3.6 times that of government spending on health, 60 per cent more than the spending on education, and 32 per cent more than their military spending. The share of government spending on housing was especially high in some countries in Latin America, above 30 per cent, reaching close to 50 per cent in the case of Uruguay in 1987.

The net result is that housing standards in developing countries have improved considerably in the past few decades. For example, the housing stock in most the Latin American countries increased between 17 to 46 per cent during the period 1977-1988. In Argentina, the housing stock increased from 7.6 million units in 1977 to 8.9 million in 1988. Housing in Venezuela increased by 800,000 units during the same period, raising the 1977 figure of 2.5 million by 32 per cent. Brazil in the mean time built 10 million new dwelling units, thus adding to the 21.5 million units it already had in 1977. Even in Tropical Africa, Zimbabwe constructed some 0.5 million new houses between 1977 and 1988, increasing the housing stock to 2.1 million units in 1988. Another African country, Nigeria, whose housing stock went up from 16.6 million units to 25.3 million units during the same period—registering a 53 per cent increase.

In the two most populous countries, China (275 million units in 1988) and India (118 million), the increase over the same 12-year period was 53 per cent and 11 per cent, respectively. The most spectacular improvements were, however, in countries and areas that have attained rapid economic growth in recent years. For example, in the Republic of Korea, total housing stock increased by one and a half times during the same 12-year period to reach 7 million units in 1988, while Hong Kong (1.7 million units registered in 1988), Kuwait (0.25 million units), Singapore (0.7 million units), Taiwan Province (4.9 million units) and Thailand (9.6 million units) all showed a 50 per cent or more increase. Closely behind these countries and areas are Indonesia (43.5 million units) in 1988, Malaysia (3.1 million units), Mexico (15 million units) and Philippines (10.3 million units), with a growth of 30 per cent or more during the same period.

The modern construction of high-rise buildings requires concrete, steel, aluminium and glass. The tremendous increase in demand for these modern building materials in developing countries indicates the qualitative aspect of the increased housing stock. Thus, the apparent consumption of construction steel increased by 400 per cent between 1960 and 1983. Per capita consumption of cement also increased from 85 kilograms in 1977 to 136 kilograms in 1987 for developing countries as a whole. This average figure was, however, greatly influenced by some oil-exporting countries in the Gulf, such as Bahrain, Iraq, Oman, Qatar and Saudi Arabia, where cement consumption amounted to more than 600 kilograms per head.

Access to safe water and sanitation, including sewage facilities, are vital for better housing and living standards. Although the population of developing countries increased by more than 40 per cent between 1970 and 1985, the percentage of population with access to safe water doubled, and surpassed the 50 per cent level. However, there is still a great difference between urban and rural areas. In 1970, 13 per cent of rural households had access to safe water. In 1985, this proportion changed to cover more than 40 per cent of rural households. Yet, the coverage in urban areas, at 75 per cent in 1985, remains substantially higher. Improvements in sanitation are less spectacular. One third of the dwellings in developing countries were equipped with sanitary facilities in 1985, while the figure was below one quarter in 1970.

(d) Durable goods. In developed countries, durable household goods such as refrigerators, washing-machines and family automobiles are all considered necessary items. The fact that developing countries have not reached this level of affluence is quite obvious. But the progress achieved by them in their "consumption" of these and other consumer durables is still remarkable by any standard. Thus, the demand for household refrigerators and washing-machines in developing countries, while only for the privileged few in the 1960s, reached such a level in 1986 as to justify, in addition to imports, domestic production of 10.9 million household refrigerators and 12.3 million washing-machines.

Audio-visual equipment including radios, television sets and videotape recorders are part of modern-day life. The number of radio receivers per 1,000 inhabitants in developing countries more than quadrupled between 1965 and 1987, and television sets increased more than fivefold, with some developing countries exceeding, or on a par with, the standard set by developed countries. In 1987 in India and China, the two most populous countries, there were, respectively, 62 million and 200 million radio receivers in use. Indeed, in 1986, most developing countries with a population of 10 million or more seemed to have had a stock of

1 million or more television sets, with the exception of some sub-Saharan countries. Videotape recorders, the latest addition to household leisure goods in developing countries, are owned by more than 50 per cent of television-set owners in Malaysia, and more than 40 per cent in Bahrain, Hong Kong, India, Lebanon, Nigeria, Panama, Philippines, Qatar, Saudi Arabia, Singapore and United Arab Emirates.

Passenger cars, the ultimate status symbol in developing countries only a decade or so ago, have also shown a rapid increase. The number of officially registered passenger cars in 1985 in developing countries as a whole amounted to 42.3 million, which represented a fivefold increase since 1965. In the same year, consumers in developed countries possessed 323 million cars—one for every three and a half persons, while the average for developing countries was 81 persons per car. This average figure for developing countries is, however, expected to be substantially lowered, for no other reason than the tremendous increase in passenger cars both in India and China. Unofficial estimates put the latest Indian figure at around 3 million and the Chinese figure at more than 2 million, reducing the combined persons-per-car ratio in these two countries to no more than 400 to 1. The sudden increase in passenger cars in developing countries has, however, been responsible for increased road accidents, the rate of which has doubled since 1975 in many developing countries, including Chile, Jordan, Kuwait, Lesotho, Malawi, Republic of Korea, Saudi Arabia and Senegal

(e) Telecommunications. So far as telecommunications are concerned, in 1985 developing countries had some 81 million installed telephones, or roughly one telephone for every 43 persons. This represents a 171 per cent increase since 1975 in the number of telephones installed and a 126 per cent improvement in per capita terms. Again the picture is expected to have changed substantially, because since 1986 many developing countries have invested heavily in modernizing their telecommunications system. In 1986 alone, China, India, and the Republic of Korea each invested more than $1 billion each in telecommunications equipment, while Argentina, Brazil, Hong Kong, Indonesia, Mexico, Saudi Arabia and Taiwan Province are reported to have spent between $0.5 to $1 billion each on their telephone services. In the same year, Brazil had the largest number of installed telephones among developing countries and areas with 12.2 million units in use, followed by the Republic of Korea with 7.7 million, Mexico 7.6 million, China 7.1 million, Taiwan Province 6.1 million and India with 4.1 million. Although the absolute number is less in Western Asian countries, the rate of growth in telecommunications has been extensive in Kuwait, Oman and other oil-exporting countries. Algeria, Brunei, Burkina Faso, French Guiana and Mauritius all managed to double the number of telephones per capita between 1975 and 1985.

(f) Leisure activities. One way to measure how well off a person has become materially is to check how much time that person spends on travelling, reading and other leisure activities. In the past three decades many developing countries started operating their own national airlines, carrying an ever-increasing number of foreign and domestic passengers. In 1987, the total combined air travel originating in developing countries reached 2.4 billion passenger kilometres, compared with 1.7 billion passenger kilometres recorded in 1977. In 1975, 50.1 million people in developing countries read newspapers daily. In 1986, the daily newspaper readership in these countries reached 133.5 million. In the mean time, reflecting the world-wide trend, the cinema-attending population in developing countries has decreased dramatically (from a 1960-1970 average of 8.7 billion in annual attendance by 2 billion people to a 1977-1983 average of 1.4 billion in attendance by 963 million people), but these figures reflect a large drop in the number of countries reporting in the second period. This phenomenon should be attributed to the growing prominence of other modes of entertainment, including home video machines. In spite of the decreasing cinema attendance, India, the world's leading film-making country, produced 806 films in 1986, followed by the United States and Japan with 578 and 286 films, respectively.

The improved living standard thus far described concerns the "private" dimension of material well-being. There are also the "social" dimensions of material progress, which are discussed in the following section.

E. Industrialization and quality of life

One of the most common complaints in public discussion about highly industrialized societies is that economic growth does not seem to bring about a noticeably improved quality of life. Too often economic growth seems to be associated with more of the bad than the good things in life, such as congested city traffic, longer commuting times, increasing crime rates and atmospheric pollution. In developing countries, however, the reality is such that the choice between economic growth and the quality of life has a surreal quality, and the discussion surrounding it seems to be of a metaphysical nature.

The Universal Declaration of Human Rights, adopted in 1948 by the General Assembly of the United Nations, specifically proclaims the right of everyone to "a standard of living adequate for the health and well-being of himself, and of his family, including food, clothing, housing and medical care and necessary social services . . .". It did not specify a minimum level of per capita GDP. Since the mid-1970s, some economists have come forward to claim that the material rights specified in the Declaration should be monitored through the use of indicators other than per capita GDP, including life expectancy, calorie intake, infant mortality, school enrolment ratios, access to safe drinking water and so forth. The reason is that while economic growth brings about material progress, it often strays away from the true course of improving the "human condition". In that connection, the United Nations Development Programme (UNDP) has recently issued a report in which progress is measured by using a combined index—the human development index—of longevity, literacy and real purchasing power of the average person rather than the traditional per capita GDP ([3] pp. 9-16).

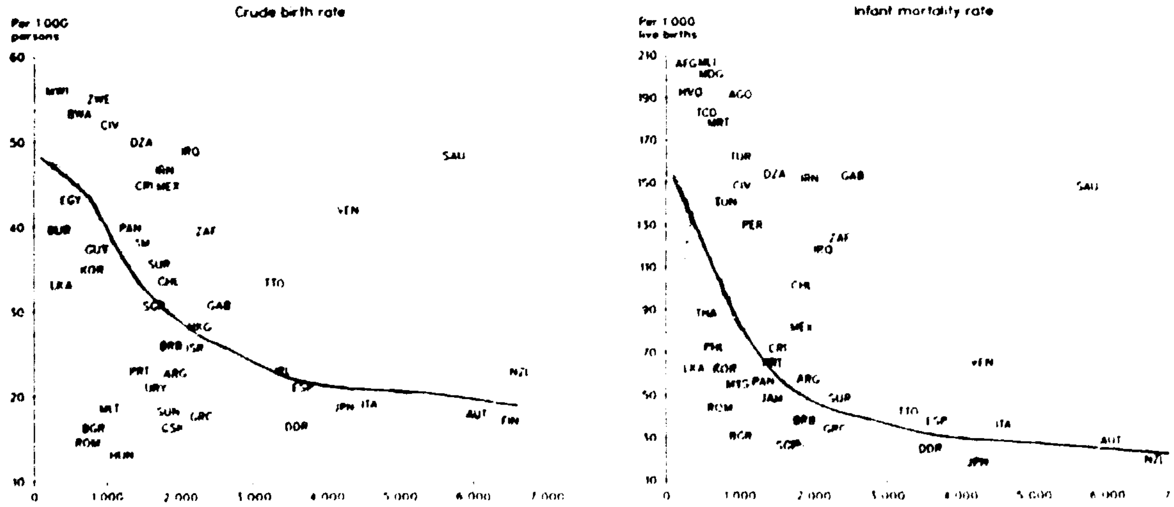
Most of the so-called growth-sceptics are not really against growth, but against growth which they regard as having neither sense nor purpose. While skyscrapers dot the urban landscape, it is disfigured by slums with dismal sanitary conditions. While imported luxury goods proliferate in the urban department stores, the average diet of the population in developing countries remains far below the international standard. While large industrial plants are being built, schools seem dilapidated and overcrowded. In the mean time, after decades of economic growth, the numbers of the absolute poor seem to be increasing rather than decreasing in developing countries. These are all legitimate concerns of any conscientious observer of the development scene. And the fact that a strikingly similar story can be told of developed countries prompts the following question: for whom and for what is growth to be achieved?

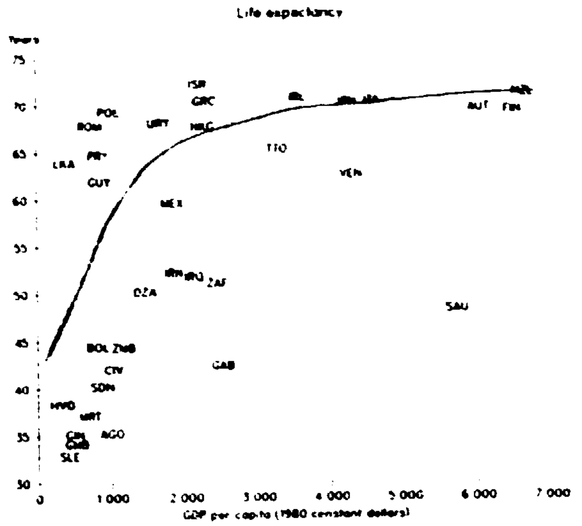
Some economists argue that income does not improve the human condition. However, this argument has been based on inter-country comparisons. For example, in 1987 an average person in China had an income of only $290, but could be expected to live until the age of 70, or 28 years more than a person born in Sierra Leone, who had a per capita income of $300. On the other hand, an average person in Oman, blessed with an income of $5,810, could expect to live no longer than 57 years, and the chance of males, and especially females, being literate was less than one in three. The Saudi Arabian had one of the highest per capita incomes ($6,200) among developing countries in 1987. Life expectancy was, however, not much higher than the overall average for developing countries as a whole, and the adult literacy rate was less than 60 per cent. In the same year, life expectancy of Costa Rica reached 75 years with roughly a one quarter of the per capita income of Saudi Arabia.

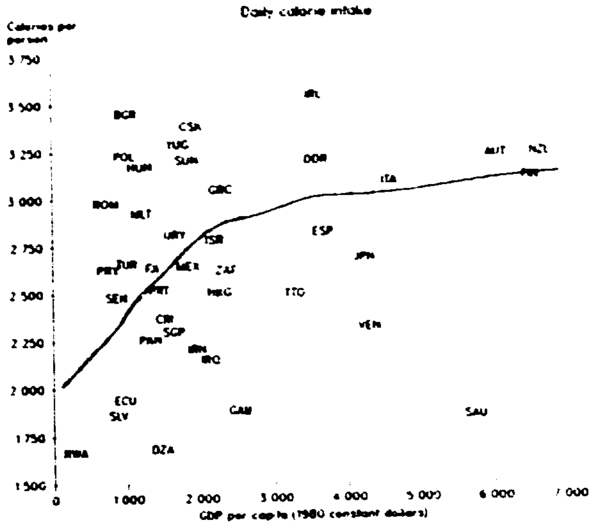
Any policy conclusion derived from such an inter-country comparison would, however, be grossly misleading, because it is not a genuine and fair comparison. What each country can show today in terms of human development is by definition the cumulative result of its past effort and achievements. How fair is it then to compare a country with a development history of not more than three decades with one that has more than two centuries of industrialization behind it? But more to the point, how valid is the criticism made against certain high-income developing countries for their conspicuous failure to translate their income into human development, when their high income came about only recently and their human development effort has outstripped all others since then? As stated before, the past three decades encompass practically the entire span of development history for most developing countries. Some obviously had an earlier start and a longer tradition. On the other hand, many started in much more unfavourable circumstances. Thus, if conditions in Mauritania, Niger, Rwanda, United Republic of Tanzania, Togo and Zaire seemed poor in 1987, their situations were far worse in 1960—especially in the case of Niger. Their current circumstances, difficult as they are, represent substantial improvements (50 per cent to 240 per cent improvements in terms of the human development index), and if a judgement is to be made against their human development record, it should be based more appropriately on the progress made by these countries since 1960.

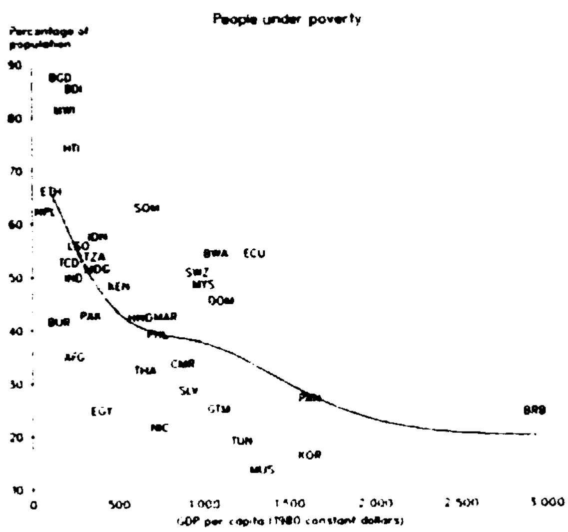
In examining the social progress made by developing countries, one can go beyond the three variables that make up the human development index. Ten additional variables are examined below. They relate broadly to the three dimensions selected by human development index—longevity, literacy and income in relation to the poverty line. But they also add the dimensions of health, gender and urbanization. For each of these variables the progress in various countries over the years 1965-1986 is plotted graphically against real per capita income. The trajectory over time for each country is given by the length and the direction of a country-specific arrow (see figure I.4). While the overall pattern soon emerges, in each case a curve is fitted to the data, using the Loess interpolation algorithm. (This is the heavy dark line in each figure.)

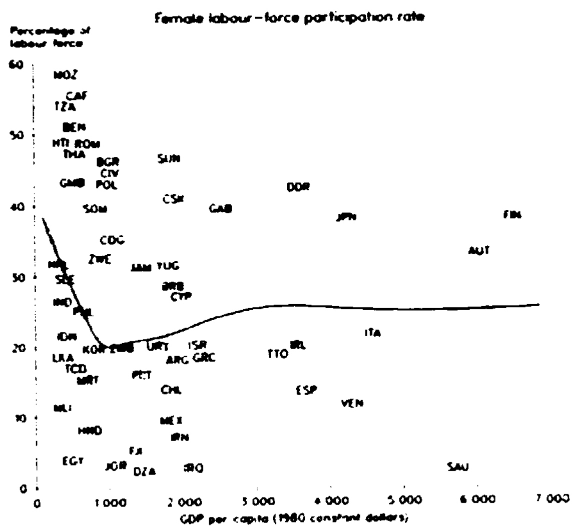
Figure I.4. Growth in income and social indicators

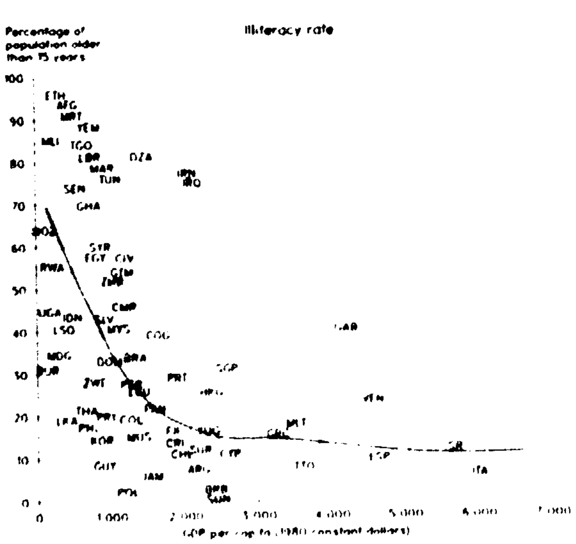



Life expectancy
Years
GDP per capita (1980 constant dollars)


Daily calorie intake
Calories per person
GDP per capita (1980 constant dollars)


People under poverty
Percentage of population
GDP per capita (1980 constant dollars)


Female labour-force participation rate
Percentage of labour force
GDP per capita (1980 constant dollars)


Illiteracy rate
Percentage of population older than 15 years
GDP per capita (1980 constant dollars)

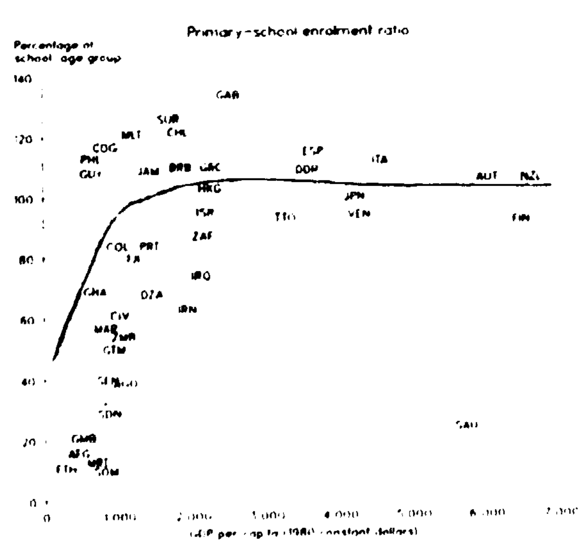
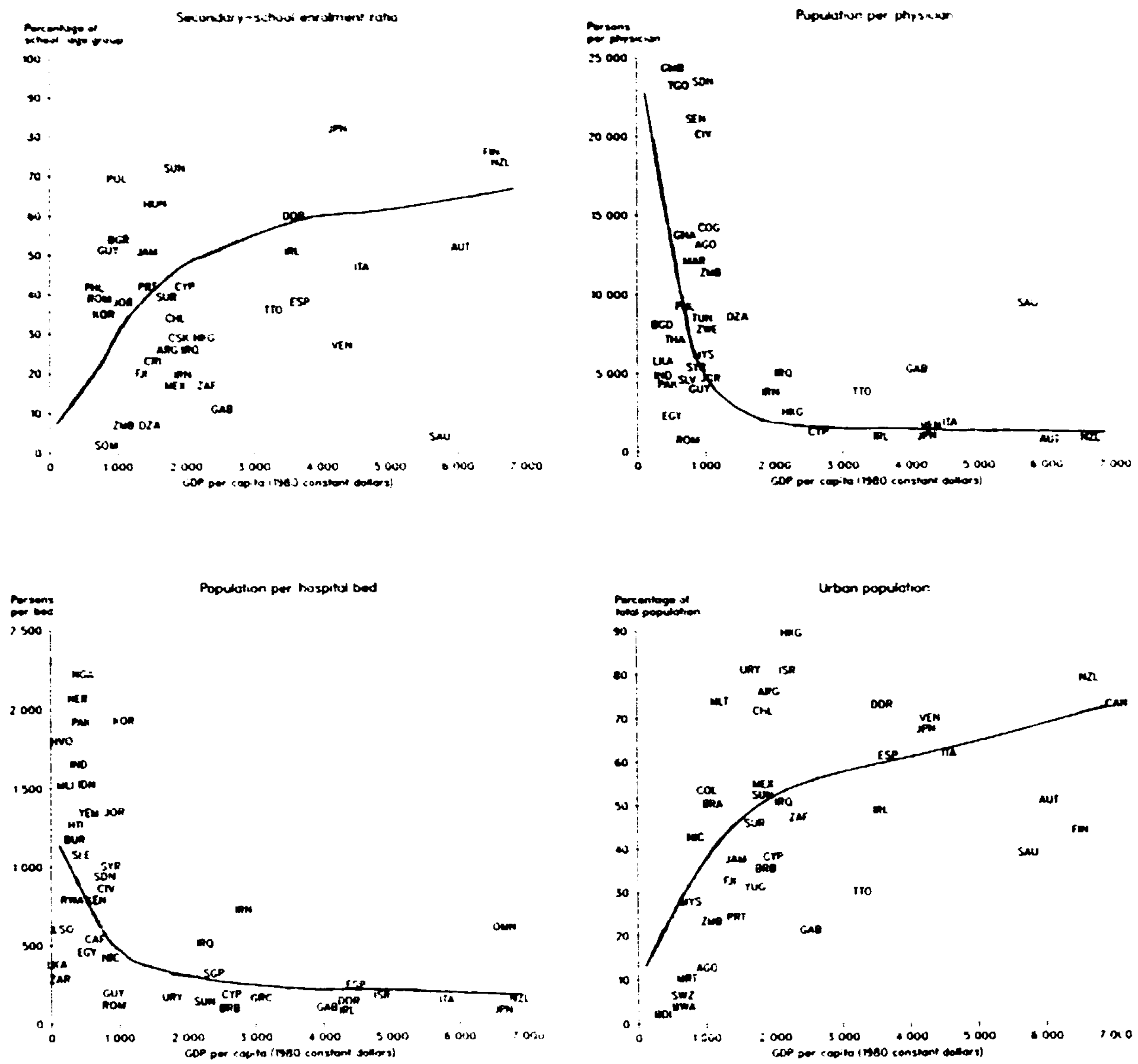

Primary-school enrolment ratio
Percentage of school age group
GDP per capita (1980 constant dollars)

Figure I.4 *(continued)*



Key

AFG Afghanistan
AGO Angola
ARG Argentina
AUT Austria
BDI Burundi
BEN Benin
BGD Bangladesh
BGR Bulgaria
BOL Bolivia
BRA Brazil
BRB Barbados
BUR Myanmar
BWA Botswana
CAF Central African Republic
CAN Canada
CHL Chile
CIV Côte d'Ivoire
CMR Cameroon
COG Congo
COL Colombia
CRI Costa Rica
CSK Czechoslovakia
CYP Cyprus
DDR German Democratic Republic
DOM Dominican Republic
DZA Algeria
ECU Ecuador
EGY Egypt

ETH Ethiopia
FIN Finland
FJI Fiji
GAB Gabon
GHA Ghana
GIN Guinea
GMB Gambia
GRC Greece
GTM Guatemala
GUY Guyana
HKG Hong Kong
HND Honduras
HTI Haiti
HUN Hungary
HVO Burkina Faso
IDN Indonesia
IND India
IRL Ireland
IRN Iran (Islamic Republic of)
IRQ Iraq
ISR Israel
ITA Italy
JAM Jamaica
JOR Jordan
JPN Japan
KEN Kenya
KOR Republic of Korea

LKA Sri Lanka
LSO Lesotho
MAR Morocco
MDG Madagascar
MEX Mexico
MLI Mali
MLT Malta
MOZ Mozambique
MRT Mauritania
MUS Mauritius
MWI Malawi
MYS Malaysia
NER Niger
NGA Nigeria
NIC Nicaragua
NPL Nepal
NZL New Zealand
OMN Oman
PAK Pakistan
PAN Panama ex. Canal Zone
PER Peru
PHL Philippines
POL Poland
PRT Portugal
PRY Paraguay
ROM Romania
RWA Rwanda

SDN Sudan
SEN Senegal
SGP Singapore
SLE Sierra Leone
SLV El Salvador
SOM Somalia
SUN USSR
SUR Suriname
SWZ Swaziland
SYR Syrian Arab Republic
TCD Chad
TGO Togo
THA Thailand
TTO Trinidad and Tobago
TUN Tunisia
TUR Turkey
TZA United Republic of Tanzania
UGA Uganda
URY Uruguay
VEN Venezuela
YEM Yemen
YUG Yugoslavia
ZAF South Africa
ZAR Zaire
ZMB Zambia
ZWE Zimbabwe

Sources: Social Indicators of Development data base, World Bank and UNIDO data base.

The overall pattern in each case is remarkably strong and demonstrates the strong correlation with income growth. The pattern is in each case a non-linear one and increases with income growth but levels off with life expectancy, calorie intake, primary enrolment, secondary enrolment and urbanization, or diminishes with income growth but levels off with infant mortality rate, illiteracy rate, crude birth rate, population per hospital bed and population per physician. A slight variation on these two basic patterns occurs for people below the poverty line. Although there is a decline it is by steps rather than smooth. Thus there is an initial decline as income goes up to $500 (1980 prices) and there is little change up to about $1,200. The decline then resumes up to $2,500 and again levels off.

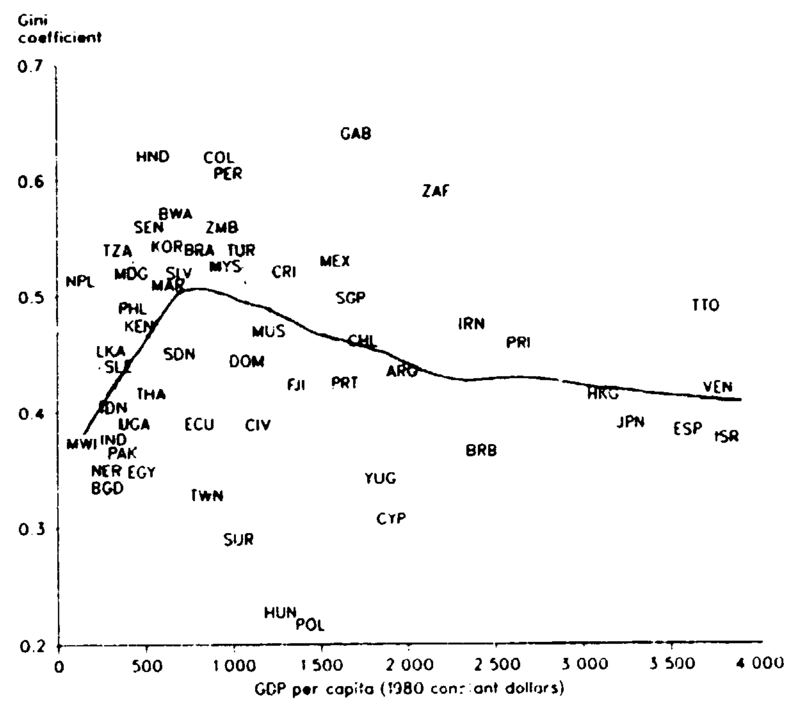
A different type of pattern emerges for female labour-force participation. It is spoon-shaped. As income rises to $1,000, there is a fall in the participation rate from about 40 per cent to 20 per cent. But then it rises up to $3,000 and reaches a plateau at 25 per cent. Further rises in income show no increase in participation rates.

These patterns are not meant to be universal laws, and changing social practices as well as a concerted policy effort can no doubt modify their shape. This is especially true of the last two variables discussed. These patterns do, however, argue against the naive idea that income growth bears no relation to dimensions of well-being. The patterns tell us that countries are progressing along these general lines, albeit with many of country-specific variations.

After decades of economic change, most developing countries remain absolutely and relatively poor, and the poorest among the poor seem to be falling behind. Recent concern about social development is shifting the world's attention from the economic disparities among countries to those within individual countries. The concern is genuine because in developing countries poverty is increasing. Growth sceptics would use this as evidence against growth which has failed to "trickle down" to the poor, creating an unequal income distribution.

When growth is still in its early stages, income distribution is said to deteriorate (becomes less even) before improving (becomes more evenly distributed). This is known as Kuznets' Law. Figure I.5 depicts the progress achieved by individual developing countries over a specific period of time ranging anywhere from 4 to 16 years, depending on the availability of data. In

Figure I.5. Growth and income distribution in developed and developing countries over different time periods



Key

ARG	Argentina	GAB	Gabon	MUS	Mauritius	SLV	El Salvador
BGD	Bangladesh	HKG	Hong Kong	MWI	Malawi	SUR	Suriname
BRA	Brazil	HND	Honduras	MYS	Malaysia	THA	Thailand
BRB	Barbados	HUN	Hungary	NER	Niger	TTO	Trinidad and Tobago
BWA	Botswana	IDN	Indonesia	NPL	Nepal	TUR	Turkey
CHL	Chile	IND	India	PAK	Pakistan	TWN	Taiwan Province
CIV	Côte d'Ivoire	IRN	Iran (Islamic Republic of)	PER	Peru	TZA	Tanzania
COL	Colombia	ISR	Israel	PHL	Philippines	UGA	Uganda
CRI	Costa Rica	JPN	Japan	PRI	Puerto Rico	VEN	Venezuela
CYP	Cyprus	KEN	Kenya	POL	Poland	YUG	Yugoslavia
DOM	Dominican Republic	KOR	Republic of Korea	PRT	Portugal	ZAF	South Africa
ECU	Ecuador	LKA	Sri Lanka	SDN	Sudan	ZMB	Zambia
EGY	Egypt	MAR	Morocco	SEN	Senegal		
ESP	Spain	MDG	Madagascar	SGP	Singapore		
FJI	Fiji	MEX	Mexico	SLE	Sierra Leone		

Sources: Social-Indicators-of-Development data base, World Bank and UNIDO data base.

the figure, countries that have more or less completed their initial phase of development, such as Brazil, Mexico and Republic of Korea, and to a lesser extent Malaysia, Philippines and Sri Lanka, all show the distinct hump predicted by Kuznets. The fact that retrogressive income distribution happens predominantly in countries belonging to the lower income strata struggling to initiate a growth process (in this sense, even Chile and the Islamic Republic of Iran might not be the exceptions, especially since the data relate to the pre-1980 period), strengthens the argument that the Kuznets hump is one more hurdle that developing countries have to overcome.

It is thus true that, in certain societies, barriers to individual attainment growing out of economic, social and ethnic backgrounds remain virtually insurmountable. This means that young people trying to extricate themselves from the handicap of a lower social and economic status at birth have very little chance of moving up to a higher income bracket. However, an income distribution picture observed at any particular point in time has nothing to say about a rapidly shifting constituency within a country—making the poor of yesterday rich today and vice versa. Historically, economic development is known to play such tricks. It happened during the Industrial Revolution and again during the era of the Meiji Restoration in Japan. On a smaller scale, it is happening in China today, and will most probably happen in the countries of Eastern Europe tomorrow.

In the mean time, income distribution remains an emotive social issue in developing countries. If income were to be distributed more evenly, more people would have access to basic needs such as education, health, food and shelter, thereby reducing poverty. Appealing though the notion is, the fact is that no developing country today is in a position to eliminate mass poverty without growth. Sceptics suggest that growth and social equality are irreconcilable. But the reverse seems more the case, especially considering the drastic reappraisal of policies in Eastern Europe.

The world has come a long way in realizing that provision for equal opportunity is as important as equal income distribution. Developing countries have been increasingly persuaded of this creed. However, since this has been applied with varying shades of conviction and enthusiasm, the results have been uneven. Development requires the harnessing of energy of the entire population, and many developing countries have yet to achieve this aim by creating opportunities and spreading them as widely and evenly as possible. Yet, to indict them individually and collectively for a conscious neglect of social development seems excessive, for notwithstanding their differences, developing countries, without exception, appear to have spent large portions of the national incomes on social development—that is, whenever income growth permitted it.

It would be misleading, however, to concentrate solely on these "social" dimensions of well-being. There is the "private" dimension of improved availability of traditional consumer goods discussed earlier and an improvement in these goods through the use of modern tools and equipment. These material dimensions of improvement through production are discussed in the following section.

F. The scope of industrial production

To a developing country, industrialization means more than a simple improvement in income and output. It is a way of modernizing its primitive production structure and transforming the entire socio-economic tradition associated with it. In this context, it is important to measure industrialization in its full scope; that is, in its extensiveness as well as in its intensiveness. Usually industrialization takes its initial hold with the introduction of modern production methods in a few industries before it spreads out to encompass many others. Historically, the initial impetus has come from resource-processing industries. Lately, however, many resource-poor developing countries have made their start by manufacturing labour-intensive light consumer goods such as footwear and wearing apparel. No matter where the initial impetus originates, the most important thing is to spread the experience of initial success as widely as possible and to transform as many primitive cottage-industry types of industry into fully-fledged factory-oriented ones.

One way of obtaining a broad picture of the pace at which industrialization is taking place in developing countries is to examine the range of industrial activities existing today against that which existed three decades ago. As shown in tables I.4.A, I.4.B and I.4.C, developing countries are producing today a much bigger variety of goods on an industrial scale, and the range of industrial products covered by developing countries as a whole practically exhausts the list of industrial commodities classified by the United Nations for statistical purposes. For example, up to 1970, in the majority of developing countries food products produced on an industrial scale seem to have been limited to beer, cigarettes and wheat flour. Since then, more and more developing countries have acquired a taste for, and the necessary income to purchase, other industrially processed food items such as tinned meats and vegetables, and even frozen foods. With clothing needs, the main industrial activities in developing countries seem to have been limited to the manufacture of cotton fabrics and leather shoes, leaving the chore of converting fabrics into wearing apparel largely to households or small cottage industries. This tradition seems, however, hard to break—the new industrial activities gained by developing countries since 1970 being typified by towel-making and the manufacture of women's stockings. This is, of course, only the general picture for developing countries as a whole and the story of a few Asian countries gaining a predominant position in the export of textiles is well known. So far as other sundry consumer products are concerned, the most frequently observed industrial activities in 1970 were the manufacture of toilet soaps and laundry detergents, as well as gasoline, lubricating oil and automobile tyres. In subsequent years, developing countries have extended their range of manufactures to include paints, explosives and photographic film-making.

What distinguishes developing countries from developed is their inability to fabricate metals and other materials into modern machinery and tools required by factories as well as by ordinary households. Thus, the consumer durable goods and capital goods industries have both shown limited growth, except in a few

Table I.4.A. Scope of industrial activities in developing countries: consumer products

production started before December 1970
production started after January 1971

Commodity
Vegetables, frozen
Meals, frozen prepared
Milk and cream, condensed
Cheese
Butter
Sausages
Chocolate and chocolate product
Meat, canned
Fruit and vegetable juices
Ice-cream
Vegetables, tinned or bottled
Fruits, tinned or bottled
Bread, ships' biscuits and oth
Fish, tinned
Refined sugar
Sugar confectionery
Fish, frozen
Distilled alcoholic beverages
Fish, salted dried or smoked
Soft drinks
Flour, wheat
Cigarettes
Beer and stout
Knitted sweaters
Woven fabrics, non-cellulosic
Women's stockings
Towelling
Woven woollen fabrics
Cordage, rope and twine
Socks and other stockings
Blankets
Footwear, excl. rubber plastic
Woven cotton fabrics
Photographic film, sensitized
Explosives
Printers' ink
Paints, cellulose
Paints, water
Tyres for bicycles and motorcy
Tyres for road motor vehicles
Paints, other
Lubricating oils
Washing powder and detergents
Motor gasoline
Soap
Household ware, other ceramic
Household ware, porcelain
Clocks, instrument panel
Drying machines, household
General hardware
Cameras, photographic
Scales, other than industrial
Clocks, other
Typewriters
Fuses, electrical
Calculating machines
Clocks with watch movements
Vacuum cleaners
Ovens, household
Irons, electric smoothing
Watches
Sound tape recorders
Sound reproducers
Fountain pens, ball-point pens
Pencils, crayons etc
Slide fasteners (zippers)
Tubes, fluorescent
Telephones
Sewing-machines
Washing machines, household
Gramophone records
Wire and cable, insulated
Air-cond. flooring machines
Stoves, ranges and cookers
Electric lamps (excl. fluoresc.)
Passenger cars, assembled
Motor cycles, scooters etc
Bicycles
Refrigerators, domestic
Batteries and cells, primary
Nails, screws, nuts, bolts, rivets
Television receivers
Radio receivers
Country: [illegible]
Number of commodities
1967: [illegible]
1970: [illegible]

Source: [illegible] industrial statistics, United Nations Statistical Office.

Table I.4.B. Scope of industrial activities in developing countries: capital goods

Commodity	production started before December 1970 production started after January 1971
Forging and stamping machines	
Generators for hydraul. turbine	
Other metal forming machine tool	
Rolling mills for rolling metal	
Electromechanical hand tools	
Printing presses	
Commercial planes (pass./cargo)	
Spinning machines	
Fork-lift trucks	
Motor-vehicle engines, gasoline	
Locomotives, electric	
Grinding and sharpening machine	
Other metal-cutting machine tool	
Machinetools for working wood	
Locomotives, diesel	
Motor-vehicle engines, diesel	
Drilling and boring machines	
Planing shaping slotng machines	
Metalworking presses	
Knitting machines	
Bulldozers	
Transformers less than 5 KVA	
Internal combustion engines	
Combine harvester-threshers	
Lathes	
Milling machines (cutters)	
Looms	
Passenger cars, produced	
Coaches and buses, produced	
Lorries	
Diesel engines (excl. for cars)	
Compressors	
Cranes	
Electric motors 1 HP and over	
Electricity-supply meters	
Rail passenger carriages	
Ploughs	
Transformers 5 KVA and over	
Refrigerators (oth. than domest.)	
Pumps for liquids	
Tractors of 10 HP and over	
Coaches and buses, assembled	
Lorries, including articulated	
Country	[illegible]
Number of commodities	
1987	[illegible]
1970	[illegible]

Source: Commodity production statistics, United Nations Statistical Office.

developing countries. Products in these two categories are not only technology-intensive, but require large investment which in most cases cannot be justified because of the limited size of domestic markets. The fact that more countries are producing technologically complicated radio and television sets than less technology-intensive clocks or household scales attests the importance of domestic market size.

An indigenous capital goods industry used to be an essential element of any ambitious industrialization plan. Both the United States and Japan, and later the USSR, all relative latecomers on the industrial scene in the nineteenth century, invested heavily in the capital goods industry to catch up with Germany and the United Kingdom. Modern-day developing countries have, however, followed a more logical sequence of industrialization, preferring to start with domestic production of imported non-durable consumer goods, thereafter moving into the import substitution of consumer durables before investing in the capital goods industry proper. This decision to postpone the development of a domestic capital goods industry to the last stems from two reasonable suppositions. The first is that the shallowness and narrowness of domestic markets in developing countries make domestic production of capital goods economically non-viable. The overall size of markets limits all industrial activities, but capital goods producers are more likely to be affected because they are, in a sense, twice removed from final consumers. It is always easier to find a hundred consumers willing to buy bicycles than to find 10 bicycle manufacturers seeking a domestic machine-tool producer in developing countries. The second supposition is that developing countries can produce agro-based products and textiles relatively cheaply compared with machinery and machine tools, and therefore trading light consumer goods produced domestically for capital goods produced in developed countries on the international market would be a sensible option, if this were permitted.

From the early 1960s to the late 1970s, when world trade was expanding rapidly and international movement of capital was becoming more and more widespread, the second supposition seemed perfectly valid and would have functioned without any problems. Thus, during that period, developing countries spent more than 20 per cent of their gross domestic product on fixed capital formation annually, while

Table I.4.C. Scope of industrial activities in developing countries: intermediate goods

production started before December 1970
production started after January 1971

Commodity
Hides, cattle & horse undressed
Oils and fats of aquatic animal
Tobacco, prepared leaf
Oils and fats of animals
Prepared animal feeds
Raw sugar
Yarn of discont. man-made fibre
Wool yarn, pure and mixed
Cotton yarn, pure and mixed
Sawn wood, broad leaved
Sawn wood, coniferous
Kraft paper and kr. paper-board
Cigarette paper
Wood pulp, mechanical
Newsprint
Aluminium oxide (excl. natural)
Ethylene oxide
Aniline
Brown-coal briquettes
Rubber, unhardened vulcanized
Ethanediol (ethylene glycol)
Acrylonitrile
Titanium oxide
Rubber, transmission, conveyor
Acetaldehyde
Vegetable tanning extracts
Phenolic and cresylic plastics
Propylene
Acetone
Potassic fertilizers
Hard-coal briquettes
Styrene
Butylenes, butadiene
Naphthalene
Zinc oxide
Sodium silicates
Synthetic rubber
Copper sulphate
Dyestuffs, synthetic
Phenol
Methanal (formaldehyde)
Polypropylene
Benzene (benzol)
Methyl alcohol (methanol)
Calcium carbide
Phosphoric acid
Soda ash
Aluminium sulphate
Sulphur, recovered from pyrites
Ethylene
Nitric acid
Polyethylene
Carbon black
Ammonia (N content)
Polystyrene
Chlorine
Cellulosic staple and tow
Paraffin wax
Polyvinyl chloride
Glycerine
Non-cellulosic staple and tow
Hydrochloric acid
Non-cellulosic continuous fibre
Caustic soda
Insecticides, fungicides, herbi
Sulphuric acid
Phosphatic fertilizers
Naphthas
Acetylene
Nitrogenous fertilizers
Asphalt (bitumen)
Kerosene
Glass, cast, rolled, drawn, blown
Toughened, lamin. safety glass
Sanitary ceramic fittings
Tiles, floor and wall
Glass bottles & oth. containers
Building bricks made of clay
Quicklime
Cement
Lead-base alloys
Copper-base alloys
Aluminium-base alloys
Zinc-base alloys
Sheets, electrical
Medium plates, 3 to 4.75 mm
Zinc plates, sheets, strip, foil
Lead tubes and pipes
Sheets under 3 mm, cold-rolled
Sheets under 3 mm, hot-rolled
Copper tubes and pipes
Copper wire
Heavy plates, over 4.75 mm
Nickel, unwrought
Zinc, unwrought
Tin-plate
Galvanized sheets
Pig iron, foundry
Copper, refined, unwrought
Aluminium bars, rods, angles
Aluminium plates, sheets, strip
Tin, unwrought
Other ferro-alloys
Wire rods
Aluminium, unwrought
Lead, refined, unwrought
Crude steel, ingots

Country [illegible]

Number of commodities

1987 [illegible]

1970 [illegible]

Source: Commodity production statistics, United Nations Statistical Office.

actively encouraging the import of modern machinery from developed countries with low or zero import duties, and often with large subsidized bank credits. This contrasted with their policy of protecting domestic consumer goods industries (users of imported capital goods) through high tariffs and import licensing.

Unfortunately, the 1980s brought with it a serious strain in the financial relationship between developed and developing countries, forcing trade between them to contract precipitously. The supposition of comparative advantage became operationally obsolete when developing countries were told that their discrimination against imported consumer goods in favour of capital goods not only causes domestic price distortions, but also violates the free trade principle, and should therefore be ended. Many developing countries have since then gradually "liberalized" their trade policies, effectively abandoning their stage-by-stage development strategy. A passing note on this episode might be that trade between two countries is possible even when one partner country produces everything in the cheapest manner, because both countries deliberately choose to swap goods based on domestic rather than on international price relationships. At present, only a few developing countries actually possess the capacity to produce industrial goods more cheaply than developed countries. But if they are prevented from swapping consumer goods for capital goods, they will not be able to develop their capacity to produce goods for export to international markets.

International trade is becoming more and more competitive, and seems to be functioning on an "absolute" rather than on a "comparative" advantage basis. Thus, tradable goods that developing countries can offer are becoming sparse. The consequent overcrowding among developing-country suppliers in commodity markets make their international prices low and volatile. Natural resource- and agro-based industries are typical examples. Resource-rich developing countries should have been encouraged to invest in the processing of industrial raw materials because most of the minerals and agricultural crops exported from developing countries are shipped out with minimal industrial processing. But new industrial activities in the intermediate-goods-producing sector during the past two decades has mostly been limited to resource-poor and resource-importing developing countries.

Returning to the general picture, the most frequently observed intermediate-goods-producing activities in developing countries are domestic-market-oriented and include cement, kerosene, asphalt, cotton yarn, bricks, fertilizers and prepared animal feeds. In 1970, some 80 developing countries possessed cement plants, while only 43 countries produced their own cotton yarns. During the past two decades, only three more countries, namely Benin, Singapore and Togo, were able to join in the production of cement, while the number of countries producing cotton yarns remained the same. This, in turn, sums up the status of, and the development prospects for, some 40 other developing countries that were unable to produce even such basic and essential goods because of the smallness and limited scope of their economies. There are, however, some success stories as well. Chile, Peru and Venezuela, expanded their range of intermediate goods production by introducing zinc, copper and aluminium processing and fabricating industries, as well as some basic and industrial chemicals. During the same period, the Republic of Korea also extended its range of intermediate goods production in petrochemicals, including plastics and synthetic fibres, and in metal processing, to support its shipbuilding and automobile industries. The most spectacular growth in the intermediate goods sector was, however, observed in Brazil and Turkey, each extending its range to cover almost the entire spectrum of intermediate goods production.

G. The stock of human and physical capital

Although the improved levels of consumption and production discussed so far indicate the apparent progress made by developing countries up to now, what really matters is progress in the accumulation of capital, both physical and human.

In 1987, the developed market economies as a group produced some $3,200 billion worth of manufactured goods (net value added), employing 62 million industrial workers and investing $311 billion in new plants and equipment, just over $5,290 per worker. In the same year, developing countries excluding China produced $476 billion worth of manufactured goods with 38 million industrial employees, and invested some $100 billion. The investment per worker was $2,600, or roughly one half of the per-worker investment by developed countries in that year. Physical investments once made, however, last longer than a year, and continue to provide service until they are scrapped or become obsolete. What counts, therefore, is the amount of physical capital stock still useful for productive purposes.

Only a few countries in the world make occasional attempts to estimate national wealth: that is, to assess the total value of all its physical assets including the values of buildings, plants and equipment used in commercial and industrial activities. Thus, according to national wealth data, Japan possessed (in 1986) some $4,500 billion worth of physical capital (excluding the value of land), while the United States owned (in 1985) some $3,500 billion worth of physical capital devoted to commercial and industrial activities. Comparable data for developing countries are hard to obtain, but a perspective is provided by the figure of $400 billion for the Republic of Korea in 1987.

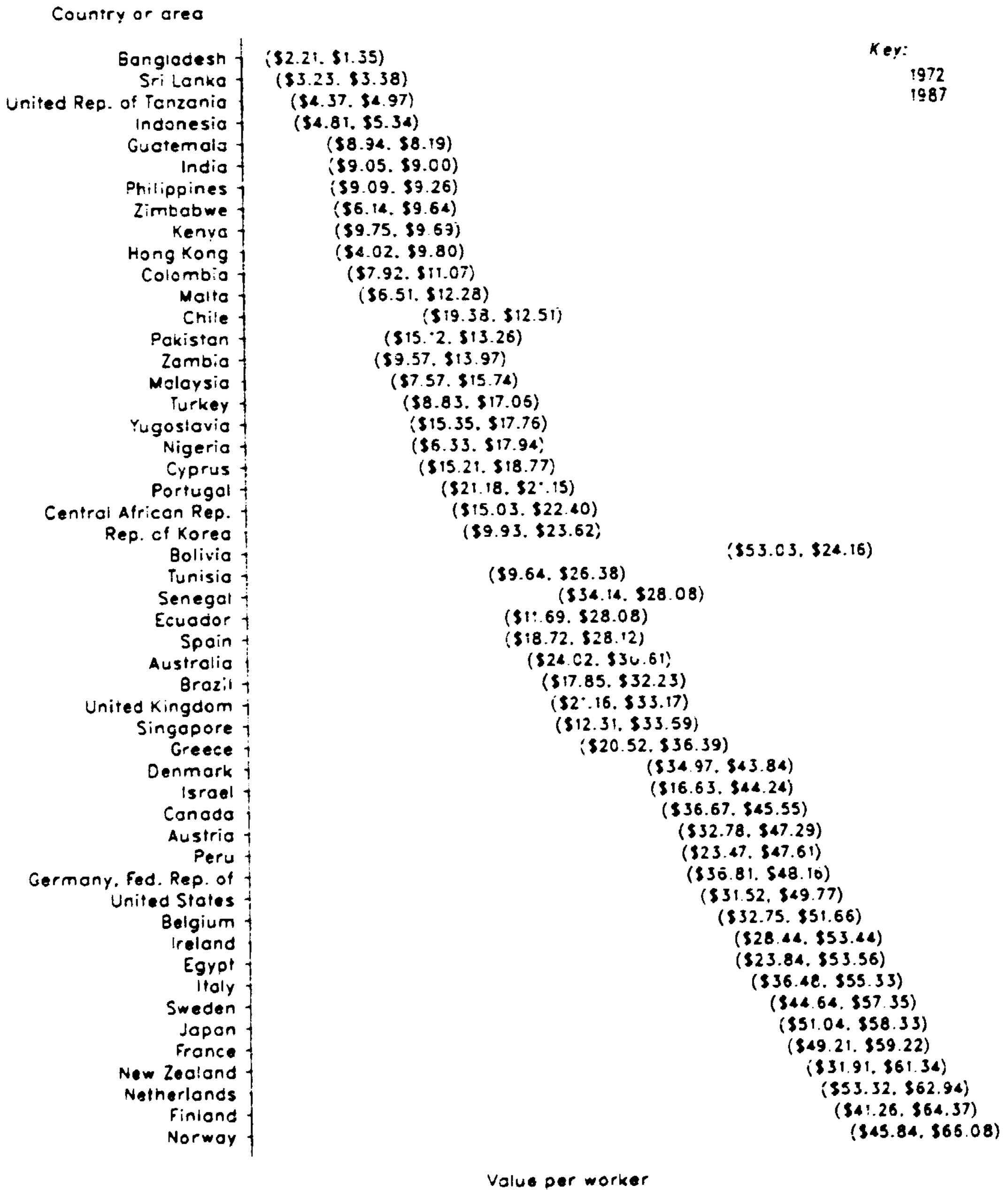
An approximation to the real picture of how much physical capital developing countries as a whole own is provided by simply tabulating their combined yearly spendings on gross capital formation in the past. Since physical assets depreciate in value over time, at various rates for different reasons, it is necessary to specify a cut-off point that is reasonable though arbitrary. Using a 10-year cut-off point, the estimated combined value of the physical capital stock outstanding for all 130 developing countries was $4,622 billion in 1987 (in 1980 constant dollar terms). This figure can be compared with that similarly computed for the 26 countries of the Organisation for Economic Co-operation and Development (OECD) countries, amounting to $18,325 billion. The contrast becomes sharper if these physical capital stock figures are put in per capita terms. Thus in 1987, people living in developing countries had $1,750 per head at their disposal, while in developed countries this figure was $22,500 (all in 1980 dollar terms), more than 12 times greater.

The productivity of workers in developed countries is expected to be higher not only because they have more ports and highways, but because they have more and better-designed factories and machine tools to work with. Thus, for example, industrial workers in Pakistan produced $7,500 in net value added per head in manufacturing, endowed with $13,200 worth of plant and equipment capital in 1987. Japanese industrial workers, on the other hand, became the world's most productive with $58,000 worth of manufacturing physical capital and producing $66,400 per head (all in current prices).

Japanese workers had, however, a lower per capita physical capital than their counterparts in Finland, Netherlands and Norway in 1987. The high capital-to-labour ratios observed in these countries reflect the rather specialized nature of their manufacturing activities and smaller and less complex industrial bases. In this regard, the capital-intensity figures for developing countries would be much higher than the norm. Moreover, developing countries starting industrialization with a minimal industrial base often find problems in manning the newly completed physical plants with skilled labour and trained personnel. This is another factor that causes a high capital-to-labour ratio in the initial phase of development.

Figure I.6 compares the physical capital stock (10-year accumulated gross investments) made available to each industrial worker engaged in manufacturing activities in 51 countries. In 1972, for example, the

Figure I.6. Stock of physical capital in manufacturing values of plant and equipment per worker, 1972 and 1987



Source: UNIDO data base.

Note: Figures in parentheses represent 1972 and 1987 figures respectively in thousands of deflated 1987 dollars.

industrial workers in Bangladesh were equipped with $2,210 worth of physical capital per head, which was one quarter of the figure prevailing in the Republic of Korea, and less than one twenty-fourth of the amount available to Japanese workers. In the same year, the output per worker in Bangladesh was merely $1,743 (in net value added) which was a little more than one fifth of the Korean workers ($7,706) and one twenty-fourth that of the Japanese ($41,843) worker's productive prowess. By 1987 Bangladesh was able to accumulate some $643 million worth of physical capital in manufacturing, which was approximately a 50 per cent increase over the $436 million in 1972. Yet, in the mean time, employment in the manufacturing sector has more than doubled—from 198,000 to 476,000, reducing the total physical capital available to each worker to $1,350. The output per worker, however, improved to reach $2,417, despite the rapid increase in employment and the thinly spread capital stock.

Because of the "lumpiness" in investment, a relatively large investment made at any one time pushes up the capital-per-worker figure unreasonably in some countries. Bolivia, Chile and Senegal all had unusually high capital-to-labour ratios in 1972. Among these three countries, Chile brought this ratio down through restrained investment programmes which sought diversification as well as cost-effectiveness. By 1987, Chile's total manufacturing employment was reduced from 259,000 to 213,000, and the output per worker improved from $13,256 to $23,344. In Bolivia, capital investment comes in large chunks and almost sporadically with huge differences in the level of investment from one period to another, and with the inevitable consequence of constantly changing capital-to-labour and output-to-labour ratios. As stated before, this is symptomatic of any developing country with a limited industrial base. In the end, however, Bolivia brought down its capital-to-labour ratio through a more orthodox manner of doubling its manufacturing employment from 70,500 to 145,320. In sharp contrast to Bolivia, investment behaviour in Senegal has been completely predictable, involving roughly $80 million every year since 1975. This means the country's total physical capital stock in manufacturing has not changed for some time. The result of this constant stock of capital was also predictable—because manufacturing employment in Senegal doubled between 1972 and 1988, the output per worker declined almost by half.

As can be seen from the above examples, investment in physical capital often fails to improve labour productivity immediately or directly in developing countries. This is because investment in developing countries is often carried out primarily to build a new or expand the existing industrial base that is too small or too fragile to provide self-sustaining growth. Investment in developing countries in such a case should be seen more in terms of its employment creation aspect, which in due time bestows a country with a sufficiently large industrial labour force, thereby improving its overall productivity. Unfortunately, however, such an indirect route to procure productivity gains entail a much longer time horizon than what is usual in the international financial markets. Many critics have pointed out that such long-term development capital should be generated within the countries concerned, rather than by relying on outside sources. Such criticism, however, ignores the crucial fact that domestic savings are not fungible for importing capital goods from abroad. The scarcity of external capital, therefore, remains the most serious development obstacle for most developing countries.

Physical capital stock is only part of the explanation of the difference in output per worker in developed and developing countries. A larger stock of physical capital leads to improved productivity and higher output and income. However, it is human skills and human enterprise, as well as the institutions organized and operated by men and women which make the crucial difference in determining the speed and direction of economic development. This depends vitally on the creation of a labour force equipped both with the necessary technological skills for modern industrial production and with a motivation or philosophy that facilitates the acceptance and promotion of economic and technical change. There is an essential complementarity between capital equipment and technology and a skilled and motivated labour force.

Between 1970 and 1987, literacy rates in developing countries rose from 58 per cent to 77 per cent, with 1,300 million more people in developing countries possessing functional literacy in 1987. This increase in human capital was a considerable achievement, both because it enabled the increased number of people better to exercise civic and cultural rights, but also because of the productivity increases that literacy brings. There is evidence from some developing countries that farmers with four years of basic education achieve crop yields 9 per cent higher than those without education ([4] p. 132).

Other bench-marks for measuring increases in the stock of human capital are provided by data on percentage distribution of population by educational attainment, on annual graduate output and on annual output of engineers and scientists. Thus, between 1965 and 1986, the percentages of the age group enrolled in first-, second- and third-level education in the population of developing countries increased from 78, 22 and 3 per cent to 103, 40 and 7 per cent, respectively. In 1986, for Asia, Africa and Latin America and the Caribbean, the annual output of graduates from tertiary-level educational institutions numbered 4 million, in contrast to 1.5 million in 1970 [5]. Moreover, the stock of scientists and engineers engaged in research and development in developing countries increased by 52 per million inhabitants in 1986. These numbers give an indication of the very considerable investment in human capital in developing countries over the period mentioned. The whole of the input costs associated with the provision of education at various levels obviously cannot be set against investment in human capital, at least a proportion of these costs have to be reckoned as consumption expenditure, and this proportion may vary with the level and field of education. Thus, while the education provided to liberal arts graduates may be reckoned to be less directly productive than that provided in science and technology, it may nevertheless be the case that broadly-based education and an understanding of the fundamental values that society espouses may be essential in transforming and modernizing the economies of developing countries.

Table I.5. Engineering products manufactured in developing countries, 1970 and 1987

Products — Level of skills: Total, Net

production started before December 1970
production started after January 1971

[illegible]

Perambulators [illegible]

Overall level of skills in developing countries [illegible]

[illegible]

Technology complexity index

Since 1979, UNIDO has maintained a small team of experts who have rendered technical assistance to developing countries in the acquisition of technology for the capital goods sector. The team uses the "technological complexity analysis", which, in essence, breaks down a particular finished capital good into all its constituent parts, each of which undergoes a series of separate production processes before they are put together with the components purchased externally at the final assembly stage. The detailed list of parts and components so identified receives expert appraisal as to their levels of difficulty in manufacturing, on the basis of the particular set of production processes involved and the degree of skill needed in the production processes to obtain an output of standard quality (see *Global Report 1989 90*, pp. 123-128).

Information about the level of skills which is required to start and operate a factory to assemble machinery is an important technological component needed to assess the feasibility of a planned investment project or analyse the current level of technology of a country. It is therefore of wide concern and interest to many Governments. But it is also well known that the quantitative measurement of the level of skills is very difficult and tedious, mainly because the kind of skills required in each production assembly process is quite different, and a tremendous amount of technical information is necessary for any systematic measurement. Also, the credibility of the result largely depends on the expertise of the team that worked on the assessment.

The UNIDO team measured the level of skill required for 145 sub-products in the machinery and equipment industry, and has published a technological complexity index for 107 countries for 1970 and 1984. The present report provides further results based on the extension of the methodology and newer data.

The production of machinery can be seen as manufacturing and assembling of many parts and components. It requires two basic skills: running a factory (start-up and operation), and producing the necessary parts, when they are supplied domestically. The UNIDO experts defined the skill score (S) for each assembling and parts and components production activity, considering 45 distinct technology elements including organizing, managing and executing factory operations, besides different machine-operating skills. Thus the technological complexity index (TCI) of the i-th machinery production ($(TCI)_i$) is the sum of the skill score of the assembling activity (S_i) and the sum of the TCI of each part and component (j).

$$(TCI)_i = (S)_i + \sum_j (TCI)_j \cdot P_j$$

When a country imports some parts, that country does not require the necessary skills to produce these parts. Therefore the necessary skills to produce parts must only be counted if these are domestically produced. Thus, in the above equation, P_j will become unity when the j-th part is domestically produced and will be zero when imported. In *Global Report 1988 89*, the average pattern observed in manufacturing establishments in developed countries was adopted to determine whether these parts were domestically produced or not. The TCI of a part was defined in a similar fashion following the same formula. Thus $(TCI)_i$ reflects the complexity of the entire range of domestic processes undertaken to produce i.

In the present report two further extensions have been made and new data used up to 1987. First, two different patterns of domestic production (Q, R) were calculated and then two indices, namely the total technological complexity index (TTCI) and the net technological complexity index (NTCI) were defined.

$$(TTCI)_i = (S)_i + \sum_j (TCI)_j \cdot Q_j$$

$$(NTCI)_i = (S)_i + \sum_j (TCI)_j \cdot R_j$$

Q and R take the value of unity only when the j-th part is domestically produced. As before, Q was calculated on the basis of the pattern of developed countries that showed a high self-sufficiency in production of parts. But R was calculated on the basis of the pattern of developed countries with low self-sufficiency of parts. Thus two different skills scores for each sub-product of machinery and equipment industry was tabulated. Out of the two different patterns of domestic production, it was observed that the pattern of developed countries with low self-sufficiency described better the current pattern of developing countries.

Secondly, the overall technological complexity index (OTCI) for each developing country was calculated by adding the NTCI of each sub-product of the machinery industry when this sub-product was domestically produced. The OTCI of the k-th country is thus defined as follows:

$$(OTCI)_k = \sum_i (NCTI)_i \cdot H_i$$

H will take the value of unity or zero depending on whether the i-th sub-product is domestically produced or not. The index for a country will therefore be bigger when this country produces a wider range of sub-products in the machinery industry and when this country produces more sophisticated sub-products.

One of the prerequisites for industrialization is the availability of a skilled work-force. Technology can be imported through the purchase of advanced machinery designed and produced abroad, or of the design and engineering specifications for the machinery. The skills required to operate the machines expertly are, however, only acquired through practice. The basic aptitude of workers is important. However, even this takes a long time to change, especially in developing countries without constant exposure of the population to modern modes of production. Developing countries have, however, come a long way, and some of them have acquired skills to produce most of the industrial products currently manufactured in developed countries.

Table 1.5 below gives an indication of the progress achieved by developing countries in their capacity to manufacture various engineering products between 1970 and 1987. The distinguishing aspect of engineering products is that they require so-called metal-processing and metal-fabricating skills and technologies. Since these are crucial skills and technologies needed for industrialization, UNIDO maintains a complete inventory of them with a set of scores designed to indicate the level of difficulty in mastering each specific skill. Each industrial product, in turn, receives an overall score of skill requirements based on a careful examination of its production process (see box).

In table I.5 a representative sample of some 140 engineering products is shown in descending order of "skill-intensiveness" estimated by UNIDO. The names of countries appear at the bottom of the table with their respective productive activities for 1970 and 1987. Cumulative scores indicating the overall skill level for each country are shown in table I.6. These are based on the analysis of skil.. ised to produce the particular mix of engineering products each country is reported to have produced in 1970 and 1987.

Table I.6. Technological capability and industrial skills in developing countries, 1970 and 1987

Country or area	1987	1970
Yugoslavia	9 210	7 861
Brazil	6 925	2 020
Republic of Korea	6 346	2 570
Turkey	4 677	1 778
Colombia	4 620	2 623
India	4 566	2 814
Philippines	3 466	1 082
China	3 114	611
Algeria	2 830	1 248
Peru	2 758	427
Indonesia	2 731	889
Mexico	2 543	1 791
Iran (Islamic Republic of)	2 487	1 187
Egypt	2 116	1 454
Ecuador	1 965	821
Cuba	1 812	637
Tunisia	1 714	1 137
Argentina	1 705	1 705
Chile	1 635	722
Myanmar	1 470	1 028
Sri Lanka	1 280	724
Pakistan	1 261	253
Angola	1 189	829
Venezuela	1 139	555
Thailand	1 081	210
Hong Kong	1 001	275
United Republic of Tanzania	812	478
Syrian Arab Republic	801	477
Nigeria	792	249
Malaysia	791	198
Iraq	680	58
Mozambique	639	461
Singapore	599	355
Bangladesh	498	58
Viet Nam	492	492
Morocco	488	152
Cyprus	452	-
Zambia	418	305
Zaire	417	417
Côte d'Ivoire	408	-
Trinidad and Tobago	400	400
Ghana	381	298
El Salvador	378	142
Malta	359	58
Nicaragua	327	51
Central African Republic	315	192
Dominican Republic	313	176
Gabon	285	-
Sudan	238	198
Cameroon	232	192
Democratic Yemen	229	-
Jamaica	190	190
Kuwait	188	-
Mali	177	-
Madagascar	177	177
Zimbabwe	142	-
Togo	137	-
Burkina Faso	137	137
Fiji	138	-
Guyana	136	136
Kenya	136	-
Mauritius	136	136
United Arab Emirates	136	-
Barbados	123	-
Antigua	109	-
Rwanda	96	54
Bolivia	87	87
Senegal	82	82
Chad	54	-
Malawi	54	54
Jordan	51	51
Cambodia	42	42
Ethiopia	42	42
Haiti	42	-
Sierra Leone	42	42
Yemen Arab Republic	42	-
Belize	40	-
Nepal	40	-
Congo	30	-

Sources: Commodity production statistics, United Nations Statistical Office, and UNIDO data base.

Thus, in 1987, Yugoslavia led developing countries with a score of 9,210, with second and third places occupied by Brazil and the Republic of Korea registering overall skill levels of 6,925 and 6,346 points, respectively. All three countries produced an extensive range of engineering products in 1987 (more than 80 out of 140) that are more than comparable to some of those produced by developed countries. In 1970, however, Brazil had only 24 engineering products with an overall skill content of 2,020, while the Republic of Korea had 37 items with a skill content of 2,570. In 1987, Colombia, India and Turkey all received a similar score and positioned themselves just ahead of China and the Philippines. The progress made by the latter two since 1970, however, is noteworthy.

Some 18 developing countries received scores ranging between 1,000 and 3,000 in 1987, producing from 16 to 40 different engineering products. They represent the typical sample group for developing countries, in the sense that they belong neither to the NICs nor to the least-developed-countries group. The average level of skills acquired by this group of countries in 1987 was still one fifth the level found in developed countries. This, however, compares with the extremely low level (roughly one tenth that of developed countries) of skills prevailing in these countries less than two decades ago.

The real problem lies with some 90 other developing countries that have either a small or no engineering industry to provide the training ground for the basic metal-processing and metal-fabricating skills needed. In 1987, some 30 developing countries did manage, in their own fashion, to convert and transform metals with traditional methods; that is, without the use of specialized machine tools. Invariably these countries belong to the group of least developed countries with a long and tortuous road ahead in their economic development. During the past two decades, however, the rest of the 50 countries in this group have made head starts, 19 of them from scratch and the rest from a minuscule base, and include star performers such as Bangladesh, Côte d'Ivoire, Cyprus, Gabon, Iraq and Malaysia.

Technological change is a prime force for economic development. For developing countries, new technology as organized knowledge in itself or as embodied in new products and new processes, comes mainly from outside. What is important for developing countries, therefore, is the diffusion of newly-gained knowledge which it is hoped will start a chain of progress in which technology feeds upon itself. Economists have frequently argued that new technology coming from outside is by definition alien to the socio-cultural and economic environment of developing countries and is therefore frequently resisted. During the past two decades, however, developing countries have shown not only the determination to change, but some two thirds of them seem to have succeeded in imbuing their societies with an ethos of change which is driven by modern production technology.

H. The relative status of developing countries in international co-operation

It is possible for some countries to industrialize alone. The United Kingdom, where the modern industrial revolution was born, was alone at the beginning. But even here, the foundations for this first Industrial Revolution were laid upon that country's prowess in overseas trade; that is, international co-operation, whether with its many colonies spanning the globe or with foreign sovereign States. That such co-operation was not always easy, nor peaceful, can be seen in the great efforts sovereign States made to keep markets open or closed. Apart from trade, other forms of international co-operation, in particular investment in its direct and indirect forms, also facilitate industrialization and development. This can be seen, for example, in the early development of the United States, where direct foreign investment, as well as bank loans and foreign bond flotations, facilitated the construction of a modern transport and communications infrastructure, and the establishment of a wide range of directly productive industrial facilities. The present section focuses on the three crucial aspects of international co-operation—international trade, foreign direct investment and foreign borrowing—and on the progress achieved by developing countries in mobilizing international co-operation to foster their industrial development.

Between 1970 and 1987, the merchandise exports of developing countries increased from $57 billion to $496 billion per annum, while over this same period the exports of developed countries rose from $257 billion to $1,987 billion per annum. What is particularly significant in the trend of developing country exports is the rising proportion of manufactures in this trade, so that by the year 1985, more than half the total exports of developing countries consisted of manufactures, and by 1987, no less than 62 per cent of developing country exports consisted of manufactured goods. If attention is focused on trade exchanges between developed and developing countries, between 1970 and 1987 developing countries sold $4,262 billion (in current dollars) to developed countries, of which $1,848 billion (43 per cent) consisted of manufactures, and developed countries sold $3,992 billion to developing countries, of which $3,329 billion consisted of manufactures; that is, developing countries had a surplus of trade with developed countries over the 17-year period. Moreover, this trade imbalance has been even more pronounced in the post-1982 debt crisis period. This situation had admittedly been abnormal: countries that are developing usually run trade deficits as they import capital goods, and such countries usually manage to balance their accounts by direct foreign investment and external borrowing. A closer examination of the trade data reveals that the bulk of trade surpluses occurred in the post-1982 period when the debt crisis erupted. Many countries were forced to curtail their imports (and this affected the exports particularly of the United States), and at the same time to run an export surplus to keep up with debt servicing. Yet, while too much weight cannot be placed on the trade situation in a single year, in 1986 when there was over 9 per cent expansion of world trade, exports of developing countries actually declined by 10 per cent. Part of that stagnation was accounted for by the decline in the price of oil exports, but more significant was the fact that exporters of manufactures from developing countries could only manage a rise of less than 3 per cent in 1986. The problem is that developing countries are finding market access for their products increasingly difficult. Their agricultural exports face the twin difficulty of low income elasticity of demand in developed country markets coupled with agricultural régimes that are highly protective of domestic producers. Moreover, industrial raw material exports face structural changes within developed countries away from smoke-stack industries. Developing-country-manufactured exports also face increasingly stiff protectionist barriers in developed countries—that was one reason why these manufacturers did not share significantly in the global trade expansion in 1986. In one sense, the problem is quite simple: after having lent significant sums to developing countries in the 1970s, much of which was used for industrialization based on technology and capital equipment exported from the North, developed countries legitimately demand debt repayment and servicing, but irrationally place barriers before manufacturers in the South who have the competence and capability to sell their goods in markets of the North, and so as to obtain the foreign exchange to deal with their debts. The world was much more interdependent in 1987 than in 1970: international trade comprised 15 per cent of world GNP in 1987 compared with 10 per cent in 1970. The world as a whole gains from interdependence, but to continue to make such gains, all must co-operate and the opening-up must be mutual.

Many developing countries have in the past had mixed feelings regarding foreign direct investment. Some of these countries have been afraid of the power of the ubiquitous transnational corporations, whose sales revenues sometimes dwarf the gross national product (GNP) of smaller economies. More recently, however, a combination of factors has led to a revised perception of transnational corporations. Developing countries have gained a better appreciation of the management know-how, market access and technology which transnational corporations can deliver. The initial unwillingness to accept prescriptions from the International Monetary Fund (IMF) and the World Bank has changed for some countries to enthusiastic endorsement. The external commercial banking community has been unwilling to lend to many countries, thus prompting an even more desperate search for investment resources. Perhaps the most significant factor, however, is that some countries have become more self-confident—and more experienced—in dealing with foreign investors, and less willing to let perceptions of infringements of national sovereignty stand in the way of co-operation that is reckoned to be mutually beneficial. Foreign investors have also become more flexible in regard to the type of co-operation in which they are willing to engage. Traditionally a transnational corporation would have owned most of the equity investment in its empire of foreign companies and subsidiaries. The new trend is towards joint ventures, international sub-contracting arrangements, licensing agreements, franchising, management and marketing contracts, and production and other risk-sharing agreements. These new forms of mutual co-operation provide a framework for entrepreneurs, owners of tangible and intangible assets such as land, equipment, technology and other forms of know-how, and financiers to join forces, divide risks and responsibilities and share effective control among owners of equity. Deals can be negotiated involving a mix of cash, technology, production management and marketing know-how that can be better suited to the needs of various investment partners. For the countries involved, it can provide a vehicle for developing production capacities and competitive strengths in key industries.

The experience of developing countries in attracting foreign direct investment has varied considerably, but the policy package adopted and implemented by countries that have been most successful in attracting increased foreign direct investment (including some countries with relatively high levels of indebtedness), has been based on the following: a good macro-economic performance and confidence in its sustainability; realistic, sound and effective economic policies; effective use of scarce financial resources; open, market-oriented trade and industrial policies and a dynamic private sector; and stable and predictable foreign investment policies that provide fair and transparent rules of the game. Data on foreign direct investment flows to developing countries are inadequate. Such flows are subject to a variety of influences, including conditions in the developed countries from which investment is derived, global economic conditions, the availability of other sources of investment, and, in the new decade of the 1990s, the attractions of other host country destinations such as the countries of Eastern Europe.

While direct foreign investment flows have fluctuated considerably since 1970, the changing trends during this period have been marked. In current dollar terms, the flow in 1970 was $3.7 billion, and it fluctuated around this level before falling to $1.1 billion in 1974; thereafter it increased to around $10 billion in the post-1975 period until 1985, at which point only $6.7 billion was invested. Subsequently there was recovery in 1986 and 1987 to $12.2 and $13.2 billion, respectively. Since these figures are in current dollars, and given the explosion in international direct investment as a whole over the 1970 to 1987 period, from about $10 billion to about $110 billion annually, it can be seen that an ever-falling proportion of direct investment has been attracted to developing countries. There has also been a significant shift in the destination of direct investment among developing countries, with the share of Latin America falling from 51.6 per cent in the 1976-1980 period to 47.8 per cent in 1981-1986 period; the share of Africa falling from 11 per cent to 9.5 per cent; and the share of South-East Asia rising from 21.5 per cent to 29.8 per cent. It is also noteworthy that in Africa, during the 1981-1986 period, some 90 per cent of the foreign investment went to Algeria, Cameroon, Nigeria and Tunisia, and that there was a significant deterioration after 1982 in sub-Saharan Africa, with investment falling from $2.2 billion to $337 million in 1983, and with disinvestment of $229 million and $65 million in 1984 and 1985 respectively, before recovering slightly to an inflow of $543 million in 1986 [6].

While the picture painted above is somewhat gloomy, particularly for sub-Saharan Africa, it is relieved somewhat by the buoyancy of investment in Asia, especially South-East Asia, and by the maintenance of direct foreign investment flows to Latin America of $12 billion to $13 billion in 1986 and 1987. Despite the debt problem and the economic and social dislocation caused by that problem, the region was still able to regain the confidence of foreign investors and attract sums that are not insignificant.

The change of policies with regard to direct foreign investment has been part of a wider range of policies placing greater emphasis on the place of market forces in economic development: for example, financial liberalization, a reduction of import controls and high tariff barriers and greater reliance on competition and the private sector. Financial liberalization has been accompanied often by measures to expand stock markets as a mechanism for the mobilization and allocation of financial resources, and in a number of cases has served to open channels for new types of foreign investment. While the total capitalization of these markets is still small compared with the GNPs of the countries in which they operate, the end of 1989 this capitalization amounted to $550 billion in the 16 most important markets. There has been the recognition in many developing countries that equity markets can be more than an adjunct to capital markets. As loans dry up, developing countries have increasingly turned to equity markets as a conduit for foreign financial resources. Moreover, some countries have been more receptive to portfolio investment than to direct investment because the infringement on sovereignty is perceived to be less. The International Finance Corporation (IFC) has played a major role, both in the modernization of developing-country equity markets and in the launching of the "country fund" concept as a conduit for investment. A mutual fund would be launched primarily geared to the external institutional investor, which would promote the country as an investment location in the major external stock markets, and which would be a "closed-end" fund, so that money would not flow into and out of the market rapidly. From a handful of country funds prior to 1986, more than 50 country funds were launched between 1986 and 1989, 20 alone in 1989. The IFC has been involved in 24 of these funds as sponsor, lead or co-lead manager, placement agent or investor, and has supported both new money funds and debt-equity conversion funds.

This change of policy stance has recently began to show benefits. The capital markets of developed countries have begun most recently to take an optimistic view of the export prospects of some highly indebted countries, despite protectionism. After a decade of virtual absence from the international capital markets, in 1989 a number of Latin American companies were able to issue some $500 million of foreign bonds. Thus in June 1989, the Banco Nacional de Comercio Exterior of Mexico was able to borrow $100 million on the Euromarkets, followed later by Cemex (cement), Nafinsa (development finance), La Moderna (tobacco industry), Sivensa (steel), Tamsa (steel fabrication) and Pemex (oil and petrochemicals), all of which raised significant amounts of bond finance. Foreign investors in bond markets viewed these Latin American companies as having the competence and capacity to produce and to market their exports and, moreover, no major Latin American company has defaulted in the international bond markets in recent years. Since domestic interest rates in many countries of Latin America have been high over the past year—of the order of 40 per cent per annum in Venezuela and over 30 per cent in Mexico—Latin American enterprises have been willing to take risks related to exchange rates and protectionism because they know they have the capacity to produce for export. Reportedly, some Latin American companies are seriously considering borrowing on the commercial paper market, a segment of the international capital market which has expanded tremendously with the innovations in financing techniques of recent years.

At the end of 1989, the external debt of developing countries amounted to about $1,200 billion, with annual interest and amortization payments at $163 billion. The background to the external debt crisis is clear, and the *ex post* effect of unfavourable external shocks has invariably been a deterioration of the current account balance and a reduction in the import capacity which have made it more difficult than otherwise for developing countries to upgrade and boost export-oriented industries in the short run. Given the narrow margin for paring other essential imports such as foods and fuels, restrictions on imports have been applied rapidly to industrial raw materials and machinery and equipment which are vital to capital formation and to the survival of fledgling industries. Because of the embryonic stage of capital goods industries and highly import-dependent basic industries with relatively undeveloped inter-industry linkages, capacity under-utilization and production disruptions have resulted, along with stunted investment. The loss of momentum towards building up basic technological and industrial capabilities could generate long-lasting damage, substantially outweighing the foreign exchange savings or other short-term benefits from import reduction. Commercial lending has almost dried up for most countries, and the hammer-blows caused by the external shocks have forced countries to adjust both by demand contraction and by economic restructuring designed to increase export competitiveness.

At the end of 1989, the external debt of the 15 "heavily indebted" developing countries (namely Argentina, Brazil, Bolivia, Chile, Colombia, Côte d'Ivoire, Ecuador, Mexico, Morocco, Nigeria, Peru, Philippines, Uruguay, Venezuela and Yugoslavia), amounted to $510 billion. Their debt service ratios, in aggregate, amounted to no less than 41 per cent of their exports of goods and services. These countries borrowed when liquidity was abundant, and are attempting to service their debt via export revenues at a time when international liquidity has dried up. Most of them have the ability to place their goods—manufactures and raw materials—on external markets, which, if these markets were free, would enable them to service their debts. What these countries face is a liquidity crisis. Their vendors of capital goods and of credit have the joint responsibility to solve the crisis, just as the debtor countries have the responsibility for the eventual repayment of debts. Bankers who have built up relationships with industrial borrowers in good times usually recognize a responsibility to maintain that relationship when these same borrowers face a shortage of liquidity. Both suppliers of credit and exporters of goods have benefited from interdependence in the past; this interdependence must be maintained. The very nature of interdependence depends on co-operation, and such co-operation is possible only when each partner benefits. Countries which typically export capital and high value-added goods must be willing to purchase typically lower level value-added goods in return. International co-operation is impossible without mutuality of interest.

I. Concluding remarks

The material progress of developing countries as a whole over the past 30 years has been considerable when their achievements are placed in the context of progress made in any 30-year period of their past economic history. Even when compared with countries now considered "developed", and in particular at a similar stage of industrial development, this progress calls for praise rather than disparagement. To be sure, it is possible to argue that developing countries—individually or collectively—should have done even better, but it is in the nature of things that this argument can always be put to any country or group of countries, developed or developing. Whether attention is focused on improvements in the human condition, such as increasing life expectancy, improvement in health care and diet, strides made towards eradicating illiteracy and the provision of basic education for all children and young people, the achievement has been significant. And the achievement is no less significant when industrial development is considered. In 1960, not many industrial goods were produced by developing countries, and their range was fairly limited; today, at least in a dozen developing countries the volume and range of products are comparable with industries of developed countries not so long ago. Their quality is sophisticated enough to compete with the manufactured products of most developed countries. There are also a dozen other developing countries that are currently undergoing a similarly rapid industrialization process, generating excitement internationally. Undoubtedly, there is another group of countries waiting for the "window of opportunity" to change.

While these achievements by developing countries were based on their own determined efforts to develop, it was certainly facilitated by a variety of forms of international co-operation. Here too it is possible to say that the role of international co-operation should have been stronger, and that the achievements of the developing countries would have been greater, had they been able to strengthen co-operation with the developed countries, as well as among themselves. However, countries have different perceptions in their understanding of international co-operation, and these different perceptions have been sometimes hidden. The most recent achievement of many developing countries has been to grow out of their utopian vision of international co-operation, in accepting a new reality in which competition has largely replaced co-operation, and in accepting that some countries still need help in confronting this new reality.

II. Industrial performance, policy and prospects in major regions of the world: Age of global integration and challenges in the 1990s

The decade of the 1980s witnessed unmistakable signs that the world economy is being integrated at an accelerated pace. Rising trends in trade volume and foreign direct investment, rapid diffusion of technological progress and the formation of a virtually single financial market that combines New York, Tokyo, Hong Kong, Singapore, London and Frankfurt are all aspects of this phenomenon. Regional integration movements have reinforced the globalization trend, as may be seen in the progress toward a single EEC market, the Free Trade Pact between Canada and the United States,* and the Asia-Pacific Economic Co-operation Council. Eastern Europe and the USSR have also recently joined the trend of global integration by opening up their economies. In short, the world economy is in flux as it sheds the old order and enters a new and yet undefined one. Challenges and opportunities abound in the 1990s to make use of the march towards a single global market. But that requires sharing benefits, costs and responsibilities among the component countries and regions. However, as the following regional reviews will disclose, there is a danger that inter-regional gaps in income, industrial capacity and technology could widen in the next decade, even among developing regions. Herein lies a great challenge facing the international community.

A comparison of MVA growth performance during the 1980s and 1970s between major regions of the world reveals a striking degree of diversity (see table II.1). North America and Western Europe saw annual MVA growth declining from over 2 per cent a year in the 1970s to below 2 per cent in the 1980s. In contrast, the annual MVA growth of Japan rose from 3.1 per cent in the 1970s to 3.7 per cent in the 1980s. Numerous studies suggest that the difference between Japan on the one hand and North America and Western Europe on the other stems in large part from differences in commercial application of technological knowledge and sharpened competitiveness.**

Table II.1. Annual average growth rates of MVA and manufacturing employment during the 1970s and 1980s, by major regions of the world

Region	1970s a/		1980s b/		1987 MVA per capita (1980 dollars)
	MVA	Employment	MVA	Employment	
	(percentage)		(percentage)		
World	3.5	1.4	2.4	0.0	705
Developed regions	3.1	0.5	2.2	-0.4	2 549
North America	2.7	0.6	1.6	-0.7	2 987
Western Europe	2.1	-0.4	1.7	-1.2	2 687
Eastern Europe and USSR	5.8	1.6	2.9	0.3	1 951
Japan	3.1	-0.6	3.7	0.6	3 800
Other	2.5	0.9	1.2	-0.2	991
Developing regions	7.4	5.0	3.9	1.1	176
Latin America	6.6	4.0	1.6	-0.7	461
Tropical Africa	5.7	4.7	0.5	1.2	32
North Africa	7.0	5.6	5.3	3.8	138
Western Asia	7.6	5.4	4.0	2.0	305
Indian Subcontinent	3.4	3.9	6.2	0.4	53
South-East Asia	11.6	7.2	7.5	2.5	329

Source: UNIDO database, consolidated Industrial Statistics.

a/ Between 1970 and 1980.

b/ Between 1980 and 1990 (estimates).

Increasing awareness of lagging behind Japanese progress in technology and innovation led Western Europe to quicken the formation of a region-wide science and technology programme, and indeed the transition to EEC 1992 itself. A short-run fallout of this movement may be seen in flurries of investment and in Euro-optimism replacing worries over "Euro-sclerosis". Furthermore, Eastern European countries seem eager to join the expected prosperity by transforming their economic system. The long-term overall prospects of Western and Eastern Europe would appear promising.

Similar awareness in North America is also stirring debates, studies and even joint ventures between Japanese and United States enterprises. The region, the global storehouse of inventions and scientific knowledge, if properly stimulated by policy incentives, will restore its industrial competitiveness sooner or later. Propitiously, Japanese manufacturing enterprises in the United States and Canada are forcing the laggards to innovate.

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*Discussions are under way on the possible accession of Mexico at a later date.

**For revealing studies, see Chalmers Johnson, Laura d'Andrea Tyson and John Zysman, *Politics and Productivity-The Real Story of Why Japan Works* (New York, Ballinger Publishing Company, 1989), David H. Brandin and Michael A. Harrison, *The Technology War-A Case for Competitiveness* (New York, John Wiley Inc., 1987), and B. R. Inman and Daniel F. Burton, Jr., "Technology and competitiveness: the new policy frontiers", *Foreign Affairs*, vol. 69, No. 2 (Spring 1990), pp. 116-134.

A major problem is that the current technological revolution is bypassing the developing world. Particularly, the long-term prospects of Tropical Africa and (less so) Latin America appear bleak. During the 1980s, the regions registered annual MVA growth of 0.5 per cent and 1.6 per cent, respectively. Those rates, being below their population growth rates, imply negative growth per capita. Under a heavy burden of debt servicing there seems simply no room to worry about long-term progress in technology and innovation. Quite possibly the 1990s may see a neglected and marginalized Tropical Africa (a possibility which represents a global policy challenge).*

In the following review of regional growth prospects, emphasis is given to the role of foreign direct investment.** In recent years, FDI activities, particularly in the form of joint ventures, have been soaring worldwide and changing the meaning of national boundaries, policy sovereignty and balance-of-payments figures. This also reflects a reassessment of the importance of foreign direct investment as a versatile policy tool at all levels—enterprise, sectoral, regional and international. Indeed, foreign direct investment can be used to circumvent protectionism, to bring in new technology and scarce capital, to supplement marketing networks, and to provide managerial and organizational skills. Policy-makers now recognize foreign direct investment as an instrument of industrial growth rather than as foreign-based exploitation. The best illustrations of this changed perspective are coming from Eastern Europe. It seems that useful lessons can be learned from burgeoning experiences in virtually every region of the world.

A. North America

Though the immediate outlook for industrial growth in 1990 is for a slow-down to 1.8 per cent, the intermediate and long-term prospects seem basically optimistic. This is true especially for the following reasons:

(a) The competitiveness of industry has been enhanced by new investment and restructuring;

(b) In part, Japanese investment and joint ventures in the region have prompted local industries to adopt new technologies;

(c) The potential global market for United States goods and services has expanded to include Eastern Europe and the USSR;

(d) "Peace dividends" may be expected;

(e) Relaxed rules of the Co-ordinating Committee for Multilateral Export Controls (COCOM) will push up United States exports of high-technology goods.

Opposing factors, however, include the following:

(a) Slow improvements in the twin trade and budget deficits of the United States;

(b) Interest and exchange rate volatility and even perversity, tending to increase risks and uncertainties in industrial transactions;

(c) Possibility of a trade war, however remote.

Nevertheless, barring a deliberate government policy to use recession as a tool to fight inflation, as in the 1981-1982 period, a "soft landing" is expected in 1990, and a gradual and continued recovery is expected several years thereafter (see figure II.1 for GDP and MVA growth in recent years, and also for the pattern of structural change in industry).

In a slow-down phase of the business cycle, enterprises are usually reluctant to invest. But a survey by DRI/McGraw-Hill reports that the manufacturing sector intends to increase investment spending by 6.2 per cent in 1990. It seems that the need for factory and office modernization has not yet been fully met, despite a mini-investment-boom in the 1988-1989 period. The unexpected boost in investment demand could make the soft landing easier.

Additional help could come from the ever-increasing foreign direct investment in the United States. In 1988, the stock of foreign direct investment from all countries jumped to $328.9 billion from $271.8 billion in 1987, an increase of over 21 per cent (see table II.2). The increase between 1986 and 1987 was 23 per cent. A high growth rate of foreign direct investment is expected to continue. The reasons for this are several. The United States remains the largest profitable market; it provides attractive opportunities for learning new technology, as exemplified by Silicon Valley; United States protectionist measures, such as voluntary export restraints, could be overcome by foreign direct investment; a low dollar value compared with that of several years ago still makes United States assets rather inexpensive. Table II.3 provides a breakdown of foreign direct investment position in the United States by country or region of origin and type of investment for 1988.

Despite the alarm expressed in the United States against foreign investors (particularly from Japan), in general foreign direct investment seems to be welcome. Some 40 states of the United States are reported to have opened offices in Japan to attract investment.

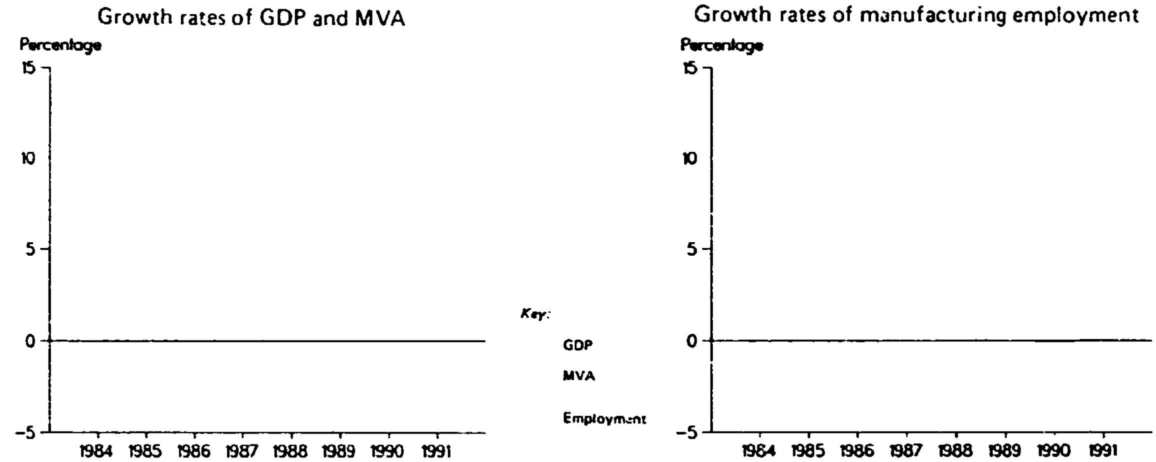
Foreign direct investment creates employment opportunities, adds income and tax sources, and brings new technologies and management skills. Opponents argue, however, that uncontrolled foreign direct investment may create over-capacity, cause cut-throat competition, provide an opportunity to steal vital technology, and even endanger national security if defence-related industries are penetrated. Despite these concerns, the United States remains one of the most open economies for such investment.

By making use of the liberal policies of the United States, Japan has achieved the fastest build-up of

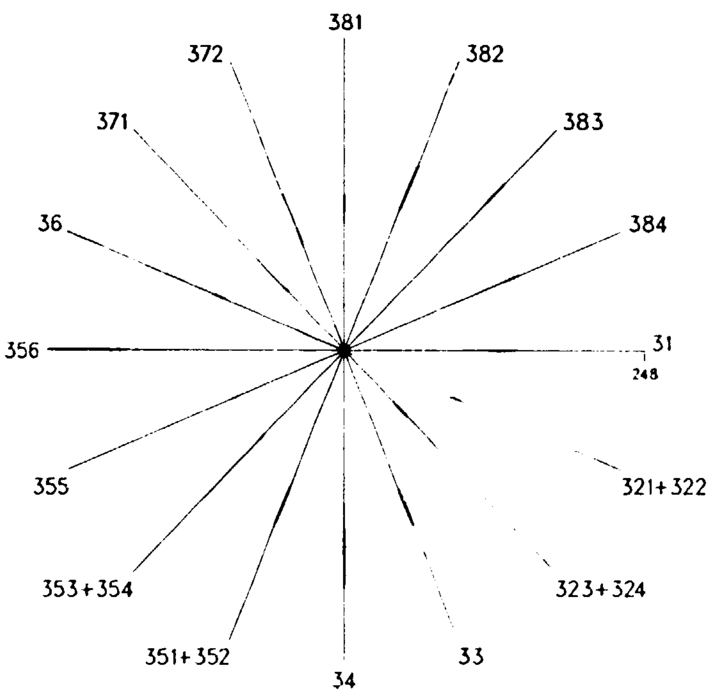
*For a warning on the lagging technological and investment effort in the countries of sub-Saharan Africa, see Bernhard Fischer, "Developing countries in the process of economic globalization", *Intereconomics*, vol. 24, No. 2 (March/April 1990), pp. 55-63, and Manuel Castells, "High technology, world development, and structural transformation: the trends and the debate", *Alternatives*, vol. XI, No. 3 (July 1986), pp. 297-340.

**This emphasis confirms the special interest of UNIDO in monitoring and analysing the phenomenon of structural upgrading of the industrial base. The reason is simple but important. Conventional macro-economic analysis neglects changes in industrial competitiveness of countries and regions partly because of measurement difficulties in model building. However, it seems imperative to pay special attention to factors determining industrial competitiveness, such as structural upgrading, innovative activities and technological progress, along with foreign direct investment. The recent disputes on trade and industry between the United States and Japan dramatize the issue.

Figure II.1. Growth rates of GDP, MVA and manufacturing employment, 1984-1991, and industrial structural change, 1975-1991: North America



Industrial structural change
(Index of value added: 1975 = 100)



g =	2.44
θ =	9.96

Key:

ISIC code	(industries):
31	(Food products)
321, 322	(Textiles)
323, 324	(Leather)
3	(Wood and furniture)
34	(Paper and printing)
351, 352	(Chemicals)
353, 354	(Petroleum and coal)
355	(Rubber products)
356	(Plastic products)
36	(Non-metal mineral products)
371	(Iron and steel)
372	(Non-ferrous metals)
381	(Metal products)
382	(Non-electrical machinery)
383	(Electrical machinery)
384	(Transport equipment)

Constant prices of 1980

g = Average annual growth rate, 1975 1991 (percentage)

θ = Index of structural c... 1975 1991

1985–1991 forecast
1980–1985
1975 1980

Sources: UNIDO data base; estimates and forecasts by UNIDO/PPD/IPP/GLO.

Table II.2. Foreign direct investment position in the United States
(Millions of dollars)

Country or region of origin and type of investment	Direct investment 1986	1987	1988
All areas	220 414	271 788	328 850
Petroleum	29 094	35 598	34 704
Manufacturing	71 963	84 745	121 434
Wholesale trade	33 997	39 754	50 160
Other	85 360	101 691	122 522
Canada	20 318	24 013	27 361
Petroleum	1 432	1 426	1 614
Manufacturing	6 108	7 636	9 392
Wholesale trade	1 496	2 264	2 543
Other	11 282	12 688	13 803
Europe	144 181	186 076	216 418
Petroleum	26 139	32 957	31 536
Manufacturing	56 016	73 981	91 932
Wholesale trade	16 430	20 202	24 825
Other	45 596	58 938	68 124
Netherlands	40 717	49 115	48 991
Petroleum	--a/	--a/	--a/
Manufacturing	13 293	16 137	17 153
Wholesale trade	2 621	2 250	3 270
Other	--a/	--a/	--a/
United Kingdom	55 935	79 669	101 909
Petroleum	11 758	--a/	18 779
Manufacturing	16 500	27 061	37 021
Wholesale trade	5 676	8 200	10 049
Other	22 001	--a/	36 060
Japan	26 824	35 151	53 354
Petroleum	-34	-2	-79
Manufacturing	3 578	5 345	12 222
Wholesale trade	13 687	15 352	18 390
Other	9 593	14 456	22 820
Other	29 091	26 547	31 718
Petroleum	1 556	1 218	1 633
Manufacturing	6 261	7 783	7 890
Wholesale trade	2 344	1 936	4 396
Other	18 890	15 610	17 799

Source: United States Department of Commerce, Survey of Current Business (Washington, D.C., August 1989), p.52.
a/ Suppressed to avoid disclosure of data of individual companies.

outside investment in that country. From 1986 to 1988, its total investment stock nearly doubled from $26.8 billion to $53.4 billion, and its investment stock in manufacturing jumped 3.4 times from $3.6 billion to $12.2 billion. In comparison, United Kingdom investment in manufacturing increased from $16.5 billion in 1986 to $37 billion (a 2¼-time increase and three times bigger than foreign direct investment by Japan in manufacturing). And yet, United States producers appear more worried about Japanese competition than that from the United Kingdom.

The reason for this is that the Japanese appear far more competitive and threatening than any other investors. The Commission on Industrial Productivity of the Massachusetts Institute of Technology studied 200 companies selected from the United States, Europe and Japan. The major findings were as follows:

> "United States industry indeed shows systematic weaknesses that are hampering the ability of many firms to adapt to a changing international business environment. In particular, the commission observed six such weaknesses: outdated strategies; neglect of human resources; failures of co-operation; technological weaknesses in development and production; Government and industry working at cross-purposes; and short-time horizons."*

These conclusions largely reflect the difference in competitiveness between United States and Japanese firms. For a specific example, the Commission found that United States carmakers took five years from a conceptual design of a new model to the commercial introduction, while carmakers in Japan took only three and a half years.

In response to Japanese competition in automobiles, so-called voluntary export restraints have been applied since 1981. The level of restraint for 1990 is set at 2.3 million units. However, Japanese carmakers have circumvented the restraints by investing heavily in the United States. Thus, while the market share of Japanese car imports remained at around 20 per cent of total United States retail sales, the share of Japanese imports plus makes built by Japanese affiliates jumped from 19.6 per cent in 1984 to 30.7 per cent in 1989 (see table II.4). In 1989, the Japanese affiliates built a little over 1 million cars, while planned annual capacity was over 2 million units. There is much concern among United States carmakers about this addition to production capacity.

Fierce competition is expected in the coming years. This prospect is forcing United States carmakers to improve efficiency and quality by Japanese methods. In many United States firms, a comprehensive production and management system is being reformulated, including "continual training, participation in shop-floor decision-making, team-based production, and group bonus or profit-sharing plans" ([1], p. 34). In this process, quite often United States-Japan joint ventures have provided a convenient tool for mutual learning.

A similar phenomenon—the sequence of voluntary export restraints leading to joint ventures and technological co-operation—can also be observed in other industrial branches such as steel, numerical-control machines and semiconductors. It appears rather ironical that the combination of protectionist measures and a liberal foreign direct investment policy is helping United States industry to regain a competitive edge through induced competition and co-operation.** In the long run, such a gain in industrial competitiveness could help reduce the United States trade deficit, especially if the Japanese affiliates begin to re-export to Japan from the United States, as Honda has begun to do already.

The present review has so far focused on how foreign direct investment is helping to restructure United States industry toward greater capacity utilization and efficiency. But it seems also true that direct investment abroad by United States firms is soaring, thus making themselves more competitive.

*Suzanne Berger and others, "Toward a new industrial America", *Scientific American*, vol. 260, No. 6 (June 1989), p. 22. This article summarizes the book by the same authors, *Made in America: Regaining the Productive Edge* (Cambridge, Massachusetts Institute of Technology Press, 1989).

**This can be regarded as *de facto* industrial policy, though officially its existence may be denied.

Table II.3. Foreign direct investment position in the United States by source and type of investment, 1988
(Millions of dollars)

Investment source	All industries	Mining	Petroleum	Total	Food and kindred products	Chemicals and allied products	Primary and fabricated metals	Machinery	Other manu-facturing	Wholesale trade	Retail trade	Banking	Finance, except banking	Insurance	Real estate	Other industries
All countries	328 850	6 390	34 704	121 434	16 437	34 146	12 541	19 281	39 030	50 160	14 770	17 453	2 124	20 252	31 929	29 635
Canada	27 361	900	1 614	9 391	531	623	3 414	2 346	2 477	2 584	965	1 458	600	2 993	4 169	2 724
Europe	216 418	1 843	31 556	91 932	14 316	31 832	5 324	13 874	25 985	24 825	11 884	9 099	12 417	15 812	10 532	16 537
EEC	193 912	1 751	31 169	79 525	12 424	28 173	10 347	4 318	24 264	21 040	11 858	8 894	3 745	13 535	10 016	14 469
Belgium	4 024	..a/	..a/	989	..a/	594	..a/	-67	258	523	172	34	56	b/	12	-5
France	11 364	..a/	..a/	9 908	455	4 549	592	3 459	505	15	687	-764	139	139	95	604
Germany, Federal Republic of	23 845	319	172	13 268	633	7 537	457	2 483	2 159	5 677	1 174	293	-626	1 776	1 079	715
Italy	664	..a/	..a/	107	..a/	-15	..a/	-59	155	520	-5	446	..a/	..a/	..a/	104
Luxembourg	525	5	..a/	346	..a/	-	..a/	14	68	92	..a/	12	15	-	18	41
Netherlands	48 991	311	..a/	17 153	5 852	4 964	921	1 972	3 443	3 270	1 883	2 729	3 190	4 685	3 348	..a/
United Kingdom	101 909	563	18 779	37 021	5 204	10 534	1 688	5 378	14 224	10 049	8 598	3 669	878	6 863	5 323	18 174
Other EEC	2 587	-	..a/	733	..a/	18	..a/	52	504	404	..a/	935	..a/	..a/	..a/	..a/
Other Europe	22 505	92	367	12 407	2 493	3 659	1 806	3 528	1 721	3 785	26	295	671	2 277	517	2 068
Japan	53 354	..a/	-79	12 222	302	1 137	2 323	2 542	5 917	18 390	346	3 895	2 863	..a/	10 017	5 374
Australia, New Zealand and South Africa	5 624	..a/	287	2 279	208	-103	803	18	1 361	330	88	11	-838	..a/	416	276
Latin America and other Western Hemisphere	17 019	723	898	4 221	68	539	276	404	2 940	2 589	1 344	1 942	-3 108	1 158	5 217	2 043
Middle East	5 831	..a/	..a/	281	1	2	..a/	..a/	-18	907	3	657	216	-	923	..a/
Other Africa, Asia and Pacific	3 243	..a/	..a/	1 109	418	114	..a/	..a/	359	570	139	390	-26	8	655	..a/
OPEC c/	6 221	..a/	745	571	..a/	-18	..a/	-16	-1	..a/	3	363	26	-	879	..a/

Source: United States Department of Commerce, Survey of Current Business (Washington, D.C., August 1989), p.52.
a/ Suppressed to avoid disclosure of data of individual companies.
b/ Less than $500,000.
c/ The OPEC member countries are Algeria, Ecuador, Gabon, Indonesia, Islamic Republic of Iran, Iraq, Kuwait, Libyan Arab Jamahiriya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates and Venezuela.

Table II.4. United States retail car sales, 1983-1989
(Units)

Item	1983	1984	1985	1986	1987	1988	1989
Domestic makes built by the big three a/	6 659 855	7 744 078	7 905 641	7 675 109	6 402 422	6 735 422	6 042 452
Domestic makes built by Japanese Affiliates	50 402	133 601	221 364	465 637	617 776	766 065	1 030 364
Total Japanese imports	1 915 621	1 906 208	2 217 860	2 372 489	2 162 280	2 088 013	2 000 844
Total imports	2 385 734	2 441 713	2 841 063	3 239 043	3 144 048	3 065 073	2 794 598
Total domestic makes	6 795 302	7 951 517	8 204 721	8 214 662	7 081 262	7 526 034	7 072 816
Total market	9 181 036	10 393 230	11 041 784	11 453 705	10 225 310	10 591 107	9 867 414
Market share of Japanese imports (percentage)	20.9	18.3	20.1	20.7	21.2	19.7	20.3
Market share of Japanese imports and domestic makes built by Japanese affiliates	21.4	19.6	22.1	24.8	27.2	26.9	30.7

Source: Automotive News, as quoted in JEI Report, No.3B (Washington, D.C., Japan Economic Institute, 19 January 1990), p.12.
a/ Honda, Nissan and Toyota.

The United States stock of direct investment abroad jumped from $211.5 billion in 1984 to $326.9 billion in 1988, an increase of 56 per cent in four years (see table II.5). However, over three quarters went to developed countries—47 per cent to Europe and 19.3 per cent to Canada in 1988. During the same period, United States direct investment stock in Japan grew fastest—by 114 per cent, despite allegations by United States firms of difficulties in penetrating the Japanese domestic market. The rapidly growing market and opportunities to learn Japanese technology in some specific industries appear to be the major attraction.

Among developing regions, Latin America received the largest increase of United States direct investment stock—$49.3 billion in 1988, doubling the $24.6 billion recorded in 1984. Such investment, large shares of which went to Bermuda, Brazil, Mexico and Panama, will certainly help lighten the debt burden, and more is needed. In contrast, Africa, with only a modest investment increase, appears to have been not so fortunate as Latin America.

The outlook is for a continued increase in United States direct investment abroad following the opening of new markets in areas such as the EEC and Eastern Europe. The United States Commerce Department

Table II.5. United States direct investment abroad by region, 1984-1988
(Billions of dollars)

Region, country or economic grouping	1984	1988	1988/1984[a]
All countries	211.5	326.9	1.55
Developed countries	157.1	245.5	1.56
Canada	46.7	61.2	1.31
Europe	91.6	152.2	1.66
Japan	7.9	16.9	2.14
Other	10.9	15.2	1.39
Developing countries	49.2	76.8	1.56
Latin America	24.6	49.3	2.00
Africa	4.5	4.6	1.02
Middle East	5.0	4.1	0.82
Asia and Pacific	15.0	18.9	1.26

Source: United States Department of Commerce, Survey of Current Business (Washington, D.C., August 1989), pp.85-86.
a. 1988 figures divided by 1984 figures.

projects that United States firms overseas will increase plant and equipment spending by 13 per cent in 1990, after a 14 per cent increase in 1989 and a 24 per cent increase in 1988. The United States appears to be leading in foreign direct investment activities in Western Europe. For instance, in 1989 United States companies spent $16 billion for acquisitions, followed by France with $11.5 billion and Japan with $1.6 billion (mostly for joint ventures and building their own plants, and not much for acquisitions).

United States direct investment stock reached a new high of $324 billion in 1988. That amount surpassed $184 billion for the United Kingdom, $114 billion for Japan, $78 billion for the Federal Republic of Germany and $57 billion for France in the same year. These five countries own three quarters of all foreign direct investment stock in the world, although they account for only 42 per cent of world trade. Their total foreign direct investment stock is expected to climb to $1,706 billion by 1995, growing much faster than world trade total, owing mainly to the global movement for integration, which encompasses both Eastern and Western Europe.

Much foreign direct investment can be considered as an effective substitute for trade. The traditional measure of trade imbalances should therefore perhaps be redefined and reinterpreted. In the case of the United States, for instance, "foreign sales" including sales of United States subsidiaries abroad were estimated at $1,145 billion and "foreign purchases" at $1,088 billion in 1986. This calculation implies a United States foreign sales surplus of $57 billion, in contrast to the $144 billion deficit in merchandise trade. A significant part of the trade imbalance is now recognized as a result of United States subsidiaries abroad importing high-technology products (for instance, semiconductors) and labour-intensive goods into the United States. These globalized offshore production units tend to give cost advantages for United States firms to compete in the world market.

This short review of foreign direct investment flows into and out of the United States suggests that United States industry is being challenged by ever-increasing competition from abroad. Conversely, United States industry is making similar challenges abroad. The beneficial effects can be expected in the form of greater efficiency through market competition and through co-operation combining complementary factors at the firm level as well as between countries. It is no accident that output per work hour in the United States manufacturing has jumped by 41 per cent since 1982, compared with only 7.6 per cent in United States non-manufacturing sectors where foreign competition is less severe. Furthermore, prices of manufactured goods are reported to be more stable than service prices, which are rising faster in the United States economy.

To sum up, the competitive pressures coming from foreign trade and investment are prompting United States industry to reorganize for greater competitiveness. The Japanese challenge in this regard stands out. Although United States industry must bear the cost of restructuring, the long-term efficiency enhancement should be welcome. As reflected in table II.6 showing

Table II.6. United States patent grants, by nationality of inventor, 1970-1986

Year	All United States patent grants	Nationality of inventors: United States	All other countries	Japan	Germany, Federal Republic of	United Kingdom	France	Other countries
1970	64 429	47 077	17 352	2 625	4 435	2 954	1 731	5 607
1971	78 317	55 984	22 333	4 029	5 522	3 464	2 214	7 104
1972	74 551	51 349	23 202	5 129	5 709	3 249	2 219	6 996
1973	74 143	51 500	22 643	4 939	5 587	2 856	2 144	7 118
1974	76 278	50 641	25 634	5 892	6 153	3 146	2 569	7 877
1975	72 000	46 715	25 285	6 352	6 036	3 043	2 367	7 487
1976	70 226	44 280	25 946	6 543	6 180	2 995	2 408	7 820
1977	65 269	41 485	23 784	6 217	5 537	2 654	2 108	7 268
1978	67 002	42 154	24 848	6 911	5 850	2 722	2 119	7 246
1979	48 854	30 079	18 775	5 251	4 527	1 910	1 604	5 483
1980	61 819	37 356	24 463	7 124	5 423	2 406	2 088	7 098
1981	65 771	39 223	26 548	8 388	6 252	2 475	2 181	7 252
1982	57 888	33 896	23 992	8 149	5 408	2 134	1 972	6 329
1983	56 860	32 871	23 989	8 793	5 423	1 931	1 895	5 947
1984	67 200	38 365	28 835	11 110	6 255	2 271	2 162	7 037
1985	71 661	39 554	32 107	12 746	6 665	2 495	2 400	7 801
1986	70 860	38 124	32 736	13 209	6 803	2 409	2 369	7 946

Sources: United States Department of Commerce, Patents and Trademark Office Special Report: A Profile of United States Patent Activity (1978), Indicators of Patent Output of United States Industry, 1963-1979 (June 1980), Indicators of Patent Output of United States Industry, 1963-1981 (June 1982), Patenting Trends in the United States, 1963-1985 (May 1986), Patenting Trends in the United States, 1963-1986 (June, 1987), and unpublished data.

the number of United States patents granted to various nationalities, the United States has technological resources far greater than those of Japan, even though the latter is catching up fast. Japan is forcing United States industries to activate and commercialize their technological resources in order to create new products, new processes and new applications faster than before.

United States industry, being more and more integrated with the global economy, is going through a period of transition from the status of an absolute industrial superpower to a partnership with Europe and Asia.

B. Japan

The year 1989 was marked by high investment-led growth, further strengthening of industrial competitiveness, a continued high level of trade surplus, though somewhat reduced, particularly with the United States, and intensified trade disputes between Japan and the United States. Furthermore, policy-makers became increasingly concerned that not only did the high value of the yen fail to improve the trade imbalance, but it even began to fall against the dollar in the early months of 1990, despite Japan's ever-increasing foreign assets. The conventional wisdom or theory seems to be losing validity in the face of such a perverse phenomenon, and new efforts to find a solution through policy co-operation between trading partners seems to be creating frictions in new areas. However, Japanese industry appears basically strong, thanks to the on-going restructuring toward an "information society" which has been providing a major thrust of growth, and which is expected to continue.

Barring an unlikely event such as a world-wide collapse of the financial system or the eruption of a trade war, another year of high industrial growth performance is foreseen, in the order of 6.5 to 7 per cent, along with a GDP growth of around 5 per cent (see figure II.2 for GDP and MVA growth in recent years, and also for the pattern of structural change in industry).

An investment boom once more led the economy in 1989, as in 1988. In spite of earlier predictions of falling investment after a presumed peak of 15.9 per cent achieved in 1988, plant and equipment expenditures surged by 17 per cent in real terms. This investment boom more than offset the negative growth contribution coming from the trade sector (see table II.7). In fact, investment in plant and equipment has been growing twice as fast as real GNP since 1984, regardless of changes in the yen value.

The soaring yen value since 1985 swayed many analysts to predict a plunge in the Japanese economy. But the economy bounced right back to the normal high-growth track after a 2.5 per cent dip in GNP growth in 1986. The independent force of investment, strong enough to pull up GNP growth in the face of declining net exports, demands an explanation.

A major factor behind the investment boom has been the need to transform the economy from an export-dependent economy to a domestic-demand-oriented one. The high yen value compelled import-competing industries and exporters to act quickly. The soaring yen value, instead of depressing investment, seems to have forced enterprises to introduce automation, input cost-saving measures (involving labour, energy, etc.) and new information-processing systems. These investments enabled enterprises to meet the intensified competition domestically, and at the same time to counteract competitive disadvantages in markets abroad due to high yen value.*

Another factor to be added is the relative price decline favouring plant and equipment investment since 1981 (see table II.8). There may be various reasons for the changes in relative price, but undoubtedly the cheaper dollar since 1985 has contributed to lower yen prices of imported capital goods. It is noteworthy that one quarter of Japanese imports from the United States consists of capital goods.

The spurt of aggregate investment in recent years, however, hides the fact that Japanese industry has been increasing its reliance on high technology in production. Some indication can be gleaned from growth rates of high-technology capital goods by sub-branch. For instance, according to estimates given by the Japan Center for Economic Research, output of numerical-control machine tools increased by 27.5 per cent and 31.3 per cent in 1988 and 1989, respectively. To quote another example, robots output increased by 22.3 per cent and 22.8 per cent in 1988 and 1989, respectively.

Will the rising trend and shifts toward high-technology investment continue? There appears to be a consensus that investment will be the leading factor at least during the medium term. The equipment-investment ratio is forecast to climb to 29 per cent of GNP in 1994 from 21 per cent in 1988. The high-technology components of investment would include machining centres, robots, numerical-control-aided manufacturing, telefacsimile systems, videotext, etc. Table II.9 lists different types of high-technology goods demanded increasingly by various sectors and branches of the economy.

Many of these high-technology goods have been developed or improved in Japan, so that Japan already possesses a comparative advantage in them. Japan has been especially strong in fusing machines and equipment with electronic gadgets—the so-called Mechatronics technology. Further improvements in such technologies can easily be expected during the 1990s, judging from the past record* and the current zeal in commercialization of science and technology as reflected in R + D expenditures by private enterprises (see table II.10).

The success of Japan in technological progress appears, however, to be creating problems in trade.

If the industrial competitiveness of Japan has basically been harnessed by speedy technological change, the prospects of improving the United States trade deficit with Japan appear rather dim. There is no sign yet that the speed of technological "catch-up" in Japan will slow down. The United States share of manufactured goods imported by Japan has declined from 36 per cent in 1985 to 26 per cent in 1988. This could be interpreted as a sign that United States manufacturers are losing competitiveness *vis-à-vis* other suppliers to Japan. The decline provides a contrast to the overall increase of manufactured goods as a proportion of total Japanese imports during the

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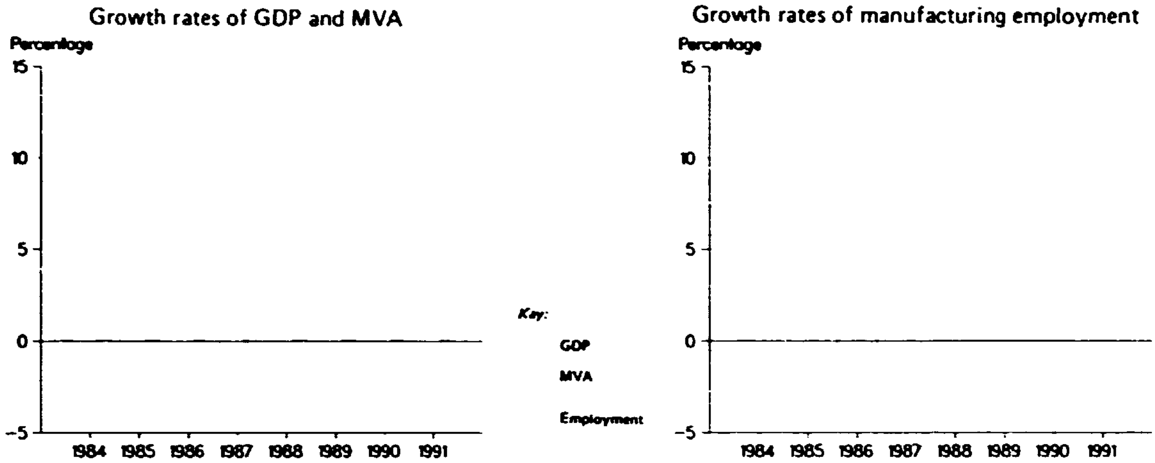
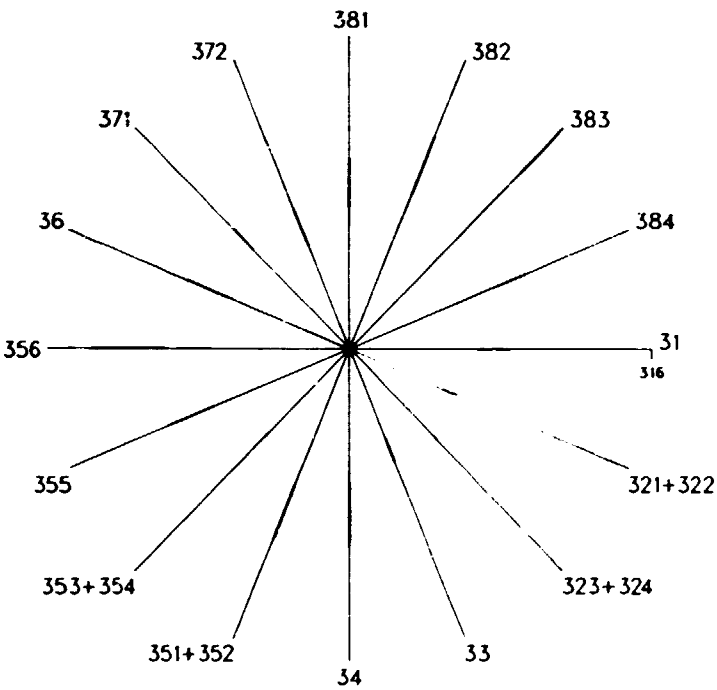
*It has been reported that about 30 per cent of 1989 investment in plant and equipment was for capacity expansion. By implication the rest (70 per cent) was designed either to replace old capacity or to achieve greater efficiency, for example through cost-cutting. See "Investments in plant and equipment increased by 17 per cent, Economic Planning Agency survey reports", *Nihon Keizai Shumbun (Japan Economic Journal)*, 8 November 1989.

*The past record of progress in Japan's technological capability can be gauged by a telling indicator—United States patent grants. In 1970, Japanese inventors acquired 2,625 United States patents, behind the Federal Republic of Germany (4,435) and the United Kingdom (2,954). In 1986, the figure for Japan jumped to 13,209, ahead of the Federal Republic of Germany (6,803) and the United Kingdom (2,409). But still, the number of United States patents acquired in 1986 by Japanese inventors was only 35 per cent of those acquired by United States inventors (See table II.6.)

Figure II.2. Growth rates of GDP, MVA and manufacturing employment, 1984-1991, and industrial structural change, 1975-1991: Japan



Industrial structural change
(Index of value added: 1975 = 100)



g =	4.42
θ =	13.25

Key:

ISIC code	(industries):
31	(Food products)
321, 322	(Textiles)
323, 324	(Leather)
33	(Wood and furniture)
34	(Paper and printing)
351, 352	(Chemicals)
353, 354	(Petroleum and coal)
355	(Rubber products)
356	(Plastic products)
36	(Non-metal mineral products)
371	(Iron and steel)
372	(Non-ferrous metals)
381	(Metal products)
382	(Non-electrical machinery)
383	(Electrical machinery)
384	(Transport equipment)

Constant prices of 1980

g = Average annual growth rate, 1975–1991 (percentage)

θ = Index of structural change, 1975–1991

1985–1991 forecast
1980–1985
1975–1980

Sources: UNIDO data base; estimates and forecasts by UNIDO/PPD/IPP/GLO.

Table II.7. Private plant and equipment spending and GNP in Japan, 1984-1989

Year	Real GNP growth (percentage)	Real plant and equipment growth (percentage)	Contribution to GNP growth: Real plant and equipment (percentage points)	Contribution to GNP growth: Net exports (percentage points)
1984	5.1	11.5	1.8	1.3
1985	4.9	12.7	2.1	0.8
1986	2.5	5.8	1.0	-1.4
1987	4.5	8.0	1.5	-0.9
1988	5.7	15.9	3.1	-1.5
1989	4.6	17.0	..	-0.7

Source: Economic Planning Agency of Japan.

Table II.8. Real versus nominal plant and equipment spending in Japan, 1979-1988

Year	Nominal plant and equipment spending as a percentage of GNP	Real plant and equipment spending as a percentage of GNP a/	Change in relative price of plant and equipment b/ (percentage)
1979	14.8	15.2	2.2
1980	15.7	15.7	2.1
1981	15.5	15.9	-2.8
1982	15.1	15.8	-1.8
1983	14.8	15.8	-1.8
1984	15.4	18.0	-1.8
1985	16.2	18.0	-1.8
1986	16.1	18.5	-4.2
1987	16.2	19.2	-2.5
1988 c/	17.4	21.0	-2.1

Source: Economic Planning Agency of Japan.
a/ 1980 prices for plant and investment and GNP.
b/ Plant and equipment deflator minus GNP deflator.
c/ Preliminary estimates.

same period—from 28.1 per cent to 45.7 per cent (see table II.11). As of 1989, the United States-Japan trade imbalance still stood at around $50 billion.

The United States responded to this state of affairs by enacting in 1988 the Omnibus Trade and Competitiveness Act. In effect, this legislation has revised and augmented the authority of the Government to retaliate against foreign trade practices judged as unfair. A novelty in the law known as Super 301 enables the United States trade representative to name priority countries which have persistent trade surpluses against the United States and to request them to remove barriers against imports from the United States.

In May 1989, Japan was listed along with India and Brazil as priority countries. Japan was asked to increase market access for United States-produced wood products, supercomputers and satellites. If no satisfactory solutions could be arrived at, the United States could retaliate. However, it seems difficult to evaluate the extent to which this policy tool could contribute to reducing the bilateral United States-Japan trade imbalance.*

*"... In the congressional debate on the trade bill, it was recognized that the bulk, probably 80 per cent of the United States trade deficit, had been caused by United States budget deficits and macro-economic policies". See Dick K. Nanto, "Japan's response to the 1988 Omnibus Trade Bill", *CRS Report for Congress*, No. 89-133 E, 14 February 1989, p. 4.

Table II.9. High-technology products likely to increase in demand, by various sectors and branches of the economy

Sector or branch	Product
Household	Refrigerators, washing machines, television sets, videotape recorders, musical instruments, calculators, electronic handbooks, family computers, word processors and personal computers
Manufacturing	Fabricating process equipment, assembling and painting machines, numerical control machines, machining centres, robots, measuring equipment for inspection and repairs, and monitoring and scanning equipment for control and adjustment
Transport	Unmanned distribution vehicles, automatic warehousing, automatic ticketing and home delivery service
Office	Copying machinery, word processors and personal computers
Communications	Telefacsimile systems, videotext, cable television, televized telephones, automotive telephone, communication satellites and integrated systems digital networks
Information	Data-base services and meteorological information services
Money and banking	Electronic banking; compact disks, home trade and cash management systems
Wholesale and retail	Rationalization of cash registers, inventory management, best-seller-record tracking and credit cards
Security	Building surveillance and guard protection systems
Construction	Unmanned construction equipment
Medical service	Medical electronic equipment
Agriculture, fisheries	House cultivation and culture management systems

Source: Hisao Kanamori, "Prospect towards a ten trillion dollar economy in the 1990s", Shukan Toyo Keizai (Asian Economic Weekly), 18 November 1989, p.69.

Table II.10. Japan's top 10 companies in R + D, 1988

Company	R + D (billions of yen)	Capital expenditure (billions of yen)	R + D as percentage of capital expenditure
Toyota	275	225	120
Matsushita Electrical	271	66	410
Hitachi	262	103	255
NEC	250	172	150
Toshiba	190	109	175
Fujitsu	184	119	155
Nissan	155	74	210
Sony	128	134	95
Mitsubishi Electric	122	59	205
Canon	75	45	165

Source: Japan Company Handbook (Tokyo), as quoted in "A survey of Japanese technology", The Economist, 2 December 1989.

Meanwhile, on the Japanese side, the Ministry of International Trade and Industry (MITI) is reportedly working on a programme of "import targeting". The Ministry has invited the 50 largest exporters of automobile, electric and electronic machines and equipment and non-electric machines to prepare enterprise-level plans for medium-term import expansion and export restraints. The aim is to double, by 1993, the imports of products and parts from the level achieved in 1988.

Table II.11. Japan's imports of manufactured products, 1985-1989[a]
(Millions of dollars, c.i.f. value)

Type of product	1985	1986	1987	1988	First eight months of 1989
Chemicals	8 072	9 733	11 845	14 830	11 008
Manufactured goods classified by material	10 886	12 390	18 055	27 340	20 229
Machinery and transport equipment	11 106	13 283	17 264	24 727	19 194
Miscellaneous manufactures	6 349	8 634	13 396	18 702	15 058
Manufactured imports	36 413	44 040	60 560	85 599	65 489
Total imports	129 539	126 408	149 515	187 354	138 314
Percentage of manufactures in total imports	28.1	34.8	40.5	45.7	47.3

Source: Japan Tariff Association.

a/ Standard Industrial Trade Classification code 5-8.

Another policy proposal by MITI, now under debate, concerns an "import subsidy scheme". The purpose is to encourage imports by allowing a certain proportion of incremental imports to be deducted from corporate income tax. Such an allowance would be given only for selected import items (those most likely to be imported from the United States, consisting mainly of capital goods and intermediate goods). If, for example, a small- or medium-size enterprise increases its imports over and above the level of 1989, 10 per cent of that increment can be allowed for deduction. For large enterprises, 5 per cent, and for general trading companies, only 3 per cent is allowable for deduction but in all cases with a limit of up to 20 per cent of the corporate income tax of the enterprises.

It should be noted that import-targeting and import subsidies schemes represent a mirror image of erstwhile export-targeting and export subsidies. Japanese success in export promotion may be reversed by import promotion, though the result remains to be seen.

Meanwhile, the recent debate on trade imbalances between Japan and the United States has continued with a focus on the so-called structural impediments. The United States argues that Japanese markets are impenetrable for the following reasons:

(a) the pricing mechanism fails to pass on the real cost reduction to consumers immediately;

(b) the multilayered distribution system hampers the workings of a competitive market mechanism;

(c) the Japanese save too much and invest too little in social overhead capital;

(d) urban land prices are too high because agricultural land is irrationally protected;

(e) the *keiretsu* system governing the relationship between big and small businesses wards off competition from outsiders;

(f) exclusionary business practices under visible and invisible cartel arrangements, particularly against foreigners, make it difficult for new market entrants.

Japan claims that the United States economy suffers from low industrial competitiveness because of the following:

(a) A low rate of savings, particularly by households, and negative savings by the Government;

(b) Low growth of productivity and inadequate corporate investment;

(c) Short-term corporate time horizons or a quick-return mentality;

(d) Too harsh government restrictions on business co-operation (that is, anti-trust law enforcement);

(e) Too low spending on research and development;

(f) Too little concern for export by both business and Government;

(g) Inadequate training and education of workers.

But it seems clear that the debate has proceeded so far as to question the basic framework of business organization deeply rooted in cultures and values.* Two kinds of systems, namely the distribution network and the *keiretsu*, can well illustrate the depth of the problem. The distribution system refers to the marketing chains with several layers of wholesale and retail units which operate before the product reaches the consumers. The *keiretsu* system refers to the relationship between the assemblers and suppliers of inputs, such as automobile assemblers and part suppliers. In both systems, it is now well known that buyers and sellers establish a long-term relationship which tends to limit the entrance of new competitors. It has been asserted, however, that the relationship ensures stable long-term supplies, guaranteed quality and timely delivery on the basis of mutual trust.

Furthermore, the maze of wholesale-retail suppliers has been accused of failing to pass on lowered import prices to consumers. This seems to be mainly due to the lack of price competition. Indeed, it is not uncommon to find producers' ownership of wholesale and retail stock, exclusive sales contracts, discriminatory rebates and even price-fixing cartels. In Japan, such business behaviour is not necessarily regarded as a violation of the anti-monopoly law, while in the United States, and in the EEC to a lesser extent, it often constitutes a criminal case under the anti-trust laws.

Concerning the criticism coming from the United States and EEC, the Japanese say that the distribution and *keiretsu* systems, being a part of the history of Japan, cannot easily be reformed into a United States or a European system. During the post-Second-World-War period, the distribution system has developed as an appendage of production centres or *zaibatsu* groups, and often involved investment and marketing guidance by the latter. Thus, in Japan, reliance on price-cutting, solely and excessively as a means of competition, is looked down upon since it disturbs the existing order of business relationships and is therefore considered unethical.

*For an insightful discussion on the intra-firm (black box) organization in comparison with that of the United States, see Masahiko Aoki, "Toward an economic model of the Japanese firm", *Journal of Economic Literature*, March 1990, vol. 28, No. 1, pp. 1-27.

Clearly these complaints from each side contain at least some truth, but tackling the grievances would involve some fundamental values and the culture of each society, if not the question of sovereignty itself. The debate could thus end up only with some cosmetic exercises and nothing more. It is difficult to imagine how a society could be completely reshaped at short notice to make it fit some preconceived image. While this approach, adopted in the United States Structural Impediments Initiative, provides a useful method for exploring structural factors, little meaningful action could be expected to follow as an immediate result of the debate. Sooner or later, some new approach would be needed.

While the Governments of Japan and the United States have been debating, Japanese businesses have continued to invest abroad, especially in the United States, as a best hedge against future protectionism. Japanese foreign direct investment in the United States sky-rocketed from $3.4 billion in 1984 to $21.7 billion in 1988. As of the end of March 1989, the cumulative sum of Japanese foreign direct investment in the United States amounted to $71.9 billion. This sum compares with $32.2 billion in Asia, $31.6 billion in Latin America and $30.2 billion in Western Europe (see table II.12).

Table II.12. Japan's foreign direct investment by country, fiscal year 1984 - fiscal year 1989
(Millions of dollars)

Region, country or area	Fiscal year 1984	1985	1986	1987	1988	Cumulative up to a/ 31 March 1989
United States	3 360	5 395	10 165	14 704	21 701	71 860
Canada	184	100	276	653	626	3 231
North America	3 544	5 495	10 441	15 357	22 328	75 091
Indonesia	374	408	250	545	586	9 804
Hong Kong	412	131	502	1 072	1 662	6 167
Singapore	225	339	302	494	747	3 812
Republic of Korea	107	134	436	647	483	3 248
China	114	100	226	1 226	296	2 036
Thailand	119	48	124	250	359	1 992
Malaysia	142	79	158	163	387	1 834
Taiwan Province	65	114	291	367	372	1 791
Philippines	46	61	21	72	134	1 120
East and South-East Asia	1 628	1 435	2 327	4 868	5 569	32 227
Panama	1 671	1 533	2 401	2 305	1 712	12 858
Brazil	318	314	270	229	510	5 596
Cayman Islands	1	132	930	1 197	2 609	5 085
Bahama	97	298	792	734	737	2 718
Mexico	56	101	226	28	87	1 671
Bermuda	29	148	16	36	337	991
Netherlands Antilles	66	62	66	199	172	747
Peru	6	10	-	1	-	696
Latin America	2 290	2 616	4 737	4 816	6 428	31 617
United Kingdom	318	375	984	2 473	3 956	10 554
Netherlands	452	613	651	829	2 359	5 525
Luxembourg	315	300	1 092	1 764	657	4 729
Germany, Federal Republic of	245	172	210	403	409	2 364
France	117	67	152	330	463	1 764
Switzerland	229	60	91	224	454	1 432
Spain	140	91	86	283	161	1 045
Belgium	71	84	50	70	164	1 027
Europe	1 937	1 930	3 469	6 576	9 116	30 164
Australia	105	468	881	1 222	2 413	8 137
Oceania	157	525	992	1 413	2 669	9 315
Liberia	281	159	289	267	648	3 658
Africa	326	172	309	272	653	4 604
Kuwait	55	34	41	54	20	1 383
Iran (Islamic Republic of)	-	-	-	-	1	1 005
Western Asia	273	45	44	62	259	3 338
TOTAL	10 155	12 217	22 320	33 364	47 022	186 356

Source: Ministry of Finance of Japan.
a/ Since beginning of data collection for foreign direct investment.

The reasons for the surge of Japanese foreign direct investment abroad are clear, though varying from region to region. The problem of market access appears to be the dominant factor in the case of North America and Western Europe. Resource complementarity might be a more weighty reason in the case of Asia (abundant well-trained labour and natural resources) and Latin America (natural resources plus perhaps the proximity to United States markets).

When Japanese management skills, capital and technological prowess combine with cheaper local factors (be it labour, entrepreneur or natural resources) a formidable efficiency and competitiveness is created. Furthermore, a network of Japanese subsidiaries and joint ventures abroad seems to yield more strategic room for manoeuvring. One example of this is provided by the possibility that Japanese cars produced in the United States can be imported into Japan if the yen value rises high enough.

Conventionally, foreign direct investment has been mainly an activity of large enterprises. But recently even small- and medium-size enterprises have begun to go abroad. If the movement progresses far enough, a cross-country *keiretsu* system could also be formulated. In fact, a prototype of this system can be seen already in Asia.* This mode of *de facto* integration without formal agreement has been providing a powerful push for industrialization in East and South-East Asia.

In sum, Japanese industry seems well poised to compete, but also to co-operate in and contribute to world economic progress by sharing their financial and technological assets with others.**

*For example see section I on East and South-East Asia.

**In Shinji Fukukawa, *Japan's Choice in the 21st Century* (Tokyo, TBS Britannica Publishing Co., 1990) (in Japanese), it is suggested that Japan should contribute to the world economy and peace under the three headings of globalism, humanism and industrialism.

C. Western Europe*

Epoch-making events are taking place in Europe; namely, the unification of the Federal Republic of Germany and the German Democratic Republic, the process of transition to the single EEC market of 1992 and East-West détente. The confluence of these events has created ample opportunities for increased trade and investment, strong enough apparently to offset the slow-down phase of the business cycle in Western Europe in 1990. The demand pull is expected to maintain its force for at least several years. Policy-makers seem ready to face the challenge of managing the strong growth momentum and controlling inflationary pressure. Gone are the days of worrying about "Eurosclerosis" (see figure II.3 for GDP and MVA growth in recent years, and also for the pattern of structural change in industry).

It is further expected that virtually all branches of manufacturing will face strong demand. In a united Germany, pent-up demand for consumer goods (durables and non-durables) will come particularly from the area that constituted the German Democratic Republic. Reconstruction and retooling of inefficient firms will also push up demand for machines and equipment to satisfy its needs and those of other European CMEA countries and the USSR. In addition, the EEC 1992 project has already sparked the building of infrastructure such as roads, railways, bridges, tunnels, communication systems etc., causing a boom for construction materials.

The flux of change and massive inflow of investment resources into the region, however, cause some analysts concern regarding the question of whether resources are going to be shifted from developing countries to Eastern Europe now that ideological confrontation is no longer a factor in development co-operation. Notwithstanding such a concern in the short run, the long-run impact of economic reconstruction in the German Democratic Republic, within the framework of a united Germany, could bring positive effects to the economies of developing countries, as was the case with European recovery following the Second World War.

It appears that the process of unifying the German Democratic Republic and the Federal Republic of Germany is creating a new, robust force of industrial growth. The German Democratic Republic will provide markets for consumer goods, thanks to the tremendous past build-up of household savings and the one-to-one exchange rate for conversion of current income and pensions. The German Democratic Republic also provides a place for investment, currently estimated at $6 billion a year, by businesses from the Federal Republic of Germany.

Furthermore, restructuring industry for modernization with new machines and equipment and with new management and market competition is expected to improve productivity. According to one estimate, "productivity in East Germany could improve by up to 15 per cent a year, with some plants reaching Western levels in three years"[2].** A well-educated and well-trained work-force, but inexpensive compared with that of the Federal Republic of Germany, lures investment that will help raise productivity of both labour and capital in the German Democratic Republic.

Fortunately the German Democratic Republic has access to not only investment funds but a strong mechanical engineering industry which is expected to contribute greatly to the rebuilding process there and in other CMEA countries. In 1989, the sales of this industry grew by 13 per cent to 115 billion deutsche mark (DM), with sales to the USSR soaring by 32 per cent to DM 3 billion. "Sales to East Germany could triple in the next two or three years to an annual level of DM 5 billion-DM 6 billion"[3].

Technological supremacy places the Federal Republic of Germany at an advantage in helping reconstruction not only in the German Democratic Republic but also in other parts of Eastern Europe. The Federal Republic of Germany has been the major supplier of machines and equipment with up-to-date technologies needed to meet fierce competition expected in Europe with the establishment of the single EEC market 1992.

This foreseen need spearheaded the investment-led boom in Western Europe in the 1988-1989 period. But just as the boom was expected to subside in 1990 (or perhaps in 1991), two new "structural positives" arrived, namely the fall of the Berlin wall and the waves of market-oriented restructuring in Eastern European countries. Those countries will be purchasing much more machinery and equipment on credit from the Federal Republic of Germany, which the latter can easily finance thanks to its trade surpluses accumulated over the past few years. In other words, the investment-led boom may very well continue in the Federal Republic of Germany, the German Democratic Republic and Western Europe as well, at least for the next couple of years.

Additional impetus to the investment-led boom has come from foreign direct investment flowing into EEC countries. The prospect of a large and dynamic EEC market after 1992 obviously attracts foreign direct investment into the region. But fears of being left out owing to possible protectionism seems to have worked also to accelerate the inflow. Table II.13 shows the share of the EEC in foreign direct investment of eight industrial countries. The EEC share of United States foreign direct investment jumped from 15 per cent in the 1981-1983 period to 55 per cent in 1984-1987. This compares with the EEC share of Japanese foreign direct investment increasing from 10 per cent to 17 per cent for the corresponding periods.*

The trend of foreign direct investment in the EEC is expected to continue increasing, particularly in view of even greater market possibilities created by events in Eastern Europe and the USSR.** Such foreign direct investment is not only adding a demand force to

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*In the present *Global Report*, this and the following section D are closely related for obvious reasons.

**Productivity in the German Democratic Republic is about half that of the Federal Republic of Germany.

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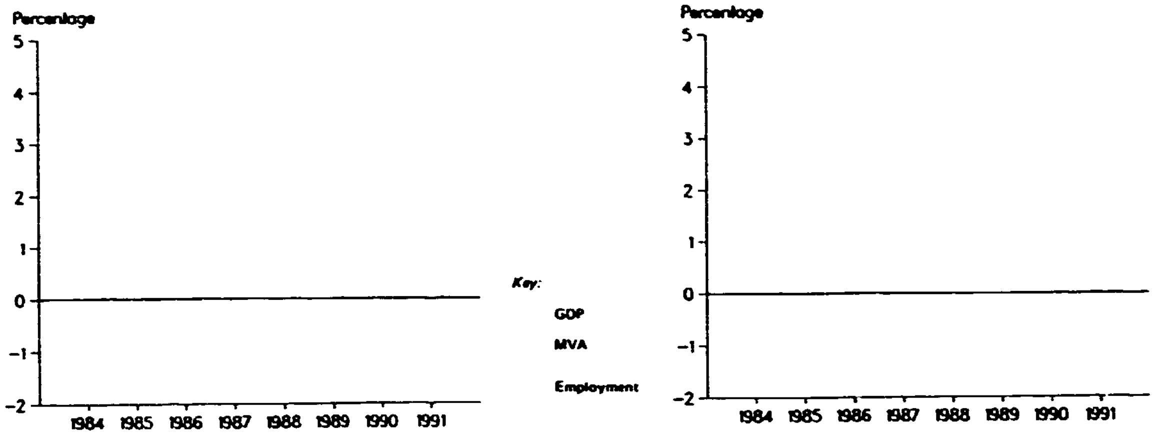
*In absolute figures, the cumulative foreign direct investment of the United States in Europe amounted to $152 billion compared with $30 billion for Japanese foreign direct investment in 1988. And yet it appears that the presence of Japan is more feared than that of the United States.

**The investment-led boom may be maintained at the expense of some developing countries, most likely the sub-Saharan region, whose share of United States direct investment abroad (cumulative) declined from 1.1 per cent in 1984 to 0.8 per cent in 1988.

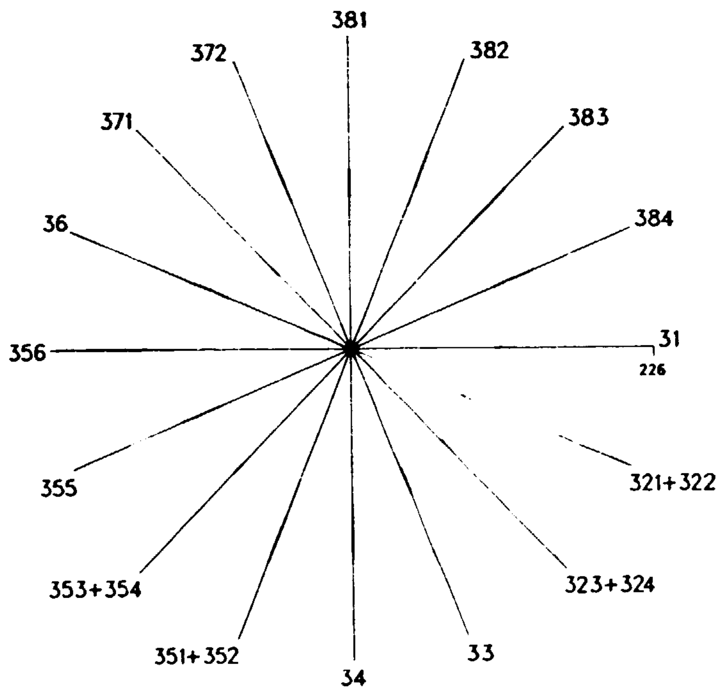
Figure II.3. Growth rates of GDP, MVA and manufacturing employment, 1984-1991, and industrial structural change, 1975-1991: Western Europe

Growth rates of GDP and MVA

Growth rates of manufacturing employment



Industrial structural change
(Index of value added: 1975 = 100)



g =	1.96
θ =	10.15

Key:

ISIC code	(industries):
31	(Food products)
321, 322	(Textiles)
323, 324	(Leather)
33	(Wood and furniture)
34	(Paper and printing)
351, 352	(Chemicals)
353, 354	(Petroleum and coal)
355	(Rubber products)
356	(Plastic products)
36	(Non-metal mineral products)
371	(Iron and steel)
372	(Non-ferrous metals)
381	(Metal products)
382	(Non-electrical machinery)
383	(Electrical machinery)
384	(Transport equipment)

Constant prices of 1980

g = Average annual growth rate, 1975–1991 (percentage)

θ = Index of structural change, 1975–1991

1985–1991 forecast

1980–1985

1975–1980

Sources: UNIDO data base, estimates and forecasts by UNIDO PPD IPP GLO

Table II.13. Annual foreign direct investment flows from 8 major countries and percentage shares to the EEC, 1981-1987

(Outflow in millions of dollars)

Country of origin and level of investment	1981	1982	1983	1984	1985	1986	1987	1981-1983 (average)	1984-1987 (average)
Denmark									
Total outflow	160	72	102	238	255	646	618	111	439
EEC share	49	21	31	31	51	41	57	37	47
France									
Total outflow	4 624	3 073	1 848	2 127	2 232	5 238	..	3 182	3 199
EEC share	21	39	30	35	19	34	..	28	31
Germany, Federal Republic of									
Total outflow	4 347	4 023	3 069	3 256	4 634	7 241	6 368	3 813	5 375
EEC share	24	34	25	37	37	37	27	28	35
Netherlands									
Total outflow	3 712	2 642	2 188	2 620	3 468	4 244	7 162	2 847	4 374
EEC share	55	49	58	66	46	69	41	54	53
United Kingdom									
Total outflow	9 472	3 715	5 249	7 923	11 545	17 077	..	6 145	12 151
EEC share	5	..	..	..	30	21		1	19
Five-country total	22 315	13 525	12 456	16 164	22 043	34 446	14 148	16 099	25 538
EEC share	21	28	20	21	33	33	35	22	30
Canada									
Total outflow	5 755	709	2 759	2 278	3 735	3 254	..	3 074	3 089
EEC share	33	98	15	25	14	13	..	32	16
Japan									
Total outflow	8 930	7 707	8 146	10 157	12 218	22 320	33 364	8 261	19 515
EEC share	8	10	12	17	15	15	19	10	17
United States									
Total outflow	12 704	6 286	3 509	4 798	13 823	22 494	41 897	7 500	20 753
EEC share	27	12	..	...	87	57	50	15	5
Three-country total	27 389	14 702	14 414	17 233	29 776	48 068	75 261	18 835	43 357
EEC share	22	15	4	12	48	34	36	16	35
Eight-country total	49 704	28 227	26 870	33 397	51 819	82 514	89 409	34 934	68 895
EEC share	21	21	11	16	42	34	36	19	33

Source: Centre on Transnational Corporations, The CTC Reporter, No.27 (Spring 1989), p.22.

aggregate expenditures, but also expanding the supply capacity and competitive environment in the region.

It is important to note that the greater part of United States foreign direct investment in the EEC went to chemicals and allied products and non-electrical machinery, areas where United States firms excel (see table II.14). In the case of Japanese foreign direct investment in Europe, a large share went to electric and electronic machines and also to transport equipment, areas where Japanese firms excel (see table II.14 for a breakdown of Japanese foreign direct investment).

However, the penetration of Japan appears more menacing than that of the the United States. Table II.15 shows that European firms possess relative disadvantages in consumer electronics, electronics parts and office machines, when compared with Japanese products in terms of quality, productivity and profitability. European firms in chemicals, pharmaceuticals and non-electrical machinery appear to enjoy competitiveness at a level equal to Japanese firms. Perhaps these differences in product-level competitiveness explain at least partly the worries of policy-makers regarding inflows of Japanese investment.

Initially, Japanese export penetration of EEC markets met with anti-dumping measures. Then Japanese producers tried to circumvent them by direct investment. But this effort met with "rules of local content", with Japanese firms being asked to procure a certain proportion of parts locally (80 per cent in the case of cars). In essence, these measures turned out to be an EEC industrial policy to maximize employment creation, value added and technology transfer into the region. Japanese investors appear to have accepted the tasks as demanded, considering their efforts in localization of R + D, product design and parts supply through various forms of joint ventures and technical co-operation. Mutual gains thus accrued; the Japanese secured access to the market and the Europeans received investment and technology from Japan in areas where Europe is at a disadvantage.

Meanwhile, European efforts to catch up with technology development in the United States and Japan have been stepped up. The EUREKA programmes contain 302 joint R + D projects developing semiconductor technologies, with some 1,600 companies participating and a budget plan of $10.3 billion. This includes the $4 billion, eight-year Joint European

Table II.14. Japan's cumulative foreign direct investment flows to Europe by industry, fiscal years 1951-1987

Industry	Number of cases	Amount (millions of dollars)
Manufacturing		
Foodstuffs	52	112
Textiles	163	245
Lumber and pulp	4	2
Chemicals	127	347
Iron, steel and non-ferrous metals	319	276
Machinery	198	365
Electrical and electronics equipment	191	704
Transport machinery	50	797
Others	189	462
Total	1 293	3 310
Non-manufacturing		
Agriculture and forestry	8	5
Fisheries	6	3
Mining	15	890
Construction	23	57
Commerce	2 071	3 374
Finance and insurance	497	10 508
Service industries	244	540
Transport	56	93
Real estate	38	268
Other	234	1 056
Total	3 192	16 794
Establishment and expansion of branch offices	196	905
Purchase of real estate	180	38
TOTAL	4 861	21 047

Source: Centre on Transnational Corporations, The CTC Reporter, No.27 (Spring 1989), p.66.

Submicron Silicon (JESSI) programme to develop new generations of semiconductors and machines to produce them. The ESPRIT programme involves over 400 projects on computers and information technology, with a spending plan of $5 billion by 1993. Under the BRITE programme $722 million are to be spent by 1992 to develop new technology for traditional industries, particularly aeronautics and advanced materials. The RACE programme includes a plan to spend $580 million by 1992 to develop technology for high-speed data telecommunications networks. Altogether, these programmes will be spending over $16 billion in five years, and they dwarf similar civilian research attempts in the United States.

However, the importance of the EUREKA programme stands out not only because of the large sum to be spent, but also because of its strategy to keep the market for EEC producers. This programme enables producers to define exclusively European specifications for high-technology markets such as high-definition television sets, digital mobile telephones, and office and home automation equipment. The aim is to pre-empt competition from the United States or the Japanese high-technology suppliers. This action can be regarded as a European response to the Japanese reluctance to share technology or sell the latest machines for chipmaking. It should be considered whether a new form of co-operation scheme could be devised to bring global efficiency, rather than compartmentalizing the high-technology markets into a pattern of trading blocs.

While competition in R + D and markets for future high-technology products rages, it is comforting to contemplate the great trade possibilities soon to be

Table II.15. Indicators of industrial trends and competitiveness of Western European industries compared with Japanese industries, 1989

Industry and indicator	Industrial trends: Domestic demand	Industrial trends: Output	Industrial trends: Exports and imports	Competitiveness: Technology and quality	Competitiveness: Productivity	Comparison with Japanese industries: Profitability	Comparison with Japanese industries: Overall assessment
Iron and steel	B	C	B	C	C	D	C
Chemicals and pharmaceuticals	B	B	A	A	A	A	A
Textile:							
Cloth	C	D	D	A	D	B	C
Weave	C	C	A	A	D	B	C
Automobile	B	B	C	C	D	C	C
Consumer electronics	C	D	D	C	D	D	D
Industrial computers	A	B	D	B	C	C	C
Communications	B	B	B	A	B	B	A
Electronic components	B	B	D	D	D	D	D
Office machines	C	D	D	C	D	D	D
Non-electrical machines	B	B	B	B	C	B	B
Construction machines	B	B	A	B	C	B	B

Indicator	(For domestic demand and output)	(For exports and imports)	(For other)
A	Big increase	Increase in surplus	Superior
B	Some increase	Some surplus	Equal
C	Little change	Balance	Somewhat inferior
D	Decrease	Deficit	Inferior

Source: Nihon Keizai Shimbun (Japan Economic Journal), 1 May 1989.

unleashed by relaxing the COCOM rules. Thanks to the passing of the cold war era, many prohibited high-technology products could be exported to Eastern European countries and the USSR, and Western European suppliers stand to gain mainly because of their proximity (geographical and political) to the new markets. These opportunities may provide chances for European suppliers to recover some of the share of the world high-technology market lost in competition with Japan and the [illegible] States.

To conclude, the [illegible]n faces an unprecedented opportunity to reshape the European industrial base, to make it competitive and to grow at a healthy pace. Policy-makers are confronted with historical tasks to beat swords into ploughshares—switching human and non-human resources to peaceful uses. Having experienced the success of the Marshall Plan after the end of the Second World War, Europeans seem confident about how to transform the end of cold war into a new period of prosperity. But some observers are concerned that, in that process, the EEC may turn inward or that the problems of sub-Saharan Africa and those of Latin America may be neglected.

D. Eastern Europe and the Union of Soviet Socialist Republics

A great experiment in reform is taking place in the region, namely the integration of hitherto closed economies into the world system. The reforms aim in part at bringing in new complementary resources such as advanced technology, investment and management skills needed to make stagnating enterprises viable and efficient. The reforms aim also at introducing decentralization and market competition for profit-making among enterprises. Adapting a market system to the local conditions appears to involve enormous social costs, including inflation, unemployment, loss of job security, widening income differences, initial declines in real income etc. There is no theory or experience to help the transition move smoothly. However, some countries, such as Czechoslovakia and the German Democratic Republic, seem better placed than others to cope with the problems. Approaches to introducing a market system range from a "big bang", as in Poland, to "incrementalism", as in Hungary. On the whole, the region is expected to experience zero or negative growth during the next couple of years. The reforms, if successful in the long run, will bring about net benefits to the global economy and all the regions in it.

One basic problem common to all countries in the region is the lack of infrastructure and "institutional tools" that enable a market system to function. Examples include a banking system, various financial instruments such as bonds, debentures and stocks, an accounting system, a labour market with reasonable labour mobility, a goods distribution system and commercial communications networks. These tools have to be developed and applied, and through the accumulation of experience, all participants in the system—accountants, bankers, factory managers—must become skilful in their use. Thus, human capital formation with an embodiment of these skills must proceed synchronously with the hardware or construction side of the tools and institutions. The systematic change from a centrally planned economy to a market-competition system may require at least a decade before reaching a reasonable, working level of perfection.

The lack of these tools and institutions makes the social costs of system transformation unduly high. Introduction of market competition presupposes the existence of a large number of competitors. The traditional bilateral, fixed buyer-seller relationship must be multilateralized, which means breaking up existing monopolies and monopsonies and introducing many new competing suppliers. To do so, entrepreneurs must be able to discern bankable business projects from non-bankable ones. But distorted prices make it impossible to judge future profitability. Furthermore, the ability of factory managers to make right decisions has not been adequately tested. In short, everything looks uncertain, and decisions have to be made in the dark (meaning very little information or almost total ignorance) as an act of faith.

Nevertheless, through trial and error, the reform process is going on. For instance, in Hungary where reform efforts have lasted two decades, the private sector now accounts for over 25 per cent of economic transactions. But the rest is still in the hands of the state, and the existing system of incentives reportedly is not working to eliminate inefficiency in the State sector.

> "Poorly performing enterprises received Government support in the form of reductions in taxes, easing of credit conditions, price increases, preferential wage arrangements, and straight subsidies, while good performance often led to additional charges . . . It has been suggested that, under present conditions, the removal of firm-specific support would result in the bankruptcy of 40-50 per cent of Hungarian firms. This has been said to be the case because of the lack of effective labour and capital markets in Hungary" ([4], p. 39).*

Although closing down inefficient firms would release resources for more efficient uses, political considerations (for example, unemployment) seem to be holding back the reform process. Whether to speed up privatization is being seriously debated.

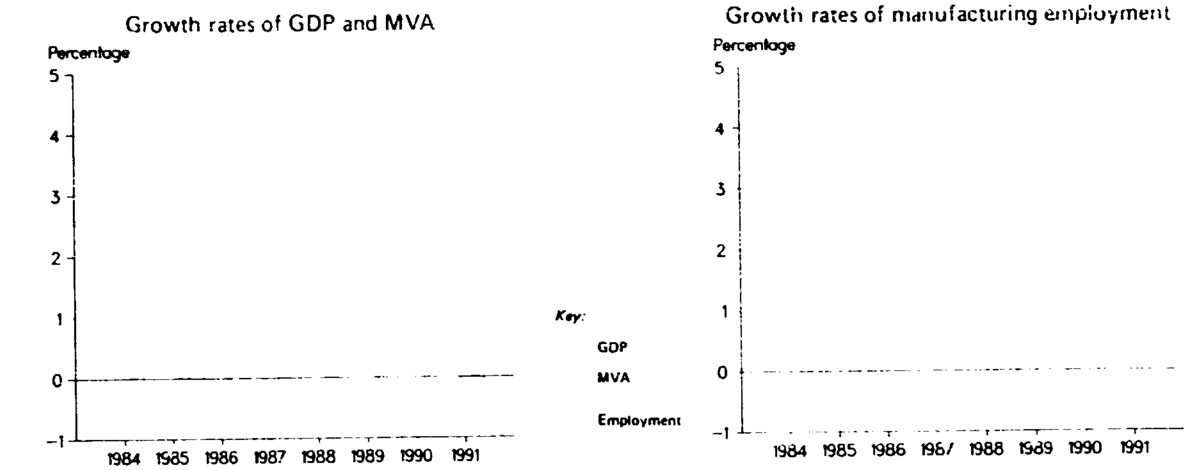
On the foreign direct investment front, Hungary passed a landmark law in 1989 allowing 100 per cent foreign ownership. This provision is expected to accelerate foreign direct investments, which numbered 178 cases as of April 1989, with total foreign capital of $263.2 million. Of the total, 108 cases went to the manufacturing sector.** For its distribution by industrial branch, see table II.16.

Several advantages appear to attract foreign direct investment to Hungary. On an average, wages are less than one third of those in Western Europe. Exports from Hungary receive preferential status in the EEC and the United States. A joint venture with 20 per cent

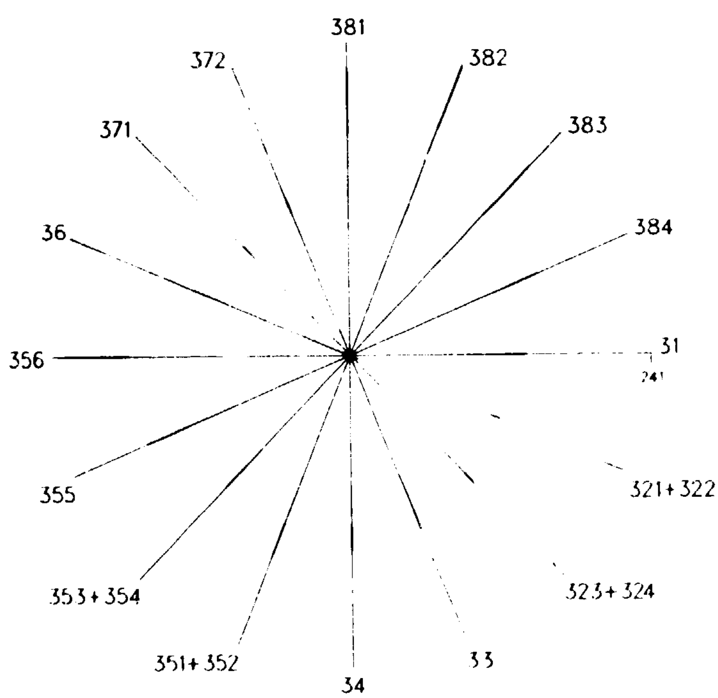
*Bela Balassa, "Next Steps in the Hungarian Economic Reform", in *Eastern European Economics*, Fall 1989, p. 39.

**The latest estimate gives a total of over 900 joint ventures contracted by the end of 1989. Contracts for more than 2,000 cases are expected to be signed in 1990. See Philip Revzin, "Hungarians test power of Western cash", *Asian Wall Street Journal*, 11 April 1990.

Figure II.4. Growth rates of GDP, MVA and manufacturing employment, 1984-1991, and industrial structural change, 1975-1991: Eastern Europe and the USSR



Industrial structural change
(Index of value added: 1975 = 100)



g =	3.27
θ =	14.93

Key:

ISIC code	(industries):
31	(Food products)
321, 322	(Textiles)
323, 324	(Leather)
33	(Wood and furniture)
34	(Paper and printing)
351, 352	(Chemicals)
353, 354	(Petroleum and coal)
355	(Rubber products)
356	(Plastic products)
36	(Non-metal mineral products)
371	(Iron and steel)
372	(Non-ferrous metals)
381	(Metal products)
382	(Non-electrical machinery)
383	(Electrical machinery)
384	(Transport equipment)

Constant prices of 1980

g = Average annual growth rate, 1975–1991 (percentage)

θ = Index of structural change, 1975–1991

1985–1991 forecast

1985

1980

Sources: UNIDO data base; estimates and forecasts by UNIDO/PPD/IPP/GLO.

Table II.16. Manufacturing joint ventures in Hungary, by branches of industry
(As of 1 April 1989)

Industry	Total capital (million forint)	Foreign capital (million forint)	Foreign capital (million dollars)	Number of joint ventures
Food	1 464.5	535.8	11.5	10
Textiles	932.0	464.1	9.2	4
Wearing apparel	552.6	217.1	4.5	7
Leather	51.6	19.7	0.3	2
Wood and wood products	800.1	383.1	7.8	7
Paper and paper products	119.5	60.8	1.2	3
Publishing and printing	153.8	84.2	1.6	6
Chemicals	946.2	362.4	8.0	12
Rubber and plastics	82.7	36.0	0.8	3
Non-metallic products	1 088.3	498.1	10.2	7
Basic metals	21.4	10.7	0.2	2
Metal products	348.6	165.6	3.3	8
Machinery and equipment n.e.c.	524.2	244.5	5.4	13
Office equipment and computers	1 006.5	325.7	6.5	3
Electrical equipment	128.9	52.9	1.1	4
Communications equipment	1 294.4	439.1	8.7	5
Precision instruments	500.7	250.1	5.3	3
Motor vehicles	44.0	25.5	0.5	1
Other transport equipment	158.4	80.8	1.6	1
Furniture	181.4	81.0	1.6	4
Recycling	219.2	96.1	1.9	3
TOTAL	10 619.1	4 433.2	92.2	108

Source: Economic Commission for Europe data base on joint ventures.

Table II.17. Manufacturing joint ventures in Poland, by branches of industry
(As of 1 June 1989)

Industry	Statutory capital: Total (million zlotys)	Statutory capital: Foreign (million zlotys)	Statutory capital: Foreign (million dollars)	Number of joint ventures
Food	2 693.9	1 345.9	2.7	23
Tobacco	61.1	30.5	0.0	1
Textiles	324.0	142.6	0.2	2
Wearing apparel	860.7	562.0	0.9	15
Wood and wood products	2 285.4	1 980.8	3.3	11
Paper and paper products	160.0	80.0	0.1	2
Publishing and printing	232.5	126.0	0.3	2
Chemicals, of which:	1 130.3	340.0	0.7	7
Basic chemicals	68.0	33.3	0.1	1
Other chemicals, of which:	1 062.3	306.6	0.6	6
Cosmetics	42.0	25.2	0.0	6
Other	1 020.3	281.4	0.6	1
Rubber and plastics	92.7	66.0	0.1	3
Non-metallic products	770.8	356.1	0.7	10
Metal products	4 465.1	1 217.3	2.5	12
Machinery and equipment n.e.c., of which:	3 375.2	1 341.0	2.3	11
General purpose machinery	1 855.2	697.0	1.3	3
Special purpose machinery of which:	1 520.0	644.1	1.1	8
Agriculture and forestry machinery	686.9	236.7	0.5	3
Food processing machines	100.0	44.0	0.1	1
Textile machinery	48.0	25.0	0.0	1
Other	685.0	338.5	0.5	3
Office equipment and computers	222.0	115.1	0.3	2
Communications equipment, of which:	293.6	89.7	0.2	3
Television, radio transmitters	96.4	36.6	0.1	1
Other	197.2	53.1	0.1	2
Precision instruments	206.1	118.0	0.2	2
Motor vehicles	200.0	80.0	0.2	1
Other transport equipment	3 503.7	772.7	1.1	3
Furniture and manufacturing n.e.c.	2 026.1	734.9	2.6	3
Recycling	2 252.5	949.3	2.3	6
TOTAL	25 155.7	10 358.0	20.6	119

Source: Economic Commission for Europe data base on joint ventures.

or more foreign ownership can enjoy an income tax exemption for as long as five years, and Hungary's geographical location between Austria (entrance to Western Europe) and the USSR (a potentially big market for Hungary) plays a very big role.

In contrast to the Hungarian approach of a slow but measured reform process, Poland has decided to plunge into a so-called big-bang approach. As of 1 January 1990, the Government of Poland cut State expenditures drastically and let prices soar. The consequences were, as expected, a 45 per cent inflation in January; wages increased only by 1.3 per cent; production fell and unsold stock piled up. Mass bankruptcy seems to be threatening. It is too early to judge whether the shock-therapy will bring about the desired results; namely, new prices settling soon into equilibrium, enterprises being selected to survive according to efficiency criteria, and growth being sufficiently robust to absorb displaced labour.

Despite the uncertainty facing the economy, foreign direct investment is expected to continue to increase. Since the liberalization of foreign direct investment in December 1988, the number of joint ventures climbed to 657, as of October 1989, one fifth of which went to manufacturing. See table II.17 for branch-level distribution.

It is interesting to note that a large number of joint ventures took place in light industries such as food processing, wearing apparel and wood products. Apparently the need to meet immediate shortages in consumer goods is great. One great attraction for foreign direct investments in Poland is the convertibility of the zloty—an important element of the reform package. Foreign investors seem also impressed by the patience shown by Poland and the support given to the shock-therapy approach despite the expected pain. Poland has also been able to negotiate on the rescheduling of its debt, under favourable terms, making industrial restructuring relatively easier.

If the approach followed by Poland is successful, the experience could provide an inspiration, if not a model, to other reforming countries. The basic reason for optimism can easily be attributed to the fact that the reform movement began from the grassroots level. The origin of the reform movement in the USSR gives a contrasting picture—it came from above.

Compared with Hungary and Poland, the history of *perestroika* in the USSR is quite short. It began actually in 1987, and the Government is still trying to work out an optimum mix of central planning and the market economy. Debate between conservatism and radicalism is expected to continue. The outcome could be a compromise taking some middle measures in such critical areas as freeing prices, defining property ownership, subsidizing state enterprises and giving independence to the banking system from State control. If policy-makers are forced to resort to the trial-and-error approach in these areas, uncertainties will multiply, and domestic and foreign investors are likely to lose confidence.

In spite of these uncertain factors, foreign direct investment flows into the USSR have accelerated. As of September 1989, total joint ventures climbed to 929 cases involving $1.6 billion. In 1987, only 23 cases were initiated, rising to 168 in 1988 and to 738 in 1989. See table II.18 for the origin of foreign partners in joint ventures. It is noteworthy that most of the joint ventures have come from EEC, EFTA and CMEA member countries. The United States and Japan have signed only 86 and 18 contracts respectively. The concept of the "European House" seems to have strong support from European-based foreign investors. Especially the smallness of the role played by Japan does not seem congruent with its financial and technological ability. Meanwhile, the large role of the Federal Republic of Germany* stands out conspicuously with 139 cases of joint ventures, and Finland with 101 cases.

Among other Eastern European countries, the German Democratic Republic and Czechoslovakia appear well poised to reap the benefits of opening up. Although the imminent integrating of the German Democratic Republic with the Federal Republic of Germany makes a special case, Czechoslovakia and the German Democratic Republic have been the most industrialized area in the region. There is high return potential for the infusion of foreign investment and technology. Furthermore, the two countries have the least burden of external debt. As of December 1989, there were 50 joint ventures in Czechoslovakia as compared with 35 in Bulgaria and one in Romania.

Though the rush of foreign direct investment into the region looks impressive, the value of the total investment is estimated to be approximately $2.2 billion (as of October 1989). The sum compares rather modestly with the foreign direct investment total of the United States—$49.2 billion in Latin America or $18.9 billion in Asia and Pacific (in 1988). The Eastern European region could make use of far more foreign direct investment than accumulated so far to expedite the process of industrial restructuring. The region stands to gain by introducing more attractive foreign direct investment regimes and improved infrastructure for the market mechanism to function better.

Fears have arisen as to whether the flow of investment resources into the region may not be in fact at the expense of developing countries. Existing studies have yielded little evidence to validate such worries [6]. On the contrary, long-term benefits to developing countries could be substantial if the building-up of new industrial capacities in this region along with Western European industrial vitality brought a spill-over effect.

*"Of all western countries, West Germany is the most active in Soviet joint ventures. But even small West German companies have had perhaps a 15-year history of Soviet trading before signing a joint venture agreement. West Germany recently got another advantage over the competition with the announcement that by 1992, two thirds of the technical standards in the Soviet Union will be based on the German industrial norms" ([5], P.22).

Table II.18. Joint ventures in the USSR, by origin of foreign partner
(As of 1 October 1989)

Region, country or area	Statutory capital: Total (million roubles)	Statutory capital: Foreign (million roubles)	Statutory capital: Foreign (million dollars)	Number of joint ventures
Western Europe	1 588.3	639.4	1 017.2	599
EEC	992.6	390.7	620.4	327
Belgium	2.1	1.2	1.9	7
Denmark	2.5	0.9	1.6	2
France	190.1	80.4	127.9	32
Germany, Federal Republic of	358.0	144.0	227.1	139
Greece	5.8	2.8	4.4	5
Ireland	16.8	8.1	13.3	3
Italy	227.7	77.2	124.9	53
Luxembourg	1.3	0.5	0.8	6
Netherlands	40.0	15.1	23.4	15
Spain	46.9	19.3	31.1	12
United Kingdom	101.4	41.2	64.0	53
EFTA	491.7	202.5	321.4	247
Austria	142.9	45.5	72.2	53
Finland	183.9	81.4	127.7	101
Norway	3.5	0.9	1.5	4
Sweden	78.4	37.5	59.6	4
Switzerland	67.0	29.4	47.9	45
Liechtenstein	15.9	7.8	12.4	12
Other	104.0	46.2	75.5	25
Cyprus	7.2	2.6	4.1	9
Malta	1.5	0.6	1.0	1
Yugoslavia	95.3	43.0	70.4	15
Japan	44.4	21.2	33.9	18
United States	250.2	121.7	190.6	86
Developing countries or areas	56.2	23.1	36.6	49
Afghanistan	2.2	1.1	1.7	1
Brazil	9.2	2.3	3.8	2
Hong Kong	0.6	0.3	0.5	1
India	13.7	5.4	8.6	14
Jordan	0.3	0.2	0.2	2
Kuwait	3.1	1.5	2.5	3
Lebanon	2.4	1.2	1.9	2
Pakistan	5.5	3.3	5.1	1
Panama	2.3	1.1	1.8	3
Republic of Korea	0.5	0.3	0.4	1
Saudi Arabia	0.2	0.1	0.1	1
Singapore	3.1	1.1	1.8	5
Syrian Arab Republic	6.7	2.6	4.2	3
Thailand	0.6	0.0	0.0	1
United Arab Emirates	3.0	1.5	2.3	2
Venezuela	2.7	1.1	1.8	7
Centrally planned economies	253.6	113.1	181.6	88
CMEA	199.1	87.9	141.6	68
Bulgaria	100.9	43.8	71.6	26
Czechoslovakia	4.0	1.8	2.9	3
German Democratic Republic	5.0	2.5	4.0	1
Hungary	50.0	21.9	34.9	12
Poland	36.1	16.5	26.0	23
Viet Nam	3.0	1.4	2.2	3
Other centrally planned economies	54.5	25.3	40.0	20
China	25.5	11.1	17.4	13
Democratic People's Republic of Korea	29.0	14.2	22.6	7
Other countries or joint ventures	262.8	101.1	161.2	89
Australia	19.1	9.5	15.1	9
Canada	56.2	24.6	39.8	20
New Zealand	1.5	0.6	0.9	2
Multi-party a/	186.0	66.4	105.4	58
TOTAL	2 454.4	1 019.3	1 620.8	929

Source: Economic Commission for Europe data base on joint ventures.
a/ Joint ventures with foreign partners from two or more countries.

E. Latin America and the Caribbean

Though the region is still fighting against the problems of high inflation, debt service and unemployment, the prospects for industrial growth have improved in general, albeit marginally. In 1989, GDP and MVA grew by 1.6 per cent and 1.8 per cent respectively (up from 1.1 per cent and −0.3 per cent in 1988) (see figure II.5 for GDP and MVA growth in recent years, and also for the pattern of structural change in industry). In 1990, they are expected to grow by 2.4 per cent and 2.3 per cent, respectively—slightly above the region's population growth rate of 2.1 per cent annually (see table II.19 for MVA growth rates for the 1960s, 1970s and 1980s by country).

Signs of improved growth prospects abound, including a significant pick-up in exports both intra-regionally and extraregionally, lower inflation in major countries (for example, Brazil, Chile and Mexico), some progress in debt-for-investment swaps, gradual removal of trade barriers, and vigorous "informal sectors" and private sectors offsetting difficulties experienced in some State-owned enterprises. On the whole, the region seems to be ready to leave behind the "lost decade" of the 1980s, in which per capita income declined by 8 per cent, to enter into a new decade of recovery and industrial revitalization.

An item for current concern is, however, low investment for both physical and human capital which does not bode well for future productive capacity and productivity ([7], pp. 31-40). In the short run, there is concern about Brazil's shock therapy (anti-inflation measures), which may possibly produce a severe recession, thereby bringing adverse repercussions for the fragile recovery in the region.

On the brighter side, regional exports of manufactured goods apppear to have been soaring according to available fragmentary evidence. In 1988, for example, Brazilian exports of industrial products jumped by 34 per cent to $24 billion. Notably, the leading items included semi-manufactures ($4.9 billion worth of exports in 1988, up 50 per cent from $3.2 billion in 1987), iron and steel ($2.2 billion worth of exports in 1988 from $500 million in 1987) and transport equipment ($3.4 billion in 1988 from $2.8 billion in 1987) (see table II.20). Apparently, the vigorous growth in Western Europe has been playing a part in pushing up Latin American exports. It has been reported that the Federal Republic of Germany alone imported $19.8 billion from the region in 1989, an increase of 15.1 per cent over the previous year ([8], p. 24). This portends what is to come as growth in Western Europe benefits from the EEC 1992 project coupled with economic reforms in Eastern Europe.

Internally, informal sectors and private sectors of the economies appear to be faring rather well in spite of high inflation and the vagaries of policy change. Equally encouraging news comes from the Caribbean Community (CARICOM), which achieved a 20 per cent growth in intraregional trade in 1989. This surpasses 14 per cent growth in 1988 and 8 per cent in 1987, when four years of decline was halted. It should be remembered that in 1987 CARICOM agreed to free trade in a list of products of regional origin including processed foods, chemical products and footwear. In the same year, the regional export bank was also reactivated after encountering some difficulties in achieving the capitalization target.

The uptrend of trade coincides with regional efforts to open up and integrate more with the world economy as a way of making industry more competitive. Instead of continuing to protect domestic industries and thus making them uncompetitive in the world market, the new policy is to expose them to import competition gradually. The aim is to force domestic producers to become more efficient. Thus, for instance, in recent years Mexico has relaxed restrictions on importing automobiles, computers and pharmaceutical products. At the same time, attractive measures to invite foreign direct investment have been introduced, thereby stimulating exports as well as domestic competition. The new measures allow 100 per cent foreign ownership* (compared with 49 per cent before), with no approval required for investments under $100 million, simplification of paperwork on investment requiring authorization by the National Foreign Investment Commission (the approval decision to be made within 45 working days) etc.

Similar movements towards greater trade-and-investment liberalization can be observed in other countries in the region—notably in Brazil, Chile, Ecuador, Venezuela and most of the Caribbean countries. But the challenges facing Brazil appear most formidable. Having failed with the Cruzado Plan of 1986 and the Summer Plan of 1989 to cut inflation and revive industry, the newly elected Government is resorting to drastic measures to freeze "savings", to stop various subsidies, to replace quantitative restrictions on imports by tariffs, to lift major restrictions on foreign investment and to step up privatization of State-owned enterprises. The immediate impact of the policy package is most likely to be a recession, as the package implies the withdrawal of 80 per cent of money supply.

However, those industries which can export will survive because for many of them exports provide the way to generate cash flow. For instance, the steel industry will try to export 70 to 80 per cent of the 22 million tonnes produced in 1990 (compared with 50 per cent of the 24 million tonnes produced in 1989).

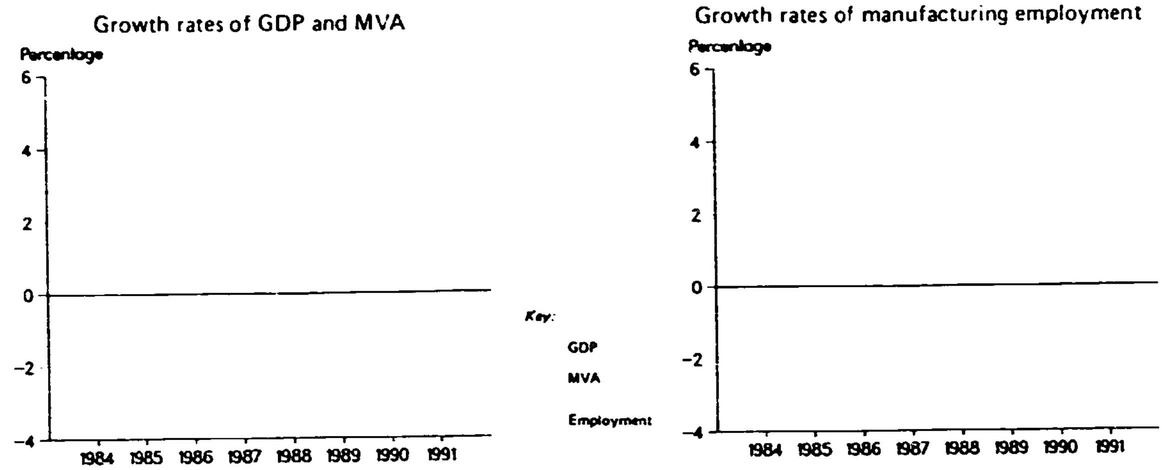
Similar survival strategies could apply to aluminium, paper and wood products. These are the resource-based industries where Brazil enjoys comparative advantage. In contrast, the consumer durables industry, sustained under heavy protection, may have to suffer the most.**

Indeed, the major countries of the region—Brazil, Mexico, Argentina and Chile—were subject to a "stop-go" pattern of stabilization (anti-inflation) policies throughout the 1980s. But interestingly, the industries in each country under stress have undergone the Brazilian pattern of structural change; that is, those industries with a strong domestic natural resource

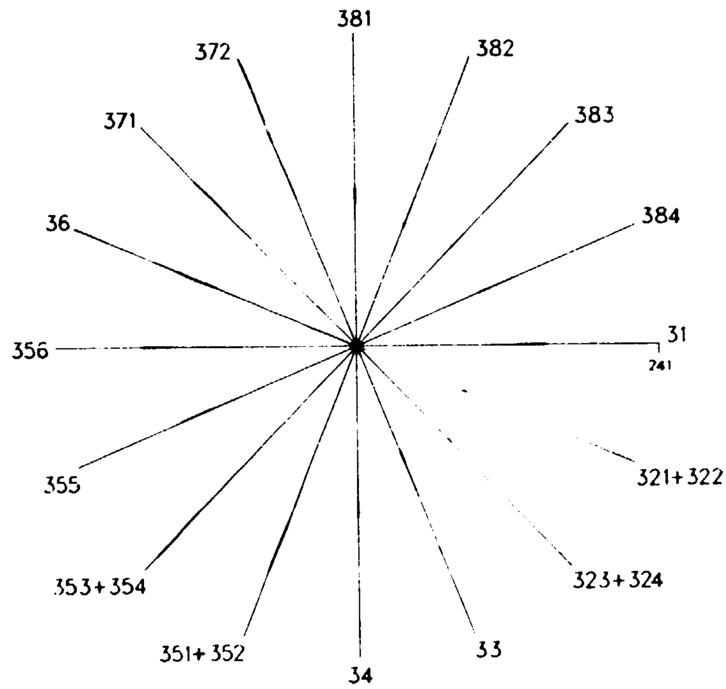
*Up to 100 per cent foreign ownership is allowed in nylons, polyesters, polyvinyl chloride, plastics, automobile parts, explosives, firearms and mining. Strategic sectors, such as petroleum, hydrocarbons and basic petrochemicals, and social overhead, such as electricity, railways, radio broadcasting and banking, are still preserved for Mexican nationals.

**As a result of this situation, a significant trade surplus is expected again in 1990. Export surplus was over $20 billion in 1988. These surpluses are needed to service the debt for many years to come.

Figure II.5. Growth rates of GDP, MVA and manufacturing employment, 1984-1991, and industrial structural change, 1975-1991: Latin America and the Caribbean



Industrial structural change
(Index of value added: 1975 = 100)



g =	2.27
θ =	13.24

Key:

ISIC code	(industries):
31	(Food products)
321, 322	(Textiles)
323, 324	(Leather)
33	(Wood and furniture)
34	(Paper and printing)
351, 352	(Chemicals)
353, 354	(Petroleum and coal)
355	(Rubber products)
356	(Plastic products)
36	(Non-metal mineral products)
371	(Iron and steel)
372	(Non-ferrous metals)
381	(Metal products)
382	(Non-electrical machinery)
383	(Electrical machinery)
384	(Transport equipment)

Constant prices of 1980

g = Average annual growth rate, 1975-1991 (percentage)

θ = Index of structural change, 1975-1991

1985 1991 forecast
1980- 1985
1975 1980

Sources: UNIDO data base; estimates and forecasts by UNIDO PPD IPP GLO

Table II.19. Latin America: manufacturing growth and share in GDP, by country, 1960-1988
(Percentage)

Country	Average share in GDP			Annual average growth rates		
	1960-1969	1970-1979	1980-1989	1961-1970	1971-1980	1981-1988
Argentina	23.0	24.1	20.7	5.2	1.6	-1.7
Bahamas	..	..	..	..	..	..
Barbados	8.3	9.6	10.4	6.5	6.2	-1.2
Bolivia	11.3	13.4	11.7	6.4	6.2	-4.8
Brazil	26.5	28.8	26.7	6.8	9.0	.6
Chile	24.2	23.8	20.6	5.3	1.1	1.8
Colombia	20.9	22.8	21.2	5.7	6.0	2.4
Costa Rica	16.2	20.8	21.9	8.8	7.4	2.2
Dominican Republic	14.9	18.6	17.5	7.4	6.8	1.4
Ecuador	12.6	16.1	18.0	5.0	12.8	0.8
El Salvador	17.0	18.7	17.4	8.1	3.0	-.6
Guatemala	14.4	15.9	15.9	7.6	6.2	-.7
Guyana	9.2	10.2	11.1	2.1	5.1	-5.4
Haiti	14.0	15.1	16.4	.5	8.4	-2.8
Honduras	10.6	13.3	13.2	7.1	6.5	2.6
Jamaica	18.6	17.7	15.9	5.9	-2.1	1.5
Mexico	19.3	21.7	21.2	9.2	7.1	.6
Nicaragua	19.0	21.8	25.3	10.0	2.4	-3.2
Panama	11.6	11.7	9.2	10.8	3.6	-3.1
Paraguay	17.0	17.6	16.5	6.6	8.3	1.6
Peru	25.3	24.8	22.9	5.3	3.3	.5
Suriname	14.7	16.5	12.7	6.9	3.6	-4.8
Trinidad and Tobago	13.6	11.9	9.8	2.9	1.7	-3.0
Uruguay	19.8	20.1	18.3	1.2	3.3	-1.2
Venezuela	14.9	15.9	18.7	7.5	5.2	2.9
TOTAL	21.4	23.3	22.3	6.7	6.4	.5

Source: Inter-American Development Bank, Economic and Social Progress in Latin America (Washington, D.C., 1989), p.30.

Table II.20. Brazil's exports of goods, 1983-1988
(Millions of dollars)

Item	1983	1984	1985	1986	1987	1988
Basic products	8 535	8 755	8 538	7 349	8 020	9 397
Coffee beans	2 096	2 564	2 369	2 063	2 000	1 998
Iron ore	1 428	1 445	1 402	1 234	1 563	1 828
Soya meal	1 793	1 460	1 175	1 181	1 450	2 024
Other	3 218	3 286	3 592	2 871	3 007	3 547
Industrial products	13 057	17 955	16 822	14 867	18 008	24 082
Semi-manufactures	1 782	2 824	2 758	2 481	3 177	4 892
Manufactures	11 275	15 131	14 064	12 386	14 831	19 190
Transport equipment	1 452	1 354	1 694	1 568	2 780	3 387
Boilers, mechanical appliances	1 106	1 396	1 590	1 443	1 634	1 415
Electrical machinery	448	591	581	794	888	859
Footwear	713	1 072	968	1 017	1 169	1 168
Orange juice	608	1 415	749	636	832	1 144
Iron and steel manufactures	1 259	1 548	1 206	999	501	2 185
Other	5 689	7 755	7 276	5 929	7 027	9 032
Other products	307	295	279	177	185	302
TOTAL	21 899	27 005	25 639	22 393	26 213	33 781

Source: Latin American Economic Report, 31 January 1990, p.18.

base have performed better than others that have grown under heavy protection. The former group includes industries such as chemicals, petroleum refining, petroleum products, plastic products, non-metallic mineral products and iron and steel. The latter group includes textiles, metal products, electrical and non-electrical machinery and transport equipment.* See table II.21 for the regional pattern of industry growth during the 1970s and 1980s.

Such differences in growth performance suggest the need for sharpening the competitiveness of lagging industries. One way, which has become popular recently, is to induce foreign direct investment to flow into the lagging industry with new technology and skills for management and marketing. The region, in fact, has been doing rather well in attracting foreign direct investment in manufacturing compared with other developing regions. There has been an increasing foreign direct-investment trend in recent years, despite the region's difficulties in servicing its heavy debt and the question of credit-worthiness.

United States direct investment stock in Latin America soared to $49.3 billion in 1988, up from $44.9 billion in 1987 and $36.9 billion in 1986. Likewise, Japanese direct investment stock jumped to $31.6 billion in fiscal year 1988 from $25.2 billion in fiscal 1987 and $20.4 billion in fiscal 1986.** Apparently,

*The experience of Argentina is similar and typical. "While overall industrial production in 1989 was 3.9 per cent above 1985, the output of sectors linked to the export market had grown the most: chemicals by 51.5 per cent, iron and steel by 45.3 per cent, plastics by 38.6 per cent and aluminium by 27.1 per cent. In contrast, industrial sectors selling primarily to the domestic market and with high income elasticity of demand for their products had suffered: the output of the capital goods sector had dropped by 32.5 per cent, consumer durables by 27.1 per cent, stoves and water heating system by 9.5 per cent and automobiles by 3.2 per cent" ([9], p. 15)

**Much investment by Japan in recent years has gone to Bahamas, Caymen Islands and Panama where export springboards to neighbouring countries (such as the United States) could be built

Table II.21. Latin America: annual average growth rates of MVA and manufacturing employment by industry, 1970s and 1980s
(Percentage)

Industry	1970s a/		1980s b/	
	MVA	Employment	MVA	Employment
Manufacturing	6.62	4.07	1.62	-0.74
Food	5.04	3.45	3.47	0.19
Beverages	6.45	3.32	1.63	-0.14
Tobacco	3.13	0.40	3.11	0.40
Textiles	3.85	1.54	-0.77	-0.93
Wearing apparel	5.57	3.55	-3.49	-2.71
Leather and fur	2.78	3.08	2.62	-2.32
Footwear	3.89	3.80	-2.00	-1.84
Wood and cork	7.36	6.10	-2.69	-1.08
Furniture	7.31	4.05	-4.22	0.01
Paper and paper products	7.44	4.36	0.86	0.19
Printing	5.39	2.86	1.45	-0.02
Industrial chemicals	8.45	4.44	3.49	1.13
Other chemicals	6.01	4.21	4.79	-0.46
Petroleum refining	9.74	2.45	4.11	-0.15
Petroleum and coal products	14.00	6.89	4.27	0.26
Rubber products	4.80	4.18	2.79	-0.96
Plastic products	10.07	9.23	1.66	0.92
Pottery, china	2.36	1.76	-0.37	-1.30
Glass	7.28	3.86	2.65	-1.92
Non-metal minerals	6.91	5.45	2.52	0.11
Iron and steel	7.97	6.17	3.66	-1.79
Non-ferrous metals	3.70	5.18	4.57	-0.29
Metal products	6.89	4.20	0.05	-1.88
Non-electrical machinery	11.77	7.83	-2.16	-0.53
Electrical machinery	7.45	3.52	-1.11	-2.39
Transport equipment	7.15	3.52	-2.47	-1.82
Professional equipment	14.60	7.09	2.05	-0.01
Other	7.31	5.91	0.59	-0.35

Source: UNIDO data base, consolidated Industrial Statistics.
a/ 1970-1980.
b/ 1980-1990 (estimates).

Table II.22. Foreign direct investment stock of the United States and Japan in Latin America, 1988
(In millions of dollars)

Industry	United States	Japan a/
Manufacturing	17 850	5 437
Food products	1 796	223
Textiles	b/	439
Wood and paper	b/	200
Chemicals	4 107	590
Metals	1 277	1 933
Non-electrical machinery	2 081	378
Electrical machinery	1 057	491
Transport equipment	2 828	1 050
Other manufactures	4 704	132
Non-manufacturing	31 433	26 180
Agriculture	c/	190
Fisheries	c/	146
Mining	c/	1 557
Petroleum	4 974	d/
Construction	c/	208
Trade and sales	2 812	1 508
Banking	4 800	e/
Finance and insurance	14 535	10 990
Services	1 079	931
Transport	c/	9 236
Real estate	c/	142
Other non-manufactures	3 234	1 271
TOTAL	49 283	31 617

Source: United States Department of Commerce and Japan Ministry of Finance.
a/ As of 31 March 1989.
b/ Included in other manufactures.
c/ Included in other non-manufactures.
d/ Included in mining.
e/ Included in finance and insurance.

the debt-for-investment swap deals have played a part in the increases, but the extent is not known.

It is interesting to note that, of the United States total investment, 36 per cent went to the manufacturing sector compared with only 17 per cent in Japanese investment. The prowess of Japanese manufacture is yet to be tested in the region. Japanese investment in electrical machinery and transport equipment is dwarfed by that of the United States, for example, though the Japanese have a stronger competitive edge in these industries (see table II.22 for other industries).

As if to compensate for the Japanese lag behind the United States in investment, the Japanese general trading companies are stepping up their activities in the region. The major companies such as C. Itoh, Marubeni, Mitsui, Mitsubishi, Nissho Iwai and others have been expanding their presence through joint ventures, representative offices and subsidiaries. They provide services organizing counter trade, both domestic and international marketing, equity investment as well as new plant construction, and integrated (custom-made) business services involving banking, insurance, shipping and warehousing services with formidable global information networks. These multi-purpose companies have a track record of helping the horizontal division of labour among Asian developing countries. They have already posted high profit earnings from their Latin American operations. The movement of the region toward greater liberalization of trade and investment can be greatly helped by these companies, particularly to create greater economic linkages with Asia.* Such linkages appear overdue, considering the rapid global integration process in progress.

The traditional ties of the region with the United States are well known. But recently a new twist has been added to the scene by the prospect of a free trade pact between the United States and Mexico. Already, the United States and Mexico have agreed to conclude trade accords on textiles, steel, petrochemicals, fruit, coffee and beef. Reportedly also, both Governments are studying the possibility of forming a "North American common market". Furthermore, the region seems to be building a bridge to Western Europe through Spain. Argentina, Chile, Mexico and Venezuela have concluded treaties of friendship and economic co-operation with Spain.

To sum up, industrial growth in the region is still shackled by the high level of debts. Inflation, though tamed in Chile and now in Mexico, is still plaguing many of its countries. Yet there are signs that the poor growth performance of the 1980s may not be repeated in the coming decade. The global process of economic integration is giving birth to positive growth impulses in virtually all regions of the world, and Latin America is no exception. How to make use of this new force is the question and challenge facing policy-makers.

*However, if it wishes to avoid the possibility of being foreign-dominated, it behoves the region to develop its own multi-purpose general trading companies by learning from the Japanese counterpart.

F. Tropical Africa

The short-run prospect for industrial growth in Tropical Africa has improved mainly because of economic revival in Western Europe (its major trading partner) and the surprisingly good growth performance in agriculture in recent years. But long-run hindrances to healthy and continuous industrial growth in the region remain, namely, poor infrastructure in transport, communications, education, power, water and industrial services (such as engineering consultation) and generally weak institutional and administrative capabilities to carry out reform programmes. Short-run gains are often dissipated because of defects in infrastructure needed to make a market system function properly. In the meantime, the region faces a set of new challenges brought about by EEC 1992 and system reforms in Eastern Europe and the USSR. These changes demand a greater industrial competitiveness if the region does not wish to miss sharing the benefits from the integration of a greater Europe. Indeed, there is a danger that Tropical Africa may lose out in competing for resources and become marginalized, unless concerted efforts are initiated soon and effectively. But options appear limited, partly because of the heavy burden of debt-service requirements (see table II.23).

Table II.23. Short-term and long-term external debt outstanding and debt service payments for Tropical Africa, 1985-1989[a]
(Billions of dollars unless otherwise indicated)

Item	1985	1986	1987	1988	1989[b]
Total debt	161.6	190.1	219.2	225.2	225.6
Short-term	19.3	18.8	19.1	19.8	[illegible]
Long-term unguaranteed	11.6	13.8	14.8	14.2	13.4
Long-term guaranteed	133.2	157.5	185.3	190.2	192.3
To official creditors	93.2	113.0	133.2	139.5	142.9
To financial institutions	27.0	28.5	29.2	28.4	27.5
To other private creditors	13.0	17.0	21.8	21.3	21.9
Ratio of debt service payments to exports of goods and services (percentage)					
Debt service ratio[c]	27.4	33.1	28.8	30.5	31.5
Interest payments ratio[d]	13.7	15.3	13.1	13.9	15.1
Amortization ratio[e]	13.7	17.8	15.7	16.6	16.4

Source: African Development Bank, African Development Report 1990 (Abidjan, 1990), p.24.

a Comprising only regional member countries of the African Development Bank.

b Estimates.

c Amortization payments on long-term debt and interest payments.

d On total interest payments.

e Amortization payments (that is, principal repayments) on long-term debt only.

In 1989, GDP in the region grew by 2.8 per cent and MVA by 1.7 per cent, an improvement over 1988 growth rates of 1.9 per cent for GDP and 0.7 per cent for MVA. This upward trend is expected to continue in 1990, with GDP and MVA growth of 3.5 per cent and 3.9 per cent, respectively (see figure II.6 for GDP and MVA growth in recent years, and also for the pattern of structural change in industry). A major impetus in 1989 came from rapid growth of agricultural output, most notably in East Africa, with nearly 8 per cent growth. Some non-food items such as cocoa, cotton lint, tea and coffee led other items in boosting the growth rate.

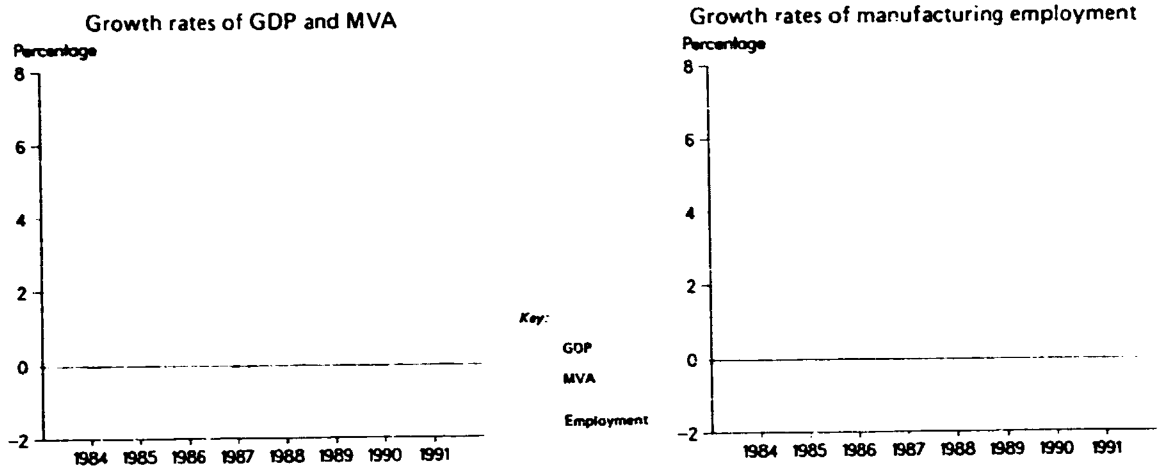
Increased export earnings enabled some countries (including Botswana, Ghana, Mozambique, Senegal, Seychelles and Zimbabwe) to import a greater amount of manufacturing inputs and increase capacity utilization. In part, rehabilitation activities also contributed to the improvement in MVA growth. The textiles industry in Sudan and plastics in Burkina Faso provide examples. On the whole, capacity utilization appears to have improved in such industries as textiles, weaving, apparel and leather products, while little improvement was made in the electrical and electronics branches. In Nigeria a great jump has been noted in capacity utilization, to 44 per cent in 1988 from 37 per cent in 1985, and in Zambia to 30 per cent in 1988 from 20 per cent in the 1983-1986 period.

These noteworthy recent performances notwithstanding, the long-run prospects for industrial growth in the region appears rather dim. During the 1970s, the manufacturing sector provided the thrust with annual growth rates of 5.7 per cent and 5 per cent in, respectively, MVA and manufacturing employment (see table II.24). But in the 1980s, the annual growth achieved was only 0.5 per cent for MVA and 1.2 per cent in manufacturing employment, far below the population growth rate of 3.1 per cent. What explains the difference between the 1970s and 1980s?

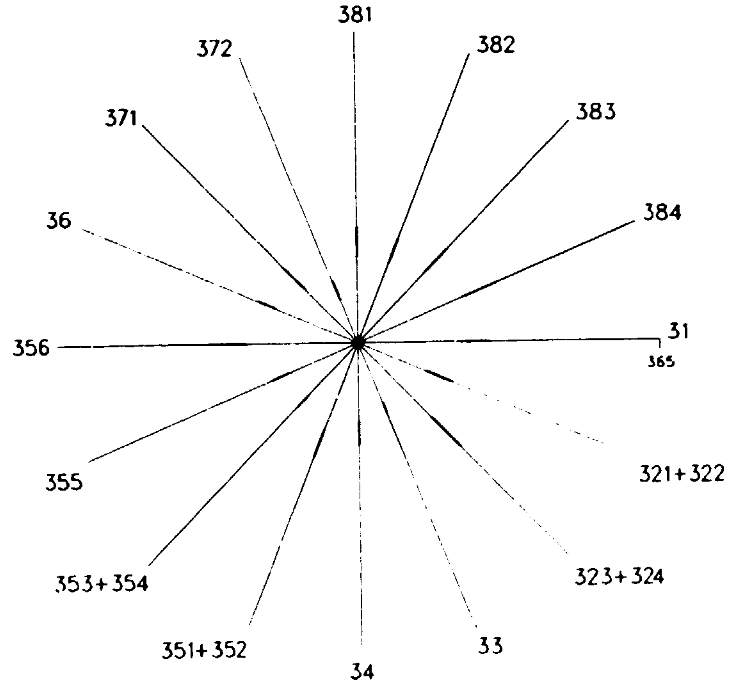
In the earlier decade, import-substitution industries thrived, supported by surging commodity export earnings, cheap credit in international money markets, generous aid and easy sales in heavily protected domestic markets. The weakness of the "screwdriver industry" so created (including automobiles and radio or television assembly), however, was exposed suddenly when the 1979 crisis came, followed by the 1981-1982 world recession. The process of "input strangulation" took place owing to shortages of foreign exchange, and many industries have not yet been able to recover to the 1970s level of output. Indeed, industries with negative growth during the 1980s are many, and they include textiles, wood and cork, furniture, printing, other chemicals, plastics, glass, non-ferrous metals and transport equipment (see table II.25 for negative-growth industries in manufacturing output and employment). Most of these industries require the mastery of relatively advanced machinery, technology and management skills as compared with other industries. They also require a well-developed infrastructure including transport networks, telecommunications, power and water supplies, educational and training systems and engineering services. These cannot be developed in a short period of time. The difficulties encountered during the 1980s do not bode well for the 1990s. The geography of the region appears far from helpful.

The land-locked countries suffer most from deficiencies in external connections. The costs of their imports and exports are raised by the distance that has to be covered (over an often inferior road-rail network), customs delays and potential transport disruptions as a result of conflicts between countries. The region has a higher share (one quarter) of landlocked countries than any other continent. Although regional markets may, in the long run, prove more important than overseas markets, overseas markets for industrial products would certainly have a growing importance for countries such as Zambia and Zimbabwe.

Figure II.6. Growth rates of GDP, MVA and manufacturing employment, 1984-1991, and industrial structural change, 1975-1991: Tropical Africa



Industrial structural change
(Index of value added: 1975 = 100)



g =	2.07
θ =	6.67

Key:

ISIC code	(industries):
31	(Food products)
321, 322	(Textiles)
323, 324	(Leather)
33	(Wood and furniture)
34	(Paper and printing)
351, 352	(Chemicals)
353, 354	(Petroleum and coal)
355	(Rubber products)
356	(Plastic products)
36	(Non-metal mineral products)
371	(Iron and steel)
372	(Non-ferrous metals)
381	(Metal products)
382	(Non-electrical machinery)
383	(Electrical machinery)
384	(Transport equipment)

Constant prices of 1980

g = Average annual growth rate, 1975–1991 (percentage)

θ = Index of structural change, 1975–1991

1985–1991 forecast
1980–1985
1975–1980

Sources: UNIDO data base; estimates and forecasts by UNIDO/PPD/IPP/GLO

Table II.24. Tropical Africa: annual average growth rates of MVA and manufacturing employment by country, 1970s and 1980s

Country	1970s[a] MVA (percentage)	1970s[a] Employment (percentage)	1980s[b] MVA (percentage)	1980s[b] Employment (percentage)	1987 MVA per capita (1980 dollars)
Tropical Africa	5.66	4.66	0.52	1.24	32
Burkina Faso	2.54	1.39	4.71	1.78	20
Burundi	4.42	5.06	5.93	5.30	19
Cameroon	5.26	2.15	3.10	0.88	72
Cape Verde	4.35	-8.34	21.85	-5.11	27
Central African Republic	-5.11	-5.63	-5.47	-1.16	34
Congo	-3.75	-10.35	0.33	5.50	134
Côte d'Ivoire	6.24	7.25	1.20	-1.63	91
Ethiopia	3.80	4.41	1.69	3.08	12
Gabon	6.38	11.08	1.73	6.51	253
Gambia	11.92	-7.06	3.61	6.51	24
Ghana	-3.09	3.36	-7.01	-0.78	25
Kenya	6.63	7.62	1.09	3.28	48
Madagascar	-0.40	-3.35	2.59	2.42	41
Malawi	7.22	7.62	-0.51	-0.38	23
Mali	6.21	10.66	1.50	3.55	12
Mauritius	7.40	12.07	12.63	10.64	282
Niger	7.48	4.06	1.10	1.98	15
Nigeria	11.98	12.87	-5.30	-1.21	8
Rwanda	11.95	-0.64	2.11	2.26	37
Senegal	0.12	5.24	1.13	2.74	94
Somalia	-0.98	6.95	-6.01	2.51	17
Swaziland	10.47	6.21	-4.83	0.46	106
Togo	-5.83	4.60	-1.62	3.30	25
United Republic of Tanzania	6.70	7.57	-4.18	1.27	16
Zaire	-15.47	-6.37	1.62	-3.49	5
Zambia	4.43	3.81	8.18	2.67	105
Zimbabwe	6.39	4.04	4.35	1.87	167

Source: UNIDO data base, consolidated Industrial Statistics.
a/ 1970-1980.
b/ 1980-1990 (estimates).

Table II.25. Annual average growth rates of MVA and manufacturing employment in Tropical Africa by industry, 1970s and 1980s
(Percentage)

Industry	1970s[a] MVA	1970s[a] Employment	1980s[b] MVA	1980s[b] Employment
Manufacturing	5.66	4.66	0.52	1.24
Food	3.27	3.23	1.28	2.37
Beverages	5.06	5.77	4.18	2.98
Tobacco	2.64	4.24	1.16	-0.81
Textiles	3.61	3.70	-1.28	0.68
Wearing apparel	2.19	4.49	7.46	7.79
Leather and fur	10.37	7.85	1.73	3.71
Footwear	4.71	5.55	3.31	2.13
Wood and cork	6.12	3.40	-5.84	-4.57
Furniture	8.28	6.42	-3.76	-2.07
Paper and paper products	7.55	3.92	1.12	3.69
Printing	5.11	4.81	1.29	-0.28
Industrial chemicals	5.18	5.38	3.03	1.61
Other chemicals	10.83	6.51	-0.51	2.87
Petroleum refining	1.60	3.93	0.30	3.81
Petroleum products	4.37	16.69	4.11	4.18
Rubber products	3.73	3.25	1.63	-2.33
Plastic products	16.77	17.73	-2.30	-3.62
Pottery, china	6.30	3.98	0.77	1.69
Glass	8.56	3.58	-3.49	2.06
Non-metal minerals	3.64	3.34	1.76	0.44
Iron and steel	9.87	6.89	0.28	5.42
Non-ferrous metals	1.83	6.20	-0.97	2.96
Metal products	6.17	5.82	0.97	0.05
Non-electrical machinery	7.22	6.82	0.36	-0.74
Electrical machinery	8.86	9.07	1.40	0.16
Transport equipment	19.24	7.07	-6.89	-0.80
Professional goods	13.24	18.54	12.60	6.00
Other manufacturing	5.34	5.39	1.52	4.79

Source: UNIDO data base, consolidated Industrial Statistics.
a/ 1970-1980.
b/ 1980-1990 (estimates).

In Southern Africa, industrial development has suffered much from the destruction of transport lines and port facilities. The Beira railway, for example, an essential connection for both Zambia and Zimbabwe, has been disrupted on several occasions.

A deficient internal transport network is an impediment to industrial development. Markets cannot be properly supplied, and the cost of domestically produced inputs or equipment is raised. The latter is a further obstacle to the growth of intersectoral and inter-industry linkages, which are weak enough as it is. A bad domestic transport network can have a disastrous influence on the performance of large-scale plants; the Cellucam pulp mill in Cameroon and the CIMAO cement plant in Togo provide illustrations of this point.

Regional markets are likely to become more important in the future. Their development has been hampered, *inter alia*, by the fact that basic transport arteries are often relics of colonial days. The interior is connected to a major port, but the development of nation-wide road networks and connections with neighbouring countries has been neglected. This is changing, however. Examples are the TanZam railway and the Pan-African highway project.

Telecommunications are another area where much progress is yet to be made in most African countries. Supplying a factory and marketing its products are both crucially dependent on long-distance communications. With regard to the functioning of the plant itself, a regular supply of power and water are essential. In many African countries there is no guarantee that electric power will be continuously available.

The expansion of physical infrastructure is time-consuming and highly capital-intensive. The trans-Gabonese railway cost $3 billion for a length of 657 kilometres. A complicating factor peculiar to Africa is the low density and wide dispersal of the population, which increases the per capita cost of infrastructure works. Given the present constraints on national budgets, infrastructure improvement is likely to suffer. The bias against expenditure on public goods (which may be found in some of the adjustment programmes) militates against infrastructure improvements as well. Here, a better weighing of short-term balance-of-payments considerations against long-term development needs would be called for.

The educational system is another essential element of the institutional infrastructure. The challenge that the region faces daunts any strong-willed policy-maker. In 1985, 54 per cent of the population had no formal education, and only 6 per cent completed secondary or higher education.* The shortage of qualified personnel is felt by virtually all industries.

*"Returns to investment have generally been higher in education than in physical assets. Economic rates of return to primary education in developing countries have averaged 26 per cent, compared with estimated returns on physical capital of 13 per cent. This suggests that lack of education is a greater obstacle to industrialization and development than lack of physical assets" ([10], p. 63)

The problems of an inadequate infrastructure are of a general nature applicable to all industries. But some modern industries in the region suffer also from industry-specific problems, adding to the difficulties of industrial restructuring needed to sharpen competitiveness. A few salient examples are given below to illustrate the challenges that policy-makers face.

Pulp and paper mills have been established in some sub-Saharan countries with large forest reserves. On the whole, the record of the industry is not encouraging: some of Africa's major "white elephants" are pulp mills. The Cellucam plant in Cameroon is an example. There are several reasons for their failure. First, a modern mill has a capacity that often far exceeds the demand for paper in the average African country with its small population, low incomes and low literacy levels. The mills are very capital-intensive and need a well-developed physical infrastructure, since the industry uses great amounts of water and energy. Moreover, the absence of smoothly functioning regional markets and heavy international competition are not conducive to exports. Finally, much of the African forest is unsuitable for paper manufacturing in the first place.

With the development of petroleum refining, a number of African countries have acquired a good basis for the chemical industry. Details are scarce, since in many cases the petrochemicals industry is a very recent addition to manufacturing. In small oil-producing countries such as Gabon, the viability of the highly capital-intensive industry may be in serious danger as a combined result of a world market glut, the small size of the domestic market and the steep drop in oil earnings needed to pay off and maintain the plants. Other chemical industries, such as those based on phosphates, do not seem to perform well in the smaller economies either. Countries like Togo and Zambia have experienced severe difficulties in this field.

Many African countries now have their own non-metallic minerals industries. Resources are often readily available, and for many products the domestic market (private consumers, the construction industry) is sufficiently large. Unfortunately, this is not always the case for the cement industry, the only non-metallic minerals industry for which details are available. The main problem again appears to be the capital-intensive nature of this type of manufacturing. A modern cement plant is large, complex and costly. A sizeable domestic market is therefore essential, but the general decline of many economies has also caused a steep reduction in the demand for building materials. In sub-Saharan Africa the domestic product is, moreover, often more expensive than imports from the Mediterranean area. The complexity of the plants frequently causes breakdowns, which cannot always be remedied locally, as the industrial support services or the required manpower are not available. A shortage of industry-specific skills, for example, has been mentioned as a serious problem for the cement industry in Senegal.

Basic metals, likewise, are represented in a limited number of countries. Even where large raw material deposits exist, the highly capital-intensive nature of these industries and their heavy demands on infrastructure often make processing non-viable. Basic metals such as iron and copper are increasingly facing a highly competitive international environment and substitution by synthetic products. In Zambia, a major copper producer, copper deposits are being rapidly depleted, which seriously exacerbates the problems of this single-product economy.

Conceptually, the engineering industries have a secure source of inputs where a basic metal industry exists. In practice, however, widely varying types of metals are needed, and even Africa's larger metal producers have therefore remained partially dependent on imports. Import dependence on special metal products is quite common wherever engineering industries exist, but in the case of Africa the present foreign exchange squeeze makes it very difficult to obtain such essential materials. The development of the engineering industries is also hindered by the serious shortage of skilled labour and engineers.

Capital-intensive, large-scale engineering (as in heavy machinery and motor vehicles) has only proved viable in a handful of the more developed sub-Saharan economies. The production of simple metal goods and equipment, especially for agriculture, is often better suited to the particular situation of many countries. This is one of the potential growth industries.

In order to help solve these problems, UNIDO has been carrying out various studies to discover new strategies for industrial revival in the region. These activities have led to the following recommendations which reflect a rather broad-based challenge and the complexity of the issue.* The key elements in summary form are as follows:

(a) Re-assessment of industrial development priorities in light of the medium-term overall outlook (this may entail closure of plants);

(b) Improving industry-level data collection, in order to provide a more solid basis for such assessment;

(c) Special incentives for industries to strengthen domestic linkages (current regulations often favour import-dependent industries);

(d) Identification of new ways of supplying import-dependent industries with essential inputs and spare parts;

(e) More attention to the development of medium- and small-scale industry; in other words, a policy shift away from large-scale, capital-intensive manufacturing;

(f) Infrastructural improvement, including institutional infrastructure;

(g) Better vocational and high-level (technical, managerial) training within the context of overall educational improvements;

(h) Stimulation of agriculture and meshing of industrial and agricultural projects where possible;

(i) Greater price flexibility or abolition of price regulations;

*For country-specific recommendations, see "Regenerating African manufacturing industry: Country Briefs" (PPD.97).

A small island in the Indian Ocean, Mauritius, despite its limited population and area, finds itself today a subject of consideration by all those who are interested in development problems. Not because the country is a source of concern; on the contrary, the dramatic take-off of the island, which in 1968, the date of its accession to independence, faced numerous handicaps, is a subject of satisfaction.

For more than two centuries, the island of Mauritius knew only a monocultural economy based on sugar-cane, the industrial sector being, until quite recently, virtually non-existent. Still, it is from industry that the economic success of the country has come, a success that can be gauged by numerous indicators, such as the growth rate (averaging 6.7 per cent a year from 1980 to 1988), or the unemployment figure, which stands at around 5 per cent. This achievement is the result of an economic policy that is both realistic and bold, and that is based on a mixed economy. Above all, however, it rests on a process of rapid industrialization whose driving forces are not only the textiles industry and the Mauritian free zone.

Reasons for success

The free zone

The free zone consists of 573 enterprises employing 20 per cent of Mauritian labour and generating 60 per cent of the gross export revenue of the country. The reasons for the success of the free zone are to be found in the incentives and advantages granted to industrialists interested in doing business in Mauritius. The following are the rules of the free zone:

(a) Total exemption from the payment of custom duties and import taxes on capital goods, spare parts and raw materials;

(b) A corporation tax of 15 per cent for exporting enterprises (as opposed to 35 per cent for others);

(c) Total exemption from the tax on dividends during the first 10 years of the existence of an enterprise;

(d) Free repatriation of capital and dividends by foreign investors;

(e) Enjoyment of preferential electricity rates;

(f) Availability of bank term loans and working capital and preferential interest rates;

(g) The possibility of financing through an export credit scheme and the opportunity to subscribe to an export insurance plan managed by the Bank of Mauritius;

(h) Accelerated depreciation and tax deductions for export-oriented enterprises;

(i) Possibility of leasing or buying industrial buildings;

(j) A 50 per cent remission, following submission of plans, on the costs of registering land and premises acquired by the enterprise;

(k) Granting of residence and working permits to investors and shareholders, depending on the size of the projects;

(l) Labour legislation tailored to the needs of exporting enterprises;

(m) Formal guarantee that no enterprise will be nationalized.

Moreover, through its accession to the Convention on the Settlement of Investment Disputes between States and Nationals of Other States, the Government has undertaken that the disposition of such disputes will be in accordance with the provisions of that instrument.

Other measures have also played a significant role in the development of the free zone. For example, the decision of the Government of Mauritius to peg the Mauritius rupee (Mau Rs) to a foreign-currency basket representative of the country's external trade is regarded very favourably by investors. In addition, industrialists operating in the free zone are able to manage foreign currency portfolios, which is not true of the other exporters. Mention might also be made of the opportunity available to entrepreneurs who have recorded losses over a financial period to obtain, under certain conditions, a deferral of payment against future profits.

Numerous incentives to the setting-up of industry in the zone have been established. The Mauritius Export Development and Investment Authority owns an industrial park covering an area of 80,000 square metres, which it makes available to industrial operators at an advantageous price. If entrepreneurs prefer to own their premises, and if the area in question exceeds 1,000 square metres, they are eligible for a 20 per cent remission on their corporation tax, bringing it down to 15 per cent instead of 35 per cent.

The performance of the free zone has made possible the take-off of Mauritian exports of manufactured products, the value of which rose from Mau Rs 1.2 billion in 1981 to Mau Rs 8.2 billion in 1988. So strong has been this activity that, since 1985, the gross revenue from the free zone has surpassed the income obtained from sugar-cane. This is a very positive sign, even though the sugar operations continue to generate the largest amount of foreign exchange for the Mauritian economy.

Furthermore, the added value of the free-zone products has increased substantially, rising from 23 per cent in 1984 to 28 per cent in 1988, equivalent in monetary terms to Mau Rs 1.9 billion.

Since the island of Mauritius is linked to the EEC under the Lomé Convention accords, it follows that the country's exports are primarily (70 per cent) intended for the EEC countries. Within the EEC, France remains the principal customer, with 34 per cent in 1988, followed by the Federal Republic of Germany and the United Kingdom, which together absorb 25 per cent of free zone exports. Finally, the United States is also an important client, accounting for 24 per cent of the total production of the zone. However, while the free access of Mauritian products to North American and European markets may have represented a major triumph, in future this narrowly focused targeting of exports could become a handicap for the Mauritian economy, since any recession in developed countries would have serious repercussions on the economic life of the island. For this reason, Mauritius has decided to pursue the diversification of its markets, even though, for the time being, the commercial promotion efforts undertaken by the Mauritius Export Development and Investment Authority in new markets, specifically the Indian Ocean market, have yet to bear fruit. In any case, the unanimous view in Mauritius on this point is clear—diversification is seen as the linchpin of the country's industrial future.

The textiles industry

The good results recorded by the Mauritian economy are to be credited to the growth of the textile industry, which alone accounts for 80 per cent of the export revenue of the free zone. Mauritius is the world's third-largest producer of knitted goods, exporting more than 10 million units a year. The largest knitwear producers are the Afasia group (4 million units a year), Crystal (4 million), Summit (2.5 million), Poul Lee Textile (1.2 million), Bonair Knitwear and Tara Knitwear (about 1 million). In addition to these high-technology enterprises, other factories can be found specializing in hand-made articles, which offer the advantage of a high value added.

The island is also one of the world leaders in the manufacture of pure wool articles, for which the largest producer is Floreal Knitwear, which has a capacity of 5 million units a year. Of the approximately 50 enterprises operating in this industry, 40 are authorized to use the Woolmark label, which is a sign of quality.

However, despite the successes achieved in this area, Mauritius is aware of the danger implicit in over-specialization in a single field. Accordingly, the Government has decided to grant no further authorizations to enterprises intending to operate exclusively in this industry. On the other hand, it is prepared to assist enterprises engaged in three selected areas of activity, namely morocco-leather goods, jewellery and electronics. So far as this last industry is concerned, there are a number of problems with regard to markets, since a recent World Bank study on the Mauritian economy, entitled *Managing Success*, concluded that the quality of the island's electronic products would not be in conformity with EEC standards.

Labour

As a result of its economic expansion, at the beginning of the 1980s Mauritius faced certain problems in the balancing of supply and demand in the job market. This work-force crisis was characterized by a feminization of labour in the free zone (in 1983, men accounted for only one sixth of the persons employed there) because the law required wages for men to be 55 per cent higher than those offered to women. In 1984, the Government adopted a decision to liberalize wages, which are now set on the basis of negotiations between employers and employees. From 1983 to 1988, the number of men employed in the free zone rose from 4,000 to 31,500.

Environmental protection

Another consequence of the Mauritian industrial take-off, and specifically of the expansion of activities in the textiles industry, is the problem of environmental protection, which has become particularly acute. The building of dye-works in many locations on the island has resulted in pollution and led to the fear that ground water sources, which supply 60 per cent of the water used on the island, would also be ultimately affected. This fear is all the more justified in view of the fact that the plants do not have the necessary facilities for the treatment of process water.

In addition, industrial activities have been developed on land formerly set aside for agriculture, thus posing a problem in terms of preserving the ecological balance of the island.

Aware of these dangers, the Government has called on the technical and financial assistance of the World Bank. The latter has prepared a report, entitled *Economic Development and Environmental Management-Strategies for the Island of Mauritius*, which has provided a basis for discussions between the United Nations Development Programme and the World Bank during a meeting of bankers held in Paris in February 1989. This document proposes a strategy consisting of three elements:

(a) The introduction of a land policy designed to address the development needs of the country while safeguarding its ecological future;

(b) The reform of laws and institutions in the area of natural resource management;

(c) The creation of a data bank which, in addition to ensuring the viability of industrial projects, would also incorporate the proper responses to ecological concerns.

The Government of Mauritius has itself also taken up the challenge. Over the short term, it intends to enact extremely stringent requirements regulating dye-work operations. Over the medium term, its intention is to carry out a project for the establishment of a park reserved essentially for these facilities. This park will be equipped with the necessary infrastructure for the treatment of process water, including a strict monitoring of the colouring agents used.

Thus, after having demonstrated that rapid development is possible, it remains for Mauritius to show that this development can be harmonious and unharmful. The latest decisions adopted by the Government appear to be moving in this direction.

Source: *Industry Africa*, No 2, December 1989, pp 18-19

(j) Simplified administrative procedures, including price controls;

(k) Decentralization of economic decision-making within public sector industries;

(l) Encouragement of private entrepreneurship and industries;

(m) Involvement of private sector representatives in the policy-making process;

(n) Reduction of regional trade barriers.

Another approach, not mentioned in the above list, is the use of foreign direct investment and joint ventures. Fortunately, there is a growing recognition that foreign direct investment could bring quickly crucial factors that the region lacks—modern technology, capital and even management and marketing skills. An increasing number of sub-Saharan countries, such as Nigeria and Zimbabwe, are liberalizing their rules to attract foreign direct investment and even creating free trade zones. Serious efforts in this area have barely begun, and Mauritius can be said to provide the first successful case (see box, pp.68-69).

The region has received an increasing amount of foreign direct investments, but those in manufacturing appear rather meagre. For instance, United States investment stock in 1987 amounted to $2.4 billion, up from $1.9 billion in 1986. Less than 10 per cent of this amount was invested in manufacturing and more than three quarters in petroleum. Japan's foreign direct investment stock in the region reached $4.6 billion in fiscal 1988, but the manufacturing sector shared less than 5 per cent. Private investors obviously pursue profitability, and the region may not be attractive when compared with other regions. But attractiveness can also be enhanced by policy measures properly designed and implemented as the case of Mauritius demonstrates.

Whether foreign direct investment is used as an instrument for industrial growth or not, the ultimate concern for enterprises and policy-makers is to enhance competitiveness. The proven way to do so is to expose enterprises to competition from abroad or domestically. In this regard, recent movements toward regional market integration by lowering tariffs and non-tariff barriers appear encouraging. For instance, the Preferential Trade Area is seriously considering formation of an economic community. The member countries have even agreed to set up their own currency for all transactions within the Area.* Such a movement could also provide an effective way to respond to the challenges coming from EEC 1992 and the opening up of the Eastern European countries.

Enhancing industrial competitiveness also requires the development of African technological capability. It is high time to think about an "African version" of ESPRIT (information technology), RACE (telecommunications), BRITE (new industrial technology), EURAM (materials technology) etc.

*The Preferential Trade Area consists of Burundi, Comoros, Djibouti, Ethiopia, Kenya, Lesotho, Malawi, Mauritius, Mozambique, Rwanda, Somalia, Swaziland, Uganda, United Republic of Tanzania, Zambia and Zimbabwe.

G. North Africa and Western Asia*

The expected rise of oil prices and revenues in the 1990s offers a bright prospect for returning the region to an industrial high-growth path. Added to this prime factor are the gradual increases in private sector participation, gradual liberalization in trade and foreign investment, and ever-increasing opportunities for import substitution and oil-based downstream industry development.

In the immediate future (1990), GDP and MVA growth for North Africa are projected to be, respectively, 3.8 per cent and 5.1 per cent, an improvement from 2.3 per cent and 3.6 per cent in 1989, respectively. For Western Asia, the 1990 projection shows 2.9 per cent GDP growth and 4.9 per cent MVA growth, again an improvement from 0.8 per cent and 2.8 per cent, respectively. The year 1991 is expected to bring even higher growth than in 1990 (see figure II.7 for GDP and MVA growth in recent years, and also for the pattern of structural change in industry).

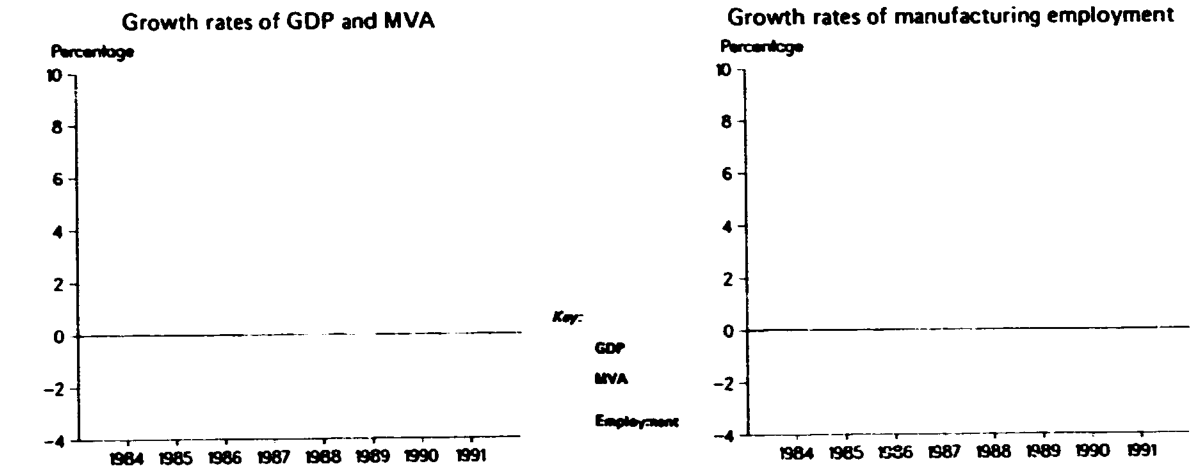
The prime reason for the optimism stems from a rather rosy picture of expected oil revenues. In 1989, OPEC oil revenues grew by 40 per cent owing to increasing demand, resulting in a price hike from an average of $14 to $16 per barrel. A forecast shows that oil revenues will rise from $107.4 billion in 1989 to $126.8 billion for OPEC in 1990, and from $74 billion in 1989 to $87.8 billion in 1990 for Gulf Co-operation Council (GCC) countries (see table II.26 for a breakdown by country). World demand for and the price of crude oil are expected to rise continuously up to the year 2000 (see table II.27 for annual forecasts for the coming decade). The EEC 1992 projects coupled with the developments in Eastern Europe add cogency to the forecasts. Rising oil revenues will undoubtedly fuel the industrialization process in the region.

Looking at MVA growth performance during the 1970s, virtually all countries did quite well (see table II.28). Double-digit growth occurred for Cyprus, Islamic Republic of Iran, Jordan, Kuwait, Libyan Arab Jamahiriya and Tunisia, albeit starting from a small base except for the Islamic Republic of Iran. In the 1980s, the world recession of 1981-1982 wrought havoc in Latin America and Tropical Africa; but North Africa and Western Asia suffered relatively smaller damage from the recession, perhaps because of the petrodollar reserves spent continuously on industrialization programmes and also because of the war-related spending by the Islamic Republic of Iran and Iraq.

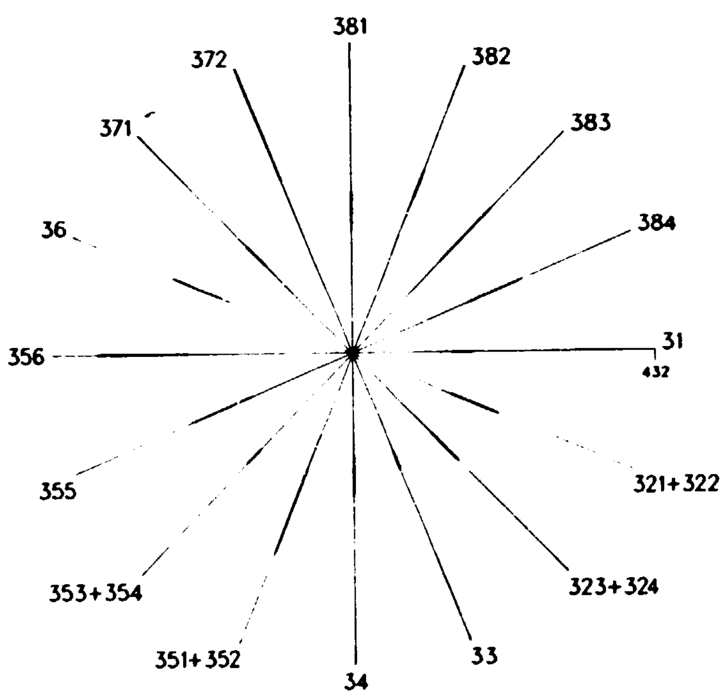
For the 1990s the region stands most likely to gain from rising oil revenues and also from reconstruction spending by the Islamic Republic of Iran and Iraq. Furthermore, the oil producers and non-oil producers in the region have evolved to become complementary rather than competitive. Non-oil producing countries such as Egypt, Tunisia and Turkey have started supplying light manufacturing goods to the oil-producing countries. Mediterranean co-operation seems to have come of age, provided the quality of light manufactured goods is upgraded.

* The assessment of the region was made before the current Gulf crisis, which brought total uncertainty.

Figure II.7. Growth rates of GDP, MVA and manufacturing employment, 1984-1991, and industrial structural change, 1975-1991: North Africa and Western Asia



Industrial structural change
(Index of value added: 1975 = 100)



g =	5.33
θ =	10.27

Key:

ISIC code	(industries):
31	(Food products)
321, 322	(Textiles)
323, 324	(Leather)
33	(Wood and furniture)
34	(Paper and printing)
351, 352	(Chemicals)
353, 354	(Petroleum and coal)
355	(Rubber products)
356	(Plastic products)
36	(Non-metal mineral products)
371	(Iron and steel)
372	(Non-ferrous metals)
381	(Metal products)
382	(Non-electrical machinery)
383	(Electrical machinery)
384	(Transport equipment)

Constant prices of 1980

g = Average annual growth rate, 1975–1991 (percentage)

θ = Index of structural change, 1975–1991

1985–1991 forecast
1980–1985
1975–1980

Sources: UNIDO data base, estimates and forecasts by UNIDO/PPD/IPP/GLO

Table II.26. Oil revenues of OPEC countries, 1989 and 1990
(Billions of dollars)

Country or area	1989	1990 (estimated)
Saudi Arabia	23.2	28.5
Iran (Islamic Republic of)	12.0	13.4
Iraq	15.4	17.7
Kuwait	8.7	11.1
United Arab Emirates	10.3	12.1
Qatar	2.2	2.4
Neutral zone	2.2	2.5
Western Asia OPEC	74.0	87.8
Venezuela	7.6	9.8
Nigeria	9.3	11.0
Indonesia	4.5	3.9
Libyan Arab Jamahiriya	6.3	7.7
Algeria	3.4	[illegible]
Gabon	1.2	1.6
Ecuador	1.1	1.3
Other OPEC	33.4	39.0
TOTAL	107.4	126.8

Source: Petroleum Intelligence Weekly, as quoted in "OPEC's oil revenues increased by 40 per cent last year", North-South News Service, 13 February 1990.

Table II.27. OPEC: crude oil demand and average oil prices, 1990-2000

Item	1990	1991	1992	1993	1994	1995	2000
Demand (million barrels/day)	21.7	22.3	23.3	24.3	25.2	26.5	32.3
Oil price (dollars per barrel)							
Nominal	17.5	18.9	20.4	22.5	24.7	28.4	50.5
Real (1989 prices)	16.7	17.2	17.7	18.6	19.5	21.4	30.0

Source: Middle East Economic Digest, vol.34, No.5 (9 February 1990), p.5.

The oil producers of the region have developed strong comparative advantage in oil-based downstream industries such as petrochemical products (methanol, ethylene, naphtha, polypropylene etc.) and fertilizers (ammonia, urea etc.), in addition to energy-using industries such as iron and steel, aluminium and cement. These products can offer feedstock advantages to further downstream industries (metal products, aluminium products, plastic products etc.). These products meet not only regional demand, but also demand from Western Europe (the major market), Japan and South-East Asia. But recent performances are mixed: for instance, petrochemicals, fertilizers and aluminium did well, while cement and iron and steel suffered from over-capacity and severe global competition.

Petrochemicals and fertilizers continued to be the growth leader during 1989, owing to several factors; namely, better management, increased global demand for petrochemicals and higher international prices. However, petrochemical plants are facing marketing difficulties in the EEC countries. High transport costs and the 13 per cent customs duties imposed by EEC countries render GCC petrochemicals non-competitive. Marketing problems are expected to continue with the emergence of the single European market in 1992. Nevertheless, GCC petrochemicals companies, and more particularly the Saudi Basic Industries Corporation (SABIC), intend to enter the European market through the establishment of joint ventures. Joint ventures with foreign partners in downstream industries that have buy-back arrangements would further promote the marketability of primary petrochemicals.

Table II.28. North Africa and Western Asia: annual average growth rates of MVA and manufacturing employment by country, 1970s and 1980s

Country	1970s a/		1980s b/		MVA 1987 (millions of 1985 dollars)
	MVA	Employment	MVA	Employment	
	(percentage)		(percentage)		
Algeria	6.2	9.7	4.5	4.9	6 263
Cyprus	10.3	4.2	5.1	2.9	429
Egypt	7.8	3.8	6.4	3.4	6 958
Iran (Islamic Republic of)	10.6	6.6	1.8	5.8	13 182
Iraq	8.7	7.1	6.3	1.4	3 906
Jordan	12.8	7.4	8.4	6.0	856
Kuwait	15.5	12.1	1.5	1.9	1 879
Libyan Arab Jamahiriya	15.5	9.5	6.7	2.9	772
Morocco	5.7	4.8	2.6	6.4	1 083
Saudi Arabia	2.0	..	3.9	..	7 493
Sudan	-2.3	..	1.0	..	295
Syrian Arab Republic	8.8	5.8	-2.4	-4.3	1 184
Tunisia	11.9	8.6	6.5	4.8	1 098
Turkey	6.9	4.6	7.4	3.5	14 136
Yemen	5.6	4.3	6.2	4.7	164
North Africa	7.0	5.6	5.3	3.8	15 657
Western Asia	7.6	5.4	4.0	2.0	44 427

Source: UNIDO data base, consolidated Industrial Statistics.
a/ 1970-1980.
b/ 1980-1990 (estimates).

In Saudi Arabia, SABIC, which controls major petrochemicals and fertilizer complexes in the Kingdom, has achieved good economic results. The production of petrochemicals, fertilizers and iron and steel amounted to 10.95 million tonnes in 1988, representing a 13 per cent increase in output over the preceding two years. SABIC revenues increased from $2.14 billion in 1987 to $3.75 billion in 1988, while net profits reached $?49 million in 1988, up from only $288 million in 1987. Sales and profits were expected to increase in 1989, since in the first half of 1989 SABIC profits increased by 20.5 per cent over the corresponding period of 1988.

The production of compound fertilizers would enable Saudi Arabia to meet the requirements of an expanding agricultural sector, and to export the surplus in regional and international markets. SABIC, which already produces 930,000 tonnes per year of urea, plans to expand the plant into compound fertilizer production in the early 1990s. On the other hand, the National Chemical Fertilizer Company, an affiliate of SABIC, which produces 500,000 tonnes per year of ammonia, is installing new units to produce 810,000 tonnes per year of compound fertilizers, 500,000 tonnes per year of granular urea and 10,000 tonnes per year of liquid ammonia.

The aluminium industry in the region continued in 1989 to build on its previous successes. All capacities were fully utilized and production, exports and intra-regional sales rose to record levels. In Bahrain and the United Arab Emirates, which are the two most important centres of the aluminium industry in the region, downstream industries also further diversified and increased their output. Low international oil and gas prices, in addition to increased demand, have also strengthened the competitive position of Arab aluminium exporters in world markets. The region is witnessing the expansion of existing capacities and the establishment of additional ones, owing to increasing world demand and existing shortages in supplies of the metal, following the significant decline in production capacities in Europe, the United States and Japan.

The removal of tariffs between GCC member States and recent infrastructural improvements including the causeway link to Saudi Arabia, have also greatly helped to strengthen the competitive position of Bahrain-based aluminium process industries. Most of the share of Saudi Arabia and Bahrain in production (77.9 per cent), corresponding to about 140,000 tonnes per year, is now sold in the GCC market to downstream industries. Thus, sales of aluminium metal to GCC countries including Bahrain increased from 40,000 tonnes in 1984 to 120,000 tonnes in 1989, with Bahrain alone absorbing 75 per cent of total sales to GCC countries. Downstream industries expanded in Bahrain. The Bahrain Aluminium Extrusion Company increased its production from 5,925 tonnes in 1987 to 7,000 tonnes in 1988. The sales of power-line cables, aluminium powders, rods for door and window frames and other products have all increased by between 16 and 30 per cent per annum during the past three years. The company was expected to expand its designed capacity from 6,000 tonnes per year to 14,000 tonnes per year by 1989.

For the cement industry 1988 and 1989 have been particularly difficult years of structural and cyclical adjustment. In those two years new plants have begun operations in Egypt, Jordan, Kuwait, Saudi Arabia, the United Arab Emirates and Yemen. In 1988, aggregate production capacity is estimated to have reached almost 50 million tonnes, but actual production and consumption in the region has only reached some 85 per cent of that figure. The cement industry in the region therefore faced the sudden problem of over-capacity, which was even aggravated by an extended period of economic recession.

Governments and industrialists have belatedly realized that investment decisions had not been co-ordinated, and had been based on overly optimistic projections of continuously booming demand. While new cement plants were still under construction, demand declined as a result of the continuing slump in oil prices. Total consumption in the GCC countries was 20.1 million tonnes in 1986, but fell to 18.5 million tonnes in 1987. The latest projections foresee a further decline, and aggregate subregional demand may not exceed 16 million tonnes in 1990. This development created very intense competition between previously established importers, regional cement producers and newly established plants.

Arab iron and steel producers had considerable problems establishing themselves in their markets, being faced with heavy international competition resulting from the existence of excess capacity in the world production of steel. In the GCC subregion, cheap products flood the markets, and this has caused financial difficulties for newly established plants. Moreover, competition among regional producers has aggravated the situation still further. Qatar, with the start of Saudi Arabian production at Hadeed, has lost most of the potential Saudi Arabian market. However, while there is a shortfall in iron and steel production to meet consumption needs in the GCC market, the industry suffers from under-use of capacity. Another major problem is that production is currently focused on products, namely bars and rods, that are largely oriented to the needs of the construction industry. For some of the relatively new plants, both technical and marketing difficulties caused heavy losses during the first few years of operation. In 1989 the industry made reasonable progress. Production and marketing has been consolidated. Most plants improved their viability and further capacity expansions are currently under consideration. The common concern for the development of the iron and steel industry brought Arab Governments closer together in their efforts further to improve regional industrial co-operation and intra-regional trade.

Despite short-run adjustment difficulties in production of steel as well as cement, heavy industry in general can be expected to fare well in the long run. The major reason is that the region has the advantage of cheap energy, the demand for which is projected to rise during the coming decade as in the 1970s. Thus, during the 1970s and even in the 1980s these industries have played the role of growth leaders in the region (see tables II.29 and II.30 for industry details). It should be noted that not only the downstream industries mentioned already but also the capital goods industries thrived; for example, electrical and non-electrical machinery and professional goods. A part of the growth appears to reflect machines and equipment produced in the region to service oil-related industries—a form of import substitution through "upstream linkages". Another part of the growth may reflect import substitution in consumer durables such as automobile parts, air-conditioning units and washing machines.

Such import-substituting manufacturing has been receiving encouragement through policy packages attractive to private investors (domestic or foreign).* The Jebel Ali Free Zone in Dubai provides an example of government efforts to lure foreign investors. The Zone permits 100 per cent foreign ownership, eliminates personal income tax and currency restrictions, and grants repatriation of capital and profits as well as tax holidays on corporate income for the initial 15 years. The Zone also provides first-class infrastructure, with cheap energy, water and low-priced feedstock from petrochemicals and natural gas as well as low-cost capital funding. Considering the regional market, with high per-capita income and consumption,

*On average, about 60 per cent of the industrial (mainly oil related) sector in the region is owned and run by the Government. Virtually all Governments are reportedly eager to reduce the high ratio.

Table II.29. North Africa: Annual average growth rates of MVA and manufacturing employment by industry, 1970s and 1980s
(Percentage)

Industry	1970s a/		1980s b/	
	MVA	Employment	MVA	Employment
Manufacturing	7.0	5.6	4.9	3.8
Food	6.3	4.9	4.5	3.8
Beverages	4.1	6.9	5.0	5.6
Tobacco	2.2	4.5	2.5	0.4
Textiles	5.7	3.7	2.6	3.2
Wearing apparel	6.5	9.2	5.0	7.5
Leather and fur	3.2	4.2	5.2	4.5
Footwear	4.4	5.4	4.2	3.9
Wood and cork	5.2	2.7	5.1	3.0
Furniture	4.4	4.3	4.5	4.2
Paper and paper products	7.7	3.7	3.2	3.1
Printing	5.6	3.9	5.3	2.7
Industrial chemicals	9.8	8.8	6.8	5.4
Other chemicals	5.3	4.2	10.4	2.7
Petroleum refining	11.5	5.1	4.5	1.7
Petroleum and coal products	14.9	13.3	-1.9	4.7
Rubber products	4.4	3.0	3.8	3.9
Plastic products	14.5	11.7	4.4	5.9
Pottery, china	8.7	6.0	4.2	2.9
Glass	11.5	4.8	4.3	3.3
Non-metallic minerals	13.1	8.6	6.1	4.6
Iron and steel	9.2	9.5	6.9	1.5
Non-ferrous metals	23.2	22.0	7.3	7.1
Metal products	4.7	5.7	6.8	3.7
Non-electrical machinery	10.6	7.6	8.0	5.3
Electrical machinery	8.3	7.8	7.3	2.8
Transport equipment	6.7	5.2	5.6	2.9
Professional goods	7.9	7.5	5.9	4.1
Other manufactur-	8.8	3.3	5.7	2.8

Source: UNIDO data base consolidated Industrial Statistics.
a/ 1970-1980.
b/ 1980-1990 (estimates).

Table II.30. Western Asia: annual average growth rates of MVA and manufacturing employment by industry, 1970s and 1980s
(Percentage)

Industry	1970s a/		1980s b/	
	MVA	Employment	MVA	Employment
Manufacturing	7.63	5.44	4.03	2.04
Food	6.41	4.39	1.20	0.82
Beverages	7.59	4.36	3.83	1.24
Tobacco	-0.55	3.76	3.78	-3.54
Textiles	8.47	2.30	4.54	1.42
Wearing apparel	9.55	8.82	6.66	6.71
Leather and fur	9.23	3.35	4.00	3..7
Footwear	3.58	5.73	4.02	3.68
Wood and cork	6.66	8.21	0.73	-6.33
Furniture	8.71	3.19	1.83	0.99
Paper and paper products	9.01	7.73	6.22	2.05
Printing	4.64	4.29	4.93	0.01
Industrial chemicals	14.78	11.67	7.80	5.35
Other chemicals	9.12	2.51	9.59	3.63
Petroleum refining	6.05	13.58	0.44	-3.07
Petroleum and coal products	25.06	18.67	6.56	5.86
Rubber products	10.36	3.46	6.19	3.47
Plastic products	13.28	13.36	4.87	2.18
Pottery, china	11.59	7.30	9.32	3.16
Glass	9.35	4.75	6.44	2.70
Non-metallic minerals	11.99	8.15	3.84	2.61
Iron and steel	8.43	10.15	4.27	3.45
Non-ferrous metal	12.85	10.31	8.61	3.35
Metal products	7.50	3.80	4.93	1.04
Non-electrical machinery	13.91	10.06	4.82	3.40
Electrical machinery	11.84	9.63	8.17	4.80
Transport equipment	5.73	5.76	9.09	4.24
Professional goods	16.34	7.87	8.82	6.51
Other manufactures	9.67	5.54	5.35	2.88

Source: UNIDO data base, consolidated Industrial Statistics. Employment data for Saudi Arabia not available.
a/ 1970-1980.
b/ 1980-1990 (estimates).

the Zone seems to contain ample growth potential for the coming decade. But whether these efforts to invite foreign direct investment into the region will in fact reverse the negligible or declining activity in recent years is a moot question (see table II.31).

Table II.31. Foreign direct investment in North Africa and Western Asia, 1984-1988

Investing country	1984	1985	1986	1987	1988
United States (million dollars)	15 377	15 306	16 259	16 260	..
Japan a/ (million dollars)	4 273	45	44	62	259
France b/ (million French francs)	238	1 115	652	738	..
United Kingdom (million pounds sterling)	- 8	-108	125	..	..
Germany, Federal Republic of b/ (million deutsche marks)	498	175	-143	165	318

Source: Middle East Economic Digest, vol.34, No.1 (12 January 1990), p.6.
Note: Exchange rates in January 1990: $1 = 5.889 French francs; $1 = 0.62 pounds sterling; and $1 = 1.713 deutsche marks.
a/ Including all OPEC countries.
b/ OPEC countries only.

Behind the generally rosy picture lurks a contrast between oil and non-oil producers. Among the countries belonging to the later group are the heavily indebted ones with total debt greater than their gross national products; namely, Egypt, Jordan, Morocco, Sudan and Yemen. They have more urgent needs than others to develop industries capable of exporting, and yet market conditions and factor endowments are unfavourable for them to do so. International (including inter-Arab) co-operation is desperately needed.

H. Indian Subcontinent

The change of Government in India in December 1989 appears to have been an event of the highest importance for industrial growth in the region.* There is some uncertainty regarding the extent to which the new Government might change the liberalization process set in motion by the previous régime. The current debate in India concerns whether the traditional policy stances based on the principles of egalitarianism and self-reliance should be re-emphasized. For the past few years, the rising demand by the burgeoning middle-class urban population boosted industrial growth. But higher growth of consumer durables (automobiles, colour television sets, washing machines etc.) is viewed as likely to produce import dependence, and as skewed in favour of the richer sections of society. Further, the consumer-durable-goods industry, being dependent on imported inputs, is held partly responsible for the recent balance-of-payments difficulties. A re-examination of policy is now in process, and mixed signals can be expected.

Meanwhile, other countries of the region have proceeded with their own policy steps to deregulate industry and to liberalize trade restrictions. For example, the Government of Sri Lanka, the leading proponent of free trade in the region, changed its policy stance from "regulating" to "facilitating", and from an "import-substituting" to an "export-

*India produces over three quarters of manufactures in the region.

promoting" type. A five-year tax holiday has been introduced for pioneering industries. Pakistan has also lately introduced a new policy package to stimulate private investment-led growth. A large number of rules restricting industrial activities have been abolished. For example, enterprises no longer need to obtain approval for output expansion and modernization (up to an as yet unspecified investment ceiling), for using 50 per cent or more imported raw materials, or for forming joint ventures with up to 49 per cent foreign equity. As in other regions, these steps to open up the region to the world economy are expected to bring new opportunities for trade and investment.

In reviewing the long-term MVA growth performance of the region, substantial improvement in the 1980s over the 1970s can be observed (see tables II.32 and II.33). MVA in the region grew by an annual average rate of 6.2 per cent in the 1980s, up from 3.4 per cent in the 1970s, despite a world recession in the early 1980s, fluctuations in exchange rates, interest rates and commodity prices, and several stock market disturbances. As a result of the region being relatively insulated from world business cycles, the impact of external shocks was minimal, and Governments could pursue an independent course of industrial development, in contrast to the experiences of Latin American and even South-East Asia.

Table II.32. Indian Subcontinent: annual average growth rates of MVA and manufacturing employment by country, 1970s and 1980s

Country and region	1970s a/ MVA	1970s a/ Employment	1980s b/ MVA	1980s b/ Employment	1987 MVA (millions of 1985 dollars)
	(percentage)		(percentage)		
Bangladesh	3.6	7.2	3.6	1.2	1 046
India	3.0	4.0	6.1	0.3	14 898
Pakistan	4.8	0.8	7.1	1.4	3 707
Sri Lanka	10.3	5.2	9.4	3.3	705
Region	3.4	3.9	6.2	0.4	..

Source: UNIDO data base, consolidated Industrial Statistics.
a/ 1970-1980.
b/ 1980-1990 (estimates).

The manufacturing sector achieved a weak employment growth in the 1980s (0.4 per cent per year) compared with MVA growth (6.2 per cent per year). In part, this resulted from an emphasis on capital-intensive, modern industries such as industrial chemicals, petroleum refining, plastic products, non-electrical machinery and transport equipment, and also from the negative employment growth in the textiles industry. Whether the long-run growth path should be a labour-intensive one under a more open policy régime remains moot.

In the short run, the regional MVA is expected to grow by 4.4 per cent in 1990 and 4.9 per cent in 1991—below the average for the past decade (see figure II.8 for GDP and MVA growth in recent years, and also for the pattern of structural change in industry). But the regional MVA is dominated by that of India. The situation in India is dealt with in greater detail below.

Table II.33. Indian Subcontinent: annual average growth rates of MVA and manufacturing employment by industry, 1970s and 1980s

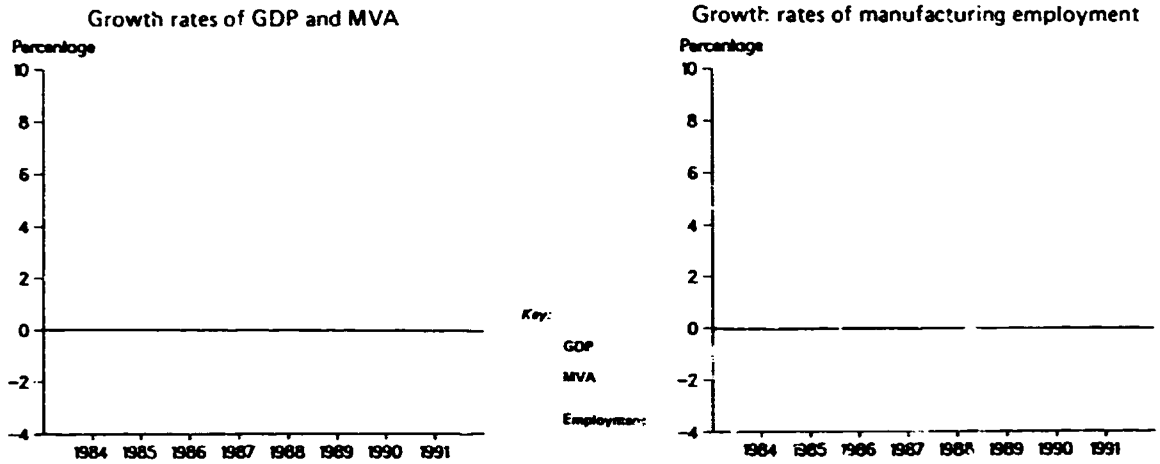
Industry	1970s a/ MVA	1970s a/ Employment	1980s b/ MVA	1980s b/ Employment
	(percentage)		(percentage)	
Manufacturing	3.4	3.9	6.2	0.4
Food	1.2	6.8	8.1	-3.0
Beverages	4.9	8.1	6.7	3.4
Tobacco	4.3	11.0	5.9	0.6
Textiles	2.3	2.6	..	-1.2
Apparel	9.1	8.8	9.3	6.1
Leather	4.4	1.1	4.1	3.3
Footwear	11.4	12.6	6.9	2.8
Wood products	4.1	2.7	0.9	0.8
Furniture	-2.1	-2.9	1.8	-1.4
Paper and paper products	1.5	3.6	1.7	1.2
Printing	1.0	-0.2	3.7	0.9
Industrial chemicals	2.6	5.7	10.9	2.8
Other chemicals	5.2	5.7	7.6	3.2
Petroleum refining	3.9	6.4	14.0	-0.2
Petroleum and coal products	16.5	10.6	4.2	5.4
Rubber products	0.0	2.6	7.2	0.9
Plastic products	4.0	2.1	7.7	3.0
Pottery	7.0	2.5	0.7	1.6
Glass	2.2	1.2	4.8	0.9
Non-metallic minerals	4.4	4.2	8.2	4.8
Iron and steel	4.8	4.1	4.9	2.6
Non-ferrous metals	-8.8	3.4	7.3	0.9
Metal products	2.2	1.1	3.4	0.9
Non-electrical machinery	5.5	2.8	6.9	2.1
Electrical machinery	5.7	3.9	9.3	3.1
Transport equipment	5.2	2.3	4.9	-0.8
Professional goods	3.7	2.2	16.1	2.5
Other manufactures	0.4	-3.3	11.6	1.5

Source: UNIDO data base, consolidated Industrial Statistics.
a/ 1970-1980.
b/ 1980-1990 (estimates).

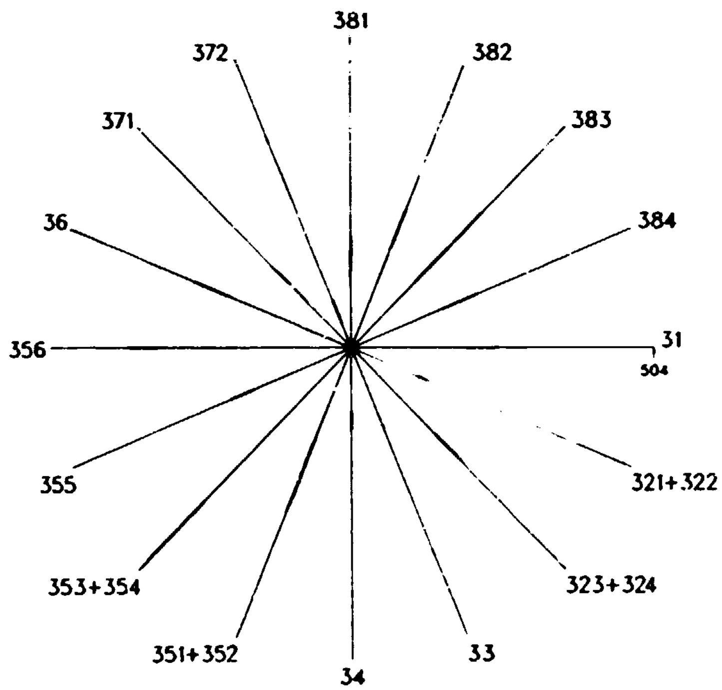
Assuming little policy change, Indian MVA is expected to grow by 6.9 per cent in 1990, a slow-down from an estimated 10 per cent in 1989 and 8.7 per cent in 1988, but still above the average of the region as a whole for all three years. Manufacturing exports boosted industrial growth. For example, cotton textiles recorded a 37 per cent increase to 14.5 billion Indian rupees (Rs) in fiscal 1989/90 from Rs 10.6 billion in the previous fiscal year, far ahead of the Rs 12 billion targeted. Likewise, exports of engineering products surged by 40 per cent to Rs 22 billion in fiscal 1989/90. Total exports grew by 37.8 per cent while total imports grew by 25.7 per cent. By dint of such export performance, the Government may raise the export target to Rs 400 billion for the fiscal 1990/91, up from Rs 280 billion in fiscal 1989/90, a 43 per cent increase. Rising export income permits greater amounts of intermediate inputs and parts to be imported for many modern industries in India.

One group of modern industries consists of consumer durables such as television sets, motor cycles, vacuum cleaners, refrigerators, sewing-machines and automobiles. A decade ago only about 150,000 televisions sets were sold; in 1989 over 6 million units were sold. In the case of automobiles, the decade saw a quadrupling of sales to 160,000 a year. Other items jumped also in production and sales, a phenomenon reflecting the formation of a middle class and vigorous entrepreneurship.

Figure II.8. Growth rates of GDP, MVA and manufacturing employment, 1984-1991, and industrial structural change, 1975-1991: Indian Subcontinent



Industrial structural change
(Index of value added: 1975 = 100)



g =	5.30
θ =	18.64

Key:

ISIC code	(industries):
31	(Food products)
321, 322	(Textiles)
323, 324	(Leather)
33	(Wood and furniture)
34	(Paper and printing)
351, 352	(Chemicals)
353, 354	(Petroleum and coal)
355	(Rubber products)
356	(Plastic products)
36	(Non-metal mineral products)
371	(Iron and steel)
372	(Non-ferrous metals)
381	(Metal products)
382	(Non-electrical machinery)
383	(Electrical machinery)
384	(Transport equipment)

Constant prices of 1980

g = Average annual growth rate, 1975–1991 (percentage)

θ = Index of structural change, 1975–1991

1985–1991 forecast
1980–1985
1975–1980

Sources: UNIDO data base; estimates and forecasts by UNIDO/PPD/IPP/GLO

Indeed, the 1980s witnessed 6.2 per cent average annual growth of the manufacturing sector compared with 3.4 per cent in the 1970s. Apparently, a package of measures designed gradually to liberalize external and internal businesses activity has played a crucial role in raising industrial growth performance. The package included a more liberal policy towards imports, freer entry into industry, emphasis on incentives for exports, modernization of industry, introduction of high technology, steps towards rationalization of the indirect tax structure and a revamping of infrastructure to raise its efficiency level. Together these measures created more room for industry to grow, especially in the consumer goods sector, and, by making the financing to modernize more accessible, led to an improvement in product quality, thereby increasing the competitiveness of a number of Indian products in export markets.

It should further be noted that the second half of the 1980s saw a higher MVA growth than the first half. The growth rate in the first four years of the 1980s was 6.6 per cent, while in the latter four years it was 6.9 per cent. This performance coincides with the progress of liberalization policies as well as with the easing of infrastructural bottle-necks, particularly in the supply of electricity. In addition, the improved industrial growth was sustained during the 1986-1988 period when bad weather damaged the agricultural sector. In earlier years, lowered agricultural output and income used to pull down the growth of the manufacturing sector. This did not happen in the last four or five years, suggesting a new growth track for the manufacturing sector as the latter has been increasingly linked with the world economy.

The economic variables that link the local economy with the world economy are numerous, including exports and imports of goods and services, flows of loans, foreign direct investment, technology transfers etc. But the last two have come to receive more attention in recent years because, as policy-makers realize, they can contribute quickly to productive capacity and strengthen the structure and competitiveness of industry. India, like other countries, saw a rapid pace of growth in foreign direct investment inflows and technology transfer in the 1980s (see tables II.34 and II.35). Undoubtedly, these factors also helped to boost industrial growth as observed already, as well as to churn out new consumer durables for the urban middle class. However, compared with other regions of the world, foreign direct investment in India appears rather minuscule. For instance, in 1988 India received Rs 2,398 million (equivalent to $137 million), compared with over $10 billion received by Thailand in the same year.

Table II.34. Foreign direct investment in India, 1984-1989
(Millions of rupees)

Country or investor	1984	1985	1986	1987	1988	1989a/
United States	89.50	399.25	293.70	295.15	971.37	182.55
United Kingdom	18.13	37.06	77.15	84.51	139.08	76.20
Japan	61.52	156.76	56.16	69.06	174.26	64.57
Germany, Federal Republic of	28.45	118.08	201.57	98.69	309.99	1 112.43
France	12.18	23.55	20.48	53.54	117.80	81.57
Italy	7.70	69.48	23.30	29.71	278.67	10.20
Indians abroad	146.40	190.40	79.04	207.74	167.99	177.19
Others	766.14	266.08	318.12	238.65	238.41	284.73
TOTAL	1 130.02	1 260.66	1 069.52	1 077.05	2 397.57	1 989.44

Source: Indian Investment Centre.
a/ January - June.

Table II.35. India: Number of permits issued for technology imports and joint ventures, 1981-1989

Country	1981	1982	1983	1984	1985	1986	1987	1988	1989a/
United States	85 (15)	110 (24)	135 (32)	147 (36)	197 (66)	189 (71)	196 (57)	191 (71)	82 (19)
Germany, Federal Republic of	74 (14)	110 (9)	129 (22)	135 (19)	180 (36)	183 (40)	149 (39)	178 (47)	72 (23)
United Kingdom	79 (9)	106 (16)	119 (22)	126 (16)	147 (26)	130 (23)	122 (27)	134 (36)	40 (12)
Japan	27 (4)	51 (5)	58 (7)	78 (5)	108 (15)	111 (15)	71 (15)	96 (16)	33 (16)
Italy	18 (1)	37 (5)	30 (2)	37 (4)	56 (11)	58 (8)	50 (10)	53 (18)	16 (5)
France	23 (3)	28 (6)	40 (4)	38 (5)	61 (8)	39 (9)	44 (10)	42 (13)	15 (2)
Switzerland	26 (4)	40 (8)	47 (9)	30 (4)	42 (4)	32 (8)	31 (11)	41 (8)	9 (4)
Netherlands	9 (2)	14 (-)	13 (2)	14 (-)	16 (3)	26 (11)	23 (6)	15 (3)	3 (1)
Australia	2 (-)	3 (-)	4 (1)	2 (-)	7 (-)	9 (3)	12 (5)	12 (2)	5 (1)
Sweden	11 (-)	16 (4)	15 (1)	14 (5)	29 (4)	29 (7)	19 (4)	11 (3)	10 (3)
Denmark	1 (1)	4 (1)	3 (2)	6 (1)	13 (2)	7 (2)	11 (3)	11 (4)	3 (-)
Republic of Korea	- (-)	2 (1)	2 (-)	3 (-)	5 (-)	14 (1)	15 (3)	11 (3)	4 (-)
Canada	2 (1)	1 (-)	6 (2)	8 (2)	15 (6)	15 (6)	9 (4)	10 (4)	5 (1)
Austria	8 (2)	8 (-)	3 (-)	8 (1)	14 (4)	16 (6)	9 (2)	6 (2)	1 (-)
Indians abroad	1 (1)	11 (11)	20 (16)	48 (36)	52 (36)	25 (8)	28 (27)	25 (23)	6 (5)
TOTAL	398 (57)	590(113)	673(129)	752(151)	1 024(238)	957(240)	853(242)	926(282)	355(102)

Source: Indian Investment Centre, as quoted in Japan External Trade Organization, Foreign Direct Investments, 1990 White Paper (Tokyo, 1990), p.442.
Note: Figures in parentheses indicate numbers of permits under joint venture arrangements. Total includes other countries not specified.
a/ January - June.

Despite the recent process of opening the economy and the accelerating MVA growth, the inward-looking policy régime still seems basically intact. Other major laws governing Indian industry have not been overhauled; they have been marginally tinkered with. The laws include the following: the Industrial Development and Regulation Act of 1951, with elaborate industrial licensing rules and a highly protective foreign trade regime; the Monopoly and Restrictive Trade Practices Act of 1969 to ensure against business concentration, with stringent and long inquiries to protect small-scale industries; and the Foreign Exchange Regulation Act designed to control foreign investment in India. These laws incorporate the basic Indian philosophy of egalitarianism and self-reliance, but, when implemented, they are often pointed out as the ultimate source of creating inefficiency, inhibiting growth and even encouraging rent-seeking activities on account of the perverse incentive system ([11], [12] and [13]).

If this analysis is correct, India seems to have a powerful avenue for industrial growth by continuing the process of gradual opening to the world market. However, the voice of opponents (inward-lookers) appears to have become stronger lately. One of them has argued as follows:

> "A more egalitarian and more self-reliant growth path might lead to a decline in the growth rate in the short run as the economy adjusts to lower imports and a different structure of production. But as the endogenous process of technology acquisition, absorption, diffusion and local adaptation gets going and as more and more people are productively employed, the rate of growth will pass that achieved under the inequalizing spiral strategy and, besides, will be more sustainable in the long run" ([14], p. 317).

Similar views are reportedly coming from Indian policy-makers.* It appears that India has come to a crossroads, and a choice must be made soon.

Whichever way India may choose to go, it seems clear that the industrial stagnation coupled with inefficiency of factor use experienced in the 1970s should not be repeated. The stagnating growth of Indian industry has been attributed to several factors, including: a slow-down in public investment; poor management of infrastructure; slow growth of agricultural incomes; and an industrial policy framework tending to discourage competition domestically and from abroad (i.e., imports) ([16], p. 4). In this connection, the estimate of total factor productivity (TFP) growth presented in table II.36 seems worth noting.

Table II.36. India: estimates of total factor productivity growth, selected industries and years
(Annual percentage)

Industry group	1959/60 to 1965/66	1966/67 to 1979/80
Food	-3.3	-3.7
Beverages	-2.2	-3.4
Tobacco	2.1	-6.1
Textiles	1.0	1.0
Footwear	0.9	0.7
Wood and cork	-7.9	-1.0
Furniture and fixtures	0.5	2.8
Paper and paper products	0.8	-0.2
Printing and publishing	2.3	-0.3
Leather and fur products	-1.4	-2.9
Rubber products	-10.9	-3.2
Chemicals and chemical products	-0.4	-1.6
Petroleum products	-20.5	0.8
Non-metallic mineral products	0.3	-1.8
Basic metals	2.1	-2.2
Metal products	-2.4	-2.2
Non-electrical machinery	-3.7	-0.1
Electrical machinery	-2.6	0.8
Transport equipment	0.9	-0.2
Miscellaneous	-12.7	-1.5
Total manufacturing	-0.1	-0.6

Source: I.J. Ahluwalia, "Industrial growth in India: performance and prospects", Journal of Development Economics, vols.23-24 (1986), p.4.

Between 1959/60 and 1965/66, TFP declined by an annual rate of 0.1 per cent for manufacturing as a whole, and 12 out of 20 industries registered negative TFP growth. This situation even deteriorated during the period from 1966/67 to 1979/80, with a 0.6 per cent annual decline in total manufacturing and 16 industries showing negative growth. Lack of competition or complacency appears to account largely for the retrogression in TFP growth.

Fortunately, in the 1980s India has been able to pull itself out of the long-term industrial stagnation, despite the world recession in the early years of the decade. The four factors mentioned above seem to have shifted toward improvement. In particular public investment increased its pace; infrastructure served industrial activities better; agricultural income rose thanks to the spreading of the green revolution; and industrial liberalization sparked investments, trade and competition.

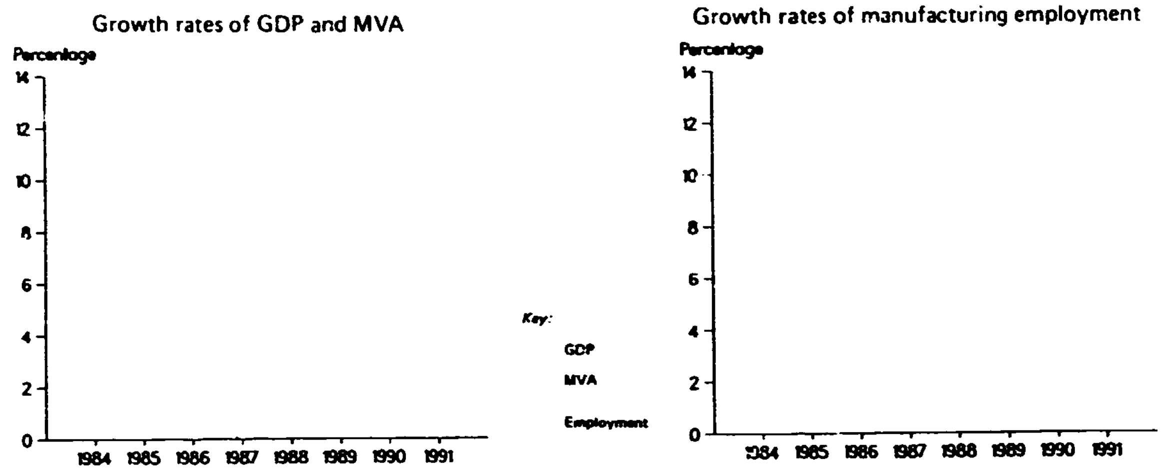
Unfortunately, higher industrial growth in the 1980s was accompanied by problems of inflation, external debt, income distribution and the persistence of a substantial proportion of the population living below the poverty line. Whether the new Government could produce a new policy package capable of solving those problems remains to be seen. But the decade of the 1990s presents a challenge to Indian policy-makers as to India's response to integration taking place in Europe, the western hemisphere, and even in the Asia-Pacific region.

I. East and South-East Asia

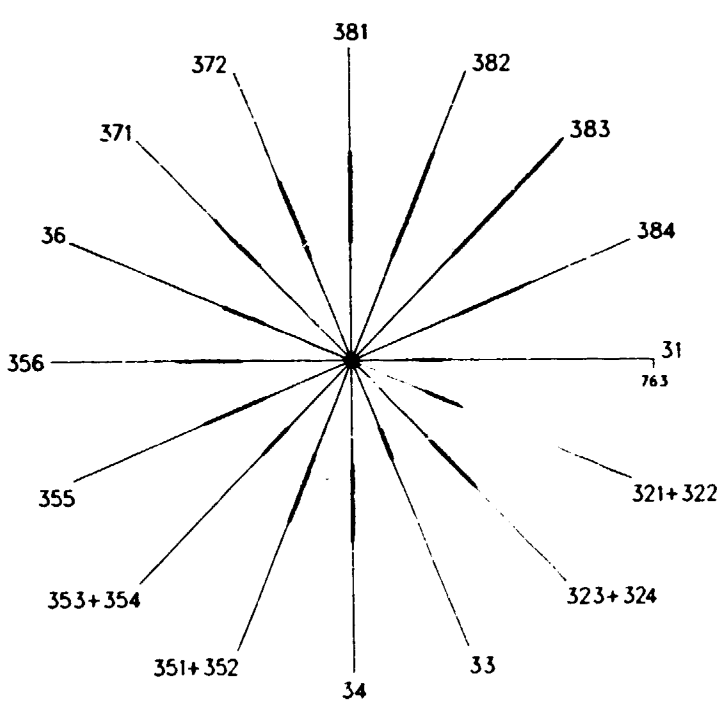
Burgeoning intraregional trade and foreign direct investment have helped to sustain a 6.7 per cent growth in both GDP and MVA in East and South-East Asia in 1989. Though this growth performance represents the highest figure compared with other regions, it still marks a considerable slow-down from an 8.3 per cent growth of GDP and 10.5 per cent growth of MVA in 1988 (see figure II.9 for GDP and MVA growth in recent years, and also for the pattern

*"Opposition to liberalization also appears to be coming from the Prime Minister's Economic Advisory Council, which has moved into a position of policy-making prominence. Chaired by academic economist Sukhamoy Chakravarty, the council has called for a strategy with adequate emphasis on removing disparities between sections of the population and regions, rather than just aiming for a higher rate of growth in aggregate output" ([15], p. 45).

Figure II.9. Growth rates of GDP, MVA and manufacturing employment, 1984-1991, and industrial structural change, 1975-1991: East and South-East Asia



Industrial structural change
(Index of value added: 1975 = 100)



g = 8.77
θ = 21.45

Key:

ISIC code	(industries):
31	(Food products)
321, 322	(Textiles)
323, 324	(Leather)
33	(Wood and furniture)
34	(Paper and printing)
351, 352	(Chemicals)
353, 354	(Petroleum and coal)
355	(Rubber products)
356	(Plastic products)
36	(Non-metal mineral products)
371	(Iron and steel)
372	(Non-ferrous metals)
381	(Metal products)
382	(Non-electrical machinery)
383	(Electrical machinery)
384	(Transport equipment)

Constant prices of 1980

g = Average annual growth rate, 1975–1991 (percentage)

θ = Index of structural change, 1975–1991

1985–1991 forecast
1980–1985
1975–1980

Sources: UNIDO data base; estimates and forecasts by UNIDO/PPD/IPP/GLO.

Table II.37. Foreign direct investment flows within East and South-East Asia, 1988

From to:	Indonesia		Malaysia		Philippines		Thailand	
	Million dollars	Percentage change on previous year	Million dollars	Percentage change on previous year	Million dollars	Percentage change on previous year	Million dollars	Percentage change on previous year
Japan	226	-56	214	134	95	229	3 063	217
Hong Kong	232	90	50	350	27	-3	446	266
Republic of Korea	209	1 249	9	1 013	2	100	109	742
Singapore	255	1 576	66	22	2	166	275	330
Taiwan Province	923	11 584	147	212	109	1 109	850	184
Total Asia	1 844	175	508	134	253	222	5 019	221
Total world	4 426	267	768	158	452	171	6 225	220

Source: Nigel Holloway, "NICs expand investment in Southeast Asia", Far Eastern Economic Review, 16 November 1989, p.71.

of structural change in industry). The downward trend reflects the world-wide cyclical phase and the dependence of the region on trade for growth. Barring an unexpected catastrophe in the world economy, growth in the region seems ready to bottom out in 1990. In the medium term, economic fundamentals appear sound.

The basic reasons for the dynamism of the region remain solid; namely, growing intra-industry trade among its countries, made possible through foreign direct investment and joint ventures; gradual shifts in policy toward more liberal movements of goods, services, capital, technology and management skills; continuous upgrading of the industrial base by introducing new products and new skills; and generally conservative macro-economic policy régimes, compared with the Latin American ones with rampant inflation and money-printing.

However, growth pains also abound, including: the problem of bottle-necks in infrastructure (electricity, water, harbours, roads, railways, warehouses, communication facilities etc.); a shortage of managers and skilled manpower; the threat of inflation (cost-push type); and political unrest in some countries. Some details of these and other factors are assessed below, and policy lessons and implications drawn.

During the past few years, flows of foreign direct investment from Japan and Asian NICs to Indonesia, Malaysia, Philippines and Thailand have accelerated (see table II.37 for 1988 figures). These flows play the role of a potent vehicle to spread industrial dynamism from one country to another and from one region to another. In the region, foreign direct investment from developed countries brought not only investable funds but technology, management skills and marketing knowledge. These factors, combined with cheap labour, abundant natural resources or both, make latent comparative advantage a powerful reality.*

*Most foreign direct investment went to build firms producing textiles, clothing, sport shoes, furniture, bicycles, sporting goods, toys etc. These are the products with which the Asian NICs started their industrialization in the early 1960s, often with Japanese funds and technology as Japan needed to shed them and move into more sophisticated products such as tape-recorders, transistor radios, colour television sets, automobiles and cameras. A study suggests that the export basket of the Republic of Korea is similar to that of Japan with a 15-year lag if calculated in terms of a "revealed comparative advantage" index ([17], p. 55).

A milestone was reached when the foreign direct investment contribution of Asian NICs to South-East Asia surpassed that of Japan in 1988. This seems to reflect the rapidity with which the Asian NICs need to restructure and upgrade their industries so as to keep up their competitiveness in international markets. Several circumstantial factors suggest themselves to explain the upsurge of foreign direct investment flows in the region.

One obvious reason first of all is that the Asian NICs have begun to experience labour shortages because of the success of their industrialization, and consequently rapidly rising wages (see table II.38). Labour intensive

Table II.38. Growth rates of wages in selected Asian countries and areas, 1985-1989
(Percentage)

Country or area	1985	1986	1987	1988	1989
Hong Kong	9.3	7.1	9.3	16.6	n.a.
Japan	2.1	3.2	2.7	1.5	5.2
Singapore	10.0	1.6	1.7	5.2	6.0
Republic of Korea	9.2	8.2	10.1	15.5	18.7
Taiwan Province	1.4	8.1	11.1	12.0	[illegible]

Source. Japan Economic Journal, 11 December 1989, p.9.

goods have lost comparative advantage, and firms have had to close down or migrate. Secondly, their export successes resulted in trade surpluses, and their currencies had to be revalued, an additional pressure for moving production sites. Thirdly, protectionism has increased in the developed importing countries against labour-intensive goods from Asian NICs. Last but not the least is the substantial relaxation of rules and regulations against foreign direct investment in the receiving countries.

All four receiving countries have been liberalizing their foreign direct investment policies gradually. But the experience of Indonesia stands out, particularly because of its erstwhile inward-looking stance with high protective walls. A sharp shift from this policy occurred in 1989, when the Government released an "Investment Negative List" to replace the "Investment Priority List". In effect this change opened 349 product lines previously closed to foreign investors (see table II.39 for industry details). Under the new

Table II.39. New activities open for foreign direct investment in Indonesia, 1989

Activity	Newly opened areas	Open with 65 per cent export commitment	Open to transnational corporations linked with small local firms	Other
Agricultural	2	1 (3)	8 (2)	5
Forestry	0	0	0	0
Manufacturing				
Various	179	16 (1)	22 (1)	6 (2)
Basic chemical	27	7	0	1
Basic metals and machinery	16	28 (16)	2	17 (15)
Small-scale	69	0	3	0
Support services	1	0	0	0
Mining and energy	13[a]	0	0	0
Communications	13	0	0	8 (3)
Tourism	6	0	0	1
Trade	6	0	0	4 (1)
Health	15	0	0	2 (1)
Housing and environment	0	0	0	1
Public works	2	0	0	5 (1)
TOTAL	349	52	35	50

Source: Investment Co-ordinating Board of Indonesia, as quoted in Business Asia, 5 June 1989, p.185.

Note: Figures in parentheses are the numbers of newly closed areas

a. Terms of investment set by the Ministry of Mines and Energy.

list, only 110 out of over 1,000 items are now restricted (including restrictions on rattan furniture, palm-oil processing, veneer, plywood, sawmilling etc.). The new rules also slashed the minimum investment to $250,000 from $1 million. This measure promises to lure medium-sized firms from Asian NICs.* Furthermore, firms that commit themselves to exporting 65 per cent or more of output will be permitted to invest in 52 more areas normally closed to foreigners.

These revised rules are expected to boost further the increasing tendency of foreign direct investment activities in export-oriented areas. In 1988, 72 per cent of all foreign direct investment projects were committed to export 65 per cent or more of output, a jump from 38 per cent in 1986. A large part of surging Indonesian exports are attributed to non-traditional manufactures produced by foreign subsidiaries or joint ventures. Apparently, the country has come to recognize and reap the benefits of making foreign direct investments an instrument of growth, using them to bring new technology and management skills along with capital and international marketing networks, all tailor-made to meet the needs of Indonesian industry and to speed up its restructuring.**

Looked at from the viewpoint of the whole region, these foreign direct investment activities are playing the role of "industrial linkage creator" among countries in the region. The cross-country industrial linkages so created represent *de facto* economic integration of a sort, without a formal agreement for membership or common tariff walls as in the case of the EEC.

In this process Japanese firms have been the initial economic catalyst. Through co-operating firms, for example, a Japanese electronics company could procure resistors made in the Republic of Korea, condensers made in Taiwan Province, transformers made in Hong Kong, magnetic heads and integrated circuits made in Malaysia and television cathode-ray tubes made in Singapore, and assemble them in Singapore or Malaysia for markets in Asia, the United States or even Western Europe. More and more manufactured goods are coming under this sort of cross-country arrangement for production and marketing, including automobiles, computers, telecommunication equipment, copying machines, videotape recorders and other electronic goods.

Transnational firms from Hong Kong, Republic of Korea, Singapore and Taiwan Province seem to be building (following the example of Japanese firms) their own networks of investment, production and trade in the region involving an increasing number of products and markets.* This is a region where first-rate engineers and corporate executives earn only about one quarter of the salary level of their United States counterpart. However, along with the well-trained work-force, they learn skills quickly in production and marketing.

Meanwhile, Asian NICs have shifted their output structure toward more capital- and skill-intensive industries. The major leading items of export now include colour television sets, videotape recorders, microwave ovens, automobiles, copying machines, personal computers, telefacsimile machines etc. But the policy-makers in Asian NICs realize the need to keep on moving into higher skill- and technology-intensive industries if their industrial dynamism is to be kept alive in the absence of natural resource endowments. Thus, for instance, the Republic of Korea has launched an R + D and investment programme for the next decade to enter into the aerospace industry, new materials, mechatronics, microelectronics (for example, 16-megabit dynamic random access memory) etc. (see table II.40). The new

Table II.40. Technology programme of the Republic of Korea in the 1990s (Millions of won)

Field of activity	1990-1994 Facility investment	R + D	Total	1995-2000 Facility investment	R + D	Total
Micro-electronics	68 200	47 760	115 960	..	..	..
Mechatronics	4 800	970	5 770	13 730	2 760	16 490
Aerospace industry	3 993	3 556	7 549	..	..	..
New materials	37 402	25 652	62 054	120 070	59 801	179 871
Fine chemicals	23 990	10 350	34 340	39 560	24 970	64 530
Biotechnology	..	4 157	..	..	..	..
Lasers	..	20 500	..	..	..	..

Source: Ministry of Commerce and Industry of the Republic of Korea, as quoted in Far Eastern Economic Review, 28 September 1989, p.142.

*Particularly those firms with Chinese connections in Indonesia, but with little financial and political clout.

**Thailand and Malaysia seem to have gone ahead of Indonesia in using foreign direct investments as an important growth agent.

*Some Japanese economists have coined a new phrase "the flying geese pattern" to describe the Asian pattern of industrial take-off in sequence beginning with Japan, Asian NICs and ASEAN countries. Conceptually, the product cycle approach has been applied and changes in the international competitiveness index have been plotted graphically to create an image of flying geese ([18], pp. 12-14).

The crucial role that productivity gains play in long-term industrial development cannot be over-emphasized. Development could be pushed through injections of more capital and labour without productivity gains (without, for example, technological innovation and structural change). Indeed, such "resource-intensive" growth could take place as in the case of the USSR (1970-1985) and India (1959-1979). Evidence from the Republic of Korea provides a contrast to the above cases, and reflects a rather significant contribution to industrial growth.

Table II.41 provides a measurement of total factor productivity (TFP) for manufacturing in the Republic of Korea during the period 1966-1985. For the 19-year period, TFP grew on average by a remarkable 3.1 per cent per year. Although the TFP growth shows an uneven pattern across different industries, positive growth is widespread with only one negative-growth industry (iron and steel). Some industries with a high proportion of import substitution have registered high TFP growth; namely, chemicals, petroleum refining and production, and paper products. This seems to contradict the generally accepted notion that import substitution is a poor route to productivity increases, a point further dealt with later.

As conventionally measured, TFP is a mixed bag of many dynamic elements, such as the following: increasing levels of skill through education and training, injection of superior technology either imported or domestically invented; successful introduction of new products; new ways of organizing factory floors; improvement of office management; and upgrading of output mix by factories as well as by the manufacturing sector as a whole. These elements come into play in fast-growing economies under competitive conditions and through government promotional measures.

While an investigation of the causes of TFP growth requires intensive quantitative research, the following historical facts should be kept in mind in considering the experience of the Republic of Korea They could provide historical and institutional clues as to how productivity gains have been achieved.

The fact to be noted first is the speed at which new products are added to exports composition. This information provides telling evidence of how new products made in the Republic of Korea have been accepted in the world market in terms of quality and price, thus indirectly revealing how quickly the producers have mastered new technology.

The export basket of the Republic of Korea has changed from silk yarn, tungsten ore, ginseng, plywood, cotton fabric, garments, footwear and wigs in the early 1960s to automobiles, colour television sets, videotape recorders, microwave ovens, telephones, computers, semiconductors, electronic chips, oil rigs, manufacturing plant facilities and petrochemical derivatives in the late 1980s.

In 1962 export items numbered only 69, but reached 5,270 by 1987 on the basis of the 8-digit classification of the Customs Co-operation Council Nomenclature (CCCN). In other words, on average, over 200 new products were added to the export basket every year. Export records imply that manufactures of the Republic of Korea were competitive in price and quality on the international market.

This also reflects rapid structural change in the industry of the Republic of Korea, from labour-intensive to capital- and skill-intensive, within the past couple of decades. Indeed the share of engineering industries (defined as the share of ISIC 381 to 385 in total MVA) climbed to over 40 per cent in 1986 from less than 15 per cent in 1965.

Such a rapid structural change has not come about under a *laissez-faire* régime. Studies reveal that government policy intervention has been extensive. Policy régimes can be reviewed from many different angles, but the following two aspects will be taken up since they provide a strong contrast to those of other developing countries: policies on competition in domestic and world markets; and policies on technological change.

The régime existing in the Republic of Korea could be described as pro-big-business and highly competition-oriented. It is well known that the Government fostered "*Chaebol* groups" with subsidized loans, and encouraged them to expand their output and exports as fast as possible—a growth-oriented policy

Table II.41. Annual growth rate of total factor productivity in the Republic of Korea by industry, 1966-1985 [a/]

(Percentage)

Industry	Total factor productivity growth	Growth rate of MVA	Growth rate of Capital	Growth rate of Labour
Food	4.4	14.8	11.7	6.7
Beverages	2.2	7.6	7.3	1.7
Tobacco	3.1	10.7	7.7	1.9
Textiles	2.0	12.3	12.8	5.9
Apparel and footwear	1.7	16.1	16.0	12.2
Leather and fur	6.3	30.9	10.7	18.1
Wood and cork	4.5	7.6	6.5	4.8
Furniture and fixtures	4.2	15.4	12.1	7.6
Paper	4.1	12.7	10.4	7.3
Printing	2.1	11.5	10.8	5.2
Chemicals	5.5	17.3	10.1	7.3
Petroleum refining and production	3.7	18.6	13.9	1.3
Rubber	1.2	15.2	15.2	10.6
Pottery, glass	0.6	13.6	16.1	7.5
Iron and steel and metals	-1.4	18.7	22.7	10.1
Metal products	1.8	18.2	19.5	9.7
Non-electrical machinery	2.5	20.7	20.2	10.8
Electrical machinery	1.9	25.0	26.8	17.1
Transport equipment	3.4	20.1	13.9	10.7
Other manufactures	1.8	15.9	19.3	10.1
Average	3.1	14.2	14.1	8.8

Sources: Hak-Kil Pyo, "Estimates of capital stock and capital/output coefficients by industries for the Republic of Korea (1953-1986)", Working Paper No.8810, (Seoul, September 1988, Korea Development Institute) and UNIDO data bank.

a/ Total factor productivity is measured using a Cobb-Douglas production function (Solow index).

from the Republic of Korea

even at the risk of sacrificing egalitarian concerns.*

The encouragement came in the form of subsidized loans, reduced profit tax, automatic use of foreign exchange to import raw materials for export production, and free commercial and technical information. Thus, risk-taking was made easier for the *Chaebols*. But these incentives were strictly linked to export performance. The fierce competition among *Chaebols* for exports resulted in the addition of new products such as automobiles, colour television sets, computers, videotape recorders etc., which tend to raise technological capabilities. However, to manufacture those products the *Chaebols* initially imported machines, technology and intermediate inputs from abroad (mostly from Japan). This meant that as output and exports to the world market soared (mainly in the United States), the Republic of Korea's bilateral trade deficits with Japan worsened. Furthermore, average domestic value-added content tended to decline as more new products were added to the export basket.

The Government stepped in to mitigate the balance of payments difficulties and to increase the domestic value-added contents of exports. The first step was to identify the following candidates for import substitution: machine parts and intermediate inputs that had been imported in large quantity, home production of which would save foreign exchange significantly; and products for which technological requirements could be met within a few years. The selection is done by a task-force committee consisting of industrial specialists, engineers, economists, bankers and government officers. The committee also selects "capable suppliers", who then become entitled to enjoy subsidized loans from special industrial development funds installed in the banking system.

To illustrate, in 1987 the Ministry of Trade and Industry designated 603 items in machinery, parts and advanced materials to be locally produced. Successful implementation of the scheme would save $1 billion from import substitution. Specific items include rubber injection presses, automobile parts cleaners, drum testers, high-vacuum coaters, chlorine automatic controllers etc. Over 400 suppliers, mostly medium-size enterprises, were to participate in the Koreanization projects, and received loans with low interest rates of about 5 per cent per year (compared with 10 to 12 per cent for commercial loans). If they learn to produce competitively against imports, these enterprises would create new linkages with the *Chaebols* which assemble parts. *Chaebols*, however, are not bound to buy domestically produced parts, putting pressure on suppliers to be up to world market standards in quality.

Another important policy instrument to enhance competitiveness was provided by import liberalization. This was used as a tool to expose domestic industry to international competition in a gradual manner. The Government has been pursuing a long-term goal of import liberalization by reducing tariff rates and import licensing. Since the mid-1960s the average tariff rate was gradually reduced from 40 per cent until in 1984 it stood at 21.9 per cent, although the rate for finished products was higher than that for intermediate products or raw materials.

Licensing requirements for imports have also been gradually reduced since the mid-1970s. The trend is reflected in the number of product items placed on the automatic approval list announced annually. As a proportion of items at the four-digit level of the CCCN, the automatic approval items increased from 49 per cent in 1975 to 92 per cent in 1986, and to 95 per cent in 1988. Every year new product items have been added to the list; the choice is based on whether a specific product has become competitive enough to be able to meet foreign competition. Also, pre-announcement of specific items warns producers to prepare themselves. However, if there is a sign that producers may falter because of the import competition, then the product is placed on the import surveillance list. The government authority monitors carefully whether imports are hurting the industry, and if necessary, the product is pulled from the list of automatic approval for import.

Regarding technology policy, the Republic of Korea had been restrictive in technology imports, like many other developing countries, to protect domestically developed technology. But the restrictions have been gradually removed since the early 1970s. For instance, the ceiling on royalties, the limit on contract duration, and the prohibition on export restrictions were abolished. In 1984, the approval system was changed to a reporting system. The Government then turned to the encouragement of domestic R+D by means of subsidized loans, tax holidays and special depreciation allowances for R+D-related investments and training facilities. Competition among producers, particularly *Chaebols*, in innovation and new products along with these incentive measures forced enterprises to increase R+D expenditures. As a result, the government-private ratio of R+D expenditure reversed from 71-29 in 1970 (totalling 10.4 billion won or 0.4 per cent of GNP) to 20-80 in 1986 (totalling 1,378 billion won or 2.5 per cent of GNP).

An evaluation of R+D in in the Republic of Korea suggests that domestic R+D efforts complement technology imports by making them more effective through adaptation and improvement rather than competition with domestic technology development capabilities.

To sum up, policy-makers in the Republic of Korea have seemingly been more concerned with dynamic efficiency gains than static efficiency. They have used policy tools well known as price distorters, such as subsidized loans, tax reductions, foreign exchange allowances and accelerated depreciation. However, these tools were used to promote exports, new products, innovation and modernization of the industrial base (towards, for example, a higher level of technology). Building up an export record provided clear-cut performance criteria for the Government to award incentive benefits to an enterprise. Thus the stringent market test of producing quality output at an acceptable price in the international market was adopted. The criteria served to minimize rent-seeking activities, since falsifying export records was rather difficult. The record of industrial growth suggests that dynamic gains in efficiency have more than offset losses in static efficiency or the adverse effect of price distortions.

*By contrast, in India, industrial enterprises both public and private are subject to the Monopolies and Restrictive Trade Practices Act. Under the law, enterprises must obtain permission to expand output beyond a licensed amount or to produce new merchandise. The primary aim is to protect small-scale industries and to discourage monopoly power.

United States rethinks

A confluence of world trends and events has turned the attention of the United States toward rethinking the structure under which it conducts its economic relations with the developing economies of Asia. The United States now faces chronic trade deficits, strong competition from Asian exporters, a growing Asia-Pacific trading bloc, the need to recycle East Asian capital surpluses and volatility in foreign exchange markets. Such economic considerations have combined with a thaw in East-West military relations that has placed more emphasis on economic factors in discussions of national security policy. This has elevated the importance of the Asian economies in United States policy-making.

Both the administration of President George Bush and members of Congress have proposed new institutional arrangements for United States relations with Asian trading partners. These include Secretary of State James Baker's proposed pan-Pacific entity, Senator William Bradley's Pacific-8 proposal, Senator Alan Cranston and Representative Mel Levine's Pacific Basin Forum, and various combinations of free-trade agreements.

Limits on power

A decade ago, similar proposals died out primarily because most people in the United States could see no compelling need for closer economic co-operation among countries of the Pacific Rim. Many in the United States also suspected that such a formal organization could cost more than it would provide in benefits. Since then, however, the limits on United States economic power have forced it to reach out to co-operate and build coalitions with its Asian trading partners. For example, the United States is unlikely to be able to resolve world financial problems, such as developing-country debt, without co-operation from the cash-rich Pacific economies.

In addition, many in the United States feel that more needs to be done to resolve trade issues despite the passage of the Omnibus Trade Act in 1988. One line of thought calls for more free-trade areas patterned after the Canada-United States agreement or the more unified EEC. The rationale for such an approach is that the level of interdependence between the United States and the economies of the Asia-Pacific region is so great that relationships should not be threatened by constant bickering over market access and perceived unfair trade practices. Trade friction has often threatened to damage political, security and cultural ties.

In terms of legislation, most of the bills introduced in the United States Congress focus on a free-trade agreement with Japan. Representative Philip Crane, however, has sponsored bills that would also authorize such agreements to be established between the United States and Taiwan Province, the Republic of Korea and ASEAN. The advantages envisaged include mutual economic benefits in the form of trade generated, greater economic efficiency, enhanced competition and lower consumer prices, removing the remaining formal and informal barriers to trade in each

*By Dick K. Nanto, Congressional Research Service, Library of Congress. The personal viewpoint of the author is expressed in the above article.

programme envisages raising R + D expenditures to 5 per cent of GNP by the year 2000 from about 2 per cent in 1987 ([19], p. 49). Total factor productivity (see box, pp. 82-83) is expected to increase as a result of the programme.

The real source of Asian dynamism and industrial competitiveness thus stems from the commercial application of new technology as well as its quick spread among countries in the region. In this process, foreign direct investment has become a leading agent for technology transfers. The policy shift toward liberalizing the movement of goods, services, technology, capital and management skills is expected to continue in the region, in line with world trends, and the dynamism so created can even spill over to trade partners in other regions.

However, some country-specific problems have emerged. For instance, the infrastructure of Malaysia seems to be lagging behind the surging demand particularly for water, electricity and highway systems. Japanese consumer electronics companies (representing more than half of Japanese total investment) complain about power failures, even for a few seconds, which cripple computer-controlled equipment. There is also a shortage of industrial managers, systems analysts and engineers. Rapid industrial growth in Thailand has also brought similar problems of bottle-necks and shortages. The Republic of Korea has suffered from labour unrest, while the Philippines has been plagued by political problems and business uncertainties. But on the whole, these problems do not appear damaging to the basic dynamism of the region.

As to the extraregional concerns, the EEC 1992 and the opening up of Eastern Europe loom large. Especially ASEAN countries have had historical ties with Western Europe, and hence they seem to be more worried than others about the possibility of a weakening economic linkage with Europe, or even losing out in the flux of events. For instance, fears have been expressed about foreign direct investment and overseas development assistance being diverted to Eastern Europe. But at least for the next couple of years, the absorptive capacity of Eastern Europe may not be so large as to cause ASEAN to lose out in sharing global foreign direct investment or overseas development co-operation. Foreign direct investments, in particular, aim at long-term private profitability, and whether Eastern Europe will offer superior profitability is debatable.* In the case of overseas development co-operation, fiscal constraints in co-operating countries (for example, the United States—see box above) may prompt some diversion to Eastern Europe at the expense of ASEAN countries, depending upon the pull of geopolitical factors.

*See section D on Eastern Europe and the USSR in the present chapter.

trade ties with Asia*

country, and providing an effective vehicle for developing rules in non-traditional areas such as services, investment and intellectual property rights.

United States opinion leaders seem to feel that if a free-trade agreement were established, it should be consistent with GATT and broad in its coverage of other economic issues. One concern is that the United States market is so large that a free-trade agreement with an Asian economy would give away more market opportunities than it would gain.

The earliest that Congress could give serious consideration to the free-trade agreement bills would probably not be before the mid-1990s. As of 1990 the focus of United States trade policy has been to proceed with the Uruguay Round and to continue bilateral, market-opening efforts.

In June 1990, Secretary of State Baker announced that the administration would explore the possibilities for a new mechanism for multilateral co-operation among the countries of the Pacific Rim. He indicated that he did not intend to offer a definitive blueprint but would be looking for consensus among Asia-Pacific leaders.

In Congress, Senator Bradley has proposed forming a coalition of eight Pacific countries to co-ordinate exchange rates, seek solutions to the debt crisis of developing countries and negotiate common positions for GATT negotiations. Although members of the group would not provide trade preferences to each other, the four industrial and four industrializing countries would co-operate on international economic policy.

Wrong focus

Senator Cranston and Representative Levine have introduced bills calling for a Pacific Basin Forum to discuss economic, diplomatic and other issues unique to the region. The forum would include annual meetings with a permanent secretariat to do research and pursue dialogue on long-range concerns of mutual interest in the Pacific.

United States policy has long favoured close co-operation among Pacific Basin countries. In 1985, former President Ronald Reagan directed executive branch officials to promote closer co-operation with countries in the Pacific Basin through expanded involvement in such regional forums as the ASEAN 6+5 dialogue framework (ASEAN plus the five industrialized countries of the Pacific) and the Pacific Economic Co-operation Conference. As of mid-1989, however, there was no agreement on a detailed plan to create a governmental Pacific Basin institution.

The current consensus seems to be that the United States should remain actively engaged in discussions on creating a Pacific institution, if only to avoid formation of an organization that would pursue Western Pacific interests at the expense of those of the Eastern Pacific. There is some concern, however, that the focus on creating a formal institution could divert attention from the actual work of fostering greater economic co-operation or could provide participating countries with an excuse to delay further market liberalization.

Source: Journal of Japanese Trade and Industry, vol 8, No 6 (November/December 1989) p 16

In a broader view, greater Europe, including the USSR, could also be important to East and South-East Asia, as a possible area of market diversification. The bulk of the region's trade depends on markets in North America. But the latter region would seem to offer little room for further expansion of export and investment outlets for Asian business. The new development of market forces in Eastern Europe and the USSR could offer the desired opportunities for co-operation and diversification.*

J. China

The drastic contractionary policy imposed on the economy in 1989 yielded a growth recession and unemployment, reversing the trend of double-digit industrial growth throughout the 1980s. The next three years or more are likely to witness a carefully measured pace of industrial growth, at for instance around 6 per cent (GDP at 5 per cent) in 1990 (see table II.42 for growth performance in 1989). The Government announced in November 1989 an economic adjustment programme aimed at "rectifying" a series of problems that emerged in recent years. They include inflation and run-away money supply and investment, mismatching of industrial output (that is, acute shortages of raw materials and intermediate inputs), infrastructure bottle-necks (with overloaded systems of transport, communications, power and water supply etc.) and enterprise-level inefficiency, tax evasion, and disarray in decision-making power and accountability. The essence of the policy challenge still remains finding an "optimum mix" of planned economy and market forces tailored to the needs of China. For a while, government controls are expected to increase under the new programme.

In 1989, virtually all industrial growth indicators dropped sharply: light industry output grew by only 8.4 per cent, down from 22.1 per cent in 1988; likewise heavy industry output grew by 8.2 per cent, down from 19.4 per cent in 1988 (see table II.43 for other indicators). It should be kept in mind that the rate of inflation was 17.8 per cent in 1989, slightly down from 18.5 per cent in 1988. Investment appears to have borne the major brunt of the contractionary policy measures. State-owned enterprises slashed investment by 9.2 per cent, collective enterprises by 28.1 per cent, and private enterprises by 4.3 per cent.

The change in output composition reflects the policy-induced negative growth in investment. The hard-hit capital-goods industry includes steel ships, locomotives, machine tools, motor vehicles and tractors (see table II.43). In the case of consumer-goods

*Exports of the Republic of Korea to the USSR went up by 40 per cent and imports by 128 per cent in 1989, while trade with Eastern Europe almost doubled in the same year

Table II.42. China's economic indicators, 1988 and 1989

Item	1988	1989	Percentage change 1988-89 (nominal)	Percentage change 1987-88 (nominal)
	(billion yuan renminbi)			
Output				
Total industrial output	2 020.3	2 188.0	8.3[a]	20.8[a]
Light industry	987.1	1 070.0	8.4[a]	22.1[a]
Heavy industry	1 033.3	1 118.0	8.2[a]	19.4[a]
Gross agricultural output	634.1	655.0	3.3[a]	3.9[a]
Net material product[b]	1 253.6	1 300.0	3.7[a]	11.1[a]
Gross national product[c]	1 508.9	1 567.7	3.9[a]	10.8[a]
Investment				
Investment in fixed assets	449.4	400.0	-11.0	18.5
State-owned enterprises	276.4	251.0	-9.2	17.3
Collective enterprises	71.2	51.2	-28.1	13.5
Private enterprises	102.2	97.8	-4.3	25.4
Capital construction	157.4	153.8	-2.3	14.9
Energy	60.0	62.6	4.3	24.0
Transport and telecommunications	33.0	33.9	2.8	14.1
Investment in projects under construction	1 054.7	992.5	-5.9	12.0
Domestic trade				
Total value of retail sales	743.9	810.1	8.9	27.8
State enterprises	293.6	314.4	7.1	29.9
Collective enterprises	255.8	272.7	6.6	21.2
Joint ownership	2.7	3.0	11.4	27.7
Individual ownership	132.4	148.4	12.1	21.2
Peasants (sales to non-rural residents)	59.5	71.7	20.5	29.1
Consumer goods	653.5	708.4	8.4	27.9

Source: State Statistics Bureau of China.

a/ Real growth rates.

b/ Net material product is national income.

c/ Gross national product is the added value of all material and non-material production, excluding the value of all intermediate products and services.

Table II.43. Capital goods and consumer goods produced in China, 1988 and 1989

Item	1988	1989	Percentage change 1988-1989
Capital goods output			
Cotton yarn[a]	4.66	4.74	1.8
Paper and paper board, machine made[a]	12.70	12.80	0.8
Synthetic detergents[a]	1.32	1.43	8.4
Aluminium wares[b]	89.90	79.20	-11.9
Energy production, i.e. standard fuel[c]	0.96	1.00	4.4
Crude coal[c]	0.98	1.04	6.1
Crude oil[a]	136.32	137.00	0.5
Electricity (billion kilowatt-hours			
Hydroelectricity	109.14	118.20	8.3
Steel[a]	59.46	61.24	3.0
Rolled steel[a]	46.91	47.55	1.7
Cement[a]	209.94	207.30	-1.4
Timber (million cubic metres)	62.18	61.00	-1.9
Sulphuric acid[a]	11.11	11.41	2.7
Soda ash[a]	2.61	2.98	14.2
Chemical fertilizers[a]	17.40	18.55	6.6
Chemical insecticides[b]	179.10	223.70	24.9
Power-generating equipment capacity (million kilowatts)	11.09	11.56	4.2
Machine tools[d]	191.76	165.30	-13.8
Motor vehicles[d]	644.61	573.70	-11.0
Tractors[d]	47.22	43.30	-8.3
Steel ships, civilian use[a]	1.60	1.23	-23.0
Consumer goods output			
Cloth (billion metres)	18.79	18.60	-1.0
Woolen fabrics (million metres)	286.02	270.00	-5.6
Sugar[a]	4.61	4.96	7.6
Crude salt[a]	4.61	28.02	23.8
Cigarettes (million crates)	30.97	31.96	3.2
Bicycles[e]	41.40	36.72	-11.3
Television sets[e]	25.06	27.01	7.8
Colour television sets[e]	10.38	9.38	-9.6
Tape-recorders[e]	25.41	22.46	-11.6
Cameras[e]	3.12	2.30	-26.3
Washing-machines, household[e]	10.47	8.26	-21.1
Refrigerators, household[e]	7.57	6.62	-12.6

Source: State Statistics Bureau of China.

a/ Million tonnes.

b/ Thousand tonnes.

c/ Billion tonnes.

d/ Thousands.

e/ Millions.

output, "luxury items" suffered negative growth, namely cameras, washing-machines, refrigerators, tape-recorders and colour television sets.

The austerity programme knocked down the inflation rate to around 7 per cent by the first quarter of 1990, but at the cost of factory closures, bankruptcies in the private sector* and lay-offs of over 15 million of the 135 million workers in State enterprises. Furthermore, wage earners' incomes have been reduced by stopping bonus payments, with 10 per cent of wage payments being diverted to the compulsory purchase of government bonds.

The reason for economic retrenchment is evident. Between 1979 and 1988, GNP grew by an annual average of 9.6 per cent and the trade volume by 17.4 per cent annually. Although per capita income rose in both rural and urban areas, "run-away development" brought with it tremendous inflationary pressures particularly because of the "underdeveloped banking system". Given the political and administrative régimes, the central bank has little power to control the money supply created by local banks in different provinces as well as by fiscal deficits of Government at various levels.** It would seem rather difficult and costly to control inflation at below 10 per cent, as the Government aspires, without reforming the banking system itself.

The decade-long rapid industrial growth also gave rise to the problem of raw materials and other input shortages for many industries. The problem stems in part from the legacy of central planning and under-development of the raw-materials distribution system or the market. By contrast, processing industries burgeoned, requiring ever-increasing input materials of all sorts. The practice of reselling raw materials and intermediate inputs allocated to the planned sector fetched easy profits to State enterprises and State bureaux overseeing the allocation processes.* The rising raw material prices failed to bring about supply increases as the market was not yet well developed, that is, the State monopoly was still dominant.

Similar observations can be made regarding infrastructure bottle-necks, particularly in energy, trans-

*The industrial shake-out closed 1 million "township enterprises" and 2.1 million private businesses in 1988.

**For an informative discussion and analysis, see Li Yungi, "China's inflation: causes, effects, and solutions", *Asian Survey*, vol. 24, No. 7 (July 1989), pp. 655-668.

*Examples are rolled steel, petroleum products, plywood, timber, silicon manganese, paper and compressors. See Liu Jianjun, "China cleans up companies to stop official profiteering", *Beijing Review*, 13-19 November 1989, pp. 14-19.

port and communications. For example, the energy bottle-neck became acute in 1989 after the industrial sector grew by over 20 per cent in 1988, triple the power growth rate (6.7 per cent for electricity production and 6.1 per cent for coal production). The long-term energy plan envisages a 7 per cent annual growth of electricity until the end of the century. This is likely to set a physical constraint for the industrial sector to remain at single-digit growth rates.

The three-year economic adjustment programme contains both macro- and micro-policy elements affecting industrial growth by attempting to solve the above-mentioned problems. Major items in the package are as follows: monetary and fiscal squeezes that infringe upon enterprise activities; government expenditures that attempt to ease the mismatching of industrial output and infrastructural bottle-necks; and introduction of an "enterprise contract system".

Concerning monetary and fiscal squeezes, the Government tightened credit in 1989 largely by reducing public investment projects. These projects have been usually financed by money creation. Money supply jumped by 46.8 per cent in 1988, compared with 19.4 per cent in 1987, but the latest report indicates only 9.8 per cent growth in money supply in 1989.* Though the grip may be somewhat loosened in 1990, tight credit is expected to continue.

With respect to the problem of shortages (of, for example, raw materials, intermediate inputs, energy and transport), the policy position appears to be oriented toward more control than in the past. A Government report states the following:

> "In industrial production the State will set more mandatory targets this year for some major raw and semi-finished materials and products in short supply . . . More key and scarce materials will be distributed solely by the State. We shall also place a proportion of the sales by enterprises of certain important means of production under state guidance in order to guarantee production and construction of key projects specified by the State . . . We shall also introduce a public sales system and fix price ceilings for major means of production manufactured and sold by enterprises outside the State plan".**

At the enterprise level, the Government is also trying to exercise its control by introducing a "contracted managerial responsibility system". The system could take varied forms, but essentially the amount of profits retained by enterprises is connected to the total wage bill and "overall enterprise performance" to be defined by annual negotiation between the State and the manager. The negotiable items include planned allocation of energy, raw materials, semi-finished materials etc., in exchange for a certain amount of tax payments. How these new devices will work out toward greater efficiency over the earlier planning method remains to be seen.

While domestic reform measures represent a retrenchment, the reform measures on foreign direct investment toward greater liberalization provides a contrast. In April 1990, the Government revised the earlier (1979) law on joint ventures, adding several important features. First, the new law did away with the time limit on foreign contracts. The purpose is to encourage foreigners to keep on investing. With a time limit they became reluctant to invest in their operation as the end of their contract drew near (the average has been 14 years). Secondly, a foreigner is now allowed to chair the board of joint ventures. Thirdly, the State will not nationalize or expropriate joint ventures. Finally, a joint venture need not necessarily use only the Bank of China for its remittances abroad; any bank with State approval to handle foreign exchange transactions will do. The apparent aim of these reforms is to attract more foreign capital, technology and skills in management and marketing. These measures may, to a certain extent, compensate for the curtailed domestic investment under the austerity programme.

Between 1979 and 1989, 21,739 projects have been approved, with a total contractual investment of $33.8 billion. But only $14.9 billion have been used, of which $6.9 billion came from ethnic Chinese abroad. Recently, China has been urging foreigners to invest more, especially Japanese companies, which appear rather cautious. Although Japan's direct investment in China has more than doubled between 1984 and 1988 (from $225 million to $514 million), the rate lags far behind that for other regions (see table II.44). Japan's total direct investment has grown nearly fivefold during the 1984-1988 period (from $10.2 billion to $47 billion). Japan has been the target of criticism as tending to move too quickly into other countries and regions. Japan has also been the second-largest trade partner of China (see table II.45). It remains to be seen whether the more liberal foreign direct investment policy will stimulate greater foreign direct investment activities under the austerity programme currently in effect.

To sum up, China is still searching for an optimum mix of central control and market mechanism. This provides a challenge not only to China, but to some Eastern European countries as well. The trial-and-error method demands patience, time and money. The short- and medium-term outlooks do not seem to allow unmixed optimism.

Table II.44. Utilization of Japanese capital in China, 1984-1988
(Millions of dollars)

Item	1984	1985	1986	1987	1988
Total utilized capital	1 071	1 591	2 898	2 859	3 345
	(39.6)	(35.7)	(39.9)	(33.8)	(32.8)
Borrowing	847	1 276	2 697	2 593	2 756
	(65.9)	(50.9)	(50.1)	(44.7)	(42.5)
Direct investment	225	315	201	219	514
	(15.9)	(16.1)	(10.7)	(9.5)	(16.1)

Source: Ministry of Foreign Economic Relations and Trade of China, as quoted in Business China, 12 February 1990, p.19.

Note: Figures in parentheses show the percentage share of Japan in total foreign capital utilization by China. Direct investment includes equity, co-operative, and wholly owned ventures as well as oil exploration.

*In part, the contraction of money supply originates from the decision of the Government in October 1988 to postpone 18,000 construction projects involving 13 billion yuan renminbi worth of investment loans.

**See Zou Jiahua, "Report on implementation of the 1989 Plan for National Economic and Social Development and the Draft 1990 Plan", as printed in *Beijing Review*, vol. 33, No. 17 (23-29 April 1990), p. viii.

Table II.45. Major trade partners of China, 1989

Country or area	Total trade (million dollars)	Exports f.o.b. 1989 (million dollars)	Exports f.o.b. 1988-89 (percentage change)	Imports c.i.f. 1989 (million dollars)	Imports c.i.f. 1988-89 (percentage change)	Balance
Hong Kong	34 457.56	21 915.91	20.0	12 541.65	4.7	9 374.26
Japan	18 896.96	8 362.46	5.8	10 534.50	-4.5	-2 172.04
United States	12 254.39	4 391.01	29.8	7 863.38	17.9	-3 472.37
Germany, Federal Republic of	4 987.77	1 608.67	8.4	3 379.20	-1.6	-1 770.43
USSR	3 996.58	1 849.25	25.3	2 147.33	20.5	298.08
Singapore	3 191.73	1 692.83	14.3	1 498.90	47.2	193.93
Italy	2 550.05	714.69	-4.2	1 835.36	18.5	-1 120.67
France	1 947.67	527.41	2.4	1 420.26	43.9	892.85
Australia	1 894.98	423.13	17.0	1 471.85	32.9	-1 048.72
United Kingdom	1 718.67	635.14	-3.6	1 083.53	20.6	-448.39
Canada	1 489.59	411.73	5.6	1 077.85	-41.9	-666.13
Thailand	1 256.16	499.89	-1.9	756.27	19.6	-256.38
Netherlands	1 209.54	759.39	1.4	450.15	22.6	309.24
Malaysia	1 044.60	352.21	[illegible]	[illegible]	21.7	-340.18
Brazil	1 024.47	84.46	[illegible]	[illegible]	17.8	-855.55
Czechoslovakia	897.10	375.56	2.2	[illegible]	10.6	-145.98
Indonesia	805.22	222.88	-5.7	[illegible]	-14.6	-359.46
Romania	777.86	304.81	-25.0	[illegible]	-18.4	-168.24
Switzerland	705.32	179.21	-21.5	[illegible]	7.1	-346.90
German Democratic Republic	670.69	331.41	7.0	339.28	-12.6	-7.87
Belgium	624.70	249.62	-0.1	375.08	2.6	-125.46
Macau	615.00	468.99	6.1	146.01	-0.3	322.98
Pakistan	592.43	368.07	11.6	[illegible]	306.3	143.71
Argentina	576.01	8.91	[illegible]	567.10	36.9	-558.19
Democratic Republic of Korea	562.72	377.37	9.3	185.35	-20.7	192.02
Spain	498.31	158.10	36.8	340.21	9.9	-182.11
Cuba	441.29	212.25	36.4	229.04	-21.8	-16.79
Sweden	422.97	138.59	15.5	284.38	-5.3	-145.79
Poland	371.34	382.82	3.2	365.12	9.5	17.70
Jordan	351.63	319.18	-56.0	32.45	-15.5	286.73
New Zealand	344.03	39.60	1.1	304.43	-25.3	-264.83
Philippines	340.02	257.14	-4.6	82.88	-38.6	174.26
Saudi Arabia	319.27	249.10	8.4	70.17	-64.1	178.93
Myanmar	313.72	187.66	40.5	126.06	-8.1	61.60
United Arab Emirates	303.90	244.32	32.4	59.58	-15.5	184.74
Austria	280.80	27.55	-24.5	253.25	7.0	-225.70
India	271.19	168.71	13.5	102.48	4.9	66.23
Turkey	256.09	56.73	-35.6	199.36	0.1	-142.63
Norway	249.21	46.29	12.1	202.92	41.2	-156.63
Chile	240.72	61.48	76.9	179.24	49.6	-117.76
Denmark	238.07	101.13	-10.4	136.94	-3.8	-35.81
Hungary	227.07	84.07	-38.0	143.00	-38.8	-58.93
Bangladesh	226.54	191.55	93.7	34.99	15.6	156.56
Peru	203.42	21.66	186.5	181.76	-14.1	-160.10
Mexico	191.46	42.62	210.4	148.84	-9.0	-106.22
Kuwait	191.22	133.72	1.8	57.50	-23.1	76.22
Finland	186.92	67.98	-8.6	118.94	-15.3	-50.96
Iran (Islamic Republic of)	179.07	131.86	-40.8	47.21	177.4	84.65
Zaire	56.76	53.92	-94.5	2.85	-61.0	51.06
TOTAL	111 627.55	52 485.92	10.5	59 141.63	7.0	-6 622.71

Source: General Administration of Customs, *China's Customs Statistics*, No.1 (Hong Kong, March 1990), table 4.

K. Concluding remarks: any lessons for the 1990s?

The spurt of globalization in the manufacturing economy in recent years has brought more competition among producers, diffused new technologies in wider areas, and increased interdependence between them through greater trade and investment. This world-wide process seems to be playing a part (an essential part according to some analysts) in sustaining the eighth year of global output expansion. The long-run prospect appears promising especially because relentless global competition seems effective in suppressing price inflation and increasing productivity.

The new global environment, however, has failed to help counteract increasing gaps of income, production capacities and technological capabilities even among developing regions. The regional review clearly brought out the basic difference between Tropical Africa and Latin America, on the one hand, and East and South-East Asia, on the other. Does the difference contain any lessons and guidance for the next decade?

Experience as well as common sense teaches that a dollar borrowed abroad has to be repaid ultimately with a dollar earned abroad through efficient investment, production and export. But in Latin America and Tropical Africa, this route of earning and repayment has not been possible on a sufficient scale. Consequently, when payments became due, the borrower has had to squeeze consumption, investment and imports while expanding exports. This approach has meant an immediate immiserization of living standards of the population whose interest was originally intended to be served but was actually victimized in the end.

What appears more dangerous than a reduction of consumption levels is the reduction of investment that will determine production capacity in the 1990s. It has been reported that in Latin America, per-worker investment fell by over 30 per cent during the decade of the 1980s. This provides a warning signal: the inability to produce and export would prompt debtor countries to borrow more just to be able to pay interest charges on snowballing debts.

Furthermore, interest rates are not determined by policy-makers in debtor countries, but by central bankers of developed countries. This means that the latter will determine the magnitude of interest charges for the debtor countries year after year with little regard given to the debtors' ability to repay. This prospect is appalling especially because many highly indebted countries have a large part of their debt on variable interest rates, for instance, over 93 per cent for Venezuela and over 80 per cent for Brazil and Mexico. Thus, the financial-market risks and uncertainties are disproportionately borne by debtor countries, and the negative impacts of instability accrue largely to industrial sector investment in debtor countries.

Under the circumstances, the eroded industrial base could be perpetually deprived of new investment needed for increased production and exports of manufactured goods, and ultimately for debt payment in the 1990s. Exports of primary goods alone, it is well recognized now, would not suffice to pay for debts. The declining trend of investment during the 1980s must be reversed during the early 1990s—a formidable challenge for policy-makers deeply preoccupied with the short-run urgency to service the debt and to fight inflation.

The need for a strong industrial base has been amply demonstrated by East Asian experience, lately including ASEAN countries. These countries have faced external shocks during the 1980s similar to those of Latin American and the sub-Saharan countries. But they could withstand the shocks thanks to their strong industrial competitiveness. As more studies are conducted, the lessons coming from the region become clear. Manufactured goods produced in these countries can compete in international markets in price and quality. And the competitiveness resulted from learning new technology and upgrading their industrial structure year after year toward a higher level of technology content.

Crucial to the success and speed of industrial transformation has been a clear performance criterion that everyone has understood, and rewards and incentives given according to that criterion. The volume of exports an enterprise achieved during a year served as the criterion in East Asia. The incentive measures included subsidized loans, tax holidays, free information services for new technology, preferential depreciation allowances and, not least, social recognition. These incentives were liberally granted to enterprises that would venture into new products, new markets and new technologies. The market forces and competition, especially in international markets, took care of the rest; that is, the winners secured the resources needed for expansion. Getting incentives right was more important than getting prices right.

In general terms, upgrading the industrial structure implies an effort to change the existing pattern of comparative advantage. In other words, new competitive products are created by learning new technology and the skills required to produce and sell. Policy-makers in East Asian countries rejected the dictate of static or existing comparative advantage as a long-term guiding principle. They wanted to change it, and succeeded.

The question remains whether policy-makers in Latin America and Tropical Africa should adopt a similar policy stance. The history of one region cannot be transplanted, but the inner logic of efficiency and strategy could provide guiding principles. Apparently, it is not just an accident that Eastern European countries are trying to introduce a competitive mechanism in their own system, and to integrate it with the world economy and world-level technology through joint ventures. In Poland and Botswana as well as in Peru there is a need to master new technology. And it seems imperative to establish new priorities and as well as institutional and industrial restructuring for greater competitiveness. But optimal strategies differ depending upon historical heritage and the stages of industrial development reached by the countries concerned. UNIDO should be ready to help those who try to help themselves.

III. Industry and environment

A. Overview

1. *Industry and the environmental crisis*

In recent years, world wide attention has been focused on environmental degradation as an issue of crucial importance to the survival of mankind and a major arena for international co-operation. Despite the shared perception and heightened awareness of environmental issues, environmental degradation continues unabated as the global environment is constantly bombarded on all fronts by impure air, contaminated water, oil spills, toxic wastes, acid rain, global warming, thinning of the ozone layer, desertification, deforestation and soil erosion.

Environmental issues are all-encompassing and interdisciplinary in nature, and cut across all development activities. In particular, the pressing global issues of population, natural resources, environment and economic development are all closely interlinked. It seems essential, therefore, that the question of industrial pollution should be considered in a broader context of the complex interactions among these issues.

A paradoxical situation exists between the North and the South in the environmental problem. In many countries of the South, mass poverty is the root cause of environmental degradation. Since the United Nations Conference on the Human Environment, held at Stockholm in 1972, it has been widely accepted that poverty linked to excessive population growth is the most important cause of pollution, and that the improvement of environmental conditions can be achieved only with development. Abject poverty, overpopulation and intolerable living conditions in many regions of the South force people to resort to environmentally unsound farming, grazing and fishing or human settlement on ecologically fragile marginal lands, giving rise to environmental disasters such as desertification, deforestation, flooding and depletion of top soils. Untreated human and other wastes dumped into the nearest body of flowing water remain one of the most serious environmental concerns: four out of five common diseases in developing countries are caused either by contaminated water or unsanitary living conditions. The result is a vicious circle of poverty leading to environmental degradation, which in turn further impoverishes the larger population by destroying the natural resource base.

By contrast, environmental damage in developed countries has been caused by consumerism and materialistic life-styles supported by the mass production of a bewildering array of goods and services which consume energy and exploits natural resources in massive scales.

Environmental degradation in either form can cause irreversible changes in ecosystems and play havoc with the natural resource base upon which many countries continue to depend on for industrialization and economic development. Industrialization is a means to fight against poverty and its primacy as an element of development strategy can hardly be called into question. But uncontrolled industrial development can bring about damage to the environment and deplete related natural and environmental resources. Against the backdrop of deepening environmental crisis, environmentally sound industrialization seems to be of paramount importance. Above all, environmentally sound industrial development calls, *inter alia*, for rational management of natural resources and adoption of low-waste or environmentally clean technologies. More importantly, in recent years, there has been mounting evidence that growth and environment do not necessarily conflict with each other and can evolve in a complementary fashion. Many new clean or low-waste technologies cannot only reduce pollutants substantially, but can also economize on the use of energy and raw materials to such an extent that resultant material and energy cost savings can more than offset initial higher investment costs, thus lowering the unit production cost. Many such actual examples will be given later in the present chapter. In short, the new clean or low-waste technologies are economically profitable in their own right in many cases.

As discussed earlier, environmental issues cut across all sectors of the economy and national boundaries. Industry is only one of many sources of environmental pollution in the economy but a very important one. Agriculture, mining, energy, transport, services and households all contribute in varying degrees to all forms of environmental degradation. The relative extent to which industry is responsible for the overall environmental degradation is little known in developing countries. The relative importance of industry in environmental degradation may vary considerably according to different types of pollutants and to the wide variety of natural resources used in industrial processes. In assessing the impact of industrialization on the environment, it is important to recognize that rapid structural change in the world industrial landscape fuelled by dynamic technological development may bring about far-reaching environmental changes in different regions of the world. This is simply because changing world patterns of industrial production can shift the distribution of environmental pressures created by different industrial activities, and new technologies may open new avenues for reducing industrial pollution and economizing on the use of natural resources. In this regard, it seems important to note a marked redeployment in the past decade from the North to the South of traditional industries such as textiles, leather, iron and steel, industrial chemicals and petrochemicals. At the same time, the North has forged ahead with the growth of new technology-based industries such as micro-electronics, information-processing and biotechnology. For instance, the MVA of 15 manufacturing industries in developing countries grew at least twice as fast as their counterparts in the North during the period 1980-1985; included were tobacco, petroleum refineries, textiles, other non-mineral products, food products, beverages, footwear, wearing apparel, wood products, glass and glass products, pottery and china, iron and steel, industrial chemicals, petroleum and coal products and non-ferrous metals ([1], p. 106). The developing countries as a whole have yet to make a significant penetration into the domain of high-technology and skill-intensive industries such as micro-electronics and information-processing equipment.

This overall trend toward rapid growth of traditional industries in developing countries seems likely to accelerate in the 1990s, and many of those traditional manufacturing industries are known to be heavy polluters. As a result, such structural change could lead to increased environmental pressures in the South, unless clean and efficient technologies are adopted on a large scale, and could mitigate burdens in the North, particularly as a result of the combined effects of improved energy efficiency in industry and structural shifts away from energy and material-intensive industries.

However, the growing technology-based industries (such as micro-electronics) can create new types of pollution problems, since some toxic materials are used in their production processes, and hence can produce more complex toxic pollutants instead of traditional pollutants. These include heavy metals, toxic air and water pollutants and hazardous wastes. Worse yet, the environmental impacts, of some of the high-technology industries is not well known, particularly in such areas as biotechnology or new materials. The problem of industrial pollution from high-technology industry will be examined later in greater detail.

In view of the foregoing analysis, it seems essential to present a clear picture of the environmental pressure of each individual manufacturing industry as well as the manufacturing sector as a whole in an economy-wide context. Without a firm grasp of such information, the environmental implications of industrialization in the South cannot be drawn clearly. In the following study, a broad perspective is presented of where the industrial sector stands *vis-à-vis* other sectors of the economy in the depletion of broad categories of natural resources; that is, water, energy and raw materials on the input side, and in the generation of selected air, water and land pollutants including hazardous wastes on the output side. This sectoral overview of environmental pollution will then be followed by a more detailed analysis of industry-specific pollution within the manufacturing sector, and finally of selected process-specific industrial pollutants within a given manufacturing branch. The study concludes with a review of the economic implications of promoting environmentally sound industrial development, and particularly the question of conflict or complementarity which may exist between the environment and industrialization. It should be noted at the outset that the terms "industry" and "manufacturing" are interchangeably used in this study, referring to the manufacturing sector proper and excluding mining and public utilities, unless otherwise specified.

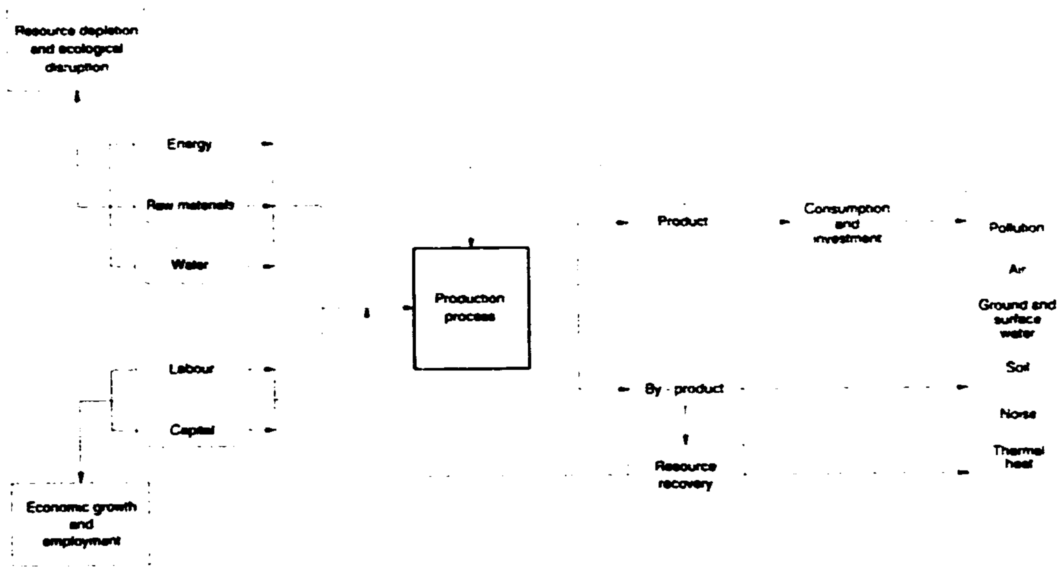
2. *The relative importance of industrial sources in overall environmental degradation*

Industry plays a critical role in economic development and in enhancing the economic welfare of the population. Industry produces a wide range of consumer goods and, more importantly, a whole range of intermediate and capital goods for other sectors and branches of the economy such as agriculture, services, mining, construction and utilities, as well as those required for diverse manufacturing industries. It generates substantial employment in producing those consumer and investment goods, and is the most dynamic sector of the economy in generating and disseminating technological change.

Despite obvious benefits of industrial development, it frequently entails damage to the environment and human health. Industry contributes to environmental degradation from both input and output sides of its activities. As summarized in figure III.1, the production of manufactured goods involves the extraction and exploitation of natural resources as inputs to manufacturing processes. On the input side, industry is a major consumer of energy, whose power generation is to a significant extent responsible for air pollution and environmental damage such as acid rain and global warming. Industrial production requires the use of a wide variety of natural resources such as minerals, forest products, and other raw materials whose rapid depletion may contribute to serious ecological disequilibrium and environmental damage. Many industrial processes rely heavily on the use of water, which may create water scarcity and bring about ecological disruption, although agricultural uses much more water. In particular, wasteful use and depletion of scarce natural resources may pose serious long-term danger to the sustainability of industrialization and even to the survival of species on earth, including mankind.

On the output side, manufacturing processes generate the myriad forms of waste that may pose serious environmental hazards. Gaseous by-products pollute air; liquid wastes pollute the soil as well as underground and surface water; and hazardous solid wastes lead to soil contamination and the pollution of surface and underground water, and above all create public health hazards. In a similar vein, the use of final products produced by industry for consumption and investment also creates a similar negative environmental impact on air, water and land as exemplified by pesticides, detergents, plastics and the combustion engine of motor vehicles. In addition, industry creates a major problem in industrial safety—risk of accident,

Figure III.1. Industrial production and environmental impact



Source: Adapted from United Nations Environmental Programme, *Industry and the environment*, Environmental Brief No. 7 (Nairobi, 1988)

risk of exposure to dangerous chemicals and risk in the work-place.

As mentioned earlier, the major focus of the present study will be on the identification and quantification of industrial sources in environmental degradation to the extent of data availability, in order to provide a basis for drawing some environmental implications of pursuing a given strategy of industrial development in developing countries. Each of the major aspects of industry on the environment is analysed below, beginning with industrial water consumption. Other important environmental issues such as industrial waste management, methods and techniques for environmental monitoring and impact assessment, institutional, infrastructure and investment requirements, and environmental regulations and policies will be the subject-matter of further investigations in the future.

B. Impact of industrial development on natural resources

1. Industrial water consumption

Unlike other natural resources such as minerals and timber, the total amount of water on earth is constant, estimated at 1,406 million cubic kilometres. But the vast majority of this, about 97 per cent, is sea water, and of the remaining 3 per cent, slightly over 20 per cent is ground water and 75 per cent is ice. Therefore, agriculture, industry and domestic use are competing for less than 1 per cent of the supply of freshwater. Even this very small share of freshwater supply in the total volume of water available on earth is believed to be sufficient to meet the demand now and for some time in the future. The world's water crisis stems mainly from its extremely uneven distribution of the supply of freshwater [2]. The key issue is not so much the scarcity of freshwater as the cost of delivery of usable water to where it is needed. The supply costs of water are rising partly because of the necessity to carry water over longer distances using costly energy-using distribution systems to meet increasing competing demands, and partly because of additional water treatment costs where lower quality sources are tapped.

Agriculture consumes most of freshwater, about 73 per cent of the total supply, used mainly for irrigation; industry uses much less, about 21 per cent; and domestic use is 6 per cent globally according to the UNEP estimate [2]. Although the industry share is much smaller than that of agriculture, industry pollutes the water more. Although more than 80 per cent of the water used for cooling and cleaning is returned, the returned water is often contaminated by industrial effluents and thermal pollution.

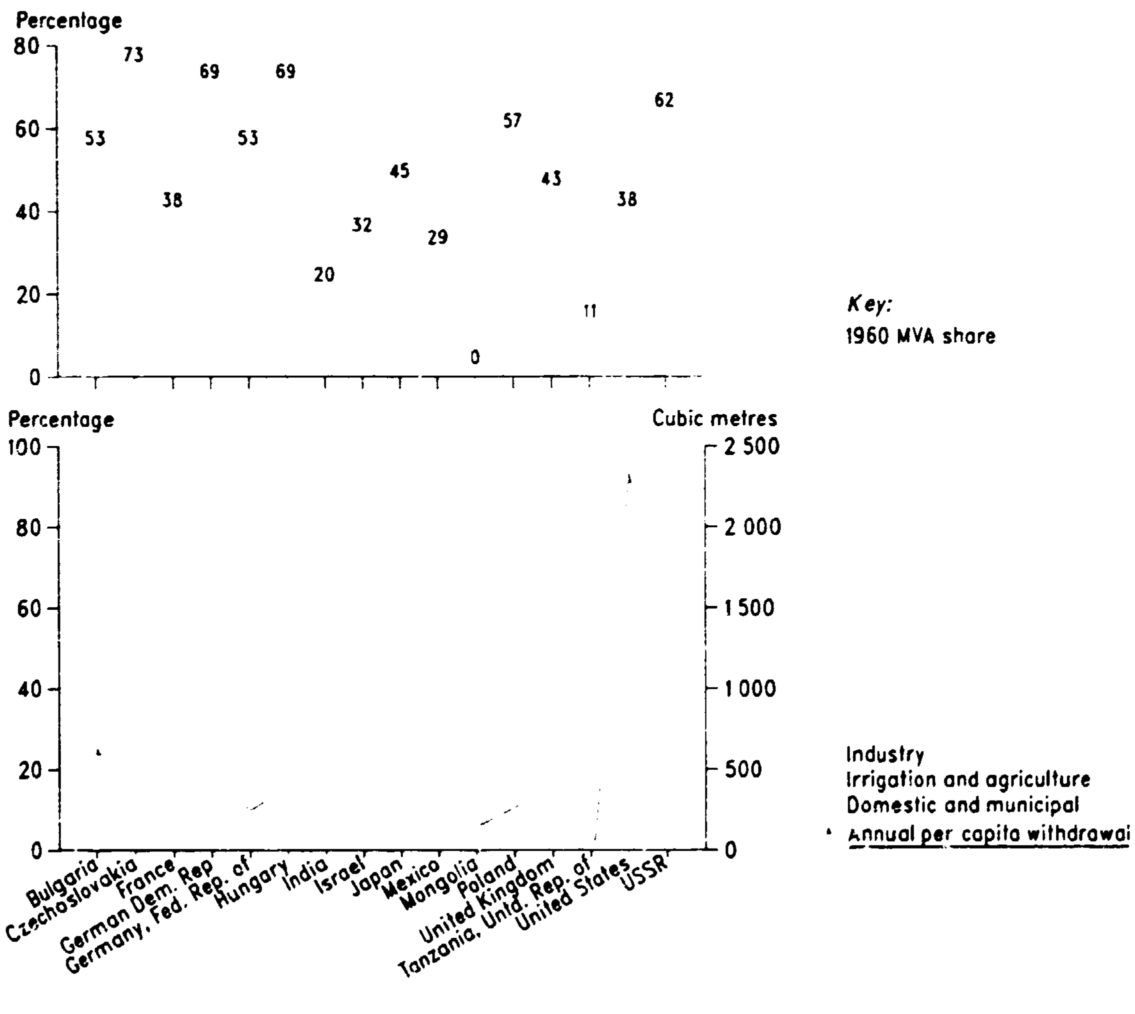
The share of industrial water in total water demand, however, varies substantially among countries, since the share of industrial water demand is expected to be a function of a number of factors, such as the stage of industrialization, resource endowments, the structure of the economy, the composition of manufactured output, geographic and climatic conditions, prevailing process technologies, population density, extent of urbanization and many other socio-economic factors.

Figure III.2 provides a comparison of total per capita withdrawals, share distribution between different uses and MVA share of GDP in selected countries. The figure reveals wide variations in the industry share ranging from 1 per cent in India to 81 per cent in Czechoslovakia in the late 1960s. In general, most countries with a small industrial base measured by the MVA share of GDP showed the smaller share of withdrawals for industrial use, with the greater percentage for irrigation and agriculture (India, Israel, Mexico, Mongolia and the United Republic of Tanzania), and the converse is true for most Eastern European countries which put an emphasis on heavy industry (Czechoslovakia, German Democratic Republic and Poland). Japan's relatively low share of industry water withdrawals despite its advanced stage of industrialization may reflect the use of water-efficient technologies.

Table III.1 summarizes freshwater withdrawals and their share distribution between agriculture, mainly irrigation, and public and industry uses in selected developing countries in different years. It seems quite clear from the table that the lion's share of freshwater is used for agricultural purposes and a very small share of the supply for industry in most developing countries at early stages of industrialization. The industry share is, however, expected to rise sharply as developing countries accelerate their industrialization process, as shown in figure III.2.

There are obviously wide variations in industrial water use among different manufacturing branches. According to the 1976 survey of industrial water use in Canada, total water withdrawal for manufacturing was 8,693 billion litres per year (see table III.2). Of this total, the paper and allied industries accounted for 36 per cent, followed by primary metals (24 per cent), chemical and chemical products (17 per cent) and petroleum and coal products (7 per cent) [3]. It is worth noting that heavy industries producing basic industrial materials such as primary metals, chemicals, petroleum products and paper products, and some of the resource-based light industries such as food and beverages, textiles and leather, tend to consume a large volume of water, most of the light industries

Figure III.2. Sectoral water consumption and MVA share of GDP in selected countries, 1960-1970



Source ESCAP (ST/ESCAP/SER.F/54), 1980.

Notes Line graph represents annual per capita withdrawal of water in cubic metres. Data correspond to the following years: Israel 1960; India 1968; Mexico and United Republic of Tanzania 1970; other countries 1965. Industry includes manufacturing and mining.

Table III.1. Freshwater withdrawal in developing countries, 1970-1986 [a]

Country	Year of data	Total (billion cubic metres)	Percentage used for: Public and industry	Agriculture
Algeria	1980	3.00	28	72
Argentina	1976	27.60	27	73
Botswana	1980	0.09	25	75
Cape Verde	1972	0.04	8	92
China	1980	460.00	13	87
Colombia	1960	..	14	86
Costa Rica	1970	1.35	8	92
Cuba	1975	8.10	17	83
Cyprus	1985	0.54	9	91
Egypt	1985	56.40	12	88
El Salvador	1975	1.00	17	83
Ghana	1970	0.30	46	54
Guatemala	1970	0.73	18	82
Honduras	1970	1.34	4	96
India	1975	380.00	7	93
Iran (Islamic Republic of)	1975	45.40	3	97
Iraq	1970	42.80	5	95
Israel	1986	1.90	21	79
Jordan	1975	0.45	3	97
Madagascar	1984	16.30	1	99
Mauritania	1978	0.73	2	98
Mexico	1975	54.20	12	88
Morocco	1985	11.00	9	91
Oman	1975	..	2	98
Peru	1975	..	7	93
Saudi Arabia	1975	2.33	42	58
South Africa	1970	9.20	17	83
Sri Lanka	1970	6.30	2	98
Sudan	1977	18.60	1	99
Syrian Arab Republic	1976	3.34	6	94
Tunisia	1985	2.30	10	90
Turkey	1985	15.60	42	58
Yemen	1975	1.53	1	99

Sources: World Resources 1987 and World Resources 1988-1989 (New York, Basic Books, 1987 and 1988).

a/ Including water taken from surface and ground-water sources in the year shown in the "year of data" column.

Table III.2. Water use in the Canadian manufacturing industry, by major industrial groups, 1976

Industry	Number of establishments	Water withdrawal: Total (millions of litres per year)	Fresh	Brackish
Food and beverages	2 123	358 811 (4.14)	307 373	51 438
Rubber and plastic products	359	59 471 (0.69)	58 507	964
Leather	1	214 (-)	214	-
Textile	414	138 717 (1.60)	138 717	-
Wood	1 079	331 040 (3.82)	271 324	59 716
Furniture and fixture	2	14 (-)	14	-
Paper and allied industries	461	3 132 171 (36.12)	121 361	10 810
Printing, publishing and allied industries	6	164 (-)	164	-
Primary metals	238	2 094 329 (24.15)	1 988 626	95 702
Fabricated metal products	22	8 406 (0.09)	8 406	-
Non-electrical machinery	5	246 (-)	246	-
Transport equipment	476	375 709 (4.33)	375 677	32
Electrical products	3	255 (-)	255	-
Non-metallic minerals	641	94 711 (1.09)	93 175	1 536
Petroleum and coal products	85	615 750 (7.10)	535 603	62 148
Chemicals and chemical products	656	1 462 730 (16.86)	1 395 927	66 804
TOTAL	6 571	8 672 718 (100.00)	8 323 571	349 146

Source: D.M. Tates and P.J. Reynold, "The regional context of industrial water demand forecasting in Canada", International Symposium on Water Resources Management in Industrial Areas, vol. 1 (Lisbon, Laboratorio Nacional de Engenharia Civil, 1981).

Note: Figures in parentheses indicate percentage of total.

(apparel, wood, furniture etc.) and capital goods industries (for example, metal fabrication, machinery and electrical machinery with the exception of transport equipment) are likely to consume relatively less water.

A large proportion of the industrial water supplies is used for cooling. For example, over 75 per cent of total industry water use in Belgium is for cooling, while about 13 per cent of total Belgian industry water use is for processing (see table III.3). Usually heavy industry requires a larger volume of water than light industry for cooling purposes. In the Belgian case, industries using more than 80 per cent of the total intake for cooling were chemicals, rubber, coke manufacturing, steam power plants, iron and steel, petroleum, fabricated metal products and mining. Industry using a high proporation of water intake for processing purposes included paper (76 per cent), leather (80 per cent), textiles (55 per cent), terracotta (60 per cent) and ceramics (60 per cent).

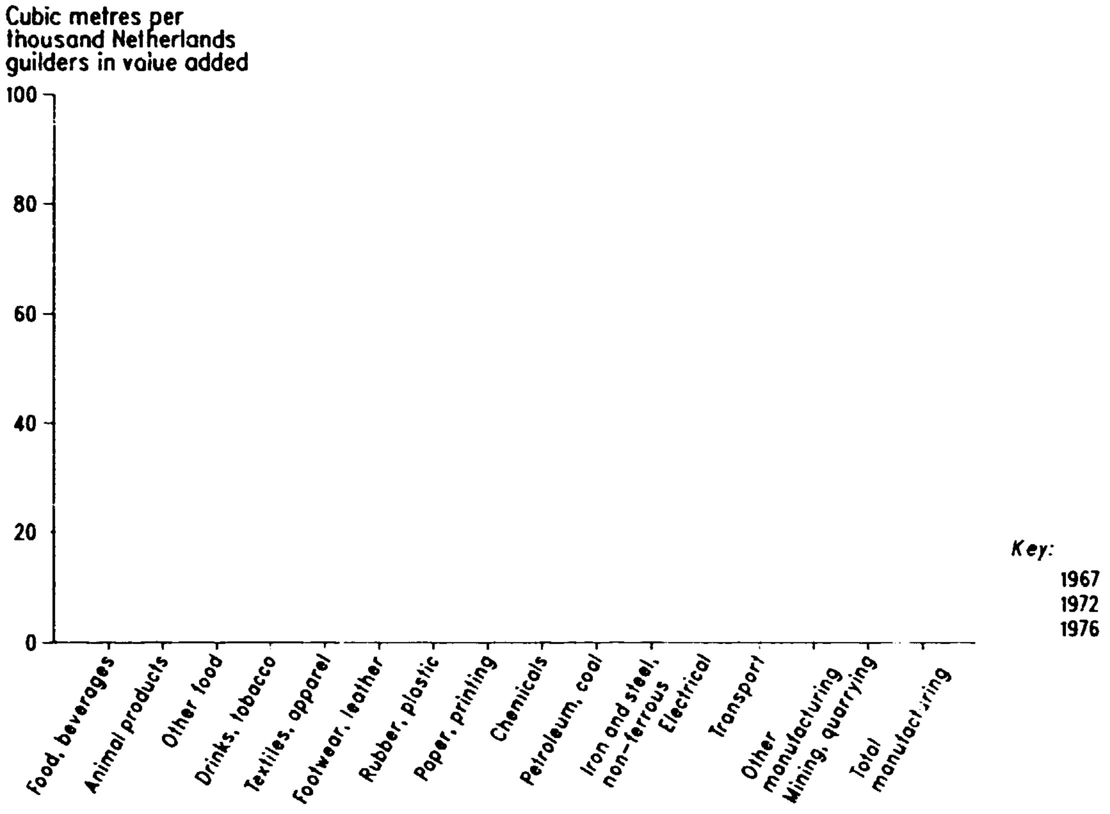
Table III.3. Magnitudes of basic water use in major industries in Belgium, 1965

Industry	Gross intake (millions of cubic metres)	Percentage distribution: Process water	Cooling water	Other uses
Mines	149	10	80	10
Quarries	48	46	..	54
Chemicals	404	11	86.5	2.5
Rubber	7	8.6	85.7	5.7
Paper	95	75.8	21	3.2
Leather	5	80	14	6
Textiles	54	55	35	10
Coke manufacturing	79	11.4	84.8	3.8
Steam power plants	3 298	0.4	99.2	0.4
Glass	21	38	47.7	14.3
Terra cotta	2	60	30	10
Ceramics	1	60	20	20
Iron and steel	1 010	7.6	84.6	7.8
Foods	107	16.6	66.4	16.8
Non-ferrous metals	191	1	59	40
Cement	14	36	57	7
Wood products	2	30	20	50
Petroleum	201	1	98.75	0.25
Fabricated metal products	134	11	80	9
Total, excluding steam power plants	2 528	13.0	76.8	10.2
TOTAL	5 826	5.9	89.5	4.6

Source: Economic Commission for Europe, "Compendium of low- and non-waste technology" (ENV WP.2 5 Add.124), pp. 1-6.

A more meaningful measure of industrial water requirements may be the water-use intensity coefficient as measured by the amount of water required per unit of output. Such water-use coefficients would be greatly influenced by industrial products, process-specific technologies and the kind of raw materials used in production. Statistics on industrial water-use coefficients are very difficult to come by. Water used per unit of value-added for broad industry groups in the Netherlands in 1967, 1972 and 1976, is given in figure III.3. Most notable in the figure is the dramatic improvement in the water-use efficiency across industries in the Netherlands between 1967 and 1976 except for rubber, plastic products, and primary metals. The water-use coefficient for the manufacturing sector as a whole was almost halved from 30.4 to 18.1 between

Figure III.3. Water-use intensity of industry in the Netherlands, 1967, 1972 and 1976



Source: J. Muelschlegel, *Drinking and Industrial Water Demands in the Netherlands* (Laxenburg, Austria, International Institute for Applied Systems Analysis, 1979).

1967 and 1976. Remarkable gains in water-use efficiency were noted in this period in the following industries: food processing, textiles and apparel, paper and publishing, and industrial equipment. Based on the 1976 coefficients, the heavy water users excluding mining and quarrying are, in descending order, as follows: animal products processing (63.5), primary metals (32.8), petroleum products (31.8), paper products (30.6), industrial chemicals (25.8) and rubber and plastic products (21.4) [4]. The enforcement of water-pollution control programmes may account for a large part of the notable improvement in industrial water-use efficiency.

Once again, basic industrial materials industries (for example, primary metals, chemicals, petroleum and coal products, pulp and paper) are shown to be most water-intensive not only in terms of total amount used as shown earlier, but also in terms of water use per unit of output. By contrast, fabricating and assembly industries such as electrical machinery (5.5), transport equipment (5.4), and other manufacturing (5.8) seem to use much less water than basic industrial materials industries.

At the process level, apart from different climatic conditions, the amount of water required is predominantly determined by the type of process technology employed. Given a wide range of technologies available for the production of a given product, industrial water requirements diverge sharply even among different firms producing the same products, let alone across different products and different countries. Statistics on process-specific water requirements are relatively scarce and fragmentary. In 1976, the United Nations assembled process-specific data on industrial water requirements for a large number of industries in various countries, using the questionnaire method [5]. Some examples selected from the United Nations data are given in appendix table III.54 to illustrate vast inter-industry and inter-country variations in industrial water requirements at the process level. In general, paper and pulp products and chemicals including synthetic rubbers tend to use more water per tonne of output than any other product groups. It is worth noting that water requirements per tonne of iron and steel products vary remarkably, depending on the process technology used, as shown in the cases of France and the United States. Also the same product may require vastly different amounts of water, depending on whether water recycling technology is used or not as shown in the case of the Netherlands, where the finished and semi-finished steel process requires 61,000 litres of water per tonne of steel without recycling, but only 27,000 litres of water with recycling technology.

Equally noteworthy are considerable inter-country variations in the industrial water requirements per tonne of the same products such as sugar-beets, beer, cheese, milk, ammonia, caustic soda and soap. The wide variations in industrial water use obviously reflects wide differences in the process technologies used in different countries.

Process-level data seem to suggest that the inter-industry comparison and generalization of industrial water use becomes more difficult at the process level because of an extremely wide range of process technologies used in different industries and in different countries. They also provide a valuable lesson that increasing industrial output need not necessarily be accompanied by increasing industrial water requirements. New water-saving technology designed to increase recirculation and water reuse can reduce industrial water requirements and at the same time their pollution loads. Proper economic incentives are, however, needed to induce industry to adopt water-saving technology. The same holds for energy consumption.

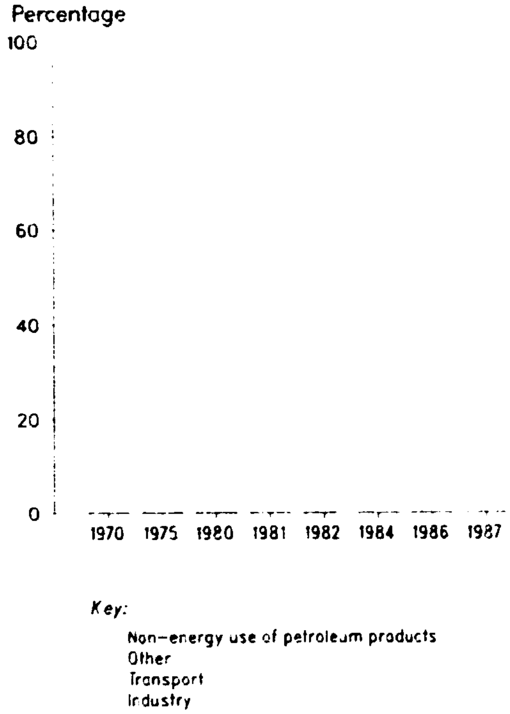
2. *Industrial energy consumption*

Energy is vital to all spheres of economic activity and industry is only one of these spheres. There are many different forms of energy: oil, gas, coal, nuclear power, hydropower and a large number of new and renewable sources of energy. Energy-sector behaviour encompasses all phases of activity ranging from the extraction, conversion, transport and consumption of energy to the disposal of energy wastes. These activities, in turn, have many significant impacts on both the economy and the environment.

It is well known that the energy scarcity could lead to various economic problems such as inflation, foreign exchange squeezes, increasing developing-country debt and even production disruptions. The environmental impact of energy-sector activity are equally serious. Environmental problems such as acid rain, the greenhouse effect, thermal pollution and the general degradation of the quality of air, water and land are exacerbated by excessive energy use. It is beyond the scope of this study to describe fully the major environmental consequences of energy-sector activities. The major impact of the various sources of energy on different parts of the environment (air, water, land and soils, and wild life) are summarized in appendix table III.55. Given the energy-environment links, the determination of the relative importance of the industry share in total energy consumption and the identification of the energy-intensity of various manufacturing branches within the industrial sector could make possible an assessment of the extent to which the industrial sector as a whole, as well as individual manufacturing industries, expect to contribute to environmental problems through industrial energy consumption. At the same time it may suggest ways of alleviating environmental burdens, for instance, through the promotion of industrial energy efficiency and conservation.

Among the OECD countries, industry used more energy than any other sector during the period 1970-1987, ranging between 40 per cent in 1970 and [illegible] per cent in 1987 and energy consumption by the transport sector crept up from 24 per cent in 1970 to 30 per cent in 1987, and the energy consumption share of residential, commercial and public establishments averaged around 32 per cent in the same period (figure III.4).

Figure III.4. Total final consumption of energy by sector, OECD, 1970-1987



Source: Organisation for Economic Co-operation and Development, 1989 Environmental Data Book, Paris, 1989.

However, the sectoral distribution of energy consumption in non-OECD countries differed markedly from the OECD group averages. Among Eastern European countries, industry accounted for 52 per cent of total energy consumption on the average in 1985, although the same share in the USSR in 1987 was only 33 per cent. Variations in the industrial share of energy consumption among developing countries were more pronounced than in any other sector, as shown in table III.4, with Brazil at 45 per cent, China 68 per cent, India 22 per cent, Indonesia 44 per cent, Latin America 38 per cent, West Africa 20 per cent, and Republic of Korea 41 per cent in different years. The relatively low industry share in India is due to the inclusion of sizeable non-commercial energy in total consumption. The share of transport among developing countries varied widely between 7 per cent in China and 44 per cent in West Africa. Despite considerable inter-country variations, and regardless of the stage of industrialization, it seems quite clear that industry is likely to be the largest source of energy consumption in both developed and developing countries, except perhaps for West African countries.

The pattern of industrial use of energy is less clear. According to one United States study in 1973, about 37 per cent of industrial energy was used for process steam, 24 per cent for direct heat, [illegible] per cent for

Table III.4. Sectoral energy consumption of selected regions, countries and economic groupings (Petajoules)[a]

Sector	OECD[b] 1985	USSR 1987	Eastern Europe[c] 1983	China 1980	India 1984	West Africa[d] 1984	Latin America[e] 1984	Brazil 1983	Indonesia 1984	Republic of Korea 1985
Agriculture[f]	1 745 (1.63)	934 (2.01)	g ..	1 237 (7.00)	251 (3.34)	.. ..	g ..	274 (5.36)	.. ..	.. ..
Industry[f]	37 878 (35.40)	15 295 (32.89)	5 920 (52.38)	11 130 (63.10)	1 667 (22.18)	172 (19.93)	2 066 (37.82)	2 309 (45.12)	516 (43.77)	802 (41.0[illegible])
Transportation[f]	32 758 (30.62)	6 045 (13.00)	870 (7.70)	1 413 (8.00)	746 (9.92)	381 (44.15)	2 072 (37.92)	1 067 (20.85)	328 (27.82)	281 (14.38)
Residential commercial public[f]	33 260 (31.10)	6 729 (14.47)	.. ..	3 887 (22.00)	489 (6.51)	109 (12.63)	g ..	1 467 (28.67)	335 (28.41)	787 (40.28)
Other[f]	1 336 (1.25)	.. ..	4 511[h] (39.92)	.. ..	4 364[i] (58.05)	201[i] (23.29)	1 325[k] (24.26)	.. ..	.. ..	.. (4.35)
TOTAL[l]	106 972 (100)	46 509[m] (100)[n]	11 301 (100)	17 667 (100)	7 517 (100)	863 (100)	5 462 (100)	5 117 (100)	1 179 (100)	1 954 (100)

Source: World Resources 1988-1989 (New York, Basic Books, 1988).

Note: a/ Conversion factors: 1 petajoule = 10^{15} joules; 1 megatonne of oil equivalent (mtoe) = 41.87 petajoules; 1 megatonne of coal equivalent (mtce) = 29.31 petajoules.

b/ Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Federal Republic of, Greece, Iceland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, United States and Yugoslavia.

c/ Bulgaria, Czechoslovakia, German Democratic Republic, Hungary, Poland and Romania.

d/ Senegal, Morocco, Nigeria and Côte d'Ivoire.

e/ Argentina, Mexico, Paraguay and Venezuela.

f/ Data are not from sources, but are a summation of individual fuel consumption from sources.

g/ Data for agriculture and residential/commercial/public sectors are included in the "other" sector.

h/ Combination of the residential, agricultural, trade and other sectors.

i/ Estimated 1984 consumption of noncommercial energy: fuelwood, agricultural waste and animal dung.

j/ Undefined use; balance of total consumption unaccounted for in sectoral data.

k/ Combination of agriculture, commercial, residential and public sectors.

l/ Data are not from sources, but are a summation of sectoral energy consumption.

m/ Primary electricity and heat are included in total energy consumption, but are not presented on a sectoral basis.

n/ Rounded figure.

Figures in parentheses are sectoral percentage shares.

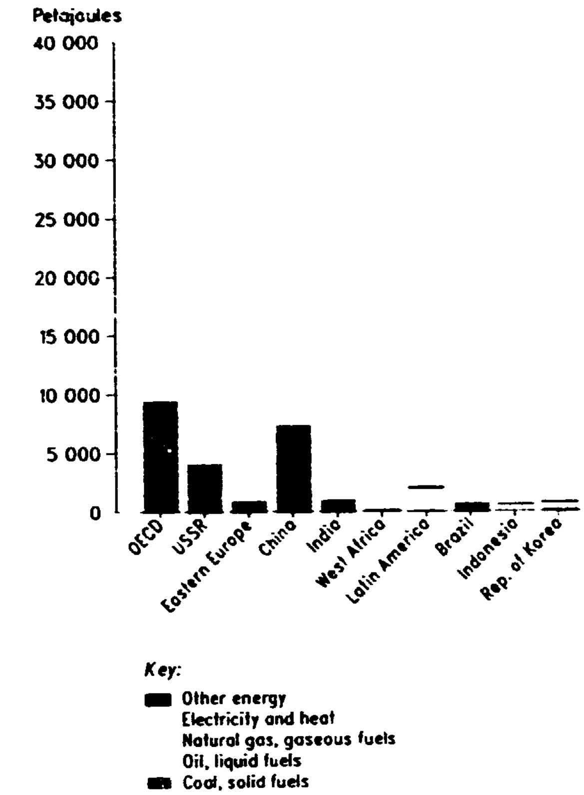
electric drive, 13 per cent for feedstocks, 3 per cent for electrolytic processes and 1 per cent for other electric processes ([6], p. 396).

Industry depends on different sources of energy and this varies among countries as shown in figure III.5. The industrial energy use in OECD countries is more or less equally distributed among four sources: oil (30 per cent), coal (25 per cent), natural gas (25 per cent) and electricity (20 per cent). In the USSR and Eastern Europe, industry relies heavily on both coal and natural gas. Coal is the dominant source of energy for industry in China (67 per cent) and India (72 per cent). Brazilian industry depends on hydroelectricity (41 per cent) and non-coal solid fuels (35 per cent) such as fuel wood, and biomass. Oil is also important for Indonesia (50 per cent) and West Africa (73 per cent), but Indonesian industry is also helped by natural gas (40 per cent).

Since OPEC first sent oil prices soaring in 1973-1974, coal consumption has risen sharply. In the 1980s, world consumption rose over 31 per cent even after oil prices dropped by more than 50 per cent in 1986. Coal consumption increased sharply in China (53 per cent), Turkey (400 per cent), the Republic of Korea (170 per cent) and Canada (180 per cent) during the period of 1978-1988, while consumption in the Soviet Union and Britain was down by 10 per cent and 7 per cent respectively [7]. Electricity generation claimed the lion's share of coal consumption. Between 70 per cent and 90 per cent of the total quantity of coal consumed in centrally planned economies is utilized for electricity generation. Among OECD countries, the percentage of electricity generated from oil dropped sharply from 25 per cent in 1973 to 12 per cent in 1983, while the coal share climbed from 37 per cent to 41 per cent in 1983. Globally, the coal share ranges from 55 per cent in the United States, 70 per cent in the United Kingdom and 64 per cent in the Federal Republic of Germany to 13 per cent in Japan, although some countries with rich water resources are highly dependent on hydroelectricity, particularly Norway (99 per cent), Canada (65 per cent), and Sweden (58 per cent) ([8], p. 209).

Given the large known coal reserves world-wide, over 600 billion tonnes of hard coal and brown coal, the increasing utilization of coal may represent a viable alternative source of energy in face of diminishing oil reserves. However, major environmental concerns about increased coal utilization have been raised, as coal combustion produces sulphur dioxide and other pollutants contributing to acid deposition with effects on human works and natural ecosystems. More specifically, coal combustion generates a considerable number of gaseous and liquid effluents as well as solid

Figure III.5. Industrial energy consumption by sources of energy for selected regions, countries and economic groupings, 1980-1987



Source: *World resources 1988-1989* (New York, Basic Books, 1988).

Note: Data for China 1980, Brazil and Eastern Europe 1983, India, Indonesia, Latin America and West Africa 1984, Organisation for Economic Co-operation and Development countries and Republic of Korea 1985, and USSR 1987.

wastes. The effluents from a coal-fired power plant generating 1,000 megawatts of electricity per year are listed in table III.5. Many of the effluents are known to be environmentally damaging. For instance, apart

Table III.5. Annual effluent production from 1,000-megawatt coal-fired power plant

Effluents	Tonnes
Airborne emissions	
Particulates	3×10^3
Sulphur dioxides	11×10^4
Nitrogen oxides	2.7×10^4
Carbon monoxide	2×10^3
Hydrocarbons	400
Liquid effluents	
Organic material	66.2
Sulphuric acid	82.5
Chloride	26.3
Phosphate	41.7
Boron	331
Suspended solids	497
Solid wastes	
Bottom ash and recovered fly ash	3.6×10^5

Source: W.J. Chadwick and others, eds., *Environmental Impacts of Coal Mining and Utilization* (Oxford, Pergamon Press, 1987).

from the relatively well-known environmental significance of sulphur dioxides, nitrogen oxides and carbon monoxide, the hydrocarbons in the flue gases as vapour are largely polycyclic aromatic hydrocarbons (PAHs). Many PAH compounds such as benzo(a)-pyrene are carcinogenic and could be potentially dangerous in spite of their low concentrations in emissions ([9], p. 91). The bulk of benzo(a)pyrene emissions to the atmosphere world-wide originates from coal sources: coal heating and power generation (47 per cent), industrial coke production (20 per cent), and open-burning of coal refuse (14 per cent) (see table III.6). It seems clear that as developing countries depend increasingly on coal as an alternative source of energy for rapid industrialization, the environmental problems of coal combustion such as acid rain and thermal pollution would also become serious and could pose a formidable challenge to a sustainable development strategy, unless more environmentally sound coal-combustion technologies are developed and adopted.

Data on industrial energy consumption at disaggregated manufacturing industry levels are relatively scarce. A 1986 survey of United States manufacturing industries contains detailed statistics on manufacturing energy consumption [10]. Table III.7 shows energy-use coefficients at the two-digit United States industrial classification levels for the period 1980-1985, where the energy-use coefficient is measured by the ratio of energy consumption to the constant dollar value of shipments. A decrease in the coefficient shows an improvement in energy efficiency.

Table III.6. Estimated benzo(a)pyrene emissions to the atmosphere (Tonnes per year)

Emission sources	United States	World-wide excluding United States	World-wide
Heating and power generation			
Coal	431 (34.0)	1 945 (52.0)	2 376 (47.0)
Oil	2 (0.2)	3 (0.1)	5 (0.1)
Gas	2 (0.2)	1 (0.1)	3 (0.1)
Wood	40 (3.0)	180 (5.0)	220 (4.0)
Total	475 (37.0)	2 129 (57.0)	2 604 (52.0)
Industrial processes			
Coke production	192 (15.0)	841 (22.0)	1 033 (20.0)
Catalytic cracking	6 (0.5)	6 (0.1)	12 (0.2)
Total	198 (15.0)	847 (23.0)	1 045 (21.0)
Refuse and open burning			
Enclosed incineration			
Commerce and industry	23 (1.8)	46 (1.0)	69 (1.4)
Other	11 (0.9)	22 (0.6)	33 (0.7)
Open burning			
Coal refuse	340 (27.0)	340 (9.0)	680 (13.5)
Forest and agriculture	140 (11.0)	280 (7.5)	420 (8.0)
Other	74 (6.0)	74 (2.0)	148 (3.0)
Total	588 (46.0)	762 (20.0)	1 350 (27.0)
Vehicles			
Trucks and buses	12 (1.0)	17 (0.5)	29 (0.6)
Automobiles	10 (0.8)	6 (0.2)	16 (0.3)
Total	22 (1.7)	23 (0.6)	45 (0.9)
TOTAL	1 283	3 761	5 044

Source: W.J. Chadwick and others, eds., *Environmental Impacts of Coal Mining and Utilization* (Oxford, Pergamon Press, 1987) p.219.

Note: Numbers in parentheses are percentage shares.

Table III.7. Energy-use coefficients by United States manufacturing industries, 1980 to 1985

Industry	Energy-use coefficients [a]		Change [b] (percentage)
	1980	1985	
Food and kindred products	3.5	[illegible]	22.9
Tobacco	c	c	c
Textiles	5.7	4.8	16.3
Apparel and other textile products	..	..	.
Lumber and wood products	c	c	c
Furniture and fixtures	1.9	1.6	17.4
Paper and allied products	16.0	13.9	13.0
Printing and publishing	1.1	0..	15.2
Chemicals and allied products	15.1	12.4	17.6
Petroleum and coal products	5.4	4.4	19.8
Rubber and miscellaneous plastics products	4.3	3.1	27.8
Leather and leather products	c	c	c
Stone, clay and glass products	21.6	16.6	23.0
Primary metals	16.4	14.6	11.0
Fabricated metal products	2.8	2.3	16.4
Non-electrical machinery	1.7	0.9	43.6
Electrical and electronic equipment	1.7	1.2	26.4
Transport equipment	1.5	1.1	25.0
Instruments and related products	1.7	1.2	29.3
Miscellaneous manufacturing industries	1.8	1.4	23.9
All manufacturing	5.8	4.4	25.1

Source: Energy Information Administration, *Manufacturing Energy Consumption Survey: Changes in Energy Efficiency, 1980-1985* (Washington, D.C., January 1990).

a Thousand British thermal units per constant 1980 dollar of value of shipments and receipts.

b A decrease in the energy-use coefficient represents an increase in energy efficiency and is shown as a positive value in this column. Percentage changes are calculated on the basis of unrounded energy-use coefficients.

c Data withheld because relative standard error is equal to or greater than 50 per cent.

Following the second oil shock of 1979-1980, United States manufacturing industries considerably improved their energy-use efficiency in the first half of 1980s, largely prompted by escalating energy prices and the uncertainty of energy supplies, particularly of imported oil. In 1985 the United States manufacturing sector consumed 9.7 quadrillion* British thermal units (B.t.u.) of energy, compared with the 11.9 quadrillion B.t.u. consumed in 1980, while manufacturing output at 1980 constant prices rose by 8 per cent. As a result, the energy-use coefficient of United States manufacturing industries as a whole improved by 25 per cent as its use coefficient dropped from 5.8 to 4.4 between 1980 and 1985 (table III.7.).

Among the individual industry groups included table III.7, the largest energy users in 1985 are listed in table III.8.

As major producers of basic industrial materials, the five industry groups mentioned in table III.8 accounted for 70 per cent of all manufacturing energy consumption in 1985. The same five energy-intensive groups curtailed their energy consumption collectively from 8.6 quadrillion B.t.u. in 1980 to 6.8 quadrillion B.t.u. in 1985, a reduction of 21 per cent, while the output of the groups declined by 5 per cent, resulting

Table III.8. Largest energy users in the United States manufacturing sector, 1985

Industry	Energy consumption	
	Quadrillion B.t.u.	Percentage of all manufacturing
Chemicals and allied products	[illegible]	[illegible]
Primary metals	1.5	15.5
Paper and allied products	1.3	13.4
Petroleum and coal products	0.9	9.3
Stone, clay and glass products	0.9	9.3
TOTAL	[illegible]	[illegible]

Source: Energy Information Administration, *Manufacturing Energy Consumption Survey: Changes in Energy Efficiency, 1980-1985* (Washington, D.C., January 1990), table ES1.

in an overall reduction in the energy-use coefficient of 17 per cent for the five groups. The heavy energy users in the ratios of energy consumption to shipments (thousand B.t.u. per constant 1980 dollar value of shipments and receipts) in descending order in 1985 were stone, clay, and glass products (16.6), primary metals (14.6), paper and allied products (13.9), chemicals and allied products (12.4), textile mill products (4.8), and petroleum and coal products (4.4). Once again, the energy-intensive industries measured in terms of the energy-use coefficient are those producing basic industrial materials except textiles.

Statistics on total energy consumption by disaggregated manufacturing groups in different countries are scarce, but some data on industrial consumption of electricity are available for an international comparison. Table III.9 provides such an intercountry comparison of the intensity of industrial electricity use as measured by kilowatts per dollar of value added. Needless to say, electrical energy intensity varies substantially across countries and industries, given the wide range of manufacturing technologies and energy sources used to generate electricity.

A number of interesting observations can be noted from the energy coefficients given in table III.9. First, for manufacturing industry as a whole, Japan and the Federal Republic of Germany are shown to be the most efficient in the use of electricity, while India uses almost five times the amount of electricity per dollar value added in those two countries. It is also surprising to find industry in the Republic of Korea using electricity more efficiently than in Canada or the Netherlands, perhaps because electricity costs more in the Republic of Korea, with its few energy sources.

Secondly, the manufacture of basic industrial materials such as chemicals, iron and steel, non-ferrous metals and paper and pulp tends to be far more energy-intensive than the manufacture of capital goods such as general machinery, electrical machinery, transport equipment and professional goods. The energy-intensity of the former group tends to be several times higher than that of the latter group, and this is the case for all seven countries listed in the table.

Thirdly, the list of heavy users of electrical energy is likely to be the same everywhere regardless of the stage of industrialization and industrial technologies used. The top five energy-intensive industries are listed below for the seven countries (table III.10). Sur-

*1 quadrillion = 10^{15}

Table III.9. Coefficients of electrical energy use of manufacturing industry in selected countries, 1983
(Kilowatts per dollar of value added)

ISIC code	Industry	Canada Coefficient	Canada Rank	Netherlands Coefficient	Netherlands Rank	Germany, Federal Republic of Coefficient	Germany, Federal Republic of Rank	Japan Coefficient	Japan Rank	Mexico Coefficient	Mexico Rank	India Coefficient	India Rank	Republic of Korea Coefficient	Republic of Korea Rank
311.312	Food products	0.55	14			0.13	20	0.34	13	0.19	15	2.33	10	0.77	6
313	Beverages	0.31	21	0.76d/	9	0.24	15	0.22	16	0.30	14	1.22	16	0.27	20
314	Tobacco	0.24	23			0.03	22	..		0.06	21	1.12	26	0.04	24
321	Textiles	0.93	10	0.92	8	0.68	7	0.56	9	0.36	12	3.45	7	1.85	5
322	Wearing apparel	0.15	26	0.15	12	0.09	21	0.08	23	..	..	0.60	22	0.16	22
323	Leather and products	0.41	17			0.21	16	0.11	21	..	..	1.00	17	0.45	13
324	Footwear	0.22	24	0.30d/	11	0.14	19	0.08	29	..	..	0.56	24	0.27	19
331	Wood products	1.62	7					0.22	16	0.12	19	1.37	13	0.00	25
332	Furniture, fixtures	0.33	19	0.43	10	0.40	12	0.14	19	..	..	1.35	14	0.23	21
341	Paper and products	6.67	1	2.44	5	2.00	3	2.50	4	2.17	4	10.00	1	2.63	3
342	Printing, publishing	0.19	25	0.32	11	0.31	14	0.10	22	..	..	0.58	23	0.18	22
351	Industrial chemicals	5.26	2	5.00a/	4	2.44	1	2.63	3	0.63	10	9.09	2	2.63	3
352	Other chemical products	0.27	22	a/		..	..	0.24	15	0.18	16	1.30	15	0.48	12
353	Petroleum refining	1.64	6	1.82	6			1.14	7	..	..	5.56	3	0.22	21
354	Petroleum, coal products	0.70	12	1.32	7	0.46d/	10	1.56	5	1.15	6	9.09	2	0.31	18
355	Rubber products	0.83	11	7.69	3	0.55	9	0.58	9	0.32	13	2.17	12	0.76	10
356	Plastics products n.e.c.	0.97	9	a/		0.71	6	0.56	10	..	..	2.38	9	0.89	7
361	Pottery, china etc.	0.68	13			0.41	11	0.53	11	..	..	2.27	11	0.87	8
362	Glass products	1.19	8			1.08	4	0.65	8	1.37	5	4.00	6	1.09	6
369	Non-metal products n.e.c.	2.22	4	1.32d/	7	1.03	5	1.16	6	2.50	3	5.00	5	3.03	2
371	Iron and steel	1.96	5	8.33	2	2.13	2	3.13	1	3.70	1	5.26	4	2.22	4
372	Non-ferrous metals	4.35	3	11.11	1	0.58	8	2.70	2	2.63	2	2.94	8	4.35	1
381	Metal products	0.42	16			0.32	13	0.21	17	0.09	20	1.00	17	0.71	11
382	Machinery n.e.c.	0.32	20	0.76d/	9	0.19	17	0.21	17	0.04	22	0.71	21	0.39	16
383	Electrical machinery	0.35	18	b/		0.19	17	0.26	14	0.13	18	0.75	20	0.42	15
384	Transport equipment	0.43	15	b/		0.15	18	0.38	12	0.17	17	0.96	18	0.44	14
385	Professional goods	0.22	24	b/		0.15	18	0.19	18	..	..	0.42	25	0.30	19
390	Other industries	0.24	23	0.15	12	0.15	18	0.12	20	..	..	0.80	19	0.36	17
3	Manufacturing	1.39		1.24		0.66		0.68c/		..		3.16	..	1.01	

Sources: Industrial Statistics Yearbook 1986 (United Nations publication, Sales No. E.88.XVII.9), pp. 75, 202, 258, 309, 323, 394 and 405 and UNIDO data base.

a/ Major groups 352 and 356 are included in 351.

b/ Major groups 383 to 385 are included in 381 and 382 combined.

c/ Excluding major group 314.

d/ Weighted industry average

Table III.10 Top five electrical-energy-intensive industries in selected countries, 1983
(Kilowatts per dollar of value added)

Rank	Canada	Coefficient	Netherlands	Coefficient
1	Paper and products	6.67	Non-ferrous metals	11.11
2	Industrial chemicals	5.26	Iron and steel	8.33
3	Non-ferrous metals	4.35	Rubber products	7.69
4	Non-metal products n.e.c.	2.22	Industrial chemicals	5.00
5	Iron and steel	1.96	Paper and products	2.44
	Manufacturing average	1.39	Manufacturing average	1.24

Rank	Federal Republic of Germany	Coefficient	Japan	Coefficient
1	Industrial chemicals	2.44	Iron and steel	3.13
2	Iron and steel	2.13	Non-ferrous metals	2.70
3	Paper and products	2.00	Industrial chemicals	2.63
4	Glass products	1.08	Paper and products	2.50
5	Non-metal products	1.03	Petroleum, coal products	1.56
	Manufacturing average	0.66	Manufacturing average	0.68

Rank	Mexico	Coefficient	India	Coefficient
1	Iron and steel	3.70	Paper and products	10.00
2	Non-ferrous metals	2.63	Petroleum, coal products	9.09
3	Non-metal products n.e.c.	2.50	Industrial chemicals	9.09
4	Paper and products	2.17	Petroleum refining	5.56
5	Glass products	1.37	Iron and steel	5.26
	Manufacturing average	..	Manufacturing average	3.16

Rank	Republic of Korea	Coefficient
1	Non-ferrous metals	4.35
2	Non-metal products n.e.c.	3.03
3	Industrial chemicals	2.63
4	Paper and products	2.63
5	Iron and steel	2.22
	Manufacturing average	1.01

Source: Industrial Statistics Yearbook 1986 (United Nations publication, Sales No. E.88.XVII.9), pp. 75, 202, 258, 309, 323, 394 and 405 and UNIDO data base.

prisingly, the same group of manufacturing industries are ranked among the top five energy consumers for each country, although the ranking order and their energy-intensity differ from country to country. They are the basic material-producing industries, namely paper and paper products, industrial chemicals, iron and steel, non-ferrous metals, glass, rubber products, and petroleum and coal products.

The same pattern of energy-intensity of United States manufacturing industries in 1970 is revealed at more detailed industrial classification levels (see table III.11). The most energy-intensive manufacturing industries (excluding mining industries in table III.11) as measured by kilowatt-hours per dollar of value-added are listed in table III.12.

It is clear from table III.12 that all heavy energy consumers except fabrics and yarn are found in the basic material-producing industries. By contrast, the majority of fabricating and machinery industries and food-processing industries consume far less electricity per dollar of value added, often 10 to 20 times less.

The energy and environmental implications of the patterns of energy consumption among different manufacturing industries in developing countries seem quite significant. Those heavy energy-consuming industries, mainly the basic materials producers at the early stages of the manufacturing hierachy of processing and fabrication, are the growth industries in the South, and their growth is expected to accelerate in the 1990s. However, their importance in the North is

Table III.11. Coefficient of electrical energy use in United States industry, 1970
(Kilowatt-hours per dollar of value added)

CHIC[a/] code	Industry	Coefficient
05	Iron ore mining	9.5540
06	Non-ferrous ore mining	4.6400
07	Coal mining	3.6100
08	Petroleum mining	2.2730
09	Minerals mining	4.2310
10	Chemical mining	12.7150
11	Ordnance	0.7950
12	Meat packing	0.1306
13	Dairy products	0.4197
14	Canned and frozen foods	0.4507
15	Grain mill products	0.5741
16	Bakery products	0.4935
17	Sugar	0.7221
18	Candy	0.5059
19	Beverages	0.4011
20	Miscellaneous food products	0.5252
21	Tobacco	0.1852
22	Fabrics and yarn	1.9330
23	Rugs, tyre cord and miscellaneous textiles	0.6471
24	Apparel	0.2865
25	Household textiles and upholstery	0.2698
26	Lumber and products, excluding containers	0.8749
27	Wooden containers	0.4644
28	Household furniture	0.5618
29	Office furniture	0.5427
30	Paper and products, excluding containers	5.3390
31	Paper containers	0.6487
32	Printing and publishing	0.4009
33	Basic chemicals	10.0160
34	Plastics and synthetics	3.1540
35	Drugs, cleaning and toilet items	0.4653
36	Paint and allied products	0.3286
37	Petroleum refining	1.2370
38	Rubber and plastic products	1.7080
39	Leather tanning	0.9579
40	Shoes and other leather products	0.3078

CHIC[a/] code	Industry	Coefficient
41	Glass and glass products	3.0910
42	Stone and clay products	2.8440
43	Iron and steel	3.9440
44	Copper	0.8044
45	Aluminum	16.3900
46	Other non-ferrous metals	2.0310
47	Metal containers	0.5375
48	Heating, plumbing, and structural metal	0.6085
49	Stampings, screw machinery products	0.9770
50	Hardware, plating and wire products	0.9124
51	Engines and turbines	0.6948
52	Farm machinery and equipment	0.4849
53	Construction and mining machinery	0.7733
54	Material handling equipment	0.4135
55	Metalworking machinery and equipment	0.8538
56	Special industrial machinery	0.5544
57	General industrial machinery	0.7495
58	Machine shops and miscellaneous machinery	1.0300
59	Office and computing machines	0.4736
60	Service industry machines	0.3826
61	Electric apparatus and motors	1.2510
62	Household appliances	0.6973
63	Electric light and wiring equipment	0.7310
64	Communication equipment	0.6269
65	Electronic components	1.1680
66	Batteries and engine electrical equipment	0.8771
67	Motor vehicles	0.4257
68	Aircraft and parts	0.7049
69	Ships, trains, trailers and cycles	0.4751
70	Instruments and clocks	0.6308
71	Optical and photographic equipment	1.0760
72	Miscellaneous manufactures	0.4753

Source: Organisation for Economic Co operation and Development, Energy and Environment (Paris, 1974) p.39.

a/ Curtis Harris' Industry Classification.

Table III.12. Most energy-intensive United States manufacturing industries

Rank	Industry	Kilowatt-hours per dollar of MVA
1	Aluminium	16.39
2	Basic chemicals	10.02
3	Paper and paper products, excluding containers	5.34
4	Iron and steel	3.94
5	Plastics and synthetics	3.15
6	Glass and glass products	3.09
7	Stone and clay products	2.84
8	Other non-ferrous metals	2.03
9	Fabrics and yarn	1.93
10	Rubber and plastic products	1.71

Source: Organisation for Economic Co-operation and Development, Energy and Environment (Paris, 1974) p.39.

markedly declining as the structure of the economy in the North shifts rapidly towards service-oriented and high-technology industries.

Altogether three major implications may be drawn. First, the problem of energy scarcity may grow more severe if most developing countries undergo the energy-intensive phase of industrialization with emphasis on the production of basic industrial materials. Secondly, the environmental pressures of this trend toward energy-intensive industrialization are likely to increase sharply, since both the manufacturing processes of basic industrial materials and power generation that those processes heavily require are significant sources of environmental pollution. In this regard, industrial energy efficiency takes on added importance, since it plays the dual role of alleviating energy-scarcity and mitigating the environmental burden simultaneously.

Thirdly, energy requirements associated with the manufacture of specific products, which could be estimated from particular process technologies, are undoubtedly more useful and revealing than aggregate information. There are literally thousands of case-studies on product-specific energy requirements but it is outside the scope of the present study to search and compile such product- and process-level data. For illustrative purposes, a comparative assessment of energy requirements for the manufacture of different containers is presented in table III.13. It is interesting to note that a plastic bottle weighing 0.12 pounds (54.43 grams) requires about 8,496 B.t.u., whereas an equivalent paper carton weighing 0.14 pounds (63.5 grams) needs 6,053 B.t.u.

Adding the energy content of raw materials, total energy inputs to a plastic bottle and an equivalent paper carton are 11,310 B.t.u. and 7,453 B.t.u., respectively. It must be noted that owing to a wide range of possibilities of material substitution that exists in the manufacture of containers and packaging, energy requirements for the manufacture of a given product are likely to vary considerably, depending on which process technology is selected. Once again, as in the case of industrial water use, this would make it extremely difficult to compare and generalize the patterns of industrial energy use across industries and countries on the basis of micro-economic process- and product-level technical and engineering information.

Table III.13. Energy requirements for the manufacture of containers

Container type	Weight	Pounds of raw material required			Energy use		Energy content of raw materials	Total energy per container
	(pounds)	Natural gas	Crude oil	Wood	B.t.u.	(B.t.u./pound of product)	(B.t.u.)	(B.t.u.)
1. Half-gallon milk container								
Polyethylene plastic	0.120	0.0380	0.107	-	8 495 5 445a/	70 790 45 370a/	2 814	11 310
Paper	0.140	-	-	0.28	6 053 2 840a/	43 230 20 280a/	1 400	7 453
2. Size-6 meat tray								
Polystyrene plastic	0.148	0.0047	0.013	-	892	60 268	344	1 236
Wood pulp	0.045	-	-	0.064	875	19 440	320	1 195
3. Flexible container (bag or sack)								
Polyethylene plastic	0.040	0.0130	0.36	-	2 730	68 250	951	3 681
Kraft paper	0.080	-	-	0.16	1 640	20 500	800	2 440

Source: H. Makino and R.S. Berry, Consumer Goods. A Thermodynamic Analysis of Packaging, Transport and Storage (Chicago, Illinois Institute for Environmental Quality, 1973).

a/ These values exclude energy required for filling the containers.

Notes: 1 pound = 453.6 grams.
1 gallon = 4.55 litres.

3. *Industrial use of mineral resources*

Industry uses a wide variety of raw materials in manufacturing processes (see appendix table III.56 for a list of selected raw materials used by different industries). The industrial raw materials can be divided into two groups of renewable and non-renewable raw materials. Generally speaking, food processing and light industries such as textiles, wearing apparel, leather goods and wood products use largely renewable agricultural and forest resources as raw materials, whereas heavy industries producing basic industrial raw materials (for example, iron and steel, chemicals, glass products, non-ferrous metals and metal products) heavily rely on non-renewable mineral resources, as shown in appendix table III.56. In the subsequent analysis, the focus will be mainly on the industrial use of non-renewable mineral resources, excluding fossil fuels which were discussed earlier.

The industrial use of mineral resources raises the two fundamental problems, namely the depletion of finite, limited resources and the environmental impact of resource extraction. The theoretical controversies surrounding the depletion of exhaustible resources have been widely debated and there is a voluminous literature on the subject ([11]-[18]).

Irrespective of the theoretical arguments and formal principles underlying the economics of exhaustible resources, considerable evidence now exists that the overly pessimistic predictions of the "limits-to-growth" approach to resource exhaustibility in the 1970s are not true. The central issue is the role of technology and relative prices in determining the availability of exhaustible resources. Technology launched a two-pronged assault on the resource problem: a steady reduction of the extraction costs of raw materials and a remarkable improvement in the efficiency of industrial use of raw materials. Moreover, as a natural resource becomes scarcer, its price rises and the rising relative price induces conservation and more investment to develop substitutes. As a result, an increase in total demand for raw materials is likely to be less than proportionate to the increase in output. At the same time, the total supply of raw materials may expand in response to lower extraction costs and higher relative prices.

The implausibility of the depletion of natural resources, at least in the coming several decades, seems to be corroborated by the expanding world reserves of four major minerals: copper, lead, zinc and aluminium, as shown in table III.14. These reserves steadily increased up to the end of the 1970s, although they declined slightly in the first half of the 1980s owing to a drop in metal prices relative to their extraction costs. Most importantly, reserves of those minerals grew considerably faster than their production. This pattern of reserve growth is likely to be true for many other minerals, and at least estimated reserves grew as fast as production until the 1970s. In essence, there seems to be no cause for concern about supply exhaustion within the foreseeable future, although political disruptions might lead to temporary shortages.

Table III.14. Growth of world reserves of selected minerals
(Millions of tonnes near end of relevant decade)

Item	Copper	Lead	Zinc	Aluminium[a]
1940s	91	31 to 45	54 to 70	1 605
1950s	124	45 to 54	77 to 86	3 224
1960s	200	86	106	11 600
1970s	543	157	240	22 700
1980s (first half)[b]	500	135	300	22 335
Annual percentage growth, 1950s-1970s	7.5	5 to 5.75	4.75 to 5.25	9.75
Annual percentage growth of mine production, 1950s-1970s	3.75	1.75	2.75	-

Source: P. Crowson, *Mineral Handbook 1988-1989: Statistics and Analysis of the World Mineral Industry* (New York, M. Stockton Press, 1988), p.9.

a/ Gross weight of bauxite.

b/ Reserve base in 1985.

A more important issue concerns the environmental problems that the production and industrial use of mineral raw materials pose. Environmental pollution from mining takes many different forms, and some of the more well-known pollutants are the following.*

(a) *Mine gases*	*Harmful effects*
Carbon dioxide (CO_2)	Asphyxiating (for lack of oxygen)
Carbon monoxide (CO)	Asphyxiating, explosive
Hydrogen sulphide (H_2S)	Irritant, poisonous, explosive
Methane (CH_4)	Asphyxiating (for lack of oxygen) explosive
Nitrogen (N)	Asphyxiating (for lack of oxygen)
Nitrogen dioxide (NO_2)	Irritant
Nitrogen monoxide (NO)	Irritant, poisonous
Oxygen (O)	Non-toxic
Sulphur dioxide (SO_2)	Irritant, poisonous

(b) *Dust*

Dust is defined as solid particulate matter thrown into suspension by mining operations. Dust has explosive properties and harmful physiological effects, particularly on lungs;

(c) *Radiation*

The radiation in mines poses the health hazard of radon, a gaseous decay product of the uranium series found in all uranium mines in varying degrees and in other types of mine such as fluospar mines and iron ore mines. The major health hazard of radon is lung disease, particularly lung cancer.

(d) *Mine drainage*

Mine drainage contains many dissolved solids including dissolved metals and suspended solids raising the acidity of mine drainage, which in turn causes some negative impact on the aquatic environment.

*For more detailed technical treatment of this subject, see [19].

Table III.15. Various rankings of minerals in world trade, 1972

Rank	World production By value	World production By weight	Traded internationally By value	Traded internationally By weight	Importance in engineering	Composite index
1	Iron	Iron	Iron ore	Iron ore	Iron	Iron ore
2	Copper	Manganese	Alumina bauxite	Bauxite	Aluminium	Copper
3	Aluminium	Sodium	Nickel	Manganese	Copper	Lead
4	Manganese	Aluminium	Zinc ore	Zinc	Lead	Zinc
5	Magnesium	Chromium	Tin	Copper	Zinc	Bauxite
6	Zinc	Copper	Manganese ore	Lead	Manganese	
7	Mercury	Zinc	Lead ore	Nickel	Chromium	
8	Lead	Lead	Tungsten ore	Tin	Nickel	
9	Nickel	Potassium			Magnesium	
10	Tin	Nickel			Tin	
11	Potassium	Zirconium				
12	Uranium	Lithium				
13	Silver	Tin				
14	Beryllium	Magnesium				
15	Gold	Antimony				

Source: Yuan-li Wu, Raw Material Supply in a Multipolar World (New York, October 1973, National Strategy Information Center).

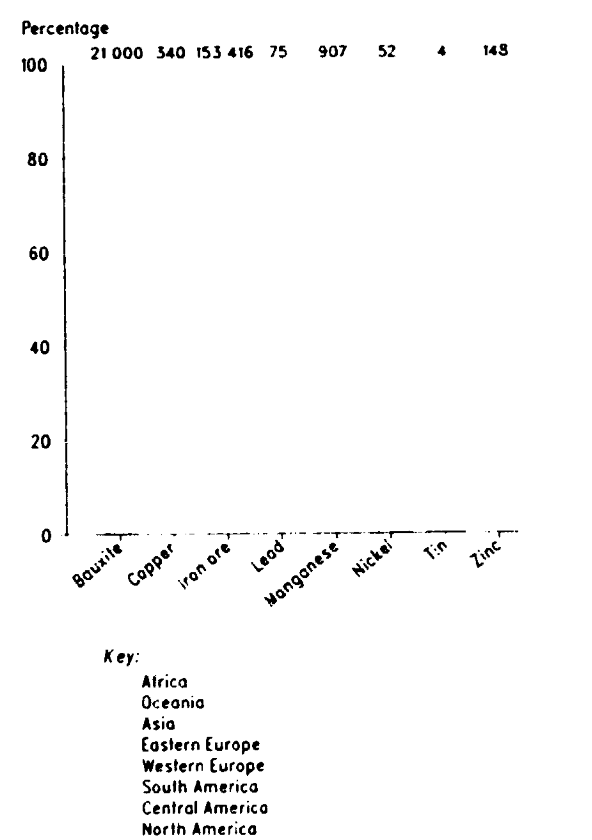
Many other types of damage to the environment and human health result from mining operations. They include excessive heat and humidity, and noise pollution leading to possible loss of hearing. The technical literature on this subject is abundant and should be consulted for further detailed information.*

Table III.15 provides rankings of various minerals in world production and trade excluding energy resources. The top five most important minerals in world trade as measured by composite indexes in descending order are iron ore, copper, lead, zinc and bauxite. It is furthermore clear from figure III.6 that many developing regions account for a sizeable share of the world reserves. For instance, South America and Asia together hold about 30 per cent of world reserves of iron ore, South America and Africa together about 40 per cent of world reserves of copper, all developing countries 22 per cent of world lead deposits, 45 per cent of total zinc reserves, and 70 per cent of all bauxite reserves.

The environmental implications of the presence of substantial mineral reserves and increasing mining activities in developing countries could be quite significant. The majority of mineral-producing developing countries depend on mineral export revenues to escape problems of foreign exchange deficits, debt-servicing and development finance. Bauxite production is a case in point, with Africa alone accounting for almost 40 per cent of world reserves. It seems plausible to expect, therefore, that mineral production in developing countries will continue to rise to meet the import requirements of high-consuming developed countries as well as their own ever-increasing domestic demand resulting from accelerated industrialization. Unless environmentally sound mining technologies are soon adopted on a massive scale in developing countries, the pollution problems stemming from mining activities will further deteriorate and add to already intolerable levels of environmental pollution from other major sources such as industry, agriculture, energy use and households.

*For instance, [9] and [19]

Figure III.6. Major reserves of selected minerals, 1988



Source: *World resources 1988 1989* (New York, Basic Books, 1988).
Note: Numbers on top of bars represent world reserves in millions of tonnes.

To analyse such environmental problems more fully, it is important to identify those manufacturing industries which use mineral resources most intensively. The problem in identifying the principal users of a particular resource is that the intermediate producers of goods are the largest users of a particular mineral resource: for instance, the aluminium fabrication industry as a major user of aluminium. It is, therefore, essential to observe the path of inputs through successive processes to product outputs. This can be done in two ways. First, a complete micro-economic analysis of material flows can be conducted, involving an integrated set of technical activities such as exploration, extraction, refinement, conversion, transport and fabrication of material resources into the final products. This method is often referred to as the reference materials systems (RMS), an example of which will be given shortly.* Secondly, a sufficiently disaggregated input-output table can be used to trace resource flows through different industries until they are transformed into end-products. Various United States tables are used to estimate the final destinations of selected key minerals in table III.16.

Table III.16. Principal uses of resources [a] in the United States economy, 1970
(Percentage)

Aluminium		**Chemical and fertilizer minerals**	
Construction	26.9	Food manufacture	14.9
Motor vehicles	11.2	Construction	13.5
Industrial machinery	7.5	Industrial chemicals	10.0
Aircraft	6.1	Wholesale and retail trade	3.2
Food manufacture	5.1	Motor vehicles	3.1
Ordnance and accessories	4.8	Clothing	2.9
Other transport equipment	4.6	Fertilisers	2.7
Communication equipment	2.8	Cleaning preparations	2.3
Wholesale and retail trade	2.0	Petroleum refining	1.9
Refrigeration equipment	0.9	Industrial machinery	1.7
Metal household furniture	0.8	Drugs	1.0
		Cigarettes, cigars etc.	0.9
Total	72.6	Total	58.0
Copper		**Lead**	
Construction	29.5	Construction	17.6
Industrial machinery	9.0	Storage batteries	15.1
Motor vehicles	8.2	Motor vehicles	11.0
Communication equipment	3.9	Industrial machinery	9.5
Electrical apparatus	3.1	Food manufacture	4.8
Aircraft	3.0	Ordnance and accessories	4.5
Ordnance and accessories	2.1	Industrial chemicals	4.3
Refrigeration machinery	1.7	Aircraft	3.9
Food manufacture	1.5	Wholesale and retail trade	3.3
Wholesale and retail trade	1.5	Communication equipment	2.3
Pipes, valves and fittings	0.9	Jewellery	1.5
Shipbuilding and repairs	0.8	Clothing	1.3
		Petroleum refining	1.2
		Shipbuilding and repairs	1.2
Total	65.2	Total	81.2
Steel		**Zinc**	
Construction	30.0	Construction	25.6
Motor vehicles	19.6	Motor vehicles	19.5
Industrial machinery	10.7	Industrial machinery	10.2
Food manufacture	5.6	Aircraft	4.1
Other transport equipment	4.0	Domestic appliances	3.8
Domestic appliances	2.3	Ordnance and accessories	2.4
Aircraft	2.2	Wholesale and retail trade	2.3
Whole and retail trade	1.6	Storage batteries	1.9
Fabricated plate works	1.3	Industrial chemicals	1.7
Shipbuilding and repair	1.0	Miscellaneous hardware	1.2
Communication equipment	0.9		
Total	79.3	Total	72.7

Source: D.W. Pearce and J. Rose, The Economics of Natural Resource Depletion (London: Macmillan, 1975), pp. 156-157.

a/ Percentage of total resource use attributable to direct or indirect use by the specified industries.

*For further details, see [20].

The data in table III.16 suggest that a small number of industries are the most notable users of mineral resources. For instance, the construction and motor vehicle industries together consume 50 per cent of steel, about 40 per cent of lead and 38 per cent of copper and aluminium. A more meaningful measure of this use would require examining the resource-intensity of products as measured by the total value of output accounted for by the direct and indirect use of a given resource. Such a measurement is given in table III.17, but it excludes all intermediate goods

Table III.17. Resource-intensive industries [a] in the United States, 1970
(Percentage)

Aluminium		**Chemical and fertilizer minerals**	
Metal foil	28.4	Fertilizers	11.6
Electrical industrial goods	7.0	Industrial chemicals	3.4
Sheet metal work	6.3	Plastics	1.5
Tanks and components	5.7	Miscellaneous chemical products	2.7
Trucks and trailers	4.9	Paints	0.9
Copper		**Lead**	
Small arms and ammunition	7.7	Storage batteries	24.5
Pipes, valves and fittings	6.5	Small arms and ammunition	8.4
Transformers	3.7	Paints	1.4
Motors and generators	3.3	Printing trade machinery	1.2
Welding apparatus	2.8	Metal foil	1.1
Switchgear	2.4	Industrial chemicals	1.1
Steel		**Zinc**	
Fabricated plate works	39.8	Miscellaneous hardware	2.6
Railway trams and cars	35.7	Storage batteries	2.2
Sheet metal work	34.1	Small arms and ammunition	1.0
Safes and vaults	34.0	Household laundry equipment	0.7
Metal stampings	29.8	Commerical laundry equipment	0.6
Fabricated metal goods	25.9	Electric housewares	0.5

Source: D.W. Pearce and J. Rose, The Economics of Natural Resource Depletion (London: Macmillan, 1975), pp. 156-157.

a/ Percentage of total value of product accounted for by direct and indirect use of the specified resource.

such as steel tubes using steel as raw material (here intermediate goods are defined to be all products for which more than 95 per cent of the total domestic sales are made to other producers) The most important implications of this measurement is that the catastrophic consequences of resource depletion advanced by some writers and their sweeping policy prescription such as zero growth would seem to be missing the point when the problem of resource depletion is examined at more detailed product levels. As has been correctly pointed out ([21], p.159), "... when we know that lead mostly goes into car batteries, we realize that if we want to conserve lead it is a good deal easier and more effective to design a car that does not need a lead-acid accumulator than to halt economic growth".

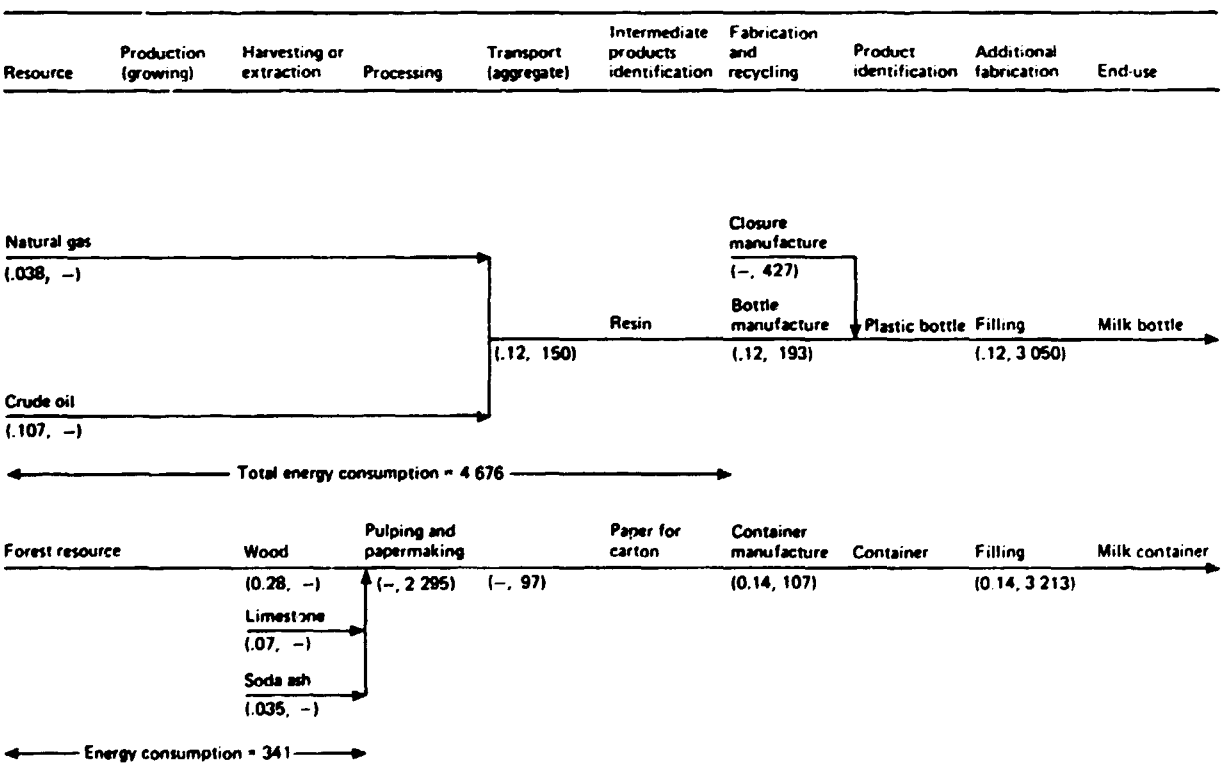
As in the case of energy and water, the wide variations in the patterns of use of raw materials by both country and industry suggest that the process-specific approach mentioned above is more useful. In particular, the RMS approach could be highly useful not only for assessing the industrial use of raw materials, but also for determining energy requirements, labour and capital needs and environmental effects. The RMS approach provides a network representation of the flow of materials from the resource side through all intermediate processes and production steps to a specific end-use. Materials and other input requirements (energy, labour, capital) can also be quantified at each technical process or production step in the flow of materials. It is not difficult to see that the technical coefficients and material substitution for input-output tables can also be estimated from the information given in the RMS. In particular, the RMS method may make it possible to identify promising areas for substituting non-renewables by renewables, recycling used material, conserving scarce raw materials, improving energy efficiency and reducing industrial pollutants.

For illustrative purposes, a network representation of the flow of materials for the manufacture of two types of milk container, a plastic bottle and a paper carton, is presented in figure III.7. The milk container was chosen partly because of its relatively simple technical processes, and partly because of the numerous possibilities for material substitution that exist in containers and packaging. It should also be noted that the energy requirements of manufacturing milk containers summarized in table III.13 were derived from this process information. The figure refers to half-gallon milk containers made of plastic or paper. The energy requirements of these products were already compared earlier. As to their material requirements, the plastic bottle requires 0.038 pounds (17.24 grams) and 0.107 pounds (48.5 grams), respectively, of natural gas and crude oil as chemical feedstock, while an equivalent paper carton needs 0.28 pounds (127 grams) of ground wood. The possibility of reusing the plastic containers must, however, be taken into account when the material costs of the plastic products are compared with similar wood products.

Apart from the apparent advantage of adopting low-waste technology, industry could minimize the environmental impact associated with the industrial use of raw materials in two principal ways: by substituting high-pollution-content materials by low-pollution-content materials; and by recycling and reuse of waste as secondary industrial raw materials. In principle, recycling can considerably reduce the new materials for industrial output. But apart from some inevitable loss due to irretrievable dispersal of materials in the production process, there are also engineering and economic limitations on the amount of recycling possible, given the difficulties of obtaining a product with recycled materials at a quality level comparable to and at a price competitive with the original materials. Obviously, as the price of the latter rises, more sophisticated technologies for recycling become economically profitable. In addition, there are a number of institutional barriers to recycling. They include freight rates, tax policies, regulations, existing capital equipment or tradition-bound practices, all of which have deterred the increased use of recycled materials in the United States.*

*For more detailed discussions on the United States experience, see [22].

Figure III.7. Reference materials system for half-gallon plastic-bottle or paper-carton milk containers



Source: H. Makino and R. S. Berry, *Consumer Goods—A Thermodynamic Analysis of Packaging, Transport and Storage* (Chicago, Illinois Institute for Environmental Quality, 1973).

Note: Numbers in parentheses below the activity links refer to mass flow in, respectively, pound and energy requirements in B.t.u. for the manufacture of one half-gallon milk container.

Table III.18. Recycling percentages, usage patterns and alternative materials of selected metals

Metal	Percentage recycled	Uses with good recovery	Uses with poor recovery	Uses	Alternatives
Copper	40.9	Brass alloys	Chemical	Electrical	Aluminium, sodium alloys
		Coinage	Fungicides	Construction	Stainless steel
		Electrical	Fertilizers		
				Plumbing	Plastics
Gold	15.9	Alloys	Jewellery	Jewellery	Platinum, palladium
			Electronics	Electronics	Silver, aluminium
			Bullion	Dental	Plastics
Lead	40.0	Storage	Gasoline	Storage cells	Cadmium, mercury, nickel, silver
		batteries	additives		Zinc
		Lead- and	Solder		
		copper-base	Pigments	Gasoline	Nickel (catalytic
				additives	reforming)
				Pigments	Tin, Zinc
				Cable cover	Plastics
				Plumbing	Plastics
Mercury	20.6	Mercury cells	Fungicides	Mercury cells	Other processes
		in chloride	Germicides		
		plants	Paints	Medical	Sulphur, Organics
		Electrical		Germicides	Organics
		Amalgams		Protective	Plastics
				paint	Copper paint
Silver	47.2	Stampings	Photographic	Photographic	Selenium
		Bimetal scrap	solutions	Reflectors	Aluminium, rhodium
		Batteries		Coinage	Copper-nickel alloys
Zinc	27.0	News scrap	Galvanized	Diecasting	Aluminium, magnesium, plastics
		(75 per cent)	products	Anti-corrosion	Aluminium sheet, stannum,
		Brass	Pigments	agent	ceramics
		Bronze alloys		Reducing	Aluminium, magnesium
		Batteries		agent	

Source: A.W. Mann, "Resources", in Environmental Chemistry, J.O.M. Brokris, ed. (New York, Plenum Press, 1977) pp. 121-178.

Substitution of one material for another has been widespread practice in manufacturing for a long time and for many reasons. For instance, the rapid growth of the use of aluminium and plastics as substitutes for wood or steel can be explained by the superior properties of those materials, not by the scarcity or high prices of iron or wood.* By and large, however, the material substitutions have been dominated by economic considerations, and have taken on greater urgency since the sharp escalation of oil prices in the 1970s. Environmental considerations have seldom been a major factor in decisions about substitution in the past, although to the extent that material substitution is motivated by energy-saving, such substitution may also have a favourable effect on the environment. Further research is needed to develop a rational approach to industrial material substitution that carefully balances economic benefits with environmental costs.

The actual data for the recycling of some key materials in the United States and some examples of the use of alternative materials for those selected materials are summarized in table III.18. It must be noted that only the technical possibilities for substitution are listed, but the economic and environmental costs of substitution for those minerals are not given.

*A useful interpretation of the major material substitution patterns that have appeared over the past century can be found in [23].

In short, the choice of mineral resources in manufacturing depends on the quantity and quality of their long-term supply potential, the costs of exploration, extraction and refinement, energy requirements for converting them into useful materials, environmental impacts and many other social and institutional factors.

4. *Summary*

Finally, it would be useful at this point to recapitulate the salient points of this section on the impact of industrial development on natural resources.

(a) *Industrial water consumption*

Industry uses much less water than agriculture, but it pollutes the water more. Although more than 80 per cent of the water used for cooling and cleaning is returned, the returned water is often contaminated by industrial effluents and thermal pollution.

In general, heavy industries producing basic industrial materials (primary metals, chemicals, petroleum products, paper products etc.) and resource-based light industries (food and beverages, textiles and leather etc.) tend to consume a large volume of water. A large proportion of the industrial water supplies is used for cooling, particularly in heavy industries, and less for processing.

At the process levels, there exist vast inter-industry and inter-country variations in industrial water requirements. In general, paper and pulp products, chemicals and primary metals tend to use more water per tonne of output than any other product groups. The wide variations in industrial water use reflects wide differences in the process technologies used in different countries. The process-level information suggests that increasing industrial output need not necessarily be accompaneid by increasing industrial water requirements. New water-saving technology designed to increase recirculation and water reuse can reduce industrial water requirements and at the same time their pollution load.

(b) *Industrial energy consumption*

Among the OECD countries, industry used more energy than any other sector during the period 1970-1987, ranging between 40 per cent in 1970 to 33 per cent in 1987. The industrial share of energy consumption in developing countries varied widely from country to country, ranging from 63 per cent in China to 20 per cent in West Africa. Despite considerable inter-country variations, and regardless of the stages of industrialization, it seems quite clear that industry is likely to be the largest source of energy consumption in both developed and developing countries, perhaps except for West African countries.

Industry depends on different sources of energy, and this varies among countries. The industrial energy use in OECD countries is more or less equally distributed among four sources; namely, oil, coal, natural gas and electricity. In the USSR and Eastern Europe, industry relies heavily on both coal and natural gas. Coal is the dominant source of energy for industry in China (67 per cent) and India (72 per cent). Since OPEC first sent oil prices soaring in 1973-1974, coal consumption has risen sharply. In the 1980s, world consumption rose over 31 per cent even after oil prices dropped more than 50 per cent in 1986. Given the world-wide known coal reserves, over 600 billion tonnes of hard coal and brown coal, the increasing utilization of coal may represent a viable alternative source of energy in face of the diminishing oil reserves. As developing countries depend increasingly on coal as an alternative source of energy for rapid industrialization, the environmental problems of coal combustion such as acid deposits and other gaseous and liquid pollution also become serious and could pose a formidable challenge to sustainable industrial development, unless clean technologies are developed and adopted on a massive scale.

On the heels of the second oil shock of 1979-1980, the manufacturing sector in developed countries has considerably improved energy efficiency, largely prompted by rising energy prices and the uncertainty of energy supplies, particularly of imported oil. For instance, the energy efficiency of the United States manufacturing sector improved by 25 per cent between 1980 and 1985.

According to the recent energy consumption survey of United States manufacturing industries by the Energy Information Administration, the heavy energy-users in terms of total consumption are again major producers of basic industrial materials; namely, chemicals, primary metals, paper and allied products, petroleum and coal products, and stone, clay and glass products. The five industry groups accounted for 70 per cent of all manufacturing energy consumption in 1985. Statistics on total energy consumption by disaggregated manufacturing groups in different countries are scarce, but some data on industrial consumption of electricity are available for an international comparison. An intenational comparison of the intensity of industrial electricity use in 1983 as measured in kilowatts per dollar of value added shows among other things that across countries and irrespective of the stages of industrialization and technologies used, the most electric-energy-intensive industries tend to be producers of basic industrial materials; namely, paper and paper products, industrial chemicals, iron and steel, non-ferrous metals, glass, rubber products, and petroleum and coal products.

The past trend of industrial energy consumption has important implications for developing countries. First of all, the problem of energy scarcity may grow more severe if most developing countries undergo the energy-intensive phase of industrialization with emphasis on the production of basic industrial materials on a massive scale. Secondly, the environmental pressures of this trend toward energy-intensive industrialization are likely to increase sharply, since both the manufacturing processes of basic industrial materials and power generation which those processes require are significant sources of environmental pollution. In this regard, industrial energy efficiency takes on added importance, since it plays the dual role of alleviating energy scarcity and mitigating the environmental burdens simultaneously.

(c) *Industrial use of mineral resources*

There seems to be no cause for concern about the supply exhaustion of mineral resources within the foreseeable future, although political disruptions might lead to temporary shortages. A more important issue relating to mineral resources concerns the environmental problems posed by the production and industrial use of mineral resources. The environmental pollution of mining takes many different forms, such as mine gases, dust, radiation and mine drainage effluents, and some of these pollutants are known to be quite harmful.

The environmental implications of substantial mineral reserves and increasing mining activities in developing countries could be quite significant. The majority of mineral-producing developing countries depend on mineral export revenues to escape problems of foreign exchange deficits, debt-servicing and development finance. Unless environmentally sound mining technologies are soon adopted extensively all across developing countries, the pollution problems stemming from mining activities will further deteriorate and add to already intolerable levels of environmental pollution from other major sources such as industry, agriculture, energy use and households.

The principal users of mineral resources are intermediate producers of goods; for instance, the aluminium fabrication industry, which is a major user of aluminium. Excluding all such intermediate goods producers, a small number of industries are found to be the most notable users of mineral resources. For instance, the construction and motor vehicle industries together consumed 50 per cent of steel, about 40 per cent of lead and 38 per cent of copper and aluminium in the United States in 1970. In addition, industrial chemicals, industrial machinery, food manufacture, aircraft and other transport equipment were identified as principal users of mineral resources.

Apart from the apparent advantage of adopting low-waste technology, industry could minimize the environmental impact associated with the industrial use of raw materials in two principal ways: by substituting high-pollution-content materials by low-pollution-content materials; and by recycling and re-use of waste as secondary industrial raw materials. Material substitution has taken on greater urgency since the sharp escalation of oil prices in the 1970s. However, environmental considerations have seldom been a major factor in decisions about substitution in the past. To the extent that material substitution is motivated by energy saving, such substitution may also have a favourable effect on the environment. Further research is needed to develop a rational approach to industrial material substitution that carefully balances economic benefits with environmental costs.

C. Industrial pollution

The manufacturing sector contributes to environmental degradation through the use of inputs and the production of outputs. On the input side, it uses natural resources; in particular energy, water and raw materials. This aspect of the environmental impact of manufacturing has already been discussed. On the output side, manufacturing industries also directly generate both traditional and newly emerging pollutants in three major forms; namely, air, water and solid wastes, including hazardous wastes. These output pollutants are examined in the present section. The relative importance of industry as opposed to other sectors of the economy in generating major pollutants is assessed, and the major polluters among manufacturing industries are identified.

At the outset, it would seem highly useful to present an overview as to which major pollutants different industries generate in the process of their manufacturing activities. The known major pollutants generated by 27 selected industries are listed in appendix table III.57. Such information may prove to be useful not only in identifying the sources of specific pollutants, but also in providing a check-list for identifying environmental problems in planning and designing industrial plants.

Another useful approach to the present analysis would be to characterize manufacturing industries by the potential environmental stress that they can create. A Canadian government study has classified manufacturing industries by three stress types: high, medium and low. The high stressor group is associated with processes that extract raw materials from the environment and transform them into early-stage industrial materials, such as making pulp and paper, metal smelting and refining, producing industrial chemicals, mining and thermal power generation. The medium stressor group is characterized by the further processing of materials into specialized products required for the next and final stage of manufacturing, although some final products are included in this category because of special environmental considerations (for example, processed foods and pharmaceuticals). The low stressor group captures the remaining industries which are mainly composed of a large proportion of the industries producing final goods. Such an industrial classification by stressor type is given in appendix table III.58. The environmental stress of industrial plants is determined by a multitude of factors such as the scale of operations, the process technology employed, the type of pollution abatement equipment used, ecological characteristics of the surrounding area and meteorological conditions. The classification in the table should be considered, therefore, as a first approximation to a more thorough stress evaluation of the different manufacturing processes.

1. Industrial air pollution

The major air pollutants most commonly found are particulates, sulphur dioxide, carbon monoxide, nitrogen dioxide and hydrocarbons. Their principal characteristics, emission sources, health and other effects, control techniques and United States ambient standards are summarized in appendix table III.59. It is evident that natural events such as forest fires and volcanic eruptions are in great measure responsible for the emission of these pollutants. So far as anthropogenic emissions are concerned, air pollution is generated by six major sources: transport, domestic heating, electric power generation, refuse burning, agricultural fires and industrial fuel burning and process emissions. In general, manufacturing is not responsible for the emissions of most pollutants. Each major pollutant has its different major sources. Most importantly, electricity generation accounts for the major bulk of anthropogenic emissions of sulphur dioxide, transport activities for nitrogen oxides and carbon monoxide and motor vehicles for hydrocarbons and lead. Industry, however, is a major source of particulate emissions in different countries, as shown in table III.19. Some estimates suggest that industrial sources contribute about 20 per cent of total air pollution, but this may be an understatement. Many manufacturing industries consume a large quantity of electricity as described earlier, and power generation is a major source of pollution, particularly sulphur dioxide. The manufacturing sector should be held responsible for some of the air pollution problems caused by electricity generation.

A major question is how much does industry contribute to the emissions of major air pollutants. Unfortunately, statistics on pollutants by major sources are scarce. United States data given in appendix table III.60 provide a rough estimate of the industry contribution to air pollution during the period 1970-1986. From the table, the industry contribution to the emissions of five pollutants in millions of tonnes in 1986 can be determined as follows (see figure III.8). Industry was responsible for about 37 per cent of particulates emitted in 1986, 15 per cent of sulphur oxides, 8 per cent of carbon monoxide, 41 per cent of volatile organic compounds and 3 per cent of nitrogen oxides. By contrast, fuel combustion in stationary sources generates over 70 per cent of sulphur oxides;

Table III.19. Anthropogenic emissions of air pollutants in selected countries, 1970-1985a/

Pollutant		Australia b/ c/	Canada	France d/	Germany, Federal Republic of	Czechoslovakia	Hungary	Ireland e/	Japan f/	United Kingdom	United States
Sulphur dioxide											
Total	1970	..	6 678	3 743	3 640	..	..	180	..	6 120g/	28 200
emissions	1980	1 479b/	4 612	3 460	3 200	3 100	1 633	217	1 259	4 670g/	23 200
	1985	..	3 727f/	2 185	2 640i/	3 150	1 400	140	1 079	3 580g/	20 700
Electricity	1970	..	8	27	46	..	..	..	..	45g/	56
generation	1980	..	17	36	53i/	..	..	..	..	61g/	67
(percentage)	1985	..	..	31	..	..	..	31	..	71g/	69
Nitrogen oxides											
Total	1970	..	1 329	1 699	2 400	..	..	56	..	1 832i/	18 100
emissions	1980	242	1 716	1 847	3 090	1 204	370	68	1 339	1 932	20 300
(percentage)	1985	..	..	1 674	3 030i/	1 120	400	57	1 416	1 837	20 000
Transport	1970	..	60	51	42k/	..	..	..	..	34i/	42
(percentage)	1980	59	63	56	55k/	..	..	..	40	37	45
	1985	..	..	65	57k/	5k/	30	33	49	42	45
Particulates											
Total	1970	..	2 028	310	1 300	..	..	88	..	720l/	18 100
emissions	1980	271h/	1 873	278	725m/	..	547	91	..	290l/	8 400
	1985	.	..	187	..	1 370	492	100	..	260l/	7 300
Industry	1970	..	70	37	58	..	..	..	..	11l/	56
(percentage)	1980	..	64	26	61m/	..	..	..	..	16l/	38
	1985	..	..	27	..	..	..	3	..	12l/	37
Carbon monoxide											
Total	1970	..	11 584	..	13 470	..	..	399	..	4 690i/	98 700
emissions	1980	2 416	10 256	5 200h/	8 960	..	1 730	497	..	5 127	76 000
	1985	..	..	..	7 410i/	..	1 800	472	..	5 394	67 500
Transport	1970	..	81	..	44k/	..	..	..	..	77i/	73
(percentage)	1980	86n/	76	..	59k/	..	..	..	..	82	69
	1985	..	..	..	59k/	..	60k/	81	..	84	70
Lead (metric tonnes)											
Total	1970	..	..	..	..	..	..	700	..	6 500	203 800
emissions	1980	4 011	13 000m/	..	..	..	600o/	900	..	7 500	70 600
	1985	..	..	..	..	..	530o/	500n/	..	6 500	21 000
Motor	1970	..	..	..	..	..	..	..	..	..	77
vehicles	1980	93	62m/	..	..	..	..	..	..	..	80
(percentage)	1985	..	..	..	..	..	..	..	..	..	69
Hydrocarbons											
Total	1970	..	1 876	..	1 840	..	..	54	..	1 838i/	27 200
emissions	1980	659	1 838	2 185	1 860	350	..	62	..	1 954	22 800
(percentage)	1985	..	..	..	1 830i/	350	..	62	..	2 059	21 300
Motor	1970	..	50	..	36k/	..	..	..	..	24i/	41
Vehicles	1980	47	36	..	45k/	..	..	..	..	26	30
(percentage)	1985	..	..	..	45k/	..	..	..	..	26	28

Source: The World Resource Institute. World Resources 1988-1989 (New York, Basic Books, 1988), table 10.1.

a/ Emissions measurement methods differ, therefore country data are not strictly comparable.

b/ 1980 data refer to 1976.

c/ Seven capital cities, except for sulphur dioxide and particulates, which are national estimates.

d/ 1970 data refer to 1973; 1985 data refer to 1983.

e/ 1970 data refer to 1972; 1985 data refer to 1983.

f/ 1985 data refer to 1983.

g/ Data refer to fuel combustion only; non-combustion sources are excluded.

h/ Refers to 1978, excluding industrial processes.

i/ Refers to 1984.

j/ Refers to 1975.

k/ Mobile sources.

l/ Data on suspended particulate matter (SPM) are for coal combustion only in the United Kingdom; coal combustion was estimated to have contributed approximately 70 per cent of total SPM emissions.

m/ Calculated from weighted average of 1978 and 1982 data.

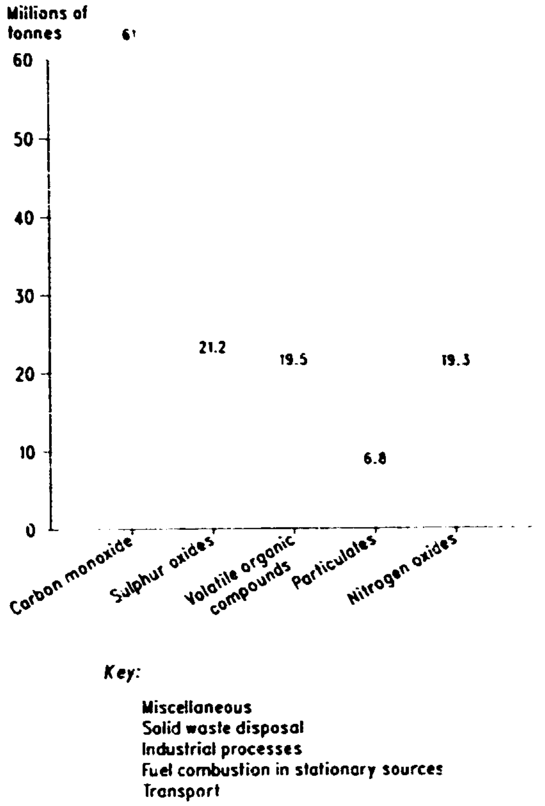
n/ Motor vehicles only.

o/ Transport only.

transport accounts also for nearly 80 per cent of carbon monoxides and 45 per cent of nitrogen oxide; and power generation is again responsible for almost 70 per cent of sulphur oxides and 35 per cent of nitrogen oxides. It is important to note, however, that industrial activities are in varying degrees related to the activities of other sectors, and hence any industry's real contribution to air pollution would be far greater than what its direct emissions indicate. For instance, industry is a major consumer of commercial energy, about 33 per cent of total energy consumption in OECD countries in 1983 [24]; all transport equipment is produced by industry; and industrial waste accounted for about one-eighth of 8 billion tonnes of all waste generated in OECD countries in 1980, and municipal waste accounted for 350 million tonnes, part of which was also from industrial sources ([8], p. 159).

Data on air pollutant emissions by disaggregate industry sources are not easy to come by. Not surprisingly, the fragmentary available data point to

Figure III.8. Nation-wide air pollution emissions by pollutant and source, United States 1986



Source: *Statistical Abstract of the United States 1989* (Washington D.C., United States Bureau of Census, 1989).

Note: Figures on top of bars represent totals.

Table III.20. Industrial air pollutant emissions in the United States, 1970

Industry	Annual emission levels (billions of kilograms)	Type of emission
Petroleum refining	3.8	Particulates, sulphur oxides, hydrocarbons, carbon monoxide
Smelters for aluminium, copper, lead and zinc	3.7	Particulates, sulphur oxides
Iron foundries	3.4	Particulates, carbon monoxide
Kraft pulp and paper mills	3.0	Particulates, carbon monoxide, sulphur oxides
Coal cleaning and refuse	2.1	Particulates, carbon monoxide
Coke (for steel manufacturing)	2.0	Particulates, carbon monoxide, sulphur oxides
Iron and steel mills	1.6	Particulates, carbon monoxide
Grain mills and grain handling	1.0	Particulates
Cement manufacturing	0.8	Particulates
Phosphate fertilizer plants	0.3	Particulates, fluorides

Source: R.D. Ross, *Air Pollution and Industry* (New York, Van Nostrand Reinhold, 1972).

the dominant share of the total air pollution accounted for by the industries producing basic industrial materials. The top 10 heavy polluting industries in the United States in terms of the total quantity of emissions per year are listed in table III.20. These industries roughly correspond to the list of industries earlier classified as high stressors.

More revealing are direct pollution coefficients for all industries, namely the quantity of emissions per unit value of output. Usually an input-output table was linked to a pollutant matrix to derive the direct and indirect pollution coefficients for different sectors. Coefficients can be estimated for individual pollutants or for a composite weighted emission index of any number of pollutants combined. These coefficients tend to vary substantially across different countries and studies, mainly owing to differences in industrial classifications as well as coefficient measurement problems. Moreover, the ranking of industries by the size of its direct coefficients often varies from one study to another.

Direct composite emission indicators of 15 major air pollutants for 60 industries in the Netherlands in 1973 are given in descending order in appendix table III.61. The total direct coefficients are broken down by process emissions, combustion emissions and transport emissions. Except for transport and other services, the highest coefficients are again found among producers of basic industrial materials such as fertilizers, chemicals, building materials and primary metals. However, like any country case-study, the coefficients may be unique to the Netherlands, and less relevant for other countries.

2. *Industrial water pollution*

Water pollution requires industries to precondition water before its use and to treat waste water afterwards. Pre-treatment of the water is required to avoid many problems such as the following: alkalinity and hardness which cause scaling, particularly in boilers; staining of iron and manganese; and micro-organisms which form coatings in pipes, produce stains, tastes and odours, and decompose organic substances.

Although the pre-treatment problem is important in its own right, the present study will focus primarily on the problems of industrial waste waters. In contrast to the general uniformity of substances found in domestic waste waters, industrial waste waters show remarkable variations in the type of contaminants found in them. Table III.21 shows some of the variations found in various industrial waste waters.

The type of contaminants found in industrial waste waters depends on the type of industry and the manufacturing processes in question. These contaminants can be classified into three broad categories: floating materials such as oils and greases; suspended matter such as mineral tailings; and dissolved impurities such as acids, alkalis, heavy metals and insecticides.

There is also the problem of thermal pollution, the raising of the temperature of a waterway by heat discharged from the cooling system or effluent wastes of an industrial establishment. Thermal pollution would obviously disturb the ecological balance of the waterway and pose a threat to the aquatic environment. However, power stations are largely responsible for thermal pollution in most cases.

Table III.21. Selected examples of industrial waste waters

Industry	Process or waste	Result
Brewery and distillery	Malt and fermented liquors	Organic load
Chemicals	Various	Stable organics, phenols, inks
Dairy	Milk-processing, bottling, butter- and cheese-making	Acid
Dyeing	Spent dye, sizings, bleach	Colour, acid or alkaline
Food-processing	Canning and freezing	Organic load
Laundry	Washing	Alkaline
Leather-tanning	Leather-cleaning and -tanning	Organic load, acid and alkaline
Meat-packing	Slaughter, preparation	Organic load
Paper	Pulp and paper manufacturing	Organic load, waste wood fibres
Steel	Pickling, plating etc.	Acid
Textile manufacture	Wool-scouring, dyeing	Organic load, alkaline

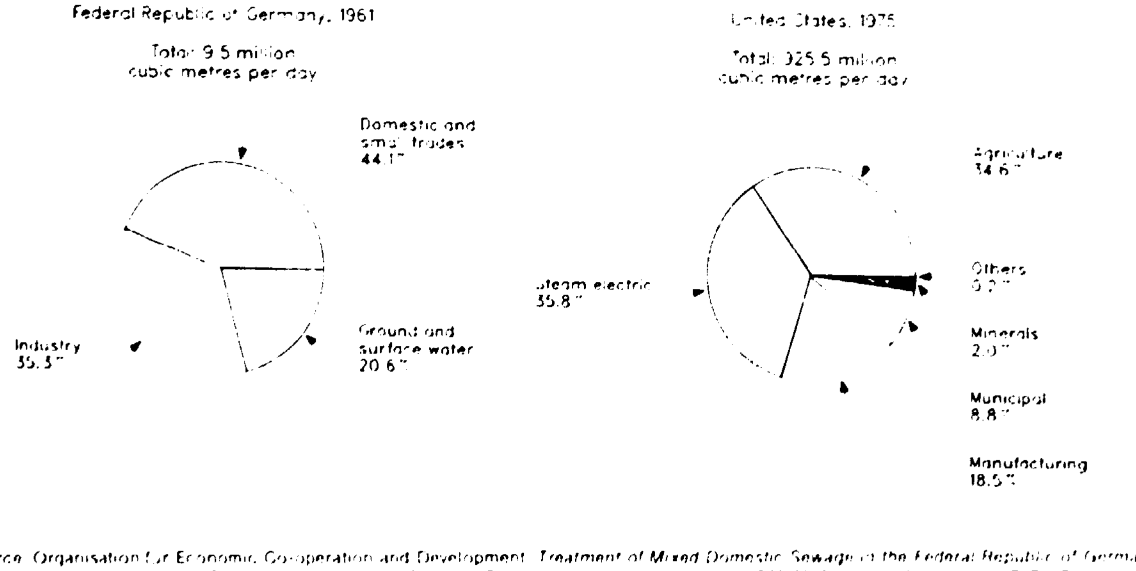
Source: S.P. Parker, *McGraw-Hill Encyclopedia of Environmental Science* (New York, McGraw-Hill, 1980), p. 787.

Industry is responsible for a fairly large share of waste-water discharge of a number of traditional water pollutants. In addition, water pollution is contributed by domestic sources, agricultural run-off and many diffuse sources such as precipitation of air pollutants, soil pollution caused by the application of fertilizers and pesticides, intensive animal husbandry, land-fill disposals and urban run-off. Moreover, in most countries, industry is also discharging into the municipal waste-water systems. These factors make it extremely difficult to estimate the industry share of total waste-water generated.

But fragmentary available data indicate a significant share of industry in total waste-water discharges. For instance, the industry discharge of waste water including ground-water infiltration and surface-water run-off into public sewers in the Federal Republic of Germany in 1961 is given in figure III.9. The industry share of total waste-water discharges was around 35 per cent. However, this industry share includes waste water discharged by public utilities, mining and construction. Manufacturing alone may account for a smaller percentage of total waste-water discharges as reflected in United States data in figure III.9 (18.5 per cent).

Conventional water pollution is usually determined by the amount of biological oxygen demand and chemical oxygen demand, total suspended solids, faecal coliform bacteria, the level of acidity, the amount of phosphorus and the oil and grease content. Industry-level and process-level data on some of these conventional water pollutants are available in some countries. Some of the available data are presented below for illustrative purposes. While almost all industrial activities generate some pollution, a relatively small number of industrial processes are responsible for the bulk of the industrial water, air and solid waste loads generated in a given area. Careful identification of the main heavy-polluting industries can thus help to simplify the pollution assessment while still covering most of the polluting loads originating from industry. For instance, table III.22 reflects the dominance of a small number of industries in industrial waste-water discharges. Chemicals, primary metals, paper and petroleum and coal accounted for about 85 per cent of the total volume of waste waters in the United States manufacturing sector in 1983. It is worth noting that over 55 per cent of the total water used in the manufacturing sector was discharged untreated and the percentage of untreated discharged water was much higher for many individual industries as shown in table III.22. Moreover, according to the more recent United States Environmental Protection Agency survey of toxic chemical release inventories in 1987, five industries accounted for over 90 per cent of total industry releases of toxic chemicals to surface water in 1987, estimated at 4,355 billion kilograms. These top five industries are chemicals (2,648 billion kilograms), paper products (990 billion kilograms), petroleum refining (166 billion kilograms), textile mill products

Figure III.9. The discharge of waste waters by source in the Federal Republic of Germany and the United States



Source: Organisation for Economic Co-operation and Development, *Treatment of Mixed Domestic Sewage in the Federal Republic of Germany* (Paris, 1966), p. 15, and United States Water Resource Council, *The Nation's Water Resource*, 1975-2000, vol. 1 (Washington, D.C., Government Printing Office, 1978).

Table III.22. Water use in manufacturing, 1968-1983, and by industry group, 1983[a/]

Industry or year	Reporting establish-ments[b/]	Total: Quantity	Total: Average	Water intake	Water[c/] recycled	Water discharged	Percentage untreated	Capital expenditures	Operating cost
		(Billions of litres)						(millions of dollars)	
1968	9 402	135 664	144 129	58 775	..	54 249	69.5	..	..
1973	10 668	164 970	15 462	57 091	d/	53 747	56.5	511	966
1978	9 605	169 077	17 602	49 370	129 956	44 392	59.7	1 249	2 119
1983	10 262	128 573	12 529	38 148	90 425	33 873	54.9	919	1 255
Food and allied products	2 656	5 343	2 010	2 462	2 884	2 098	64.5	105	137
Tobacco products	20	129	6 460	19	110	15	e/	e/	5
Textile mill products	761	1 265	1 664	505	760	441	52.6	e/	25
Lumber and wood products	223	828	3 716	327	502	270	63.4	4	23
Furniture and fixtures	66	27	403	11	11	11	100.0	2	4
Paper and allied products	600	28 257	47 093	7 216	21 041	6 718	27.1	66	438
Chemicals and allied products	1 315	36 594	27 827	12 924	23 670	11 324	67.0	187	1 013
Petroleum and coal products	260	23 473	90 280	3 108	20 364	2 656	46.2	165	543
Rubber, miscel-laneous plastic products	375	1 246	3 325	289	958	239	63.5	4	37
Leather and leather products	69	27	384	23	4	23	e/	f/	6
Stone, clay and glass products	602	1 281	2 128	589	692	505	75.2	10	38
Primary metal products	776	22 363	28 819	8 879	13 387	8 026	56.1	100	421
Fabricated metal products	724	980	1 353	247	733	232	49.2	33	106
Non-electrical machinery	523	1 167	2 231	456	707	399	67.6	19	76
Electrical and electronic equip-ment	678	1 273	1 877	281	992	266	61.4	45	108
Transport equipment	380	3 842	10 112	581	3 264	528	67.6	55	171
Instruments and related products	154	426	2 763	114	312	106	50.0	10	45
Miscellaneous manu-facturing	80	57	714	15	42	15	e/	2	*

Source: United States Bureau of the Census, Statistical Abstract of the United States: 1987 (Washington, D.C., 1989).

a/ Based on establishments reporting water intake of 76 million litres. This represented 95 per cent and 96 per cent of the total water use estimated for mining and manufacturing industries. Water intake refers to that which is used or consumed in the production and processing operations and for sanitary services.

b/ Establishments reporting water intake of 76 million litres or more. These counts do not apply to water pollutants abatement columns for manufacturing in 1983.

c/ Refers to water recirculated and water reused.

d/ Data estimated; not strictly comparable to other years.

e/ Withheld to avoid disclosing individual company data.

f/ Figure does not meet publication standards.

(82.6 billion kilograms) and primary metals (48.1 billion kilograms) (see appendix table III.64). It should be noted that in terms of the measurements of strength and volume usually quoted, wastes of manufacturing establishments are about two and a half times as great as those of the United States sewage establishments.

The character of the effluents from different industries is remarkably varied, and hence the complexity of the effects of industrial waste and the measures needed to control them also vary greatly. Data on more detailed characteristics of discharged water wastes are needed for a more meaningful assessment of industrial water pollution. Data for India given in table III.23 provide some detailed information on industrial waste-water discharges. The volume of waste-water and various pollutants per unit of output are given for different processes. The characteristics, volume of wastes and pollutants vary depending on the nature of the product, raw materials and processes used and the by-products recovered.

A recent case-study of industrial water pollution in the metropolitan area of Alexandria, Egypt ([25], pp. 56-61), provides useful insights into the nature and magnitude of industrial water-pollution problems in developing countries. The study shows that 57 industries out of about 1,243 industrial plants and production units located in the metropolitan area in 1980 were found to be major sources of water pollution. Waste loads from different industries in the metropolitan area are summarized in table III.24, and the average concentration of trace metals appears in

Table III.23. Characteristics of waste waters from different industries in India, 1970

Industry	Volume of waste-water	pH value	Suspended solids (milligrams per litre)	Biological oxygen demand (milligrams per litre)	Chemical oxygen demand (milligrams per litre)	Miscellaneous constituents	Pollutional aspects
Pulp and paper (kraft)	50 000 to 100 000 gallons per tonne of paper	6.9 to 9.8	600 2 300	150 to 420	700 to 1 000	Mercaptans	Large volume, high pH and SS, colour and toxity
Strawboard	20 000 gallons per tonne of board	7.5 to 12.9	3 000	2 000	5 000	-	High pH, SS and BOD
Cotton, textiles	30 000-93 000 gallons per 1 000 yards of cloth	8.0 to 11.0	30 to 50	200 to 600	-	Detergents, Chromium (3 mg/l)	Alkalis, BOD, dyes and varying chemical quality
Tannery	340 gallons per 100 pounds of processed hide	9.5	3 200	7 000	-	Chromium (15-20mg/l)	High BOD, SS, Chromium and colour
Slaughterhouse	-	6.8	2 000	600 to-2 500	3 000 6 800	-	High BOD and SS
Milk-bottling	4-6 gallons per gallon of milk handled	8.1	1 800	3 100	4 500	Fat (1 400 mg/l)	High BOD, SS and grease and ready putrescibility
Distillery	600 gallons per 1 000 pounds of molasses	4.3	4 000	29 000	65 000	High sulphate	High BOD, SS and putrescibility and low pH
Synthetic drugs							
Alkaline waste	33 000 gallons per tonne	9.3	-	15 300	28 500	Ammonia and several organics	Alkaline, highly toxic organics and ammonia
Acid waste	29 000 gallons per tonne	1.0	-	9 400	13 700	Sulphanilic acid (1 per cent)	Highly acidic
Steel mill							
Coke ovens	125-155 gallons per tonne of steel	-	-	630	-	Grease and oil (1 000 mg/l) NH_4-N (460 mg/l), phenols (1 300 mg/l)	Highly toxic phenols, cyanides and ammonia
Steel (finished)	530-650 gallons per tonne	-	310	280	-	Phenols (97.5 mg/l) NH_4-N (440 mg/l) cyanide (12 mg/l) CNS (180 mg/l) sulphides	Highly toxic phenols, cyanides and ammonia
Refining	350-400 gallons per tonne of oil processed	-	-	200	-	Oil (30 mg/l) phenols (30 mg/l)	Mineral oils and phenols
Fertilizers, ammonia Urea	2 000 gallons per tonne of NH_3 1 500 gallons per tonne of urea	8.0	3 700	30	330	NH_4-N (510 mg/l) arsenic	Toxic ammonia and arsenic, promotes eutrophication

Source: G.J. Mohanrao and P.V.R. Subrahmanyam, Proceedings of the Seminar on Pollution and Human Environment, 26-27 August 1970 (Bhaba Atomic Research Centre, 1970).
Notes: BOD = biological oxygen demand; pH = acidity; SS = suspended solids.
1 gallon = 4.55 litres; 1 pound = 0.45 kilograms.

table III.25. The paper, textile and food industries are the major contributors to the organic load. The concentration of trace metals is extremely high in tannery wastes which are discharged without treatment into the sea. High levels of some trace metals are also found in paper conversion, foundry, copper and electronic effluents.

One useful approach to assessment of pollutant loads generated by different industrial processes is an analysis of industrial waste-load factors. Waste-load factors are the normalized waste volume, or waste volume per unit of product or raw materials. The waste-load factors are usually derived from different industrial processes. There is, at present, no com-

Table III.24. Estimated waste loads of pollution-contributing industries in Alexandria Metropolitan Area, Egypt, 1982

Industry	Number of plants	Discharge	Flow (million litres per day)	Biological oxygen demand	Chemical oxygen demand	Oil and Gas	Suspended residues	Volatile residues	Phenols	Aqueous Ammonia
				(kilograms per day)						
Pulp and paper	2	Sea	93	83 462	[illegible]	[illegible]	56 069	80 635	302	[illegible]
Paper conversion	3	Lake, Sea, Drain	5	3 679	7 374	1 996	7 543	7 454	43	12.6
Textiles	13	Lake, Sea, Drain	37	19 895	37 877	3 114	29 949	41 312	116	[illegible]
Dyes	2	Sea	4	943	580	48	366	447	3.2	2.5
Fertilizers	2	Sea	30	252	1 392	276	558	1 032		
Steel	1	Sewer	13	520	1 430	170	585	890	8.6	4.3
Oil and soap	8	Sewer, Canal	32.5	30 935	61 943	9 830	44 685	51 202	6.7	56
Tyres	1	Sewer	4.3	504	1 260	236	940	1 092	5.4	4.3
Refineries	2	Sea, Lake	230	17 615	41 875	[illegible]	24 370	44 770	36.6	37.5
Chemical (inorganic)	2	Sea	35	10 850	22 035	3 225	39 050	35 600	74.1	195
Tanneries	6	Sea	1.6	2 688	4 109	405	13 600	11 424	43.1	24.3
Power	2	Canal	324	7 662	12 022	[illegible]	15 606	12 987	135	128
Match	2	Lake	1.1	496	862	98	1 085	1 452	8.2	28.6
Electronics	1	Drain	0.5	138	269	59	320	356		2.2
Refractories	1	Drain	0.5	147	297	171	806	716		
Plastics	1	Drain	2.5	788	725	395	713	905	11.3	19.4
Bottling	2	Sewer	1.9	484	693	89	256	432	6.0	9.3
Canning	2	Drain	4	3 000	4 264	177	1 137	2 258	5.8	3.2
Dairy	1	Drain	0.8	1 240	3 660	950	2 982	6 055	2.5	3.0
Yeast and starch	3	Sewer, Lake	3.2	2 440	3 360	106	1 950	2 130	8.6	5.2
Brewery	1	Sewer	1.2	386	184	41	160	192	1.6	0.6
Poultry	1	Drain	0.5	429	583	51	681	693	2.5	3.1
Pharmaceuticals	2	Sewer	0.9	576	936	39	108	475	4.5	0.7

Source: A. Hamza, "Management of industrial hazardous wastes in Egypt", UNEP Industry and Environment (Nairobi, United Nations Environment Programme, 1983).

Table III.25. Average analysis of trace metals in selected industrial effluents in Alexandria Metropolitan Area, Egypt, 198[illegible]
(Milligrams per litre per day)

Industry source	Zinc	Copper	Nickel	Chromium	Cadmium	Iron	Manganese	Lead
Copperworks	594	450	388	a	a	[illegible]	148	290
Canning	1 600	30	5	20	0.9	2 290	18	30
Dairy	1 144	185	224	210	0.5	[illegible]	355	255
Tyres	6 285	400	a	150	0.5	2 550	216	40
Textiles	102	177	198	a	2	32	[illegible]	102
Paper conversion	11.3 b	22	20	360	3	8 096	460	410
Electronics	6 250	70	a	50	a	1 325	373	255
Oil and soap	5 550	96	60	30	0.5	3 625	445	285
Tanneries	2 133	603	545	1270 b	715	14 b	[illegible]	1 238
Chemicals (inorganic)	381	355	475	a	26	1 774	216	527
Foundry	8 400	290	30	460	2	22 800	690	290

Source: A. Hamza, "Management of industrial hazardous wastes in Egypt" UNEP Industry and Environment (Nairobi, United Nations Environment Programme, 1983).

a Not detected.

b Concentrations in milligram per litre.

prehensive compilation of waste-load factors for numerous industrial processes. Recently, a limited list of industrial waste-water-load factors for selected important industrial processes was prepared, and its results are applicable in several developing countries to yield a reasonable initial assessment of industrial waste-water loads [26]. It must be cautioned that these factors are still preliminary, and as more data and factor survey results become available, they should be periodically reviewed and adjusted, and the coverage of the list expanded.

3. *Industrial solid wastes*

Solid waste generation is largely determined by the patterns of consumption and production in the economy. Municipal waste and industrial waste are particularly important, but a considerable amount of waste also results from air and water pollution abatement. As before, we will only review the nature and sources of industrial solid waste, but not the problem of waste management such as the transport and disposal of industrial solid waste. Furthermore, hazardous industrial waste will be treated separately in the following section because of its crucial importance to the environment and human health.

It must be noted at the outset that the problem of solid waste is closely interrelated with that of air and water pollution. For instance, an open dump can contribute to air, water and land pollution. Likewise, solid wastes dumped into the sea can pollute the marine environment. Moreover, waste generated by air and water pollution abatement can create a solid waste disposal problem.

The generation of industrial solid waste is also significantly influenced by the rising prices of raw materials and of energy on world markets in recent years. Particularly, higher prices of energy and raw materials coupled with higher waste-disposal costs have prompted the development of low-waste and clean technologies in developed countries which reduce and recycle industrial waste within a production cycle. The environmental and economic implications of low-waste and clean technologies will be examined in greater detail later.

Table III.26 shows total amounts of waste generated by different sources in different OECD countries. Although a cross-country comparison of waste generation using this table may not be entirely correct because of the different definitions used by the different member countries for each category of waste, the table, nevertheless, makes it possible to gauge the relative quantitative importance of industrial waste compared with that from other sources. For instance, solid waste production in the United States in 1985

Table III.26. Amounts of waste generated by source, selected countries, mid-1980s
(Thousands of tonnes)

Country	Year	Municipal a/	Industrial	Energy production	Agriculture	Mining	Demolition wastes	Dredge spoils	Sewage sludge	Other
Austria	1983	1 727b/	13 258c/	707	..	456	330	2 100	1 350	..
Australia	1980	10 000	20 000d/	2 760	..	..	..	..	..	..
Belgium	1980	3 082	8 000	..	53 000	7 069	..	..	13	..
Canada	1985	16 000	61 000e/	12 400	48 000	910 213	1 540e/	26 000e/	500	38 500
Denmark	1985	2 161	1 317	1 173e/	..	..	1 200	..	125f/	..
Finland	1985	2 000	15 000	700	41 000	17 700	2 000g/	1 500	137f/	..
France	1985	15 000	50 000	..	399 400	100 000h/	..	..	600	2 800
Germany, Federal Republic of	1984	19 387	55 932	10 605	..	3 454	12 429	..	1 591i/	..
Greece	1985	2 500e/	3 904	1 280j/	..	3 900	..	..	..	..
Ireland	1984	1 100	1 580	130	22 000	1 930	240	..	573	962
Italy	1985	15 000	35 000d/	..	29 830e/	57 000e/	..	..	..	..
Japan	1985	41 530	312 000	7 595	90 544k/	26 017	48 948	..	2 003	..
Luxembourg	1985	131	135	..	..	..	..	..	11	..
Netherlands	1985	6 510	3 942l,m,n/	876l,n/	40 000n/	99l,n/	7 700l/	23 466e,o/	250	544
New Zealand	1982	2 106	300p/	..	..	..	..	..	45	594
Norway	1985	1 970	2 186e,p/	..	18 547q/	9 000q/	..	..	73	..
Portugal	1985	2 246	11 200e/	260	..	3 900e/	..	..	..	
Spain	1986	10 568	5 108	..	45 000	180 000r/	..	..	10 000n/	
Sweden	1985	2 650	4 000e/	550	17 000k/	28 000	3 000s/	..	372	
Switzerland	1985	2 500	..	..	..	..	..	..	255n/	
United Kingdom t/	1984	16 668	50 000	12 000	250 000	110 000	3 000	..	..	
United States	1985	178 000d/	628 000u/	72 000d/	1 400 000v/	1 300 000w/	31 960	..	8 400x/	
OECD Total d,x/		370 000	1 300 000	..	..	..	..	..	..	

Source: Organisation for Economic Co-operation and Development, 1989 Environmental Data Book (Paris, 1989), p. 155.

a/ Wastes originating from households, commercial activities etc., and which are collected by municipalities or by order of them.
b/ Household waste only.
c/ Partial figure based on national survey data. Estimate for total industrial waste: 31 million tonnes.
d/ Organisation for Economic Co-operation and Development, Secretariat estimate.
e/ 1980.
f/ 1977.
g/ 1984.
h/ Including demolition waste.
i/ 1983.
j/ Southern Greece only.
k/ Livestock excreta, disused plastics etc.
l/ Data refer to enterprises of more than 10 employees; office and canteen wastes included.
m/ Non-chemical wastes only.
n/ 1986.
o/ Dumped at sea only; unit is $1,000 m^3$.
p/ Chemical industrial wastes only.
q/ 1985.
r/ This waste is fully recycled.
s/ Including non-chemical industrial waste.
t/ England and Wales only.
u/ Including waste-waters that meet United States definitions of solid wastes.
v/ Upper limit.
w/ 1982. Excluding coal mining wastes.
x/ Rounded figures.

was almost 4 billion tonnes per year and agriculture and mining accounted for the bulk of this total, about 38 per cent and 35 per cent, respectively. The industry share of total waste production was less at about 17 per cent. Likewise, in France agricultural waste claimed a lion's share of about 70 per cent of total waste generation, equalling 600 million tonnes in 1985, followed by 17 per cent held by the mining sector, compared with an industry share of about 9 per cent. In contrast, agriculture and mining generated only 17 and 5 per cent, respectively, of slightly over half a billion tonnes of the total wastes generated in 1985 in Japan, while industrial wastes accounted for almost 60 per cent. These results are not surprising because of the dominant position of industry over agriculture and mining in Japan, while agriculture and mining are more important in the United States and France.

Agricultural wastes are principally organic, such as crop wastes, and a large part of them are either ploughed back into the soil or composted. On the other hand, municipal and industrial wastes are relatively heterogeneous in nature, consisting of both organic and inorganic materials, and pose special problems of disposal with varying degrees of toxicity and hazardous contents. Table III.27 compares municipal and industrial waste generation in a larger sample of countries along with hazardous and special waste generation. In general, industry generates a far larger quantity of waste than municipal sources, for instance 3.8 times more in Canada, 3.5 times in the United States, 3.3 times in France and 7.5 times in Japan. In all cases, industrial waste generation is much greater than municipal sources, even considering significant inter-country variations.

Table III.27. Waste generation in selected countries, 1975-1986

Country or area	Average annual municipal waste generation: Total 1975	1980	1983	1984-1985 b/	Per capita a/ (kilograms)	Per unit area (tonnes per km² per year)	Year of estimate	Industrial waste generation: Total (thousand tonnes per year)	Per million dollars of industrial GDP c/	Per unit area (tonnes per km² per year)	Hazardous and special waste generation: Total (thousand tonnes per year)	Per unit area (tonnes per km² per year)
	(thousand tonnes per year)											
Americas												
Canada	..	12 600	16 000	..	642	1.7	1980	61 000	730	6.6	3 290	0.4
Costa Rica	..	..	534	..	211	10.5	..	..	..	..	..	..
Mexico	..	..	..	32	-	-	1986	192	3	0.1	..	..
United States	140 000	160 000	178 000	..	744	19.4	1985	613 000	501	66.9	250 000	27.3
Asia												
Cyprus	..	..	..	..	..	..	1985	56	..	6.2	..	..
Israel	..	..	..	1 400	330	65.1	..	..	..	..	30	1.4
Japan	38 074	41 511	41 095	..	342	110.8	1983	220 548	494	594.5	768	2.1
Republic of Korea	..	..	15 746	..	679	160.7	1981	7 030	274	71.7	180	..
Singapore	..	1 082	..	1 498	..	2 496.7	..	..	..	..	..	..
Europe												
Austria	1 407	1 560	1 630	..	216	19.4	1983	5 119	197	60.8	100	1.2
Belgium	2 900	3 082	..	..	..	205.2	1980	8 000	196	242.4	915	27.7
Bulgaria	..	..	..	6 773	757	0.6	..	..	..	..	..	..
Czechoslovakia	..	..	..	..	..	..	1982	80 910	..	647.3	..	..
Denmark	..	2 046	..	..	399	48.7	1980	814	..	19.4	90	2.1
Finland	..	..	1 200	..	247	3.9	1984	14 000	804	45.9	124	0.4
France	..	14 000	..	..	260	25.6	1980	32 200	137	59.0	2 000	3.7
Germany, Federal Republic of	20 423	21 417	20 268	27 544	447	112.9	1982	52 464	172	215.0	4 900	20.1
Greece	..	..	2 500	..	259	19.1	..	..	..	..	..	..
Hungary	..	..	..	7 000	658	76.1	1985	21 146	2 509	229.8	7 081	77.0
Iceland	..	..	..	93	388	0.9	1985	105	..	1.1	..	..
Ireland	565	640	1 100	1 270	359	15.9	1984	1 580	346	22.9	20	0.3
Italy	14 095	14 041	..	..	249	47.8	1980	35 000	207	119.0	2 000	6.8
Luxembourg	..	..	..	190	514	76.0	1985	95	..	38.0	15	6.0
Netherlands	..	7 450	7 180	7 242	500	213.0	1984	4 137	97	121.7	280	8.2
Norway	..	2 200	..	1 700	280	7.1	1980	2 186	93	7.1	120	0.4
Poland	..	..	..	7 900	212	25.9	1985	274 885	..	901.3	..	..
Portugal	..	1 300	1 700	2 246	233	24.4	1980	11 200	1 110	121.7	1 049	11.4
Spain	..	8 028	..	10 600	275	21.2	1985	1 500	..	3.0	..	..
Sweden	2 400	2 500	..	..	301	6.1	1980	4 000	102	9.7	550	1.3
Switzerland	1 600	2 146	..	..	336	53.7	..	..	..	..	100	2.5
United Kingdom	16 036	15 816	16 398	..	291	67.8	1984	50 000	327	206.6	1 500	6.2
USSR	..	..	..	..	..	..	1985	306 258	..	13.8	..	..
Oceania												
Australia	..	10 000	..	..	681	1.3	1980	20 000	..	2.6	300	0.0
New Zealand	1 150	1 528	2 106	1 160	653	4.3	1982	300	38	1.1	45	0.2

Source: World Resources Institute, World Resources 1988-1989 (New York, Basic Books, 1988), table 20.7.

a/ Figures are for most recent year available.

b/ Refers either to 1984 or to 1985.

c/ The portion of GDP contributed by industry.

Appendix table III.62 provides information on selected groups of industrial wastes generated in OECD countries. Data do not represent all industrial wastes nor their potential toxicity, but reveal the relative importance of different types of industrial wastes in different countries, such as waste oil, concentrated acids, metal finishing and plastics and rubber.

Data on solid wastes generated by various industries is very scarce, and average data, even if available, tend to be less useful because of wide variations in process technologies, production efficiencies and waste recycling among different industries. However, the types of wastes that are expected to be generated by various industries are known, and they have been identified in appendix table III.63.

4. *Hazardous industrial wastes*

The question of what constitutes hazardous waste is a highly contentious issue from both conceptual and practical viewpoints. Tremendous differences exist between countries in both the methods used for defining wastes and the type of wastes included, owing to variations in the legal, institutional, and environmental conditions in different countries. Thus, what is considered hazardous in one country may not be so in another. This makes it extremely difficult to make an international comparison of hazardous waste generation. Different countries, including Belgium, Denmark, France, Federal Republic of Germany, Netherlands, Sweden, United Kingdom and United States, have developed their own comprehensive list of hazardous wastes for regulatory purposes. The merits and demerits of the listing approach have been discussed extensively in a World Health Organization (WHO) report [27]. Furthermore, international organizations such as OECD and CEC are attempting to develop a cross-reference list of hazardous wastes as a first step towards harmonization of waste definitions.*

According to the present intepretation, hazardous industrial wastes can be categorized according to the nature and degrees of risks such as toxicity, flammability, explosivity, infectivity and corrosivity. An illustrative example of the classification of hazardous wastes by the nature of risks is given in table III.28. A partial list of hazardous industrial wastes is presented in table III.29.

Table III.28. Category and source of hazardous wastes

Category	Source
Toxic chemicals	Chemical industry, heavy industries, coal-based thermal power plants pharmaceuticals, pesticides, plastics and polymers
Flammable	Oil sludges, solvents, plasticizers, light metal discards
Explosives	Ordnance factories, oil tankers, safety matches, pyrotechnics
Corrosives	Acid slurries
Infective, biologicals	Hospital wastes, wastes from vaccine and serum institutes, fermentation industries, biotechnology

Source: C.R.K. Murti, "Health implications of hazardous waste disposal" in *Hazardous Waste Management*, S.P. Maltezou and others, eds. (London, Tycooly, 1989).

Table III.29. Selected hazardous wastes in developing countries

Waste	Source
Cyanide wastes	Electroplating, metal processing, chemicals
Metal-finishing wastes	Cutting oils, acid slurry
Solvents	Vegetable oil recovery, chemical industry
Mercury wastes	Chloralkali plants
Fluoride	Bauxite, fertilizers
Arsenic	Fertilizers, wood-processing
Pesticides	Manufacture and formulation, outdated disposal
Plastics, monomers	Plastics
Phenols	Iron and steel, petrochemicals
Asbestos	Asbestos cement, insulation industry, building industry

Source: C.R.K. Murti, "Health implications of hazardous waste disposal", in *Hazardous Waste Management*, S.P. Maltezou and others, eds. (London, Tycooly, 1989).

National data on hazardous wastes are scarce and incomplete. Even if available, they are not comparable because of variations in the definitions and classification schemes of hazardous wastes adopted by different countries. Table III.30 provides incomplete information on hazardous and special wastes (excluding nuclear waste) along with chemical and non-chemical wastes in OECD countries in the mid-1980s. Bearing in mind the severe limitation of international comparison, it is estimated that OECD countries generate about 300 million tonnes of hazardous wastes, including 265 million tonnes reported by the United States, around 1 million tonnes from Pacific OECD countries, and 20 million to 24 million tonnes from European OECD countries. About 88 per cent of these hazardous wastes are generated in the United States. France, Federal Republic of Germany, Italy and United Kingdom are the main generating countries in Europe. Data from non-OECD countries, especially developing countries, are not available. In Hungary, 3.5 million tonnes of hazardous wastes are generated annually [29]. Serious hazardous waste problems are likely to exist in some developing countries such as Brazil, China, India and Republic of Korea, given the industrial structure of those countries.

By far the largest portion of the total hazardous wastes generated tends to be produced by industrial production with some minor exception. For instance, in the United States over 85 per cent of the hazardous waste is accounted for by the manufacturing sector ([30], p. 43). On the other hand, in Hungary, the mineral industry is responsible for 66 per cent of the hazardous waste, with the chemical industry accounting for only 17 per cent [29]. Recent United States data show that among United States industries, chemical and allied products accounted for almost 50 per cent of the total industry hazardous waste of 266 million tonnes generated in 1983 (figure III.10).

*For detailed discussion on establishing a practical classification scheme for hazardous wastes adapted to the needs of a country, see [28].

Table III.30. Industrial waste and hazardous and special wastes in selected countries, 1980-1987[a]

(Thousands of tonnes)

Country	Year	Chemical waste	Non-chemical waste	Total	Hazardous and special wastes[b]
Austria	1983	525	12 733[c]	13 258	200
Australia	1980	..	..	20 000[c]	300
Belgium	1980	..	..	8 000	915
Canada	1980	..	..	61 000	3 290[d]
Denmark	1985	78[e]	..	1 317	125
Finland	1985	..	..	15 000	124
France	1985	..	..	50 000	2 000[f]
Germany, Federal Republic of	1984	10 419	45 513	55 932	5 000[g]
Greece	1985	..	..	3 904	..
Ireland	1984	..	..	1 540	20
Italy	1985	..	..	35 000[c]	1 000 - 3 000
Japan	1985	..	..	312 000	666[h]
Luxembourg	1985	..	..	135	4
Netherlands[i]	1986	..	3 942	..	1 500[j]
New Zealand	1982	..	300	..	30 - 60
Norway	1980	2 186	..	..	120
Portugal	1980	..	..	11 200	1 049[h]
Sweden	1980	500	3 500	4 000	500
Switzerland	1987	..	..	..	120
Spain	1986	..	..	5 108	1 708[k]
United Kingdom	1984	..	..	50 000	3 900[h,l]
United States	1985	93 000[e]	..	628 000	265 000

Source: OECD Environmental Data 1989 (Paris, Organisation for Economic Co-operation and Development, 1989).

a/ Special wastes that are considered hazardous.

b/ Organisation for Economic Co-operation and Development Secretariat estimates based on national definitions.

c/ Organisation for Economic Co-operation and Development Secretariat estimate

d/ Wet weight.

e/ Hazardous chemical wastes only.

f/ Amount of toxic or hazardous waste. The total amount of special waste is 18 million tonnes.

g/ 1985.

h/ 1986.

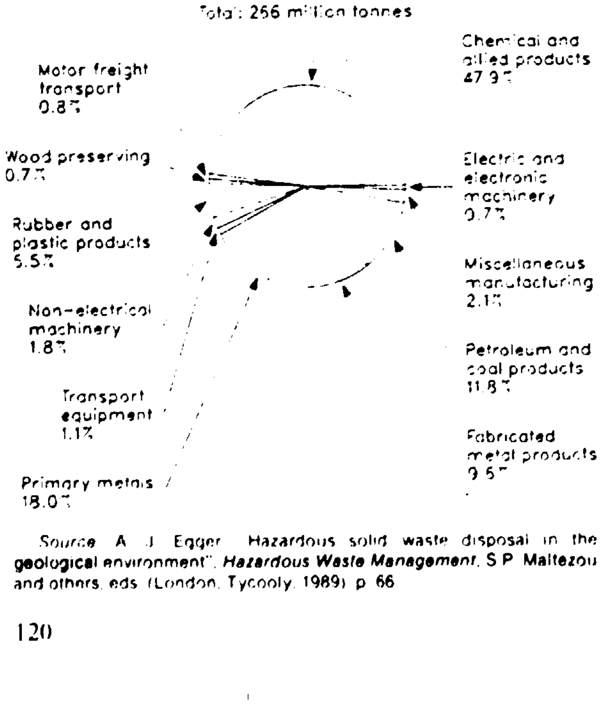
i/ Data refer to enterprises of more than 10 employees, office and canteen wastes included.

j/ Excluding ship cleaning residuals.

k/ 1987.

l/ England and Wales only; year ending 31 March 1987; excluding mine and quarry waste.

Figure III.10. Industrial hazardous waste generation in the United States, 1983



Source: A. J. Egger, "Hazardous solid waste disposal in the geological environment", *Hazardous Waste Management*, S.P. Maltezou and others, eds. (London, Tycooly, 1989), p. 66.

Trailing far behind the chemical industry are primary metals (18 per cent), petroleum and coal products (11.8 per cent), fabricated metal products (9.6 per cent), rubber and plastic products (5.5 per cent) etc.

At more disaggregated industrial classification levels, industrial organic chemicals tend to be the highest-volume generator of hazardous waste in the United States, according to a recent survey [31]. In fact, the top 10 generating industries of hazardous waste in the United States in 1987 are dominated by various chemicals, as shown in table III.31.

Table III.31. Top 10 industries producing hazardous waste in the United States, 1987

United States standard industrial classification (SIC)	SIC category	Hazardous waste volume (million tonnes)
2869	Industrial organic chemicals	60-80
2800	General chemical manufacturing	40-50
2911	Petroleum refining	20-30
2892	Explosives	10-15
2821	Plastic materials/resins	6-10
4953	Refuse systems (commercial TSDR[a] facility)	5-8
2879	Agricultural chemicals	5-8
2865	Cyclic crudes, intermediates	5-8
2816	Inorganic pigments	3.5-5
2812	Alkalis, chlorine	2.5-4.5

Source: Environmental Protection Agency, The Toxics Release Inventory, 1987 (Washington, D.C., Government Printing Office, 1989).

a. Transport, storage, disposal or recycling.

Needless to say, the type and volume of hazardous waste generated depends on the compositon and size of the industry. A case in point is the electronics industry in Malaysia, one of the most important industries, with an MVA share of nearly 15 per cent. According to a 1983-1984 hazardous waste survey by the Department of Environment of Malaysia, 52 per cent of toxic and hazardous waste generation is accounted for by the electronics industry, 14 per cent by the metals and electroplating industries, and the rest by the chemical, rubber, plastic, printing, packaging, tannery and pharmaceutical industries [32].

5. *Toxic chemicals*

Chemicals have become such an indispensable part of modern life that almost all products contain some chemicals or are processed or wrapped by means of chemicals. More than 7 million chemicals are now known and the list grows steadily longer. About 80,000 chemicals are currently known to be used to manufacture a wide range of products to satisfy the ever-expanding material consumption of modern life. Over 1,000 billion dollars' worth of chemical products are today produced and sold all over the world. The United States and Europe each produce over 200 billion dollars' worth of chemical products ([33], p. 185). Each one of these chemicals used in manufacturing processes is potentially hazardous if wrongly applied or if released in large quantities by design or accident.

Worse yet, they tend to remain in some form or shape as polluting agents long after their original job is done. Moreover, not only has the number of chemicals been expanding rapidly over the past 20 years, but also their quantities have seen phenomenal growth. Global production of organic chemicals, for example, made quantum jumps from about 1 million tonnes a year in the 1930s to 7 million in 1950, 63 million in 1970 and about 250 million in 1985 [34].

Because of the overwhelming importance of chemical pollutants in terms of the quantities of pollutants generated and potential health risks and threats to the environment, chemical industry pollution in general and toxic chemicals in particular would seem to warrant a special separate treatment. As in the case of hazardous wastes in the foregoing analysis, it is difficult to estimate exactly how much hazardous chemical waste is produced every year partly because of problems of defining the term "hazardous", as discussed earlier. Recent United States data will be largely relied on below to identify the types and industry sources of major chemical pollutants and toxic chemicals and to quantify them, since United States data on chemical pollution appear to be by far more comprehensive and complete than any other country data available.

In the conventional sense, toxic chemicals discharged into the environment from a manufacturing or processing operation consist primarily of two categories of toxic substances, namely heavy metals and organic compounds. The sources of these toxic chemicals are found in many varied manufacturing industries as well as in the chemical industry.*

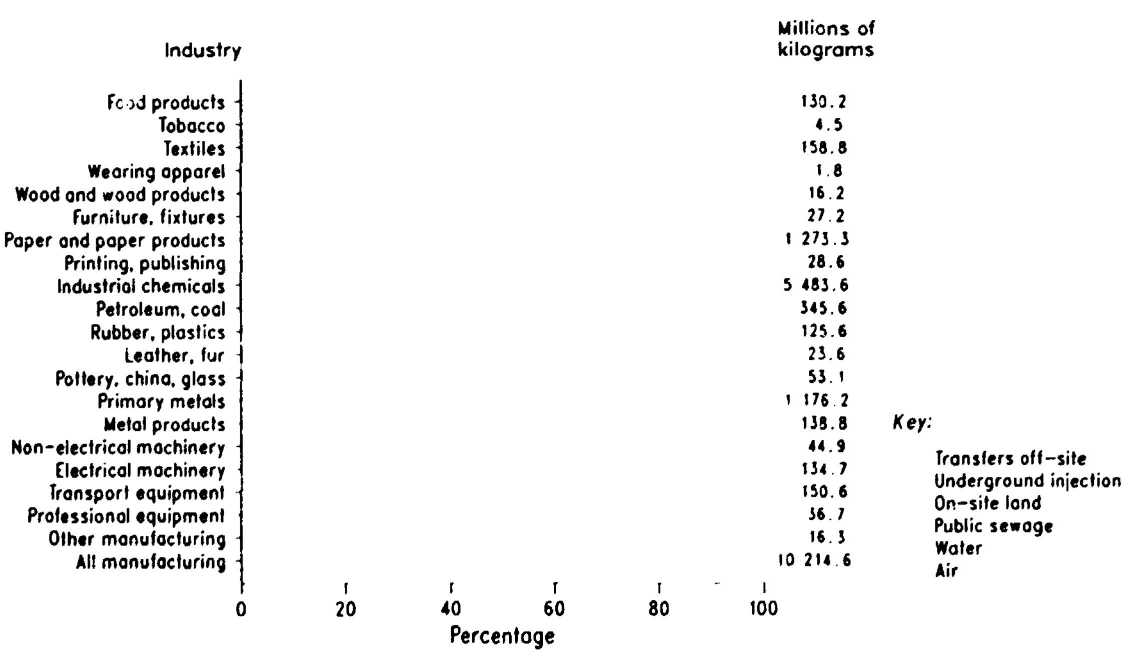
*For detailed descriptions of some of the known or potentially toxic metals and organic compounds, their sources and environmental effects, see [8], tables 4 and 5.

A more detailed review of sources and quantities of a wide range of important potentially toxic chemicals from various industries will now be presented on the basis of 1987 United States survey data. In 1987, the United States Environmental Protection Agency initiated the Toxics Release Inventory (TRI) programme under which manufacturing establishments reported to the Agency information on more than 300 chemicals used or released to the environment by manufacturers. According to this first TRI survey, manufacturing establishments reported the release of 8.2 billion kilograms of 328 TRI chemicals into the air, water and land or underground wells, in addition to 2.1 billion kilograms of TRI chemicals transferred off-site to other facilities, such as public sewage systems or incinerators for treatment or disposal (see appendix table III.64 and figure III.11). The most important of the 328 TRI chemicals along with their industry emission sources and quantities are given detailed treatment in table III.31 at the end of the previous section.*

A total of 10.2 billion kilograms in releases and transfers of TRI chemicals was reported in 1987. It must be noted, however, that sodium sulphate accounted for more than half of all releases and transfers of TRI chemicals in 1987, amounting to more than 5.4 billion kilograms. Therefore, the removal of sodium sulphate from the TRI list owing to its apparently insignificant toxicity would not only reduce the total amount of release and transfers from 10.2 billion to 4.7 billion

*TRI chemicals cover a broad spectrum of toxicity concerns. The data do not, however, directly measure the amounts of human or environmental exposure to chemicals, nor do they estimate the risks posed by TRI chemicals. Moreover, total release or transfer amounts may conceal the fact that a small release of a highly toxic chemical might be of much greater concern than a large release of a mildly toxic substance.

Figure III.11. Amount of all categories of chemical releases and transfers by type of industry in the United States, 1987



Source: Environmental Protection Agency, *The Toxics Release Inventory, 1987* (Washington, D.C., Government Printing Office, 1989) kilograms, but also drastically alter the composition and percentage distribution of outlets for chemicals release and transfers. For instance, discharges into surface water, which ranked first with a very large share of the sodium sulphate (75 per cent of the total sodium sulphate release in 1987) would be reduced to last place for all types of releases and transfers (see figure III.12). The acids, bases and salts class of chemicals, which accounts for 69 per cent of total releases and transfers of TRI chemicals, would drop by only 33 per cent when sodium sulphate is not included in the list.* Figure III.12 shows that 43 per cent of the total releases and transfers of TRI chemicals was discharged into surface water, 14 per cent was injected into underground wells, 12 per cent emitted into air, 9 per cent discharged to public sewage and 12 per cent transferred to off-site facilities.

With regard to industrial patterns of release and transfer, the chemical industry topped the list by producing about 5.5 billion kilograms, or 54 per cent, of the total releases and transfers of TRI chemicals, followed by paper products (1.3 billion kilograms) and primary metals (1.2 billion kilograms). The rest of the top 10 are petroleum refining (345.6 million kilograms), textiles (158.8 million kilograms), transport equipment (150.6 million kilograms), metal products (138.8 million kilograms), electrical machinery (134.7 million kilograms), food products (130.2 million kilograms) and rubber and plastics (125.6 million kilograms) (see figure III.11).

The environmental burden of the chemical industry in the United States is further underscored by the fact that the chemical industry accounted for 48 per cent of total chemical discharges into surface water, 24 per cent by underground injection and 41 per cent to public sewage treatment plants.

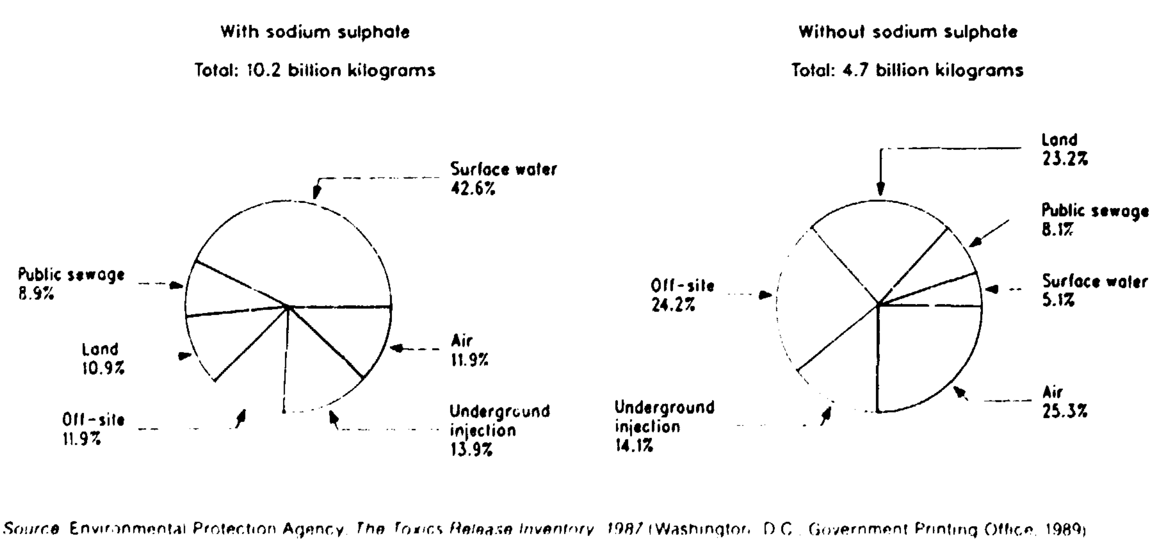
The chemical industry tops the list for toxic chemical emissions, even when chemical emissions are measured against industry output. Whether measured in terms of emissions per 1,000 dollars of MVA or gross output, the chemical pollution coefficient for industrial chemicals is almost twice as large as the second-highest coefficient for paper products (see table III.32). Little change in ranking was noted between the MVA coefficients and the gross output coefficients. It is also worth noting that there is a close rank correlation between total emissions and unit output coefficients in most industries producing basic industrial materials, but weaker correlation in capital goods industries. For instance, industrial chemicals, paper products and primary metals ranked among the top three in terms of both total emissions and unit output measurement. By contrast, transport equipment and electrical machinery ranked seventh and ninth, respectively, in total chemical emissions, but twelfth and tenth in terms of emissions per 1,000 dollars of MVA.

Regarding specific chemicals, TRI requires reporting on 308 individual chemicals and 20 chemical categories. The chemicals cover a gamut of toxicity, ranging from acutely lethal chemicals to mildly toxic chemical which may be subject to removal from the TRI list as part of the ongoing review process of the Environmental Protection Agency. It should be cautioned, therefore, that the large reported release of chemicals of relatively low toxicity may be less environmentally damaging than smaller quantity of highly toxic chemicals. TRI chemicals cover a wide range of well-known chemicals such as ammonia, benzene and copper, as well as obscure ones such as 4-dimentylamino-azobenzene. TRI chemicals are produced not only as products, but are also used as raw materials for other products such as solvents, disinfectants, dyes and catalysts.

Although more than 300 chemicals are included in the TRI list, the top 25 chemicals accounted for about 94 per cent of total 1987 releases and transfers (see figure III.13). It was noted earlier that sodium sulphate alone represented 54 per cent of all releases and transfers of TRI chemicals in 1987.

*For a more detailed and complete description of the TRI chemical release data base, see [31].

Figure III.12. Total release and transfers of TRI chemicals, United States, 1987



Source: Environmental Protection Agency, *The Toxics Release Inventory 1987* (Washington, D.C., Government Printing Office, 1989).

Table III.32. Chemical pollution coefficient by industry in the United States, 1987

ISIC code	United States SIC[a] code	Industry	Total release or discharge (thousand pounds)	Manufacturing value added (millions of dollars)	Cost of materials (millions of dollars)	Gross output (millions of dollars)	Coefficient of manufacturing value-added (pounds per thousand dollars)	Coefficient of manufacturing value-added (rank)	Gross output coeffic[ient] (pounds per thousand dollars)	Gross output coeffic[ient] (rank)
311/2/3	20	Food products	287 012	122 073	208 629	330 702	2.35	13	0.87	14
314	21	Tobacco products	10 462	14 261	6 498	20 759	0.73	18	0.50	17
321	22	Textiles	349 911	26 61?	37 902	63 916	13.45	5	5.47	6
322	23	Wearing apparel	4 770	33 311	32 868	66 179	0.14	20	0.07	20
331	24	Wood and wood products	35 961	28 591	41 181	69 772	1.26	15	0.52	16
332	25	Furniture and fixtures	59 715	20 239	17 068	37 307	2.95	11	1.60	11
341	26	Paper and paper products	2 807 409	49 726	58 788	108 514	56.46	2	25.87	2
342	27	Printing and publishing	62 936	89 208	46 028	135 236	0.71	19	0.47	18
351	28	Industrial chemicals	12 088 830	121 242	109 354	230 596	99.71	1	52.42	1
353/4	29	Petroleum refining	762 361	18 399	113 172	131 571	41.43	4	5.79	5
355/6	30	Rubber and plastic products	277 097	44 293	42 291	86 584	6.26	7	3.20	7
323	31	Leather and fur products	52 087	4 275	4 682	8 957	12.18	6	5.82	4
361/2	32	Pottery, china and earthenware and glass products	116 907	33 076	27 901	60 977	3.54	9	1.92	9
371/2	33	Primary metals (iron and steel and non-ferrous)	2 593 238	46 471	74 238	120 709	55.80	3	21.48	3
381	34	Metal products (fabricated metals)	306 289	75 503	73 025	148 528	4.06	8	2.06	8
382	35	Non-electrical machinery	99 091	119 214	100 599	219 813	0.83	17	0.45	19
383	36	Electrical machinery	297 117	95 958	76 432	172 390	3.10	10	1.72	10
384	37	Transport equipment	33[illegible]	135 783	198 719	334 502	2.45	12	0.99	13
385	38	Professional and scientific equipment	81 141	71 487	37 375	108 862	1.14	16	0.75	15
390	39	Other manufacturing industries	36 324	17 432	14 579	32 011	2.08	14	1.13	12
		TOTAL	22 519 040[b]	116 556	1 321 329	2 487 884	19.30		9.05	

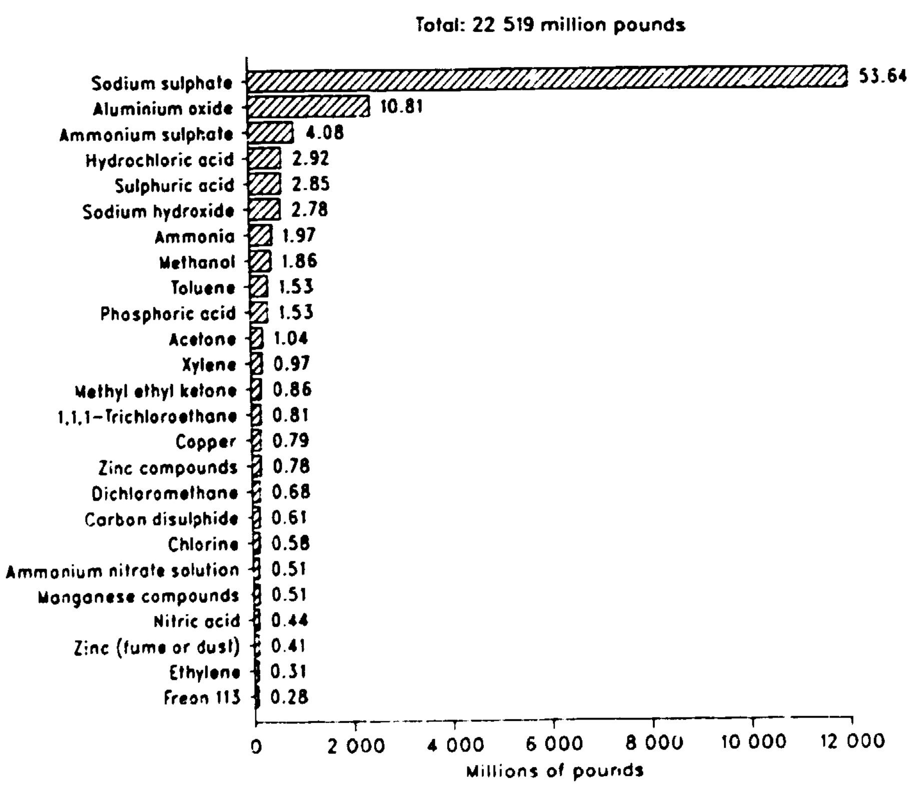
Source: Department of Commerce, 1987 Census of Manufactures-Preliminary Report Summary Series (Washington D.C., 1989), pp. 4-26, and Environmental Protection Agency, The Toxics Release Inventory, 1987 (Washington, D.C., Government Printing Office, 1989), p.216.

Note: 1 pound = 0.4536 kilograms.

a/ Standard Industrial Classification.

b/ Including releases and discharges attributed to multiple SIC codes in SIC 20-39.

Figure III.13. Top 25 chemicals with the largest release and transfers in the United States, 1987



Source Environmental Protection Agency. *The Toxics Release Inventory, 1987* (Washington D.C., Government Printing Office, 1989)

Notes 1 pound 0.4536 kilograms

Figures next to bars indicate percentages of the total

Table III.33 summarizes over 100 chemical releases and transfers by various manufacturing groups in 1987 in the United States. In particular, the table makes it possible to identify readily the number and type of different chemicals discharged by different industry groups and their quantities. It is not surprising to find that apart from emitting the greatest amount of total chemicals among industry groups, the industrial chemicals group generates also the greatest varieties of chemicals. Other industry groups that discharge a relatively large number of different chemicals are iron and steel, non-ferrous metals, paper products, other chemical products, wood products, furniture and fixtures, and capital goods industries comprising machinery, electrical machinery and transport equipment.

By contrast, some light industry groups, such as food products, beverages, tobacco, leather products and footwear, seem to generate a far narrower range of chemicals than other industry groups. The table may serve as a rough check-list of the types of chemicals and their quantitative significance associated with the development of a given manufacturing industry in developing countries.

Table III.33. Toxic release chemicals by industry and by weight, United States, 1987
(Thousands of pounds)

Chemical	311/2 Food products	313 Beverages	314 Tobacco	321 Textiles	322 Wearing apparel	323 Leather and leather products	324 Footwear
Acetone				2.6 (16)			
Acrylamide							
Acrylonitrile							
Aluminium (fume or dust)							
Aluminium oxide							
Ammonia	225.4 (452)	29.2 (76)		49 (48)		2 581.1 (9)	
Ammonium nitrate (soln)							
Ammonium sulphate (soln)		51.5 (2)		60 (50)		4 800.8 (20)	
Aniline							
Antimony							
Arsenic							
Asbestos (friable)							
Barium							
Benzene							
Biphenyl				34 (32)			
Bromomethane (methyl bromide)	11.7 (5)						
1,3 - Butadiene							
Butyl acrylate							
n-Butyl alcohol							
sec-Butyl alcohol							
1,2-Butylene oxide							
Cadmium							
Carbon tetrachloride							
Chlorine	34.8 (230)						
Chlorine dioxide							
Chlorobenzene							
Chloroethane (Ethyl chloride)							
Chloroform							
Chloromethane (Methyl chloride)							
Chlorothalonil (1,3-Benzenedecarbonitrile, 2,4,5,6-tetrachloro-)							
Chromium							
Cobalt						1 054.6 (20)	
Copper							
Cumene							
Cumene hydroperoxide							
Cyclohexane							
2,4-D (acetic acid, (2,4-dichlorophenoxy)-)							
Decarbromodiphenyl oxide							
Di-(2-ethylhexyl) phthalate (DEHP)							
Dibtyl phthalate							
Dichlorobenzene (mixed isomers)							
1,2-Dichloroethane (Ethylene dichloride							
Dichloromethane (methylene chloride)				14.8 (10)			
Diethanolamine							
Diethyl phthalate							
Dimethyl sulphate							
n-Dioctyl phthalate							

Chemical	311/2 Food products	313 Beverages	314 Tobacco	321 Textiles	322 Wearing apparel	323 Leather and leather products	324 Footwear
Ethyl acrylate							
Ethylbenzene							
Ethylene							
Ethylene glycol							
Ethylene oxide							
Formaldehyde							
Freon 113							
Hydrochloric acid							
Hydrogen cyanide							
Hydrogen fluoride							
Isopropyl alcohol							
Lead							
Manganese							
Mercury							
Methanol			62.3 (3)				
Methyl acrylate							
Methyl ethyl ketone				96 (35)		12.9 (13)	
Methyl isobutyl ketone						12.9 (8)	
Methyl methacrylate							
Methylenebis (phenylisocyanate) (MBI)							4.8 (1)
Methylene bromide							
Molybdenum trioxide							
2-Methoxyethanol							
Naphthalene							
Nickel	27 (16)						
Nitric acid	126.5 (98)						
2-Nitropopane							
Phenol							
p-Phenylenediamine							
Phosphoric acid	63.1 (345)						
Phosphorus (yellow or white)							
Phthalic anhydride							
Polychlorinated biphenyls (BCPs)							
Propylene (propane)							
Propylene oxide							
Sodium hydroxide (soln)	1 306.9 (789)	68.6 (204)		552.2 (229)		4 500 (16)	
Sodium sulphate (soln)		503 (11)		1 421.2 (153)			
Styrene							
Sulphuric acid	37.6 (239)	55.4 (65)		102.9 (88)		3 700 (30)	
Tetrachloroethylene (perchloroethylene)	17 (2)			46.8 (25)			
Trade secrete							
1,1,1,-Trichloroethane (methyl chloroform)			47.4 (58)				
1,1,2-Trichloroethane							
1,2,4-Trichlorobenzene			140 (2)				
Trichloroethylene							
1,2,4-Trimethylbenzene							
Toluene			83.3 (34)		30.2 (16)	3.6 (3)	
Toluene-2, 4-diisocyanate							
o-Toluidine							
Vinyl acetate							
m-Xylene							
Xylene (mixed isomers)			99.7 (41)				
Zinc (fume or dust)							

Chemical	331 Wood products	332 Furniture, and fixtures	341 Paper and paper products	342 Printing, publishing	351 Industrial chemicals	352 Other chemical products	353 Petroleum refining
Acetone	49.2 (37)	270 (102)	363.9 (129)		65 (281)	1 765.6 (312)	
Acrylamide					151 (30)		
Acrylonitrile					35.7 (80)		
Aluminium (fume or dust)						322.7 (3)	
Aluminium oxide					71.2 (170)		3 118.5 (116)
Ammonia	10.7 (19)				1 726.4 (606)	10.5 (123)	11.7 (102)
Ammonium nitrate (soln)						644.3 (31)	
Ammonium sulphate (soln)							
Aniline					736.6 (54)		
Antimony					1 (16)		7.6 (8)
Arsenic	3.1 (47)				1.3 (12)		
Asbestos (friable)			89.6 (6)				

Table III.33 continued

Chemical	331 Wood products	332 Furniture, and fixtures	341 Paper and paper products	342 Printing, publishing	351 Industrial chemicals	352 Other chemical products	353 Petroleum refining
Barium							
Benzene					90.2 (128)		18.3 (172)
Biphenyl							
Bromomethane (methyl bromide)							
1,3 - Butadiene					93.9 (94)		
Butyl acrylate			23.6 (1)		1 (83)	0.7 (48)	
n-Butyl alcohol	9 (28)	49 (85)	3 (11)	14 (11)	26.2 (134)	228.7 (151)	
sec-Butyl alcohol					47 (23)	32.1 (14)	
1,2-Butylene oxide					98.9 (6)		
Cadmium					1 (7)		
Carbon tetrachloride					80 (56)		
Chlorine			30 (220)		59.6 (449)		
Chlorine dioxide							
Chlorobenzene					2 115 (45)		
Chloroethane (Ethyl chloride)					153 (37)		
Chloroform			290 (90)				
Chloromethane (Methyl chloride)					1 421 (55)		
Chlorothalonil (1,3-Benzene-decarbonitrile, 2,4,5,6-tetrachloro-)					0.2 (5)		
Chromium	0.2 (63)						
Cobalt					1 (43)		
Copper	1.3 (40)						
Cumene					37.6 (28)		
Cumene hydroperoxide					0.3 (15)		
Cyclohexane						10.3 (17)	
2,4-D (acetic acid, (2,4-dichlorophenoxy)-)					28.2 (21)		
Decarbromodiphenyl oxide			6 (2)				
Di-(2-ethylhexyl) phthalate (DEHP)	10.7 (4)	26.7 (25)			19.7 (44)	6 (24)	
Dibutyl phthalate						3.6 (25)	
Dichlorobenzene (mixed isomers)						65.6 (5)	
1,2-Dichloroethane (Ethylene dichloride)					16.7 (49)		
Dichloromethane (methylene chloride)					11 653.1 (170)	1 146.6 (279)	640 (66)
Diethanolamine					1.8 (66)		
Diethyl phthalate					1.6 (10)		
Dimethyl sulphate					7.6 (16)		
n-Dioctyl phthalate						24.5 (15)	
Ethyl acrylate		406.4 (59)			440.4 (59)		
Ethylbenzene		156.8 (6)			54.3 (111)		
Ethylene					264.6 (122)		
Ethylene glycol	80.7 (6)				16.1 (287)	506.2 (259)	
Ethylene oxide					77.2 (72)		
Formaldehyde	4 300.6 (96)				119.7 (243)	2.2 (107)	
Freon 113					1 056.5 (39)		
Hydrochloric acid		144.6 (15)	2 (145)		45 003.4 (550)	40.8 (254)	
Hydrogen cyanide					134 (28)		
Hydrogen fluoride							
Isoprophyl alcohol	22.7 (18)	198.3 (65)		225 (60)		94.3 (109)	
Lead							
Manganese							
Mercury					10.8 (20)		
Methanol	22.2 (41)	403.1 (147)	606.6 (159)	0.2 (21)	99.9 (499)	176.6 (371)	
Methyl acrylate							
Methyl ethyl ketone	45.1 (55)	121.1 (194)	161 (84)	102.2 (37)	294.5 (136)	974.2 (335)	
Methyl isobutyl ketone	12 (25)	138.6 (59)	854.1 (19)			186.3 (164)	
Methyl methacrylate					250.5 (88)		
Methylenebis (phenylisocyanate) (MBI)					2 (40)		
Methylene bromide					18.3 (3)		
Molybdenum trioxide							130 (21)
2-Methoxyethanol							
Naphthalene	93.7 (89)				7 (71)		
Nickel					3 (42)		
Nitric acid		12.3 (3)					
2-Nitropopane			12.9 (1)				
Phenol			6.6 (21)		0.4 (168)		
p-Phenylenediamine					0.1 (6)		
Phosphoric acid	10.7 (12)					1.6 (190)	470 (53)

Chemical	331 Wood products	332 Furniture, and fixtures	341 Paper and paper products	342 Printing, publishing	351 Industrial chemicals	352 Other chemical products	353 Petroleum refining
Phosphorus (yellow or white)					35 (34)		
Phthalic anhydride					1 750 (105)		
Polychlorinated biphenyls (BCPs)			53.5 (14)		18 (18)		
Propylene (propane)					6 400 (103)		
Propylene oxide					64 (63)		
Sodium hydroxide (soln)	4.6 (121)		71.8 (377)		268 (1 054)	67.9 (563)	
Sodium sulphate (soln)			97.2 (149)		4 462.1 (404)		
Styrene		5.8 (10)			364.2 (255)		
Sulphuric acid					4 639.4 (931)	1.3 (309)	
Tetrachloroethylene (perchloroethylene)				920.8 (23)	39.2 (62)	82 (55)	
Trade secrete	78 (9)		470 (4)			1.2 (5)	
1,1,1,-Trichloroethane (methyl chloroform)	47.4 (58)	138.2 (21)	13.3 (51)	38.3 (39)	1 158.8 (135)	50.4 (247)	
1,1,2-Trichloroethane					970.6 (16)	4.7 (8)	
1,1,4-Trichloroethylene					1 058.8 (48)		
Trichloroethylene							
1,2,4-Trimethylbenzene					21 (22)		
Toluene	122 (130)	698.7 (239)	89.7 (117)	191.5 (100)	316.9 (360)	1 312.3 (574)	56.1 (163)
Toluene-2, 4-diisocyanate						0.7 (27)	
o-Toluidine					16.4 (12)		
Vinyl acetate					218 (88)		
m-Xylene							
Xylene (mixed isomers)	101.7 (74)	815.1 (201)	12.9 (44)	42.0 (41)	743.9 (289)	1 482.4 (496)	
Zinc (fume or dust)					4.1 (47)	1.8 (57)	

Chemical	355 Rubber products	356 Plastic products n.e.c.	361 Pottery, china etc.	362 Glass products	369 Non-metal products n.e.c.	371 Iron and steel	372 Non-ferrous metals
Acetone		1 131 (203)	24.3 (5)			19.2 (1)	1.5 (101)
Acrylamide							
Acrylonitrile							
Aluminium (fume or dust)						5 213.9 (37)	1 006.6 (114)
Aluminium oxide		660 (25)	9 (26)		155.5 (167)		853.8 (261)
Ammonia							21.6 (208)
Ammonium nitrate (soln)						105.6 (4)	
Ammonium sulphate (soln)							
Aniline							
Antimony						2. (1)	18 (31)
Arsenic						1.2 (1)	
Asbestos (friable)					2 040.6 (16)	379.4 (5)	
Barium			2 (3)		1.4 (15)	346.3 (7)	
Benzene						774.1 (19)	
Biphenyl						1.5 (2)	
Bromomethane (methyl bromide)							
1,3 - Butadiene							
Butyl acrylate							
n-Butyl alcohol		1.7 (16)				66.3 (1)	72 (209)
sec-Butyl alcohol							11.8 (10)
1,2-Butylene oxide							
Cadmium						12.9 (4)	
Carbon tetrachloride							
Chlorine						1 040.9 (22)	29 (208)
Chlorine dioxide							
Chlorobenzene							
Chloroethane (Ethyl chloride)							
Chloroform							
Chloromethane (Methyl chloride)							
Chlorothalonil (1,3-Benzenedecarbonitrile, 2,4,5,6-tetrachloro-)							
Chromium						11 642. (119)	46.6 (221)
Cobalt						72.2 (11)	524 (38)
Copper						628.3 (54)	1 341.7 (554)
Cumene						10.6 (1)	

Table III.13 continued

Chemical	355 Rubber products	356 Plastic products n.e.c.	361 Pottery, china etc.	362 Glass products	369 Non-metal products n.e.c.	371 Iron and steel	372 Non-ferrous metals
Cumene hydroperoxide						1.4 (2)	
Cyclohexane							
2,4-D (acetic acid, (2,4-dichlorophenoxy)-)							
Decabromodiphenyl oxide		4 (4)					
Di-(2-ethylhexyl) phthalate (DEHP)							
Dibutyl phthalate						0.5 (2)	
Dichlorobenzene (mixed isomers)							
1,2-Dichloroethane (Ethylene dichloride)							
Dichloromethane (methylene chloride)	25.8 (14)	238.8 (121)	1.0 (2)			425.7 (12)	209.2 (121)
Diethanolamine						3.5 (1)	
Diethyl phthalate							
Dimethyl sulphate							
n-Dioctyl phthalate							
Ethyl acrylate							
Ethylbenzene						3.3 (5)	
Ethylene						26.3 (5)	
Ethylene glycol						2 845.4 (38)	77.5 (97)
Ethylene oxide							
Formaldehyde						509.5 (19)	
Freon 113	11.8 (3)					216.5 (6)	
Hydrochloric acid		169 (26)				45 191 (92)	2 743 (776)
Hydrogen cyanide						14 (1)	
Hydrogen fluoride						22 015.4 (35)	228.4 (128)
Isopropyl alcohol		30 (16)				136.8 (5)	11 (50)
Lead					24.1 (4)	10 338.5 (58)	1 573.3 (227)
Manganese					2.8 (32)	20 978.7 (113)	
Mercury							
Methanol		100 (34)				303 (8)	
Methyl acrylate							
Methyl ethyl ketone		532.3 (120)				400.9 (7)	883 (308)
Methyl isobutyl ketone		4 (21)				8.9 (1)	92 (111)
Methyl methacrylate		736.2 (18)					
Methylenebis (phenylisocyanate) (MBI)						107.9 (11)	
Methylene bromide							
Molybdenum trioxide						97.5 (10)	
2-Methoxyethanol							16.5 (3)
Naphthalene	254 (1)						
Nickel						8 496 (96)	2 978.6 (287)
Nitric acid						24 585.8 (44)	428.6 (550)
2-Nitropropane							
Phenol						3 688.2 (68)	
p-Phenylenediamine						279.2 (3)	
Phosphoric acid						56.3 (32)	666 (259)
Phosphorus (yellow or white)						1 571.3 (2)	
Phthalic anhydride							
Polychlorinated biphenyls (PCBs)						941 (10)	
Prophylene (propene)						0.5 (2)	
Propylene oxide							
Sodium hydroxide (soln)		123.4 (38)				7 733.1 (93)	3 069.3 (1 248)
Sodium sulphate (soln)							119.9 (167)
Styrene		939 (170)					
Sulphuric acid					139 (29)	85 449.3 (150)	3 235.2 (1 102)
Tetrachloroethylene (Perchloroethylene)	1.5 (20)					333.7 (7)	175.2 (129)
Trade secrets							
1,1,1,-Trichloroethane (methyl chloroform)	107.7 (100)	66.9 (103)			21.4 (32)	5 417.2 (54)	1 115.5 (572)
1,1,2-Trichloroethane						148.2 (2)	7.5 (4)
1,2,4-Trimethylbenzene						1 288.3 (17)	
Trichloroethylene						7.7 (3)	492.4 (286)
1,2,3-Trimethylbenzene							
Toluene	193 (92)	121.1 (91)		8.2 (4)	200 (36)	576.4 (28)	787.1 (276)
Toluene-2, 4-diisocyanate							58.2 (7)
o-Toluidine							
Vinyl acetate							
m-Xylene						5.9 (3)	
Xylene (mixed isomers)	5.2 (34)	138 (44)				831.1 (24)	447.3 (365)
Zinc (fume or dust)			0.8 (2)			42 274.6 (56)	1 083.4 (230)

Chemical	381 Metal products	382 Machinery n.e.c.	383 Electrical machinery	384 Transport equipment	385 Professional goods	390 Other industries
Acetone		96.5 (42)	4.6 (185)	639 (273)		
Acrylamide						
Acrylonitrile						
Aluminium (fume or dust)				10 (27)		
Aluminium oxide			2.9 (47)	63.6 (67)		
Ammonia			87.4 (102)	50.9 (55)		80.1 (25)
Ammonium nitrate (soln)						
Ammonium sulphate (soln)						140.5 (2)
Aniline						
Antimony						
Arsenic						
Asbestos (friable)				13[illegible] (27)		
Barium						
Benzene						
Biphenyl						
Bromomethane (methyl bromide)						
1,3 - Butadiene						
Butyl acrylate						
n-Butyl alcohol						
sec-Butyl alcohol						
1,2-Butylene oxide						
Cadmium						
Carbon tetrachloride						
Chlorine						
Chlorine dioxide						
Chlorobenzene						
Chloroethane (Ethyl chloride)						
Chloroform						
Chloromethane (Methyl chloride)						
Chlorothalonil (1,3-Benzenedecarbonitrile, 2,4,5,6-tetrachloro-)						
Chromium		6.4 (78)		63 (67)	3 (10)	
Cobalt						
Copper	8.8 (23)	5 427.8 (83)	80.4 (219)	3.8 (85)		
Cumene						
Cumene hydroperoxide						
Cyclohexane						
2,4-D (acetic acid, (2,4-dichlorophenoxy)-)						
Decarbromodiphenyl oxide						
Di-(2-ethylhexyl) phthalate (DEHP)						
Dibutyl phthalate						
Dichlorobenzene (mixed isomers)						
1,2-Dichloroethane (Ethylene dichloride)						
Dichloromethane (methylene chloride)	13 (13)	29.4 (63)	406.5 (144)	218.6 (165)		95.6 (32)
Diethanolamine		12.9 (24)				
Diethyl phthalate						
Dimethyl sulphate						
n-Dioctyl phthalate						
Ethyl acrylate						
Ethylbenzene						
Ethylene						
Ethylene glycol		1.6 (38)			191 (18)	
Ethylene oxide					381.6 (37)	
Formaldehyde						
Freon 113		205.1 (121)	587 (381)	756.9 (132)	242 (123)	31.7 (23)
Hydrochloric acid	257.2 (23)		8.7 (336)	21 (142)		
Hydrogen cyanide						
Hydrogen fluoride			8.2 (87)	150 (34)		
Isoprophyl alcohol			17.7 (56)			14.5 (13)
Manganese		1.0 (48)				
Mercury						
Methanol		64 (80)	2.2 (102)			37.7 (13)
Methyl acrylate						
Methyl ethyl ketone	25 (24)	1.7 (66)	472.9 (98)	284.2 (239)	24.9 (32)	63.8 (54)
Methyl isobutyl ketone		0.4 (20)	0.9 (17)	1.8 (69)		7.8 (14)
Methyl methacrylate						
Methylenebis (phenylisocyanate) (MBI)						
Methylene bromide						
Methyl isobutyl ketone						

Table III.33 continued

Chemical	381 Metal products		382 Machinery n.e.c.		383 Electrical machinery		384 Transport equipment		385 Professional goods		390 Other industries	
Molybdenum trioxide												
2-Methoxyethanol												
Naphthalene					19.4	(4)						
Nickel			83.8	(57)	22.1	(43)					49	(12)
Nitric acid					520.3	(216)	344	(157)			69	(24)
2-Nitropopane												
Phenol												
p-Phenylenediamine												
Phosphoric acid					5.7	(136)					77.[illegible]	(8)
Phosphorus (yellow or white)												
Phthalic anhydride												
Polychlorinated biphenyls (BCPs)												
Prophylene (propane)												
Propylene oxide												
Sodium hydroxide (soln)			552.4	(187)	1 148	(593)	158	(307)	16.5	(82)		
Sodium sulphate (soln)					420.2	(244)						
Styrene							8.4	(129)				
Sulphuric acid			38.5	(170)	544.6	(607)	86	(280)			164.3	(45)
Tetrachloroethylene (perchloroethylene)			174.3	(32)	245.9	(83)	363	(72)			69.3	(14)
Trade secrete					17.7	(8)						
1,1,1-Trichloroethane (methyl chloroform)	13	(75)			800.6	(463)	568.6	(334)			374.3	(82)
1,1,2-Trichloroethane							7.2	(5)	11.2	(5)		
1,2,4-Trichlorobenzene												
Trichloroethylene			257	(91)	106.1	(130)	465.9	(75)			28.1	(35)
1,2,4-Trimethylbenzene												
Toluene			43	(123)	38.8	(120)	99	(244)	25.6	(32)	43	(74)
Toluene-2, 4-diisocyanate												
o-Toluidine												
Vinyl acetate												
p-Xylene					22.4	(1)						
Xylene (mixed isomers)	34.4	(43)	56.9	(168)	70.5	(201)	117	(242)	16.6	(24)		
Zinc (fume or dust)												

Source: Environmental Protection Agency, TRI List of Chemicals for 1987 Reporting, Section 313, Toxic Chemical List, (Washington, D.C., Government Printing Office, 1989).
Notes: Figures in parentheses are number of firms reporting, soln = solution.

6. *Summary*

The environmental impact of industrial use of natural resources, in particular water, energy and mineral resources, was summarized at the end of section B of the present chapter. Similarly, the salient points concerning industrial pollutants generated in the course of manufacturing activities are recapitulated below.

(a) *Industrial air pollution*

In general, manufacturing is not responsible for the emissions of most pollutants. Each major pollutant has its different major sources. Most importantly, electricity generation accounts for the bulk of anthropogenic emissions of sulphur dioxide, transport activities for nitrogen oxides and carbon monoxide, and motor vehicles for hydrocarbons and lead. Industry, however, is a major source of particulates emissions in different countries. Some estimates suggest that industrial sources contribute about 20 per cent of total air pollution, but this may be an understatement. Many manufacturing industries consume a large quantity of electricity, and power generation is a major source of pollution, particularly sulphur dioxide. The manufacturing sector should also be held responsible for some of the air pollution problems caused by electricity generation.

Data on air pollutants by disaggregated industry sources are not easy to come by. Not surprisingly, the fragmentary available data consistently show that the heavy polluters are those industries producing basic industrial materials; namely, chemicals, primary metals, paper, petroleum and coal products, fertilizers and building materials, whether measured in terms of the total quantity of emissions or the quantity of emissions per unit value of output.

(b) *Industrial water pollution*

Industry is responsible for a fairly large share of waste-water discharge of a number of traditional water pollutants. In addition, water pollution is contributed by domestic sources, agricultural run-off and many diffuse sources such as precipitation of air pollutants, soil pollution caused by the application of fertilizers and pesticides, intensive animal husbandry, landfill disposals and urban run-off. Moreover, in most countries, industry is also discharging into the municipal waste-water systems. These factors make it extremely difficult to estimate the industry share of total waste water generated. Fragmentary data indicate a significant share of industry in total waste water discharge, roughly around 20 per cent.

While almost all industrial activities generate some pollution, a relatively small number of industrial processes are responsible for the bulk of the industrial water, air and solid waste loads generated in a given area. For instance, a small number of industries, including paper, chemicals, petroleum and coal and primary metals, together accounted for about 85 per cent of the total volume of waste waters generated in the United States manufacturing sector in 1983. Moreover, according to the more recent United States Environmental Protection Agency inventory of toxic chemical releases in 1987, five industries accounted for over 90 per cent of total industry releases of toxic chemicals into surface water in 1987, estimated at 4,355 billion kilograms. These top five industries are chemicals, paper products, petroleum refining, textile mill products and primary metals.

(c) *Industrial solid wastes*

A cross-country comparison of waste generation may be difficult owing to the different definitions used by different countries for each category of wastes. Available international data, nevertheless, makes it possible to gauge the relative quantitative importance of industrial waste compared with that from other sources. For instance, the solid waste production in the United States in 1985 was almost 4 billion tonnes per year, and agriculture and mining accounted for the bulk of this total, about 38 per cent and 35 per cent respectively; the industry share of total waste production was less, at about 17 per cent. Likewise, in France agricultural waste claimed a lion's share of about 70 per cent of total waste generation amounting to 600 million tonnes in 1985, followed by 17 per cent held by the mining sector, compared with an industry share of about 9 per cent. In contrast, agriculture and mining generated about 17 per cent and 5 per cent of slightly over half a billion tonnes of the total wastes generated in 1985 in Japan, while industrial wastes accounted for almost 60 per cent. These results are not surprising because of the dominant position of industry over agriculture and mining in Japan, while agriculture and mining are more important in the United States and France.

Data on solid wastes generated by various industries is very scarce, and average data, even if available, tend to be less useful because of wide variations in process technologies, production efficiencies and waste recycling among different industries. However, the types of waste that are expected to be generated by various industries are known, and they have been identified in the present chapter.

(d) *Hazardous industrial wastes*

National data on hazardous wastes are scarce and incomplete. Even if available, they are not comparable because of wide variations in the definitions and classification schemes of hazardous wastes adopted by different countries. Bearing in mind these limitations, the fragmentary data show that by far the largest portion of the total hazardous wastes generated tends to be produced by industrial production with some minor exceptions. For instance, in the United States over 85 per cent of the hazardous waste is accounted for by the manufacturing sector. Recent United States data show that among United States industries, chemical and allied products claimed almost 50 per cent of the total industry hazardous waste of 266 million tonnes generated in 1983. Trailing far behind the chemical industry are primary metals (18 per cent), petroleum and coal products (11.8 per cent), fabricated metal products (9.6 per cent), rubber and plastic products (5.5 per cent) etc. At more disaggregated levels, industrial organic chemicals tend to be the highest-volume generator of hazardous wastes in the United States.

(e) *Toxic chemicals*

It is difficult to estimate the exact amount of toxic chemicals produced in different countries every year partly because of problems of defining the term "toxic" as used in different countries. Only recent United States data seem to be sufficient to permit the identification and quantification of the types and industry sources of toxic chemicals.

According to the first Toxics Release Inventory of the Environmental Protection Agency in 1987, manufacturing establishments reported the release of 8.2 billion kilograms of 328 TRI chemicals into the air, water, land or underground wells, in addition to 2.1 billion kilograms of TRI chemicals transferred off-site to other facilities, such as public sewage systems or incinerators for treatment or disposal. Out of this total, the chemical industry topped the list by producing about 5.4 billion kilograms, or 54 per cent of the total releases and transfers of TRI chemicals, followed by paper products and primary metals. The rest of the top-10 list includes petroleum refining, textiles, transport equipment, metal products, electrical machinery and food products.

The chemical industry accounted for 48 per cent of total chemical discharges into surface water, 24 per cent by underground injection and 41 per cent to public sewage treatment plants. The chemical industry tops the list for toxic chemical emissions, even when chemical emissions are measured against industry output. Whether measured in terms of emissions per 1,000 dollars of MVA or gross output, the chemical pollution coefficient for industrial chemicals is almost twice as large as the second-highest coefficient for paper products.

Industrial pollution problems encountered in the Katowice Province of Poland, situated 250 kilometres south of Warsaw, adjacent to the Czechoslovak border, may typify the severity of environmental damage caused by industrial pollution in other highly industrialized regions of Eastern Europe. The largest number of the so-called "dirty-process plants" in Poland are concentrated in the Katowice province. The bulk of these plants still use out-of-date technologies. This Province accounts for nearly all the zinc and lead minerals mined and processed in Poland, 98 per cent of hard coal produced, 52 per cent of the steel and 31 per cent of the coke manufactured, and 32 per cent of the coal-fired electric power generated. All these activities occur in an area that covers 2.1 per cent of Poland with a population share of 10 per cent, or slightly over 3.5 million in 1980 [35].

Under the existing conditions, about 30 per cent of gaseous substances and about 35 per cent of total particulate matters of the global emission are discharged into the atmosphere by about 3,500 large sources. As a result more than 20 out of 54 pollutants listed by the Council of Ministers exceeded national standards in the Katowice Province and, worse yet, many of these pollutants have annual average concentrations 5 to 20 times the national standards ([36], pp. 99-107).

Water pollution is equally serious in this region. The Vistula River in the Katowice Province is so polluted that it is not suitable for industrial or agricultural use, much less for drinking. The major pollution source is salt contamination from a dozen coal mines located in the region that discharge 250 million litres of salt-laden waste water into the river each day. The high salinity of the river water contributes to the corrosion of pipes and boilers in those plants that have no other sources of water ([37], pp. 20-24).

Air and water pollutants in the Katowice Province contain a large variety of hazardous substances such as dust, sulphur dioxide, nitrogen oxides, carbon monoxides, soot, hydrocarbons including carcinogenic compounds, hydrogen cyanide, phenol and heavy metals. The Institute of Environmental Protection in Katowice recently measured the exposure of the local population

Table III.34. Metal concentrations in selected vegetables from allotments in Katowice, Chorzow and Zabkowice Bedzinskie

Place of sampling and item	Metal	Metal content in fresh vegetables (milligrams per kilogram): Parsley, Leaves	Parsley, Root	Carrot	Celery, Leaves	Celery, Root	Red beet	Potatoes	Weekly metal intake with vegetables (milligrams per week)
Katowice	Lead	13.2	5.4	2.7	13.0	4.1	2.4	0.5	2.8
	Cadmium	0.44	0.40	0.48	2.66	2.07	0.67	0.20	0.71
Chorzow	Lead	8.5	3.5	4.0	9.8	6.0	2.0	0.8	3.3
	Cadmium	0.84	0.75	1.38	3.05	2.83	0.73	0.13	0.81
Zabkowice	Lead	12.2	6.6	4.7	5.1	1.1	2.1	0.8	3.5
	Cadmium	1.41	2.90	1.64	3.25	0.25	0.52	0.20	0.99
Average weekly consumption per capita a/ (grams)		35	35	190	22	22	145	1 900	..

Source: R. Kucharski and E. Marchwinska, "Exposure of edible and pasture plants and consumers in the Katowice District" (Katowice, Institute of Environmental Protection, 1990) (mimeograph).

Note: Maximum allowable concentration limits recommended by FAO and WHO are 3 milligrams for lead and 0.4-0.5 milligrams for cadmium per week.

a/ Based on the results of a 1989 survey of 205 households in Katowice District, conducted by the Institute of Environmental Protection at Katowice.

to two toxic metals, lead and cadmium, through the consumption of vegetables grown in the metal-contaminated soils in the Katowice Province.

Lead is known to be harmful to the circulatory system and to cause neurological disorders. The main origin of lead emission is non-ferrous metallurgical plants, mainly zinc and lead smelters in this region. Other sources such as iron and steel plants (mainly open-hearth furnaces) and automobiles are also important. Cadmium is also known to damage the lungs, blood, liver and kidneys. The main source of cadmium emission is zinc smelting plants in this area, as cadmium is a trace element of zinc blende. Not surprisingly, the highest concentrations of cadmium are found around zinc processing plants in Katowice Province.

In order to estimate the average weekly per-capita intake of lead and cadmium through vegetable consumption by the local population, a study was conducted covering 431 vegetable plots in the Katowice region on the basis of a random sample of the most commonly consumed vegetables from each plot; that is, carrots, parsley, celery, red beets and potatoes. From each selected plot, 30 to 50 sample vegetables were picked, washed as normally done in households, dried, ground and mineralized, and then the metal content for each vegetable was measured. The results for three districts in the Katowice Province are summarized in table III.34 [38].

The sample results show that vegetable leaves are not surprisingly, more readily exposed to metal contamination than roots. Thus, the highest concentration was found in celery leaves and parsley leaves, followed by celery roots, carrot roots, red-beet roots, parsley roots and potatoes. The study group also estimated the average weekly per-capita consumption of selected vegetables from a sample survey of 205 households in the Katowice Province to arrive at the weekly intake of lead and cadmium through vegetable consumption. The estimates of weekly vegetable consumption and weekly metal intake are given in table III.34. Particularly notable is a very high per-capita consumption of potatoes, around 2 kilograms per week.

Given the maximum concentration limits, recommended by the Food and Agriculture Organization of the United Nations (FAO) and WHO, of 3 milligrams per week for lead and 0.4-0.5 milligrams for cadmium, the estimated lead intakes of the local population all exceeded the desired limits except in the Katowice District, and cadmium intakes are almost twice the maximum limits for all districts. It should be noted that these estimates of metal intake are based on the measurement of metal concentrations in a small number of selected vegetables grown in the region, and exclude local consumption of many other vegetables and fruits that may be exposed to metal contamination, let alone intakes from other sources such as inhalation of air-borne pollutants and consumption of contaminated livestock products. They are, therefore, likely to be considerably underestimated.

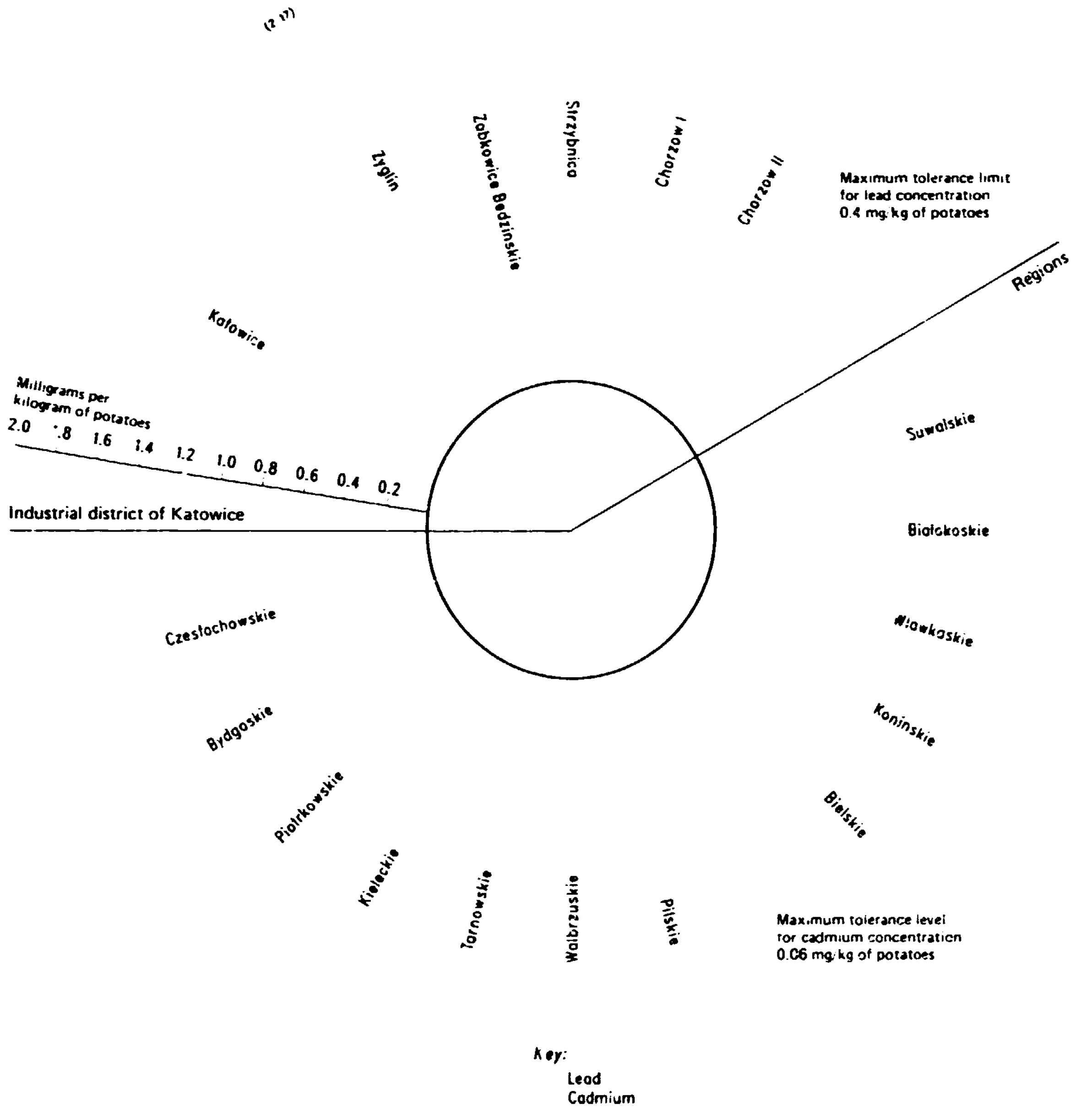
These results are much more shocking than comparable results obtained from Western European countries. Investigations carried out in Austria, Belgium, Denmark, France and Federal Republic of Germany, in the period 1979-1982 showed that the weekly per-capita intake of cadmium through the consumption of vegetables, fruits and corn products were estimated to range between 0.11 and 0.34 milligrams, and between 0.5 and 1.5 milligrams for lead ([38], p. 5). The intakes of cadmium and lead in the Katowice Province are several times higher than comparable figures in Western European countries.

It is worth noting that the thorough washing of vegetables in tap water reduced their lead content by over 20 per cent, but with little effect on their cadmium content. Peeling root vegetables can, however, be an effective way of removing some of the metal contents, for instance, a 20 per cent decrease of lead content and a 20-30 per cent reduction of cadmium content in meals prepared from these vegetables. Moreover, over 90 per cent of lead and cadmium was removed from potatoes and deposited in the waste when potatoes are subjected to alcoholic fermentation. These contaminated wastes are, however, often fed to livestocks as a fodder in the Katowice region ([38], p. 6).

Given the relatively large quantities of potatoes consumed in Poland as a staple food, the per-capita weekly consumption of which ranges between 2 and 5 kilograms (nearly twice the amount of consumption in other countries), scientists at the Institute of Environmental Protection at Katowice conducted an investigation of lead and cadmium concentration in raw potato samples from 13 regions in Poland ([39], pp. 113-118). Four of these regions, including the Katowice Province, are highly industrialized centres, and the remaining nine regions have less industrial intensity. The results are summarized in figure III.14. As expected, all the districts within Katowice Province as well as Katowice Province as a whole, noted for their high concentration of heavy polluting industries as described earlier, showed much higher concentrations of lead and cadmium than other regions. In fact, most of the districts in Katowice Province greatly exceeded the maximum tolerance limits set by the Government of Poland for lead and cadmium concentations in potatoes, respectively 0.4 milligrams and 0.06 milligrams per kilogram of potatoes. By contrast, lead and cadmium concentrations in raw potatoes in other regions of Poland appear to be less serious with few exceptions.

This case-study of lead and cadmium concentrations in potatoes in Poland illustrates forcefully one of the numerous links between industrial pollution and health hazards, and once again underscores the importance of environmentally sound industrial development.

Figure III.14. Lead and cadmium concentrations in potato samples from different regions of Poland



Source E. Marchwinskia and others, Stezenie kadmnu i olowiu w Probkach Ziemniakow Z Roznych Rejonow F... ki, Roczn. vol. XXXV, No. 2 (1983).

D. Industrial processes and pollution in selected industries

1. Pollution in high-technology industry: the case of electronics manufacturing

High-technology industry is generally regarded as the most dynamic and growth-oriented industry. Broadly speaking, high-technology industry encompasses knowledge-intensive, sophisticated technological activities such as electronics, biotechnology and new materials. In the present section the industrial pollution problems of one high-technology industry, namely electronics manufacturing, are examined.

High-technology industry is generally perceived as a clean industry, since an industry such as electronics manufacturing requires spick-and-span cleanliness at the work station, which is essential to producing micro-electronics devices, while generating little of the traditional industrial pollutants such as sulphur dioxide and carbon monoxide. This is a gross misconception. A large quantity of solvents and cleaners are used to keep the work place clean, and some of the chemical cleaners are released into the environment. Worse yet, the electronics industry is highly chemical-intensive, using a wide range of toxic chemicals in the various phases of the manufacturing process such as cleaning, diffusion, chemical vapour deposition and etching in the case of semiconductor manufacture. Major toxic chemicals generated from semiconductor and printed-circuit-board manufacture are listed in tables III.35 and III.36.

Table III.35. Characteristics of raw waste streams from the manufacture of semiconductor devices

Parameter	Concentration range (milligrams per litre)	Mean concentration (milligrams per litre)	Industry-wide pollutant discharge (kilograms per day[a/])
Antimony	001-0.187	0.021	13.2
Arsenic	003-0.067	0.018	13.2
Beryllium	001- .015	0.002	1.9
Cadmium	001-0.008	0.003	1.9
Chromium	001-1.150	0.129	99.9
Copper	005-2.588	0.570	540.7
Cyanide	005-0.01	0.005	3.8
Lead	04-1.459	0.145	61.5
Mercury	001-0.051	0.004	5.7
Nickel	005-4.964	0.502	655.6
Selenium	002-0.045	0.021	6.9
Silver	001-0.013	0.005	3.8
Thallium	001-0.012	0.015	11.3
Zinc	001-0.289	0.093	46.5
Phenols	002-6.1	0.630	812.6
Oil and grease	ND-20.8	5.058	2 778.3
Total suspended solids	ND-203	31.610	30 470.6
Total organic carbon	ND-80	55.676	17 094.2
Biochemical oxygen demand	9-202	52.768	38 848.1
Fluoride	ND-330	62.000	35 909.0
1,2,4,-trichlorobenzene	01-27.1	4.643	257.5
1,1,1-trichloroethane	01-7.7	1.395	928.2
Chloroform	01-0.05	0.015	15.7
1,2-dichlorobenzene	01-186.0	15.972	499.3
1,3-dichlorobenzene	01-14.8	1.450	174.0
1,4-dichlorobenzene	01-14.8	1.341	156.4
1,1-dichloroethylene	01-0.071	0.029	9.4
2,4-dichlorophenol	01-0.017	0.012	9.4
Ethylbenzene	01-0.107	0.021	6.3
Methylene chloride	01-2.4	0.244	276.1
Naphthalene	01-1.504	0.214	19.5
2-nitrophenol	01-0.039	0.024	27.6
4-nitrophenol	01-0.18	0.061	15.1
Phenol	014-3.5	0.519	203.5
Di-n-octyl phthalate	01-0.01	0.010	6.3
Tetrachloroethylene	01-0.80	0.122	363.0
Toluene	01-0.14	0.018	33.9
Trichloroethylene	007-3.5	0.322	177.1

Source: T. Nunno and others, Toxic Waste Minimization in the Printed Circuit Board Industry (Park Ridge, New Jersey, Noyes Data Corporation, 1988).

Note: ND = not detected.

a/ Flow-rate weighted.

The electronics manufacturing industries include a wide variety of processes and products. They include electron tubes, X-ray tubes, cathode ray tubes, semiconductors, integrated circuits, diodes, memory chips, transistors, capacitors, condensers, resistors, thermistors, varistors, printed circuit boards and flexible circuits. Among these products, electronic components are a major environmental concern, in particular semiconductors and printed circuit boards, on which the present review will focus. An integrated circuit is a number of semiconductor devices interconnected on a single chip.

The assessment of toxic wastes from printed-circuit-board and semiconductor manufacturing is complex because of certain unique features of the manufacturing

Table III.36. Characteristics of raw waste streams from printed-circuit-board manufacturing

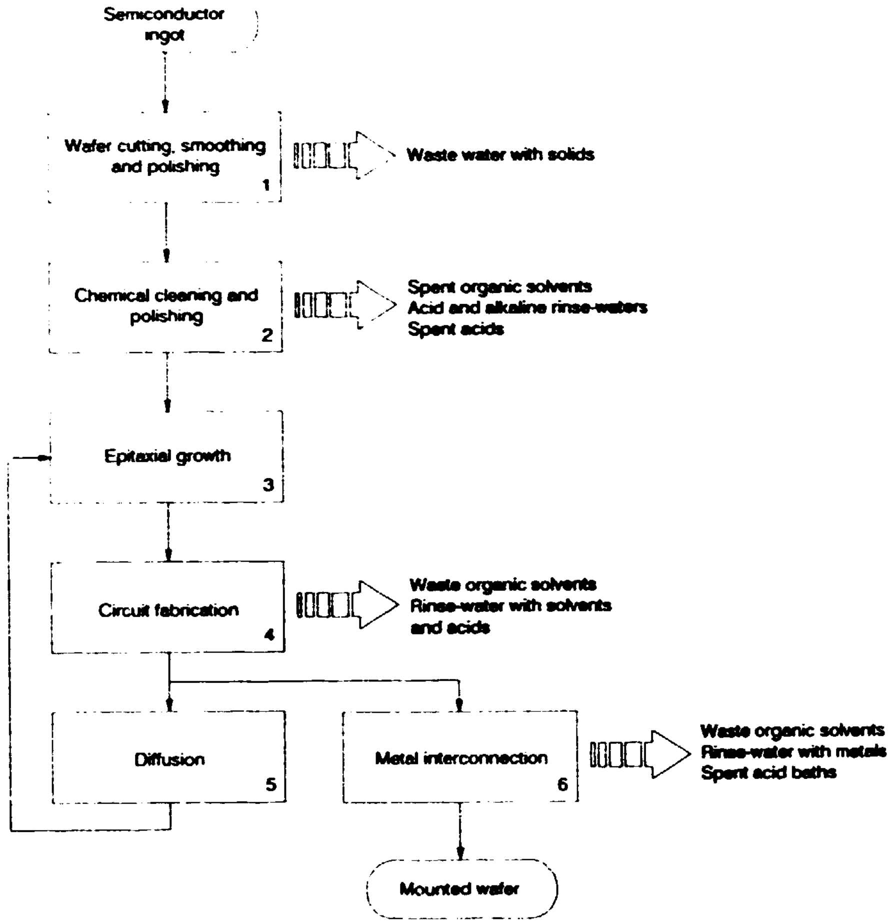
Constituent	Range (milligrams per litre)
Total suspended solids	0.938-408.7
Cyanide (total)	0.002-5.333
Cyanide (amenable to chlorination)	0.005-4.645
Copper	1.582-535.7
Nickel	0.027-8.440
Lead	0.044-9.701
Chromium (hexavalent)	0.004-3.543
Fluorides	0.648-680.0
Phosphorus	0.075-33.80
Silver	0.036-0.202
Palladium	0.008-0.097
Gold	0.007-0.190
Ethylene diamine tetra-acetic acid	15.8-35.8
Citrate	0.9-1 342
Tartrate	1.3-1 108
Nitrilotriacetonitrile	47.6-810

Source: T. Nunno and others, Toxic Waste Minimization in the Printed Circuit Board Industry (Park Ridge, New Jersey, Noyes Data Corporation, 1988).

process. First, subtractive processing, which involves coating a board or wafer with a layer of materials, etching and removing or dissolving unwanted materials, generates large quantities and varieties of toxic wastes. Secondly, numerous specialized chemicals and chemical mixtures are being developed to meet strict quality control requirements of more sophisticated electronic components emerging in the market. Thirdly, literally thousands of proprietary chemical formulae are now being used in the industry, and the composition of these chemicals are often kept confidential ([40], p.242). The manufacture of printed circuit boards and semiconductors and the waste streams associated with each process step are depicted in figures III.15 and III.16. Major waste streams of concern are spent organic solvents or metals containing wastes. Major constituent chemicals in waste streams from semiconductor and printed-circuit-board manufacture are identified and their concentration ranges quantified in tables III.35 and III.36, respectively. Organic solvents are used for wafer and board cleaning, and for the developing and stripping of photo-resist materials used in the image transfer and circuit fabrication processes. Major hazardous wastes generated in substantial quantities by semiconductor manufacture include chlorinated solvents, unchlorinated solvents, ferons, photoresist developers and strippers, and contaminated vacuum pump oils. Toxic wastes that may be generated by printed-circuit-board manufacture include solvents, developers, strippers, copper etchant, electroless copper overflow, chromic and fluoroboric acids, solder strippers, fluxes, fusing fluids and wave oils.

The primary pollutants in the manufacture of printed circuit boards and other electronic devices are copper and lead. To a lesser extent are found cyanide, silver, chromium nickel and some precious metals. Tin and fluorides also pose potential problems in direct discharge to waterways. Typically, rinses after plating or etching account for about a half of the pollutants generated. The rest come from dumping spent stripping solutions, etchants, cleaners, activators etc.

Figure III.15. Integrated printed-circuit-board production flowsheet and waste generation

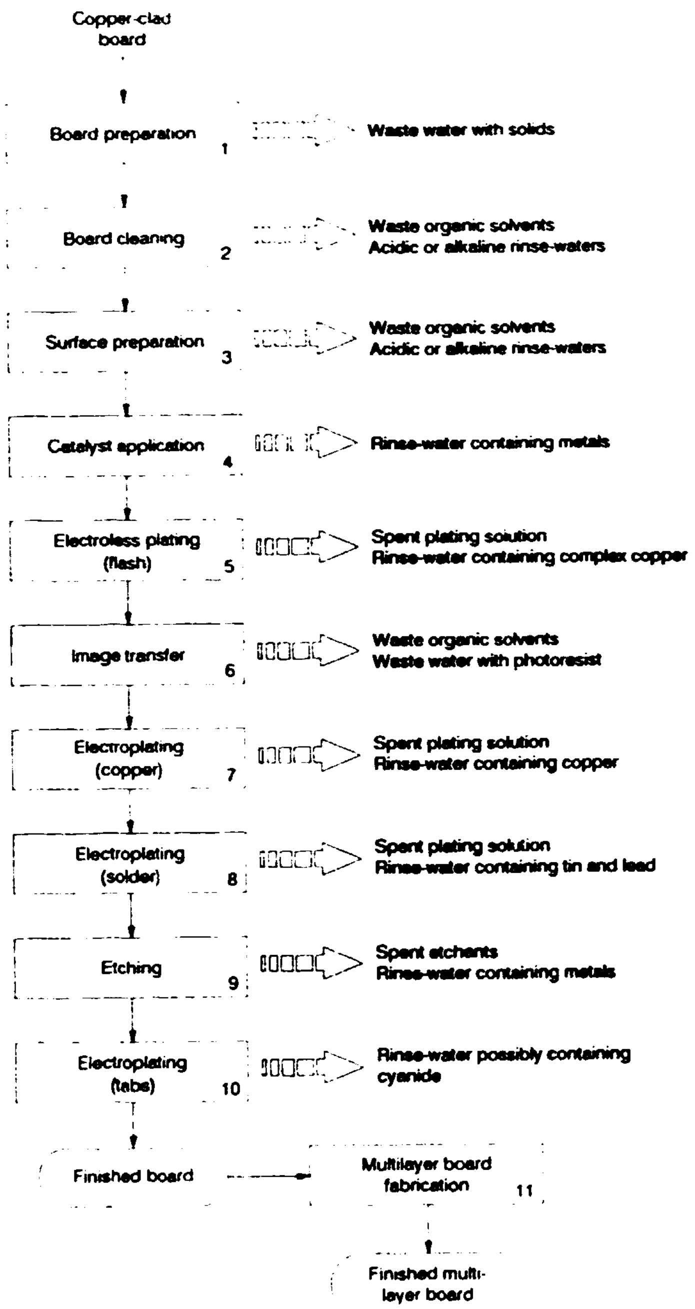


Source T. Nunno and others, *Toxic Waste Minimization in the Printed Circuit Board Industry* (Park Ridge, New Jersey, Noyes Data Corporation, 1988).

The high volume of wastes generated by electronics manufacturing processes is caused by the extreme purity required in process chemicals, which leads to a relatively high volume of waste generation per unit of output (compared with, for instance, fabrication and zinc-electroplating of fasteners). But what is more important than the volume at the plant level is the diversity of waste streams generated by these processes, as illustrated earlier ([41], p.285).

In sum, the high-technology industry is not a pollution-free industry despite the image of its clean working environment. It is true that the high-technology industry does not release highly visible traditional pollutants into the environment like smoke-stack industries, but it is beset by the ever-increasing discharges of a wide array of toxic wastes, and of numerous proprietary chemical mixtures whose toxicity and dangers to human health and the environment are yet unknown. On the other hand, the electronics industry is not only expected to play the central role in the progress and diffusion of information technology and in revolutionizing the telecommunications industry, but also such micro-electronics-based information technology is expected to be increasingly applied to better pollution control and protection of the environment. The practical applications of micro-electronics technology are numerous, including, for instance, environmental monitoring systems for air, water and land pollutants, optimal waste management, low-waste and clean technologies, and environmental auditing and impact assessment systems.

Figure III.16. Subtractive printed-circuit-board production flowsheet and waste generation



Source: T. Nunno and others, *Toxic waste minimization in the Printed Circuit Board Industry* (Park Ridge, New Jersey, Noyes Data Corporation, 1988).

2. *Summary of major process-related pollutants in selected industries*

When considering industrial pollution at the plant and process levels, many different processes that generate many different types of pollutants and many possible methods for pollution control and waste management must be taken into account. The existence of numerous process technologies within a given industry may preclude the generalization of industrial pollution characteristics at the process levels. There are, however, cases where the processes are similar. This permits a discussion of a "typical" pollution problem for a "representative" process. For illustrative purposes, an attempt will be made to determine several such representative processes from selected industries and to identify the major pollutants associated with each process. The results are summarized in table III.37. It is beyond the scope of the study to prepare a comprehensive list of pollutants specific to different production processes and characterize the nature and properties of these pollutants. There are numerous technical publications available for further detailed studies on the pollution problems of specific industries; for instance, those listed as sources for table III.37.

Table III.37. Major process-related pollutants in selected industries

Industry	Process	Major types of pollutant
Iron and steel	Sintering	Sulphur dioxide, oil, greases, hydrocarbons
	Cokemaking	Sulphur dioxide, hydrocarbons, hydrogen cyanide, ammonia, phenol, sulphide, BOD, oil, greases, acid, fluoride
	Open-hearth furnace	Oxide scale formation, dust
	Basic oxygen furnace	Heat, airborne fluxes, slag particles, carbon dioxide, oxides of submicron iron dust
	Electric-arc furnace	Various particulates
	Direct reduction	Various airborne solid and gaseous wastes, noise pollution
Motor vehicle	Stamping	Oils, metals, contaminated process and cooling water, contaminated power-house water
	Assembly	BOD, COD, hexavalent chromium, suspended solids, trivalent chromium, zinc
Petroleum refining	Drilling	Mud, salt water, free emulsified oil, tank-bottom sludge, natural gas and oil spills
	Storage	Sodium chloride, sulphurous compounds, tetraethyl lead, sand particulates, hydrocarbons
	Crude separation	Carbon monoxide, ammonia, hydrogen sulphide, hydrocarbon, sulphur dioxide, phenols, desalted water, spent amine solutions, contaminated condensates
	Light hydrocarbon processing	Phosporic acid, particulates, carbon monoxide
	Middle- and heavy-distillate processing	Spent caustics, phenols, acetaldehyde, ammonia, spent catalyst fines, acid sludges, waste clay, carbon monoxide
	Residual hydrocarbon processing	Malodorous vent gas from waste water and particulates
	Petroleum refining	Oil, sulphides, mercaptans, cyanides, ammonia, phenols, organic salts, phosphates, heavy metals
Leather tanning	Beamhouse process (washing, soaking, liming, unhairing etc.	BOD, suspended solids, dissolved salts, alkalinity, sulphides, sulphur dioxide, sulphuric acid, putrescible organic matter, hair lime-containing sludge
	Drying operation	Solvents, ammonia formaldehyde
	Tanning	BOD, COD, oils, ammonia nitrogen
Pulp and paper	Pulp mill	Sulphite liquor, fine pulp, bleaching chemicals, mercaptans, sodium sulphides, carbonates, hydroxides sizing, casein, clay, ink dyes, waxes, grease, oils, fibres
	Wood preparation	Suspended and dissolved solids, bark refuse, wood particles, sand dust
	Chemical pulping	BOD, suspended solids, alkalines, acids
	Kraft pulping	Suspended particulates, malodorous gases, sulphur compounds
	Papermaking	Suspended solids, dissolved solids, BOD.
Soda-lime glass (incandescent lamp envelopes)	Cullet quenching	Oils, suspended solids, COD.
Textiles	Raw wool scouring (cleansing)	BOD, grease, suspended solids, pH
	Yarn and fabric manufacture	BOD, total solids, pH
	Wool finishing	BOD, COD, settled solids, chlorine, sulphate, phosphate, ammonia, pH, total solids
	Woven fabric finishing	BOD, suspended solids, total dissolved solids, suspended solids, pH, oil, grease, sodium hydroxide

Industry	Process	Major types of pollutant
	Knit fabric finishing	BOD, total dissolved solids, suspended solids, pH, oil, grease, acetate, dye carrier
	Carpet manufacture	Similar to those listed under woven fabric finishing and knit fabric finishing

Sources: For iron and steel, Organisation for Economic Co-operation and Development, Emission Control Costs in the Iron and Steel Industry (Paris, 1977); for motor vehicles, N.L. Nemerow, Industrial Water Pollution: Origins, Characteristics, and Treatment (Reading, Massachussetts, Addison-Wesley, 1978); for petroleum refining, World Health Organization, Compendium of Environmental Guidelines and Standards for Industrial Discharge (Geneva, 1983), and Nelson R. Galve, "Environmental management of oil refineries", Industry and Environment, April - June 1985, pp. 11-13; for leather tanning, J.B. Carmichael and K.M. Strezepek, Industrial Water Use and Treatment Practices (London, Cassell Tycooly, 1987), and "Techno-economic study on measures to mitigate the environmental impact of the leather industry, particularly in developing countries (ID/WG.411/10); for pulp and paper, Nemerow, op.cit.; for soda-lime glass, Marshall Sittig, Pollution Control in the Asbestos, Cement, Glass and Allied Mineral Industries (Park Ridge, New Jersey, Noyes Data Corporation, 1975); and for textiles, Organisation for Economic Co-operation and Development, Emission Control Costs in the Textile Industry (Paris, 1981).

Notes: BOD = Biological oxygen demand.
COD = Carbon oxygen demand.
pH = acidity.

E. Economic implications of industrial pollution abatement

The economic cost of environmental protection is at least as important as its technological and engineering aspects. Environmental protection and particularly pollution control requires substantial investment and other resource commitments. The impact of environmental expenditures on such economic factors as output, price levels, employment and trade has become an increasingly important issue for policy-makers as well as academic researchers, as environmental degradation becomes increasingly serious and menacing. Particularly controversial among environmental issues is how much should be spent on environmental protection and whether environmental expenditure is a major factor contributing to the recent decline in productivity in developed countries, in other words, whether economic growth and environmental protection is compatible. The issue of compatibility or conflict between the environment and economic growth may have important policy implications for developing countries, since the implementation of environmental regulations and safeguards would represent a new competing demand for the limited productive resources available to those countries. This might prove detrimental to their industrialization drive, if such a conflict should arise between the environment and growth. At the same time, there is reason to believe that many of the new pollution-abating manufacturing technologies can also improve efficiency and reduce costs.

In the present section, the conceptual underpinnings for the economics of environmental protection are first briefly described, followed by an analysis of investment data on pollution abatement in selected countries. Empirical findings on the economic impacts of pollution abatement expenditures are then assessed at the following three different levels: aggregate macro-economic impacts; industry impacts, and selected process-specific cost effects of pollution abatement. Finally, tentative conclusions are drawn and policy implications derived.

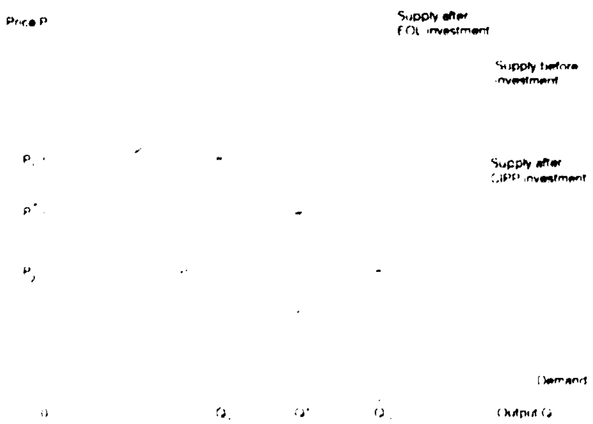
1. *Conceptual issues*

In theory, the elementary economic principle of marginal cost pricing may equally as well apply to the question of how much should be spent on pollution abatement. Namely, the optimal level of expenditure is found where an additional dollar cost (marginal cost) of pollution abatement is equal to the additional dollar benefit (marginal benefit) of pollutant removal. In practice, this marginal principle is highly inapplicable. The crux of the problem is the nature of public goods and attendant externality inherent in environmental protection. For instance, what economic value should be placed on a damaged ozone layer or extinct species? Obviously, the principle of equating marginal cost to marginal benefit breaks down when both of the two variables cannot be easily quantified. Furthermore, the law of diminishing returns applies to the costs of pollution control to make the matter more complicated. Namely, the costs of pollution abatement typically rise very slowly at low levels of removal until a critical point, say 70 per cent removal, is reached. Then they rise sharply. By contrast, the benefits increase rapidly at first and then taper off. Therefore, each additional dollar spend brings a smaller benefit. To make a rational decision regarding the optimal expenditure on pollution control, the incremental costs and benefits need to be compared instead of looking only at totals. Little is known about the shapes of those incremental costs and benefits curves in quantitative terms. This also explains why the reduction of environmentally damaging emissions to zero does not often make sense.

There are many different ways of financing pollution abatement, such as through subsidies, general taxes and the "polluter-pays" mechanism, which directly affect the cost structure of a firm. If the firm makes the capital investment necessary to abate its pollution without subsidy from outside, the firm is said to "internalize" its costs, or bear its full costs. In the case of the internalized costs, the effects of capital expenditures on output and prices will critically depend on the type of technology embodied in the capital investments, a distinction being made between plant and equipment designed to abate pollutants through add-on or end-of-line techniques and those through changes in production processes. If the end-of-line techniques are applied, costs will rise as industries internalize costs that they have not borne before. An increase in costs shifts the industry supply curve to the left, and output is reduced as depicted in figure III.17. Some of the important reasons for raising the industry supply curve are that the pollution abatement equipment installed at the end of the existing production process represents not only additional capital costs, but also requires additional labour to operate and maintain it without raising output. As a result, productivity declines. In addition, those investments in pollution abatement may compete with other output-augmenting investments in plant and equipment, thus reducing the potential output of other productive investments.

On the other hand, if the old process technology is replaced by the new clean or low-waste technology, in some cases the per-unit production costs of the firm may go down and shift the industry supply curve in figure III.17 to the right, increasing industry output and lowering prices at the same time. The reasons are that low-waste process technologies may be typically designed to eliminate or reduce not only one but multiple sources of pollution simultaneously and, more importantly, to economize energy, scarce raw materials and even labour inputs so that the initial increase in investment costs may be more than offset by those factor cost savings. Ultimately, the question of what impact environmental expenditure may have on output, productivity, employment, price levels and trade may have to be determined empirically, as explained below.

Figure III.17. Industry equilibrium before and after pollution abatement

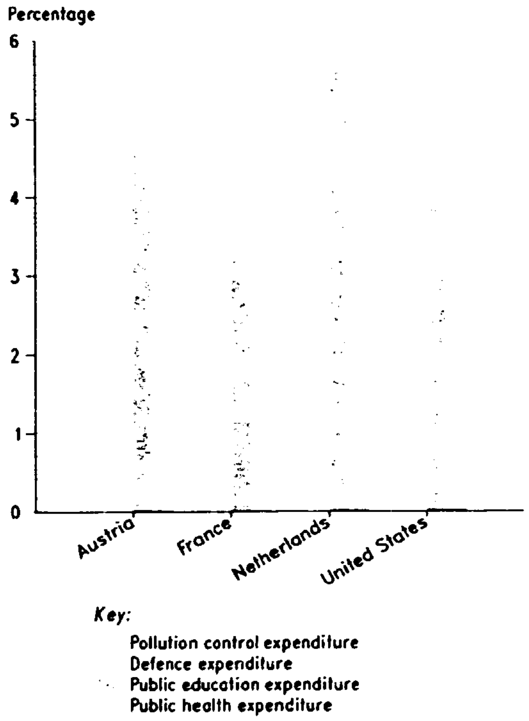


Note EOL end of line
CIPP changes in production processes

2. *Investments in pollution abatement in selected countries*

The relative quantitative importance of environmental expenditures could have a significant bearing on their final impact on the economic activity of a given economy. Data on environmental expenditures for developing countries are rarely available, but they are of limited availability in developed countries. Statistical evidence available in certain developed countries suggests that environmental expenditure is very small relative to other comparable expenditures on "public goods" such as defence and public education. Figure III.18 provides a comparison of

Figure III.18. Pollution control expenditures and selected categories of public expenditure as a percentage of gross domestic product, mid-1970s



Source: Organisation for Economic Co-operation and Development *Environment and Economics* (Paris, 1985)

pollution control expenditures with other categories of public expenditure in four developed countries in the mid-1970s, all expressed as a percentage of gross domestic product. Spending for industrial pollution abatement accounted for a small percentage of total industry investment as shown in table III.38. Except for Japan, the share of environmental expenditures in total industry investment was less than 7 per cent.

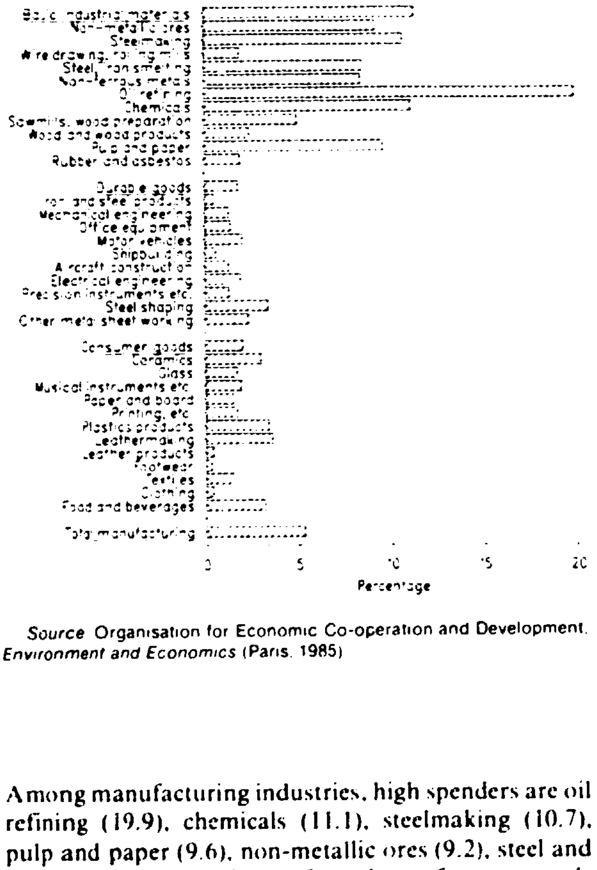
With regard to the relative importance of individual manufacturing industries, the cumulative data of the Federal Republic of Germany during the period 1971-1977 clearly points to the preponderance of basic-industrial-materials-producing industries in the relative share of total investment expenditure (figure III.19).

Table III.38. Environmental expenditures as a percentage of total investment, 1975
(Percentage)

Country	Private environmental investment as a percentage of total private investment	Industry environmental investment as a percentage of total industrial investment
Austria	..	5.1 4.3[a]
Germany, Federal Republic of	1.9	6.6
Japan	4.6	17.1
Switzerland	..	3.0[a]
United States	3.4	5.8

Source: Organisation for Economic Co-operation and Development, Environment and Economics (Paris, 1985), p. 151.
a: 1978.

Figure III.19. Industrial pollution control investment as a percentage of total industrial investment expenditure in the Federal Republic of Germany, 1971-1977



Source Organisation for Economic Co-operation and Development. *Environment and Economics* (Paris. 1985)

Among manufacturing industries, high spenders are oil refining (19.9), chemicals (11.1), steelmaking (10.7), pulp and paper (9.6), non-metallic ores (9.2), steel and malleable iron smelting (8.5) and non-ferrous metals (8.4). As discussed earlier, those basic-industrial-materials-producing industries are the heaviest polluters. In fact, the basic-industrial-materials industries as a whole spend on pollution abatement almost six times more than durable goods or consumer goods industries as a percentage of total investment expenditures.

Japanese industry data also reveals pollution-control investment concentrated in basic-materials industries (for example, pulp and paper, chemicals, petrochemicals, oil, iron and steel) between 1973 and 1976, but their share of total investment sharply declined between 1977 and 1980 except for cement and thermal power plants (table III.39). The possible reason for the high investment share of pollution control in 1972-1976 is a short-term concentration of investments required to meet the sharply increased requirements of environmental legislation enacted in the early 1970s.

The most comprehensive and up-to-date data available for environmental expenditures are survey results published by the United States Government. The United States manufacturing sector as a whole spent $2,809.7 million for pollution-abatement capital goods in 1985. Of this total, $1,292.3 million (46 per cent) was for air, $1,017.9 million (36 per cent) for water and $499.5 million (18 per cent) for solid wastes (see figure III.20).

Moreover, operating costs associated with pollution-abatement activities (including payments to government units) amounted to $11,677.9 million, four times larger than the capital expenditures. Of this total $4,330.2 million (37 per cent) was for air, $4,609.5 million (39 per cent) for water and $2,171.8 million (19 per cent) for solid wastes. By type of expenses for total operating costs, $2,043.7 million (21 per cent) was spent for depreciation, $2,204.7 million (19 per cent) for labour, $3,759.8 million (35 per cent) for materials and supplies and $2,666.7 million (25 per cent) for services, equipment leasing and other costs.

Total pollution-abatement capital expenditures in 1985 represented a 29 per cent increase over the previous year. Air, water and solid-waste capital expenditures increased by 25, 15 and 102 per cent in the same period. Meanwhile, total operating costs increased by 7 per cent, and all components of operating costs also increased. Total capital expenditure for pollution abatement for all manufacturing industries was $2,171.8 million in 1984, representing 2.89 per cent of total new industry capital expenditures. The major industry groups that devoted a relatively high proportion of total investment to pollution-control capital expenditure in 1984 were petroleum and coal products (8.26 per cent), primary metals (6.55 per cent), chemicals (5.47 per cent), fabricated metals (3.34 per cent) and paper products (3.23 per cent). Approximately 74 per cent of the $2,809.7 million in new capital expenditures for pollution control were accounted for by the five major industry groups: namely, industrial chemicals (26.26 per cent), transport equipment (16.25 per cent), paper and paper products (11.83 per cent), petroleum and coal products (10.33 per cent) and primary metals (9 per cent). The quantitative importance of operating costs over capital expenditures not only was reflected in the total industry figures, but was more pronounced in individual industry levels, as illustrated in figure III.21 by form of pollution abatment in selected industries (see appendix table III.65 for further details).

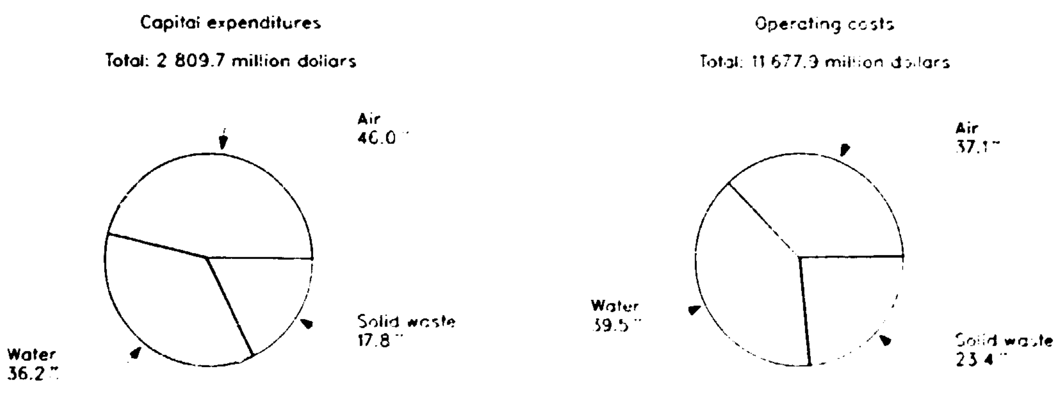
One crucial variable in assessing the economic impact of environmental expenditures is the extent of diffusion of clean technologies, a key factor affecting the cost structure of a firm with broader implications for the nature of relationships between industrialization and the environment. Fortunately, in United States data a distinction is made between plant and equipment designed to abate pollutants through add-on or end-of-line techniques and those that rely on changes-in-production processes.

Table III.39. Pollution control investment in Japanese industry, 1973-1980 [a]
(Percentage of total investment)

Industry	1973	1974	1975	1976	1977	1978	1979	1980 estimate
All industries	10.6	15.6	17.7	13.5	7.2	5.4	4.9	5.3
Iron and steel	17.3	18.6	18.4	21.1	11.5	10.9	11.5	4.9
Oil	18.5	32.6	41.7	31.4	5.9	4.5	4.8	7.7
Pulp and paper	26.4	44.7	47.1	44.0	35.1	28.0	22.1	32.0
Non-ferrous metals	22.1	22.8	22.7	17.6	9.1	6.8	5.8	3.6
Chemicals (except petrochemicals)	17.1	29.1	32.8	17.6	8.7	5.0	3.7	3.5
Engineering	4.0	5.5	5.2	3.5	2.5	2.2	1.9	1.6
Petrochemicals	15.7	18.9	18.4	13.8	9.9	7.2	3.2	2.8
Mining (except coal)	24.4	32.9	37.9	37.6	26.2	14.5	15.7	3.0
Textiles	10.1	13.7	20.4	7.4	4.0	2.4	4.9	2.2
Cement	11.2	17.4	15.0	12.2	11.4	15.8	14.8	13.2
Ceramics (except cement)	9.9	10.2	10.2	8.2	5.8	10.3	3.7	11.4
Gas	2.3	4.0	2.1	1.5	1.1	1.2	2.1	2.4
Coal	4.0	2.5	8.2	2.7	2.1	0.9	1.6	1.2
Other	8.6	9.4	9.1	4.9	3.7	1.8	1.0	1.6
Construction equipment	5.9	4.7	7.2	4.4	6.1	4.6	2.6	1.9
Electricity (except thermal power plants)	1.1	1.0	1.1	0.9	0.8	0.8	0.7	0.9

Source: Ministry of Trade and Industry of Japan.
a: Estimates based on industrial engineering studies.

Figure III.20. Pollution-abatement capital expenditures and operating costs by source of pollution in the United States, 1985

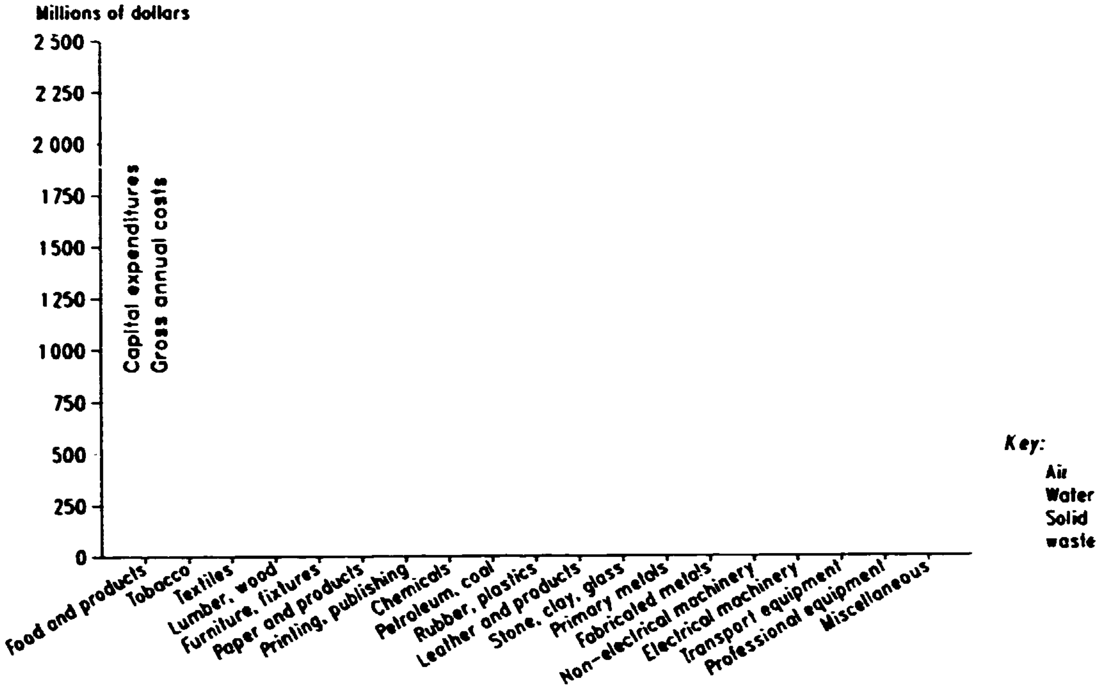


Source: Bureau of the Census, *Pollution Abatement Costs and Expenditures, 1985* (Washington, D.C., Government Printing Office, 1987).

Figure III.22 summarizes capital expenditures on the two pollution-abatement technologies at the level of major industry groups in 1985 (see also appendix table III.65 for further details). It is evident that the diffusion of clean technologies is still limited. United States manufacturing industries as a whole spent $508.9 million for new clean process technologies in 1985, $383.3 million of which was for air and $125 million for water. This expenditure on new processes represents about 18 per cent of total pollution-abatement expenditures. This percentage remained more or less constant in the past. United States industry invested about 20 per cent of its air and water pollution-abatement expenditures in changes in production processes over the period 1973-1980 [42]. In short, over 80 per cent of all pollution abatement investment was of the add-on type of pollution control, which means a fairly limited penetration by clean technologies.

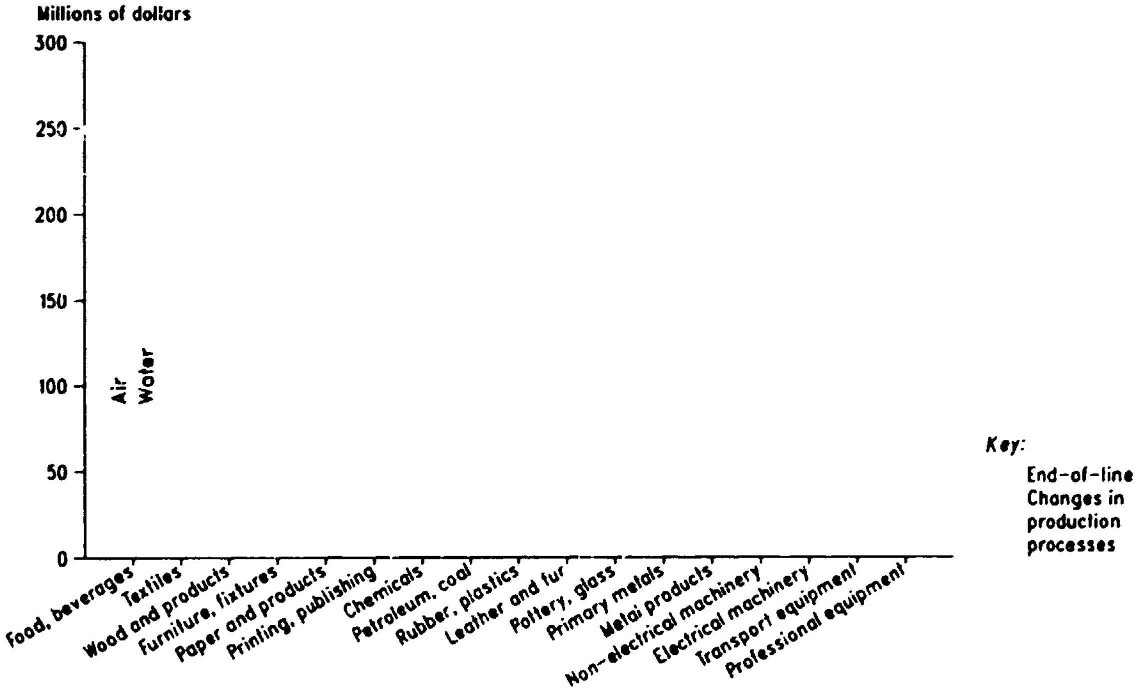
The industry average conceals, however, considerable variations among individual industries. As shown in figure III.22, both the fabricated metals and the

Figure III.21. Pollution-abatement capital expenditures and operating costs of abatement for major industries in the United States, 1985



Source Bureau of the Census, *Pollution Abatement Costs and Expenditures, 1985* (Washington, D.C., Government Printing Office, 1987)

Figure III.22. Pollution-abatement capital expenditures on end-of-line and changes-in-production processes in the United States, 1985



Source Bureau of the Census, *Pollution Abatement Costs and Expenditures, 1985* (Washington, D.C., Government Printing Office, 1987) transport equipment industries devoted a large proportion of capital expenditures to new processes for air pollution abatement, 60 and 51 per cent, respectively, but spent only 13 and 6 per cent, respectively, for water pollution abatement. Paper and allied products, and petroleum and coal products, two major industries in terms of capital expenditures for pollution control, allocated a modest proportion of total expenditures to new processes, 30 and 40 per cent respectively, for air, and 14 and 28 per cent, respectively, for water. For the chemical industry, which represents the largest share of total manufacturing capital expenditures for pollution abatement, with about 26 per cent of the industry total, the shares of technologies for new processes were equally modest, 23 per cent for air and 14 per cent for water. The remaining industries show very limited application of new technologies. The high percentage of new processes for water pollution abatement in printing and publishing (46 per cent) is largely due to its small base figure, $5 million for water pollution control.

Unfortunately, comparable statistics for other countries are not available. There is, however, some scattered anecdotal evidence. For instance, one detailed study found no significant spread of clean technologies in the Federal Republic of Germany during the period 1975-1984. The share of clean technologies in total environmental protection investments by industry increased from 19.6 per cent in 1975 to 24 per cent in 1980, only to drop to 16.3 per cent in 1982, but rising again to 23 per cent in 1983 ([43], p. 44). An OECD study also mentioned the limited diffusion of clean technologies in France, but in Denmark, about one third of firms adopted new production processes for pollution abatement between 1975 and 1980 ([44], p. 83). None of these studies provided detailed statistics on clean technologies by industry.

On the other hand, many process-specific technical and engineering case-studies are available on new technologies in different countries, some of which will be highlighted for illustrative purposes shortly. But these isolated pieces of information do not provide a clue to the extent of diffusion of new technologies in any given industry. They point, however, to the existence of a great potential for new technologies to abate industrial pollution without reducing output, and can in some cases even lower production costs. More importantly, they underscore an urgent need for the diffusion of clean technologies. Finally, it must be noted that although the diffusion of clean technologies commands priority, add-on technologies could also be innovative and even necessary where no alternative technologies can be easily developed.

3. *Economic impact of environmental expenditures: some empirical evidence*

(a) *Structural change in manufacturing industries and its implications for the environment in developing countries*

The question whether or not there exists possible conflict between output or productivity and environmental protection will probably have major implications for the future industrialization of developing countries. Some of the empirical evidence on this question will be examined shortly. The possible environmental implications of the continuance of the long-term patterns of structural change in the manufacturing sector in developing countries will now be considered.

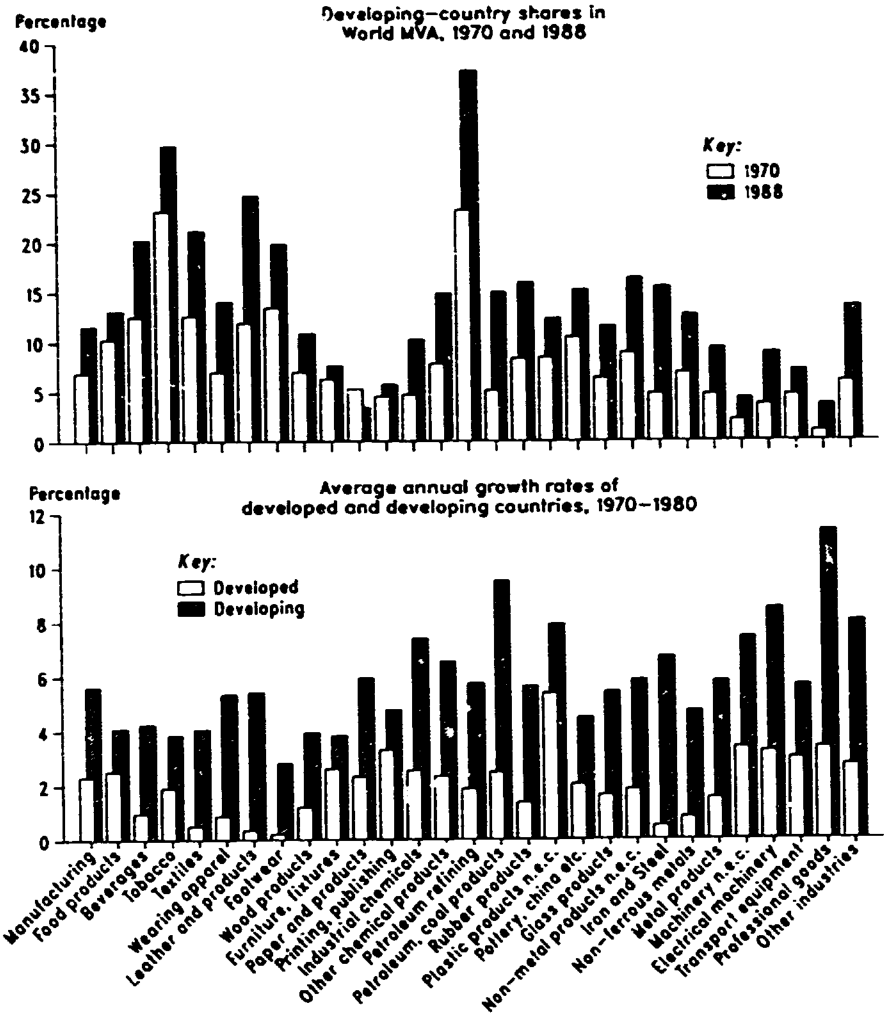
Figure III.23 shows the overall patterns of MVA growth in developed and developing countries over the period 1970-1988. The MVA of developing countries as a whole had an average annual growth two and a half times faster than developed countries, and the share of developing countries in world MVA increased from 6.88 per cent to 11.56 per cent between 1970 and 1988. In fact, the share of developing countries almost doubled during the period. However, the actual rate of progression in the developing-country share of world manufacturing output falls far short of the required rate to achieve the Lima target of 25 per cent by the year 2000.

At disaggregated industry levels, the top 10 fastest-growing industries in developing countries relative to their counterparts in developed countries are mainly concentrated in the following two groups: a labour-intensive light manufacturing group using renewable natural resources; and a capital-intensive basic-industrial-materials-producing group using largely mineral resources. They are listed in table III.40. Petroleum refining should be noted among the latter group because of its large world share (37 per cent), despite its somewhat smaller relative growth-rates ratio (3.07).

It was shown earlier that most water-intensive industries as measured by requirements per unit of output tend to be concentrated in industries that process and produce basic industrial materials. The manufacture of basic industrial materials was shown to be most energy-intensive and material-intensive among various manufacturing activities. It was further shown that those industries are the heaviest polluters of all industries.

A detailed analysis of the global industrial growth process in the period 1975-1985 was presented in *Global Report 1988/89* ([33], chap. III). One of the most significant findings from the standpoint of the environment was a clear reorientation of industrial structure between the South and the North in the early 1980s. It was carefully documented in the Report that world-wide "stagflation" during the period 1980-1982 and the subsequent growth recession forced many developed countries extensively to restructure and trim down their traditional "smoke-stack" industries and to concentrate on technology- and skill-intensive capital goods industries. As a result, some traditional manufacturing activities, particularly resource-based light industries and basic materials industries, have been redeployed to the South. The extensive world-wide restructuring was also clearly reflected in the foregoing North-South comparison of the MVA growth of 28 branches of manufacturing industry given in figure III.23. North America, Western Europe and Japan have all seen MVA growth in traditional smoke-stack industries being cut drastically as a result of their massive restructuring efforts, while those regions have solidified their dominance of the capital goods industry in both absolute and relative terms. The South as a whole has made significant headway in expanding its share of MVA in light industry and basic industry, while recording few gains in the capital goods industry.

Figure III.23. MVA share and average annual growth rates of MVA, 1970-1988



Source: UNIDO data base

Table III.40. Top 10 fastest-growing industries in developing countries

Type of manufacturing	Ratio of South-North annual growth rates, 1970-1988	Share of South in world MVA, 1988
Light manufacturing		
Leather products	15.91	24.71
Footwear	14.05	19.83
Textiles	7.96	21.26
Wearing apparel	6.13	14.07
Beverages	4.42	20.26
Basic materials		
Iron and steel	13.96	15.46
Non-ferrous metals	5.79	12.66
Plastic products	4.13	15.92
Petroleum and coal products	3.85	14.99
Metal products	3.84	9.34

Source: UNIDO data base.

If the trend towards the rapid expansion of smoke-stack industries in the South continues to accelerate, the environmental burdens of such an industrial transformation, in particular the problems posed by various traditional industrial pollutants associated with smoke-stack industries, may reach crisis proportions in the near future, unless the diffusion of clean technologies occurs on a massive scale across industries. Severe industrial pollution problems encountered now in many rapidly industrializing developing countries may foreshadow what is to come on a much greater scale in other developing countries. On the other hand, the severity of industrial pollution in the North may taper off or even steadily decline as a result of the rationalization of smoke-stack industries coupled with the enforcement of increasingly stringent environmental regulations. But as examined earlier, high-technology industries create new industrial pollution problems, particularly toxic wastes. In general, industrial pollution will probably continue to preoccupy policy-makers and researchers as well as environmentalists in the North in the foreseeable future.

The regional incidence of industrial pollution within the South differs markedly, depending upon the regional patterns of industrialization. For instance, industrial pollution may become a major problem in the rapidly industrializing countries of East and South Asia, the Indian Subcontinent and in China, while Tropical Africa, paralysed by chronic stagnation, may yet to see any visible signs of industrial pollution problems. Another influencing factor is the ability of the ecosystem of different regions to process or to support different levels and different kinds of pollution.

The need for industrialization in developing countries is a foregone conclusion. The key issue is the sustainability of industrialization in developing countries in terms of the constraints imposed by the natural resource base and environmental absorptive capacity. Continued rapid industrial growth in developing countries may accelerate the depletion of natural resources as accompanied by serious damage to the environment, and cause direct environmental degradation through unchecked industrial pollution to such an extent that the process of industrialization cannot be sustained. The environmental regulations of industrial activity may become increasingly important. But environmental protection requires heavy capital investments and additional resource commitments that developing countries cannot well afford. Environmental protection may thus put a drag on the process of industrialization, as described earlier. The question of the existence of potential conflict between environmental protection and industrial growth is of vital importance to developing countries embarked on the course of industrialization. An examination of some of the empirical evidence on this issue therefore seems to be in order.

(b) *The economic impact of environmental regulations: some aggregate empirical evidence*

In recent years, as environmental expenditures have begun to increase sharply in response to a rising wave of environmental movements in many countries, the economic impact of mounting environmental spending has also attracted the attention of many economists and policy-makers. In fact, the literature on, and the empirical investigation of, the economic impact of environmental measures is already considerable*. But the empirical findings of the studies are not easily comparable, because of marked differences in the model structure, data base and period, assumptions used in simulation exercises, statistical reliability and many other factors. The present study is not intended to be a comprehensive survey of the existing empirical studies. It may be sufficient for our purposes to highlight the results of a recent OECD modelling project in six member countries for illustrative purposes (see table III.41), because the OECD study provides a reasonably good comparative evaluation of the economic impact of environmental protection activities in different countries.

The countries selected for the OECD study were Austria, Finland, France, Netherlands, Norway and

*For simulation studies of the environmental impact, using a macroeconometric model, see, for instance, the following: [45]; [46], pp.496-615; [47]; [48]; and [49]. For an impact analysis based on the input-output table of Federal Republic of Germany, see [50], pp.203-228.

<u>Table III.41. Effects of additional environmental programmes on selected economic variables</u>

Country and period	GDP: First year	GDP: Final year	Consumer prices: First year	Consumer prices: Final year	Unemployment: First year	Unemployment: Final year
	(percentage points)				(thousands)	
Austria (1979-1985)	..	-0.6/0.5	..	0.4/1.7a/	..	..
Finland (1976-1982)	0.3	0.6	0.2	0.2	-3.5	-7.5
France (1966-1974)	-	0.1/0.4	-	0.1	-0.2/-1.1	-13.2/-43.5
Netherlands (1979-1985)	0.1	-0.3/-0.6	0.2/0.4	0.8/4.3	-1.4/-2.3	-3.8/6.9
Norway (1974-1983)	..	1.5	..	0.1/0.9	..	-25.0
United States (1970-1987)	0.2	-0.6/-1.1	0.2	5.0/6.7	-80.0	-150.0/-300.0b/
Italy (1971-1980)	..	-0.2/0.4	..	0.3/0.5	..	..
Japan (1972-1979)	1.2/2.6	0.1/0.2c/	-	2.2/3.8	d/	d/

<u>Source</u>: Organisation for Economic Co-operation and Development, <u>The Macro-Economic Impact of Environmental Expenditures</u> (Paris, 1985) and <u>Macro-Economic Evaluation of Environmental Programmes</u> (Paris, 1978).

a/ GDP deflator.

b/ Partly estimated by Organisation for Economic Co-operation and Development Secretariat.

c/ For period as a whole, suggesting negative results for final year.

d/ Lower.

United States, plus two countries from the previous study, Italy and Japan. Although all the studies used Keynesian models, there are considerable variations in the major characteristics of the models and data base. Irrespective of the structural differences of country models, all studies compared the macro-economic impacts of additional environmental expenditures and those without additional spending. Several notable observations are in order. First, the results suggest that although the short-term effects of increased environmental expenditures on GDP are all positive, albeit very small, the long-term effects are mixed; with the estimates being all negative for some countries like the Netherlands and the United States, negative and positive for others (Austria and Italy), and all positive for others (Japan, Finland, France and Norway). The short-term impact is, however, likely to be more favourable than the long-term effects. In the short run, environmental investment may have positive effects on output and employment, but some of those short-term gains may be dissipated over the longer run because of rising prices or declining productivity. Regardless of the direction of change, the effect of environmental expenditure tends to be quantitatively insignificant.

Additional environmental expenditure would seem to raise consumer prices. But the inflationary impact appears to be small in most cases, being less than a 1 per cent increase in the final year. The major exceptions are the United States, which shows a 5 to 7 per cent rise in consumer prices, and Japan with a 2 and · per cent rise in the final years. On the other hand, environmental expenditure, athough quantitatively small, reduces unemployment levels with few exceptions.

One important conclusion emerging from those results is that the macro-economic impacts of environmental expenditures tend to be quantitatively insignificant, usually in the range of a few tenths of a percentage point per year, with the exception of some of the results for consumer prices. The results are not surprising, because environmental expenditure as a percentage of total investment and also relative to other public expenditures such as education, health and welfare, and defence is very small in these countries, as discussed earlier, and hence the overall effects of such expenditures on the economy are also likely to be small.

One significant corollary of the results is the adverse effect of environmental measures on labour productivity. This implication is drawn because environmental regulations tend either to lower or to increase GDP at a rate slower than the rate at which they increase labour inputs. The nature of the relationship between productivity and environmental regulations is central to the question of complementarity (or conflict) between economic growth and the environment. This is because the decline in productivity caused by environmental regulations means that the unit production cost will increase and prices may also rise leading to a reduction of output. On the other hand, if environmental investments are of a change-in-process type, environmental expenditures may have a favourable impact on productivity, with consequent implications of compatibility between growth and the environment. Only micro-economic process-level empirical investigations may provide more definitive clues to the overall net effects of environmental expenditures on the economy. Aggregate empirical investigations may fail to capture cost-saving potentials at the firm level. It must be noted also in this regard that macro-economic empirical studies tend to show a conflict between growth and environmental control because the spread of clean or low-waste technologies economy-wide is still limited in most countries, as the United States data clearly showed.

Environmental regulations may perhaps be one small factor responsible for the recent decline in productivity in industrialized countries. It is true that environmental regulations may retard economic growth because they intervene in market processes, adversely affecting the rational decision-making at the firm level. But that is true of any government regulation, and environmental regulations are only a small part of the overall regulatory system. Moreover, there are many important causes of declining productivity growth other than environmental regulations. They include sharp rises in energy prices, a slow-down in capital investment, the changing composition of the labour force (more youth and women workers), the changing composition of output (more services and less manufacturing), a decline in the work ethic, expanded social welfare programmes, and regulatory activities including environmental regulations. An empirical study of the slow-down in manufacturing productivity growth in the United States shows that between 12 and 25 per cent of the slow-down in productivity growth in the private sector between the early 1960s and the mid-1970s can be attributed to the whole array of federal regulations, of which environmental regulations are only a small part [51].

Apart from data limitations and other conceptual and technical problems associated with econometric modelling, there are more fundamental limitations to the macro-economic approach to the impact assessment of environmental expenditures. For instance, GDP is not an adequate measure of social welfare, and most of the benefits of environmental policies are not reflected in GDP or other national income accounts. The benefits of environmental protection are manifold and can be classified into the following three broad categories for analytical convenience: "utility-increasing" benefits; "cost-reducing" benefits; and "output-increasing" benefits. Some examples of utility-increasing benefits are improved physical well-being derived from the availability of clean air, and reduced incidence of death or illness related to pollution. Cost-reducing benefits include reduced costs for municipal and industrial water treatment and less property and material damage to producers as a result of better air quality. Examples of output-increasing benefits are to be found in increased output, productivity and earnings attributable to the improved health conditions arising from the cleaner environment, the reduction in agricultural crop damage from air pollution, and the greater commercial fishery yields because of cleaner water*.

All those benefits are substantial, but the macro-economic studies do not take into consideration GNP-

*For more detailed discussion of the problem of measuring benefits of pollution, see [52].

augmenting benefits of pollution abatement expenditure, mainly because of enormous difficulties in estimating such benefits. Nevertheless, some daring attempts have been made to quantify those benefits. For instance, the realized benefits of air and water pollution control in 1978 have been estimated at $2.8 billion and utility-increasing benefits at $24.8 billion [52]. If these utility-increasing benefits were included in 1978 aggregate private output, the adjusted growth rate would be 4.11 per cent instead of the actual growth rate of 3.92 per cent. True productivity change could be roughly 0.19 per cent or about one fifth of a percentage point higher than that arrived at by the conventional measure.

In sum, the macro-economic effects of environmental expenditures have probably been small, and the accompanying regulations have not been a major cause of the recent decline in productivity in the 1970s and 1980s, nor a constraining factor on economic expansion in the future. Moreover, as a result of the failure to consider the beneficial effects of pollution control, the negative impact of environmental regulations have been somewhat overstated.

Many empirical studies on the industry impact of environmental programmes have also appeared in the literature in recent years*. Most studies used macro-econometric models linked to an input-output table to assess differential economic impacts of environmental expenditures on different industries. The empirical results of those studies on the industry impact are fairly similar to those obtained from the macro-economic impact analysis discussed earlier. Environmental regulations tend to raise costs and prices and to reduce output in different industries, although the magnitude of change varies considerably from industry to industry. The employment effects are mixed, being positive for some industries and negative for others. Those results are subject to the same limitations associated with the macro-economic analysis as described earlier, and hence should be interpreted with great caution.

The case of the United States may be taken as an example. Results concerning impacts of the major 31 industries have been obtained using the Chase Econometric macro-economic and input-output models which are linked together to derive the differential industry effects. The effects of pollution-control expenditure on 31 major United States industries are given in table III.42, which summarizes the percentage changes for prices, output and employment between the baseline forecast and the simulation with pollution-abatement expenditures. These differences are shown for both 1978 and 1983, cumulating from 1970.

Not surprisingly, those industries most directly subjected to environmental regulations showed the largest increases in prices. They include utilities, non-ferrous metals, paper, automobiles, iron and steel, stone, clay and glass, chemicals and petroleum. But it is worth noting that all industries showed price increases, including those not directly affected by pollution abatement expenditures, mainly through inter-industry linkages.

A decline in output was observed consistently in all industries except non-electrical machinery. The employment change is mixed, up for some industries, down for others, but the magnitude of the percentage change in employment seems to be generally smaller than that of output, thus implying declining productivity of labour across industries. Finally, it should be noted that the average annual percentage change of those figures should be much smaller, since they are cumulative from 1970.

*For instance, see [53 and [54].

Table III.42. Estimated impact of pollution-abatement expenditure on individual industries in the United States

Industry	By 1978			By 1983		
	Prices	Output	Employment	Prices	Output	Employment
Agriculture	0.3	-0.8	+0.6	0.6	-1.3	+1.3
Mining	0.4	-1.2	-0.1	0.7	-2.5	-0.4
Construction	0.1	-2.1	-0.4	0.2	-3.5	-0.2
Food	0.7	-0.5	+0.7	1.2	-1.5	+1.2
Tobacco	0.2	-1.0	+0.6	0.4	-2.7	+0.9
Textiles	0.5	-1.4	-0.1	0.9	-2.5	-0.2
Apparel	0.3	-1.2	-0.2	0.5	-2.2	-0.6
Lumber	0.6	-4.4	-1.3	1.5	-4.4	-0.6
Furniture	0.3	-1.5	-0.7	0.5	-3.1	-1.3
Paper	3.0	-1.3	-0.2	6.2	-2.9	-1.0
Printing	0.2	-1.2	-0.1	0.3	-3.1	-1.3
Chemicals	1.7	-1.2	-0.3	4.8	2.8	-1.1
Petroleum	1.6	-1.0	+0.4	2.3	-2.0	+0.7
Rubber	0.6	-1.6	-0.5	1.0	-4.2	-1.4
Leather	0.4	-0.8	0.0	0.9	-1.4	-0.3
Stone, clay and glass	2.0	-2.0	-0.7	3.2	-3.4	-1.0
Iron and steel	2.3	-1.4	-0.2	4.1	-2.9	-0.3
Non-ferrous metals	5.4	-0.7	+0.4	8.1	-2.4	+0.3
Fabricated metals	0.4	-1.2	0.0	0.8	-3.1	-0.6
Non-electrical machinery	1.0	+0.2	+1.1	2.8	-1.6	+0.3
Electrical machinery	0.5	-1.4	-0.3	1.2	-3.5	-1.0
Automobile	2.5	-2.1	-0.5	5.5	-5.6	-2.4
Other transport equipment	0.3	-1.0	+0.2	0.6	-0.9	+0.8
Professional instruments	0.2	-0.7	+0.4	0.4	-2.7	-0.4
Miscellaneous manufacturing	0.2	-0.9	+0.3	0.4	-1.7	-0.7
Transport services	0.3	-1.1	+0.4	0.5	-2.7	+0.5
Communications	0.2	-1.2	-0.1	0.4	-4.0	-1.5
Utilities	15.2	-0.7	+0.5	27.8	-1.8	+0.6
Trade	0.3	-1.0	+0.2	0.6	-2.7	-0.8
Finance, insurance and real estate	0.5	-0.8	+0.1	0.8	-2.4	-0.1
Other services	0.4	-1.1	+0.8	0.7	-2.6	+1.6

Source: Organisation for Economic Co-operation and Development, *Macro-Economic Evaluation of Environmental Programmes* (Paris, 1978).

(c) *Some evidence from selected process-specific case studies*

Empirical evidence from most macro-economic studies points to unfavourable effects of environmental programmes on output, prices and productivity. Such negative results are partly due to the failure of these studies to capture the benefits of environmental activities (for example, improved health and productivity of workers) in the cost-benefit calculations. More importantly, macro-economic studies can be faulted for their inability to distinguish between the end-of-line investment for pollution control and change-in-process investment for pollution prevention. At the individual plant level, this distinction may be a critical determinant of the profitability of environmental expenditures. Most aggregate studies assume investment for the end-of-line pollution-control equipment.

In such a case, additional expenditures for the purchase, operation, and maintenance of new equipment with increased labour requirements will add to production costs and reduce pollutant emissions, but will not increase measured output. As a result, labour productivity must decline under this assumption.

On the other hand, the introduction of low-waste or clean technologies through process modifications and material substitutions may achieve not only significant environmental improvements, but also lower production costs at the same time through a substantial savings of energy and raw materials, and even of labour inputs. More specifically, the following potential benefits have been identified, one or more of which an enterprise adopting clean technologies may realize while reducing industrial pollution ([55], pp. 4-8):

(a) Savings in raw materials and energy;

(b) Decreased waste management costs;

(c) Improved product quality;

(d) Enhanced productivity;

(e) Decreased down-time;

(f) Reduced worker health risks and environmental hazards;

(g) Decreased long-term liability for clean-up of waste materials that might otherwise have been buried;

(h) Improved public image for the company.

The evidence that pollution-control measures can reduce rather than increase the per-unit production cost and hence improve productivity is still fragmentary and cannot be generalized across industries and countries, since it only applies to a relatively small fraction of total environmental investments, as shown by the United States data. Nevertheless, numerous case-studies at the plant level do suggest that the pollution-prevention investment in clean technologies can lower production costs and at the same time reduce emissions*. Several selected case-studies of such new production processes are highlighted below.

(i) *Low-waste electroplating process for zinc and cadmium in metal finishing and coating industry***

In the electroplating processes of zinc and cadmium with the basic material (mostly steel or iron), large quantities of waste water, exhaust air and sludge are emitted. They pollute the environment because of their contents of heavy metals and salts. Conventional processing technologies are zinc electroplating and cadmium electroplating. New and clean technologies are used in low-waste zinc electroplating plant, which is now marketable, and low waste cadmium electroplating plant, which is at its pilot stage.

Comparative data from conventional and clean zinc and cadmium electroplating processes on materials and energy requirements and on the generation of airborne, water-based and solid residuals are given in table III.43. It was reported that the construction of a low-waste electroplating plant would increase investment costs by approximately 20-30 per cent compared with a conventional plant. But these increased costs are offset by cost savings of about 70 per cent for chemicals and around 90-95 per cent of emission fees.

*For instance, see: [56]; [57]; [58]; [59]; pp. 23-33; [60]; and [61].

**For further technical details see [62].

Table III.43. Schematic comparison of conventional and clean technologies for zinc and cadmium electroplating processes

Item	Conventional technology (1)	Clean technology (2)	Difference (2)-(1)
Zinc electroplating per 10 kgs of zinc deposit			
Fresh water (total)	13.4 m^3	1.2 m^3	-12.2 m^3
Required chemicals and energy:			
Hot degreasing	-	-	-
Pickling degreasing	8.8 kg	3.4 kg	-5.4 kg
Electrolytic degreasing	4.1 kg	1.1 kg	-3.0 kg
Plating	7.5 kg	3.4 kg	-4.1 kg
Chromating	0.9 kg	0.3 kg	-0.6 kg
Waste-water treatment	42.8 kg	5.6 kg	-37.2 kg
Thermal energy	360 000 kcal (424.2 kWh)	396 000 kcal (466.6 kWh)	+36 000 kcal (42.4 kWh)
Electric energy	222 kWh	288 kWh	+ 66 kWh
2. Cadmium electroplating per 10 kgs of cadmium deposit			
Fresh water (total)	17.0 m^3	1.6 m^3	-15.4 m^3
Required chemicals and energy:			
Hot degreasing	2.0 kg	0.7 kg	-1.3 kg
Picking degreasing	9.0 kg	3.6 kg	-5.4 kg
Electrolyt. degreasing	4.4 kg	1.1 kg	-3.3 kg
Plating	9.0 kg	4.3 kg	-4.7 kg
Chromating	3.0 kg	0.9 kg	-2.1 kg
Waste water treatment	140. kg	19.8 kg	-120.2 kg
Thermal energy	400 000 kcal (471.3 kWh)	438 000 kcal (515.1 kWh)	+38 000 kcal (44.8 kWh)
Electric energy	238.5 kWh	277.5 kWh	+39 kWh
Residuals (airborne, water-borne and solid)			
Zinc electroplating per 10kg of zinc deposit			
Waste water	13.0 m^3	0.4 m^3	-12.6 m^3
Zinc sludge	35.0 kg	1.8 kg	-33.2 kg
Cadmium electroplating per 10 kgs of cadmium deposit			
Waste water 16.0 m^3	0.6 m^3	-15.4 m^3	
Cadmium sludge	80.0 kg	2.3 kg	-77.7 kg

Source: United Nations Economic and Social Council, Economic Commission for Europe, Compendium on Low- and Non-Waste Technology (ENV/WP.2/5/Add.124), pp. 1-6.

(ii) *Waste-paper production*

Conventional technologies for waste-paper processing involve an open water circuit or a reduced water circuit. A new process technology is the closed water cycle system developed by Gissler and Pass in the Federal Republic of Germany*.

Comparative data on material and energy requirements and residuals in open, reduced and closed process water system are given in table III.44. It must

*For full technical details, see "Waste-water-free paper production technology on waste paper basis", [62].

Table III.44. Comparison of conventional and clean technologies in the waste-paper-processing industry

Parameter	Unit	Conventional technology a/ Open (1)	Conventional technology a/ Reduced	Clean technology b/ Closed (2)	Difference (2) - (1)
Water	m^3/tonne	30	9.1	1	-29
Energy	KWh	15		38	23
Amount of waste water	m3/tonne	27	7.5	..	-27
Annual quantity of waste water	m3	594 000	172 500	..	-594 000
BOD	mg/litre	1 500	2 500	2 000	
BOD freight	tonnes/year	891	431	..	-891
COD	mg/litre	2 000	3 000	2 600	
COD freight	tonnes/year	1 188	518	..	-1 188
Sedimentary substances		..c/	..c/	..c/	

Source: United Nations Environment Programme and Ministry for Research and Technology of the Federal Republic of Germany, Final Proceedings of the International Symposium on Clean Technologies, Bonn, 7-18 October 1985 (Paris, 1985).

Notes: BOD = biological oxygen demand.
COD = chemical oxygen demand.

a/ Waste-water-free closed system.

b/ Open or reduced waste-water system without water treatment.

c/ With optimal operating sedimentation cone.

be noted that the comparison of energy consumption of the open and closed system given in table III.44 is misleading. This is because installation of an open water system would today require final waste-water treatment, which would consume additional energy. The study did not provide comparative investment costs of new and conventional technologies.

(iii) *Printed circuit board manufacturing*

The Hewlett-Packard Company has replaced the conventional silk screen process by a dry-film photopolymer image transfer system developed by Dupont for the main feature of printed circuit boards*. The original manufacturing processes were extremely chemical-intensive, resulting in the emission of pollutants and increased chemical disposal costs and liabilities, while the new processes use fewer toxic chemicals, or chemicals that produce fewer by-products for disposal. However, the cost savings in terms of chemicals and their disposals have not been sufficient to offset the increased costs of other inputs for the new processes. These results are summarized in table III.45. This example goes to show that not all clean technologies are necessarily economical or cost effective. On the other hand, recent plant-level case-studies on waste minimization in the printed circuit board industry in the United States present both technically and economically favourable alternatives to existing waste minimization technologies**. One of the plant case-studies is concerned with the economic viability of a new toxic solvent waste recovery system (recyclone RX-35) compared with the conventional off-site reclamation technologies. The results are summarized in table III.46. The operation of the two-stage solvent recovery system resulted in a 97.5 per cent reduction in waste volume and a 99.8 per cent recovery of solvent in the overhead. Moreover, the recycling of about 10,625 gallons (48,301 litres) of solvent at this particular plant in the first year of operation meant a disposal savings at $0.35 per gallon of solvent, or $3,720 per year. In addition, a saving of $47,709 per year resulted from the reduction in fresh solvent purchases. The total savings of these two items amounted to $51,428, which represents a net first-year saving of $16,955 including total capital costs and an estimated investment pay-back period of 7.3 months (see table III.46).

Table III.45. Cost comparison of conventional and low-waste technologies in printed-circuit-board manufacturing
(Dollars)

Item	Conventional silk-screen technology a/ (1)	Low-waste dry-film technology b/ (2)	Difference (2-1)
Treatment	1 083	27 860	26 777
Disposal	40 101	-	-40 101
Water	261	977	716
Sewage	20	75	55
Energy	4 631	53 306	48 675
Chemicals	88 860	31 898	-56 962
Dry-Film	-	157 762	157 762
TOTAL	134 956	271 878	136 922

Source: Susan T. Johnnie, "Waste reduction in the Hewlett-Packard, Colorado Springs Division, printed circuit board manufacturing shop", Hazardous Waste and Hazardous Materials, vol.4, No.1 (1987), p.21.

*For technical details, see [63], pp. 9-22.

**For further details, see [64].

Table III.46. Annual cost savings and pay-back for the recyclone RI-35 solvent waste recovery system in printed-circuit-board manufacturing

Item	Unit requirements per year	Cost: Per unit	Before installation (dollars)	After installation
Contaminated solvent	10 625 gallons	0.35	3 719	-
Recyclone bottoms	3.2 tonnes	200	-	640
Differential solvent purchases	10 602 gallons	4.50	47 709	-
Differential energy consumption	20 092 kilowatts	0.60	-	1 205
Replacement liners				
Teflon	52 bags	45.15	-	2 348
Nylon	155 bags	6.50	-	1 010
Additional labour	208 hours	15.00	-	3 120
Total cost			51 428	8 323
Annual cost savings (first year)				43 105
Recyclone RI-35 purchase and installation cost				26 150
Pay-back period				7.3 months

Source: T. Nunno and others, Toxic Waste Minimization in the Printed Circuit Board Industry (Park Ridge, New Jersey, Noyes Data Corporation, 1988), p. 17.

Note: 1 gallon = 4.546 litres.

(iv) *Corrosion protection of components*

The conventional process technologies for corrosion protection of small components such as screws, nuts and springs as connecting elements are cadmium electroplating processes. It is well known that such processes produce toxic wastes, in particular cadmium. A new process technology designed to avoid the toxic waste problem associated with the conventional technology is the Rotalyt-Alutop process.* The new process is not only capable of reducing toxic wastes, but may also prove to be an economical means of ensuring the corrosion protection of bulk components of iron and steel. A cost comparison of the conventional and new process technologies is provided in table III.47. It is worth noting that the new process uses far less energy and raw materials, and the overall unit production cost of goods treated by the new process is 30 per cent lower than those treated by the conventional process.

(v) *Textile printing*

In textile printing, a clean technology called "transfer tex-printing technology" which was invented in the early 1960s by the French engineer Noel de Plase, has been adopted world-wide in recent years. This new process is not only environmentally clean, but also offers considerable savings in terms of cost and time compared with the conventional method.**

Comparative data on materials and energy requirements in the use of conventional and clean technologies for textile printing are given in table III.48. Energy and cost savings with clean technology are substantial. More importantly, transfer printing with an organic solvent system does not generate any

*For technical details, see [65].

**For technical details, see [62], p. R13.

Table III.47. Comparison of conventional and low- and non-waste corrosion protection technologies in the electrical and non-electrical machinery and transport equipment industries

Item	Conventional technology (cadmium electro-plating)	Low-waste technology (Rotalyt-Alutop)
Materials and energy requirements		
Electric energy	920 kWh/tonne a/	140 kWh/tonne
Organic brightener	10 litres/tonne	-
Metal	15 kg/tonne of cadmium	14 kg/tonne of aluminium
Rinse water	1 000 litres/tonne	200 litres/tonne
Promotor (catalyst)	-	5 kg/tonne
Pre- and post-treatment	120 kg/tonne	20 kg/tonne
Investment requirements and unit production costs b/ (deutsche mark)	600 000	500 000
Process costs comparison per tonne of treated goods c/ (deutsche mark)		
Labour	116	116
Energy	96	12
Metals and chemicals	56	78
Maintenance	12	12
Effluent	42	21
Amortization and interest (10 years at 10 per cent)	66	55
TOTAL	388	294

Source: Economic Commission for Europe, "Compendium on low- and non-waste technology" (ENV/WP.2/5/Add.124), pp. 4-5.

a/ Of plated parts.

b/ Approximate investment costs for a 100-tonne-per-month plant.

c/ Provisional values.

Table III.48. Comparative data on conventional and clean technologies for textile printing

Materials and energy requirements	Conventional technology (1)	Clean technology (2)	Difference (2) - (1)
Water per kg	50-150 litres	-	-(50-150) litres
Auxiliary per kg	100-400 g	-	-(100-400) g
Print paste/dyestuff per m^2	130g/5g	7g/1g	-123g/-4g
Energy per kWh	Printing machines 100-350 kWh	-	-(100-350) kWh
Energy per kg	Drying 2 x 150 kWh	-	-(2 x 150) kWh
	Working 50-60 kWh	-	-(50-60) kWh
Steam per m^2	Oil conversion 40-60 g/m^2	-	-(40-60) g/m^2
Steam tonnes per hour	1.5 tonnes/hour	0.3 t/h	-1.2 tonnes/hour

Source: United Nations Environment Programme and Ministry for Research and Technology of the Federal Republic of Germany, Final Proceedings of the International Symposium on Clean Technologies, Bonn, 7-18 October 1985 (Paris, 1985).

airborne or water-borne residuals, used solvent being recovered and reused in a closed system. Only some solid residuals are collected for burning. Comparable investment requirements for the conventional and new processes are not available.

(vi) *Potato-starch manufacturing*

The USSR developed a new low-waste technology for extracting potato starch in 1982. The new process separates the potatoes into solid and liquid elements, which are then processed independently. As a result, potato powder is produced without washing potatoes (the dry method), with natural potato cell fluid with water as a by-product. In the conventional process technology, the diluted potato cell fluid containing proteins, sugars etc. is discharged with the wastes*.

Cost data for energy and raw materials and investment requirements for the conventional and low-waste technologies are summarized in table III.49. It is worth noting that the new technology eliminates waste water and results in considerable materials and energy savings. Above all, the investment requirement for the new process is reduced, and the operational costs per tonne of output are almost 30 per cent lower.

Table III.49. Comparison of standard potato-starch process with low-pollution potato-powder process in the food industry

Item	Standard technique	Low-pollution technique	Differences
Materials and energy requirements	Five tonnes of potatoes per tonne of starch; 0.3 GJ of electrical energy and 0.17 GJ in the form of steam per tonne of end-product	Five tonnes of potatoes per tonne of potato powder; 0.2 GJ of electrical energy and 0.1 GJ in the form of steam per tonne of end-product	Energy saving
Residuals generation	Diluted internal vegetation water	No waste	Elimination of wastes
Pollution control measures	Necessity for purification plants	Co-products: natural potato cell fluid and dry fodder	No pollution
Waste discharge	Wastes in the form of diluted internal vegetation water cause pollution	Non-polluting	No waste disposal
Investment requirements and unit production costs	0.6 million roubles for purification plants	0.2 million roubles for organization of potato powder production	
Miscellaneous	Operating costs: 530 roubles per tonne of starch	Operating costs: 380 roubles per tonne of potato powder	Reduction of unit production costs by 150 roubles per tonne of end-product

Source: Economic Commission for Europe, "Compendium on low- and non-waste technology" vol. V, (ECE/ENV/36), p.6.
Note: 1 GJ = 1 gigajoule.

(vii) *Preparation of moulding sands for metal casting in the foundry industry*

The cost-effectiveness of the traditional and low-waste process technologies for preparing sand moulds for metal castings was studied by the Government of Poland in 1981 and the results are summarized in table III.50**. Compared with the conventional technology, the low-waste technology yields substantial savings in energy and raw materials, while reducing the emission of pollutants. More importantly, the unit cost of moulding sands per tonne of castings was more than halved for different weight factors as a result of adopting the low-waste technology.

Table III.50. Comparison between conventional technology and low-waste technology with respect to sand use and reutilization in foundry mould technology

Item compared	Production parameters	Conventional technology	Low-waste technology	Difference
Materials	A. Bentonite sands			
New sand consumption per litre of castings	$m = 5$ $u_{sp} = 50\%$	2.5 tonnes	0.75 tonnes	1.75 tonnes
	$m = 5$ $u_{sp} = 90\%$	0.5 tonnes	0.15 tonnes	0.35 tonnes
	$m = 20$ $u_{sp} = 50\%$	10.0 tonnes	3.0 tonnes	7.0 tonnes
	$m = 20$ $u_{sp} = 90\%$	2.0 tonnes	0.6 tonnes	1.4 tonnes
	B. Self-hardening sands	5.0 tonnes	1.5 tonnes	3.5 tonnes
Energy	A. Bentonite sands			
Energy consumption per litre of castings	$m = 5$ $u_{sp} = 50\%$	1 500 MJ	450 MJ	1 050 MJ
	$m = 5$ $u_{sp} = 90\%$	300 MJ	90 MJ	210 MJ
	$m = 20$ $u_{sp} = 50\%$	6 000 MJ	1 000 MJ	4 200 MJ
	$m = 20$ $u_{sp} = 90\%$	1 200 MJ	360 MJ	940 MJ
	B. Self-hardening sands	3 000 MJ	900 MJ	2 100 MJ
Emission of waste per litre of casting	A. Bentonite sands			
	$m = 5$ $u_{sp} = 50\%$	2.5 tonnes	0.75 tonnes	1.75 tonnes
	$m = 5$ $u_{sp} = 90\%$	0.5 tonnes	0.15 tonnes	0.35 tonnes
	$m = 20$ $u_{sp} = 50\%$	10.0 tonnes	3.0 tonnes	7.0 tonnes
	$m = 20$ $u_{sp} = 90\%$	2.0 tonnes	0.6 tonnes	1.4 tonnes
	B. Self-hardening sands	5.0 tonnes	1.5 tonnes	3.5 tonnes
Type of emitted waste	Bentonite and self-hardening sands	Knocked-out sand	Knocked-out sand and rejects from reclamation plant	Not significant
Investment outlays for installation	Capacity			
	$Q = 4$ tonnes/hour	-	8 million zl	8 million zl
	$Q = 10$ tonnes/hour	-	20 million zl	20 million zl
Unit cost of some moulding sand components in relation to litres of castings	A. Bentonite sand			
	$m = 5$ $u_{sp} = 90\%$	221 zl	102.45 zl	110.55 zl
	$m = 20$ $u_{sp} = 90\%$	882 zl	400.90 zl	472.20 zl
	B. Self-hardening sands	1 865 zl	916.50 zl	948.50 zl

Source: Economic and Social Council, "Compendium on low- and non-waste technology" (ENV/WP.2/5/Add.15), p. 11.
Notes: Factor $m = \frac{\text{moulding sand weight}}{\text{casting weight}}$.
u_{sp} = sand recovery rate in used sand processing.
The monetary unit in Poland is the zloty (zl).
1 MJ = 1 megajoule.

(viii) *Production of semi-synthetic antibiotics from penicillin*

In some cases, the end-of-line or add-on process technology for pollution abatement could also be profitable, largely through the recovery and recycling of useful by-products. The recovery of pyridine from an effluent derived from the production of semi-synthetic antibiotics from penicillin, using a clean technology developed by Gist Brocades in the Netherlands, is a case in point*.

*For further details, see [66].

**For a detailed technical description of the conventional and new processes, see [67].

*For a detailed technical description of the conventional and clean process technologies, see [68].

Semi-synthetic antibiotics are produced from penicillin by chemical processes. In various processing stages several chemicals and solvents are used. During this process, effluents containing several inorganic and organic substances ar[illegible]duced. These are normally discharged into sewag[illegible]stems. The new clean technology is an add-on te[illegible]nology for the recovery of pyridine from water and its reuse in production processes. Pyridine recovery facilities have been in operation since mid-1983.

None of the wastes generated by this clean technology is directly discharged into the environment. More importantly, the economic value of the recovered pyridine more than compensates for the operational and capital costs of the new add-on technology, as shown in the cost breakdown below. A comparison of the conventional and clean technologies is given in table III.51.

Economics of the process of pyridine recovery	*Annual expenditure (1983 Netherlands guilders)*
Investment costs	2 500 000
Plant capacity: Elimination of 3 000 population equivalents Recovery of 100 tonnes per year of pyridine	
Materials: Sodium hydroxide 25 per cent	52 000
Solvent	10 000
Utilities: steam, cooling, electricity	150 000
Incineration: residue	10 000
Maintenance and insurance	100 000
Capital cost: amortization and interest	325 000
Labour	115 000
Total annual costs	762 000
Annual credits: Pyridine recovered	1 000 000
Total annual savings (credits minus costs)	238 000

The elimination of one population equivalent thus saves 79 guilders.

Table III.51. Comparison between conventional and low-waste add-on technologies for the production of semi-synthetic antibiotics from penicillin

Item	Conventional technology (1)	Low-waste technology (2)	Difference (2) -)
Materials and energy requirements (add-on technology):			
Sodium hydroxide 25 per cent (effluent pH adjustment)	-	350 tonnes	350 tonnes
Steam (distillation)	-	2 000 tonnes	2 000 tonnes
Electricity (pumps etc.)	-	70 000 kWh	70 000 kWh
Generation of waterborne residuals:	8 000 cubic metres per year of waste water containing 100 tonnes of pyridine 20 tonnes of a mixture of various organic compounds	Pyridine recovery, hence no pyridine in waste water	
Discharge of airborne, water-borne and solid wastes			
Effluent (population equivalents)	3 000	-	-3 000
Benefits related to implementation of low- and non-waste technology			
Total investments (in f.)		2 500 000	2 500 000
Total elimination costs (in f.)	135 000	-238 000	-373 000
Unit elimination costs (f. per population equivalent)	45	-79	-124
Gross savings			373 000 f. per year (3 000 per population equivalent x f.124 per popu[illegible]tion

Source: Economic Commission for Europe, "Compendium on low- and no[illegible]ogy" (ENV/WP.2/5/Add.131), p.4.

Note: The monetary unit in the Netherlands is the Netherlands guilder (f.).

(ix) *Summary of other case-studies*

Examples of profitable recovery and reuse of industrial wastes as secondary raw materials abound, as reflected in the list given in table III.52 of selected non-waste technologies applied in France. In all cases, the market value of recovered waste products exceeds the operating costs of new process technologies, and the gross operating profits may provide a sufficient margin to cover annual capital costs.

Some additional examples of the economic viability of clean technologies in the United States are summarized in table III.53. On the basis of a survey of more than 500 companies that adopted clean technologies, it was found that each company reduced industrial wastes by between 85 per cent and 100 per cent, and even more importantly, the investment pay-back periods were short, only three years to one month. These benefits accrued to old industries as well as to high-technology industries. The technological change includes incorporation of advanced technologies, such as ion exchange and ultrafiltration, process modifications involving the replacement of an old substance by a new less-polluting material, and the adoption of less chemical-intensive and more mechanical processes. The most dramatic case was provided by the photographic processing firm PCA International, Inc., of the United States, referred to in table III.53. The initial cost of $120,000 for the process modification was paid back in a few months by annual savings in the cost of the developing solution ($360,000), the fixer solution ($25,000), the bleach solution ($780,000) and the silver recovery ($1,410,000). This amounts to total annual savings of $2,575,000 [69].

Table III.52. Costs and benefits of selected non-waste technologies used in France

Process	Company	Cost of operating conventional pollution-control process (French francs)		Profit from alternative recovery process (French francs)	
Recovery of hydrocarbon in an oil refinery	Raffinerie Elf Feyzin (Rhône)	Investment	-	Investment	11 000 000
		Operating costs	2 435 000	Operating costs	2 644 000
				Sales of recovered product	8 000 000
				Gross operating profit	5 356 000
Recovery of Methionine mother liquor by evaporation	Société alimentaire equilibrée de Commentry (Allier)	Investment	9 600 000	Investment	7 000 000
		Operating costs	960 000	Operating costs	10 500 000
				Sales of recovered product	13 000 000
Recovery of protein and potassium from a yeast factory	Société industrielle de la levure Fala (SILF), Usine de Strasbourg (Bas-Rhin)	Investment	10 800 000	Investment	5 200 000
		Operating costs	1 080 000	Operating costs	860 000
				Sales of recovered product	1 015 500
				Gross operating profit	155 500
Recovery of lead and tin from furnace fumes	Société des alliages d'etain et derives, Montreuil (Seine-Saint Denis)	Investment	-	Investment	300 000
		Operating costs	-	Operating costs	200
		Sale of recovered product	4 400	Sales of recovered product	8 390
		Profit	4 400	Gross operating profit	8 730
Conversion of phosphoric acid waste into plasterboard	Rhône Progil, Les roches de Condreu (Isère), Rouen (Seine-Maritime)	Investment	9 000 000	Investment	35 000 000
		Operating costs	5 000 000	Operating costs	73 000 000
				Sales of recovered product	73 500 000
Water recycling in fibreboard plant	Isorel, Castel jalous (Tarn-et-Garonne)	Investment	5 000 000	Investment	2 500 000
		Operating costs	500 000	Operating costs	100 000
				Sales of recovered product	350 000
				Gross operating profit	250 000
Recycling of effluents in glue and gelatine manufacture	Société des establissements Georges Alquier Bout-du Pont-de-l'Ain, Mazamet (Tarn)	Investment	534 000	Investment	248 000
		Operating costs	53 000	Operating costs	-
				Reduced consumption of recovered product	18 000
				Gross operating profit	18 000
Recovery of iron dust in steelworks	Sacilor, Gandrange (Moselle)	Investment	3 700 000	Investment	9 800 000
		Operating costs	1 850 000	Operating costs	3 250 000
Recovery of plum juice	Etablissements Laparre Castelnaud de Gratecombe (Lot-et-Garonne)	Investment	768 000	Investment	235 000
		Operating costs	77 000	Operating costs	140 000
				Sale of recovered product	247 500
				Gross operating profit	107 500
Recovery of glycerine in a soap factory	Savonnerie de Lutterbach (Haut-Rhin)	Investment	600 000	Investment	400 000
		Operating costs	60 000	Operating costs	101 700
				Sale of recovered product	280 000
				Gross operating profit	178 300
Recovery of quarry washings	Société d'exploitation de l'entreprise Mirsaint-Lary (Hautes-Pyrénées)			Investment	188 000
				Operating costs	3 200
				Sale of recovered product	11 000
				Gross operating profit	7 800

Source: United Nations Environmental Programme, The World Environment 1972-1982 (Dublin, Tycooly International Publishing, 1982), pp. 425-426.

Table III.53. Examples of waste reduction and pay-back periods of clean technologies in the United States

Industry	Method	Percentage reduction of wastes	Pay-back period
Pharmaceutical production	Water-based solvent replaced organic solvent	100%	< 1 year
Equipment manufacture	Ultrafiltration	100% of solvent and oil 98% of paint	2 years
Farm equipment manufacture	Proprietary process	80% of sludge	2.5 years
Automotive manufacture	Pneumatic cleaning process replaced caustic process	100% of sludge	2 years
Micro-electronics	Vibratory cleaning replaced caustic process	100% of sludge	3 years
Organic chemicals production	Absorption, scrap condenser, conservation vent, floating roof	95% of cumene	1 month
Photographic film processing	Electrolytic recovery ion exchange	85% of developer 95% of fixer, silver and solvent	< 1 year

Source: D. Huisingh, "Cleaner technologies through process modifications, material substitutions and ecologically based ethical values", UNEP Industry and Environment, January - March, 1989.

(d) *Barriers to the diffusion of clean technologies*

The foregoing evaluation of selected process-level case-studies suggests that industrialization and environmental protection need not be a zero-sum game with one gaining at the expense of the other when clean or low-waste technologies are adopted. More specifically, integrated approaches to process modifications designed for pollution and waste reductions at the source and economizing on factor inputs could result in both increased productivity, or lower production costs, and improved environment. Such cost-cutting and pollutant-reducing technologies seem to be available in the market or are in the process of being developed in a sufficient quantity across industries. The key question therefore is why most of the manufacturing industries are still scarcely penetrated by such potentially profit-making clean technologies, and instead dominated by the end-of-pipe approaches to pollution controls as empirically suggested earlier.

There are numerous and diverse obstacles to the diffusion of new processes technologies among individual firms*. Any firm which explores the possibilities of adopting new environmental technologies usually faces a wide array of constraints of technical, economic, financial and political nature. Consideration will now be given to selected technical, structural and regulatory aspects which may have an important bearing on the slowness of industrial adoption of clean technologies. It must be cautioned at the outset that barriers to the diffusion of technical change is discussed largely in the context of developed market economies, and that the magnitude of the problem may appear even greater when assessed against the social and economic conditions of developing countries.

The lack of technical information about clean technologies is often cited as an important obstacle to technical change. While knowledge about new technologies is essential, it is not, however, the most significant factor affecting manufacturing decisions today in developed countries. In fact, one United States study evaluated the various obstacles confronted and found that about 90 per cent of them are political and financial (insufficient cash flows and financial capital, regulatory problems, risk and uncertainty, competitive pressures, reluctance to change etc.) and only 10 per cent of technical nature (lack of centralized and reliable information, low level of awareness and availability of technology and alternatives etc.) [59]. The technological information gap, however, could be the single important initial obstacle to the diffusion of clean technologies in developing countries. Easy access to technical information is particularly important for small- and medium-sized firms if they are to innovate.

One of the difficulties most often cited in the literature is related to characteristics of the firm and the structure of industry. In particular, the absorptive capacity of a firm for technical change is seen to be related to the size and maturity of the firm and industry in question. The firm in the early stages of its growth cycle tends to be flexible in choosing factor proportions in production methods, and hence can be receptive to new processes. In contrast, as the firm becomes mature, it becomes moulded to certain established manufacturing practices. As a result, production systems become more inflexible and technical changes tend to be marginal. For instance, sugar refining in the United Kingdom, leather tanning in the Netherlands and paper and pulp in France are all seen to be mature industries, and all these industries have shown some resistance to new process technologies and have preferred "end-of-pipe" approaches to pollution abatement. However, resistance to technical change caused by the ossification of industry structure is less relevant in a large number of developing countries, where most of the manufacturing industries are either at embryonic stages of development or are yet to be developed.

One intervening influence is that the size of firms may affect significantly their capacity to absorb new technologies regardless of the stage of development. The small size of firms may prevent them from adopting clean technologies, even if they are aware of such opportunities, since they cannot afford the capital outlay, the modernization required, or the attendant risks of using new technologies. They are not capable of undertaking any large-scale R + D, and hence become technically dependent on outside sources. Such limitations of small- and medium-sized firms are likely to be even more serious in developing countries.

Environmental regulations constitute another frequently cited obstacle to technological change. In particular, the relationship between environmental regulations and technical change is a contentious issue. The scope, contents and methods of enforcement of environmental regulations may directly affect the attitude and response of a firm to clean technologies. In all cases, it is imperative that the formulation and imple-

*For more detailed and comprehensive discussions on the importance and scope of the relationship between environmental policy and technical change and the type of environmental policy conducive to the diffusion of technical change, see [44].

mentation of environmental regulations be adjusted to the individual characteristics of the firms and industries concerned.

In general, the stringency of environmental regulations can raise production costs as a result of the law of diminishing returns in improving environmental quality. It must be noted, however, that strict regulations can also provide a stimulus for research into efficient technological solutions leading to savings in energy, raw materials and labour inputs. One of the major lessons learned from many industrial case-studies is, however, that the stringency of regulations is not a decisive factor. What is more important is the ways in which regulations are enforced; that is, the flexibility of regulation enforcement. It was shown earlier that the economic impact of environmental regulations varies considerably among industries, usually being more pronounced in certain heavy-polluting industries such as paper and pulp, chemicals, iron and steel and non-ferrous metals than in others. It is essential, therefore, that the degree of stringency and the form of regulations should be adapted to the varying conditions of individual industries. Most of all, firms should be given sufficient time in responding to environmental regulations to allow for basic process changes instead of rushing to hasty solutions such as the end-of-pipe adjustment, while too much time permitted for the enforcement of environmental regulations may result in a certain laxity and diminished motivation for technical change on the part of firms.

There are many other regulatory aspects, such as regulatory uncertainty related to the implementation schedule, contents, continuity and consistency over time of the regulations, as well as financial factors. All these factors could influence the decisions of firms regarding technological choices. For instance, high pollution charges may act as a strong financial incentive for industry to find efficient technological solutions in some cases.

In essence, any programme designed to promote the diffusion of clean technologies must focus on an array of issues much broader than only technical aspects. In this regard, developing countries could benefit considerably from the rapidly accumulating experiences of developed countries when they attempt to formulate and implement their own environmental policy to promote the diffusion of clean technologies.

F. Concluding remarks

Industrialization exerts inevitable stresses upon the environment. The present study has sought to determine what stresses arise at what stages of industrialization. In other words, it has attempted to delineate the environmental pressures emanating from the growth and expansion of different manufacturing industries.

Environmental deterioration associated with industrial development occurs at both the input and the output sides of production activities. Industrial production requires the input of a wide variety of natural resources such as water, energy, minerals, forest products, and other raw materials whose rapid depletion may cause environmental damage and ecological disruption. On the output side, the manufacturing process generates myriad forms of waste that may create serious environmental hazards involving air, surface, and ground-water pollution, hazardous wastes and toxic chemicals releases, soil contamination, thermal heat and noise. Also, the consumption of many manufactured end-products, such as pesticides, detergents, paints, plastics and combustion engines further contributes to these hazards.*

There is abundant literature on industrial pollution and its wider environmental effects. The bulk of the literature deals with certain specific aspects of industry and environment, such as industrial water pollution, air pollution from the iron and steel industy, toxic waste dumps at ground sites, acid rain and industrial hazardous wastes. Few studies have attempted to assemble a comprehensive picture covering all forms of the environmental impact of industrial development, in particular the impact on air, land and water. Such a collective or overall assessment of the environmental stress arising at different stages of the process of industrialization is urgently needed, not only to place the industry-environment relationship in a proper perspective, but also, and more importantly, to enable policy-makers and development planners in developing countries to make a correct and comprehensive assessment of the environmental implications of pursuing alternative strategies of industrial development. For instance, with such a complete picture of the industry-environment link, it becomes possible to assess the particular environmental threats and the major pollution problems for land, air and water, both actual and potential, that may arise from alternative industrial development strategies. It also makes it easier to identify the key pollutants and the major sources of environmental damage. The present study has attempted to meet this need by providing a more integrated perspective on the environmental impact of industrial development.

Economic development through industrialization has been a historically well-trodden path to the achievement of higher standards of living and expanded economic development. Industrialization and economic development is today perceived as a major cause of environmental degradation in developed countries. This perception is not, however, equally shared by developing countries, which are trapped in a cruel dilemma. These countries today cannot escape environmental problems; they are faced with a no-win situation. Without development, poverty-induced environmental degradation such as deforestation, desertification and environmental contamination caused by substandard living conditions will continue to plague developing countries. On the other hand, environmental problems will arise out of the actual attempts to eradicate

*In this regard, it is worth noting that the concept of "cleaner products", which is not being extensively discussed in various environmental forums, takes into account the environmental effects of the various elements of a product described here, such as extraction of raw materials and the manufacture, use and disposal of the product. The idea of minimizing environmental damage throughout the entire life cycle of a product is appealing, but it is conceptually and technocally difficult to determine what constitutes a cleaner product, and operationally difficult to measure and compare the environmental contents of literally millions of heterogeneous products. For an illuminating discussion on the concept of cleaner products, see Jacqueline Aloisi de Larderel and Clara Delbridge, "Product design and the environment", paper presented at *Chiudere il Cerchio-Progretto, Prodotto, Ambiente*, 2-3 February 190, Milan (mimeographed).

poverty through industrialization and development. From the perspective of developing countries, the primacy of industrialization is beyond dispute, despite its potential environmental costs. More importantly, industrialization could become a cure for their environmental problems, if an environmentally sound industrial development strategy is pursued.

In this regard, the importance of low-waste or clean technologies cannot be over-emphasized in forging ahead with the industrialization process. A number of case-studies have been reviewed which substantiate the potential of new clean technologies not only to reduce industrial pollution drastically, but also to remain economically profitable in their own right. The substantial savings achieved in materials and labour costs are often more than sufficient to offset initial higher investment costs. Low-waste or clean technologies also point to a way out of a potential conflict between industrial growth and environmental protection. Growth and environmental protection can go hand in hand with clean technologies.

One important conclusion of the present study is that if the current patterns of structural change in world industry should continue unchecked, environmental problems in developing countries will be likely to reach crisis proportions in the near future. More specifically, it has been shown that the world-wide stagflation during the period 1980-1982 and the subsequent growth recession forced many developed countries extensively to restructure and trim down their traditional smoke-stack industries and caused them to shift to the development and expansion of high-technology industries. As a result, a considerable part of the traditional manufacturing activities in developed countries have been redeployed to developing countries. For instance, the fastest-growing industries in developing countries compared with their counterparts in developed countries during the period 1970-1988 are mainly concentrated in two groups: the labour-intensive light manufacturing group (leather, footwear, textiles, wearing apparel and beverages), and the capital-intensive basic-materials-producing group (iron and steel, non-ferrous metals, plastics, petroleum and coal products, metal products, industrial chemicals and paper).

It has been painstakingly documented that most of these growth industries in developing countries are highly resource-intensive, using large quantities of water, energy and raw materials, and at the same time highly pollution-intensive, generating a large variety of pollutants and industrial wastes including toxic substances. It seems evident that the rapid expansion of smoke-stack industries in the South may become unsustainable sooner than expected, unless the diffusion of clean technologies occurs on a massive scale across industries and countries. Industrial pollution and depletion of natural resources in developing countries may soon reach a critical level that subsequently gives rise to severe environmental disruption. It is true that industrial pollution represents still more of a potential than an actual threat in many regions of the South, particularly in Africa. But severe industrial pollution problems encountered now in many rapidly industrializing developing countries may foreshadow what is to come on a far broader scale in other developing countries.

To recapitulate, the crux of the problem is the extent to which the drive to sustain industrialization in developing countries will be constrained by their natural resource base and their environmental absorptive capacity. To promote continued rapid industrial growth without also imposing environmental controls in developing countries may accelerate the depletion of natural resources, with serious ecological and environmental consequences, and cause direct environmental degradation through unchecked industrial pollution, to such an extent that the process of industrialization will no longer be sustainable.

It has been shown in the present study that the key to sustainable industrial development is clean technology. There are certain apparent advantages of adopting clean technologies in developing countries. Still at relatively early stages of industrialization, many developing countries have the option of technological choices that are less disruptive to their environment than the existing technologies used in developed countries. Moreover, when a new plant is being built, the adoption of a clean process technology or the incorporation of pollution-abatement equipment is significantly cheaper than the installation of such equipment in an existing plant.

From the perspective of individual developing countries where industrial pollution is still far less serious than in developed countries, the pervading approach is to adopt less costly and less effective industrial pollution-control methods, and to assume that technical progress will bring down pollution-abatement costs. Further economic growth may then make the costs of more effective methods much easier to bear in the future. The "fallacy-of-composition" argument, however, may make this approach untenable. While the industrial pollution problem may be manageable for individual developing countries in isolation, the environmental pressure imposed by the simultaneous industrialization processes of developing countries collectively may become unsustainable, not only for individual countries, but also for the global environment because of the transboundary migration of pollutants and their overall cumulative effects. These manifest themselves in broader ecosystem damage, such as the "greenhouse effect", the depletion of the ozone layer, acid rain and other global threats.

The mutuality of interest between developed and developing regions in environmental protection seems to provide a compelling case for North-South co-operation to promote and sustain environmentally sound industrial development in developing countries, mainly through the diffusion of such technologies. There are, however, some major obstacles to the diffusion of clean technologies in developing countries. First of all, the bulk of clean technologies engineered in developed countries may not be appropriate for the ecological conditions of developing countries. Even if appropriate technologies are found, there is still the urgent need for technical co-operation, knowledge transfer, and the development of expertise in waste management and environmental regulations and policies. More importantly, environmental protection requires heavy capital investments and additional resource commitments that developing countries cannot well afford. The question of who pays for the higher costs arising out of an environmentally sounder approach to industrialization in developing countries and how this burden is to be allocated between developed and developing countries is crucial. Given the current debt problems and resource constraints confronting most developing countries, there seems to be no alternative to the mobilization and provision of additional resources be provided by developed countries. Finding an appropriate *modus operandi* for channelling such additional resources, whether through existing bilateral or multilateral mechanisms or an entirely new avenue, such as a special fund for environmental protection in developing countries, is an issue which warrants separate serious consideration*. Otherwise, all will pay dearly for the failure to act in this vital area of international co-operation.

Closely related to industrial pollution problems in developing countries is the fact that increased pollution-control costs in certain industrial processes in developed countries could give rise to substantial differentials in international manufacturing cost-competitiveness. This price and cost differential may in turn create pressure for increased generalized protectionism or the erection of non-tariff barriers against specific products manufactured in countries unencumbered by stringent environmental regulations. Such a shift in competitiveness may also accelerate the migration of polluting industries or processes to countries facing a less urgent pollution problem, mainly developing countries. The problem of the export of pollution to developing countries appears to be particularly acute in hazardous products. Faced with strict environmental regulations at home, many manufacturers in developed countries find it economically attractive to move hazardous manufacturing plants to less restrictive places, mainly developing countries. Empirical evidence of the international migration of highly polluting industries from developed to developing countries abound particularly

*For instance, for a recent discussion on mechanisms for financing the global environment, see the World Bank paper, "Funding for the global environment", presented at the eleventh session of the Committee of International Development Institutions on the Environment, Brussels, 14-16 May 1990. UNEP, (CIDIE/90/4 1/2)

in the production of hazardous substances. The list of hazardous products and industries exported to developing countries includes asbestos textiles and friction products, arsenic and refined copper from primary smelters, mercury mining, lead mining and battery plants, primary refined zinc, pesticides, benzidine dyes, vinyl chloride and iron and steel*.

Given the accelerating trend towards the international redeployment of polluting industries to developing countries, the latter may face a difficult decision regarding whether to create a favourable climate for foreign investment at the cost of the environment, or to protect the environment, at the cost of slowing down foreign capital inflows. In the absence of international co-operation for the promotion of clean industrial technologies in developing countries, in most cases those countries are likely to opt for development at the expense of the environment, particularly where industrial pollution has not yet reached a critical level. But in doing so, developing countries fail to benefit from the experience of developed countries in avoiding the worst forms of environmental damage by implementing preventive strategies for pollution control rather than reactive strategies involving clean-up after pollution. Such preventive strategies call for the integration of environmental concerns into industrial development plans at the initial stages of formulation. Above all, its calls for massive financial support to promote clean technologies in developing countries. Ultimately, North-South co-operation will make it possible not only to create a cleaner global environment, but also to obviate the need for the North-South migration of polluting industries. In this regard, it must be emphasized that the increasing preoccupation with the environment in developed countries should not be allowed to detract from their support for the continued industrialization of developing countries, by reducing resource transfers or distorting aid priorities.

*For extensive documentation on United States exports of plants producing various hazardous products to developing countries, see [70], pp. 569-607. For general surveys of the question of hazardous exports, see [71], chap. 10 [72]; and [73], pp. 3A-3D.

Appendix

Statistical Tables

Table III.54. International comparison of water requirements per unit of selected manufactured products

Industry, product and country	Unit of product (tonnes, except as specified)	Water required per unit (litres)
Food products		
Bread, United States		2 100 to 4 200
Bread, Cyprus		600
Bread or pastry, Belgium		1 100
Canned food		
Fruit, Belgium		15 000
Vegetables, Belgium		8 000 to 30 000
Fruits and vegetables, Canada		10 000 to 50 000
Vegetables, Israel		10 000 to 15 000
Fruits, vegetables and juices (1965), United States		24 000

Industry, product and country	Unit of product (tonnes, except as specified)	Water required per unit (litres)
Meat		
Meat freezing, Cyprus	Tonne of carcass	500
Meat freezing, New Zealand		3 000 to 8 600
Meat packing, United States	Tonne of prepared meat	23 000
Meat packing, Canada	Tonne of carcass	8 800 to 34 000
Milk and milk products		
Cheese		
Cyprus		10 000
New Zealand		2 000
United States		27 500
Milk		
Belgium	1 000 litres	7 000
Finland		2 000 to 5 000
Israel		2 700
Sweden		2 000 to 4 000
United States		3 000
Sugar		
Denmark	Tonne of sugar-beets	4 800 to 15 800
Finland	Tonne of sugar-beets	10 000 to 20 000
Italy	Tonne of sugar-beets	10 500 to 12 500
United States	Tonne of sugar-beets	3 200 to 8 300 (range) 6 000 (average)
France	Tonne of sugar-beets	10 900
Germany, Federal Republic of	Tonne of sugar-beets	10 400 to 14 000
Israel	Tonne of sugar-beets	1 800
United Kingdom	Tonne of sugar-beets	3 200 to 8 300
Beverages		
Beer		
Belgium	Kilolitre	7 000 to 20 000
Canada	Kilolitre	10 000 to 20 000
France	Kilolitre	14 500
United States	Kilolitre	15 200
Finland	Kilolitre	10 000 to 20 000
Israel	Kilolitre	13 500
United Kingdom	Kilolitre	6 000 to 10 000
Pulp and paper		
Groundwood pulp, Finland	Tonne of wood pulp	30 000 to 40 000
Sulphate pulp		
Finland	Tonne of pulp	250 000 to 350 000
Sweden	Tonne of unbleached pulp	75 000 to 300 000
Sweden	Tonne of bleached pulp	170 000 to 500 000
Sulphite pulp, Finland	Tonne of bleached pulp	450 000 to 500 000
Finland	Tonne of unbleached pulp	250 000 to 300 000
Sweden	Tonne of bleached pulp	300 000 to 700 000
Sweden	Tonne of unbleached pulp	140 000 to 500 000
Wood pulp		
Industry average, United States	Tonne of pulp and paper	236 000
Industry average, United Kingdom	Tonne of paper and board	90 000
Industry average, France	Tonne of pulp and paper	150 000
Chemicals		
Ammonia, naphtha, reforming, Japan		256 000
Ammonium nitrate, Belgium		52 000
Ammonium sulphate, United States		835 000
Caustic soda and chlorine, Canada		125 000
Caustic soda, Solvay process, United States		60 500
Caustic soda, dual process, Germany, Federal Republic of		160 000
Soap, Belgium		37 000
Soap, Cyprus		4 500
Soap, laundry, United States		960 to 2 100
Textiles		
Dyeing and finishing		
Cotton yarn, Israel		60 000 to 180 000
Synthetic yarn, Israel		90 000 to 180 000
Wool yarn, Israel		70 000 to 140 000
Fabrics, Israel		60 000 to 100 000
Mills		
Cotton		
Finland		50 000 to 150 000
Sweden		10 000 to 250 000
Wool		
Finland	Tonne of cloth or yarn	150 000 to 350 000
Sweden	Tonne of wool	400 000

Table III.54 continued

Industry, product and country	Unit of product (tonnes, except as specified)	Water required per unit (litres)
Iron and steel products		
Belgium		
Blast furnace, no recycling		58 000 to 73 000
Blast furnace, with recycling		50 000
Finished and semi-finished steel, no recycling		61 000
Finished and semi-finished steel, with recycling		27 000
Canada		
Pig iron		130 000
Open hearth steel		22 000
France		
Smelting		46 000
Martin process (open hearth)		15 000
Thomas process (Bessemer converter)		10 000
Electric furnace steel		40 000
Rolling mills		30 000
United States		
Fully integrated mills		86 000 (average)
Rolling and drawing mills		14 700 (average)
Blast furnace smelting		103 000 (average)
Electrometallurgical ferro-alloys		72 000 (average)
Industry, consumption use		3 800 (estimated)
Miscellaneous products		
Automobiles, United States	Vehicle	38 000
Cement, Portland		
Belgium		1 900
Cyprus, dry process		550
Finland		2 550
United States, wet process		900
Fertilizer plant, Finland	Tonne of saltpetre (25 per cent nitrogen)	270 000
Glass, Belgium		63 000
Leather, South Africa		50 100
Leather, Finland	Tonne of hides	50 000 to 125 000
Leather tanning, United States	Square metre of hide	20 to 2 550
Leather tanning, Cyprus	Square metre of small animal skins	110

Source: The Demand for Water: Procedures and Methodologies for Projecting Water Demands in the Context of Regional and National Planning, Natural Resources/Water Series No.3 (ST/ESA/38).

Note: Table based on data from the following countries: Belgium, Canada, Cyprus, Denmark, Finland, France, Germany, Federal Republic of, Israel, Italy, Japan, Netherlands, New Zealand, South Africa, Sweden, United Kingdom, United States. Most of the data was provided by the respective Governments in response to requests from the Secretary-General of the United Nations for such information in 1957 and 1968. The wide range of variations in specific water amounts reflects differences in technologies.

Table III.55. Selected environmental effects of the energy sector [a]

Energy sources	Air	Waters (surface, underground/inland and marine)	Land and soils	Wild life	Other effects - solid waste, risks, to human health, noise, visual impact etc.
Coal [b]	- SO_x, NO_x, particulates	- Acid mine drainage - Mine liquid waste disposal - Water availability - Wash water treatment - Water pollution from storage heaps	- Land subsidence - Land use for mines and heaps - Land reclamation of open cast mines	- Natural habitat disturbed - Exploitation of wilderness or natural areas for surface mining	- Noise or rail transport of coal - Dust emission - Visual impact of coal heaps - Occupational risks

Energy sources	Air	Waters (surface, underground/ inland and marine)	Land and soils	Wild life	Other effects - solid waste, risks, to human health, noise, visual impact etc.
Petroleum products b/	- H_2S production SO_x, NO_x, CO, CO_2, HC, ammonia, particulates, trace elements	- Oil spills - Water availability	- Land use for facilities and pipes	- Natural habitat disturbed - Pipeline impact on wild life - Wild life polluted through leaks or spills	- Blow-outs - Explosions and fires - Pipeline leaks - Spills (accidental and operational) - Visual impacts of pipelines
Gas b/	- HC emission (mainly methane) - Trace metal emission - H_2S and combustion emissions	- Liquid residual disposal	- Land use for facilities and pipes	- Natural habitat disturbed - Impact of pipelines on wild life	- Blow-outs - High leak potential - General safety - Spills and explosions - Visual impact of pipelines
Uranium fuel cycle and electricity from nuclear power plants	- Radioactive dust - Gaseous effluent (radionucleids, F, NO_x) - Noble gas, H-3, I-131, C-14 - Local climatic impact of cooling towers - Decontamination and decommissioning of nuclear power plants	- Mine drainage - Underground water contamination - Water availability - Thermal releases - Liquid radionucleid emission (H-3, CO-60, Sr-90, I-131, Ru-106, Cs-136 and 137)	- Land subsidence (mine) - Land reclamation of open cast mines - Land use for mines	- Secondary effects of impact on water, land and air (toxic metal liquid and solid chemical wastes, radiological wastes) - Recycled fission products - High-level radioactive wastes - Visual impact of cooling towers and power lines - Noise - Occupational risks	- Radioactive products - Mine water - Mill tailing water
Hydropower c/		- Effect on hydrological cycles - Water quality and resources	- Land irreversibly flooded - Landslide risks affected	- Wild life habitat of rivers - Change in ecosystems - Fish migration	- Visual impacts - Risk of dam rupture
Others c/ Biomass, geothermal, wind and solar energies	- Biomass combustion: air pollution, particulates - Geothermal: air pollution	- Biomass conversion: pollution water availability - Geothermal: water pollution	- Land use for energy plantations - Land requirement of solar energy	- Biomass: ecosystem disruption by energy plantations wind generators - Biomass risk to workers - Photovoltaic toxic pollution when decommissioning	- Noise of wind generators - Visual impact of
Electricity generation from fossil fuels (excluding nuclear energy)	- SO_x, NO_x, CO, CO_2, HC, trace elements, particulates, radionuclides - Long-range transport and deposition of pollutants - Climatic impact of cooling towers	- Water availability - Thermal releases	- Land requirement	- Secondary effects on water, air and land - Solid wastes - Ash disposal - Noise	- Visual impact of cooling towers and power lines

Source: Organisation for Economic Co-operation and Development, The State of the Environment 1985 (Paris, 1985).
a/ Excluding energy use in transport, agriculture and other activities (heating etc.)
b/ Fossil fuels, extraction, treatment, transport and waste disposal.
c/ Renewable energy.

Table III.56. Industrial use of raw materials

ISIC code	Industry	Raw materials
311/2	Food products	Livestock, fruits, vegetables, salt, glucose, water
313	Beverages	Fruits, malt, hops, glucose, water
314	Tobacco	Raw tobacco, paper wrappers and package, menthol
321	Textiles	Raw cotton, wool and silk, ethylene oxide and terephthalic acid (for polystar), water
322	Wearing apparel	Textile products
323	Leather and fur products	Animal hides and skin, chromium, sodium chloride
324	Footwear	Leather, plastic, wood
331	Wood products	Wood fibres
332	Furniture, fixtures	Wood products, plastic, metals
341	Paper and paper products	Pulp, aluminium sulphates
342	Printing, publishing	paper, ink
351	Industrial chemicals	Inorganic and organic chemicals, limestone
352	Other chemical products	Inorganic and organic chemicals
353	Petroleum refineries	Crude oil
354	Miscellaneous petroleum products	Coal Crude oil, coal
355	Rubber products	Latex, polymers, chemicals
356	Plastic products n.e.c.	Polyvinyl chloride (PVC), polyethylene terephthalate (PET), recycle plastics
361	Pottery, china etc.	China clay, fireclay, ball clay, dolomite
362	Glass and products	Silica sand, limestone, soda ash, recycle glass
369	Non-metallic products, n.e.c.	Limestone, chalk, gypsum/anhydrite
371	Iron and steel	Iron ore, limestone, recycle scrap
372	Non-ferrous metals	Bauxite, copper, lead, zinc, cadmium
381	Metals products	Recycle scrap, metal sheet
382	Non-electrical machinery n.e.c.	Steel, recycle scrap
383	Electrical machinery	Tungsten, glass-ceramics, silicon, copper
384	Transport equipment	Glass steel fibre, reinforced plastic, aluminium, chrome
385	Professional and scientific goods	Silicon, steel, diamond, platinum
390	Other industries	Steel, other intermediate raw materials.

Sources: D.E. Highley, D.E., "Non-Metallic Resources", in Indigenous Raw Materials for Industry The Metals Society (London, Luton, 1984), p.9, and Sell Nancy, Industrial Pollution Control: Issues and Techniques (New York, Reinhold, 1981).

Table III.57. Known significant water pollutants for selected industries

Categories of sources	Known significant pollutants
1. Pulp and paper mills	BOD, COD, SS, bac, WSL, NH_3, DS biocides
2. Paperbased, builder's paper and board mills	BOD, COD, SS
3. Meat product and rendering process	BOD, DS, SS, N, NO_3, NH_3, O&G, P, bac.
4. Dairy product processing	pH, BOD, COD, DS, SS, set.s.
5. Grain mills	BOD, SS, pH, DS, N, P, heat
6. Canned and preserved fruits and vegetables processing	BOD, SS, pH
7. Canned and preserved seafood processing	BOD, COD, SS, DS, O, fecal coliform, Cl
8. Sugar processing	BOD, COD, SS, DS, coli, NH_3, pH, heat

Categories of sources	Known significant pollutants
9. Textile mills	BOD, COD, DS, colour, SS, O&G, heavy metals (Cu, Cr, Zn)
10. Cement manufacturing	DS, SS, pH, heat
11. Feedlots	BOD, DS, SS, NO_3, P, coli
12. Electroplating	Heavy metals (Cr, Zn, Ni, Cd, others), CN, acidity, pH, DS, SS
13. Organic chemicals manufacturing	O, unreacted raw materials, BOD, COD, SS, acidity or alkalinity, heavy metals and heat
14. Inorganic chemicals manufacturing	Divided into 22 discrete subcategories[a/], BOD, DS, COD, pH, heat
15. Plastic and synthetic materials	BOD, COD, SS, heavy metals, pH (subcategories vary extensively)
16. Soap and detergent manufacturing	BOD, COD, SS, O&G, surf, pH
17. Fertilizer manufacturing	
Subpart A - phosphate type	pH, P, F, Cd, As, V, U
Subpart B - ammonia	pH, N, O
Subpart C - urea	pH, N
Subpart D - ammonium nitrate	ph, N, NO_3
Subpart D - nitric acid	ph, N, NO_3
18. Petroleum refining	O,S, Phen, NH_3, BOD, COD, heavy metals, alkalinity
19. Iron and steel manufacturing	Phen, CN, NH_3, O, SS, heavy metals, (Cr, Ni, Zn, Sn), DS, acidity, heat
20. Non-ferrous metals manufacturing	BOD, SS, DS, COD, CN, pH, colour, turb, heavy metals, P, -, O&G, heat
21. Phosphate manufacturing	F, As, P, H_3PO_4, H_2SO_3, H_2SO_4, HCl, SS, Cr, DS, NH_3
22. Steam electric power plants	BOD, SS, DS, COD, CN, pH, surf, colour, O&G, phen, turb, heavy metals, VS, P, N, heat
23. Ferroalloy manufacturing	
Subpart A - open electric furnaces with wet air pollution control	SS, Cr, Cr^{6+}, CN, Mn, O, phen, PO_4
Subpart B - covered electric furnaces with wet air pollution control	SS, Cr, Cr^{6+}, Mn, O, phen, PO_4
Subpart C - slag processing	SS, Cr, Mn, O
Subpart D - noncontact cooling	Heat, SS, Cr, Cr^{6+}, O, PO_4
24. Leather tanning and finishing	BOD, COD, DS, alkalinity, hard, colour, NaCl, SO_3, S, amines, Cr, Na_2CO_3, O&G
25. Glass and asbestos manufacturing	
Glass	NH_3, pH, colour, turb, heat, phen, BOD, COD, DS, SS, O&G
Asbestos	SS, BOD, pH,
26. Rubber processing	BOD, COD, N, surf, colour, Cl, S, O&G, phen, Cr
27. Timber products	BOD, COD, SS, DS, colour, TOC

Source: N.S. Azad, ed., Industrial Wastewater Management Handbook (New York, McGraw Hill, 1976), pp. 1-12.

Note: Definition of parameters:

1.	alk	Alkalinity	20.	hard	Hardness
2.	As	Arsenic	21.	HCl	Hydrochloric acid
3.	bac	Bacteria	22.	heat	Thermal
4.	BOD	Biological Oxygen Demand	23.	Mn	Manganese
5.	Cd	Cadmium	24.	N	Nitrogen (organic or Kjelhahl)
6.	COD	Chemical Oxygen Demand	25.	NaCl	Sodium chloride
7.	Cl	Chlorine	26.	Na_2Co_3	Sodium carbonate
8.	coli	Total coliform	27.	NH3	Ammonia
9.	colour	Colour (APHA) and/or dyes	28.	Ni	Nickel
10.	CN	Cyanide	29.	NO^3	Nitrate
11.	Cr	Chromium (total)	30.	O	Oil
12.	Cr^{6+}	Chromium hexavalent	31.	P	Phosphate
13.	Cu	Copper	32.	phen	Phenols
14.	DS	Dissolved solids	33.	pH	Acidity
15.	F	Fluoride	34.	S	Sulphide
16.	G	Grease	36.	set.s	Settleable solids
17.	H_2SO_3	Sulphorous acid	36.	SS	Suspended solids
18.	H_2SO_4	Sulphuric acid	37.	surf	Surfactants
19.	H_3PO_4	Phosphoric acid	38.	turb	Turbidity

a/ Inorganic chemicals manufacturing subcategories.

1. Aluminium chloride	6. Chlorine, sodium, hydroxide, potassium, hydroxide
2. Aluminium sulphate	7. Hydrochloric acid
3. Calcium carbide	8. Hydrofluoric acid
4. Calcium chloride	9. Hydrogen peroxide
5. Calcium oxide	10. Nitric acid

Table III.58. Industries by stressor type a/

Industry and stressor

High stressor (pollutants to air and water)

Metal mines
Coal mines
Crude petroleum and natural gas
Non-metal mines
Pulp and paper mills
Iron and steel mills
Smelting and refining
Petroleum refining
Manufacturers of industrial chemicals
Electric power (thermal and nuclear)

Medium stressor (pollutants to air)

Quarries and sand pits
Bakery products
Sawmills, planing and shingle mills
Veneer and plywood mills
Iron foundries
Manufacturers of miscellaneous electrical products
Clay products manufacturers
Cement manufacturers
Concrete products manufacturers
Glass and glass products manufactures
Abrasives manufacturers
Lime manufacturers
Miscellaneous non-metallic mineral products
Miscellaneous petroleum and coal products
Manufacturers of mixed fertilizers
Manufacturers of plastics and synthetic resins

Medium stressor (pollutants to water)
Logging
Quarries and sand pits
Meat and poultry products
Fruit and vegetable processing
Dairy
Flour and breakfast cereal products
Feed industry
Beverage industry
Tyre and tube manufacturers
Leather tanneries
Textile industries
Asphalt roofing manufacturers
Steel pipe and tube mills
Iron foundries
Aluminium rolling, casting and extruding
Copper and copper alloy rolling, casting and extruding
Metal rolling, casting and extruding, n.e.s.
Metal frabricating
Clay products manufacturers
Cement manufacturers
Ready-mix concrete manufacturers
Lime manufacturers

Manufacturers of lubricating oils and greases
Miscellaneous petroleum and coal products
Manufacture of mixed fertilizers
Manufacturers of synthetic plastics and resins
Manufacturers of pharmaceuticals and medicines
Paint and varnish
Soap and cleaning compounds
Miscellaneous chemicals

Low stressor (pollutants to air)

Logging
Food and beverage industries
Tobacco products
Rubber and plastics products
Leather industries
Textile industries
Knitting mills
Clothing industries
Wood industries
Furniture and firtures
Asphalt roofing manufacturers
Paper box and bag manufacturers
Miscellaneous paper converters
Printing, publishing and allied products
Steel pipe and tube mills
Aluminium rolling, casting and extruding
Copper and copper alloy rolling, casting and extruding
Metal fabricating
Machinery
Transportation equipment
Electrical products

Industry and stressor

Ready-mix concrete manufacturers
Manufacturers of lubricating oils and greases
Manufacturers of pharmaceuticals and medicines
Pain and varnish
Soap and cleaning compounds
Manufacturers of toilet preparations
Miscellaneous chemicals
Miscellaneous manufacturing

Low stressor (pollutants to water)

Bakery products
Miscellaneous food industries
Tobacco products
Rubber footwear
Miscellaneous rubber products
Plastic fabricating, n.e.s.
Shoe factories
Leather glove factories
Luggage, handbag and small leather goods
Knitting mills
Clothing industries
Wood industries
Furniture and firtures
Paper box and bag manufacturers
Miscellaneous paper converters
Printing, publishing and allied products
Machinery
Transport equipment
Electrical products
Stone products
Concrete products
Glass and glass products
Abrasive manufacturers
Miscellaneous non-metallic mineral products
Manufacturers of toilet preparations
Miscellaneous manufacturing

Source: Statistics Canada, Human Activity and the Environment (Ottawa, 1986).
a/ Including primary industries (excluding agriculture), manufacturing industries and the electric power generation industry.

Table III.59. Major air pollutants a/

Pollutant	Characteristics	Principal sources	Principal effects	Controls	National ambient standards (micrograms per cubic metre) b/ c/
Photochemical oxidants (O_x)	Colourless, gaseous compounds which can comprise photochemical smog; for example, ozone (O_3) peroxyacetyl nitrate (PAN), aldehydes, and other compounds	Atmospheric reactions of chemical precursors under the influence of sunlight	Health: Aggravation of respiratory and cardiovascular illnesses, irritation of eyes and respiratory tract, impairment of cardiopulmonary function Other: Deterioration of rubber, textiles, and paints: impairment of visibility, leaf injury, reduced growth, and premature fruit and leaf drop in plants	Reduced emissions of nitrogen oxides, hydrocarbons, possibly sulphur oxides	Primary: 1 hour=160 Alert: 1 hour=200
Nitrogen dioxide (NO_2)	A brownish-red gas with a pungent odour, often formed from oxidation of nitric oxide (NO)	Motor vehicle exhausts, high-temperature stationary combustion, atmospheric reactions	Health: Aggravation of respiratory and cardiovascular illnesses and chronic nephritis Other: Fading of paints and dyes, impairment of visibility, reduced growth and premature leaf drop	Catalytic control of automobile exhaust gases, modification of automobile engines to reduce combustion temperature, scrubbing flue gases with caustic substance or urea	Primary: Annual=100 Alert: 24 hour=282 1 hour=1 130

Pollutant	Characteristics	Principal sources	Principal effects	Controls	National ambient standards (micrograms per cubic metre)[b/][c/]
Hydrocarbons (HC)	Organic compounds in gaseous or particulate form; for example, methane, ethylene, and acetylene	Incomplete combustion of fuels and other carbon-containing substances, such as in motor vehicle exhausts; processing, distribution and use of petroleum compounds such as gasoline and organic solvents; natural events such as forest fires and plant metabolism; atmospheric reactions	Health: Suspected contribution to cancer Other: Major precursors in photochemical oxidants through atmospheric reactions	Automobile engine modifications (proper tuning, crankcase ventilation, exhaust gas recirculation, redesign of combustion chamber); control of automobile exhaust gases (catalytic or thermal devices); improved design, operation and maintenance of stationary furnaces (use of finely dispersed fuels, proper mixing with air, high combustion temperature); improved control procedures in processing and handling petroleum compounds	
Total suspended particulates (TSP)	Any solid or liquid particles dispersed in the atmosphere, such as dust, pollen, ash, soot, metals, and various chemicals; the particles are often classified according to size as settleable particles: larger than 50 microns; aerosols: smaller than 50 microns; and fine particulates: smaller than 3 microns	Natural events such as forest fires, wind erosion, volcanic eruptions; stationary combustion, especially of solid fuels; construction activities; industrial processes; atmospheric chemical reactions	Health: Directly toxic effects or aggravation of of the effects of gaseous pollutants; aggravation of asthma or other respiratory or cardiorespiratory symptoms; increased cough and chest discomfort; increased mortality Other: Soiling and deterioration of building materials and other surfaces, impairment of visibility, cloud formation, interference with plant photosynthesis	Cleaning of the flue gases with inertial separators, fabric filters, scrubbers, or other electrostatic precipitators; alternative means for solid waste reduction; improved control procedures for construction and industrial processes	Primary: Annual=75 24 hour=260 Secondary: Annual=60 24 hour=150 Alert: 24 hour=375
Sulphur dioxide (SO_2)	A colourless gas with a pungent odour; SO_2 can oxidize to form sulphur trioxide (SO_3) which forms sulphuric acid with water	Combustion of sulphur-containing fossil fuels, smelting of sulphur-bearing metal ores, industrial processes, natural events such as volcanic eruptions	Health: Aggravation of respiratory diseases, including asthma, chronic bronchitis, and emphysema; reduced lung function; irritation of eyes and respiratory tract; increased mortality Other: Corrosion of metals; deterioration of electrical contacts, paper, textiles, leather, finishes and coatings, and building stone; formation of acid rain; leaf injury and reduced growth in plants	Use of low-sulphur fuels; removal of sulphur from fuels before use; scrubbing of flue gases with lime or catalytic conversion	Primary: Annual=80 24 hour=365 Alert: 24 hour=800
Carbon monoxide (CO)	A colourless, odourless gas with a strong chemical affinity for haemoglobin in blood	Incomplete combustion offuels and other carbon-containing substances, such as in motor vehicle exhausts; natural events such as forest fires or decomposition of organic matter	Health: Reduced tolerance for exercise, impairment of foetal development, aggravation of cardiovascular diseases Other: Unknown	Automobile engine modifications (proper tuning, exhaust gas recirculation, redesign of combustion chamber); control of automobile exhaust gases (catalytic or thermal devices); improved design, operation and maintenance of stationary furnaces (use of finely dispersed fuels, proper mixing with air, high combustion temperature)	Primary: 8-hour=10 000 1-hour=40 000 Alert: 8-hour=17 000

Source: Council on Environmental Quality, Environmental Quality (Washington, D.C., Government Printing Office, 1975), pp. 301-303.

a/ Pollutants for which national ambient air quality standards have been established.

b/ Primary standards are intended to protect against adverse effects on human health. Secondary standards are intended to protect against adverse effects on materials, vegetation and other environmental values.

c/ The federal episode criteria specify that meteorological conditions are such that pollutant concentrations may be expected to remain at these levels for 12 or more hours to increase; in the case of oxidants, the situation is likely to reoccur within the next 24 hours unless control actions are taken.

Table III.60. Nation-wide air pollution emissions by pollutant and source in the United States 1970-1986
(Millions of tonnes, except lead in thousands of tonnes)

Year and pollutant	Total	Controllable emissions: Transport: Total	Transport: Road vehicles	Fuel combustion a/: Total	Fuel combustion a/: Electric utilities	Industrial processes	Solid waste	Miscellaneous uncontrollable	Per cent of total: Transport	Per cent of total: Fuel combustion a/	Per cent of total: Industrial
1970											
Carbon monoxide	98.7	71.8	62.7	4.4	0.2	9.0	6.4	7.2	72.7	4.5	9.1
Sulphur oxides	28.4	0.6	0.3	21.3	15.8	6.4	-	0.1	2.1	75.0	22.5
Volatile organic compounds	27.5	12.4	11.1	1.1	-	8.9	1.8	3.3	45.1	4.0	32.4
Particulates	18.5	1.2	0.9	4.6	2.3	10.5	1.1	1.1	6.5	24.9	56.8
Nitrogen oxides	18.1	7.6	6.0	9.1	4.4	0.7	0.4	0.3	42.0	50.3	3.9
Lead	203.8	163.6	156.0	9.6	0.3	23.9	6.7	-	80.3	4.7	11.7
1980											
Carbon monoxide	76.1	52.6	45.3	7.3	.3	6.3	2.2	7.6	69.1	9.6	8.3
Sulphur oxides	23.9	0.9	0.4	19.3	16.1	3.8	-	-	3.8	80.8	15.9
Volatile organic compounds	23.0	8.2	6.9	2.2	-	9.2	0.6	2.9	35.7	9.6	0.4
Particulates	8.5	1.3	1.1	2.4	.8	3.3	0.4	1.1	15.3	28.2	38.8
Nitrogen oxides	20.3	9.2	7.2	10.1	6.4	0.7	0.1	0.2	45.3	49.8	3.4
Lead	70.6	59.4	56.4	3.9	0.1	3.6	3.7	-	84.1	5.5	5.1
1986											
Carbon monoxide	60.9	42.6	35.4	7.2	0.3	4.5	1.7	5.0	70.0	11.8	7.4
Sulphur oxides	21.2	0.9	0.5	17.2	14.3	3.1	-	-	4.2	81.1	14.6
Volatile organic compounds	19.5	6.5	5.3	2.3	-	7.9	0.6	2.2	33.3	11.8	40.5
Particulates	6.8	1.4	1.1	1.8	0.4	2.5	0.3	0.8	20.6	26.5	36.8
Nitrogen oxides	19.3	8.5	6.6	10.0	6.6	.6	0.1	0.1	44.0	51.8	3.1
Lead	8.6	3.5	3.3	5.0	0.1	1.9	2.7	-	40.7	5.8	22.1

Source: Bureau of the Census, Statistical Abstracts of the United States 1989 (Washington, D.C., Government Printing Office, 1989), p.200.
a/ Stationary.

Table III.61. Weighted direct emission coefficients of air pollution, Netherlands, 1973
(Units of air pollution)

Rank	Industry	Process	Combustion	Transport	Total
1.	Fertilizers	2 646	179	34	2 859
2.	Other chemical basic products	577	194	6	777
3.	Building materials	435	76	67	578
4.	Other transport equipment	530	10	6	546
5.	Other services	477	7	10	494
6.	Primary metals	186	151	4	342
7.	Fabricated metal products	320	8	7	336
8.	Other agriculture	0	247	16	262
9.	Machinery	173	6	8	187
10.	Rubber and synthetic chemical products	131	35	9	175
11.	Maintenance and repair	155	17	2	174
12.	Automobile manufacture	155	6	2	163
13.	Paper	100	56	5	161
14.	Sea and air transport	137	1	12	150
15.	Coal mining	72	65	0	137
16.	Construction	90	4	32	126
17.	Floor coverings, other textiles	79	20	9	107
18.	Retail trade	46	13	35	94
19.	Weaving	62	26	5	92
20.	Printing and publishing	64	12	14	90
21.	Other mining	0	77	12	89
22.	Chemical final products	64	12	8	85
23.	Sugar	0	55	27	82
24.	Lumber and wood products	26	17	23	66
25.	Wholesale trade	43	3	18	64
26.	Other manufacturing	0	50	4	54
27.	Grain mill products	10	16	19	46
28.	Dairy products	0	20	21	41
29.	Canning, preserving	0	11	29	40
30.	Electric utilities a/	6	31	4	40
31.	Margarine, oil, other foods	2	17	16	36
32.	Hotels, restaurants and bars	0	23	13	36
33.	Confectionery products	0	24	10	34
34.	Livestock (intensive)	0	8	25	33
35.	Social services	0	13	20	33
36.	Leather, shoes	0	12	18	29
37.	Electrical products	11	8	9	28
38.	Knitting	0	14	11	26
39.	Spinning	0	13	12	26
40.	Banking, insurance	0	11	15	26
41.	Beverages	0	14	11	25
42.	Medical services	0	12	11	23
43.	Bakery products	6	10	7	23
44.	Paper products	0	10	10	20
45.	Culture, recreation	0	15	6	21
66.	Clothing	0	9	10	19
47.	Water	0	19	0	19
48.	Livestock (extensive)	0	3	14	17
49.	Business services	0	7	10	17
50.	Meat products	0	5	8	13
51.	Petroleum and natural gas	5	7	1	13
52.	Other transport	2	8	5	15
53.	Communications	0	8	3	11
54.	Tobacco	0	4	6	16
55.	Petroleum and coal products a/	0	5	1	6
56.	Gas	0	0	1	1
57.	Real estate	0	0	0	0
58.	Fishing	0	0	0	0
59.	Other	0	0	0	0

Source: D.E. James, H.M.A. Jansen and J.B. Opschoor, Economic Approaches to Environmental Problems: Techniques and Results of Empirical Analysis (Amsterdam, Elsevier Scientific Publishing Co., 1978), pp. 140-141.
a/ Pollution due to combustion in this sector has been imputed directly to users of products of this sector, in order to arrive at calculated results consistent with the underlying physical flows.

Table III.62. Waste generation by types of industrial waste in selected countries, 1980-1987

(Tonnes)

Country	Year	Waste oil	Waste solvent	Paint	Concen-trated acids	Metal finishing waste	Containing silver or zinc	Containing mercury	PCBs	Biocides	Plastics, rubber	Phenolic wastes
Austria	1983	650 000 a/	7 000	5 800	1 266 300	1 394 000	270	163	1 900	39	102 000	131 900
Australia b/	1983	30 700	2 000	4 350	49 000	12 300 c/	750 d/	..	50 e/	3 500	110 f/	42 000 g/
Canada	1985	367 000	262 000	72 700	..	186 200	..	200 000 h,i/	8 000 j/	4 500	74 000 h/	19 100 h/
Finland	1982	80 000 k/	11 000	15 200	270 000 i/	6 000	500	..	89	1 600	25 000 h/	120
France	1982	250 000	250 000	90 000	..	..	..	450 h,m/	2 000 h/	..	..	23 000 n/
Germany, Federal Republic of	1984	719 611	305 215	268 065	1 493 296	222 206	65 988	..	5 481	..	734 369	..
Ireland	1980	25 000	13 500	..	..	33 000	1 600	..	..	5	45 000	..
Japan	1985	2 800 000 o/	..	..	4 237 000 p/	..	..	..	..	..	2 042 000	..
Luxembourg q/	1985	460	126	303	64	1 300	..	1 100	121	..	..	..
New Zealand	1983	900	50	10	1 000	900	-	-	800 r/	30	..	-
Norway	1987	55 000	14 000	6 000	4 000	17 000	..	3 000	150 s/	300	100 000 k/	10 t/
Sweden	1980	180 000	33 000	20 000	72 980	112 000	3 600	450	30	600	..	..
United States	1985	4 900 000 u/	3 000 000 v/	630 000 w/	2 737 740	1 800 000 w,x/	..	712 837 y/	21 000 z/	12 000	161 000 w/	360 000 y/

Source: Organisation for Economic Co-operation and Development, Environmental Data 1989 (Paris, 1989).

a/ Including refinery wastes containing mineral oils.

b/ 1983, state of Queensland only, data given in kilolitres.

c/ Metal finishing wastes plus neutral salts.

d/ Oil-based inks.

e/ 250 kilo-litres being phased out.

f/ Bituminous emulsions.

g/ Organic chemicals.

h/ 1980.

i/ Mainly from pulp mills.

j/ Including 6,500 tonnes of high level PCBs currently in storage in Canada and awaiting disposal.

k/ 1985.

l/ 1983.

m/ Containing more than 1 per cent of mercury.

n/ 1978 estimate.

o/ Includes solvent waste.

p/ Includes dilute acids.

q/ Amounts treated.

r/ Estimated total of PCB-contaminated waste to be disposed in the next 10-15 years.

s/ Organisation for Economic Co-operation and Development Secretariat estimates.

t/ 1984.

u/ 1982.

v/ 1981.

w/ Hazardous wastes only.

x/ Wastes originating from metal plating only.

y/ 1977.

z/ PCB-contaminated electric fluids.

Note: PCB = polychlorinated biphenyl.

Table III.63. Sources and types of industrial wastes

Industry groups	Waste generating processes	Expected specific wastes
Plumbing, heating, air conditioning, special trade contractors	Manufacturing and installation in homes, buildings, and factories	Scrap metal from piping and duct work; rubber, paper, and insulating materials, miscellaneous construction and demolition debris
Ordnance and accessories	Manufacturing and assembling	Metals, plastic, rubber, paper, wood, cloth, and chemical residues
Food and kindred products	Processing, packaging, and shipping	Meats, fats, oils, bones, offal vegetables, nuts and shells, and cereals
Textile mill products	Weaving, processing, dyeing, and shipping	Cloth and fibre residues
Apparel and other finished products	Cutting, sewing, sizing and pressing	Cloth and fibres, metals, plastics and rubber
Lumber and wood products	Sawmills, mill work plants, wooden containers, miscellaneous wood products, manufacturing	Scrap wood, shavings, sawdust; in some instances metals, plastics, fibres glues, sealers, paints and solvents
Furniture, wood	Manufacture of household and office furniture, partitions, office and store fixtures	Those listed under lumber and wood products, and in addition cloth and padding residues

Table III.63 continued

Industry groups	Waste generating processes	Expected specific wastes
Furniture, metal	Manufacture of household and office furniture, lockers, bedsprings, and frames	Metals, plastics, resins, glass, wood, rubber, adhesives, cloth, and paper
Paper and allied products	Paper manufacture, conversion of paper and paper-board, manufacture of paper-board boxes and containers	Paper and fibre residues, chemicals, paper coatings and fillers, inks, glues and fasteners
Printing and publishing	Newspaper publishing, printing, lithography, engraving, and bookbinding	Paper, newsprint, card-board, metals, chemicals, cloth, inks, and glues
Chemicals and related products	Manufacture and preparation of organic chemicals (ranges from drugs and soaps to paints and varnishes, and explosives)	Organic and inorganic chemicals, metals, plastics, rubber, glass, oils, paints, solvents and pigments
Petroleum refining and related industries	Manufacture of paving and roofing materials	Asphalt and tars, felts, asbestos, paper, cloth and fibre
Rubber and miscellaneous plastic products	Manufacture of fabricated rubber and plastic products	Scrap rubber and plastics lampblack, curing compounds and dyes
Leather and leather products	Leather tanning and finishing; manufacture of leather belting and packing	Scrap leather, thread, dyes, oils, processing and curing compounds
Electrical	Manufacture of electric equipment, appliances, and communication apparatus, machining, drawing, forming, welding, stamping, winding, painting, plating, baking, and firing operations	Metal scrap, carbon, glass, exotic metals, rubber, plastics, resins, fibres, cloth resides
Transport equipment	Manufacture of motor vehicles, truck and bus bodies, motor vehicle, air-craft, ship, and boat building parts etc.	Metal scrap, glass, fibre, wood, rubber, plastics, cloth, paints, solvents, petroleum products
Profession and scientific controlling instruments	Manufacture of engineering, laboratory, and research instruments and associated equipment	Metals, plastics, resins glass, wood, rubber, fibres and abrasives
Miscellaneous manufacturing	Manufacture of jewellery, silverware, plated ware, toys, amusement, sporting and athletic goods, costume novelties, buttons, brooms, brushes, signs, and advertising displays	Metals, glass, plastics, resins, leather, rubber, composition, bone, cloth, straw, adhesives, paints and solvents
Stone, clay and glass products	Manufacture of flat glass, fabrication or forming of concrete, gypsum, and plaster products; forming and processing of stone and stone products, abrasives, asbestos, and miscellaneous non-mineral products	Glass, cement, clay, ceramics, gypsum, asbestos, stone, paper and abrasives
Primary metal industries	Melting, casting, forging, drawing, rolling, forming, and extruding operations	Ferrous and non-ferrous metals scrap, slag, sand, cores, patterns, bonding agents
Fabricated metal products	Manufacture of metal cans, hand tools, general hardware, non-electric heating apparatus, plumbing fixtures, fabricated structural products, wire, farm machinery and equipment, coating and engraving of metal	Metals, ceramics, sand, slag, scale, coatings, solvents, lubricants, pickling liquors
Machinery (except electrical)	Manufacture of equipment for construction, mining, elevators, moving stairways, conveyors, industrial trucks, trailers, stackers, machine tools etc.	Slag, sand, cores, metal scrap, wood, plastics resins, rubber, cloth paint solvents, petroleum products

Source: P.B. Lederman, "Management of Solid Waste" in Encyclopedia of Environmental Science and Engineering, vol. 1, Pfafflin and Ziegler, eds. (New York, Gordon and Breach Publishers, 1976), table 5.

Table III.64. Amount of all categories of chemical releases and transfers by type of industry in the United States, 1987

ISIC code	Industry	Total releases/ transfers (thousands of pounds)	Per cent distribution: Air	Water	Public sewage	On-site land	Underground injection	Transfers off-site	Total releases/ transfers rank
311/2/3	Food products	287 012	6.04	10.65	71.71	8.02	0.07	3.51	10
314	Tobacco	10 462	72.22	1.27	21.93	0.12	0.00	4.38	21
321	Textiles	349 911	10.95	52.12	34.16	0.18	0.00	2.59	6
322	Wearing apparel	4 770	48.11	0.90	48.99	0.03	0.00	1.98	22
331	Wood and wood products	35 961	74.75	2.78	4.30	7.30	0.00	10.87	20
332	Furniture and fixtures	59 715	85.28	0.08	1.43	0.05	0.00	13.16	17
341	Paper and paper products	2 807 409	8.29	77.78	6.59	2.76	0.00	4.60	2
342	Printing and publishing	62 936	85.99	0.01	5.47	0.00	0.00	8.52	16
351	Industrial chemicals	12 088 830	7.83	48.27	6.49	7.45	24.01	5.96	1
353/4	Petroleum refining	762 361	10.38	48.02	6.63	5.21	2.78	26.99	5
355/6	Rubber and plastic products	277 096	51.88	19.52	17.40	0.29	0.02	10.89	11
323	Leather and fur products	52 087	27.07	3.76	61.41	0.32	0.00	7.45	18
361/2	Pottery, china and earthenware and glass products	116 987	23.11	1.13	6.11	21.42	5.41	42.82	13
371/2	Primary metals (iron and steel and non-ferrous)	2 593 238	9.03	4.09	6.96	39.39	3.49	37.04	3
381	Metal products (fabricated metals)	306 289	35.89	2.96	25.00	1.62	0.47	34.05	8
382	Non-electrical machinery	99 091	50.15	4.48	10.63	0.67	0.00	34.07	14
383	Electrical machinery	297 117	37.14	4.40	28.82	2.46	0.82	26.35	9
384	Transport equipment	332 397	64.25	1.17	5.48	1.62	0.01	27.47	7
385	Professional and scientific equipment	81 141	57.10	3.89	12.04	0.20	0.00	26.76	15
390	Other manufacturing industries	36 324	68.45	0.73	5.79	0.68	0.00	24.34	19
	Multiple SIC codes in 20-39	1 709 984	12.36	46.73	5.87	14.59	12.74	7.71	4
	No SIC codes in 20-39	147 939	9.96	13.68	6.09	62.42	0.21	7.64	14
	TOTAL	22 519 044	11.79	42.70	8.60	10.89	14.40	11.63	-

Source: Environmental Protection Agency, The Toxics Release Inventory, 1987 (Washington, D.C., Government Printing Office, 1989), pp.14-15.
Note: 1 pound = 0.4536 kilograms.

Table III.65. Pollution-abatement capital expenditures on end-of-line and changes-in-production process techniques in the United States 1985 a/
(Millions of dollars)

ISIC code	Industry	Total expenditures (millions of dollars)	Air: Total	Air: By pollution-abatement technique: End of line	Air: By pollution-abatement technique: Changes in production processes	Water: Total	Water: By pollution-abatement technique: End of line	Water: By pollution-abatement technique: Changes in production processes
3	All industries b/	2 809.7	1 292.3	909.0 (70)	383.3 (30)	1 017.9	892.4 (88)	125.5 (12)
311/2/3	Food products and beverages	155.1 (5.52)	66.0	52.9 (80)	13.1 (20)	77.4	71.5 (92)	5.9 (8)
321	Textiles c/	24.7 (0.88)	12.2	11.0 (90)	1.3 (10)	10.3	7.9 (76)	2.5 (24)
331	Wood and wood products	34.5 (1.23)	15.2	14.3 (94)	0.8 (6)	6.3	4.4 (69)	2.0 (31)
332	Furniture and fixtures	14.7 (0.52)	9.2	7.6 (83)	1.5 (17)	1.8	d/	d/
341	Paper and paper products	332.4 (11.83)	190.9	132.9 (70)	58.0 (30)	106.0	90.9 (86)	15.2 (14)
342	Printing and publishing	39.5 (1.41)	29.4	27.7 (94)	1.6 (6)	5.1	2.8 (54)	2.4 (46)
351/2	Industrial chemicals and other chemical products	738.1 (26.26)	194.0	148.8 (77)	45.2 (23)	271.5	233.4 (86)	38.2 (14)
353/4	Petroleum refining and miscellaneous petroleum and coal products	290.4 (10.33)	175.0	105.0 (60)	70.0 (40)	88.4	66.7 (75)	21.7 (25)

Table III.65 continued

ISIC code	Industry	Total expenditures (millions of dollars)	Air: Total	Air: By pollution-abatement technique: End of line	Air: By pollution-abatement technique: Changes in production processes	Water: Total	Water: By pollution-abatement technique: End of line	Water: By pollution-abatement technique: Changes in production processes
355/6	Rubber and plastic products	29.7 (1.05)	21.3	16.6 (78)	4.7 (22)	3.2	2.3 (72)	0.9 (28)
323	Leather and fur products	1.1 (0.04)	d/	d/	d/	0.8	0.6 (75)	0.1 (25)
361/2	Pottery, china and earthenware and glass products	61.9 (2.20)	44.4	39.1 (88)	5.4 (12)	9.9	6.9 (70)	3.0 (30)
371/2	Primary metals (iron and steel and non-ferrous)	252.9 (9.00)	142.9	128.6 (90)	14.3 (12)	84.3	79.4 (94)	4.9 (6)
381	Metal products (fabricated metals)	116.9 (4.16)	40.4	16.1 (40)	24.3 (60)	59.7	52.2 (87)	7.5 (13)
382	Non-electrical machinery	69.0 (24.46)	21.2	17.9 (84)	3.3 (16)	35.1	33.0 (94)	2.2 (6)
383	Electrical machinery	137.7 (4.90)	45.4	39.9 (88)	5.5 (12)	74.1	66.9 (90)	7.2 (10)
384	Transport equipment	456.5 (16.25)	254.5	123.7 (49)	130.8 (51)	165.1	154.9 (94)	10.2 (6)
385	Professional and scientific equipment	24.8 (0.88)	13.8	11.5 (83)	2.3 (17)	7.8	6.6 (85)	1.2 (15)

Source: Bureau of the Census, Pollution Abatement Costs and Expenditures, 1985 (Washington, D.C., Government Printing Office, April 1987).

Note: Figures in parentheses are percentage shares.

a/ Statistics in table cover manufacturing establishments with 20 employees or more.

b/ Totals may not agree with detail because of independent rounding.

c/ Excluding major group 23, apparel and other textiles.

d/ Statistics data withheld to avoid disclosing operations of individual companies.

Table III.66. MVA shares and average annual growth rates of MVA, 1970-1988

ISIC		Average annual (percentage) growth rates, 1970-1988: World	Developed countries	Developing countries	Ratio of developing countries to developed countries	Share of developing countries in world MVA	
3	Manufacturing	2.61	2.31	5.61	2.48	6.88	11.56
311/312	Food products	2.70	2.52	4.09	1.62	10.26	13.08
313	Beverages	1.48	0.96	4.24	4.42	12.51	20.26
314	Tobacco	2.40	1.89	3.83	2.03	23.15	29.73
321	Textiles	1.09	0.51	4.06	7.96	12.60	21.20
322	Wearing apparel	1.31	0.87	5.33	6.13	6.98	14.07
323	Leather and products	1.22	0.34	5.41	15.91	11.93	24.71
324	Footwear	0.63	0.20	2.81	14.05	13.46	19.83
331	Wood products	1.43	1.19	3.93	3.30	6.99	10.82
332	Furniture, fixtures	2.68	2.60	3.82	1.47	6.23	7.59
341	Paper and products	2.56	2.31	5.93	2.57	5.23	3.35
342	Printing, publishing	3.37	3.29	4.76	1.45	4.50	5.73
351	Industrial chemicals	2.87	2.53	7.38	2.92	4.71	10.21
352	Other chemical products	2.78	2.32	6.54	2.82	7.78	14.85
353	Petroleum refineries	3.01	1.87	5.74	3.07	23.23	37.20
354	Petroleum, coal products	3.10	2.47	9.50	3.85	5.07	14.99
355	Rubber products	1.85	1.36	5.62	4.13	8.27	15.92
356	Plastics products, n.e.c.	5.62	5.37	7.90	1.47	8.39	12.33
361	Pottery, china, etc.	2.33	2.02	4.48	2.22	10.44	15.17
362	Glass products	1.94	1.62	5.41	3.34	6.31	11.53
369	Non-metal products, n.e.c.	2.31	1.83	5.85	3.20	8.86	16.33
371	Iron and steel	0.18	0.48	6.70	13.96	4.75	15.46
372	Non-ferrous metals	1.75	0.81	4.69	5.79	6.85	12.66
381	Metal products	1.79	1.51	5.80	3.84	4.66	9.34
382	Machinery, n.e.c.	3.50	3.37	7.42	2.20	2.07	4.26
383	Electrical machinery	3.54	3.22	8.47	2.71	3.66	8.84
384	Transport equipment	3.13	2.98	5.66	1.90	4.60	7.12
385	Professional goods	3.52	3.37	11.33	3.38	0.97	3.61
390	Other industries	3.21	2.73	8.01	2.93	5.97	13.54

Source: UNIDO data base.

IV. A survey of selected manufacturing industries

Five relatively comprehensive industry surveys and eight less comprehensive reviews focused on selected industries and industrial branches are presented in this chapter. Included among the five comprehensive surveys are three basic industries, namely the chemical industry (ISIC 351 and 352), shipbuilding (ISIC 3841) and textile machinery (ISIC 382401-10). These are long-standing industries that must now face rapid technological change and intense international competition. The other two comprehensive surveys deal with the mineral processing of copper (ISIC 3720041) and of phosphate (ISIC 3512), which are of strategic importance to trade expansion plans for exporting developing countries.

The eight relatively brief review articles cover consumer and industrial tissue paper (ISIC 3419), engineering plastics (ISIC 3560), forgings (ISIC 371007), ironmaking (ISIC 371010), leathermaking and shoemaking machinery (ISIC 3824), paper and board for corrugated boxes or casemaking materials (ISIC 341131-341137), petroleum refining (ISIC 3530) and soft drinks (ISIC 3134).

In the comprehensive surveys, detailed statistical information is provided on each industry to illustrate current supply and demand conditions, trade patterns, profits and losses, production costs, capacity utilization and, where possible, employment at both country and company levels. The features of restructuring are examined using measures of overcapacity, of shortages, of changes in output composition, of foreign direct investment and of the role of Government. Manufacturing capacity in developing countries is given special emphasis; of particular importance are the build-up of productive capacity, project investment plans, profit potential and technological trends, as they affect the competitive position of those countries. Finally, the short- and medium-term outlook for demand, prices, employment, trade and investment is presented, within the context of an evolving world industrial structure and a changing international division of labour.

The eight review articles are more specific in their focus. The forgings review deals with an industry highly dependent on another industry, the automotive industry, and on competition with other materials, as automotive technology shifts. The review of the paper and board industry for corrugated boxes or casemaking again deals with an industry whose sales depend on the functioning of other industries that need packaging. It also shows how quickly technological changes are sweeping a traditional industry. The review of ironmaking illustrates the problems of heavy investment required at the primary stage of an industry, even though some uncertainty exists concerning the future demand for steel at the final stage. The review of leathermaking and shoemaking machinery provides insights into the evolution of a traditional industry that suddenly has become technologically intensive, including the use of computer-aided design (CAD) and of computer-integrated manufacture (CIM). The review of consumer and industrial tissue paper addresses the problem of an industry approaching market saturation in developed countries and seeking a solution through foreign investment and markets in developing countries. The soft drinks review also analyses an industry whose future sales depend on expansion in developing countries. The review of petroleum refining illustrates how rising demand together with restructuring in the early 1980s has led to new profit and investment potential. The review of engineering plastics delves into the only high-technology industry in this group and confirms the importance of specialization in product lines.

The surveys and reviews vary in scope and depth according to the availability of data, which are still obtainable in only scant quantities for certain industries, particularly those in the South. Despite the lack of uniformity in data provision, certain common threads can be discerned running through many of the individual industry surveys. These are summarized in the following 10 points:

(a) Growth has remained strong in nearly all industries despite possibilities of a slow-down in the latter part of 1990. In some of the resource-based industries, notably copper, phosphate and petroleum refining, capacity has been actively utilized and stocks have become low. Because the copper industry has just gone through a period of retrenchment, price levels are not yet sufficiently high to encourage capacity expansion. In the case of phosphates, demand increases have nudged prices upwards, with capacity additions anticipated for developing countries. The high capacity utilization in petroleum refining together with strong prices also suggests that new capacity is being planned;

(b) A growing trend towards less government involvement and more deregulation and privatization is discernible. In the ironmaking, forgings, steel and engineering plastics industries, the privatization of government-owned companies is occurring increasingly in both the North and the South. However, the converse is true in the phosphate-processing and chemicals industries, where government involvement has increased;

(c) In international trade, the United States and East Asia are of growing importance as export markets for other countries, the former because of more favourable production costs in developing exporting countries and exchange rate considerations, and the latter because demand has far outstripped the capacity of local suppliers. The Eastern European countries eventually are likely to provide markets for products with higher technology inputs. Copper, engineering plastics and refined petroleum products are products whose trade patterns have shifted;

(d) The shipbuilding industry, which experiences long upward swings in new shipbuilding and completion in contrast to downward swings resulting from the accumulation of idle capacity, has entered a rising phase of world book orders and new shipbuildings. Industry changes also suggest the moving of shipbuilding sites to low-cost developing countries;

(e) The rapid adoption of new technologies appears to be a necessity for the survival and expansion of many traditional industries. For example, CAD and CIM are essential to the modernization of leather-making and shoemaking machinery. Some of these technologies have also proved important in the case-making, textile machinery and forging industries;

(f) Almost without exception, industries in developed market economies underwent extensive restructuring during the first half of the 1980s, slimming down their productive capacity and employment in response to substantial overcapacity and prospects for weaker demand. The restructuring of these industries world-wide has been carried out not only through the closure of obsolete plants, upgrading capacity, trimming the work-force, increased research and development expenditures and a shift in production toward higher-value-added output, but also through mergers, take-over bids and acquisitions. The copper-processing industry, which is now experiencing greater sales and profits, provides a good example of the benefits gained by industries that engaged in such restructuring. Examples of other such industries include engineering plastics, forgings and petroleum refining;

(g) Among the industries surveyed, shipbuilding, petroleum refining and copper processing showed a marked improvement in capacity utilization. Conversely, the chemical, ironmaking, engineering plastics, tissue paper and casemaking materials industries continued to have problems of overcapacity;

(h) Not surprisingly, many global industries are dominated by United States, Japanese and Western European transnational corporations that are increasingly moving towards global market integration and concentration, particularly in technology- and research-and-development-intensive industries such as chemicals and engineering plastics. The location of such industries in many cases will continue to persist because of their needs for advanced technology and because their locations are contiguous to their respective end-using industries;

(i) Environmental concerns are more and more influencing the technology and the location of highly polluting industries. For example, investment plans for the chemical, plastics, leathermaking, ironmaking, forgings and petroleum refining industries are increasingly becoming hampered by more stringent environmental laws and hence higher costs of pollution abatement. There is thus likely to be a redeployment of these and other industries to locations in the South where pollution controls may be less stringent. In some cases, such as the chemical industry, the production of lower-technology chemicals would also be more suited to production in the South;

(j) Increased demand for manufacturing output in developing countries has caused a renewed shift in manufacturing capacity to these countries. Some examples of the industries involved are forgings, tissue paper, casemaking materials, chemicals and phosphatic fertilizers. In the case of engineering plastics the shift has been slower, but some attraction also exists in the availability of raw material feedstocks. An increase in the demand for such manufactured products is also expected in Eastern Europe.

A. Chemical industry (ISIC 351 and 352)*

1. *Recent trends and current conditions*

The world chemical industry is one of the most basic and important manufacturing businesses globally. Its total turnover approaches $1,000 billion, giving it a size comparable to that of other large international industries such as the automotive, steel, mechanical engineering and electronics industries. To add to the sheer scale of the industry is the degree to which its activities permeate a large number of other industries to which it provides both products and services. Typically, in most countries the chemical industry sells roughly half its turnover to other manufacturing operations rather than directly to the consumer. These commercial areas include other branches of the chemicals industry itself as well as important parts of industries such as consumer products, engineering, defence, cars, packaging and construction. This interdependence with so many other industrial branches makes the structure of the industry inherently complex and underlines its general importance to economic development generally.

(a) *Production and consumption*

The chemical industry has its most important components in the developed world, with Western Europe, Japan and North America accounting for roughly 70 per cent of world chemicals production and consumption. Among those regions, table IV.1 shows production increases between 1986 and 1987 to be the strongest in Australia, Portugal, Ireland and Sweden. Data for 1987 are provided in figure IV.1. Capital investment in production facilities also shows strong growth. Table IV.2 gives percentage increases in investments between 1986 and 1987 as high as 72.8 per cent in Finland.

Substantial opportunities also exist for developing countries to participate in the chemical industry, particularly in lower-technology production. In areas such as fibres, basic oil-derived chemicals, bulk plastics and fertilizers, several developing countries

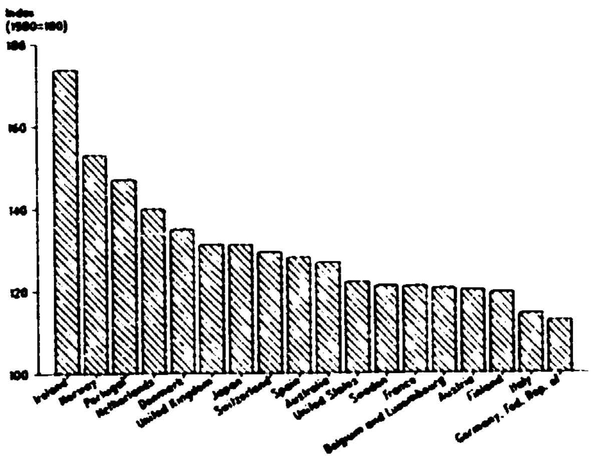
*UNIDO acknowledges the contribution of P. Marsh, Industrial Editor, *Financial Times*.

Table IV.1. World chemical industry production, 1986 and 1987

Rank in 1986	Country, region or economic grouping	Indices of production 1986 (1980=100)	Indices of production 1987 (1980=100)	Percentage change 1986-1987
1	Ireland a/	160.5	173.7	8.2
2	Norway	146.7	153.1	4.4
3	Denmark	136.0	135.0	-1.2
4	Netherlands	131.0	140.0	6.9
5	Portugal	128.0	147.1	14.9
6	Switzerland a/	125.5	129.5	3.2
7	United Kingdom	122.4	131.5	7.4
8	Japan	122.2	131.3	7.4
9	Belgium and Luxembourg a/ b/	119.8	120.5	0.6
9	Spain a/ b/	119.8	128.2	7.0
11	Finland	117.8	119.5	1.4
12	France a/	117.5	121.1	3.1
13	Canada	116.6	..	..
14	United States	115.3	122.2	6.0
14	Australia	115.0	127.0	10.4
16	Austria c/	113.8	120.2	5.6
17	Italy	111.8	114.3	2.2
18	Sweden	111.5	121.2	8.7
19	Germany, Federal Republic of	110.1	112.7	2.3

Source: National Chemical Federations.
a/ Excluding fibres.
b/ Including rubber and plastic manufacturing.
c/ 1981=100 for production indices.

Figure IV.1. World chemical industry production, 1987



Source: National Chemical Federation

Table IV.2. Capital investment in the world chemical industry, 1986-1987

Rank in 1987	Country, region or economic grouping	Capital investment 1986 (millions of dollars)	Capital investment 1987 (millions of dollars)	Percentage share 1986	Percentage share 1987	Percentage change 1986-1987
1	Japan	7 969	10 816	32.86	38.09	35.7
2	Germany, Federal Republic of	3 999	5 008	16.49	17.64	25.2
3	France a/	1 978	2 513	8.16	8.85	27.0
4	United Kingdom a/	1 935	2 288	7.98	8.06	18.2
5	Italy	1 308	1 658	4.76	5.84	26.8
6	Netherlands	1 155	1 634	4.76	5.75	41.5
7	Belgium and Luxembourg a/ b/	715	899	2.95	3.17	25.7
8	Canada	977	885	4.03	3.12	-9.4
9	Finland c/	405	700	1.67	2.47	72.8
10	Austria	526	535	2.17	1.88	1.7
11	Sweden	414	481	1.71	1.69	16.2
12	Spain a/ d/	375	421	1.55	1.48	12.3
13	Denmark	252	298	1.04	1.05	18.3
14	Norway	158	191	0.65	0.67	20.9
15	Australia a/ d/	2 001	66	8.25	0.23	-96.7
16	United States	..	..	..	..	..
17	Ireland	82	..	..	..	..
18	Portugal	..	..	..	..	..
19	Switzerland	..	..	..	..	..
	North America e/	977	885	4.0	3.1	-9.4
	Western Europe f/ g/	13 302	16 626	54.9	58.6	25.0
	Asia h/	7 969	10 816	32.9	38.1	35.7
	Australasia i/	2 001	66	8.3	0.2	-96.7
	TOTAL	24 249	28 393	100.0	100.0	17.1

Source: National Chemical Federations.
a/ Excluding fibres.
b/ Including rubber and plastics manufacturing.
c/ Capital investment for the manufacture of chemicals and of chemical, petroleum, coal, rubber and plastic products (ISIC 35).
d/ Figures refer to organics, inorganics and plastic synthetic resin products only.
e/ Figures refer to Canada only, excluding the United States.
f/ Data for Greece not included.
g/ Excluding capital investment of Austria, Ireland, Portugal and Switzerland.
h/ Figures refer to Japan only.
i/ Figures refer to Australia only.

Table IV.3. World chemical industry sales, 1987
(Billions of dollars)

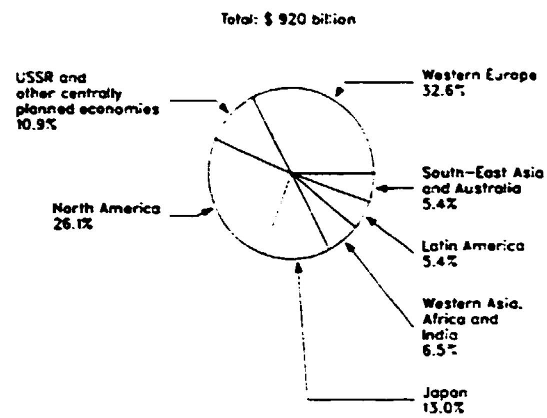
Region	Sales	Percentage share
Western Europe	300	32.6
North America	240	26.1
Japan	120	13.0
USSR and other centrally planned economies	100	10.8
Western Asia, Africa and India	60	6.5
Latin America	50	5.4
South-East Asia and Australia	50	5.4
TOTAL	920	100.0

Source: Shell.

and areas have in the past 10 years built up substantial expertise and production capacity. These countries and areas include Brazil, India, Malaysia, Pakistan, Philippines, Republic of Korea, Singapore, Taiwan Province and Thailand. Other countries that have become sizeable players in the chemical industry, particularly in petrochemicals, include Saudi Arabia, the USSR and other countries of Western Asia. Recent forecasts to 1995, prepared by Imperial Chemical Industries (ICI) of the United Kingdom, suggest that some 38 per cent likely expansion of the industry will take place in the Asia and Pacific region. This area is taken to include much of East Asia (including Japan), but does not include Australasia.

Consumption in the form of chemical industry sales for 1987 appears in table IV.3 and figure IV.2. Sales are shown to be strongest in Western Europe, followed by North America and Japan. Further details on sales in these countries can be found in the turnover figures reported in table IV.4. Turnover increases of over 20 per cent between 1986 and 1987 occurred in Japan, Federal Republic of Germany, Italy, United Kingdom, Spain, Netherlands, Switzerland, Sweden, Austria and Norway.

Figure IV.2. World chemical industry sales, 1987



Source: Shell Corporation

Table IV.4. World chemical industry turnover, 1986 and 1987

Rank in 1986	Country, region or economic grouping	Turnover (millions of dollars) 1986	Turnover (millions of dollars) 1987	Percentage share 1986	Percentage share 1987	Percentage change 1986-1987
1	United States	198 350	214 640	34.35	31.99	8.2
2	Japan a/	113 856	136 992	19.72	20.42	20.3
3	Germany, Federal Republic of	64 462	78 209	11.16	11.66	21.3
4	France b/	39 459	46 996	6.83	7.00	19.1
5	Italy	30 668	37 394	5.31	5.57	21.9
6	United Kingdom b/	30 119	37 255	5.22	5.55	23.7
7	Spain b/c/	20 711	25 478	3.80	3.80	23.0
8	Belgium and Luxembourg b/c/	17 187	19 680	2.98	2.93	14.5
9	Netherlands	16 041	19 497	2.78	2.91	21.5
10	Canada	12 977	14 490	2.25	2.16	11.7
11	Switzerland b/	9 332	11 465	1.62	1.71	22.9
12	Sweden	4 983	6 183	0.86	0.92	24.1
13	Austria	4 911	6 081	0.85	0.91	23.8
14	Finland	3 097	3 640	0.54	0.54	17.5
15	Denmark	2 749	3 256	0.48	0.49	18.4
16	Australia b/d/	2 585	2 678	0.45	0.40	3.6
17	Norway b/	2 376	2 865	0.41	0.43	20.6
18	Ireland	2 140	2 418	0.37	0.36	13.0
19	Portugal e/	1 504	1 705	0.26	0.25	13.4
	Western Europe f/	249 740	302 120	43.24	45.03	21.0
	North America	211 372	229 130	36.60	34.15	8.4
	Asia g/	113 856	136 992	19.71	20.42	20.3
	Australasia h/	2 585	2 678	0.45	0.40	3.6
	TOTAL	577 553	670 920	100.00	100.00	16.2

Source: National Chemical Federations.
a/ Including fibres.
b/ Excluding fibres.
c/ Including rubber and plastics manufacturing.
d/ Figures refer to organics, inorganics, and synthetic resin products only.
e/ Figures for organics, inorganics, fibres, fertilizers, explosives, resins and pesticides only.
f/ Greece not included.
g/ Figures for Japan only.
h/ Figures for Australia only.

(b) *Trade*

Chemical industry trade among developed countries has experienced only slight growth between 1986 and 1987. As shown in table IV.5, export increases have been particularly strong for Spain at 33.6 per cent, but many of the countries had increases of over 20 per cent. Table IV.6 shows that the most substantial increase in imports occurred in Australia at 267.2 per cent.

Table IV.5. World chemical exports, 1986 and 1987
(f.o.b. value)

Rank in 1986	Country, region or economic grouping	Exports (millions of dollars) 1986	Exports (millions of dollars) 1987	Percentage share 1986	Percentage share 1987	Percentage change 1986-1987
1	Germany, Federal Republic of	33 170	40 281	20.81	21.32	21.4
2	United States	22 815	26 381	14.31	13.96	15.6
3	Netherlands	15 718	19 000	9.86	10.06	20.9
4	France a/	15 653	19 031	9.82	10.07	21.6
5	United Kingdom	14 104	17 132	8.85	9.07	21.5
6	Belgium and Luxembourg a/b/c/	12 180	14 619	7.64	7.74	20.0
7	Japan	9 512	11 722	5.97	6.21	23.2
8	Switzerland a/	7 923	9 767	4.97	5.17	23.3
9	Italy	7 669	9 275	4.81	4.91	20.9
10	Australia a/	3 358	479	2.11	0.25	-85.7
11	Canada	3 269	3 771	2.05	2.00	15.4
12	Spain a/b/	3 120	4 169	1.96	2.21	33.6
13	Switzerland	2 497	3 033	1.57	1.61	21.5
14	Austria	1 941	2 434	1.22	1.29	25.4
15	Denmark	1 929	2 373	1.21	1.26	23.0
16	Ireland a/	1 645	1 908	1.03	1.01	16.0
17	Norway	1 267	1 621	0.79	0.86	27.9
18	Finland	1 167	1 407	0.73	0.74	20.6
19	Portugal d/	488	508	0.31	0.27	4.1
	Western Europe e/	120 471	146 558	75.57	77.58	21.7
	North America	26 084	30 152	16.36	15.96	15.6
	Asia f/	9 512	11 722	5.97	6.21	23.2
	Australasia a/	3 358	479	2.11	0.25	-85.7
	TOTAL	159 425	188 911	100.00	100.00	18.5

Source: National Chemical Federations.
a/ Including fibres.
b/ Excluding fibres.
c/ Including rubber and plastics manufacturing.
d/ Figures refer to organics, inorganics and synthetic resin products only.
e/ Figures for organics, inorganics, fibres, fertilizers, explosives, resins and pesticides only.
f/ Greece not included.
g/ Figures for Japan only.
h/ Figures for Australia only.

(c) *Major companies*

The major companies can be found in Western Europe, followed by the United States and Japan. As shown in table IV.7, the first five companies dominating the world market are BASF at 11 per cent, Hoechst at 10.5 per cent and Bayer at 10 per cent. While these companies are located in the Federal Republic of Germany, ICI in the United Kingdom at 9.3 per cent and DuPont in the United States at 8.8 per cent are almost as large. A fair amount of concentration therefore exists in the chemical market structure with these five companies accounting for 39.6 per cent of the total. However, these figures do not include sales for companies in the USSR, Eastern Europe or developing countries.

2. *Product differentiation and end-use markets*

The chemicals business is one of the most complicated of all manufacturing industries, with hundreds of different product divisions and a similar number of major end-uses. Categorizing the industry from the production side is difficult because it encompasses so many different product areas. At the primary level

Table IV.6. World chemical imports, 1986 and 1987

Rank in 1987	Country, region or economic grouping	Imports 1986 (millions of dollars)	Imports 1987 (millions of dollars)	Percentage share 1986	Percentage share 1987	Percentage change 1986-1987
1	Germany, Federal Republic of	18 826	22 656	14.92	14.81	20.3
2	United States	15 001	16 213	11.89	10.60	8.1
3	France a/	12 520	15 450	9.92	10.10	23.4
4	Italy	11 975	14 659	9.49	9.58	22.4
5	United Kingdom	10 749	13 619	8.52	8.90	26.7
6	Japan	9 785	11 916	7.75	7.79	21.8
7	Netherlands	9 513	11 496	7.54	7.51	20.8
8	Belgium and Luxembourg a/ b/ c/	9 168	10 600	7.26	6.93	15.6
9	Spain a/ b/	4 718	6 321	3.64	4.13	34.0
10	Switzerland	4 683	5 563	3.71	3.64	18.8
11	Sweden	3 177	3 906	2.52	2.55	22.9
12	Austria	2 695	3 357	2.14	2.19	24.6
13	Denmark	2 443	2 815	1.94	1.84	15.2
14	Finland	2 050	2 594	1.62	1.76	31.4
15	Ireland a/	1 410	1 676	1.12	1.10	18.9
16	Norway	1 370	1 644	1.09	1.07	20.0
17	Canada	4 322	4 830	3.42	3.16	11.8
18	Portugal d/	1 270	1 689	1.01	1.10	33.0
19	Australia a/ e/	521	1 913	0.41	1.25	267.2
	Western Asia f/	96 567	118 145	76.52	77.21	22.3
	North America	19 323	21 043	15.31	13.75	8.9
	Asia g/	9 785	11 916	7.75	7.79	21.8
	Australasia h/	521	1 913	0 41	1.25	267.2
	TOTAL	126 196	153 017	100.00	100.00	21.3

Source: Plastics supply and demand forecasts.

a/ Excluding fibres.

b/ Including rubber and plastics manufacturing.

c/ Figures for Luxembourg exports only.

d/ Figures for organics, inorganics, fibres, explosives, resins and pesticides only.

e/ Figures refer to organic, inorganic and synthetic resin products only.

f/ Data for Greece not included.

g/ Figures for Japan only.

h/ Figures for Australia only.

Table IV.7. World's largest chemical companies in 1988
(Billions of dollars)

Rank	Company	Sales	Percentage share
1	BASF (Germany, Federal Republic of)	24.4	11.0
2	Hoechst (Germany, Federal Republic of)	23.4	10.5
3	Bayer (Germany, Federal Republic of)	22.2	10.0
4	ICI (United Kingdom)	20.6	9.3
5	Du Pont (United States)	19.6	8.8
6	Dow (United States)	16.7	7.5
7	Ciba-Geigy (Switzerland)	11.4	5.1
8	Royal Dutch/Shell (United Kingdom Netherlands)	11.3	5.1
9	Rhône-Poulenc (France)	11.0	5.0
10	Enimont (Italy)	11.0	5.0
11	Exxon (United States)	10.0	4.5
12	Akzo (Netherlands)	8.4	3.8
13	Union Carbide (United States)	8.3	3.7
14	Monsanto (United States)	8.3	3.7
15	Mitsubishi Kasei (Japan)	7.9	3.6
16	Asahi Chemical (Japan)	7.4	3.3
	TOTAL	221.9	100.0

Source: Financial Times, 11 April 1990.

there are a number of product areas involving processes akin to minerals extraction, for instance production of salt or titanium-dioxide refining, where selling prices are low at around several hundred dollars a tonne. At the other extreme is the production of ultra-sophisticated chemicals, for use perhaps as the main ingredients for pharmaceuticals or agrochemicals, which require as many as 30 manufacturing steps and which may sell for several hundred thousand dollars (sometimes millions of dollars) a tonne. In basic chemicals, where the selling prices are typically between $600 and $3,000 a tonne, are found many of the most well-used chemical building blocks such as ethylene (an oil- or natural-gas-derived material used in the production of most plastics), plastics themselves such as polyethylene, fibres intermediates and many other kinds of industrial chemicals such as solvents, polyurethanes and paints.

Quantifying the output of specific chemical products is difficult because relatively little of the total production of the industry is sold to a final user in the form of a discrete product. Roughly half of the total output of the business is sold to another supplier of chemicals or to an integrated division of the originator of the material, rather than to an end-user. There is much inter-trading of the wide range of chemicals used in the dozens of reactions that may be needed to make a final product.

This means that several large and important product divisions of the chemical industry exist more or less totally as service manufacturing operations for other parts of the same industry. This category includes, for instance, many petrochemical product areas (including ethylene) that are large industries in themselves but whose output is used for making other "downstream" chemical products. As a result, it is better to look at the structure of the industry from the following two points of view: first, by generic product type; secondly, in terms of the final products that emerge from chemical processing and are sold to industrial or consumer users directly, instead of being inputs to other chemical processing links.

The general product approach to structure can be observed in the five main areas of petrochemicals, plastics, bulk inorganic substances, general fine chemicals and pharmaceuticals.

(a) *Petrochemicals*

Petrochemical products have the following three characteristics:

(a) They are derived from the oil and natural gas which constitutes the most important basic feedstock for chemicals generally;

(b) They are mostly high-volume materials sold at the rate of millions or tens of millions of tonnes a year and at relatively low prices, typically a few hundred dollars a tonne;

(c) Most of the substances are used as building-block chemicals to make other synthetic materials rather than as final products.

The total output of petrochemical products worldwide is valued at about $100 billion per year. The most important of these products shown in table IV.8 are ethylene, propylene, styrene and aromatics.

Table IV.8. Major petrochemical products, 1987

Petrochemicals	World sales (millions of tonnes)	Sales value (billions of dollars)	Percentage share: world sales	Percentage share: sales value
Ethylene	50.0	30	30.6	28.8
Styrene	12.0	16	7.3	15.4
Aromatics (for example benzene)	40.0	12	24.5	11.5
Propylene	25.0	11	15.3	10.6
Elastomers	7.0	9	4.3	8.7
Polyurethane compounds	4.0	8	2.4	7.7
Ethylene oxide	7.0	7	4.3	6.7
Hydrocarbon solvents	5.0	3	3.1	1.0
Acrylonitrile	4.0	3	2.4	2.9
High olefins	3.0	3	1.8	2.9
Chemical solvents	6.0	1	3.7	2.9
Epoxy resins	0.5	1	0.3	1.0
TOTAL	163.5	104	100.0	100.0

Source: Royal Dutch Shell.

(b) *Plastics*

Sales of plastic products add up to $120 billion per year; although plastics are sometimes categorized as petrochemicals, the former can be considered an industry in its own right. World sales of plastics in 1989 amounted to about 90 million tonnes. As shown in table IV.9, 75 per cent of all output can be

Table IV.9. Major plastic products, 1987

Type	World sales (millions of tonnes)	Sales value (billions of dollars)	Percentage share of sales value
Polyethylene	26	41	48.2
Polyvinyl chloride	16	22	25.9
Polypropylene	10	12	14.1
Polystyrene	7	10	11.8
TOTAL	59	85	100.0

Source: Shell.

accounted for by the four largest-selling plastics, namely polyethylene, polyvinyl chloride (PVC), polypropylene and polystyrene. Sales of these plastics in 1989 amounted to an estimated $90 billion. Another important component of the plastics industry is the high-value, speciality branch known as engineering plastics. This area includes materials such as polycarbonate and acrylonitrile butadiene styrene (ABS), which have especially tough or heat-resistance properties or which have other unusual characteristics in terms of their ability to be moulded. Roughly 10 million tonnes of engineering plastics were made in 1989 world-wide, worth about $25 billion. The rest of the sales in the plastics industry (this remainder being worth about $15 billion in 1989) is accounted for by a variety of other materials, mainly thermoset resins such as polyurethanes. Most sales of plastic products take place in North America and Western Europe, followed by Asia and Oceania.

(c) *Inorganic bulk materials*

The third generic area of chemicals is accounted for by inorganic bulk materials, high-volume substances not containing carbon atoms. These substances may well come from starting blocks that are other than carbon-based fossil-fuel derived chemicals such as oil and gas. Among the biggest-selling products in this area of the chemical industry are chlorine, sodium hydroxide, sodium carbonate (caustic soda), titanium dioxide and hydrogen peroxide. Some inorganic (non-carbon-containing) chemicals may be derived from organic (carbon-containing) raw materials. In this category, one of the most important products is ammonia, which is made by reacting hydrogen and nitrogen, two gases, at a high temperature and pressure. The hydrogen in this reaction is derived from methane, which is part of natural (fossil-fuel) gas. About 100 million tonnes of ammonia a year is produced, almost all of it in this manner, and most of it ends up as a feedstock for nitrogen fertilizer.

Another important inorganic product derived from an organic original material is sulphuric acid, which is used in fertilizer production and also in a number of processes to make industrial chemicals. Sulphuric acid manufacture needs sulphur as a starting product, and most of this is obtained as a by-product from oil or gas refining. In general, inorganic bulk chemicals are used in a variety of applications, either as products in their own right (thus chlorine and hydrogen peroxide are important bleaching and sanitation agents) or more commonly as starting materials for other chemicals. For example, a major use of chlorine is in making PVC, a widely used plastic, whose other major raw material is ethylene.

(d) *Fine chemicals*

Fine chemicals represent a group of materials that can be either organic or inorganic and whose main characteristic is that they are sold in small volumes and at high prices and require relatively sophisticated manufacturing methods. Another factor is that often the properties of the chemical itself are highly specific; in other words, its development has been tailored to do a particular chemical job. That is likely to have happened as a result of a long and expensive research programme, undertaken not by the industry generally, but by a particular processing company. Patenting of fine chemicals is thus often highly important. Applications vary enormously and can include use as cosmetic additives, water treatment products, dyes, sanitation agents, plasticizers, ion-exchange resins and agrochemicals (this term is taken to mean crop protection compounds such as pesticides and herbicides and does not include fertilizers, which are bulk or commodity materials as explained in the discussion of phosphates in section D of this chapter). There is also a large range of uses as intermediate materials in which the fine chemical forms a starting block for another substance with a recognizable end-use. Pharmaceuticals constitute another type of fine chemical but the industry is sufficiently large to be considered independently.

Owing to the research-intensive nature of development and also because companies making many specific types of fine chemicals face limited competition (given the difficult nature of the manufacturing route and the existence of patent protection), prices for these types of materials are often high. Products in this category often have selling prices in the range of tens of thousands (sometimes hundreds of thousands) of dollars a tonne, as opposed to a few thousand dollars a tonne or less, which is the typical selling price for most standard petrochemicals. There are many hundreds of different fine chemicals, most of them used as intermediates (starting materials) for other chemical processes. World sales of fine chemicals are difficult to estimate, but probably run to about $250 billion a year, not counting pharmaceuticals. This figure, however, seldom crops up in output statistics for the chemical industry, because such a large range of fine chemicals are used in production processes for other chemicals with more well-defined end-uses.

(e) *Pharmaceuticals*

As explained above, pharmaceuticals in some ways can be defined as specific types of fine chemicals; that is, the materials responsible for giving the products a specific property in terms of treating a particular disease or physical condition. World-wide, pharmaceuticals add up to an industry with sales of about $130 billion a year, 75 per cent of which is accounted for by sales within the developed countries of Western Europe, North America and East Asia. About $100 billion of these sales are from prescription-only drugs; that is, pharmaceuticals that can be obtained only on the prescription of a doctor. The rest of the sales are derived from non-prescription or over-the-counter medicines, which are recognized therapeutic agents, but which can be obtained from retail outlets, mainly pharmacies. The total value of the pharmaceutical industry does not include sales of other products that can be linked to health care; for example, vitamins, general tonics, fortifiers etc. The drugs industry can be divided up further into hundreds of different product classifications depending on the particular ailment (such as heart disease, arthritis, cancer and bacteria-borne infections) being treated.

(f) *End-use markets*

The second way of defining the structure of the chemical industry is to discuss the nature of end-products as opposed to generic material types. Before doing this it is instructive to consider the routes by which different types of petrochemicals interrelate and combine with other synthetic materials before reaching the end-user. To this end, the many different end-uses of chemicals can be charted in terms of the final industry or consumer area in which they are applied. The range of applications is immense, far greater than for virtually any other industry. A description of the way chemicals are used in virtually every major consumer and industrial fields is provided in table IV.10 and figure IV.3. Although this table applies to Western Europe, the proportions are unlikely to be much different in other parts of the world. The breakdown of the chemical industry according to the five categories of petrochemicals, plastics, bulk inorganics, general fine chemicals and pharmaceuticals gives a general idea as to the differences between the main types of chemicals. But it does not give a detailed view of sales of different chemical products according to the main end-use items; this is done in table IV.11. It should be noted that many petrochemicals and bulk inorganic compounds such as ethylene and chlorine are not included as main selling products because most sales of these items go to producers of other chemicals that are sold as recognized end-products and so the bulk-chemicals sales are subsumed under these.

Table IV.10. Major chemical end-use markets

Rank	Industrial use	Percentage share
1	Consumer goods (for example, domestic appliances, toys, furnishings)	27.4
2	Services (for example, hospitals, research centres, transport, commerce, laundries, administration)	19.2
3	Agriculture	10.3
4	Other industries	7.5
5	Textiles, clothing	6.6
6	Metal industry	6.5
7	Construction	5.7
8	Paper, printing	3.9
9	Electrical, electronic industries	3.8
10	Automotive industry	3.6
11	Food industry	3.1
12	Mechanical engineering	2.4
		100.0

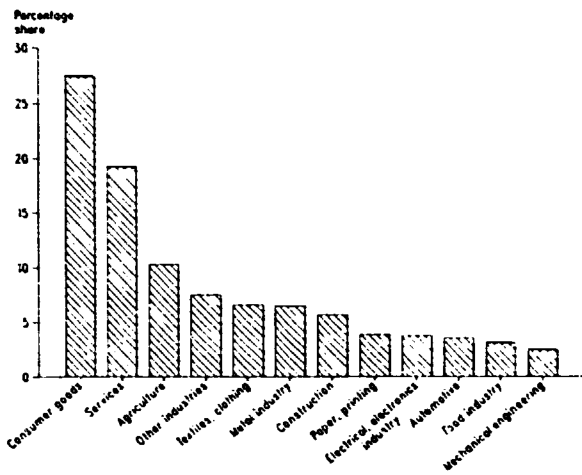
Source: European Chemical Industry Association.

Table IV.11. Chemical product sales in major end-use markets, 1987
(Billions of dollars)

Chemical product[a]	Selection of leading companies	World sales	Percentage share
General bulk organics	Various	240.0	14.6
General bulk inorganics	Various	240.0	14.6
Other fine chemicals	Various	240.0	14.6
Pharmaceuticals	Bristol Myers, Merck, Squibb	208.0	12.7
Plastics	BASF, Dow, Shell	192.0	11.7
Fertilizers	DSM, ICI, Enimont, Kemira, Norsk Hydro	80.0	4.9
Paints	ICI, PPG	48.0	2.9
Cosmetics	L'Oréal	48.0	2.9
Fibres	Akzo, Du Pont, Hoechst	48.0	2.9
Detergents	Procter and Gamble, Unilever	32.0	1.9
Agrochemicals	Ciba-Geigy, ICI, Rhône-Poulenc	32.0	1.9
Seeds	ICI, Pioneer, Sandoz	24.0	1.5
Dyes	Bayer, Ciba-Geigy, ICI, Hoechst	24.5	1.5
Synthetic rubber	Enimont, Firestone, Goodyear	24.5	1.5
Industrial gases	Air Liquide, BOC, Union Carbide	24.5	1.5
Polyurethanes	Bayer, BASF, DOW, ICI	19.2	1.2
Adhesives	Borden, Henkel, National Starch	9.2	1.2
Electronic chemicals	Du Pont, Wacker	16.0	1.0
Titanium dioxide pigments	Du Pont, NL, SCM, Tioxide	12.8	0.8
Food adhesives	Various	8.0	0.5
Fragrances	Various	8.0	0.5
Catalysts	Degussa, Engelhart, Johnson Mathey	8.0	0.5
Construction chemicals	Sandoz	8.0	0.5
Photographic chemicals	Eastman Kodak	8.0	0.5
Water treatment chemicals	Nalco	8.0	0.5
Chemical solvents	Exxon, Shell, Union Carbide	8.0	0.5
	TOTAL	1 643.2	100.0

Source: Industry estimates.
a Product sold outside the chemicals industry as end-use materials.

Figure IV.3. Major chemical end-use markets



Source. European Chemical Industry Association.

3. *Capacity utilization and expansion plans*

(a) *Investment climate*

The late 1980s have generally been extremely good for the chemical industry world-wide. The industry was in trouble in the early 1980s, during which time demand was at a lower level than capacity for many parts of the industry in most developed countries. As a result of this, prices for many chemicals products fell, profits were low and the industry went through a period of restructuring in which capacities were cut and employment reduced. Since around 1986, the situation has improved in many parts of the world. Demand for chemicals has improved in line with the general economic expansion in much of the developed world. Prices, particularly for many of the low-value, high-volume basic petrochemicals, have increased, leading to better profits, increased capacity utilization and a mood of expansion.

The principal chemical products for which capacity utilization and expansion are critical appear in table IV.12. They include ethylene, propylene, styrene, ethylene oxide, ethylene glycol, ammonia, methanol, polyethylene, polypropylene, polystyrene, and polyvinyl chloride. Reflecting the above-mentioned favourable climate of the 1980s, considerable capacity additions occurred in the new producing and developing countries. The most sizeable increases can be seen in ethylene and ammonia production. Regions gaining the largest increase were Eastern Europe and East Asia.

The outlook for the early 1990s is difficult to judge. In 1989, the growth in demand slowed down in many developed countries. At the same time, increases in capacity, which had been approved in the 1986-1988 period as a result of the feeling of buoyancy in the industry, started to come on stream. That, however, led to a checking of previous price increases and to lower profits for many of the large chemical companies. During 1990-1992, more capacity increases will come on stream in many parts of the industry. Demand expansion is likely to be less than for much of the 1986-1988 period, owing to a slow-down in the rate of economic growth world-wide. That will lead, many observers believe, to a relative slump in the industry, although this is not expected to be at all as severe as in the early 1980s, when the industry as a whole was in difficulty.

A major problem for the chemical industry is that profits and the general outlook are intrinsically linked to capacity utilization; that is, because the industry is highly capital-intensive and fixed costs as a proportion of total costs tend to be high. The cost, for example, is $500 million to build a modern ethylene plant. A titanium-dioxide factory that processes ore to make the pure material can easily represent an investment of $200 million. In the future, costs for new plants are likely to be still higher, for two reasons. The first is that new plants tend to have larger capacity. Taking ethylene plants as an example, the average capacities of such facilities have increased considerably over the past 40 years. Average annual optimum output of such plants was 30,000 tonnes a year in 1950, 60,000 in 1960, 100,000 in 1970, 200,000 in 1980, and 280,000 in 1988, according to statistics from Shell. The average capacity estimate is likely to exceed 300,000 tonnes a year in the early 1990s.

The second reason for the larger costs involved with new plants is that more expensive equipment is needed in such facilities to reduce pollution and to embody other environmental safeguards. This is tied up with

Table IV.12. Chemical capacity additions in new producing and developing countries, 1982-1987
(Thousands of tonnes per year)

Region	Ethylene	Propylene	Styrene	EO/EG a/	Ammonia	Methanol	Poly-ethylene	Poly-propylene	Poly-styrene	Polyvinyl chloride
Eastern Europe	2 925	245	..	625/ 340	2 647	2 465	1 245	435	118	652
East Asia	2 470	663	..	400/ 330	5 879	1 060	1 130	522	22	516
Western Asia and North Africa	1 920	..	..	180/ 550	2 358	2 285	897			140
Latin America	1 275	107	..	100/ -	-	565	402	-	40	116
Africa	510	200	..	- / -	660	660	-	68	-	140
Others	410	150	..	95/ 68	1 103	600	595	85	9	110
TOTAL	9 510	1 365	..	1 400/1 308	12 647	7 635	4 269	1 110	189	1 674
Current capacities	20 600	6 000	2 800	.. ..	..	..	9 200	2 100	1 400	6 700

Source: Stuart Wamsley, Focus on Chemicals (East Sussex).
a/ Ethylene oxide/ethylene glycol.

increasing environmental awareness in many countries, much of which is manifested in increasing demands on the chemical industry to implement relatively new and expensive clean-up technologies to reduce the negative environmental impact of industrial operations. Such systems can include scrubbing equipment to remove harmful gases, new waste water treatment systems, incinerators to dispose of solid waste and sensors and sophisticated control equipment to increase monitoring of reactions and to ensure output of polluting materials is kept to a minimum.

Because, in general, fixed costs are so high, there is an overwhelming pressure on managers to increase output as much as possible, particularly of low-value, high-volume petrochemical-type products. If output can be pushed to 90 per cent or more of capacity for such plants, then profitability remains reasonably good. This follows from the fact that at such an output level, demand is likely to be great enough to keep prices reasonably high. With an output below the 90 per cent of capacity, prices and, therefore, profitability are likely to be low, and if the proportion of output to capacity falls below 80 per cent for prolonged periods, the company or management group operating the plant is likely to be losing money.

The capacity utilization question relates to the need to balance plans for investment in new plant additions or replacements with whatever is likely to be the demand for chemicals in a particular period in the future. Investment decisions are often made as long as four to six years before the plant comes on stream, making it extremely difficult to forecast overall demand levels when the facilities will be in operation. Another problem is in working out the effects on overall capacities of other plants being planned by other groups which will influence the total possible output of specific chemicals. These questions apply specifically to the bulk, low-value end of the industry, where products from different companies are very similar and as a result products are sold almost totally on the grounds of price as opposed to quality or specification.

(b) *Planned investments*

Investment possibilities should be examined not just in terms of the industry as a whole but also for critical products including, as mentioned above, petrochemicals, plastics, fertilizers, specific inorganic compounds and some of the more specialized, higher-value-added chemicals such as pharmaceuticals, agrochemicals and seeds. For petrochemicals (including ethylene and styrene) and many types of bulk plastics, it is possible to analyse what is happening in terms of capacity of different geographical areas. Beginning with developed countries, table IV.13 reflects capacity additions in Western Europe, the United States and Japan. Planned additions are shown to be particularly strong in the United States.

However, many other parts of the developing world, especially East Asia, Western Asia and some parts of Latin America, are also likely to see significant expansions in these product areas as the petrochemical industry in these regions experiences more rapid industrial growth. Announced capacities for those regions are shown in table IV.14. The chemical branches likely to undergo the greatest expansions are ethylene, styrene, ammonia, methanol and polyethylene. The regions likely to have the strongest increases are the East Asia and Latin America.

(c) *Ethylene*

Ethylene is one of the basic building-blocks of the entire chemical industry. Nearly 60 million tonnes of ethylene are made each year in giant plants called crackers. Ethylene itself is a gas, made either from a fossil-fuel-derived natural gas like ethane or from naphtha, a by-product from oil refining. Products from ethylene include major plastics such as polyethylene and polystyrene and a large number of other chemicals derived from such ethylene-based compounds as glycol or ethylene oxide.

According to *Focus on Chemicals*, a United Kingdom-based newsletter for the chemical industry, in the next few years the world is likely to see a significant extra amount of ethylene capacity, in line with the generally bullish mood of expansion in many parts of the industry. Increases in this capacity by region between 1988 and 1992, shown in table IV.13, suggests that considerable growth is anticipated in both developing and developed economies. This large increase in ethylene capacity may not find a corresponding increase in demand, according to the newsletter, which sets out the following scenario for

Table IV.13. Global chemical capacity additions, 1988-1992
(Thousands of tonnes per year)

Product	World capacity		Capacity additions, 1988-1992						Other possible capacity additions
	1988	1992	Europe	United States	Japan	Rest of world	Total	Percentage increase	
Polypropylene	10 000	17 150	1 940	1 555	564	3 205	7 165	72	8 000
Styrene	12 000	16 700	1 590	480	450	2 210	4 730	39	6 400
Polyethylene	29 000	38 000	1 725	2 310	197	4 825	9 057	31	12 500
Ethylene	56 000	72 500	3 195	5 420	1 473	6 455	16 543	30	36 600
Propylene	27 000	32 650	1 795	1 055	-	2 805	5 655	21	8 400
Polyvinyl chloride	18 500	22 200	515	1 052	-	2 160	3 727	10	2 900
Polystyrene	8 900	10 650	250	258	200	1 025	1 733	19	1 700
TOTAL	161 400	209 850	11 010	12 130	2 785	22 685	48 610	30	76 500

Source: Stuart Wamsley, Focus on Chemicals (East Sussex).

Table IV.14. Announced chemical capacities for new producing and developing countries, 1988-1992
(Thousands of tonnes)

Region	Period	Ethylene	Propylene	Styrene	EO/EG a/	Ammonia	Methanol	Poly-ethylene	Poly-propylene	Poly-styrene	Polyvinyl chloride
		Product									
Western Asia	(a) 1988-1989	540	150	-	110/ 33	730	85	103	130	100	280
	(b) 1990-1992	800	300	-	20/135	1 856	1 285	240	130	60	330
	(b) - (a)	260	150	-	-90/120	1 126	1 200	137	0	-40	50
East Asia	(a) 1988-1989	2 060	470	140	5/200	5 647	-	1 150	975	197	400
	(b) 1990-1992	1 895	425	1 550	120/210	4 897	200	1 366	820	460	360
	(b) - (a)	-165	-45	1 410	115/ 10	-750	200	216	-155	263	-40
Latin America	(a) 1988-1989	872	100	5	100/125	840	900	160	170	45	320
	(b) 1990-1992	1 100	1 335	300	65/ 40	1 965	2 135	725	960	75	400
	(b) - (a)	228	1 235	295	-35/-85	1 125	1 235	565	790	30	80
Eastern Europe	(a) 1988-1989	300	230	70	- / 60	1 900	-	285	75	-	250
	(b) 1990-1992	10	-	-	- / -	445	-	555	40	90	120
	(b) - (a)	-290	-230	-70	- /-60	-1 455	-	270	-35	90	-130
Africa	(a) 1988-1989	-	-	-	- / -	425	-	-	45	-	-
	(b) 1990-1992	-	-	-	- / -	310	-	270	120	-	25
	(b) - (a)	-	-	-	- / -	-115	-	270	75	-	25
Other	(a) 1988-1989	-	35	115	- / -	1 470	250	80	70	15	40
	(b) 1990-1992	305	15	100	- / -	1 440	560	370	275	150	110
	(b) - (a)	305	-20	-15	- / -	-30	310	290	205	135	70

Source: Stuart Wamsley, Focus on Chemicals (East Sussex).
a/ Ethylene oxide/ethylene glycol.

what is likely to happen to ethylene capacities and consumption. Consumption in 1988 was reckoned at 93 per cent of total capacity; that is, 53 million out of 56 million tonnes. Across the industry as a whole this ensured that ethylene plants could operate at high output levels in relation to overall capacity. Hence profitability was good. Growth in consumption across the world between 1988 and 1992 is likely to be only about 3 per cent a year for ethylene, leading to overall consumption of the material in 1992 of 58 million tonnes. But by this time total available output, in terms of capacity, will have risen by a much higher level; that is, to 72.4 million tonnes. That will lead, if this estimate of future demand levels is correct, to a capacity utilization of just 81 per cent, which as the analysis earlier shows, is far below what is needed in the industry for good profitability.

Obviously, rough forecasts of this sort are open to many kinds of challenges as they rely on a large number of assumptions. It is safe to say, however, that scenarios pointing to world over-capacity in ethylene are generally widespread, and thus there is a reasonable likelihood of this happening in the early to mid-1990s. Such a condition would be especially serious for many developing countries planning significant increases in ethylene capacity over the next few years.

(d) *Plastics and other petrochemicals*

A similar case can be made for industry over-capacity in other petrochemicals and in bulk chemicals such as ammonia and methanol. Analysts have pointed to trends similar to those for ethylene, with large capacity increases for a number of basic chemicals over the next few years not being matched by corresponding consumption increases.

(e) *Fertilizers*

Fertilizers are another large commodity area with annual sales of about $50 billion world-wide. Fertilizers are man-made chemicals added to crops to provide nutrition and to improve yields. They can be split broadly into three types, based on nitrogen (examples here are ammonium sulphate, ammonium nitrate and urea), phosphorus (based on phosphate rock) and potassium (based on potash). Production of the best-selling nitrogen type of fertilizer is highly energy- and plant-intensive. Much of this production depends on making ammonia from hydrogen and nitrogen, a process that requires much energy and expensive, high-pressure reaction vessels. Information on phosphate-based fertilizers can be found in section D of this chapter.

The fertilizer market world-wide is highly fragmented. Also, especially in Europe and the United States, the fertilizer industry has not seen great profitability over the past decade, having experienced over-capacity, weak demand and low prices. This has been due, in part, to lags in agriculture resulting in low demand for nutrients. Another problem for the industry, particularly in Western Europe, has been the dumping of cheap imports, especially from Eastern Europe, which has depressed prices and put pressure on profit margins.

There are only a few global players in the fertilizer industry. Markets in individual countries, especially developing countries, tend to be dominated by local producers. As a corollary, the fertilizer market world-wide is far less dominated by the chemicals trans-national corporations than are other areas of the industry. In many developing countries, fertilizer production is under the control of indigenous companies, some of whose current development projects are included in the data presented in tables IV.12-IV.14.

Turning to the developed economies of both Europe and the United States, many of the main players in the fertilizer business have left the industry in recent years because of low profitability. Table IV.15 gives some idea of fertilizer capacity in Europe.

Table II.15. Main fertilizer producers in Western Europe, 1988
(Millions of tonnes)

Rank	Company	Country	Capacity	Percentage share
1	Norsk Hydro	Norway	13.0	28.3
2	Kemira	Finland	7.1	15.4
3	Enimont	Italy	5.1	11.1
4	Orkem/GP[a]	France	4.8	10.4
5	BASF	Germany, Federal Republic of	4.7	9.6
6	Ercros/Enfersa	Spain	4.4	9.6
7	ICI	United Kingdom	4.3	9.3
8	DSM	Netherlands	2.6	5.7
		TOTAL	46.2	100.0

Source: Kemira.
a/ Merged with Elf Aquitaine.

(f) *Titanium dioxide*

Titanium dioxide is a brilliant, white inorganic material used as an important additive in products such as paints, plastics, cosmetics and paper. It is made by refining ores containing raw titanium. Production of titanium dioxide has in recent years been a fast-growing, profitable part of the chemicals industry. The field is dominated by a handful of producers, many of whom have substantial operations in developing countries. Globally, the industry makes 3 million tonnes of titanium dioxide a year, worth roughly $8 billion. The titanium-dioxide branch is part of a much larger pigments industry, which provides a wide range of colouring materials for the paints and related industries around the world. In recent years, the demand for titanium dioxide has outstripped supply, one reason why prices and profits have increased. Another reason is that the number of producers in the industry has decreased substantially, as many companies in the early 1980s found the industry, which at that time was unprofitable, too difficult and withdrew from it. Companies that took this route include Laporte of the United Kingdom, American Cyanide of the United States and Montedison of Italy. The production process is highly disruptive environmentally, a large barrier to entry in recent years. The market is dominated by four companies that have about 60 per cent of world capacity. These are DuPont of the United States, Tioxide of the United Kingdom (a joint venture between ICI and Cookson), SCM (a United States-based company owned by Hanson of the United Kingdom) and NL, a United States company.

In the 1990s these companies and other, smaller groups such as Isihara of Japan are proposing a number of new titanium dioxide plants in developing countries and areas and in NICs such as Brazil, Mexico, Republic of Korea and Taiwan Province. These expansion plans will add to capacity and may lead to oversupply in the industry.

(g) *Synthetic rubber*

Synthetic rubber is a relatively stable, well-established branch of the world chemical industry, with much of the production technology dating from early in the century when chemists worked out how to make synthetic rubber from coal feedstocks. Since then, oil has replaced coal as the main feedstock in many countries. Developing countries account for an increasing share of the consumption of rubber world-wide. Total sales of synthetic rubber world-wide are estimated at about $15 billion a year.

(h) *Paints*

Paints production is a global industry in which much of the demand and plant expansion is taking place in developing countries or NICs, especially in East Asia. Total paint sales are worth about $30 billion a year. The two largest companies in the industry are transnational corporations, ICI in the United Kingdom and PPG in the United States. But in specific countries often local producers dominate, particularly in the NICs of East Asia and Latin America. Paints production depends on the availability of dozens of different types of intermediate chemicals, including resins, thickeners, pigments and specialized solvents, and many small companies establish themselves close to the large paint producers in order to supply such materials.

(i) *Fibres*

Much production of chemical fibres in recent years has moved outside the most highly developed regions. In particular, countries and areas such as China, Republic of Korea, Taiwan Province and Thailand have considerably expanded their chemical fibres manufacturing. The four main types of chemical fibres are acrylic, polyester, nylon and cellulose. Prices for many types of fibres in Western Europe, which was the leader world-wide in fibres until the late 1970s, have slipped considerable since then, largely because of depressed demand in the textiles industry and the impact of low-cost imports from other countries and areas. In particular, Mexico, Republic of Korea, Taiwan Province, Turkey and Yugoslavia have provided low-cost imports to Western Europe. The total output of chemical fibres globally is worth about $30 billion a year. This figure seems likely to climb only at slow rates in the 1990s, with growth world-wide moving at a few per cent a year and most of the expansion occurring in developing countries or NICs. There are reasonably good prospects for expansion in polyester and nylon fibres, which lend themselves to high-technology, high-value applications in areas such as industrial textiles (for conveyer belts, linings, specialist cord etc.), as opposed to the traditional outlets for garment fibres.

In garment manufacturing, volume growth in fibres will continue, but in low-price applications, with much of the industry centred on East Asia where labour costs are low. As a result of this shift, capacity expansion in this part of the industry will be low in monetary terms. DuPont, for instance, is stepping up its investments in the East Asia, particularly in carpet-fibre manufacturing. The same is true of ICI, another big maker of nylon fibres and intermediate chemicals for polyester fibres. ICI is a world leader in the production of purified terephthalic acid, an important precursor for polyester. It is making substantial investments in purified terephthalic acid plants in Taiwan Province and Thailand.

Table IV.16. Global chemical capacity utilization, 1988-1992

Rank in 1992	Product	Capacity 1992 (thousands of tonnes)	Capacity 1988 (percentage of total)	Capacity 1992 (percentage of total)	Consumption 1992 (thousands of tonnes)	Consumption 1988 (percentage of total)	Consumption 1992 (percentage of total)	Capacity utilization 1988 (percentage)	Capacity utilization 1992 (percentage)
1	Ethylene	72 000	45.3	45.5	58 500	46.5	45.0	93	81
2	Polyethylene	38 000	23.7	23.5	30 500	22.8	23.5	90	80
3	Polyvinyl chloride	22 200	13.8	15.0	19 000	15.2	14.6	93	86
4	Propylene	17 150	10.7	8.8	13 500	8.9	10.5	102	79
5	Polystyrene	10 650	6.6	7.2	8 500	6.5	6.5	83	80
	TOTAL	160 000	100.0	100.0	130 000	100.0	100.0		

Source: Stuart Wamsley, Focus on Chemicals (East Sussex).

(j) *Pharmaceuticals and agrochemicals*

With regard to pharmaceuticals and agrochemicals, it should be noted that investment patterns for these two product areas are geared mainly to production, at least of the main, high-value materials used in the products, in developed countries.

(k) *Implications*

Although it is difficult to pinpoint the amount of investment going into most specific branches of the chemical industry in individual countries, some idea of the future impact of the planned investments can be obtained by comparing capacities to forecast consumption. Table IV.16 confirms the observation made earlier that capacity is growing more rapidly than demand. Thus it appears that global capacity utilization rates will be lower in 1992 than in 1988. This implies that the recent active period of investment may be coming to an end.

4. *Manufacturing capacities of developing countries*

To some degree the subject of manufacturing capacities of developing countries has already been covered. As pointed out earlier, much of the expansion in the world chemical industry is taking place in countries outside the developed countries of Western Europe, Japan and the United States. Particular centres for this activity are East Asia, Western Asia and Latin America. Political change in Eastern Europe will also probably lead to an upsurge in the chemicals industry in that region, though this may well come at a slower pace. In all the countries concerned, chemicals development is taking place with national Governments having an equity or controlling stake in the relevant construction projects.

The reason for this growth depends on the link between GDP and chemicals consumption in different countries. Chemicals consumption is roughly proportional to the total consumption per head of population. This follows from the range of chemical products and the way in which they permeate the economies of specific countries via a number of industrial and consumer product routes. Hence expanding economies will invariably require a greater output of chemicals in any number of fields (such as fibres, paints, industrial materials, plastics, agrochemicals and fertilizers), which are linked to a wide range of industrial branches. Many types of chemicals (outside the high-value product areas of materials like drugs and crop protection compounds) are relatively low-cost. So it makes sense in these cases to have the sources of production close to the market rather than to transport the materials over long distances. That leads to a demand for new chemicals complexes (making in particular the relatively low-value, high-volume types of material at the petrochemical end of the industry) close to the demand centres in developing countries.

Tables presented in this section have reflected recent increases and capacity additions expected in the chemical industry in developing countries, particularly in East Asia. For example, information about ethylene and plastic feedstock projects, in terms of newly envisaged capacity increases in developing countries, has been provided. Unfortunately, there is little information as to what this investment will mean in terms of employment increases. But there is more information on how these trends are likely to affect chemical trade patterns around the world. At present, the main production and consumption centres for chemicals, such as Western Europe and the United States, are large net exporters of chemicals to Japan and to developing countries, especially in East Asia. However, as the build-up in capacity in developing countries takes place, this pattern will change. It is forecast that by the mid- to late-1990s, the net trade balance in petrochemicals (not counting more sophisticated products such as drugs) between Western Europe and the rest of the world will change from being positive to negative.

Although it is difficult to discuss in a comprehensive way the nature of the chemicals build-up in specific countries, some idea of the trends at work can be obtained by looking at specific investment projects involving chemicals groups often State-owned, in particular developed countries and partners from the established companies in developed countries. Examples of such projects in recent years, with dates of announcement, are as follows:

(a) *April 1989.* Royal Dutch/Shell completes deal with Government of Singapore under which it greatly expands ownership of an existing petrochemicals complex in Singapore. It has a roughly 30 per cent share of running this operation in combination with other transnational chemicals groups from Japan, the main one being Sumitomo;

(b) *July 1989.* Shell reaches deal with Government of Indonesia under which it is to have a 57 per cent stake in a chemicals complex in central Java, due to be finished in 1994. The other main groups involved in the complex are Pertamina, the Indonesian State-owned oil company, Mitsubishi and Itoh of Japan;

(c) *February 1990.* Mitsui and Sumitomo, both of Japan, and BP Chemicals of the United Kingdom agree on building a 200,000-tonnes-per-year polyethylene plant in West Java, Indonesia. The Company set up by the three partners also involves a 24 per cent stake held by Indonesian partners. Production is to start in 1992. The cost of the complex is about $250 million;

(d) *February 1990.* Amoco, of the United States, declares that it is going ahead with a $200 million facility at Zhuhai, China, to make purified terephthalic acid, material used in making polyester fibre. Production is set at 250,000 tonnes per year of the substance. ICI of Britain is pursuing a similar PTA project in Taiwan Province, as already mentioned earlier in the section on fibres;

(e) *March 1990.* Idemitsu of Japan and BP Chemicals of the United Kingdom join forces with Petronas, the national oil company of Malaysia, to build $800-million ethylene and polyethylene plants at Terengganu, Malaysia. The plants are to be operational in 1994.

Although the USSR can hardly be ranked as a developing country, a number of petrochemical projects are taking place in that country involving large joint-venture partners from developed market economies. They include the following: a $330-million project involving John Brown and Morgan Grenfell of the United Kingdom to expand an ethylene plant and provide polyethylene production at Budyennovsk; a $500-million scheme at Tobolsk involving Combustion Engineering of the United States and Neste of Finland to build a complex making polypropylene and other chemicals; Occidental of the United States and the Ministry of Chemicals Industry of the USSR plan to build a PVC plant at Kalush at an estimated cost of several tens of millions of dollars; Enimont of Italy is involved in another scheme to make alkylates; and MTBE Chemicals and Mazekhai Feruzzi of Italy plan to build five polypropylene plants in different parts of the USSR.

5. *Restructuring and redeployment*

Although many of the salient points related to the restructuring of the industry world-wide have already been discussed, the focus here is on several important aspects of capacity expansion, product specialization, shifts towards developing regions, mergers and changes in employment.

(a) *Instability in capacity formation*

Capacity reductions in many areas of the industry, especially petrochemicals and other low-value product areas, took place during 1982-1984, as a response to the over-capacity and widespread slippage in profit margins that occurred in the sector in the early 1980s. That was followed between 1985 and 1989 by a general period of plant expansion, price rises and profit increases in the industry. This healthy period for the industry coincided with demand expansions for chemicals in many countries, both developing and developed. There was also some restraint on capacity, bringing about price increases which benefited profit margins. The year 1990 saw the start of a more difficult period. A general increase in capacity in many parts of the industry started in 1989-1990, and this, coupled with a reduction in the growth rate of demand for many basic types of chemicals as a result of a decline in overall expansion rates in many economies, has brought a slow-down in price rises.

(b) *Product specialization*

A move towards research-intensive, more specialized types of chemicals has occurred among the chemicals majors. Many of the biggest chemicals groups in the world were severely shaken by the down-turn in the industry in the early 1980s. Their operations in petrochemicals and in other bulk areas of the industry suffered most. There was over-capacity and a slide in profit margins. Many companies decided not only to reduce capacities at this end of the industry, but to move more into higher-value, more specialized product fields. It was reasoned that in these areas competition and capacity problems would be fewer. In particular, product areas such as pharmaceuticals, agrochemicals and seeds, specialized plastics (engineering polymers and polyurethanes) and high-value paints (high-technology industrial coatings) stand a reasonable chance of experiencing growth, even in any future recession. Their expansion rates in most cases are less linked to the overall economic climate and to other production branches that are the chief customers of the chemical industry.

Another aspect underlying the move towards the higher-value product fields is that profit margins are generally above those at the bulk end of the industry. Drugs and agrochemicals, however, carry extremely high research and marketing costs, and this has to be borne in mind when considering expansion strategies at the high-value end. However, many of the chemicals majors in developed market economies reasoned that they would be in a better position than chemicals groups in developing countries to take commercial advantage of moving into the more research-intensive product areas. Such moves into the higher-value end of the market by the large companies would therefore protect them from the effects of recession, provide higher profits, and give some cushioning from the competition of developing countries at the low-value end of the market.

Table IV.17 provides some data about the situation in the United States with regard to the different areas of speciality in non-commodity chemicals and their relative growth rates. The product areas mentioned in this list are good examples of the kind of research-

Table IV.17. Estimated sales, growth, and apparent profitability of speciality chemicals in the United States, 1988

Product	1988 sales (millions of dollars)	Percentage share	Apparent profitability	Expected growth 1988-1993 (percentage per year)
Agricultural chemicals a/	5 600	10.46	High	5
Industrial coatings a/ b/ c/	5 030	9.39	Average	4
Industrial and institutional cleaners c/	4 400	8.22	High	4
Electronic chemicals d/ e/	3 200	5.98	Average	10
Diagnostic aids	2 800	5.23	High	10
Plastic additives f/	2 800	5.23	Average	4
Special polymers b/ c/	2 700	5.04	Average	3
Water management chemicals b/ c/	1 700	3 17	High	5
Catalysts b/ c/ e/	1 660	3.10	Average	3
Food additives	1 525	2.85	Average	3
Elastomers	1 410	2.63	High	7
Adhesives b/ f/	1 300	2.43	High	5
Photographic chemicals c/	1 300	2.43	High	6
Flavours and fragrances	[illegible]	2.27	High	6
Dyes	[illegible]	1.96	Low	4
Construction chemicals c/	1 000	1.87	High	5
Speciality surfactants f/	960	1.79	Average	4
Lubricant and functional fluid additives	950	1.77	High	2
Pigments d/ f/	820	1.53	Average	3
Biocides e/	815	1.52	Average	5
Printing inks	810	1.51	Average	4
Cosmetic additives	750	1.40	Average	4
Thickeners g/	725	1 35	Average	5
Metal plating and [illegible] chemicals b/	700	1.31	Average	2
Textile specialities	680	1.27	Average	2
Sealants	645	1.20	Average	4
Oilfield chemicals a/	640	1.20	Average	5
Lubricants and functional fluids (synthetic)	600	1.12	High	3
Laboratory chemicals c/	580	1.08	Average	4
Flame retardants c/	540	1.01	Average	5
Paper additives	535	1.00	Average	4
Plasticizers b/ e/	500	0.93	Average	4
Gasoline additives	500	0.93	High	4
Rubber-processing chemicals c/	390	0 73	Average	4
Paint additives	335	0.63	Average	4
Defoamers	310	0.58	High	3
Antioxidants c/	300	0.56	Average	3
Refinery and pipeline chemicals	280	0.52	High	3
Enzymes (industrial)	250	0.47	Average	10
Corrosion inhibitors b/ e/	240	0.45	High	4
Ion-exchange resins b/ f/	175	0.33	Average	3
Foundry chemicals c/	170	0.32	Low	4
Coal and fuel additives	160	0.30	High	4
Chelates	145	0.27	Average	4
Printing chemicals c/ e/	135	0.25	Average	4
Photovoltaic chemicals c/ e/	80	0.15	High	8
Ultraviolet absorbers	75	0.14	Average	5
Mining chemicals b/ e/	70	0.13	Average	3
TOTAL	53 555	100.00		

Source: Klein & Company.
a/ Excluding fertilizers.
b/ Low-volume, high-price types only.
c/ True commodities.
d/ Including speciality materials.
e/ Speciality chemicals.
f/ Pseudocommodities.
g/ Excluding starch.

intensive materials that many of the big chemicals groups have tried to move into as part of the trends outlined above. Finally, table IV.18 gives an estimate of the split between speciality and commodity chemicals in the annual sales of the biggest transnational chemical corporations. Speciality is taken to mean general high-value, high-profit areas of chemicals, and commodities represent the traditional bulk end of the industry, including low-value, high-volume materials such as conventional plastics, ethylene, general petrochemicals, bulk inorganic substances etc. While reasonable profits from speciality products were achieved during the 1986-1990 period, whether the shift of the industry towards the high-value end of the industry will continue in the 1990s remains unclear.

Table IV.18. World's largest chemical companies, with speciality and commodity chemicals ratio, 1988

Rank	Company	Country	Sales: Billions of dollars	Sales: Percentage share	Ratio of speciality to commodity chemicals
1	BASF	Germany, Federal Republic of	25	13.8	30:70
2	Hoechst	Germany, Federal Republic of	22	12.2	50:50
2	Bayer	Germany, Federal Republic of	22	12.2	60:40
4	ICI	United Kingdom	21	11.6	38:62
5	Du Pont	United States	19	10.5	40:60
6	Dow	United States	17	9.4	30:70
6	Shell	United Kingdom/Netherlands	17	9.4	10:90
6	Ciba-Geigy	Switzerland	17	9.4	84:16
9	Rhône-Poulenc	France	11	6.1	60:40
10	Exxon	United States	10	5.5	6:94
		TOTAL	181	100.0	

Source: *Financial Times*, 11 April 1990.

(c) *Shifts to developing regions*

Shifts in demand, production and consumption to developing regions have already been mentioned. As the 1990s unfold, these areas of the world, particularly East Asia, will continue to account for more and more of the production and sales of the chemical industry world-wide. This will be increasingly taken into account in the general business strategies of large chemicals groups in decisions on establishing research and production centres in different parts of the world, and in the planning of marketing ventures.

(d) *Mergers and employment considerations*

In general, the chemical industry is a mature industry with much of world production in the 1960s and 1970s dominated by large transnational companies. Many of these completed significant restructuring operations involving mergers with other groups or cut-backs in the labour force. This left the industry in its present situation, and it continues to be highly capital-intensive, with relatively low labour costs. At the top end of the industry, that involving the large transnational corporations, there has been little of the rationalization through cost-cutting and labour reduction of the kind seen during the 1980s in other industries, such as electronics, telecommunications, car manufacturing and shipbuilding. Table IV.19, for example, shows practically no change in total industry employment in the major developed economies between 1986 and 1987.

Some mergers and joint ventures, however, have occurred in the pharmaceuticals industry, one of the

Table II.19. Employment in the chemical industry, 1986-1987

Rank in 1987	Country	Employees (thousands) 1987	Percentage share 1986	Percentage share 1987	Percentage change 1986-1987
1	United States	1 024.0	28.17	28.46	-0.3
2	Germany, Federal Republic of	572.0	15.55	15.90	0.9
3	Japan a/	392.0	10.86	10.87	-1.3
4	United Kingdom	337.0	19.19	9.37	0.6
5	France	263.9	7.39	7.33	-2.2
6	Spain	239.0	6.56	6.64	-
7	Italy	225.0	6.31	6.25	-2.2
8	Canada	93.3	2.52	2.59	1.4
9	Netherlands	90.7	2.50	2.52	-0.3
10	Belgium and Luxembourg	69.3	2.49	1.93	-23.5
11	Switzerland	55.4	1.85	1.54	-18.0
12	Portugal	50.8	1.54	1.41	-
13	Austria	50.8	1.39	1.41	-9.3
14	Sweden	44.6	1.19	1.24	2.5
15	Denmark	26.2	0.70	0.73	1.9
16	Finland	24.3	0.67	0.68	-
17	Norway	15.0	0.41	0.42	-
18	Australia	14.0	0.38	0.39	-
19	Ireland	12.0	0.33	0 33	-
	TOTAL	3 598.3	100.00	100.00	-1.3

Source: National Chemical Federations.

a/ Data refer to people permanently employed and are not comparable to data for other countries.

most important branches. although not a typical part, of the chemical industry, being firmly anchored at the top, high-value end of the business. Noteworthy are mergers between Beecham of the United Kingdom and Smith Kline Beckman of the United States; Squibb and Bristol-Myers (both of the United States); Rhône-Poulenc (France) and Rorer (United States); the pharmaceutical division of Dow Chemical (United States) and Mario Laboratories (United States); and Hoffmann-La Roche (Switzerland) and Genetech (United States). The main rationale was to bring together marketing and research teams to obtain better economies of scale.

The joint ventures and combinations have had little effect on employment in the pharmaceuticals industry as a whole, which has gone down only fractionally as a result, nor were they intended to. That is because the pharmaceuticals industry, like chemicals in general, is not particularly labour-intensive. People employed in pharmaceuticals are much more likely to have white-collar, office-type job, as in administration, marketing or research than direct production jobs. Hence the potential for cutting back on the work-force in manufacturing, which is the easiest place to make cuts in the aftermath of a merger, is far from high.

6. *Technological trends*

Among the major technological trends that can be identified in the chemical industry, the present focus is on those related to research intensification, environmental considerations and biotechnology.

(a) *Research intensification*

As mentioned above, more effort is being put into the research-intensive, specialized end of the chemical industry. As a result, and also because of different kinds of product demand from consumers of chemicals, materials sold in the industry today are more likely to be specific types of substances made to the formulation of the customers, and known as "performance" chemicals, rather than bulk materials sold on the basis of price. A performance chemical could be a particular blend of polyurethane (a substance made from a mixture of different chemicals) that has been devised expressly to meet the needs of an individual customer, such as a shoe or a furniture manufacturer. The specification required for this application might be totally different from that needed to make a different type of polyurethane used by another customer. This has implications for the industry both in terms of the kinds of people who are employed (there is a bigger demand in the industry for scientists, scientifically qualified marketing people etc. than say 10 years ago), and also in the type of equipment that they use. There is thus more of a demand for highly sophisticated instrumentation such as mass spectrometers, chromatographs etc. in product development laboratories.

(b) *Environmental considerations*

The past five years have seen an upsurge in public interest in environmental issues world-wide. Concerns about pollution are highly relevant to the chemical industry, which is generally a large producer of waste materials, such as waste gases (which go into the air), liquids (discharged by factories into rivers and seas) and solid materials (which generally have to be either deposited as landfill, or put into the form of aqueous effluent for discharge into water, or burnt in incinerators). Many chemicals factories are also highly obtrusive visually and are common eyesores. A final point concerns the end-products of the industry. Many of these, for example plastics, are difficult to dispose of after use, which gives rise to another set of environmental problems, while others, such as polychlorinated biphenyls and other chlorinated organic chemicals, can pose health risks by possibly being linked to cancer or other unpleasant diseases.

Another possibility is that man-made chemicals can interfere with natural environmental processes that nurture the ecosystem of the earth. A case in point is provided by the chlorofluorocarbon (CFC) chemicals used in applications such as aerosols, packaging and refrigeration. In recent years scientists have traced a link between these chemicals and destruction of the ozone layer high above the earth which helps to shield the planet from dangerous ultraviolet radiation that can cause skin cancer. The chemical industry recognizes that it has to do a lot to improve its environmental performance, particularly in view of its past record. This is true of the industry in all countries.

Many of the solutions are not technological at all, but in some areas progress can be made by implementing new technological methods. The chemical industry has perceived this, and there has been a large amount of effort in the following three areas in particular:

(a) CFC substitution. Large CFC-makers such as ICI and DuPont have been in the forefront of the substitution drive. In addition much work has been done in looking at possibly toxic chemicals, such as

some pesticides, to work out their long-term effects on the health of animals or people. Trial work on new agrochemicals prior to such materials going on general sale is continually being made tougher to minimize the risk of their eventually being found to be unsafe.

(b) Waste emission reduction. One theme in the industry is to redesign chemical processes to minimize the amount of surplus by-product. Another large-scale area of application is in the so-called "end-of-pipe" treatment methods. With such techniques, engineers can clean up gas streams or waste water discharges to remove noxious or unpleasant gases, such as sulphur dioxide and nitrogen oxides, which can be removed by scrubbing systems, or to take out harmful organic residues from aqueous effluent, which can be done by bacteriological treatment systems.

(c) Material recycling. Many of the large plastics companies have in recent years been continually reminded of the general environmental impact of their products, which are very hard to dispose of after use. Thus there has been much interest in developing plastics recycling methods to collect used material and reform it into new products. This relieves pressure on the environment by finding new outlets for plastics packaging and other items that would otherwise generally find their way to landfill rubbish sites or incineration centres.

A number of companies in Europe and the United States are working on such recycling ideas, chiefly aimed at plastics packaging. The idea is to form collection schemes, perhaps jointly with municipal authorities, under which plastics can be obtained from the refuse stream and transferred to recycling plants. Here the material is screened, separated, washed and melted before reforming (perhaps by an extrusion or injection moulding technique) into materials that can be re-used. Plastics companies that are committed to working on recycling ventures include Amoco, Dow and DuPont in the United States and BASF, Bayer and Hoechst, in the Federal Republic of Germany.

The increasing pressures on the industry are manifesting themselves in the supplemental research programmes that chemicals companies are being forced to undertake to overcome certain environmental problems. They are also having to devote more resources to environmentally oriented capital spending; for example, on new systems to reduce effluent in waste water or to increase incinerator capacity and dispose of solid waste in a reasonably efficient manner. In Western Europe, about 10 per cent of the total capital spending by the chemical industry, which in 1989 was about $23 billion, is channelled towards environmental improvements. Many in the industry think that if current trends continue, the proportion will move towards 15 and 20 per cent by the end of the 1990s.

(c) *Biotechnology*

Biotechnology is the umbrella term for a number of new biological methods, most of them centred on manipulation of genetic segments in living organisms to provide new ways of making existing chemical products, or to create possibly entirely new substances that are difficult or impossible to make by conventional techniques. Many of the new biological techniques are under intensive study in the pharmaceutical industry, which is the chemicals branch most likely to be affected by biotechnology. Up to now, progress has been slow. Of the total world output of pharmaceuticals of some $130 billion a year, only about 1 per cent comes from biotechnology-derived drugs. As the 1990s proceed, however, there is a good chance that more new biotechnology-derived medicines will reach the market.

The new methods also hold out promise in other areas; for example, production of pesticides, industrial enzymes (for controlling or altering chemical reactions, or acting as catalysts to speed them up) and fine chemical intermediates (made as chemical precursors of drugs or crop protection compounds).

Progress with the technology has been slowed by the basic problems of taking new ideas (most of the novel biotechnology methods date to the mid-1970s) from the laboratory stage and turning them into products. Another problem has been the opposition from some quarters on environmental grounds to the novel biotechnology methods. This opposition, strongest in Denmark, the Federal Republic of Germany and Netherlands in Western Europe, has linked with genetic manipulation of cells the idea that such techniques could accidentally create new, possibly harmful organisms. Such materials could, in theory at least, escape from laboratories and disrupt ecological patterns, perhaps by colonizing parts of the bodies of animals, including the human intestines. Such ideas seem fanciful to many scientists working in the industry, who believe that there is only a small possibility of any laboratory-created organisms being robust enough to survive in an alien environment in people or animals. Hence they say that opposition is founded on extremely weak grounds.

None the less, this has not prevented opposition to genetic engineering, as many of the new biotechnology methods are called, from having a huge effect in one country especially, the Federal Republic of Germany. The strength of the opposition there has virtually stopped all production of genetically engineered materials on anything but a laboratory scale. This has been due to a series of court judgements delivered against the plans of large chemicals companies like BASF and Hoechst, which wanted to take their biotechnology ideas to the production stage. A new federal law on genetic engineering is due to be enacted in 1990, and so the future for biotechnology in the country will depend to a large degree on the nature of the law, how it is implemented, and the level of future opposition to biotechnology in general.

7. *Short- and medium-term industry outlook*

The future outlook of the chemical industry appears to depend on the four factors described below.

(a) *Growth in the developing countries*

The extent to which the likely take-off for the industry in developing countries will actually happen is not yet clear. Possible constraints are as follows:

(a) Shortages of capital for the necessary plant and infrastructure;

(b) Problems in obtaining oil and gas at the right prices to serve as feedstock (this is obviously less of a problem for countries such as those in the Western Asia which have their own fossil fuel supplies);

(c) Shortages of qualified labour, especially skilled research people who will be increasingly needed in the industry over the next decade;

(d) Problems in establishing joint ventures with the large transnational corporations which are often involved in chemicals project planning.

Table IV.20 provides estimates of likely sales growth in specific regions between 1987 and 1995.

Table IV.20. Anticipated growth of sales in the world chemical industry, 1987-1995

Rank in 1995	Region	Sales 1987 (billions of dollars)	Sales 1995 (billions of dollars)	Percentage share 1987	Percentage share 1995	Percentage change 1987-1995
1	Asia and the Pacific	200	300	25.0	28.04	50.00
2	Western Europe	260	340	32.5	31.78	30.77
3	North America	220	280	27.5	27.50	27.27
4	Rest of world, including centrally planned economies	100	130	12.5	12.15	30.00
5	Australasia	20	20	2.5	1.78	-
	TOTAL	800	1 070	100.0	100.00	33.75

Source: Imperial Chemical Industries.

(b) *Environmental problems*

As noted above, the industry has a public relations problem in presenting itself as an industry that can adequately deal with the environmental impact of its activities. Much will depend on the degree to which it avoids large environmental accidents (such as those at Seveso and Bhopal or the Sandoz accident on the Rhine), and can involve itself with ecologically sound projects such as plastics recycling. It needs to prove that it is a good partner for the communities that provide its work-force and live around its plants. From a purely financial point of view, increased concern with the environment will manifest itself in forcing the industry to spend more money on anti-pollution technologies and projects.

(c) *Balance between speciality and commodity products*

The industry as a whole has moved towards specializing its product composition. However, not all companies in the industry have been able to prove that they have the marketing and research resources to make a success in speciality chemicals. For many companies there will be a question mark over this element of their strategy once the pace of increase in the price of many chemicals has slackened off, giving rise to speculation that both prices and profits could collapse in the mid-1990s. At present, there is no sign that this is going to happen. More likely, there will be an orderly smoothing-off of price increases, a "soft landing" according to industry terminology. Assuming that this happens, the outlook for the industry will be generally good as it moves into the 1990s.

B. Shipbuilding industry (ISIC 3841)*

The historical development of the world shipbuilding industry has been characterized by short-term economic changes and long-term technological improvements. Strong growth in the twentieth century is believed to have been caused by the exceptional development of the world economy. Since the Second World War, the development of shipbuilding has been associated with relocation towards countries with lower labour costs. This process took place in 1938 and again in 1971. For example, in 1939 ship production in Japan was about one third of United Kingdom ship production. But by 1971 Japan had become the world leader, accounting for more than one half of total world production. At the same time, the United Kingdom, the leading ship producer in 1938, built only one tenth of the amount of Japanese production in 1971. The tendency to relocate shipbuilding capacities from developed to developing countries such as Brazil, China, Singapore and Republic of Korea continued after 1971. Measured by gross tonnage, the Republic of Korea launched 0.1 per cent of the new ships in 1972 and about 28.4 per cent in 1988. Taiwan Province launched about 0.5 per cent in 1972 and about 4.0 per cent in 1988. Brazil launched 0.6 per cent and 2.2 per cent, respectively. The performance of the United States was 2.3 per cent and 0.1 per cent, the United Kingdom 4.6 per cent and 0.8 per cent, Norway 3.6 per cent and 0.3 per cent and France 4.2 per cent and 0.8 per cent, respectively. Since the end of the shipbuilding boom in 1974, Western Europe and Japan have faced a considerable decline in their shipbuilding industries, whereas the Republic of Korea has become one of the leading producers of ships.

The development of the world economy along with expanded international trade are the main factors affecting the development of the world shipbuilding industry. International trade remained buoyant in 1989 after remarkable growth in 1988. According to GATT, the volume of trade increased by a further 7 per cent, compared with 8.5 per cent in 1988 and 6 per cent between 1983 and 1989. World sea-borne trade increased by 5.5 per cent in 1989 after a growth of 6.2 per cent in 1988. Crude oil shipments increased by about 9 per cent and iron ore and coal shipments reached new records. Only grain shipments decreased marginally in 1989. The supply of new tonnage, though higher than in 1988, remained low, and there were further decreases in sales for demolition as well as in lay-up and storage tonnage. This resulted in the increase of the world fleet in 1989 by about 2.5 per cent. The tanker tonnage balance improved further and freight rates for tankers reached high levels in the second half of 1990. Similar movements occurred in freight rates for dry bulk and gas carriers. Generally, the prices for new building and second-hand tonnage moved upwards, with the strongest increase in new tonnage. Positive future prospects caused an increase in new building orders, especially for tankers.

In general, world shipbuilding advanced strongly in 1989, introducing new confidence borne out by the increase of new orders and vessel completions. In order to explain these developments further, the

*UNIDO acknowledges the contribution made by G. Cetinic, Director, Yugoslav Bank for International Co-operation, Yugoslavia.

following three major aspects of the industry must be examined: growth of world sea-borne trade; development of the world fleet; and the structure of shipbuilding capacities.

1. *World sea-borne trade*

The most important factor in the expansion of shipbuilding production is the demand for new ships, which is determined by the demand for shipping services, and which therefore depends on both the total quantities of goods that are to be transported and on the structure of the goods. It is estimated that about 80 per cent of world merchandise trade is sea-borne trade. This trade had a strong upward trend from the mid-1960s, although it began to slow down in the 1970s. After reaching a peak in 1979, it declined mainly because of the retrenching of oil transport. After 1983 the upward trend was re-established and has persisted since then. On the basis of trade volume, table IV.21 shows that world sea-borne trade in 1989 reached a record level of 3,877 million tonnes. Measured in tonnes per mile as given in table IV.22, world sea-borne trade increased by 6.1 per cent from the 1988 level, but is still below the levels recorded in the period 1976-1979. The total weight transported in 1989 consisted of the following goods: crude oil (29 per cent), oil products (9 per cent), iron ore (9 per cent), coal (8 per cent), grain (5 per cent) and other cargo (40 per cent). Low-value commodities obviously dominate world sea-borne trade. However, trade in higher value products has increased even more than trade in raw materials. In sea-borne trade this is reflected primarily in the increasing share of container vessels in total tonnage shipments.

Table IV.21. Volume of world sea-borne trade, 1975-1989[a]

Item	Cargo				Percentage share	Percentage change	
	1975	1980	1988	1989	1989	1980-1989	1988-1989
	(millions of tonnes)						
Other cargo	995	1 310	1 460	1 540	39.7	17.6	5.5
Crude oil	1 263	1 320	1 042	1 135	29.3	-14.0	8.9
Iron ore	292	314	348	357	9.2	13.7	2.6
Oil products	233	276	325	335	8.6	21.4	3.1
Coal	127	188	304	315	8.1	67.6	3.6
Grain	137	198	196	195	5.0	- 1.5	-0.5
TOTAL	3 047	3 606	3 675	3 877	100.0	7.5	5.5

Source: Fearnleys Review 1989 (Oslo, Fearnresearch, 1990), pp. 3-4.

a/ Estimates for 1989 are based on statistics for the first 9 to 11 months of that year for the most important countries and the specified commodities, supplemented with data from official and commercial sources. "Other cargo" estimates are based on world trade growth as indicated by official sources and fleet data.

Table IV.22. World sea-borne trade: tonnage per mile, 1975-1989[a]

Item	Cargo				Percentage share	Percentage change	
	1975	1980	1988	1989	1989	1980-1989	1988-1989
	(billions of tonnes per mile)						
Crude oil	8 885	8 219	5 065	5 620	34.6	-31.6	11.0
Other cargo	2 810	3 720	4 040	4 270	26.3	14.8	5.7
Iron ore	1 471	1 613	1 919	1 965	12.1	21.8	2.4
Coal	62[illegible]	952	1 719	1 780	11.0	87.0	3.5
Oil products	845	1 020	1 445	1 490	9.2	46.1	3.1
Grain	734	1 087	1 117	1 110	6.8	2.1	-0.6
TOTAL	15 366	16 611	15 305	16 235	100.0	-2.3	6.1

Source: Fearnleys Review 1989 (Oslo, Fearnresearch, 1990), p.4.

Note: 1 mile = 1.61 kilometres.

a/ Estimates for 1989 are based on statistics for the first 9 to 11 months of that year for the most important countries and the specified commodities, supplemented with data from official and commercial sources. "Other cargo" estimates are based on world trade growth as indicated by official sources and fleet data.

(a) *Crude oil shipments*

Crude oil shipments have increased by 8.9 per cent from 1,042 million tonnes in 1988 to 1,135 million tonnes in 1989, and shipments of oil products from 325 million tonnes to 335 million tonnes. The 11 per cent increase in OPEC oil production in 1989 contributed mostly to their increase, as did the exceptional 15 per cent rise in crude oil imports into the United States. The improvement in demand and the reduced supply of tanker tonnage during 1989 led to a gradual lengthening of the charter period for tankers. For the first time since the mid-1970s, periods of five years or longer have become common. Between then and 1989, when the spot market was poor and tonnage readily available, the charter period was usually not longer than a year. The continued strong demand for oil tonnage and changes in the chartering market were responsible for the improvement of the oil tanker demand-and-supply balance. Measured in tonnes per mile, shipments of crude oil and oil products increased by 9 per cent, while the tanker fleet increased by only 3 per cent. At the same time, laid-up tankers decreased from 2.7 million to 2.3 million dead-weight tonnes, compared with the peak of 55.8 million dead-weight tonnes reached in 1982. The tankers used for the storage of oil were also reduced by 0.6 million dead-weight tonnes to 9 million dead-weight tonnes in 1989. A peak was reached in 1981 when 20.1 million dead-weight tonnes were used for the storage of oil. By the end of 1989, tanker owners almost without exception expected rate levels to rise in the crude oil transport market.

(b) *Dry-bulk shipments*

Dry-bulk shipments increased in 1989 by a modest 2 per cent, after a 7 per cent rise in 1988. Iron ore shipments increased by 2.6 per cent, and coal shipments by 3.6 per cent, while grain shipments decreased slightly by 0.5 per cent to 195 million tonnes, well below the record of 207 million tonnes in 1984. In 1989 there was a marginal rise of 0.4 per cent in world steel production by 0.4 per cent and a slight decrease in the United States, together with an increase in Japan and Western Europe, as well as in the Republic of Korea and Taiwan Province, which, being heavily dependent on sea-borne iron imports, increased their volumes of iron ore shipments. Rising oil prices and less emphasis on nuclear power sources in Europe increased the demand for thermal coal. Continuing grain purchases by China, Egypt and the USSR together with grain demands from Algeria and Turkey kept the demand strong for tonnage, with a consequent rise in freight rates. The total bulk carrier fleet increased by about 3.5 per cent, whereas the fleet of combined vessels was marginally reduced. Laid-up bulk carriers decreased from 0.9 million to 0.7 million dead-weight tonnes, and the bulk carriers used for storage reached a low level of 0.7 million dead-weight tonnes. Bulk carrier demand and supply thus moved towards an improved balance.

Adjustments in the major industrial sectors caused the categories of goods transported to be considerably modified in the 1980s. The share of goods such as oil, raw materials and primary products has been reduced, while the quantity of other cargo has increased. The latter are goods that can be easily transported but require services of a higher quality. The higher level of services and a lower need for product standardization also influenced higher price levels per tonne. In 1989, trade in manufactured goods increased more sharply than trade in raw materials (except crude oil). Other cargo shipments increased by 5.5 per cent as a result of the positive development of world trade, particularly trade from South-East Asia. Almost all of the main commodities such as minor bulk commodities, liquefied gas and chemicals, ro-ro cargo, container cargo, cars etc. should also have strong growth in 1989. The total fleet increased by only 1.5 million dead-weight tonnes, and the laid-up tonnage decreased from 2.5 million to 1.5 million dead-weight tonnes. Two to three years ago, freight rates for ocean container transport were about one third lower than at the beginning of the 1980s. A rise in rates became apparent in 1987 and continued during 1988. This favourable development in shipping revenue continued in 1989, with container shipments increasing by at least 6.5 per cent.

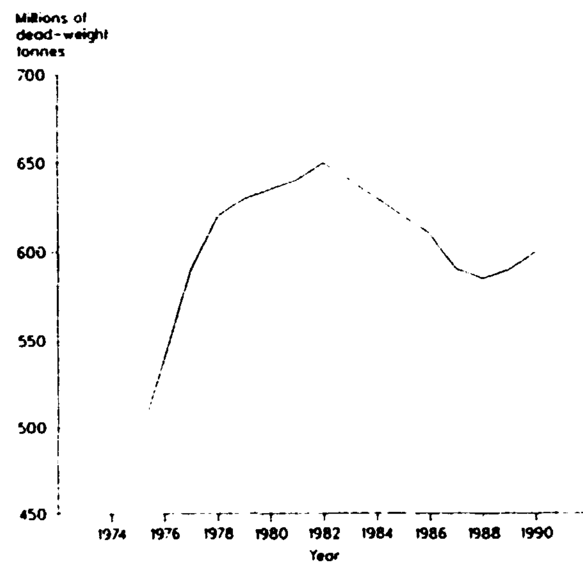
2. *The world fleet*

The expansion of the world shipping fleet in the twentieth century has been very dramatic; the number of ships increased fivefold, their tonnage more than sixteenfold, and the average ship size about fourfold. The total world gross tonnage of the merchant fleet was 62.3 million in 1923, increasing 6.6 times to 410.5 million in 1989. The following increases occurred in the fleets of the following developing countries or areas: Argentina 11 times, Brazil 13 times, China 61 times, Greece 29 times, Hong Kong 24 times, India (from 1948) 20 times, Republic of Korea (from 1960) 78 times, Saudi Arabia (from 1960) 47 times, Taiwan Province 23 times, Turkey 56 times and Yugoslavia 30 times. Much higher growth was recorded in developing countries with an open-registry fleet such as the Bahamas, Cyprus, Liberia and Panama. In 1989 about one third of the world merchant fleet was registered in those four countries, although only 1 per cent of the registered ships had their national domicile in Liberia, 4 per cent in the Bahamas, 9 per cent in Panama and 11 per cent in Cyprus.

The most dynamic period of world fleet development was in the 1970s, when the average annual rate of tonnage growth tonnage was 7.4 per cent. In that period seven ships were built with more than 500,000 tonnes of capacity each, and ships of 1 million tonnes were planned. In a 10-year period the tonnage of the world fleet doubled, producing over-capacity in tonnage supply. As shown in figure IV.4, a peak was reached in 1982 and after that year the total tonnage of the fleet declined for six consecutive years.

As reflected in table IV.23, the recent growth of the world fleet started in 1988, with an increase of 6 million dead-weight tonnes, after a decrease of

Figure IV.4. World fleet, 1975-1990



Source: *Fearnleys Review 1989* (Oslo, Fearnresearch, 1990), p. 35

Table IV.23. World fleet, 1975-1990a/

Item	Number of ships and tonnage					Percentage share	Percentage change	
	1975	1980	1988	1989	1990	1989	1980-1990	1989-1990
Oil tankers	3 406 (254.3)	3 071 (326.8)	2 488 (228.9)	2 529 (232.1)	2 580 (239.3)	10.9 (39.1)	-16.0 (-26.8)	2.0 (3.1)
Combined carriers	386 (42.1)	410 (48.2)	286 (33.7)	284 (33.3)	278 (32.3)	1.2 (5.6)	-32.[illegible] (-33.0)	-2.1 (-3.1)
Bulk carriers	2 992 (97.8)	4 020 (137.7)	4 656 (193.2)	4 651 (195.5)	4 729 (202.5)	20.0 (32.[illegible])	17.6 (47.1)	1.7 (3.6)
Others	13 579 (99.7)	15 445 (125.2)	15 692 (132.2)	1 516 (132.9)	16 030 (135.0)	[illegible].5 (22.4)	3.8 (7.8)	957.4 (1.6)
TOTAL	20 363 (493.9)	22 946 (637.9)	23 122 (588.0)	22 280 (593.8)	23 617 (609.1)	100.[illegible] (100.0)	2.9 (- 4.5)	1.4 (2.6)

Source: Fearnleys Review 1989 (Oslo, Fearnresearch, 1990), p.35.

Note: Figures in parentheses represent thousands of dead-weight tonnes.

a/ Tankers, combined carriers and bulk carriers comprise vessels of over 10,000 dead-weight tonnes. "Others" comprise all other seagoing cargo-carrying vessels of over 1,000 gross tonnes.

61 million dead-weight tonnes cumulative since 1982. In 1989, the world fleet increased by 15 million dead-weight tonnes, or about 2.5 per cent. Tanker tonnage increased by about 3 per cent and bulk carriers by about 3.5 per cent, while the combined carrier fleet decreased by 3 per cent. Other ships (fishing vessels, ferries, passenger ships, supply boats, tugs, ice-breakers, research ships and non-commercial vessels) increased in tonnage by about 1.6 per cent after a long period of stagnation.

As reflected in table IV.24, the delivery of new shipbuildings in 1988 was at the lowest level since 1964, when 14.6 million tonnes were delivered. In 1989, there was an increase to 18.8 million tonnes of new deliveries. About 8.8 million tonnes were tankers, which was the highest level since 1978, but well below the levels reached in the years preceding 1978. The new deliveries of combined carriers decreased from 367,000 dead-weight tonnes in 1988 to 61,000 in 1989. Bulk-carrier deliveries increased from 4 million dead-weight tonnes in 1988 to 6.5 million in 1989, and deliveries of other ships increased from 3.2 million to 3.5 million dead-weight tonnes.

In the mid-1980s, and especially in 1988 and 1989, the strong trend towards scrapping ships was sharply reduced. In 1988, sales for demolition reached 5.8 million dead-weight tonnes, compared with 16.3 million in 1987. In 1989, sales for demolition decreased to 3.3 million dead-weight tonnes. One of the strongest factors prolonging the lives of old ships in the past few years has been lower shipbuilding capacity. Stronger markets and improved shipowner confidence have also influenced the decision to postpone scrapping. Reduced demolition has caused an aging of the world fleet, so that a very large increase in demolition sales can be expected over the next few years.

In 1988, the laid-up tonnage was dramatically reduced to 6.7 million dead-weight tonnes from the 1982 peak of 80.2 million. A further sharp reduction is not expected, although a slight decrease will continue. The tonnage of laid-up ships was reduced by about one third in 1989. Only five tankers, above 2 million dead-weight tonnes, remained laid up in December 1989, against 168 in December 1982. Given that surplus, many ships were used for storage, particularly tankers. The use of tankers for storage, especially tankers and combined carriers, was further reduced in 1989. In January 1990, among 64 ships with 9.7 million dead-weight tonnes used for storage, 48 were tankers with 9 million tonnes, 15 ships, or about 7 per cent of the tonnage, were bulk carriers, and one ship was a combined carrier.

New building orders increased from 17.5 million dead-weight tonnes in 1988 to 32.4 million in 1989, reaching the highest level since 1980. Orders for tankers increased from 5.6 million to 17 million dead-weight tonnes, reaching the highest level since the mid-1970s, and bulk carrier orders increased from 8.1 million to 8.4 million dead-weight tonnes. In 1989, 0.7 million dead-weight tonnes of combined carriers were ordered, in addition to 6.3 million of other vessel types, compared with 3.8 million in 1988. The world order book reached its highest level since 1982, jumping from 36.8 in 1988 to 50.6 in 1989. The volume of tankers on order increased from 17.4 million to 25.2 million dead-weight tonnes, combined carriers from 0.1 million to 0.7 million, and bulk carriers from 12.9 million to 15.3 million. The order book for other ships also increased from 6.5 million to 9.3 million dead-weight tonnes, with a strong focus on container ships. At the beginning of 1990, the world order book amounted to about 8 per cent of the existing world fleet ([1], p.3).

The age analysis of the world fleet by Lloyd's states that the percentage share of ships under 10 years old declined from 62 per cent in 1979 to 36 per cent in 1989 ([2], p.5). The Federal Republic of Germany has the most modern fleet with 70 per cent of its ships under 10 years old, followed by Japan with 68 per cent and Belgium with 67 per cent. The oldest fleet is that of Canada with 59 per cent of its ships over 20 years old, followed by Saint Vincent and the Grenadines with 46 per cent. Fearnresearch estimates that the average tanker age was 12.7 years in January 1990, compared with 12.3 years in January 1989. The average age on the dates mentioned was, respectively, 13.2 and 12.4 for combined carriers, and 10.7 and 10.1 for bulk carriers ([3], p.13).

(a) *Fleet capacity in the developing countries*

The regional distribution of the total world fleet given in figure IV.5 shows OECD (31.6 per cent), developing countries (20.5 per cent), open registers (35.4 per cent), CMEA (6.6 per cent) and other groupings (6 per cent). The share of developing countries in the total world fleet at the beginning of 1989 was 20.3 per cent. Regarding individual cate-

Table IV.24. Deliveries of newly built ships, 1975-1989[a]

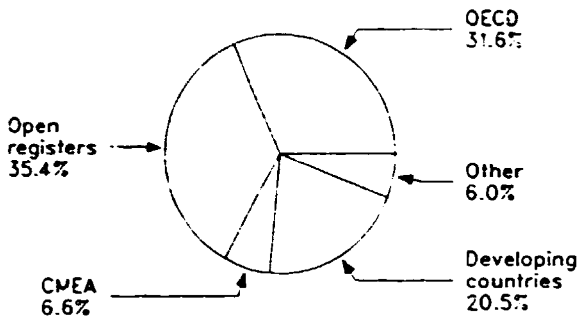
Item	Number of ships								Percentage share		Percentage change			
	1975		1980		1988		1989		1989		1980-1989		1988-1989	
Oil tankers	311	(45 376)	99	(7 015)	90	(7 086)	77	(8 788)	13.3	(46.8)	-22.2	(25.3)	14.4	(24.0)
Combined carriers	20	(2 604)	4	(4 451)	2	(367)	1	(61)	0.2	(0.3)	-75.0	(-86.5)	-50.0	(-83.4)
Bulk carriers	215	(8 241)	135	(4 698)	56	(3 956)	95	(6 463)	16.4	(34.4)	-29.6	(37.6)	64.6	(63.4)
Others	623	(5 630)	548	(6 241)	368	(3 170)	407	(3 457)	70.2	(18.4)	-25.7	(-44.6)	10.6	(9.1)
TOTAL	1 169	(61 851)	786	(18 405)	516	(14 579)	580	(18 769)	100.0	(100.0)	-26.2	(2.0)	12.4	(28.7)

Source: Fearnleys Review 1989 (Oslo, Fearnresearch, 1990), p.35.

Note: Figures in parentheses represent thousands of dead-weight tonnes.

a/ Tankers, combined carriers and bulk carriers comprise vessels of over 10,000 dead-weight tonnes. "Others" comprise all other seagoing cargo-carrying vessels of over 1,000 gross tonnes.

Figure IV.5. Regional distribution of the total world fleet, January 1990



Source: Fearnleys Review 1989 (Oslo, Fearnresearch, 1990), p. 4.

gories, they held 26 per cent of the world total for bulk and ore carriers, as well as 24 per cent of the world total of the container-vessels fleet. They also held an above-average share of general cargo ships, with 24 per cent of the world total. In January 1989, fleet of developing countries consisted of 7,927 ships. Of that total, there were 1,072 bulk and ore carriers with 39 per cent of the total dead-weight tonnage, 1,321 tankers with 29 per cent, 4,373 general cargo ships with 19 per cent, 57 ore, bulk and oil carriers with 5 per cent, 293 container vessels with 5 per cent, and 811 remaining ships with 3 per cent. Concerning the size class, 19 per cent of the ships in the fleet of developing countries fell between 100,000 and 200,000 dead-weight tonnes, about 11 per cent were between 20,000 and 30,000, and about 9.5 per cent exceeded 250,000.

At the beginning of 1989, the biggest fleet in Latin America was Panama with 77.6 per cent of the total, followed by Brazil with 10.6 per cent and Argentina with 2.9 per cent. Above 0.5 per cent of the Latin American total are the fleets of Colombia (0.6 per cent), Ecuador (0.6 per cent), Honduras (0.8 per cent), Peru (0.9 per cent), Chile (1 per cent), Cuba (1.2 per cent), Venezuela (1.5 per cent) and Mexico (1.9 per cent). It should be remembered that the percentage of domiciled owners in Panama is about 8.5 per cent of the total fleet of Panama. By type of ship the total Latin American fleet consists of one third of bulk and ore carriers, 30.5 per cent of oil carriers and 22 per cent of general cargo ships. Latin American flags account for 15 per cent of the total world fleet.

The biggest fleet in Africa is that of Liberia, with 1.4 per cent of domiciled owners and with 92.5 per cent of total dead-weight tonnage. As in Latin America, first place falls to countries having open registry. Fleets of more than 50,000 dead-weight tonnes were registered for Angola, Cameroon, Côte d'Ivoire, Ethiopia, Ghana, Madagascar, Sudan and Zaire, with a share of between 0.1 and 0.2 per cent of the total African fleet. Mauritius had a fleet of 174,000 dead-weight tonnes or 0.2 per cent, South Africa 273,000 or 0.3 per cent, Tunisia 444,000 or 0.5 per cent, Morocco 537,000 or 0.6 per cent, Nigeria 771,000 or 0.8 per cent, Algeria 946,000 or 1 per cent, Libya 1,460,000 or 1.5 per cent and Egypt 1,686,000 or 1.8 per cent.

Open-registry fleets increased further in 1989. The 1986 United Nations Convention on Conditions for Registration of Ships has not yet come into force and there is only a small chance that it will soon be applied. In the mean time, owners register their ships in open-registry countries, thus avoiding the costs and the rules they have to obey in their own countries. The world open-registry fleet on 1 January 1989 consisted of 7,049 ships. Liberia had a fleet of 1,399 ships with 41.2 per cent of total the total dead-weight tonnage of world open-registry fleets, Panama 3,792 ships with 32.6 per cent, Cyprus 1,283 ships with 15.3 per cent, Bahamas 486 ships with 7.4 per cent and Bermuda 89 ships with 3.5 per cent. Concerning the problem of fleet ownership, Lloyds Register of Shipping found that in 1989 owners from CMEA countries and countries such as Brazil, India and the Islamic Republic of Iran did not, as a rule, change the habit of registering ships under their own flag. The countries or areas with the biggest percentage of ships registered under foreign flags are Hong Kong with about 90 per cent, Greece 57 per cent, Japan 56 per cent, Federal Republic of Germany 50 per cent, United Kingdom 50 per cent, Singapore 47 per cent, and United States 41 per cent. Hong Kong and Singapore have the highest percentage of foreign-owned ships under their flags, with 63 per cent and 49 per cent, respectively. Taking the domicile of shipping companies into account, the actual size of OECD country fleets is almost two thirds of the total world tonnage, compared with one third operating under the flags of OECD countries.

At the beginning of 1989 Arab countries had a fleet of 13.6 million dead-weight tonnes. Saudi Arabia had about 28 per cent registered under its flag, Iraq 12 per cent, Egypt 10 per cent, Kuwait 10 per cent, United Arab Emirates 9 per cent, Libya 9 per cent, Algeria 7 per cent, Morocco 4 per cent, Lebanon 4 per cent and Qatar 3 per cent. Among the rest, about 4 per cent were fleets of Bahrain, Democratic Yemen, Jordan, Mauritania, Somalia, Sudan, Syrian Arab Republic and Tunisia. The six biggest Arab ship-owners had about 42 per cent of the total fleet tonnage of Arab countries. Five out of six companies are State-controlled.

So far as Asia is concerned, the Republic of Korea and Taiwan Province had the biggest gains in their fleets, with substantial amounts of new tonnage already on order during 1989. Myanmar almost doubled its fleet, with 860,000 dead-weight tonnes on 1 January 1990, compared with 480,000 on 1 January 1989. The growth was the result of a policy aimed at encouraging bareboat charters. Japan and China had the biggest single fleet increases under Asian flags, equivalent to, respectively, 6.4 per cent and 3.2 per cent of total world tonnage.

(b) *The oil tanker fleet*

The world merchant fleet is currently composed of the following types of ships: oil tankers (39.3 per cent), ore and bulk carriers (33.2 per cent), combined carriers (5.3 per cent) and other vessels (22.2 per cent). Most of the tankers were in the 200,000-tonnes category and above, with 410 ships totalling 114.1 million dead-weight tonnes. There were also 247 tankers of between 100,000 and 150,000 dead-weight tonnes totalling 31.3 million dead-weight tonnes, 324 ships of between 80,000 and 100,000 tonnes totalling 31.3 million, and 745 ships of between 25,000 and 50,000 tonnes totalling 25.6 million. The largest ship in the world is the oil tanker Hellas Fos registered in Greece with 555,051 dead-weight tonnes. A ranking of countries by size of tanker fleet appears in table IV.25. Over 73 per cent of world tanker tonnage is 10 years of age or more.

Table IV.25. Major world tanker fleets, January 1990

Country or area	Dead-weight tonnes	
	Millions	Percentage share
Liberia[a]	53.9	27.8
Panama[a]	22.0	11.4
Greece	16.5	8.5
United States	15.9	8.2
Japan	14.4	7.4
Norway	13.8	7.1
Bahamas[a]	11.7	6.0
Cyprus[a]	11.4	5.9
Bermuda[a]	6.6	3.4
USSR	6.4	3.3
United Kingdom	4.8	2.5
Italy	4.4	2.3
Gibraltar	4.1	2.1
Denmark	3.9	2.0
France	3.8	2.0
TOTAL	193.6	100.0

Source: Lloyd's Register of Shipping, Statistical Tables 1989 (London, 1990), p.5.
a/ Open-registry fleet.

Table IV.26. Developing country tanker fleets, January 1990

Country or area	Dead-weight tonnes		Gross tonnage	
	Millions	Percentage share	Millions	Percentage share
Iran (Islamic Republic of)	6.2	16.2	3.1	14.9
Brazil	3.3	8.6	1.8	8.7
India	3.0	7.9	1.7	8.2
China	2.8	7.3	1.8	8.7
Malta	2.6	6.8	1.4	6.7
Saudi Arabia	2.3	6.0	1.2	5.8
Kuwait	1.9	5.0	1.1	5.3
Iraq	1.6	4.2	0.8	3.9
Republic of Korea	1.5	3.9	0.8	3.9
Turkey	1.5	3.9	0.8	3.9
Hong Kong	1.4	3.7	0.8	3.9
Libyan Arab Jamahiriya	1.1	2.9	0.6	2.9
Indonesia	1.0	2.6	0.6	2.9
Taiwan Province	1.0	2.6	0.5	2.4
Argentina	0.9	2.4	0.5	2.4
Mexico	0.9	2.4	0.5	2.4
Philippines	0.8	2.1	0.4	1.9
United Arab Emirates	0.8	2.1	0.4	1.9
Venezuela	0.8	2.1	0.4	1.9
Yugoslavia	0.5	1.3	0.3	1.4
Egypt	0.5	1.3	0.2	1.0
Nigeria	0.4	1.0	0.2	1.0
Yemen Arab Republic	0.4	1.0	0.2	1.0
Peru	0.3	0.8	0.2	1.0
Malaysia	0.3	0.8	0.2	1.0
Ecuador	0.2	0.5	0.1	0.5
Honduras	0.1	0.3	0.09	0.4
Cuba	0.1	0.3	0.08	0.4
TOTAL	38.2	100.0	20.77	100.0

Source: Lloyd's Register of Shipping, Statistical Tables 1989 (London, 1990), p.5.

The share of developing countries in total tanker dead-weight tonnage increased marginally from 15 per cent in 1989 to 15.2 per cent in January 1990. Excluding the open-registry fleets, table IV.26 suggests that in dead-weight tonnage measurement, the Islamic Republic of Iran has the largest tanker fleet at 6.2 million dead-weight tonnes. Brazil, China and India have fleets of approximately 3 million dead-weight tonnes each. Among developing countries with a small fleet or even a tanker are the following: Algeria, Angola, Bahrain, Bangladesh, Cape Verde, Chile, Colombia, Côte d'Ivoire, Democratic People's Republic of Korea, Dominican Republic, Ethiopia, Fiji, Gabon, Ghana, Jamaica, Lebanon, Madagascar, Maldives, Mauritius, Myanmar, Pakistan, Papua New Guinea, Paraguay, Sierra Leone, Sri Lanka, Sudan, Surinam, Tunisia, United Republic of Tanzania, Uruguay and Viet Nam.

(c) *Ore and bulk carrier fleet*

On 1 January 1990 the ore and bulk carrier fleet accounted for 33.2 per cent of the total dead-weight tonnage of the world merchant fleet. The biggest ships in this group are bulk carriers of 200,000 dead-weight tonnes and more, with some 31 ships totalling 7.2 million dead-weight tonnes. There were 289 bulk carriers of between 150,000 and 200,000 dead-weight tonnes totalling 40.8 million dead-weight tonnes, 38 ships of between 80,000 and 100,000 tonnes totalling 3.3 million, and 4,372 ships of between 10,000 and 80,000 tonnes totalling 152 million. Table IV.27 provides a summary

Table IV.27. World ore and bulk carrier fleets, January 1990

Country or area	Dead-weight tonnes	
	Millions	Percentage share
Panama	31.4	15.7
Liberia	27.4	13.7
Greece	18.3	9.2
Japan	17.3	8.7
Cyprus	15.9	8.0
Norway	12.4	6.2
Philippines	12.4	6.2
China	8.1	4.1
Republic of Korea	8.1	4.1
Hong Kong	7.8	3.9
USSR	6.6	3.3
Brazil	6.0	3.0
India	5.2	2.6
Taiwan Province	3.7	1.9
Singapore	3.7	1.9
Yugoslavia	3.3	1.7
Turkey	2.5	1.3
Malta	2.0	1.0
Iran (Islamic Republic of)	1.7	0.9
Saint Vincent and	0.9	0.5
Argentina	0.8	0.4
Vanuatu	0.8	0.4
Gibraltar	0.7	0.4
Union of Myanmar	0.7	0.4
Chile	0.6	0.3
Malaysia	0.6	0.3
Egypt	0.6	0.3
TOTAL	199.5	100.0

Source: Fearnleys Review 1989 (Oslo, Fearnresearch, 1990), p.35.

of the size of the ore and bulk fleets for the major fleet-holding countries. In January 1990 the average age of a bulk carrier was 10.7 years. Among developing countries not listed in table IV.27, the following had smaller ore and bulk carrier fleets or just one ship: Algeria, Antigua and Barbuda, Bahrain, Cayman Islands, Colombia, Cuba, Democratic People's Republic of Korea, Dominican Republic, Ecuador, Honduras, Indonesia, Jamaica, Jordan, Lebanon, Maldives, Morocco, Mauritius, Mexico, Nauru, Papua New Guinea, Peru, Saudi Arabia, Sri Lanka, Tunisia, United Arab Emirates and Venezuela.

(d) *Container fleet*

The container fleet accounted for about 4.1 per cent of the total dead-weight tonnage of the world merchant fleet and 6.2 per cent of gross tonnage on 1 January 1990. At the beginning of 1989 the biggest group consisted of 44 container ships of over 50,000 dead-weight tonnes totalling 157,200 20-feet-equivalent units, or 11.4 per cent of the world total. There were 112 ships of between 40,000 and 50,000 dead-weight tonnes totalling 308,400 20-feet-equivalent units, or 22.3 per cent of the world total, 160 ships of between 30,000 and 40,000 dead-weight tonnes totalling 312,000 20-feet-equivalent units, or 22.6 per cent of the total, 105 ships of between 25,000 and 30,000 dead-weight tonnes totalling 150,200 20-feet-equivalent units, or 10.9 per cent of the total, and 752 ships between 2,500 and 25,000 dead-weight tonnes totalling 454,300 20-feet-equivalent units, or 32.8 per cent of the total. Table IV.28 provides a summary of the major container fleets of the world. The share of developing countries and areas in total container dead-weight tonnage increased marginally from 24 per cent in 1989 to 25.7 per cent in January 1990. The following developing countries and areas had smaller container vessel fleets: Antigua and Barbuda, Bahamas, Bermuda, Brazil, Cyprus, Democratic People's Republic of Korea, Greece, Hong Kong, Indonesia, Israel, Kuwait, Malaysia, Philippines, Qatar, Saudi Arabia, United Arab Emirates and Yugoslavia. In 1989, the biggest growth of container fleets was recorded in Antigua and Barbuda, Democratic People's Republic of Korea, Panama, the Philippines, Qatar, Singapore and Taiwan Province.

(e) *Ferries and passenger vessels*

The world ferry fleet accounted for 0.5 per cent of the total world merchant fleet, measured in dead-weight tonnes as of 1 January 1990. At the beginning of 1989, the biggest group consisted of 178 ships of over 10,000 tonnes, totalling 2.9 million gross tonnes. There were 326 ferries of between 5,000 and 10,000 tonnes totalling 2.3 million gross registered tonnes, and 270 ships of between 3,000 and 5,000 tonnes totalling 1.1 million gross registered tonnage. These three categories accounted for 79 per cent of the total ferry fleet. The rest consisted of 1,738 ships of between 400 and 3,000 tonnes totalling 1.7 million gross registered tonnes. Table IV.29 shows that two thirds of the world ferry fleet are located in developed countries. Of the 20 biggest ferry fleets, only six are from developing countries, three of which are open-registry countries. The biggest ferry-owners among developing countries are China, with 3.8 per cent of world gross registered ferry tonnage, Bahamas with 2.3 per cent, Philippines with 1.9 per cent, Indonesia with 1.8 per cent, Turkey with 1.7 per cent, and Cyprus with 1.2 per cent. Countries or areas with fleet sizes of less than 1 per cent are Algeria, Argentina, Bermuda, Brazil, Egypt, Hong Kong, India, Liberia, Malta, Mexico, Republic of Korea, Saudi Arabia and Yugoslavia.

On 1 January 1990 passenger ships accounted for about 0.1 per cent of the total dead-weight tonnage of the world merchant fleet. For the shipbuilding industry, passenger ships are nevertheless important because of their sales value. On 1 January 1989 the biggest group consisted of three passenger ships of more than 50,000 tonnes totalling 210,000 gross registered tonnes and six ships of between 40,000 and 50,000 tonnes totalling 269,000 gross registered tonnes. There were also 13 ships of between 30,000 and 40,000 tonnes totalling 465,000 gross registered tonnes, and 17 ships of between 20,000 and 30,000 tonnes totalling 416.5 mil-

Table IV.28. Major world container fleets, January 1990

Country or area	1,000 gross tonnes	1,000 dead-weight tonnes	Total	1,000 20-feet-equivalent units Percentage share	Percentage growth rate
Panama	3 256.3	3 700.6	208.3	15.1	13.9
United States	3 162.3	2 125.8	194.0	14.0	11.8
Taiwan Province	1 988.2	2 232.4	135.4	9.8	24.3
Germany, Federal Republic of	1 581.1	1 850.2	111.2	8.0	6.3
Japan	1 660.6	1 551.5	87.9	6.4	-9.0
United Kingdom	1 334.5	1 264.9	69.6	5.0	-2.1
Denmark	1 019.0	1 065.4	60.8	4.4	-
Liberia	848.0	916.2	55.9	4.0	20.8
Singapore	818.7	947.6	52.1	3.8	9.9
China	646.4	827.7	41.7	3.0	0.7
Other	6 418.1	7 054.1	365.2	26.5	-
TOTAL	22 733.2	24 536.4	1 382.1	100.0	7.2

Source: Lloyd's *Register of Shipping Statistical Tables 1989* (Bremen, Institute of Shipping Economics and Logistics, 1990), p.24.

lion gross registered tonnes. The rest were 176 of between 2,000 and 20,000 tonnes totalling 1.36 million gross registered tonnes. The regional distribution of the passenger fleet is reflected in table IV.29. Three countries, the Bahamas, Panama and the USSR, had 43.3 per cent of world gross tonnage of passenger ships. Countries with fleets of over 100,000 gross registered tonnes are Greece, Italy, Liberia, Netherlands, Norway, United Kingdom and the United States.

Table IV.29. Regional distribution of the world ferry fleet and passenger vessels, January 1990

Economic grouping	Number of ships	Thousands of gross registered tonnes	
		Total	Percentage share
Countries with ferries			
OECD	1 658	5 246.1	66.1
CMEA	130	664.7	8.4
Open-registry countries	129	666.7	8.4
Developing countries	481	978.7	12.3
Others	114	379.2	4.8
TOTAL	2 512	7 935.4	100.0
Countries with passenger vessels			
OECD	76	1 210.1	45.9
CMEA	51	314.7	11.9
Open-registry countries	62	1 041.7	39.5
Developing countries	19	47.7	1.8
Others	7	20.2	0.8
TOTAL	215	2 634.4	100.0

Source: Lloyd's Register of Shipping Statistical Tables 1989 (Bremen, Institute of Shipping Economics and Logistics, 1990), pp.14-20.

(f) *Fishing fleet*

On 1 January 1989 the total world fishing fleet was divided between CMEA countries with 40 per cent, OECD countries with 36.2 per cent, open-registry countries with 2 per cent and developing countries with 21.8 per cent. The USSR alone had 36 per cent of the total world tonnage. The top five countries are USSR, Japan, United States, Spain and Republic of Korea, which together had 61 per cent of the total. The biggest owners of fishing fleets among developing countries and areas were Republic of Korea with 418,000 gross registered tonnes, Peru with 144,000, Cuba with 131,700, Mexico with 119,000, Argentina with 98,000, Chile with 90,000, Taiwan Province with 88,000, Morocco with 83,000, the Philippines with 66,000, Ghana with 57,000 and Indonesia with 52,000. Almost every developing country has some fishing vessels.

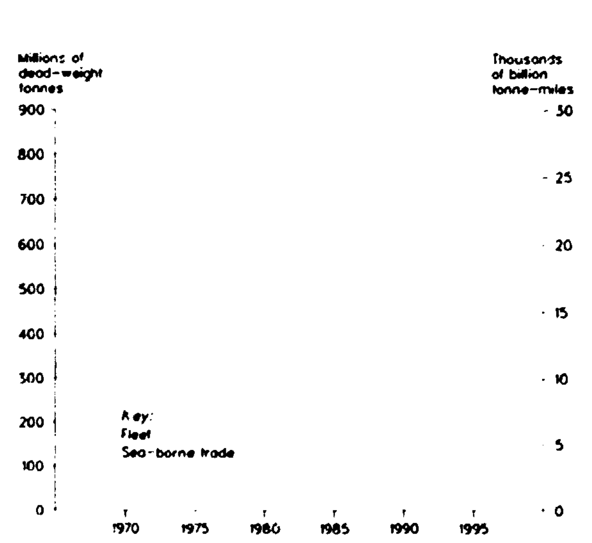
(g) *Balance between supply and demand of ship tonnage*

During the period 1970-1989 the imbalance between the supply and demand of tonnage was severe. The usual disequilibrium between supply and demand was aggravated by the most serious crisis in the history of shipping and shipbuilding. Changes in the structure of ships and fleets were the result of changes in the structure of sea-borne trade and economic development in the 1970s and the 1980s. There was a sharp rise in tanker production, followed by an increase in production of special seagoing vessels. Orders for new ships increased, reaching the record volume of about 231 million dead-weight tonnes on 1 January 1974.

After the first and second oil shock, interest in new shipbuilding diminished. In 1974 almost 50 million dead-weight tonnes of the record volume were cancelled, and new building orders started to decline. The reduced demand for transport services influenced in capacity utilization in tankers and other ships. A huge amount of tonnage was left unemployed, creating a surplus on the supply side. This gap between supply and demand first creates inactive tonnage, which is subsequently laid-up and scrapped. However, contrary to the trends in sea-borne trade and to the rise in laid-up and scrapped tonnage, the world fleet continued to grow. The fleet was not reduced because in boom years the ships had to be ordered up to five years in advance, so that as a result of the former euphoria, the new ship completions exceeded fleet reductions through demolition and laid-up tonnage. For a number of years this condition of over-supply continued.

Figure IV.6 clearly shows the heavy expansion of the world fleet caused by the high level of shipbuilding orders during the 1970s as well as the stagnation of sea-borne trade after 1973 and again after 1980. The widening of the gap between the two is obvious. Since 1984 the gap between supply and demand of tonnage has started to narrow. It took 10 painful years to cut excess capacities in world shipbuilding to the levels more appropriate to shipbuilding demand. In 1988 world shipyard production, with 15 million dead-weight tonnes, was at its lowest level since 1964. In 1989 deliveries of new buildings increased to 19 million

Figure IV.6. Difference between world fleet and sea-borne trade, 1970-1991



Source: *Fearnleys Review 1989* (Oslo, Fearnresearch, 1990), p. 35.

Note: Fleet at the end of the year, excluding coastal trade. Figures for 1989-1991 are estimates.

dead-weight tonnes and the tonnage balance continued to improve, but to a lesser extent than in 1988. Seaborne trade measured in tonnes per mile increased by 6 per cent in 1989, after 7 per cent in 1988, and the world fleet increased by about 2.5 per cent, after only 1 per cent in the previous year. The result was the narrowing of the gap between supply and demand of tonnage. The oil tanker balance was improved by the 9 per cent rise in oil shipments and the 3 per cent increase in the tanker fleet.

3. *Capacity utilization and capacity flows*

(a) *Capacity utilization*

Shipbuilding capacities throughout the world are considered to be much greater than the average yearly world production of ships, and their full utilization has never been achieved. The gap between the installed capacities and their utilization was evident during the long-term recession that started in the mid-1970s and severely affected the world-wide shipbuilding industry. Given its international character, the shipbuilding industry is exposed not only to the effects of the above-mentioned supply-and-demand imbalance, but also to the negative impact of different political, social and economic crises. Different measures to stimulate domestic production also have an effect on shipbuilding. In periods of crisis or declining cyclical movements, capacity utilization in shipbuilding is low. In so-called normal times, capacity utilization is mostly determined by better building conditions, speed of production, quality, length of building period and credit conditions.

The tendency towards inadequate capacity utilization and the distortions in the development of the largest shipbuilding industries in the world have stimulated the relocation of shipbuilding to developing countries. It has been argued that developed countries should produce more sophisticated ships embodying high-valued, high-technology equipment, and that developing countries should build ships of more simple construction embodying low-technology equipment. Although there are examples of such differentiation in practice, the shipyards of developing countries are, in a number of cases, clearly capable of building technologically sophisticated ships of any size, and they have done so. The relatively high rating of developing countries in world shipbuilding production and on the world order book testifies to their competence.

Table IV.30 clearly shows that among the nine major shipbuilders in the world, five developing countries or areas have played a leading role since 1979. Developed countries, however, remain dominant in annual new building deliveries, despite the increase in the share of developing countries, particularly the Republic of Korea. The decline of shipbuilding production in developed countries in the 1970s was caused by the crisis in the world economy and its negative effects on transport volumes in a declining global market. The over-capacity of world tonnage and the growing competitive pressure from large new ships produced mainly in Japan and the Republic of Korea were the most important factors underlying the shipbuilding crisis in developed countries.

Table IV.30. Summary of world shipbuilding order book, December 1979 - December 1989

Country or area	Capacity ordered (thousands of gross tonnes)			Percentage share	Percentage change	
	1979	1985	1989	1989	1979-1989	1985-1989
Japan	9 331	6 568	10 278	33.1	10.1	56.5
Republic of Korea	1 271	4 667	6 027	19.4	374.2	29.1
Yugoslavia	763	636	1 566	5.0	105.2	146.2
Germany, Federal Republic of	813	724	1 399	4.5	72.1	93.2
Brazil	2 529	1 130	1 201	3.9	-52.5	6.3
Spain	1 530	504	1 073	3.5	-29.9	112.9
Poland	1 750	1 031	1 007	3.2	-42.5	-2.3
China	..	688	844	2.8	-	28.5
Taiwan Province	700	1 170	865	2.8	23.6	-26.1
Other	9 615	8 744	6 755	21.8	-29.7	-22.7
TOTAL	28 302	25 862	31 055	100.0	9.7	20.1

Source: Lloyd's Register Shipbuilding Return, December 1989 (London, Lloyd's Register of Shipbuilding, 1990), table 12.

According to the EEC, the world-wide fleet volume increased by about 30 per cent from 1973 to the end of 1977, whereas the transport volume decreased by about 10 per cent ([4], p.15). The decline of the new orders intake actually started with the oil crisis of 1973, but its effects did not appear until 1976. An enormous amount of tonnage was on order all over the world. The decline of new orders continued after 1976, and the peak order level of 1973 has never again been reached. The consequences of this crisis were severe: a fall in new ship prices followed by declining shipyard employment and a huge capacity reduction in traditional shipbuilding countries.

This reduction of capacity in some countries amounted to as much as 50 per cent. By 1987 EEC merchant shipbuilding production was 3.5 times less than in its peak year of 1976, with a corresponding drop in the EEC share in world production from about 27 per cent to 18 per cent. The EEC restructuring programme for 71 shipyards reduced the total workforce level from 273,000 in 1980 to 139,000 in 1987. The effects of these reductions on the world market were diminished owing to continued excess capacity in East Asia. Shipbuilding production in Japan declined by about one third. At the same time, new production was deployed to developing countries to take advantage of lower costs, while shipbuilding production in CMEA countries remained stable. According to OECD and the Association of Western European Shipbuilders, the crisis of 1976 led to a decline of no more than 20 per cent in world production capacities. In 1984 the over-capacity was further compounded by speculative new orders unrelated to immediate demand. The upturn of world trade in 1985, 1986 and 1987 was not followed by an upturn in the volume of maritime transport, the stabilization of which was not reached until 1987.

Besides the reduction of capacities and relocation toward lower-cost countries, the general crisis in the shipbuilding industry also produced changes in ownership, organization and management of shipyards and in programmes of ship production. Some of these changes were reflected in the average tonnage and structural type of new ships. The average size of ships delivered declined very sharply in the period 1975-1980 and is still far below the 1975 level. In 1975, 73 per cent of the delivered new buildings were tankers, 4 per cent combined carriers, 14 per cent bulk carriers and 9 per cent other ships. In 1989, only 47 per cent were tankers, none were combined carriers, 34 per cent bulk carriers and 19 per cent other ships. The supremacy of dry-bulk tonnage is obviously being re-established to meet the need for the transport of liquid goods. The completion of new ships and the order book performances show that the above-mentioned downward trend was reversed in 1989. It is to be expected that new technology and innovations, as well as lower costs of building, will also influence the location of world shipbuilding capacities in the future.

(b) *New orders for shipbuilding*

The estimates provided in table IV.30 reflect the recovery in the world order book for new shipbuilding, which grew to 31 million gross tonnes in 1989, the highest level since 1983. The biggest improvement occurred in bulk carriers and oil tankers. Tankers accounted for about 38 per cent, bulk carriers 27 per cent and general cargo ships 20 per cent of the total world order books at the end of 1989, with container tonnage constituting 57 per cent of the general cargo total. Passenger vessels accounted for 50 per cent and ferries 29 per cent of the total for other ships in the order books. So far as the larger ships in the world order book are concerned, there are 12 ships of between 200,000 and 250,000 dead-weight tonnes, and 22 ships of between 250,000 and 300,000 dead-weight tonnes. There was not a single ship of over 300,000 dead-weight tonnes on order at the end of 1989. The 57 per cent rise in gross tonnage ordered in 1989 signifies a noticeable increase in shipowner confidence, following a fall of 1.5 million gross tonnes in orders in 1988. Higher ordering was recorded for all three major ship types. Oil tankers orders more than doubled and were well above those of any year in the 1980s.

In 1989 global shipbuilding supremacy shifted back to Japan, which now accounts for almost 50 per cent of world tonnage orders. The shares of other countries and regions are reflected in table IV.31. Lloyd's attributes the shift to the restructuring of Japanese shipyards in the second half of the 1980s and to a favourable exchange rate for Japan and the financial problems of yards in the Republic of Korea ([5], table 1). According to Lloyd's, much of the income increase was achieved at the expense of Korea. The relative shares of other major shipbuilding countries and areas remained steady.

Table IV.31. Regional shares of new shipbuilding orders, 1980-1989
(Percentage)

Country or economic grouping	1980	1988	1989	Percentage change 1980-1989	Percentage change 1988-1989
Japan	53	38	50	- 5.7	31.6
Republic of Korea	9	24	17	88.9	-29.2
EEC	12	17	14	16.7	-17.6
CMEA	4	6	5	25.0	-16.7
Others	22	15	14	-36.4	-6.7
TOTAL	100	100	100		

Source: Lloyd's Register Annual Report 1989 (London, Lloyd's Register of Shipbuilding, 1990), p.29.

The rate of ship completions recovered after the serious slump of 1987 and 1988, when only 11 million gross tonnes were completed. The gross tonnage completed in 1989, as shown in table IV.32, was about 13 million tonnes, 2 million tonnes more than in 1988, and that was the first increase in world tonnage since 1984. Japan was the biggest producer, accounting for about half world tonnage since 1984, followed by the Republic of Korea with about one fifth. About 72 per cent of the production of the Republic of Korea consisted of oil tankers. More than 20,000 gross tonnes were also completed in 1989 by Belgium, Canada, Mexico, Norway, Portugal and Singapore.

Table IV.32. Merchant ships completed during 1989

Country or area	Gross tonnes: Thousands	Gross tonnes: Percentage share	Dead-weight tonnes: Thousands	Dead-weight tonnes: Percentage share
Japan	5 365	40.5	8 142	42.5
Republic of Korea	3 102	23.4	5 336	27.9
Yugoslavia	499	3.8	750	3.9
Germany, Federal Republic of	431	3.3	486	2.5
Taiwan Province	406	3.1	669	3.5
Denmark	343	2.6	422	2.2
Italy	327	2.5	367	1.9
China	326	2.5	458	2.4
Romania	307	2.3	504	2.6
German Democratic Republic	287	2.2	242	1.3
Spain	231	1.7	337	1.8
Poland	199	1.5	246	1.3
Finland	194	1.5	63	0.3
CSSR	174	1.3	222	1.2
Brazil	165	1.3	276	1.4
France	160	1.2	60	0.3
United Kingdom	103	0.8	88	0.5
Argentina	90	0.7	154	0.8
Netherlands	89	0.7	92	0.5
India	80	0.6	134	0.7
Bulgaria	77	0.6	111	0.6
TOTAL	13 236	100.0	19 153	100.0

Source: Lloyd's Register Annual Survey of Merchant Ships Completed 1989 (London, Lloyd's Register of Shipbuilding, 1990), table 1.

Japan completed 13 ships of over 100,000 dead-weight tonnes. The largest ore carrier was 233,016 dead-weight tonnes and the largest oil tanker 258,076 dead-weight tonnes. The Republic of Korea completed 21 ships of over 100,000 dead-weight tonnes, including two of the largest oil tankers in the world with a capacity of 280,000 dead-weight tonnes. About 54 per cent of the 499,000 tonnes completed by the Yugoslavia were in oil tankers, the biggest with 142,031 dead-weight tonnes. Taiwan Province has concentrated on producing larger ships, the average size of its nine completed ships in 1989 being 45,233 tonnes, compared with an average size of just 8,376 tonnes in Japan.

Yugoslavia in third place almost doubled its output in 1989 to 498,716 tonnes. One of the reasons for the extraordinary position of Yugoslavia is that in the past 10 years it has been exporting between 95 and 98 per cent of its shipbuilding production, thus forcing the shipbuilders to maintain a high level of international competitiveness. In 1989 Japan exported 77.3 per cent of the tonnage built for foreign customers, including affiliates of Japanese companies.

4. *Short- and medium-term outlook*

A number of new international developments are also proving that 1989 was a crucial year for the world shipbuilding industry. In the first place, a greater number of countries became involved with shipbuilding. Despite the dominance of Japan, 15 more countries are currently taking more than 1 per cent of the total world order book. Table IV.33 shows the large number of ships on order in developing countries and areas. Shipbuilders in Argentina, Brazil and Taiwan Province showed signs of revival by securing valuable contracts. In Yugoslavia two big shipyards are planning organizational improvements, including the Split shipyard that built the ferry "Isabela", considered to be one of the finest ships built in 1989 ([6], p.38). In India the Government was in a dilemma whether to give priority to improvements in the working of existing shipyards or to set aside limited resources for building a new one.

Table IV.33. Ships on order in shipyards of developing countries and areas, mid-1989

Country or area	Number of shipyards	Number of ships	Ships delivered	Dead-weight tonnes Thousands	Dead-weight tonnes Percentage share
Republic of Korea	9	[illegible]	51	11 737.3	55.2
Brazil	6	46	15	3 018.5	14.2
Yugoslavia	5	49	17	2 198.8	10.3
Taiwan Province	1	17	5	1 951.9	9.2
China	[illegible]	60	26	1 230.4	5.8
India	2	9	9	479.5	2.3
Argentina	3	11	-	428.6	2.0
Malta	1	4	2	53.9	0.3
Singapore	5	12	3	52.7	0.2
Malaysia	2	3	-	37.3	0.2
Egypt	1	4	2	31.2	0.1
Mexico	2	3	3	19.6	0.1
Pakistan	1	2	-	17.3	0.1
Indonesia	1	3	3	10.0	-
Thailand	1	1	-	-	-
TOTAL	51	352	136	21 257.0	100.0

Source: Fairplay data.

In the Republic of Korea several shipyards worked together on a number of projects. Shipyards in that country continued to cut their work-force, the number of employees being reduced to 49,000 by the end of 1988, compared with a peak of 75,000 in 1984. At the same time, financial aid was given to some yards to overcome severe economic problems. In Finland, Wartsila Marine, after bankruptcy proceedings, now operates under the new name of MaSa Yards. There have been take-overs of North-east shipbuilders (NESL) by United Kingdom shipbuilders, and of Harland & Wolff by Norwegian interests through a management buy-out. In Poland, the Lenina and Gdinya shipyards entered negotiations with foreign investors.

Recent events in Eastern Europe could change the structure of world shipbuilding. Over the past decade the shipbuilding output of Bulgaria, the German Democratic Republic, Poland and Romania accounted for 10 per cent of total world output on a gross tonnage basis. But the production of these countries was focused on domestic demand and especially on USSR orders. At the same time, the USSR was using its shipbuilding capacities almost exclusively for military and domestic purposes. In 1989 the new building capacities of the USSR were introduced to the world market through a Soviet barter deal with Pepsi Cola. Interests in developed market economies are also looking for investments in shipyards in Poland. When the shipbuilders of the Federal Republic of Germany and the German Democratic Republic unite they will rank high on the world list of leading shipbuilders. The belief has been expressed, that shipbuilding in Eastern Europe could become a necessary counterbalance to increasing market domination by East Asian shipbuilding. This will depend on the ability of shipyards in Eastern Europe to turn to profit-oriented production and to modernize their capacities, most likely in partnership with Western European interests.

In 1989 most shipyards in Western Europe were still heavily dependent on subsidies to bridge the price gap with East Asian prices, but action is being taken to reduce subsidies. At the end of 1989 the Commission of the European Communities fixed a new production aid ceiling at 20 per cent for contracts for building new vessels. Aid for investment and the restructuring of shipyards is assessed on an individual basis according to the situation of each shipyard and is not limited by a ceiling. The lowering of the aid ceiling from 26 per cent to 20 per cent reflects a clear and continuing improvement in world market prices for new buildings and in the comparative cost structure of most EEC shipyards. At the same time, there is intense United States pressure for an end to subsidies in the shipbuilding industry. In the fourth quarter of 1989 the Shipbuilders Council of America asked the United States Trade Representative to investigate allegations of unfair government support for shipyards in the Federal Republic of Germany, Japan, Norway and the Republic of Korea. The attitude of the Commission of the European Communities is similar to that of the United States and is aimed at reducing government subsidies. At the beginning of 1990 the representatives of shipbuilding countries confirmed their commitment to strengthen international co-operation for eliminating obstacles to normal competitive conditions in the shipbuilding industry. Significant progress has been made towards multilateral agreement to discipline subsidy-awarding countries.

Regarding future shipments of different goods, it is assumed that world sea-borne trade in crude oil will rise more slowly than in 1988 and 1989, owing to the progress in fuel efficiency and the lower growth rate of the world economy. Simpson, Spence & Young foresee the continued growth of oil demand in 1990 and 1991, with the increasing trade originating in the Islamic Republic of Iran, Iraq, Kuwait, Saudi Arabia and the United Arab Emirates [7]. They believe that the demand for tankers will remain high and that the fleet will expand rapidly. But it will take a number of years to balance the supply and demand for tanker tonnage. The current high demand for oil in developed countries will cause some problems because of the under-supply of modern tanker tonnage.

Regarding ore and bulk trade, Wharton Econometrics Forecasting Associates, in a study on future patterns of international coal trade, predict that by the year 2000, coking-coal trade will be back to the levels recorded at the beginning of the 1980s, because steel industry demand will decline [8]. The coal trade will continue to be shared by Australia, Canada, South Africa and the United States, with Colombia and Venezuela as major new suppliers. According to Ocean Shipping Consultants, grain trade levels since the mid-1980s have not been able to reach the 200-million-tonne mark, with the exception of 1988 [9]. The recent increase in trade levels is likely to continue, and by 1995 it is forecast that more than 225 million tonnes will be shipped annually. Demand from East Asia is set to increase, with India and China re-emerging as significant grain import markets. The United States will remain the biggest supplier.

At the end of 1989 the average size of bulk carriers was 42,900 dead-weight tonnes, but at that time shipyards were delivering bulk carriers averaging 69,600 dead-weight tonnes. The average size of bulk carriers on order was 74,000 dead-weight tonnes. This clear trend towards larger vessels as well as the number of ships ordered could lead to over-capacity in the world bulk fleet already by the end of 1991.

Turning to ship completion, a further increase of more than one third is projected for 1990. Fearnleys estimates that at the end of 1989 the total world order book amounted to 50.5 million dead-weight tonnes, with the following delivery schedule: 22.4 million in 1990; 19.1 million in 1991 and 9 million in 1992 ([1], p.4). The other estimate is about 18 million dead-weight tonnes for delivery in 1990, representing a further output rise of more than one third. At the end of 1989 a number of shipbuilders in Japan, Spain and Yugoslavia were already committed well into 1992. New building prices were generally on the rise for most ship types. An increasing reluctance to replace aging ships, especially tankers, is leading to progressive aging of the world fleet. It is predicted that the percentage of the world tanker fleet older than 15 years will soar from 17 per cent in 1988 to about 50 per cent in 1993.

As the decade of the 1990s begins, most research institutions and shipbuilding companies are maintaining cautious optimism. There is no doubt that ship lifetime will be extended, with more economical operation and improved technology. Environmental concerns may change fleet structure. Future shipyard capacity and expansion possibilities will be mainly influenced by political change and the availability of labour. Currency fluctuations and sources of capital for financing ship production will be especially important questions for developing countries.

Because of an aging global fleet, the world shipbuilding industry will be principally concerned with replacement demand. Most analysts consider that the pattern of sea-borne trade has stabilized and that no significant growth is to be expected in major bulk commodity movements. The biggest market for shipbuilders in the 1990s will be in tankers and very large crude carriers of between 250,000 and 280,000 dead-weight tonnes. Tonnage of this size is most economical, and demand for it will grow as the old tonnages are scrapped. It is often assumed that a ship should be scrapped after its estimated lifetime. But statistics show that ships can be scrapped earlier during years of crisis, as was the case in the mid-1980s, when tankers less than 10 years old were decommissioned. In good years scrapping is insignificant, as in 1990; there is no need for a shipowner to scrap ships when cargo is available for transport. The maintenance cost, repairs and conversion of old ships could be less expensive than the cost of a new ship.

There is no doubt that the present aging fleet consisting of ships built in the first half of the 1970s and ships with widely varying technical standards will soon require replacement. At the same time, limited yard capacities for both new buildings and repairs could create an imbalance between tonnage supply and demand in the mid-1990s. Most analysts agree that irrespective of temporary market set-backs in the next few years, the coming decade will be one of expansion.

C. Textile machinery (ISIC 382401-382410)*

1. Recent trends and technological developments

The global textile industry has gone through a major technological revolution since the end of the Second World War. During this period new fibres were introduced; new dyes and chemicals and new architectural mill designs were developed; and new machinery was created and installed. As a result, the textile industry was able to offer a much better product, at a reasonable price, thus making possible a general global increase in fibre consumption. Even though this technological evolution started and continues in developed countries, developing countries have also had an opportunity to participate, albeit on a modest scale.

The term "textile industry" should include all the activities that are involved in the fabrication of a variety of consumer products, including the activities of synthetic fibre producers, mills and apparel cutters. This section concentrates only on the development of process machinery for the spinning and weaving mill.

(a) *Machinery development*

The machinery development process has gone through an evolution of its own. Up through the late 1950s, textile manufacturers would order their machines and upon installation would introduce some degree of change reflecting the proprietary technology of the mill. These changes would relate to machine settings, gears, shapes of cams, drafting aprons and other devices. They were based on the company concept of what was best engineering practice for the mill.

*UNIDO acknowledges the contribution of Jordan P. Yale, President, Statistikon Corporation.

The available textile machine technology of the time was a combination of the two manufacturing influences of mill management (internal to the mill) and machinery management (external to the mill). These influences were particularly strong in the United States, whose machinery industry became the world leader in many machinery categories. This was particularly true for spinning and weaving equipment.

By the mid-1960s a shift occurred away from leadership by the United States to that of Europe and to some degree Japan. Also at this time a fundamental change had taken place in the basic machinery development process. Textile machinery innovations became available primarily on a merchant basis, rather than being contingent on the proprietary technology of a mill. A major factor that had precipitated this shift was technological innovation stemming from many scientific disciplines, such as physics, electronics, mathematics, mechanical engineering and computer science. Even though a textile firm might have skills in some of these disciplines, it was nearly impossible to have the requisite skills in all of them. However, any firm could purchase any one of the major types of equipment, such as spinning frames or looms, embodying the latest technology. The concept of internal machine innovation now played a minimal role in the development of modern textile machinery. This permitted countries in the South to have access to the same high levels of technology as in the North.

(b) *Research expenditures and employment*

Figures on research and development expenditures by the textile machinery community are not available. However, industry sources suggest that an estimate of such expenditures might range between 4 and 5 per cent of sales for the major manufacturers. Nor are employment statistics available; it is difficult to identify the size of the work-force that builds only textile machines, since many of the leading companies also manufacture other types of machinery. One possible approach for estimating the global work-force (excluding administrative and other similar personnel) would be to divide the total value of shipments by the estimated value of shipments per production worker. This ratio results in an estimate of a global work-force of 160,000 productive employees.

(c) *Major companies in the global industry*

A list of the major textile-machinery manufacturing companies is given in table IV.34. With a ranking based on apparent sales volume, the companies are grouped by type of major machine, including spinning, weaving, knitting, dyeing, printing and finishing machines, among others. That table shows the major textile-machinery supplying countries to be Czechoslovakia, France, Federal Republic of Germany, Italy, Japan, Switzerland, United Kingdom and United States. With the possible exception of the latter, where the machinery output serves primarily the domestic market, most of the major textile machinery firms are export-oriented.

Table IV.34. World's major textile machinery companies

Type of machinery and company	
Spinning	Weaving
Howa, (Japan)	Dornier (Germany, Federal Republic of)
Investa (Czechoslovakia)	Investa (Czechslovakia)
Platt-Saco-Lowell (United Kingdom, United States)	Jumberca (Spain)
Rieter (Switzerland)	Nissan (Japan)
Schlafhorst (Germany, Federal Republic of)	Picanol (Belgium)
Société alsacienne de matériel textile (France)	Ruti (Switzerland)
Schubert and Salzer (Germany, Federal Republic of)	Saurer (Switzerland)
Toyoda (Japan)	Société alsacienne de matériel textile (France)
Zinser (Germany, Federal Republic of)	Somet (Italy)
	Sulzer (Switzerland)
Knitting	Dyeing, printing, finishing
Bentley (United Kingdom)	Adrioli and Co. (Italy)
Dubied (Switzerland)	Gaston County Dyeing Machine Co. (United States)
Fukuhara (Japan)	Kusters Corp. (Germany, Federal Republic of)
Jumberca (Spain)	Morrison Textile Machine Co. (United States)
Mayer Albstad (Germany, Federal Republic of)	Stork Brabant B.V. (The Netherlands)
Mayer Obertshausen (Germany, Federal Republic of)	Zimmer Machinery Corp. (Germany, Federal Republic of)
Monarch (Japan)	
Stoll (Germany, Federal Republic of)	
Sulzer Morat (Germany, Federal Republic of)	
Terrot (Germany, Federal Republic of)	
Other types of machinery	All categories
Cobble/Tufting Machine Co. (United States)	Bentley (United Kingdom)
Dr. Ernst Fehrer Textilmaschinenfabrik - Non-wovens (Germany, Federal Republic of)	Investa (Czechoslovakia)
	Nissan (Japan)
	Platt-Saco-Lowell (United States)
	Société alsacienne de matériel textile (France)
	Schafhorst (Germany, Federal Republic of)
	Toyoda (Japan)

Sources: *Fibres and Textiles. Dimensions of Corporate Marketing Structure*, (United Nations publication, Sales No. E.81.II.D.1) and Statistikon Corporation.

2. *Technological trends*

The techno-economic characteristics of the major companies can be summarized as follows. The Federal Republic of Germany provides high-technology machinery and precision engineering in a broad line of equipment such as spinning, weaving and finishing equipment and in some other areas. Swiss textile-machinery-makers also provide high technology, particularly in spinning (short staple), weaving and automatic controls. As a manufacturing policy, some of the Federal Republic of Germany and Switzerland machinery firms also have manufacturing plants overseas. Machinery manufacturers in France have integrated advanced levels of automation into their equipment and possess particular strengths in the filament (texturizing) and long-staple (wool) conversion processes. Manufacturers in Italy also have unique strengths in long-staple machinery processes and in fabric finishing. Textile equipment manufacturers in Japan provide high levels of automation in weaving, knitting and texturizing equipment, while firms in Czechoslovakia have strengths in short-staple spinning and apparel fabric weaving. In the United States, textile machinery firms have unique strengths in warp yarn preparation and fabric finishing equipment with automatic controls [10]. The major trends in textile machinery innovations since the end of the Second World War are traced below.

(a) *Textile process development*

The purposes of textile equipment are as follows: to convert fibres into yarn; to weave or knit the yarn into fabric; to dye, print, and finish the resulting fabric; and to produce garments or other fabric products. The economic dimensions of the process flow are illustrated in figure IV.7. The textile machines used for all of these processes are highly specialized, each performing only a given set of conversion activities. At first the fibres are subjected to an ever-increasing rate of linear speed. These relative motions reduce the mass of amorphous fibres into fine, strong thin strands (yarn spinning), according to certain product specifications. The resulting endless single strands are manipulated using a perpendicular motion to form a shed of opening and closing yarns, thus resulting in a woven fabric. An estimated 75 per cent of all fabrics produced are of this type; the remaining fabrications are knitted or are characterized as non-wovens.

The aims of these conversion processes are as follows:

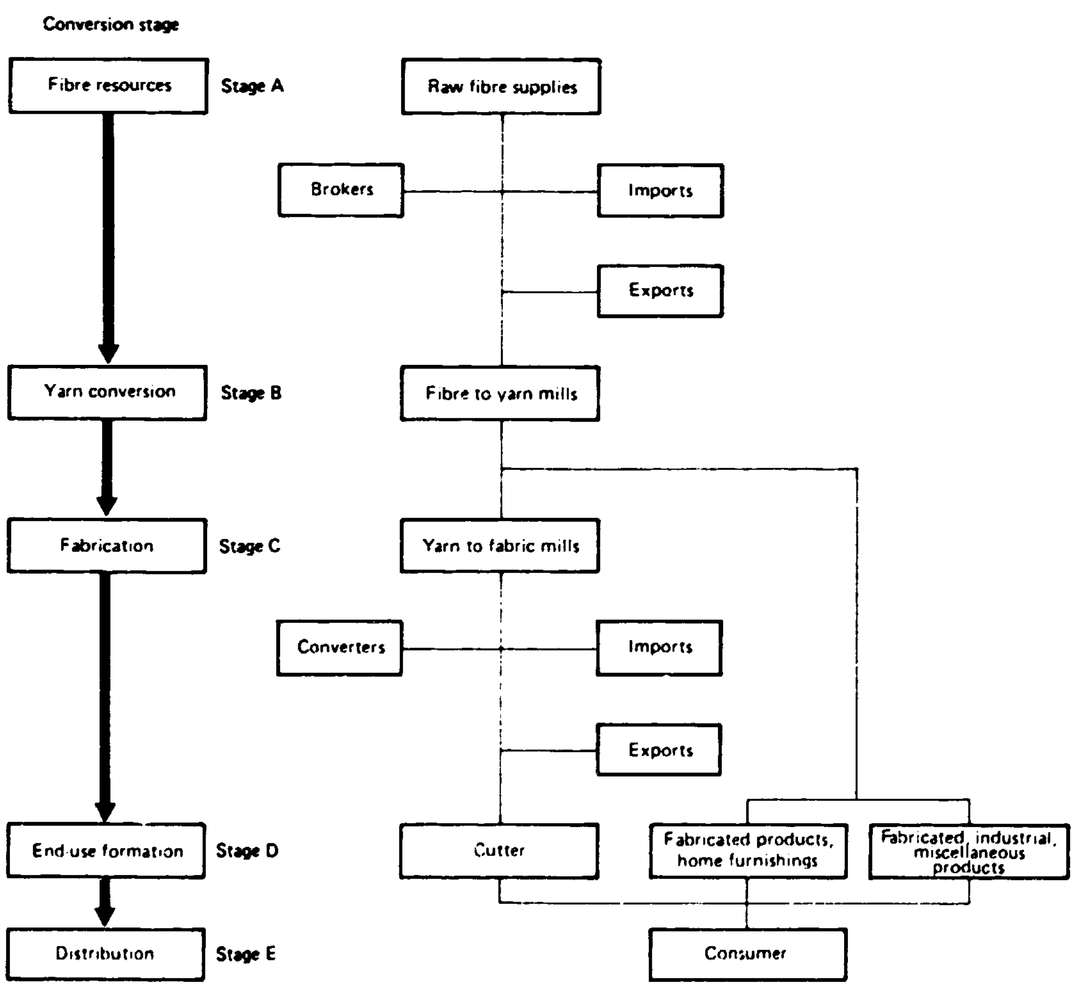
(a) To produce a highly fashionable and uniform product;

(b) To create a strong product with certain other desired physical dimensions, including touch and various aesthetic characteristics;

(c) To produce the yarn and fabric economically and in volume, with a minimum of labour inputs, a minimal number of sequential steps and a short production time.

In order to achieve those three major goals effectively, the textile machinery industry has introduced the technological innovations discussed in the following section.

Figure IV.7. Textile-industry economic process flow



Source: Statistikon Corporation

(b) *Important technological innovations*

The major technological innovations introduced in the textile industry between 1950 to 1990 are reflected in table IV.35. These innovations consisted mainly of new automatic bale feeders, aerofeed systems, high-draft spinning, texturization, shuttleless looms, needle punch machines, transfer printing, rotary screen printing and computer-integrated manufacture. They led to the following improvements:

(a) New machinery and methods were introduced, resulting in improved material handling within the mill;

(b) New yarn spinning methods were created, resulting in increased labour productivity and a reduction in the number of sequential processing steps;

(c) New types of looms with higher speeds and improved fabric quality were made available;

(d) New dyeing, printing and finishing equipment were introduced to improve the surface appearance of fabrics;

(e) New methods of carpet manufacture were created, including needle punch;

(f) Automation of machinery functions (robotics), machine self-diagnostics, machine self-correction from deviations, textile design along with colouring, and the interlinking of processes were developed and commercialized.

A more specific description of the important changes in key machinery will now be given with technological projections being made to the year 2000 in some cases. Spinning of short and long staple, texturizing and weaving equipment will be examined.

Table IV.35. Major technological innovations in the textile industry, 1950-1990

Technology innovation	Process innovation
Automatic bale feeders	Two-for-one twisters
Automatic blending feeders	Yarn texturization
Chute-fed cards	Electronic stop motion and automatic release devices
Precision draw frames	Automatic loom winders
Automatic doffers	Shuttleless looms, different types
Automatic end-piecing	Electronic knitting machines
Automatic drawing-in	Computer-aided fabric designs
Self-twisters	Latch-needle warp knit machines
Composite yarn systems	Double-knit machines
High-draft systems	Needle punch machines
Open-end spinning	Tufting machines
Balloonless spinning	Non-oriented webbing machines
Continuous staple yarn systems	Electrostatic flockers
Electronic monitoring and stop motion devices	Jet dyeing
More energy-efficient equipment	Computer colour analysis and matching
Reduction of polluted effluents	Transfer printing
Reduction of floor space requirements	Rotary screen printing
Automated handling equipment	Automated instrumentation
Fabric shrinkage control processes	Continuous dyeing and finishing ranges
Computer controlled jacquard heads	Long-staple spinning process (shortened version)
Computer integrated manufacturing	
Some form of machine intelligence	

Source: A.N. Benvignati, "The relationship between the origin and diffusion of industrial innovation", in Economica, vol. 49, No. 195 (August 1982) and Transnational Corporations in the Man-made Fibre, Textile and Clothing Industries (United Nations publication, Sales No. E.87.II.A.11).

(c) *Short-staple spinning*

Short-staple spinning involves all the preparatory equipment (blending up through yarn spinning) necessary for the conversion of short-staple fibres (cotton and synthetic staple fibres having cotton-like dimensions). Since the installation of such equipment there has been a consistent increase in machinery productivity, while investment costs have risen as expected. Empirical data confirming these trends is provided in table IV.36 for selected years, with projections to the year 2000. The specific performance changes embodied within each of the sequential conversion steps is reviewed below.

Blending and feeding. The output of this process, expressed in pounds of fibre per hour, increased from 200 in 1945 to 1,320 in 1987. It is expected to increase further to 2,200 by the year 2000. Both productivity and the cost of investment have increased. In 1945, the cost of one machine was $1,369; it reached $103,448 by 1987, and is expected to rise to $206,897 by the year 2000. This 151-fold increase in cost is much larger than the productivity increase for the same period, even if price adjustments are made for inflation. The process of blending and feeding of raw materials gives an opportunity to the mill management to blend various cotton varieties or growths on a large-volume basis. The new technology has contributed to an improved blending process.

Pickers. The introduction of new conversion technology has had a profound effect on the processing of materials. Manual transport of laps has given away to an aerofeed mode, thus increasing productivity significantly with a relatively small investment.

Cards. There has been more than a twelve-fold increase in productivity between the 1945 and 1987, and another significant increase is expected by the year 2000. There have also been mounting investment costs. It is anticipated that the nominal price of cotton card will reach $172,414 by the year 2000, a significant increase over its corresponding price of $103,448 in 1987.

Drawing and lapping. Drawing and lapping provide the means of blending the card slivers in preparation for the next process. Both types of machine have experienced significant increases in productivity and investment costs. Output per hour and investment costs are expected to increase further through the year 2000.

Combing. The objective of this process is to separate within the fibre mass the longer fibres from the shorter ones, thus leaving a processed mass of fibre that contains a preselected minimum length of fibre. The end-result of this sequence is that the yarn made out of this material will be more uniform, stronger and finer than an equivalent yarn made on the carded system. Even though the basic combing process has not changed, productivity and investments have increased. Productivity has increased because of the input of a greater lap weight an an increased machine speed. The gains in speed (nips per minute) and the cost per unit are also featured in table IV.36.

Table IV.36. Technological changes in spinning mills, selected years

Processing variables	1945	1950	1955	1962	1969	1975	1987	2000
Blender/feeder								
Output (pounds/hour)	200	200	200	200	200	550	1 320	2 200
Cost per unit (dollars)	1 369	1 775	2 069	3 872	4 500	34 483	103 448	206 897
Work-load (machines per operator)	10	10	10	10	14	2	2	2
Pickers								
Output (pounds/hour)	382	382	382	382	382	..	..	..
Cost per unit (dollars)	7 711	12 457	14 061	19 500	..	..	..	..
Work-load machines per operator)	6	6	6	6	6	..	..	..
Cards								
Output (pounds/hour)	7	7	8	10	18	55	88	154
Cost per unit (dollars)	2 211	3 950	3 950	5 001	6 000	68 966	103 448	172 414
Work-load (machines per operator)	36	48	64	88	55	24	16	12
Drawings per delivery								
Speed (feet/min)	100	100	400	800	800	273	547	874
Cost per unit (dollars)	..	..	..	..	3 200	17 241	51 724	103 448
Draft	8	8	8	8	8	8	8	8
Work-load (deliveries per operator)	40	44	32	28	38	14	6	4
Can size (inches)	12x36	12x36	12x36	18x42	20x48	20x48	24x48	24x48
Can load (pounds)	12	12	12	40	55	46	62	66
Can price (dollars)	12	12	12	14	25	..	..	..
Lapping								
Output (pounds/hour)	150	150	190	500	500	484	836	990
Draft	1.09	1.09	1.09	2.4	2.4	6	1.7	1.7
Lap weight (pounds)	10	10	10	30	30	29	55	66
Cost per unit (dollars)	4 956	7 804	9 610	11 500	14 000	68 966	124 138	172 414
Combing (8-head frames)								
Output (pounds/hour)	28	30	33	45	50	57	110	132
Speed (nips/min)	100	150	150	150	150	250	300	350
Lap weight (grain/yard)	700	750	850	1 000	1 050	7 717	9 003	10 290
Yield (percentage)	82	90	90	90	90	90	90	90
Cost per unit (dollars)	3 775	7 800	9 882	13 335	14 500	86 207	137 931	172 414
Work-load (heads per operator)	36	48	64	80	80	80	80	80
Roving '96-spindles								
Output, warp (lbs/spindle/hour)	1.01	1.01	1.15	1.53	1.75	2	2	2
Output, filling (lbs/spindle/hour)	0.696	0.696	0.795	1.06	1.3	..	..	..
Speed (rev/min)	660	660	750	1 200	1 300	1 200	1 300	1 400
Package size (ounces)	46	64	80	90	96	81	77	63
Cost per unit (dollars)	8 450	9 727	12 227	20 193	26 400	117 241	124 138	310 345
Work-load (spindle per operator)	240	288	384	480	480	310	360	500
Spinning '288 spindles								
Output, warp (lbs/spindle/hour)	0.0219	0.0232	0.0258	0.0347	0.0363	0.034	0.036	0.048
Output, filling (lbs/spindle/hour)	0.0154	0.0163	0.0192	0.022	0.0232	0.034	0.036	0.048
Spindle speed (rev/min)								
Warp	8 500	9 000	10 000	11 000	11 500	13 000	14 000	18 000
Filling	8 000	8 500	9 000	11 500	12 000	12 000	13 000	16 000
Cost per unit (dollars)	4 895	10 025	11 576	18 642	21 500	61 572	79 448	148 966
Work-load (spindles per operator)								
Warp	2 000	2 400	2 600	6 000	6 500	1 800	2 200	12 000
Filling	3 000	3 500	4 000	5 000	5 500	1 800	2 200	12 000

Sources: Data for 1975-2000 from Rieter Machine Works; data for 1945-1969 from R.P.Olsen, The Textile Industry. (Lexington, Maryland, Lexington Books, 1978); and tabulations by Statistikon Corporation.

Note: 1 inch = 2.54 centimetres
1 foot = 0.3048 metres
1 yard = 0.9144 metres
1 ounce = 28.35 grams
1 pound = 0.4536 kilograms

Roving and spinning. The major changes that have taken place within the spinning department are reflected on the spinning frame itself and involve two production parameters: through high-draft spinning and the development of new spinning methods, particularly the type exemplified by the O-E frame, or open-end spinning*. The impact of these changes has been to reduce the required number of pre-spinning steps, such as slubbing, and to limit in most cases, the need for roving to only one step instead of several as before. In addition, the newer frames run at much higher spindle speeds, with increases expected by the year 2000. Trends in speed (rotations per minute) and the cost per unit for both roving and spinning are reflected in table IV.36.

(d) *Long-staple spinning*

The long-staple spinning fibre system is basically oriented toward the processing of wool fibres (long fibres) and of synthetic staple with wool-like fibre dimensions. Over the years, modifications have been made to the traditional wool processing system for running synthetics such as acrylic and polyester staple fibres. The availability of historical data on processing wool machinery is limited, primarily because of the loss of significant wool markets to other fibres, such as acrylics and polyester staple in select apparel markets, and nylon filament and others in carpets. Table IV.37 provides a complete listing of the key characteristics of certain processes of the long-staple spinning system for 1990. It should be added that speeds for the two-key processes, flyer rover and spinning, have doubled or nearly doubled from 1,030 to 1,800 revolutions per minute for rover and from 4,300 to 9,500 revolutions per minute for spinning. A review of the 1990 costs of all the listed machines indicates that a worsted fibre mill represents a substantial investment; in particular, a single spinning frame of 204 spindles with automatic doffing costs approximately $351,000 in 1989 dollars.

(e) *Texturizing*

Synthetic fibre output is usually in the form of filament or staple. Since a filament has long strands and a smooth surface, it has proved useful in a large number of end-uses, such as women's hosiery, underwear, linings, dresses and other applications. In order to expand the market for filament fibres, particularly nylon 66, heat treatment was applied to obtain elasticity. New markets thus opened for texturized filaments, such as sport shirts, men's hosiery and sweaters, and in home furnishings, particularly carpets. As shown in table IV.38, there have been significant technological changes in texturizing. The speed of air-jet and false-twist methods have increased from approximately 250 metres per minute in 1973 to more than 1,000 metres per minute in 1989. In addition to increases in productivity, the newer texturizing machines produce yarns with higher quality levels.

*This is a relative new method of yarn formation. In this process the roving is "broken" and the individual fibres are moved on, usually by means of air current, to the next position where a revolving drum collects and regroups the fibres sequentially to form the yarn.

Table IV.37. Technological changes in long-staple spinning mills, 1990

Processing machinery and variables	Specifications and cost
Worsted comb	
Machine model PB30	
Cycles per minute	210
Input weight (grains/yard)	7 000
Production (pounds/hour)	
Wool 21	55
Wool 33	88
Cost (dollars)	82 456
Chain gill	
Machine model GC13	
Delivery speed (yards/min)	440
Production (pounds/hours)	772
Cost (dollars)	105 263
Screw gill	
Machine model GN6	
Faller speed (drops/min)	2 000
Production (pounds/yard)	330
Cost (dollars)	87 719
Horizontal rubbing frame	
Machine model FM7	
Delivery speed (yards/min)	220
Production (pounds/hour)	19
Cost per head (dollars)	
Manual doffing	9 649
Automatic doffing	12 281
Vertical rubbing frame	
Machine model	
Automatic doffing FMV32	
Delivery speed (yards/min)	275
Production (pounds/head/hour)	25
Cost per head (dollars)	17 544
Flyer rover	
Machine model BM14	
Flyer speed (rev/min)	1 800
Production (pounds/head/hour)	25
Cost per spindle (dollars)	4 386
Spinning frame, 204 spindles	
Machine model (rings diameter, 120 mm) CF43	
Spindle speed (rev/min))	9 500
Production (spindle/hour)	0.44
Cost per machine (dollars)	
Manual doffing	263 158
Automatic doffing	350 877

Sources: N. Schlumberger and Cie and Statistikon Corporation.
Note: 1 pound = 0.4536 kilograms.
1 yard = 0.9144 metres.

Table IV.38. Technological changes in texturizing machines, 1973 and 1989

Processing methods	Processing characteristics 1973	1989
Air-jet method		
Speed (meters/min)	240	1 000
Cost per installation (dollars)	..	7 000
False-twist method		
Speed (metres/min)	250	1 200
Cost per installation (dollars)	..	3 500

Source: Statistikon Corporation.

(f) *Weaving*

The construction of fabrics has accelerated technological change during the period of interest. The traditional shuttle looms were gradually replaced by shuttleless looms, which not only provide higher speeds but also improve fabric quality. Table IV.39 identifies significant changes over the period from 1945 to 1989, with projections to the year 2000. Productivity, expressed in terms of loom speed in picks per minute, is shown to have increased from 185 to 900 picks per minute, and is forecast to rise to 1,000 picks per minute by the year 2000. Another significant factor is the width of the fabric, permitting a given speed to cover a greater fabric area. In 1945 the typical apparel fabric width was 39 inches, while in 1989 this width had increased to 130 inches and is expected to grow further to 142 inches by the year 2000. These productivity improvements have been obtained with an increase in costs. The price of a loom was $700 in 1945; it rose to $40,000 by 1989, and is expected to reach $50,000 by the year 2000 in nominal terms. The new looms permit better product quality through greater yarn and woven fabric flexibility.

Table IV.39. Technological innovation in weaving mills, selected years

Processing variables	Shuttle X2 loom			Shuttle X3	Air-jet loom			
	1945	1955	1962	1975	1982	1986	1989	2000
Speed, weft insertion (yards/minute)	..	..	..	..	1 570	1 650	1 860	2 300
Speed (picks per minute)	185	195	212	210	630	800	900	1 000
Cloth width (inches)	39	45	47.5	68	..	..	130	142
Cost per unit (dollars)	700	1 500	2 000	8 500	..	..	40 000	50 000
Work-load								
Looms per weaver	60	80	100	120	..	..	19	30
Looms per fixer	60	80	100	100	..	..	..	..

Sources: Data for 1945-1975 from R.P.Olsen, The Textile Industry (Lexington, Maryland, Lexington Books, 1978) and tabulations by Statistikon Corporation.

Table IV.40. Fabrication method and product characteristics matrix

Product characteristics	Ring	Rotor	Airjet	Friction	Rapier	Projectile	Shuttle
A. Spinning							
Yarn size (Ne)	3.5-140	3-40	10-60	0.5-30			
Fibre types	Cotton blend Polyester	Cotton blend Man-mades	Any fibre types	Any fibre types			
Fibre length (inches)	Up to 2.5	Up to 2.3	1-2.31	Up to 2.5			
Yarn applications	Any type	Knitting Weaving - Sheeting - Tablecloth - Denim - Industrial	Any type of use	Industrial fabrics Other types			
B. Weaving							
Spun yarns							
Fibre and yarn types			Spun yarns Man-mades Textured		Spun yarns Natural Man-mades Textured Wool, worsted Jute	Spun yarns Natural Man-mades Textured Wool, worsted Jute, glass	Spun yarns Natural Man-mades Textured Wool, worsted
Fabric construction and end-use			Plain weaves Standard width Printcloth Drill, sateens Industrial fabrics, tyre cord, broad-cloth, sheeting, lawn Shirts Linings		Colours Patterns Fancy fabric Broadcloth Denim, drills Canvas, carp Backing Blankets Upholstery Suiting Table-cloth Muslin, silk Geotextiles	Wide fabrics Colours Terry cloth	All types of fabrics

Source: Statistikon Corporation.

(g) *Summary of machine characteristics*

The above innovations entail trade-offs between productivity, product flexibility and quality. More recently these have lessened, and the industry has obtained both higher productivity and higher product flexibility and quality. A fabrication method and product characteristics matrix, is presented in table IV.40, which outlines the relationship between machinery types (spinning and weaving) and key product characteristics (fibre and yarn types used), as well as yarn and fabric applications. With the yarn manufacturing system, ring spinning provides the greatest product flexibility. However, it is less productive than other yarn-forming systems, in particular rotor, air-jet and friction systems. The newer spinning systems, especially rotor and air-jet spinning, are able to produce a large number of yarn counts, at good quality and high speeds, suitable for most applications in knitting or weaving.

The process of weaving also provides a number c choices of loom type. There are three major types of shuttleless looms in addition to the reguiar shuttle loom, and each features some form of product specialization. Air-jet looms are primarily used on plain and other similar fabrics. Rapier and projectile looms can weave more complicated types of fabric, such as colour stripes and designs. In addition to cotton and synthetic yarns, they can use wool, worsted, jute, glass and other types of yarn.

3. *Trends in machinery sales and capital investment*

(a) *World investment patterns*

Official data on world sales of textile machinery are not available. However, the estimated level of such expenditures is provided in table IV.41. In interpreting the table, it is important to regard the terms machinery sales and c.pital expenditures on textile equipment as synonymous. That is, capital investments by the textile industry represent an equivalent value of sales by the textile machinery industry. Also estimated in table IV.41 are mill investments in spindles and looms, as well as aggregate expenditures for all the other types of equipment (opening, blending, cards, combers, dyeing, printing, finishing, tufting and other equipment with their parts and supplies). The data do not include expenditures on land and buildings. An examination of the table reveals that all the indicated regions have participated in various degrees in textile machinery investments. The largest in 1988 occurred in Asia and Oceania with a total of $7 billion in investment,

Table IV.41. Estimated world capital expenditures on textile equipment, 1979-1988

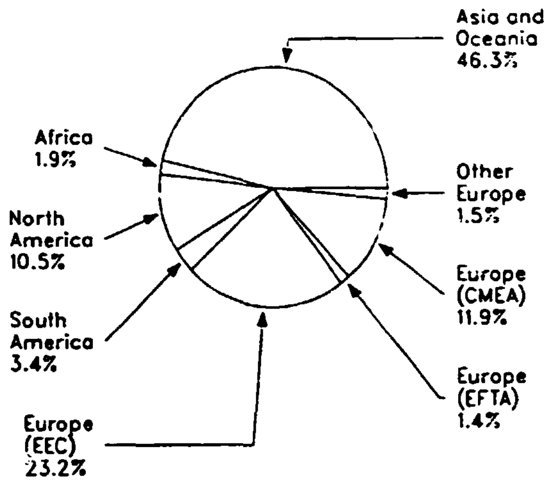
(Thousands of dollars)

Region, economic grouping, country or area	Major types of equipment, parts and supplies: Spinning	Weaving	Subtotal	Other equipment, parts and supplies	Total
Africa	92 430	55 016	147 446	137 322	284 768
North America	316 020	205 461	521 481	1 076 318	1 597 799
South America	138 844	99 668	238 512	274 020	512 532
Asia and Oceania	1 379 362	1 454 274	2 833 636	4 194 071	7 027 707
Europe					
EEC	628 823	506 645	2 135 468	2 379 883	3 515 351
EFTA	49 404	18 855	68 259	137 832	206 091
CMEA	692 199	148 406	840 605	1 509 641	1 804 246
Other	67 557	34 890	102 447	125 213	227 660
TOTAL	2 818 638	2 523 215	5 341 853	9 834 302	15 176 155
Africa					
Egypt	32 509	14 001	46 510	46 510	93 020
Ethiopia	7 177	11 030	18 207	14 896	33 103
Nigeria	6 365	4 815	11 180	11 180	22 360
South Africa	10 949	3 445	14 394	21 591	35 985
Zimbabwe	4 308	0 180	4 488	2 992	7 480
Total	92 430	55 016	147 446	137 322	284 768
North America					
Canada	5 622	11 410	17 032	37 875	54 908
Mexico	24 988	67 046	92 034	138 052	230 086
United States	276 419	122 345	398 764	886 741	1 285 505
Total	316 020	205 461	521 481	1 076 318	1 597 799
South America					
Argentina	12 752	14 285	27 037	27 037	54 075
Brazil	80 616	61 853	142 469	174 129	316 598
Venezuela	31 291	10 005	41 296	50 472	91 768
Total	138 844	99 668	238 512	274 020	512 532
Europe (EEC)					
Belgium	25 013	32 695	57 708	128 386	186 094
France	37 419	69 995	107 414	238 859	346 273
Germany, Federal Republic of	79 906	96 295	176 201	391 822	568 023
Italy	296 251	201 615	497 866	1 107 118	1 604 983
The Netherlands	1 735	1 840	3 575	7 950	11 525
Portugal	66 781	26 530	93 311	139 966	233 276
Spain	66 314	50 005	116 319	216 020	332 339
Total	628 823	506 645	1 135 468	2 379 883	3 515 351
Europe (EFTA)					
Switzerland	40 059	8 915	48 974	168 904	157 878
Total	40 059	8 915	48 974	108 904	157 878
Europe (CMEA)					
Bulgaria	8 554	3 370	11 924	7 949	19 873
Czechoslovakia	3 338	13 725	17 063	20 855	37 919
German Democratic Republic	32 668	24 300	56 968	56 968	113 936
Hungary	4 663	4 185	8 848	10 814	19 662
Poland	19 320	19 076	38 396	25 597	63 993
Rumania	10 640	12 750	23 390	15 593	38 983
USSR	581 848	56 470	638 318	780 166	1 418 484
Yugoslavia	31 168	14 530	45 698	45 698	91 396
Total	692 199	148 406	840 605	1 509 641	1 804 246
Asia and Oceania					
China	179 582	183 536	363 118	363 118	726 237
India	231 440	188 624	420 064	280 043	700 106
Japan	355 656	296 790	652 446	1 450 861	2 103 306
Republic of Korea	131 942	373 305	505 247	1 123 532	1 628 779
Taiwan Province	159 832	200 280	360 112	540 169	900 281
Total	1 379 362	1 454 274	2 833 636	4 194 071	7 027 707

Source: Statistikon Corporation. Calculations are based on raw data expressed in terms of numbers of spindles and looms released by the International Textiles Manufacturers Federation.

Figure IV.8. World textile-machinery capital expenditures

Total: $ 15 176 million



Source: Statistikon Corporation.

followed by the EEC with $3.5 billion. To illustrate the distribution, figure IV.8 portrays the share of expenditures for each region as a percentage of total world expenditures on textile machinery. Asia and Oceania account for 46.3 per cent of total capital investment. The shares of other regions are 23.2 per cent for the EEC, 11.9 per cent for Eastern Europe and the USSR, 10.5 per cent for North America and less than 4 per cent for each of the remaining areas. This investment pattern suggests that many developing countries in Asia are placing considerable emphasis on the modernization of their textile industry. A greater proportion of the investment was in spinning rather than weaving equipment. The global textile industry thus placed more emphasis on upgrading its yarn-making capacity.

The selection of leading investment countries given in table IV.42 is based on data contained in table IV.41. Japan is shown to have had the highest estimated textile investment expenditures among the developed countries, followed by Italy, USSR, United States and the Federal Republic of Germany. Among the developing countries and areas, the Republic of Korea had the highest textile investment expenditures, followed by Taiwan Province, China, India and Brazil. For an analysis of these investment patterns it is necessary to examine the specific major types of textile machinery purchased in 1988 by the mills in approximately 112 countries within the eight major geographic groupings. In table IV.43, estimates of total installed spindles and loom capacities by type of machine are given, together with the estimated rates of machinery modernization in the various regions of the world. The main field of interest is spinning equipment and weaving machinery.

Table IV.42. Leading purchasers of textile machinery, parts and supplies, 1979-1988
(Thousands of dollars)

Country or area	Expenditure
Developed	
Japan	2 103 306
Italy	1 604 983
USSR	1 418 484
United States	1 285 505
Germany, Federal Republic of	568 023
Developing	
Republic of Korea	1 628 779
Taiwan Province	900 281
China	726 237
India	700 106
Brazil	316 598

Source: Statistikon Corporation.

Table IV.43. Estimated spinning installations and machinery modernization

Region or economic grouping	1988 installed spinning capacities (thousands of spindles)			Ratio of new total installed capacity (percentage)		
	Short-staple system	Long-staple system	O-E rotors	Short-staple system	Long-staple system	O-E rotors
Africa	7 534	252	142	25.65	48.98	86.67
North America	17 687	947	749	7.88	29.36	91.99
South America	9 078	727	179	24.34	20.32	82.45
Asia and Oceania	86 098	6 067	964	17.52	21.37	83.91
Europe						
EEC	11 167	7 017	646	26.65	18.51	99.34
EFTA	1 130	225	37	40.59	32.27	89.74
CMEA	17 577	664	5 179	0.62	14.40	97.06
Other	3 850	620	105	21.36	32.35	80.36
TOTAL	154 122	16 519	8 003	16.20	21.25	94.42

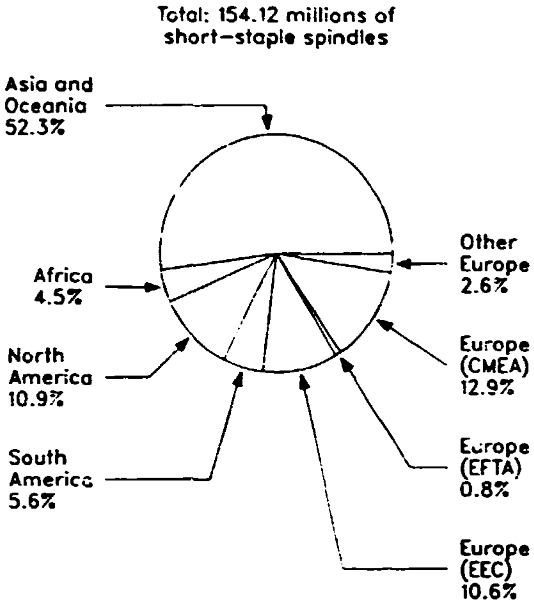
Source: Statistikon Corporation.

(b) *Investment in spinning frames*

Table IV.43 provides world investment estimates for short- and long-staple and O-E rotor spindles, as well as information on the rate of equipment modernization between 1979 and 1988. The largest installed capacities of short-staple (cotton-type) units can be found in Asia and Oceania; the largest capacities of long-staple fibre (wool-type) units are located in the EEC; and the largest O-E rotor installations can be found in Eastern Europe and the USSR. A possible explanation for the turnover in Asia and Oceania is that its population requires a large textile industry to support its needs.

Table IV.43 also shows that by far the greatest number of spindle installations are for short-staple fibres. By 1988, there were an estimated 154.1 million short-staple spindles in place. Their geographic distribution is given in figure IV.9 for 1979-1988. There were also 16.5 million long-staple spindles and 8 million O-E rotor units in place. Most interest has been in the increasing purchase of O-E rotors. Purchases of short-staple accounted for 16.2 per cent of total installed short-staple spindles during that period. Long-staple spindle purchases were 21.2 per cent of the corresponding total; and new installations of O-E rotors nearly doubled during the 10-year period. Even though O-E rotors currently have the smallest number of installed

Figure IV.9. Installed world spinning capacity, by region or economic grouping, 1988



Source: Statistikon Corporation

units, there is strong potential for rapid future growth. One of the major attractions of O-E rotors is that these rotor frames can spin at nearly twice the speed of ring frames, with a consistently good quality of output.

Global expenditures on the three types of spinning machines during 1988 are shown in table IV.44. An estimated $2.8 billion was spent for the purchase of spinning frames. The major thrust of these investments came from Asia and Oceania (primarily Asia), which accounted for an estimated $1.38 billion. The EEC also made major but lesser expenditures of $629 million. Tables IV.49 to IV.56 in the appendix to the present survey give details of 1988 expenditures on the three types of spinning frames and totals for each region, country and area. In addition, for each region estimates are given on the total installed capacities by types of spinning, together with the rates of modernization of particular countries.

The data reported in the tables show that in Africa, Egypt, Morocco and South Africa are investing heavily in spinning equipment. In the Americas, the United States, Brazil and Venezuela are the three dominant investors in spinning frames. Within Europe, the largest expenditures are made in the USSR, Italy and the Federal Republic of Germany. In Asia and Oceania, there is a greater intensity of investment, with major expenditures by more countries and areas, in particular China, India, Japan, Republic of Korea and Taiwan Province. A summary of the types of spinning equipment purchased appears in table IV.45, which provides two types of comparison of geographic areas. In what can be called a vertical comparison, it appears that Africa purchased 5.4 per cent of all short-staple spindles, while Asia and Oceania had a greater investment with 61.4 per cent. The comparison reveals the importance of a particular spindle frame to a region. As reflected in table IV.44, Asia and Oceania accounted for the largest purchases of short-staple spindles, while the CMEA and EFTA countries separately purchased the smallest portion of the same type of spindles.

The other evaluation presented in table IV.45, called a horizontal comparison, reveals the importance of the three types of spindle frames within each region. For instance, firms in Africa have made 62.8 per cent of their investment in short-staple frames, 15.4 per cent in long-staple frames and 21.8 per cent in O-E rotors.

Within the vertical type of comparison, the share of expenditures of a given region can also be compared against the total or world value which would be considered an average rate of expenditure on a particular type of spinning frame. In the case of Africa, 62.8 per cent of its expenditures on short-staple spindles can be compared against 38.5 per cent for world expenditures on the same type of machine. Such figures might suggest that Africa is placing too much emphasis on this type of equipment. Even though there are many types of technological improvements in the short-staple spinning frames (in terms of speed, draft and other production parameters), new

Table IV.44. World spinning-machinery shipments, and expenditure by type, 1988
(Thousands of dollars)

Region or economic grouping	Value of machinery shipments by spindle type: Short-staple	Long-staple	O-E rotors	Total
Africa	58 049	14 187	20 194	92 430
North America	76 993	19 484	219 542	316 020
South America	69 913	28 779	40 152	138 844
Asia and Oceania	664 009	460 671	254 682	1 379 362
Europe				
EEC	165 206	317 261	146 356	628 823
EFTA	10 424	30 423	8 557	49 404
CMEA	8 835	76 671	60 693	146 199
Other	27 410	25 105	15 042	67 557
TOTAL	1 080 839	972 581	765 218	2 818 638

Source: Statistikon Corporation.

Table IV.45. Regional comparison of spinning-machinery shipments and expenditure by type, 1988
(Percentage)

Region or economic grouping	Break-down by spindle type: Short-staple		Long-staple		O-E rotors		Total	
	Inter-area	Intra-area	Inter-area	Intra-area	Inter-area	Intra area	Inter-area	Intra-area
Africa	5.37	62.80	1.46	15.35	2.64	21.85	3.28	100
North America	7.12	24.36	2.00	6.17	28.69	69.47	11.21	100
South America	6.47	50.35	2.96	20.73	5.25	28.92	4.93	100
Asia and Oceania	61.43	48.14	47.37	33.40	33.28	18.46	48.94	100
Europe								
EEC	15.28	26.27	32.62	50.45	19.13	23.27	22.31	100
EFTA	0.96	21.10	3.13	61.56	1.12	17.32	1.75	100
CMEA	0.82	6.04	7.88	52.44	7.93	41.51	5.19	100
Other Europe	2.54	40.57	2.58	37.16	1.97	22.27	2.40	100
TOTAL	100.00	38.35	100.00	34.51	100.00	27.15	100.00	100

Source: Statistikon Corporation.
Note: See text for explanation of data.

investments should be directed more toward the O-E rotor frames. These machines offer much higher productivity at an equivalent quality of output.

Another inference from table IV.45 concerns the emphasis placed on long-staple or wool-type yarn spinning. The proportion of expenditure on this type of spinning frame reveals the regional importance of processing wool and wool-like fibres. As shown in table IV.43, the EEC and Asia and Oceania have the leading producing capacities in wool and wool-like fibre spinning. In view of the increasing demand for natural fibres including wool, it seems that the increased investment in long-staple fibre spinning is a positive strategy for those countries.

(c) *Investment in weaving loom*

Estimates of installed global weaving capacities are given in table IV.46. Weaving capacity includes the traditional shuttle looms, the various types of shuttleless looms and, for some Asiatic countries, handlooms. As of 1988, the estimated number of all types of looms installed was 3.87 million. The dominant loom installations are in Asia and Oceania, with an estimated 2.51 million units of all major types of looms, shuttle and shuttleless, for cotton fabrics, filament yarn looms and wool looms. Next in line, Eastern Europe and the USSR have the highest number of installed looms with 447,242, followed by the EEC and North America, each with approximately 235,000. Table IV.46 also shows the rate of loom modernization as measured by the number of looms (shuttle and shuttleless) purchased between 1979 and 1988. Modernization is reflected in the percentage of new looms compared with the installed capacities of the same types of looms. The table suggests that firms in Africa and Asia and Oceania placed a relatively small but still dominant emphasis on the purchase of shuttle-type looms (9.09 per cent and 6.97 per cent, respectively, in the two regions) Firms in most other regions have emphasized the purchase of shuttleless looms during the same period. Given higher productivity, it appears that investment in shuttleless looms is preferable.

Estimates of sales of shuttleless looms (rapier and projectile, air-jet, water-jet) and conventional shuttle looms in 1988 are shown in table IV.47. The predominant investment centre for shuttleless looms is Asia and Oceania, with expenditures of $1.08 billion on that type, and $376 million on shuttle looms. Investment in shuttleless looms in all regions had a combined total of an estimated $2.13 billion. Investment in shuttle looms were less significant, the EEC and EFTA making no apparent investment in that type during the same period. All the remaining regions had at least some investment. Further details on loom shipments and installed weaving capacities in 1988, with modernization rates between 1979 and 1988 for each geographic area and for about 112 countries within those areas, are given in tables IV.57 to IV.64 in the appendix to this survey.

The countries and areas with the leading weaving capacities and loom modernization rates in the different regions are briefly reviewed below.

Africa. Data for Africa are given in tables IV.57 and IV.58. The countries with the leading weaving capacities within this region are Egypt, Nigeria, Algeria and South Africa. Countries with the highest modernization rates are Botswana, Mauritius and Swaziland. In spite of extensive modernization, the last three countries have only a relatively small total investment in looms.

The Americas. The data in tables IV.59 and IV.60 show that in the Americas in 1988, the leading investors in looms were United States, Mexico and Brazil. The highest modernization rates during the indicated 10-year period were in the United States, Venezuela, Ecuador and Mexico.

Europe. Statistics for Europe are provided in tables IV.61 and IV.62. The principal loom-investing country in 1988 was Italy. However, there are many other countries with lesser but still significant investments. These include the Federal Republic of Germany, France, USSR and Spain. Modernization during the period 1978-1988 was undertaken by a number of firms in many European countries, the leading ones

Table IV.46. Estimated world weaving installations and machinery modernization, 1988

Region or economic grouping	1988 Installed weaving capacities: Looms primarily for weaving yarn spun on the cotton system – Total looms	Looms primarily for weaving yarn spun on the cotton system – Shuttleless looms	Filament weaving looms	Wool weaving looms	Total shuttle and shuttleless looms a/	Percentage of new b/ loom installations, 1979-1988: Shuttle	Shuttleless
	(thousands of units)						
Africa	155	17	..	2	157	9.09	8.74
North America	217	82	14	4	234	1.51	21.55
South America	206	19	..	21	227	3.54	5.90
Asia and Oceania	1 643	146	800	63	2 506	6.97	6.46
Europe							
EEC	149	72	39	48	235	1.04	41.64
EFTA	8	5	[illegible]	2	12	1.70	44.86
CMEA	401	195	20	26	447	0.31	10.89
Other	48	6	..	5	54	3.62	12.30
TOTAL	2 826	549	875	171	3 872	5.33	10.26

Source: Statistikon Corporation.

a/ Including filament and wool weaving looms.

b/ 10 years old or less.

Table IV.47. Estimated world weaving equipment expenditures, 1988
(Thousands of dollars)

Region or economic grouping	Shuttleless looms: Rapier and Projectile	Air-jet	Water-jet	Total	Shuttle	Total
Africa	41 220	7 400	..	48 620	6 396	55 016
North America	83 025	112 000	7 000	202 185	3 276	205 461
South America	75 600	14 040	1 200	90 840	8 788	99 668
Asia and Oceania	549 090	265 920	263 720	1 078 730	375 544	1 454 274
Europe						
EEC	389 925	107 040	9 680	506 645	..	506 645
EFTA	18 135	720	..	18 855	..	18 855
CMEA	72 090	58 240	17 920	148 250	156	148 406
Other	29 790	3 840	480	34 110	780	34 890
TOTAL	1 258 875	569 280	300 120	2 128 275	394 940	2 523 215

Source: Statistikon Corporation.

being Austria, Federal Republic of Germany, Italy, Belgium, France, Finland and Sweden. Many other European countries have also had a certain level of modernization.

Asia and Oceania. Tables IV.63 and IV.64 list many countries and areas that have made major investments, including the Republic of Korea, Japan, Taiwan Province, India and China. High rates of loom modernization have taken place in Australia, Hong Kong and Taiwan Province. Some other countries also have relatively high rates, but their loom investments are minimal

(d) *Investment intensity*

A comparison of the intensity of investment in looms in 1988, between and within the various regions, is provided in table IV.48. The percentage comparisons are based on the conversion of shipments into an equivalent dollar value. Major inter-area investments in shuttleless looms were made in Asia and Oceania (50.69 per cent), the EEC (23.81 per cent) and, to a lesser extent, in the remaining regions. The preferred types of investment have been in rapier and projectile and air-jet shuttleless looms. The dominant region for shuttle looms is Asia and Oceania. The data suggest that firms in many countries are in various degrees engaged in the modernization of their weaving industries, even though the costs are quite high.

4. *Conclusions and outlook*

Textile management has faced an array of significant technological changes since the 1950s. The following dramatic changes have resulted from the influx of new processing technologies:

(a) Productivity increases;

(b) Improvements in product quality;

(c) Greater flexibility of production;

(d) Greater quickness of response to styling and fashion changes;

(e) Reduction in the number of processing steps;

(f) Increased automation;

(g) Increased investment costs.

Today the advanced textile machinery technologies can be shared equally by the North and the South. In reality, neither of these two regions can develop a permanent competitive production advantage, technological transfer (through the acquisition of machinery) having brought an industrial democracy to textile manufacturing. Any textile firm anywhere in the world now has access to the most advanced technology through the purchase of new equipment. However, it appears that the major factors in the success of a firm or country will increasingly be improved management and marketing techniques, particularly the development of marketing strategies related to new product development, competitive price setting, better distribution and the development of an effective promotional programme, possibly through a brand name. It seems that there will be a greater need in the global textile market for high-value-added merchandise.

Table IV.48. Estimated world weaving equipment expenditures by type, 1988
(Inter-area and intra-area percentages)a/

Region or economic grouping	Shuttleless looms: Rapier and Projectile: Inter-area	Rapier and Projectile: Intra-area	Air-jet: Inter-area	Air-jet: Intra-area	Water-jet: Inter-area	Water-jet: Intra-area	Total: Inter-area	Total: Intra-area	Shuttle looms: Inter-area	Shuttle looms: Intra-area	Total: Inter-area	Total: Intra-area
Africa	3.27	74.92	1.30	13.45	-	-	2.28	88.37	1.62	11.63	2.18	100
North America	6.60	40.41	19.69	54.55	2.36	3.45	9.50	98.41	0.83	1.59	8.14	100
South America	6.01	75.85	2.47	14.09	0.41	1.24	4.27	91.18	2.23	8.82	3.9ᶠ	100
Asia and Oceania	43.62	37.76	46.71	18.29	87.87	18.13	50.69	74.18	95.09	25.82	57.64	100
Europe												
EEC	30.97	76.96	18.80	21.13	3.23	1.91	23.81	100.00	-	-	20.08	100
EFTA	1.44	96.18	0.13	3.82	-	-	0.89	100.00	-	-	0.75	100
CMEA	5.73	48.54	10.23	39.24	5.97	12.07	6.97	95.89	0.04	0.11	5.88	100
OTHER	2.37	85.38	0.67	11.01	0.16	1.38	1.60	97.76	0.20	2.24	1.38	100
TOTAL	100.00	49.89	100.00	22.56	100.00	11.89	100.00	84.35	100.00	15.65	100.00	100

Source: Statistikon Corporation.
a/ See text for explanation.

Appendix

Statistical Tables

Table IV.49. Estimated expenditures on spinning equipment in Africa, 1988
(Thousands of dollars)

Country	Short-staple spindles	Long-staple spindles	O-E rotors	Total
Algeria	-	-	-	-
Angola	-	-	-	-
Benin	-	-	-	-
Botswana	-	-	-	-
Burkina Faso	-	-	-	-
Cameroon	-	798	-	798
Chad	-	-	-	-
Congo	-	-	-	-
Côte d'Ivoire	-	-	2 117	2 117
Central African Republic	-	-	-	-
Egypt	29 344	3 165	-	32 509
Ethiopia	1 577	-	5 600	7 177
Ghana	-	-	-	-
Guinea	-	-	-	-
Kenya	1 325	1 720	403	3 448
Libyan Arab Jamahiriya	-	-	-	-
Madagascar	-	-	1 512	1 512
Malawi	-	-	-	-
Mali	-	-	-	-
Mauritius	1 060	-	-	1 060
Morocco	14 573	-	1 747	16 320
Mozambique	-	-	-	-
Niger	-	-	-	-
Nigeria	3 036	-	3 329	6 365
Senegal	-	-	-	-
Somalia	-	-	-	-
South Africa	3 191	5 642	2 117	10 949
Sudan	-	-	-	-
Swaziland	2 623	-	-	2 623
Togo	-	-	-	-
Tunisia	-	-	1 086	1 086
Uganda	-	-	-	-
United Republic of Tanzania	-	-	-	-
Zaire	-	-	-	-
Zambia	951	-	1 210	2 160
Zimbabwe	371	2 [illegible]	1 075	4 308
TOTAL	58 049	14 187	20 196	92 632

Source: Statistikon Corporation.

Table IV.50. Estimated spinning-machinery installations in Africa, 1988

Country or economic grouping	1987 installed capacities: Long-staple spindles	1987 installed capacities: Short-staple spindles	1987 installed capacities: O-E rotors	Cumulative Shipments: 1978-1988 Short-staple spindles	Cumulative Shipments: 1980-1988 Long-staple spindles	Cumulative Shipments: 1979-1988 O-E rotors	1988 Shipments: Short-staple spindles	1988 Shipments: Long-staple spindles	1988 Shipments: O-E rotors
Algeria	300 000	15 000	-	86 876	3 744	-	-	-	-
Angola	50 000	-	-	22 848	-	-	-	-	-
Benin	40 000	-	-	-	-	-	-	-	-
Botswana	15 000	-	1 300	-	-	1 344	-	-	-
Burkina Faso	7 000	-	-	-	-	-	-	-	-
Cameroon	55 000	464	-	5 184	464	168	-	464	-
Chad	8 000	-	-	944	-	-	-	-	-
Congo	11 000	-	-	-	-	-	-	-	-
Côte d'Ivoire	120 000	9 000	900	2 448	896	2 328	-	-	1 512
Central African Republic	23 000	-	-	-	-	-	-	-	-
Egypt	2 957 000	85 000	28 500	879 560	39 388	26 542	106 320	1 840	-

Country or economic grouping	1987 installed capacities: Long-staple spindles	1987 installed capacities: Short-staple spindles	1987 installed capacities: O-E rotors	Cumulative Shipments: 1978-1988 Short-staple spindles	Cumulative Shipments: 1980-1988 Long-staple spindles	Cumulative Shipments: 1979-1988 O-E rotors	1988 Shipments: Short-staple spindles	1988 Shipments: Long-staple spindles	1988 Shipments: O-E rotors
Ethiopia	200 000	-	-	48 144	120	4 000	5 712	-	4 000
Ghana	120 000	-	400	15 912	-	168	-	-	-
Guinea	8 000	-	-	8 568	-	-	-	-	-
Kenya	105 000	4 000	1 200	30 292	2 368	1 488	4 800	1 000	288
Libyan Arab Jamahiriya	-	-	-	200	1 920	-	-	-	-
Madagascar	70 000	-	2 000	19 992	-	2 952	-	1 000	-
Malawi	50 000	-	-	13 632	220	168	-	-	-
Mali	40 000	-	-	-	-	-	-	-	-
Mauritius	-	-	3 840	176	192	3 840	-	-	-
Morocco	326 000	50 000	28 000	100 736	36 904	15 950	52 800	-	1 248
Mozambique	50 000	-	-	14 040	-	-	-	-	-
Niger	14 000	-	-	-	-	-	-	-	-
Nigeria	700 000	-	16 000	186 730	2 648	18 504	11 000	-	2 378
Senegal	40 000	-	-	24 096	-	-	-	-	-
Somalia	20 000	-	-	-	-	-	-	-	-
South Africa	722 000	76 000	19 000	160 278	22 986	13 916	11 560	3 280	1 512
Sudan	500 000	-	18 000	38 904	-	18 000	-	-	-
Swaziland	18 000	-	-	27 648	-	-	9 504	-	-
Togo	26 000	-	-	13 950	-	-	-	-	-
Tunisia	90 500	6 000	3 500	24 578	3 060	6 848	-	-	776
Uganda	60 000	-	400	1 224	-	336	-	-	-
United Republic of Tanzania	400 000	-	-	155 656	2 600	338	-	-	-
Zaire	125 000	-	3 000	-	-	192	-	-	-
Zambia	50 000	-	1 800	24 432	2 648	2 648	3 444	-	864
Zimbabwe	120 000	-	4 000	17 280	2 514	7 352	1 344	1 664	768
Other	-	-	-	4 320	888	-	-	-	-
TOTAL	7 334 000	244 000	128 000	1 932 312	123 544	123 434	210 324	8 248	14 426

Source: Statistikon Corporation.

Table IV.51. Estimated expenditures on spinning equipment in North and South America, 1988

(Thousands of dollars)

Region or country	Short-staple spindles	Long-staple spindles	O-E rotors	Total
North America				
Canada	-	-	5 622	5 622
Costa Rica	-	-	302	302
Cuba	-	-	-	-
El Salvador	3 193	-	2 352	5 545
Guatemala	1 060	-	2 083	3 143
Haiti	-	-	-	-
Jamaica	-	-	-	-
Mexico	9 910	351	14 728	24 988
Nicaragua	-	-	-	-
Puerto Rico	-	-	-	-
United States	62 831	19 133	194 454	276 419
Total North America	76 994	19 484	219 542	316 020
South America				
Argentina	4 333	5 642	2 778	12 752
Bolivia	-	-	-	-
Brazil	60 537	5 194	14 885	80 616
Chile	932	-	-	932
Colombia	753	-	4 614	5 367
Ecuador	159	-	-	159
Paraguay	-	-	-	-
Peru	-	-	1 422	1 422
Uruguay	-	5 834	6 305	-
Venezuela	3 199	12 109	15 982	31 291
Total South America	69 913	28 779	40 152	138 844

Source: Statistikon Corporation.

Table IV.52. Estimated spinning-machinery installations in the Americas, 1988

Region or country	1987 installed capacities			Cumulative shipments			1988 shipments		
	Short staple spindles	Long staple spindles	O-E rotors	1978-1988 Short-staple spindles	1980-1988 Long-staple spindles	1979-1988 O-E rotors	Short spindles	Long-spindles	O-E rotors
North America									
Canada	500 000	60 000	20 000	8 672	7 116	23 046	-	-	4 016
Costa Rica	14 000	-	400	-	-	696	-	-	216
Cuba	300 000	-	-	-	-	-	-	-	-
Dominican Republic	6 000	-	-	-	-	-	-	-	-
El Salvador	215 000	-	2 800	13 200	-	2 846	11 568	-	1 680
Guatemala	140 000	-	10 000	3 840	-	11 732	3 840	-	1 488
Haiti	12 000	-	-	-	-	336	-	-	-
Jamaica	14 000	-	-	-	-	-	-	-	-
Mexico	3 300 000	117 000	39 000	654 866	142 306	51 940	35 904	204	10 520
Nicaragua	41 000	-	-	-	-	-	-	-	-
Puerto Rico	-	-	-	-	-	56	-	-	-
United States	12 636 000	759 000	520 000	672 668	126 683	598 374	227 648	11 124	138 896
Total North America	17 408 000	936 000	592 200	1 393 246	276 105	689 026	278 960	11 328	156 816
South America									
Argentina	1 000 000	350 000	25 000	159 206	35 866	21 072	15 700	3 280	1 984
Bolivia	50 000	-	2 400	1 440	2 780	72	-	-	-
Brazil	5 000 000	200 000	70 000	1 645 407	11 088	62 859	219 337	3 020	10 632
Chile	400 000	-	2 500	33 592	3 632	2 344	3 376	-	-
Colombia	870 000	-	15 000	89 332	19 238	18 136	2 728	-	3 296
Ecuador	200 000	-	6 500	26 370	19 430	6 140	576	-	-
Paraguay	50 000	-	1 000	1 752	-	960	-	-	-
Peru	600 000	70 000	12 000	195 278	30 623	12 572	-	-	1 016
Uruguay	130 000	60 900	2 000	4 000	7 648	2 334		3 392	336
Venezuela	525 000	30 000	14 000	53 648	13 556	21 160	11 592	7 040	11 416
Other	-	-	-	-	3 212	-	-	-	-
Total South America	8 825 000	710 000	150 400	2 210 025	147 073	147 659	253 309	16 732	28 680

Source: Statistikon Corporation.

Table IV.53. Estimated expenditures on spinning equipment in Europe, 1988
(Thousands of dollars)

Country or economic grouping	Short-staple spindles	Long-staple spindles	O-E rotors	Total
EEC				
Belgium	1 987	16 065	6 961	25 013
Denmark	3 378	-	-	3 378
Ireland	-	7 045	235	7 280
France	8 300	7 368	21 750	37 419
Germany, Federal Republic of	20 559	42 883	16 464	79 906
Greece	19 533	6 729	7 750	34 012
Italy	64 686	183 909	47 656	296 251
Netherlands	828	-	907	1 735
Portugal	28 012	27 692	11 077	66 781
Spain	17 688	20 155	28 470	66 314
United Kingdom	235	5 415	5 085	10 735
Total EEC	165 206	317 261	146 356	628 823
EFTA				
Austria	3 133	702	2 789	6 624
Finland	-	-	-	-
Norway	-	-	-	-
Sweden	-	-	2 722	2 722
Switzerland	7 291	29 722	3 046	40 059
Total EFTA	10 424	30 423	8 557	49 404

Country or economic grouping	Short-staple spindles	Long-staple spindles	O-E rotors	Total
CMEA				
Bulgaria	-	826	7 728	8 554
Czechoslovakia	3 338	-	-	3 338
German Democratic Republic	087	25 043	7 538	32 668
Hungary	-	743	3 920	4 663
Poland	-	-	19 320	19 320
Romania	-	-	10 640	10 640
USSR	1 214	28 731	551 902	581 848
Yugoslavia	4 195	21 328	5 645	31 168
Total CMEA	8 835	76 671	606 693	692 199
Other Europe				
Turkey	27 410	25 105	15 042	67 557
TOTAL	211 875	449 460	776 647	1 437 983

Source: Statistikon Corporation.

Table IV.54. Estimated spinning-machinery installations in Europe, 1988

Country or economic grouping	1987 installed capacities: Long-staple spindles	1987 installed capacities: Short-staple spindles	1987 installed capacities: O-E rotors	Cumulative Shipments: 1979-1988 Short-staple spindles	Cumulative Shipments: 1980-1988 Long-staple spindles	Cumulative Shipments: 1979-1988 O-E rotors	1988 Shipments: Short-staple spindles	1988 Shipments: Long-staple spindles	1988 Shipments: O-E rotors
EEC									
Belgium	245 000	235 000	34 600	24 000	29 070	38 380	7 200	9 340	4 972
Denmark	28 000	-	400	12 240	376	-	12 240	-	-
Ireland	60 000	17 738	5 000	28 064	17 738	4 032	-	4 096	168
France	1 051 000	501 000	112 000	210 940	38 802	108 528	30 072	4 284	15 536
Germany, Federal Republic of	1 752 000	602 000	124 000	374 496	221 148	140 916	74 488	24 932	11 760
Greece	1 250 000	300 000	40 000	304 844	10 882	25 844	70 772	3 912	5 536
Italy	2 106 000	3 678 000	78 800	1 154 036	779 911	161 772	234 368	106 924	34 040
Netherlands	62 000	24 000	6 800	13 104	1 429	6 356	3 000	-	648
Portugal	1 500 000	400 000	25 000	496 540	64 054	30 148	101 492	16 100	7 912
Spain	1 734 000	515 000	70 200	314 496	92 692	194 838	64 088	11 718	20 336
United Kingdom	770 000	578 000	45 000	43 680	39 858	21 268	0 852	3 148	3 632
Other	-	-	-	-	2 876	-	-	-	-
Total EEC	10 558 000	6 850 738	541 800	2 976 440	1 298 840	642 082	598 572	184 454	104 540
EFTA									
Austria	350 090	64 000	10 900	176 952	27 892	14 350	11 352	408	1 992
Finland	23 000	25 000	4 000	7 920	5 330	2 792	-	-	-
Norway	4 000	25 000	2 600	-	1 666	632	-	-	-
Sweden	12 000	19 000	3 300	9 600	398	3 084	-	-	1 944
Switzerland	703 000	74 000	10 400	264 072	37 218	12 624	26 416	17 280	2 176
Total EFTA	1 092 000	207 000	31 200	458 544	72 504	33 482	37 768	17 688	6 112
CMEA									
Bulgaria	650 000	6 490	35 000	-	6 490	17 240	-	480	5 520
Czechoslovakia	1 653 000	2 766	279 800	12 096	2 766	35 292	12 096	-	-
German Democratic Republic	1 000 000	28 018	100 000	36 548	28 018	79 568	316	14 560	5 384
Hungary	533 000	134 000	43 200	-	13 828	19 588	-	432	2 800
Poland	1 512 000	485 000	160 000	33 648	-	162 760	-	-	13 800
Romania	720 000	-	80 000	-	-	77 944	-	-	7 600
USSR	10 000 000	22 968	4 000 000	4 400	22 968	4 612 177	4 400	16 704	394 216
Yugoslavia	1 477 000	21 477	47 500	22 264	21 477	21 776	15 200	12 400	4 032
Total CMEA	17 545 000	700 719	4 745 500	108 956	95 547	5 026 345	32 012	44 576	433 352
Other Europe									
Turkey	3 751 000	605 000	94 700	684 116	188 950	84 416	99 312	14 596	10 744
Other	-	-	-	138 337	11 460	320	-	-	-
Total other Europe	3 751 000	605 000	94 700	822 453	200 410	84 736	99 312	14 596	10 744
TOTAL	32 946 000	8 363 457	5 413 200	4 366 393	1 667 301	5 786 645	767 664	261 314	554 748

Source: Statistikon Corporation.

Table IV.55. Estimated expenditures on spinning equipment, in Asia and Oceania
(Thousands of dollars)

Country or area	Short-staple spindles	Long-staple spindles	O-E rotors	Total
Australia	-	1 665	6 350	8 015
Bangladesh	6 403	4 954	3 360	14 717
China	31 490	61 493	86 598	179 582
Cyprus	-	-	-	-
Dubai	-	-	-	-
Hong Kong	197	-	-	-
India	172 184	33 182	26 074	231 440
Indonesia	112 652	14 586	7 022	34 260
Iran (Islamic Republic of)	-	-	-	-
Iraq	-	-	-	-
Israel		2 559	1 781	4 340
Japan	168 071	178 742	8 842	355 656
Lebanon	-	-	-	-
Malaysia	338	-	1 680	2 018
Myanmar	-	-	-	-
New Zealand	-	-	-	-
Pakistan	106 129		16 733	122 861
Philippines	2 815	16 540	6 272	25 627
Republic of Korea	27 993	88 023	15 926	13[illegible] 942
Singapore	2 810		13 720	16 530
Sri Lanka	-	-	-	-
Syrian Arab Republic	-	-	28[illegible]	280
Taiwan Province	72 081	48 126	39 626	[illegible]59 832
Thailand	56 960	10 802	15 579	83 341
Viet Nam	3 886	-	-	3 886
TOTAL	664 009	460 671	254 682	1 379 362

Source: Statistikon Corporation.

Table IV.56. Estimated spinning machinery installations in Asia and Oceania, 1988

Country or area	1987 installed capacities			Cumulative shipments			1988 shipments		
	Short-staple	Long-staple	O-E rotors	1979-1988 Short-staple spindles	1980-1984 Long-staple spindles	1979-1988 O-E rotors	Short staple spindles	Long-staple spindles	O-E rotors
Australia	105 000	55 000	13 600	7 072	9 070	11 881	-	968	4 536
Bangladesh	1 300 000	3 360	1 200	116 992	3 360	4 200	23 200	2 880	2 400
China	26 000 000	1 800 000	140 000	366 700	193 026	198 828	114 096	35 752	61 856
Cyprus	-	900	-	-	900	-	-	-	-
Dubai	-	2 498	-	-	2 496	-	-	-	-
Hong Kong	255 000	24 000	69 500	78 694	2 220	120 100	712	-	3 456
India	26 264 000	550 000	19 300	7 021 372	422 360	45 796	623 855	19 292	18 624
Indonesia	2 550 000	16 596	23 100	754 164	16 596	24 056	45 840	8 480	5 016
Iran (Islamic Republic of)	1 100 000	60 000	38 000	44 864	19 744	22 904	-	-	-
Iraq	212 000	15 000	2 500	11 208	2 544	2 695	-	-	-
Israel	110 000	35 000	8 000	21 548	6 200	9 396	-	1 488	1 272
Japan	8 754 000	1 738 000	179 000	1 732 116	198 618	75 096	608 952	103 920	6 316
Lebanon	85 000	300	3 000	-	300	-	-	-	-
Malaysia	400 000	-	2 276	87 576	-	2 278	1 224	-	1 200
Myanmar	150 000	-	-	-	-	-	-	-	-
New Zealand	-	70 000	-	-	6 890	-	-	-	-
Pakistan	4 346 000	32 264	52 800	1 098 908	32 264	55 648	384 524	-	11 952

Country or area	1987 installed capacities			Cumulative shipments			1988 shipments		
	Short-staple	Long-staple	O-E rotors	1979-1988 Short-staple spindles	1980-1988 Long-staple spindles	1979-1988 O-E rotors	Short staple spindles	Long-staple spindles	O-E rotors
Philippines	1 500 000	12 016	16 000	194 824	12 016	15 388	10 200	9 616	4 480
Republic of Korea	3 457 000	1 057 000	34 900	1 138 555	203 288	42 426	101 424	51 176	11 376
Singapore	80 000	15 000	7 000	10 180	2 556	14 840	10 180	-	9 800
Sri Lanka	250 000	-	200	33 152	-	200	-	-	-
Syrian Arab Republic	538 000	150 000	24 200	672	-	248	-	-	200
Taiwan Province	3 955 000	125 934	121 600	1 538 438	125 934	125 638	261 164	27 980	28 304
Thailand	2 000 000	21 488	20 000	545 789	21 488	31 318	206 377	6 280	11 128
Viet Nam	281 104	-	800	281 104	-	800	14 080	-	-
Other	324	14 842	5 400	324	14 842	5 400	-	-	-
TOTAL	83 692 428	5 799 198	782 376	15 084 252	1 296 712	809 136	2 405 828	267 832	181 916

Source: Statistikon Corporation.

Table IV.57. Estimated expenditures on weaving equipment in Africa, 1988

(Thousands of dollars)

Country	Shuttleless looms				Shuttle looms	Total
	Rapier and projectile	Air-jet	Water-jet	Total		
Algeria	1 440	-	-	1 440	-	1 440
Angola	-	-	-	-	-	-
Benin	-	-	-	-	-	-
Botswana	-	-	-	-	-	-
Burkina Faso	-	-	-	-	-	-
Cameroon	-	-	-	-	-	-
Central African Republic	-	-	-	-	-	-
Chad	-	-	-	-	-	-
Congo	-	-	-	-	-	-
Côte d'Ivoire	-	-	-	-	-	-
Egypt	6 885	-	1 760	8 645	5 356	14 001
Ethiopia	9 990	-	-	9 990	1 040	11 030
Ghana	-	-	-	-	-	-
Guinea	-	-	-	-	-	-
Kenya	360	-	-	360	-	360
Libya	-	-	-	-	-	-
Madagascar	-	-	-	-	-	-
Malawi	-	-	240	240	-	240
Mali	-	-	-	-	-	-
Mauritius	2 880	-	-	2 880	-	2 880
Morocco	7 020	-	-	7 020	-	7 020
Mozambique	-	-	-	-	-	-
Niger	-	-	-	-	-	-
Nigeria	4 815	-	-	4 815	-	4 815
Senegal	-	-	-	-	-	-
Somalia	-	-	-	-	-	-
South Africa	1 845	-	1 600	3 445	-	3 445
Sudan	-	-	-	-	-	-
Swaziland	-	-	1 680	1 680	-	1 680
Togo	-	-	-	-	-	-
Tunisia	2 295	-	1 120	3 415	-	3 415
Uganda	-	-	-	-	-	-
United Republic of Tanzania	-	-	-	-	-	-
Zaire	-	-	-	-	-	-
Zambia	-	-	-	-	-	-
Zimbabwe	180	-	-	180	-	180
Other	3 510	-	1 000	4 510	-	4 510
TOTAL	41 220		7 400	48 520	6 396	55 016

Source: Statistikon Corporation.

Table IV.58. Estimated weaving installations and machinery modernization in Africa, 1988

Country	1988 installed weaving capacities						
	Looms primarily for weaving yarns spun on the Cotton System		Filament weaving looms	Wool weaving looms	Total shuttle and shuttleless looms a/	Percentage of new b/ loom installations, 1979-1988	
	Total	Shuttleless				Shuttle	Shuttleless
		-	-	-	-	-	-
Algeria	10 532	2 032	-	-	10 532	758	1 817
Angola	860	60	-	-	860	2 570	23
Benin	1 500	-	-	-	1 500	-	-
Botswana	120	120	-	-	120	-	10 000
Burkina Faso	200	-	-	-	200	100	-
Cameroon	1 200	200	-	-	1 200	667	667
Central African Republic	500	-	-	-	500	2 000	-
Chad	280	-	-	-	280	-	-
Congo	190	-	-	-	190	-	-
Côte d'Ivoire	2 630	630	-	-	2 630	1 589	555
Egypt	58 823	3 617	-	1 230	60 053	1 195	593
Ethiopia	3 312	322	-	-	3 312	242	797
Ghana	3 640	30	-	-	3 640	5	-
Guinea	180	-	-	-	180	10 222	-
Kenya	1 718	218	-	-	1 718	594	728
Libyan Arab Jamahiriya	3 000	400	-	-	3 000		1 403
Madagascar	1 930	200	-	-	1 930	1 218	834
Malawi	666	66	-	-	666	-	991
Mali	1 120	-	-	-	1 120	-	-
Mauritius	64	64	-	-	64	5 313	10 938
Morocco	6 056	1 156	-	-	6 056	-	2 614
Mozambique	2 450	20	-	-	2 450	4	82
Niger	280	-	-	-	280	214	-
Nigeria	19 257	2 257	-	-	19 257	399	752
Senegal	650	150	-	-	650	308	2 092
Somalia	430	150	-	-	430	-	
South Africa	5 881	3 381	-	1 020	6 901	407	2 734
Sudan	10 000	-	-	-	10 000	1 506	08
Swaziland	42	42	-	-	42	-	10 000
Togo	-	-	-	-	-	-	-
Tunisia	4 779	1 079	-	-	4 779	190	1 710
Uganda	1 480	240	-	-	1 480	2 338	-
United Republic of Tanzania	5 150	150	-	-	5 150	2 229	307
Zaire	2 790	090	-	-	2 790	638	330
Zambia	1 140	140	-	-	1 140	2 061	1 263
Zimbabwe	1 954	354	-	-	1 954	174	1 592
Other	103	103	-	-	103	7 767	14 854
TOTAL	154 907	17 271		2 250	157 157	909	874

Source: Statistikon Corporation.
a/ Including filament and wool weaving looms.
b/ 10 years old or less.

Table IV.59. Estimated expenditures on weaving equipment in the Americas, 1988
(Thousands of dollars)

Country or area	Shuttleless looms				Shuttle looms	Total
	Rapier and projectile	Air-jet	Water-jet	Total		
North America						
Canada	6 210	5 200	-	11 410	-	11 410
Costa Rica	-	1 200	-	1 200	-	1 200
Cuba	-	-	-	-	-	-
Dominican Republic	-	-	-	-	-	-
El Salvador	270	880	-	1 150	-	1 150
Guatemala	990	1 280	40	2 310	-	2 310
Haiti	-	-	-	-	-	-
Honduras	-	-	-	-	-	-

Country or area	Shuttleless looms				Shuttle looms	Total
	Rapier and projectile	Air-jet	Water-jet	Total		
Jamaica	-	-	-	-	-	-
Mexico	11 610	46 240	5 920	63 770	3 276	67 046
Nicaragua	-	-	-	-	-	-
Puerto Rico	-	-	-	-	-	-
United States	63 945	57 280	1 120	122 345	-	122 345
Total North America	83 025	112 080	7 080	202 185	3 276	205 461
South America						
Argentina	7 245	7 040	-	14 285	-	14 285
Bolivia	-	-	-	-	-	-
Brazil	50 625	2 440	-	53 065	8 788	61 853
Chile	945	-	-	945	-	945
Colombia	4 455	2 880	360	7 695	-	7 695
Ecuador	900	240	840	1 980	-	1 980
Paraguay	-	-	-	-	-	-
Peru	945	-	40	985	-	985
Uruguay	1 440	480	-	1 920	-	1 920
Venezuela	9 045	960	-	10 005	-	10 005
Total South America	75 600	14 040	1 240	90 880	8 788	99 668

Source: Statistikon Corporation.

Table IV.60. Estimated weaving installations and machinery modernization in the Americas, 1988

Country or area	1988 installed weaving capacities					Percentage of new[b] loom installations, 1979-1988	
	Looms primarily for weaving yarns spun on the Cotton System		Filament weaving looms	Wool weaving looms	Total shuttle and shuttleless looms[a]		
	Total	Shuttleless				Shuttle	Shuttleless
North America							
Canada	11 638	2 638	-	350	11 988	72	1 195
Costa Rica	1 330	70	-	-	1 330		556
Cuba	6 700	-	-	-	6 700	6	-
Dominican Republic	720	170	-	-	720	3 500	111
El Salvador	3 228	128	-	-	3 228		242
Guatemala	3 485	305	-	-	3 485	204	878
Haiti	500	-	-	-	500	800	-
Honduras	-	-	-	-	-	-	-
Jamaica	520	-	-	-	520	154	-
Mexico	46 548	10 772	14 000	1 340	61 888	246	1 401
Nicaragua	1 010	160	-	-	1 010		158
Puerto Rico	-	-	-	-	-	-	-
United States	140 841	67 321	-	2 050	142 891	104	2 790
Total North America	216 520	81 564	14 000	3 740	234 260	151	2 154
South America							
Argentina	21 837	3 837	-	5 700	27 537	56	871
Bolivia	1 170	20	-	-	1 170	547	205
Brazil	138 524	8 186	-	15 000	153 524	440	324
Chile	8 571	521	-	-	8 571	86	406
Colombia	12 880	2 480	-	-	12 880	110	1 296
Ecuador	3 697	697	-	-	3 697	65	1 664
Paraguay	800	50	-	-	800	-	163
Peru	8 022	1 022	-	-	8 022	42	1 396
Uruguay	1 924	424	-	770	2 694	178	1 162
Venezuela	8 225	2 225	-	-	8 225	7	2 457
Total South America	205 650	19 462	-	21 470	227 120	354	591

Source: Statistikon Corporation.

a/ Including filament and wool weaving looms.

b/ 10 years old or less.

Table IV.61. Estimated expenditures on weaving equipment in Europe, 1988
(Thousands of dollars)

Country or economic grouping	Shuttleless looms				Shuttle looms	Total
	Rapier and projectile	Air-jet	Water-jet	Total		
EEC						
Belgium	27 855	4 840	-	32 695	-	32 695
Denmark	135	-	-	135	-	135
Ireland	405	-	-	405	-	405
France	35 595	31 320	3 080	69 995	-	69 995
Germany, Federal Republic of	69 615	26 680	-	96 295	-	96 295
Greece	2 835	280	-	3 115	-	3 115
Italy	168 975	28 520	4 120	201 615	-	201 615
Netherlands	1 800	40	-	1 840	-	1 840
Portugal	22 410	3 880	240	26 530	-	26 530
Spain	45 765	4 240	-	50 005	-	50 005
United Kingdom	14 535	7 240	2 240	24 015	-	24 015
Total	389 925	107 040	9 680	506 645	-	506 645
EFTA						
Austria	7 830	400	-	8 230	-	8 230
Finland	405	-	-	405	-	405
Norway	270	-	-	270	-	270
Sweden	1 035	-	-	1 035	-	1 035
Switzerland	8 595	320	-	8 915	-	8 915
Total	18 135	720	-	18 855	-	18 855
CMEA						
Bulgaria	3 330	40	-	3 370	-	3 370
Czechoslovakia	13 725	-	-	13 725	-	13 725
German Democratic Republic	18 540	1 760	4 000	24 300	-	24 300
Hungary	4 185	-	-	4 185	-	4 185
Poland	3 600	7 400	7 920	18 920	156	19 076
Rumania	6 750	-	6 000	12 750	-	12 750
USSR	10 350	46 120	-	56 470	-	56 470
Yugoslavia	11 610	2 920	-	14 530	-	14 530
Total CMEA	72 090	58 240	17 920	148 250	156	148 406
Other Europe						
Turkey	29 790	3 840	480	34 110	780	34 890
TOTAL	509 940	169 840	28 080	707 860	936	708 796

Source: Statistikon Corporation.

Table IV.62. Estimated weaving installations and machinery modernization in Europe, 1988

Country or economic grouping	1988 installed weaving capacities					Percentage of new[b] loom installations, 1979-1988	
	Looms primarily for weaving yarns spun on the Cotton System		Filament weaving looms	Wool weaving looms	Total shuttle and shuttleless looms[a]	Shuttle	Shuttleless
	Total	Shuttleless					
EEC							
Belgium	10 140	5 940	2 000	200	12 340	0.35	48.33
Denmark	723	183	-	-	723	-	5.12
Ireland	1 259	909	-	-	1 259	5.64	27.64
France	16 761	11 891	10 000	3 310	30 071	0.77	44.02
Germany, Federal Republic of	21 814	14 704	5 210	2 690	29 714	1.32	61.50
Greece	10 740	3 240	-	2 800	13 540	0.36	14.16
Italy	29 801	20 031	15 000	23 900	68 701	0.53	55.47
Netherlands	1 941	1 241	-	290	2 231	2.06	19.68
Portugal	23 601	7 601	-	4 000	27 601	1.59	17.16
Spain	18 203	7 343	6 940	5 900	31 043	1.32	35.48
United Kingdom	13 760	5 710	-	4 510	18 270	2.21	21.75
Total EEC	148 743	78 793	39 150	47 600	235 493	1.04	41.64

Country or economic grouping	1988 installed weaving capacities: Looms primarily for weaving yarns spun on the Cotton System – Total	Shuttleless	Filament weaving looms	Wool weaving looms	Total shuttle and shuttleless looms a/	Percentage of new b/ loom installations, 1979-1988: Shuttle	Shuttleless
EFTA							
Austria	2 664	1 904	-	540	3 204	1.31	68.32
Finland	559	559	300	300	1 159	1.21	44.61
Norway	[illegible]	[illegible]	-	-	496	-	24.19
Sweden	283	283	180	340	803	2.12	44.71
Switzerland	4 469	1 649	1 190	380	6 039	2.09	34.18
Total EFTA	8 471	4 641	1 670	1 560	11 701	1.70	44.86
CMEA							
Bulgaria	14 475	3 475	-	-	14 475	0.07	8.48
Czechoslovakia	26 905	5 105	-	-	26 905	2.45	6.96
German Democratic Republic	26 916	4 416	-	-	26 916	0.09	11.92
Hungary	7 853	3 263	-	1 070	8 923	0.03	6.50
Poland	27 879	12 803	-	5 400	33 279	0.43	3.51
Romania	13 650	1 650	-	-	13 650	3.22	6.81
USSR	261 383	161 383	20 000	20 000	301 383	-	12.25
Yugoslavia	21 711	2 941	-	-	21 711	0.59	12.8[illegible]
Total CMEA	400 772	195 036	20 000	26 470	447 242	0.31	10.89
Other Europe							
Turkey	48 460	5 930	-	5 190	53 650	3.60	11.92
TOTAL	606 446	284 400	60 820	80 820	748 086	0.80	21.20

Source: Statistikon Corporation.
a/ Including filament and wool weaving looms.
b/ 10 years old or less.

Table [illegible].63. Estimated expenditures on weaving equipment, in Asia and Oceania, 1988
(Thousands of dollars)

Country or area	Shuttleless looms: Rapier and projectile	Air-jet	Water-jet	Total	Shuttle looms	Total
Australia	4 005	-	-	4 005	-	4 005
Bangladesh	-	-	-	-	1 898	1 898
China	165 960	12 360	4 800	183 120	416	183 536
Cyprus	90	-	-	90	-	90
Hong Kong	17 730	-	-	17 730	-	17 730
India	12 870	5 720	280	18 870	169 754	188 624
Indonesia	46 530	4 800	8 000	59 330	7 774	67 104
Iran (Islamic Republic of)	1 080	12 480	-	13 560	-	13 560
Iraq	990	-	-	990	26	1 016
Israel	1 440	200	-	1 640	-	1 640
Japan	116 280	114 760	48 200	279 240	17 550	296 790
Jordan	90	-	-	90	-	90
Kuwait	-	-	-	-	-	-
Lebanon	-	-	-	-	-	-
Malaysia	720	6 360	80	7 160	-	7 160
Myanmar						
Nepal	-	-	-	-	624	624
New Zealand						
Pakistan	20 160	4 840	-	25 000	14 378	3[illegible] 378
Philippines	7 740	-	-	7 740	-	7 740
Republic of Korea	94 365	25 840	96 840	217 045	156 260	373 305
Singapore						
Sri Lanka						
Syria	1 575	-	-	1 575	3 120	4 695
Taiwan Province	36 720	67 800	95 760	200 280	-	200 280
Thailand	16 380	9 560	6 800	32 740	-	32 740
Viet Nam	1 800	-	-	1 800	-	1 800
Yemen	315	-	-	315	-	315
Other	2 250	1 200	2 960	6 410	3 744	10 154
TOTAL	549 090	265 920	263 720	1 078 730	375 544	1 454 274

Source: Statistikon Corporation.

Table IV.64. Estimated weaving installations and machinery modernization in Asia and Oceania, 1988

Country or area	1988 installed weaving capacities						
	Looms primarily for weaving yarns spun on the Cotton System		Filament weaving looms	Wool weaving looms	Total shuttle and shuttleless looms a/	Percentage of new b/ loom installations, 1979-1988	
	Total	Shuttleless				Shuttle	Shuttleless
Australia	1 279	1 099	-	280	1 559	1.22	59.97
Bangladesh	8 693	120	-	-	8 693	50.36	0.10
China	729 133	19 117	150 000	25 700	904 833	0.31	1.92
Cyprus	20	2	-	-	20	90.00	15.00
Hong Kong	17 394	7 394	-	-	17 394	2.63	45.09
India	215 175	2 166	330 000	5 550	550 725	7.45	0.80
Indonesia	103 353	8 054	-	-	103 353	12.77	7.23
Iran (Islamic Republic of)	25 536	3 536	-	-	25 536	5.65	9.43
Iraq	4 213	362	-	-	4 213	3.82	12.84
Israel	4 607	1 107	-	50	4 657	1.98	17.24
Japan	226 203	44 328	147 850	23 120	397 173	5.99	13.74
Jordan	2	2		380	382	0.26	14.40
Kuwait							
Lebanon	1 950	50	-	-	1 950	-	0.26
Malaysia	8 077	477	-	-	8 077	8.89	5.40
Myanmar	4 630	30	-	-	4 630	-	
Nepal	1 084	60	-	-	1 084	43.17	5.35
New Zealand	-	-	-	-	-	-	-
Pakistan	17 922	3 563	48 000	-	65 922	4.35	2.01
Philippines	25 472	1 472	-	-	25 472	2.17	3.35
Republic of Korea	93 174	17 164	110 000	6 400	209 574	33.02	11.32
Singapore	1 000	250	-	-	1 000	-	26.40
Sri Lanka	10 220	70	-	-	10 220	2.05	1.63
Syrian Arab Republic	2 615	1 495	-	-	2 615	34.11	27.76
Taiwan Province	78 665	31 635	14 180	1 300	94 145	11.06	36.49
Thailand	62 173	2 173	-	-	62 173	3.17	3.50
Viet Nam	80	40	-	-	80	127.50	100.00
Yemen	47	7	-	-	47	-	100.00
Other	2 594	154	-	-	2 594	62.14	45.57
TOTAL	1 645 311	145 933	800 030	62 780	2 508 121	6.96	6.45

Source: Statistikon Corporation.

a/ Including filament and wool weaving looms.

b/ 10 years old or less.

D. Phosphates (ISIC 3512)*

1. *Recent trends and current conditions*

Over 85 per cent of the phosphate ore mined throughout the world is processed to be used in fertilizers. Phosphorus is one of the three major components of fertilizers, the others being nitrogen and potassium. Phosphorus is also used as an animal feed additive and a detergent additive, and has important industrial applications. Three distinctive processing stages can be identified in the phosphate industry. The first two stages consist of raw material production and intermediate fertilizer manufacture. At the raw material production stage, phosphate rock ranging from 26 per cent to about 34 per cent phosphorous pentoxide (P_2O_5) is the beneficiated product of phosphate ore rather than the *in situ* material. The most common intermediate fertilizer materials are phosphoric acid, ammonium phosphates, triple superphosphate and normal superphosphate.

*UNIDO acknowledges the contribution of B. Bochum, Department of Mineral Resource Economics, West Virginia University.

Phosphatic fertilizers refer to the group of products at the second processing stage, which are not normally distinguished individually. The third stage of processing involving fertilizer mixing and blending is not considered in this section, since an investigation of the processing of the other two components in fertilizer mixing, namely nitrogen and potassium, would also be required. In section A, on the chemical industry, the subject of fertilizers is also discussed.

The phosphate rock and phosphatic fertilizer industries have been historically stable. Before 1960, prices, output and investment did not exhibit the cyclical swings common to other industries. This pattern abruptly changed in the 1960s, when over-capacity developed. The growth of phosphatic fertilizer trade since the mid-1960s has transformed the industry from a relatively regionalized type of business without much financial cyclicality, to an interdependent international operation, with rather pronounced cyclicality. The causes of cyclicality in the past have been mostly changing patterns of inflation and recession. In the United States, price movements have been more closely connected with swings in crop prices. As most phosphatic fertilizer export surpluses continue to be held by Morocco and the United States, market competition has been effectively limited, with prices rising by around $5 per tonne over the past two years to a 1988 level of $112 per tonne. Although the current price levels give most established producers a relatively good return compared with production costs, prices are not seen as sufficiently high to replace existing capacity. New capacity at present requires about 30 per cent higher price levels in order to be economic.

The growing diversity of the world fertilizer production base makes it difficult to control supply. Phosphate manufacturing plants have increased production to meet rising world demand. With the exception of Christmas Island, which ceased production in 1987, production rose world-wide in 1988. In some 31 countries in 1988, output amounted to 143 million tonnes, about 5 per cent higher than in 1987. The most significant production increases occurred in the United States and Morocco. West African producers also increased output in 1988, despite decreases in net sales by Togo to Western Europe. Senegal increased its sales as a result of increased exports to the Philippines. Togo balanced its losses with the Netherlands and United States markets by increasing trade with Australia, Canada, Philippines and Poland. In the United States, many plants have reopened. Elsewhere, plants intended for capacity expansion are being completed.

The phosphate rock export market is steadily gaining strength. Exports rose in 1988, mainly owing to improvements in Morocco and West Africa. In the United States, the export trend is rising thanks to increased sales to Northern Europe (Norway and the Netherlands), Asia (India and Japan) and Australia. Canada, however, reduced its purchases of United States phosphate to the benefit of overseas competitors. United States exports to Canada decreased from 1.5 million tonnes in 1987 to 1.2 million tonnes in 1988. Following a period of increasing growth, exporters in North Africa and Western Asia recorded a slight decrease in 1988. Jordan managed to maintain sales at the 1987 level, and sales by Syria rose by 0.3 million tonnes. Other exporters in the region have been less fortunate, with a total loss of 0.4 million tonnes. Morocco, owing to increased trade with Southern Europe (in particular Spain and Italy), Mexico and the United States, considerably increased its exports in 1988. On the other hand, increased government intervention in almost all domestic markets has hampered free trade.

Fertilizer demand is determined by the many diverse factors (including weather and government policy) affecting the agricultural and industrial consuming industries, rather than by producers and suppliers. Phosphate usage has thus become more susceptible to basic crop economics. For example, the degree of decline of the phosphatic fertilizer market in the United States and Western Europe from 1981 to 1987 increased significantly as a result of the deliberate curtailing of applications by growers attempting to minimize fertilizer costs. Phosphate rock consumption has been relatively depressed in recent years because of the high levels of grain stocks in key consuming areas, such as North America and Western Europe, and the resultant low level of grain prices and the compulsory set-aside of land, both of which tend to depress fertilizer usage. However, in the United States, as a result of a persistant drought that reduced the output of many crops, particularly cereals, in 1988, cereal stocks have been reduced from their previous heights to below acceptable levels, and grain prices have risen. Such factors have caused an increase in fertilizer usage, which will undoubtedly persist in the United States beyond 1990. World-wide, the economic recovery of the past few years has affected the consumption of fertilizers positively, especially that of developing countries. In 1988, consumption rose by 3 per cent. The general economic recovery has led to sustainable growth in individual branches of the phosphate industry.

In 1988, the overall good climate of the phosphate industry did not significantly affect imports into Western Europe. Plant closures in France, Federal Republic of Germany, Spain and United Kingdom, together with the recent environmental legislation and agricultural policies of the EEC, have negatively affected imports into the region. With the exception of the United States, other trading partners decreased exports to Western Europe in 1988. Eastern European countries were the second largest buyers of phosphate rock in 1988. Consumption increases stimulated imports in Bulgaria, Czechoslovakia and Yugoslavia. In Oceania, improvements in the crop export market increased imports of phosphate rock.

(a) *Production of phosphate rock*

World production of phosphate rock increased by 1.2 per cent in 1988 over the previous year, reaching 143.2 million tonnes. This figure is slightly higher than output in 1980, reflecting attempts to curtail oversupply, which precluded all but essentially new investment throughout the 1980s, and in fact led to a net reduction in capacity in the market economy countries in 1988. As a result, capacity utilization in the market economy countries increased from 73 per cent in 1987 to 78 per cent in 1988. This represents a relatively high level of capacity employment, and is one reason for the continued rise in international phosphate rock prices. Phosphate rock production in the top 20 producer countries is reflected in table IV.65. Production increases have been more pronounced in the South, where producers regularly increased capacity during the 1980s. The share of developing countries in total world output increased from 30.6 per cent in 1980 to 36 per cent in 1988, about 3 percentage points higher than that of the North. Centrally planned economies also increased their share of output during the same period. The United States, the USSR and Morocco accounted for around 70 per cent of production in 1988.

The United States is still the largest producer, although its output fell by 30 per cent between 1980 and 1988. A small change of 1.5 per cent occurred in 1988, reflecting an industry upswing. Among the individual states, Florida and North Carolina lead the country in output. Since the mines in Florida are likely to be exhausted by the turn of the century, the anticipated inability of the United States industry to maintain phosphate rock and fertilizer exports will have a serious impact on the world supply. In other developed countries, South Africa decreased its output by 25 per cent between 1980 and 1988; the output of

Table IV.65. World production of phosphate rock, 1980 and 1988

Rank in 1988	Country, area, region or economic grouping	1988 production (thousands of tonnes)	Percentage change 1987-88	Percentage change 1980-88	Percentage share 1980	Percentage share 1988
1	United States	40 954	1.5	30.3	39.59	28.60
2	USSR	34 800	1.0	29.1	17.94	24.30
3	Morocco	21 328	0.5	11.7	13.70	14.89
4	China	9 000	-8.8	-19.2	7.80	6.28
5	Jordan	6 845	8.7	42.9	2.84	4.78
6	Tunisia	6 216	6.7	27.6	3.27	4.34
7	Brazil	4 777	5.6	38.8	2.12	3.33
8	Israel	2 731	7.8	15.5	1.62	1.91
9	Togo	2 644	12.5	-10.9	2.13	1.85
10	South Africa	2 623	14.0	-25.1	2.39	1.83
11	Syrian Arab Republic	2 227	27.9	40.8	0.96	1.55
12	Senegal	1 880	1.5	22.4	1.06	1.31
13	Nauru	1 376	-8.6	-51.7	1.52	0.96
14	Egypt	1 103	-15.3	40.3	0.48	0.77
15	Algeria	1 073	-12.1	4.5	0.74	0.75
16	Christmas Island	842	2.0	-70.8	1.04	0.59
17	Mexico	640	6.3	48.4	0.24	0.45
18	Finland	553	4.7	77.4	0.09	0.39
19	Republic of Korea	500	-	0.0	0.36	0.35
20	India	450	-8.0	8.2	0.30	0.31
	North America	40 954	1.5	-30.3	38.82	28.60
	Western Europe	774	7.1	73.1	0.15	0.54
	Oceania	10	-250.0	-	-	-
	Other developed economies	5 354	-2.9	-4.4	4.07	3.74
	Africa	33 315	1.7	13.3	21.01	23.26
	Latin America	5 550	6.7	41.1	2.38	3.87
	North Africa and Western Asia	9 954	8.3	40.6	4.30	6.95
	East Asia	476	-6.3	13.2	0.30	0.33
	Other developing economies	2 218	-4.6	-58.9	2.56	1.55
	Centrally planned economies a/	44 600	-1.0	18.6	26.40	31.14
	Total North b/	47 092	1.1	-25.6	43.04	32.88
	Total South b/	51 513	3.2	18.5	30.55	35.97
	TOTAL	143 205	1.2	4.0	100.00	100.00

Source: Fertilizer Yearbook (various issues) (Rome, Food and Agriculture Organization of the United Nations).

a/ Including the USSR.

b/ Excluding centrally planned economies.

Oceania was also down by 250 per cent from its 1987 level; and Western Europe substantially increased its output from 208,000 tonnes to 774,000 tonnes between 1980 and 1988. Other major increases were achieved in 1988 by Israel, with 7.8 per cent, and Finland, with 4.5 per cent.

Turning to developing countries, phosphate rock production in Africa was up 13.3 per cent owing to sizeable increases in Tunisia and Senegal, amounting to some 28 per cent and 22 per cent, respectively, between 1980 and 1988. Algeria also experienced a moderate increase of 4.5 per cent during the same period. Morocco, with the largest reserves (approximately 21 billion tonnes compared with a world total of 35 billion tonnes) is the third largest producer in the world. Its 1988 output level of 21.3 million tonnes represents a jump of 12 per cent from 1980. Latin American output was also up 41 per cent during the same period, while North Africa and Western Asia and East Asia exhibited similar trends. In other developing countries, output decreased by more than one half from 1980 to 1988.

In the USSR, the production of phosphate rock is estimated to have reached 34.8 million tonnes in 1988, a growth of only 1 per cent over the 1987 level. The major supply source for phosphate rock is the Kola Peninsula, where the mining environment is extremely hostile. Because of the steadily rising cost of production, phosphate rock recovery profiles for the USSR are expected to continue to deteriorate during the 1990s, when considerable replacement capacity will be needed. In China, the fourth largest rock producer in the world, phosphate output was down from its 1980 level by 19 per cent. To reduce its demand-to-supply imbalance, the country planned to develop the Wengfu Mine in Guishow Province, which would increase production by an additional 2.5 million tonnes per year.

The following supply conditions exist in the remaining producer countries. Jordan increased its production by 43 per cent between 1980 and 1988. The Jordan Phosphates Mines Co. began to produce phosphate rock from the Shidiya Mine, some 120 kilometres east of Aqaba. Production at Shidiya has replaced rock from the El Abiad and El Hassa mines, 136 kilometres south of Amman. The output of Brazil was up by 38.8 per cent. *Industrias de Fosfatos Catarinense*, a joint venture among Adubos Trevo, Fertisul and Quimbrasil and possibly Petrobas Fertilizantes planned to produce phosphate rock in the southern part of the country. Plans were made to mine 900,000 tonnes per year at Anitopolis in order to produce phosphoric acid. The Tapira phosphate mine was being expanded from 1.4 million tonnes to 2 million tonnes per year.

In Togo, output was down by 11 per cent, reflecting a gradual erosion of the market share of that country. The EEC has agreed to supply funds to the *Office togolais des phosphates* to offset the loss of future phosphate rock export earnings. The EEC has also reduced acceptable cadmium levels in its phosphate rock imports, a requirement that has limited imports of high-cadmium products from Togo. As a consequence, the funds have been used to determine the optimal method of cadmium removal and to develop another carbonite phosphate deposit with lower levels of cadmium. Etibank, the only producer of phosphate rock in Turkey, has constructed a new concentrator at its Mazidagi phosphate plant. The new plant was programmed to produce 550,000 tonnes per year by 1990.

(b) *Production of phosphatic fertilizers*

The international pattern of production reflects a changing distribution of production capacity between developed market economies, centrally planned economies and developing countries. In the early 1950s, the production of fertilizers was heavily concentrated in Western Europe, North America, the USSR and the centrally planned economies of Eastern Europe, amounting to around 85 per cent of world production. This concentration resulted from the geographic distribution of reserves and technological expertise, high levels of industrialization and large domestic markets.

During the past three decades, however, the demand for fertilizer in most developing countries has grown. New emphasis on agricultural consumption has generated a need for a significant increase in the production of chemical fertilizers. Despite a production increase in phosphatic and other fertilizers, in particular nitrogen and potash, a substantial gap still prevails between fertilizer production and consumption in those countries.

During the 1980s, the processing of phosphate ore beyond the rock stage rose sharply, when the processing industry of developing countries experienced a considerable upswing. As may be seen from table IV.66, world production of phosphatic fertilizers grew by 18.3 per cent between 1980 and 1988, and by around 6 per cent in 1988 over the level of 1987. Of most significance was the substantial increase recorded in the South. The main impetus came from significant capacity expansions in Indonesia, Morocco and India, amounting to a growth of 904 per cent, 280 per cent and 120 per cent, respectively, between 1980 and 1988. Of less significance is the industry growth recorded in centrally planned economies. Production in those economies still depends on substantial rock imports from Morocco.

As shown in figure IV.10, the phosphatic fertilizer supplies continue to be dominated by the United States, the USSR and China. Their combined output in 1988 constituted 55 per cent of the world total. World production in 1988 was 39.6 million tonnes, up some 6.1 per cent from the previous year. Production in developed market economies was just over 16 million tonnes, some 3.6 per cent below 1987 and 10 per cent below 1980. Table IV.66 shows that the United States continues to dominate phosphatic fertilizer supply in the North. In the South, the major producers are India and Brazil followed by Tunisia and Morocco. Among the centrally planned economies, the biggest producers are the USSR and China.

Table IV.66. World production of phosphatic fertilizers, 1980 and 1988

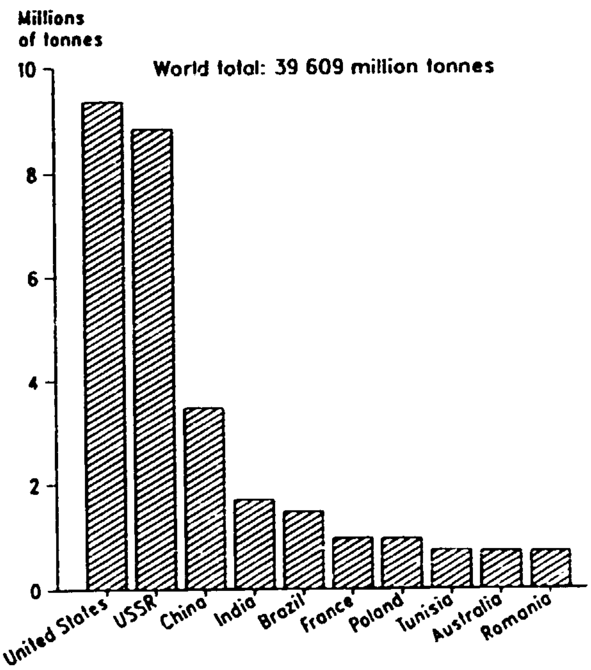
Rank in 1988	Country, region or economic grouping	1988 production (thousands of tonnes)	Percentage change 1987-1988	Percentage change 1980-1988	Percentage share 1980	Percentage share 1988
1	United States	9 359	6.18	5.02	27.14	24.08
2	USSR	8 840	4.28	49.07	17.72	22.32
3	China	3 470	44.07	85.73	5.59	8.77
4	India	1 703	0.39	118.18	2.33	4.30
5	Brazil	1 465	377.90	12.20	3.90	3.70
6	France	955	-4.50	-29.98	4.07	2.41
7	Poland	942	-0.57	1.23	2.78	2.38
8	Tunisia	726	3.49	143.79	0.89	1.83
9	Australia	703	15.35	-23.57	2.75	1.77
10	Romania	690	-12.66	-2.68	2.11	1.74
11	Indonesia	554	7.91	904.27	0.16	1.40
12	Japan	531	-7.97	-28.63	2.22	1.34
13	Morocco	525	12.58	279.36	0.47	1.32
14	Republic of Korea	513	6.31	57.76	0.41	1.29
15	Italy	490	39.48	243.11	0.42	1.23
16	Canada	436	-6.19	-37.89	2.10	1.10
17	Spain	415	-3.21	-13.11	1.43	1.05
18	Mexico	399	66.21	-	-	1.01
19	Belgium and Luxembourg	368	-5.49	-40.45	1.85	0.93
20	Turkey	285	-46.41	-56.36	0.16	0.72
	North America	9 975	5.57	1.94	29.24	25.18
	Western Europe	4 574	0.36	-24.27	17.78	11.38
	Oceania	912	12.79	-31.37	3.97	2.30
	Other developed economies	991	-7.12	-19.04	3.66	2.50
	Africa	1 398	6.64	24.31	3.36	3.53
	Latin America	2 030	5.71	23.41	4.91	5.12
	North Africa and Western Asia	1 436	6.93	169.78	1.59	3.62
	East Asia	3 217	3.62	117.25	44.24	8.12
	Other developing economies	20	5.82	-49.43	0.12	0.05
	Centrally planned economies a/	15 121	9.54	38.79	32.55	38.17
	Total North b/	16 387	-3.60	-10.06	54.65	41.37
	Total South b/	8 101	5.24	89.05	12.80	20.45
	TOTAL	39 609	6.14	18.33	100.00	100.00

Source: *Fertilizer Yearbook* (various issues) (Rome, Food and Agriculture Organization of the United Nations).

a/ Including the USSR.

b/ Excluding centrally planned economies.

Figure IV.10. World's top 10 producers of phosphatic fertilizer, 1988



Source: *Fertilizer Yearbook* (various issues) (Rome, Food and Agriculture Organization of the United Nations)

(c) *Trade in phosphatic fertilizers*

Because imbalances prevail between production and consumption in both developed and developing countries, there is considerable international trade in phosphatic fertilizers. As shown in tables IV.67 and IV.68, total trade amounted to 19 million tonnes in 1988. On the import side, quantities were distributed as follows: 41.6 per cent by developed market economies, 34.9 per cent by developing countries, and 23.5 per cent by centrally planned economies. Imports by centrally planned economies grew more than sevenfold during the period 1980-1988. Imports by China were up by 600 per cent during the same period, while in the USSR they jumped by 1,086 per cent.

Table IV.67. World exports of phosphatic fertilizers, 1980 and 1988

Rank in 1988	Country, region or economic grouping	1988 exports (thousands of tonnes)	Percentage change 1987-1988	Percentage change 1980-1988	Percentage share 1980	Percentage share 1988
1	United States	4 651	1.57	30.61	52.36	46.50
2	Tunisia	722	25.68	161.59	4.06	7.22
3	Belgium and Luxembourg	556	11.20	4.31	7.84	5.56
4	Netherlands	370	-1.33	19.87	4.54	3.70
5	Morocco	345	2.71	278.20	1.34	3.45
6	Turkey	309	48.23	-	-	3.08
7	Romania	300	-	30.43	3.38	3.00
8	Jordan	259	0.71	-	0.15	2.59
9	Republic of Korea	254	-11.29	-10.45	4.16	2.54
10	USSR	246	-3.53	2.54	3.53	2.46
11	Iraq	183	-11.16	-	-	3.53
12	Israel	148	53.69	-	0.22	1.48
13	Germany, Federal Republic of	142	-2.79	70.45	1.23	1.42
14	France	142	26.78	-24.06	2.75	1.42
15	Yugoslavia	138	-7.63	25.45	1.62	1.38
16	Denmark	134	70.17	359.33	0.43	1.43
17	Norway	119	-1.16	47.09	1.18	1.19
18	Italy	99	34.75	91.70	0.76	0.99
19	Finland	79	-6.19	128.93	0.48	0.79
20	Austria	69	6.03	91.62	0.53	0.68
	North America	4 695	1.21	23.88	55.72	55.72
	Western Europe	2 033	9.68	29.48	23.08	20.32
	Oceania	-	-	-	0.05	-
	Other developed economies	239	39.52	204.85	1.15	2.39
	Africa	1 101	13.74	192.01	5.54	11.01
	Latin America	425	9.64	40.52	1.05	0.42
	North Africa and Western Asia	434	11.36	654.26	1.47	7.55
	East Asia	434	-27.48	53.05	4.33	4.16
	Other developing economies	[illegible]0	5.82	-50.20	0.59	0.20
	Centrally planned economies a/	682	10.68	39.91	7.17	6.81
	Total North b/	6 967	-4.10	28.03	80.01	69.66
	Total South b/	2 353	5.44	169.77	12.82	23.53
	TOTAL	10 002	5.29	47.06	100.00	100.00

Source: Fertilizer Yearbook (various issues) (Rome, Food and Agriculture Organization of the United Nations).

a/ Including the USSR.

b/ Excluding centrally planned economies.

The source of such imports has changed over the years, with the import share from developed market economies now standing at 52.7 per cent. Substantial import increases were recorded in Belgium, Spain and the United Kingdom. However, import shares from developing market economies rose by only 17.6 per cent, despite a global increase in world import dependence between 1980 and 1988. The dependence of developing countries as a group declined substantially. The import-dependence ratio (the ratio of imports to consumption) of developing market economies decreased from 44.9 per cent in 1980 to 34.1 per cent in 1988. In the North, the import-dependence ratio was measured at 17.3 per cent in 1980 and 32.4 per cent in 1988. This reflects the persistent imbalances in global fertilizer allocation and use.

Table IV.68. World imports of phosphatic fertilizers, 1980 and 1988

Rank in 1988 1988	Country, region or economic grouping	1988 imports (thousands of tonnes)	Percentage change 1987-1988	Percentage change 1980-1988	Percentage share 1980	Percentage share
1	China	1 207	85.95	601.59	2.97	13.30
2	France	638	10.00	-8.12	11.97	7.03
3	Iran, Islamic Republic of	474	-28.17	183.45	2.89	5.23
4	Italy	466	15.03	8.37	7.41	5.13
5	Germany, Federal Republic of	451	11.60	40.33	5.54	4.97
6	USSR	414	0.97	-	0.60	4.56
7	Belgium and Luxembourg	336	68.00	533.96	0.91	3.70
8	United Kingdom	293	46.50	214.38	1.61	3.23
9	Japan	285	39.02	193.81	1.67	3.14
10	India	279a/	-	-	4.09	-
11	Pakistan	264	-22.53	62.53	2.80	2.91
12	Turkey	248	128.07	-29.17	6.04	2.73
13	Canada	223	4.83	30.11	2.96	2.46
14	Saudi Arabia	210	1.82	296.03	0.91	2.31
15	Spain	183	37.59	..	0.03	2.01
16	Brazil	180	-22.27	-52.22	6.50	1.98
17	Ireland	170	21.82	46.04	2.00	1.87
18	Venezuela	170	47.66	182.13	1.04	1.86
19	Hungary	167	-7.22	-15.65	3.41	1.84
20	Thailand	165	11.31	24.81	2.28	1.82
	North America	371	15.66	5.18	6.75	4.09
	Western Europe	2 967	22.70	51.73	33.72	32.68
	Oceania	155	-12.99	504.64	0.44	1.70
	Other developed economies	285	39.05	182.38	1.74	3.14
	Africa	388	15.49	88.74	3.55	4.28
	Latin America	964	9.22	5.48	15.76	10.62
	North Africa and Western Asia	1 037	42.46	50.63	11.88	11.43
	East Asia	766	-28.87	-12.99	15.18	8.44
	Other developing economies	12	18.71	132.77	0.08	0.13
	Centrally planned economies b/	2 132	32.37	237.40	10.89	23.48
	Total North c/	3 778	21.01	52.74	42.65	41.62
	Total South c/	3 168	4.40	17.57	46.46	34.89
	TOTAL	9 078	16.88	56.51	100.00	100.00

Source: Fertilizer Yearbook (various issues) (Rome, Food and Agriculture Organization of the United Nations).

a/ 1987 figure.

b/ Including the USSR.

c/ Excluding centrally planned economies.

Exports by developing countries of phosphatic fertilizers grew almost threefold between 1980 and 1988 (from 872,273 tonnes to 2,353,175 tonnes), displaying a trend towards increased trade among developing countries. However, in terms of total world exports, the share of developing countries rose by only 9 per cent during this period. Whereas the South accounted for only 12.8 per cent of world exports in 1980, it provided 23 per cent of the total in 1988; that of developed market economies and centrally planned economies was 70 per cent, and 6.8 per cent, respectively, in 1988.

At present, 88 per cent of developing-country exports are accounted for by only six countries. Among that group of countries, those endowed with natural gas, sulphur and other necessary inputs for the production of phosphatic fertilizers have recently become active in export markets, thanks largely to new productive capacity built in the 1970s and 1980s.

Although the export earnings of those countries have increased, the question remains as to how much of the earnings have accrued to domestic factors of production.

Analysis of current fertilizer tariff protection in developed market economies, reveals that, while tariffs tend to escalate somewhat at higher stages of processing, their overall protective effects do not at present pose a serious obstacle to market access. This is largely due to the broadness of product coverage under the generalized system of preferences (GSP), which eliminates or reduces the inhibiting effects of the tariffs normally levied on fertilizer products [11]. Basic inputs such as sulphur and natural calcium phosphates generally receive duty-free treatment or are covered by GSP in the markets of most developed market economies. Intermediate products such as phosphoric acid face most-favoured-nation tariffs of from 2.9 to 11 per cent. There is a mixed tariff treatment for the important end-products falling in the phosphatic and other fertilizer categories.

While the GSP limitations have been applied to a few developing-country exporters under EEC and United States regulations, several fertilizer-producing countries have been denied GSP beneficiary status by the United States, and thus face tariff protection and reduced competitiveness in that market. Although it is difficult to quantify the protective impact of non-tariff measures, they are currently imposed on fertilizer products exported by developing countries. The majority of developed market economies apply such measures of one sort or another, in particular to nitrogenous and other fertilizers. The more frequent are licensing measures, technical standards quotas, anti-dumping duties and marketing and packaging requirements [12].

Overall, developed countries have widened access to their markets for developing-country fertilizer exports. There does not appear to be any overly restrictive practices, especially in the light of emerging developing-country participation in the fertilizer industry and the current depressed world economy. Against such a background, certain structural adjustments are occurring in the form of increasing participation in the industry by developing countries endowed with oil, natural gas and phosphate rock, while at the same time some developed countries are restructuring their fertilizer industry to comply with shifts in international comparative advantage.

(d) *Consumption of phosphatic fertilizers*

World consumption of phosphatic fertilizers rose by 6 per cent between 1987 and 1988, following a series of regular annual increases. The USSR continues to be the major world consumer of phosphatic fertilizers, followed by the United States and China. India is the fourth largest consumer. While consumption in developed countries decreased significantly between 1980 and 1988, consumption in centrally planned economies increased by 47 per cent over the same period. The share of the latter in total world demand also increased from 34.9 per cent in 1980 to 43.3 per cent in 1988. Total consumption in the North remains higher than in the South by a 6 per cent margin, although consumption in the South has been rising regularly.

Phosphate demand world-wide increased to 36.9 million tonnes, a rise of about 18.6 per cent from its 1980 level. As shown in table IV.69, phosphatic fertilizer usage in North America and Western Europe has been relatively depressed in recent years because of high levels of grain stocks, the resulting low grain prices and the compulsory set-aside of land. Consequently, between 1980 and 1988 demand went down by 21.4 per cent in North America and by 15.9 per cent in Western Europe, where phosphate rock usage has declined more or less continuously since 1980. The use of phosphatic fertilizers has stagnated in many countries in the region, including France and the Federal Republic of Germany. Demand in the North is expected to remain below 20 million tonnes in the coming years, as the major agricultural countries strive to control output and to minimize pollution. The demand for phosphatic fertilizers was also down in Oceania between 1980 and 1988.

Table IV.69. World consumption of phosphatic fertilizers, 1980 and 1988

Rank in 1988	Country, region or economic grouping	1988 consumption (thousands of tonnes)	Percentage change		Percentage share	
			1987-1988	1980-1988	1980	1988
1	USSR	8 564	29.27	56.28	17.59	21.62
2	China	4 608	52.29	124.88	6.58	11.63
3	United States	3 730	2.58	-24.30	15.82	9.42
4	India	2 297	7.32	126.21	3.26	5.80
5	Brazil	1 626	-2.20	-2.97	5.38	0.41
6	France	1 405	-1.41	-29.17	6.37	3.55
7	Poland	837	-12.96	-13.56	3.11	2.11
8	Australia	831	9.60	- 8.50	2.91	2.10
9	Italy	781	17.11	- 5.95	2.67	1.97
10	Japan	766	1.72	- 7.82	2.67	1.93
11	Germany, Federal Republic of	679	-0.65	-25.64	2.93	1.72
12	Canada	634	13.99	1.36	2.01	1.60
13	Turkey	574	5.20	-14.46	2.15	1.45
14	Indonesia	569	2.25	276.67	0.48	1.44
15	Spain	537	8.87	11.39	1.55	1.36
16	Czechoslovakia	491	-6.17	8.63	1.45	1.33
17	Iran, Islamic Republic of	445	19.16	125.13	0.63	1.12
18	Romania	440	..	-15.22	1.66	1.11
19	United Kingdom	435	-2.47	- 5.43	1.48	1.10
20	Mexico	438	5.78	75.02	0.79	1.09
	North America	4 365	2.40	-21.41	17.82	11.02
	Western Europe	5 155	1.63	-15.88	19.67	13.01
	Oceania	1 089	8.46	-17.77	4.25	2.75
	Other developed	1 048	-5.82	-17.10	4.06	2.64
	Africa	1 146	7.04	70.74	1.24	1.79
	Latin America	2 867	2.06	17.21	7.85	7.76
	North Africa and Western Asia	1 631	9.17	44.20	3.63	4.42
	East Asia	4 117	5.82	102.23	6.54	11.14
	Other developing economies	12	18.71	130.85	0.02	0.03
	Centrally planned economies a/	16 004	10.66	47.11	34.92	43.31
	Total North b/	11 656	1.83	-18.31	45.80	31.55
	Total South b/	9 288	5.29	54.66	19.28	25.14
	TOTAL	36 948	6.39	18.60	100.00	100.00

Source: Fertilizer Yearbook (various issues) (Rome, Food and Agriculture Organization of the United Nations).

a/ Including the USSR.

b/ Excluding centrally planned economies.

Africa, Asia, the USSR and Latin America, however, saw an increase in phosphate consumption between 1980 and 1988. These agriculturally lagging regions of the world will continue to record higher fertilizer needs at least for the next decade. The strength of phosphate demand in Asia will benefit producers that have lower transport costs, such as Jordan. In Asian countries such as China, India and Pakistan, recent increases in food production have been largely achieved by increased applications of nitrogen, supported by soil phosphate reserves.

World consumption of phosphate rock by industry and by region is given in table IV.70. The use of phosphate products in livestock and poultry feeds occurs not only in North America, but also in other countries with sophisticated feeding practices. The animal feed industry uses from 1.7 per cent to 10 per cent of the total phosphate produced world-wide. Phosphates are used for supplemental nutrition in poultry, swine, cattle, and other animal feeds. Phosphorus-containing chemicals are also used in detergent builders, industrial cleaning aids, food and beverage additives, metallic surface treatments and other products. Although sodium tripolyphosphate is still the principal detergent builder, its levels have been reduced in detergent formulations by substituting other compounds to diminish the eutrophication effect on receiving waters [13]. The total industrial use of phosphate ranges from 1.9 to 12 per cent of total phosphate production.

In the United States, the fertilizer industry consumes about 78 per cent of total phosphate rock production. This ratio is somewhat higher in other regions of the world, but phosphate rock end-use distribution by region has remained somewhat constant over the years.

Phosphate consumption in Latin America is expected to show some growth, although the domestic rock industry in Brazil will continue to cover much of the needs of that country. In Mexico, the production of rock has not kept pace with the development of the local phosphate fertilizer production industry, and imports of rock are expected to rise in order to serve the new phosphate complex at Lazaro Cardenas.

2. *Industry restructuring*

(a) Largest phosphate companies in the North

In 1952, the six leading phosphate rock producers, namely American Agricultural Chemical Corporation, American Cyanamid Company, Cornet Phosphate Company, Davidson Chemical Corporation, Swift and Company and Virginia-Carolina Chemical Corporation, accounted for 74 per cent of total market economy output. Prior to 1960, the phosphatic fertilizer industry was traditionally dominated by large, diversified chemical firms and independent fertilizer companies. The period 1963-1967 was characterized by the expansion of capacity and a rapid succession of acquisitions and new entrants into the fertilizer and phosphate rock industries. During the early 1960s, phosphate rock and phosphatic fertilizer production increased significantly. The largest companies in the North at present are listed in table IV.71. Recent changes in phosphate market structure can be attributed to the following factors:

(a) Petroleum companies began acquisitions of phosphate firms;

(b) Merger strategy and acquisitions became important. Horizontal integration eliminated the traditional independence of primary mixed fertilizer producers. Vertical integration enabled most fertilizer companies to have control over all facets of fertilizer production from the raw material through to the distribution of the final product;

(c) Entry and acquisition activity during the mid-1960s reduced concentration in the phosphatic fertilizer industry;

(d) Investment activity in the phosphatic fertilizer industry resulted in a rapid expansion of production capacity;

(e) The shift to high-grade products facilitated the relocation of plants to the site of raw material production.

In the United States, Phoschem handles international sales of concentrated phosphates and phos-

Table IV.70. Phosphate consumption by major end-uses, 1985

Consuming country or region	Total[a/] (10^3 tonnes)	Fertilizer Amount (10^3 tonnes)	Fertilizer Percentage	Animal feed Amount (10^3 tonnes)	Animal feed Percentage	Industry Amount (10^3 tonnes)	Industry Percentage
North America							
United States	5 480	4 270	77.92	550	10.04	660	12.04
Canada	640	530	82.81	60	9.37	50	7.82
Latin America	2 769	2 480	89.56	46	1.66	243	8.78
Africa	1 620	1 500	92.59	45	2.78	75	4.63
Oceania and Asia	10 328	9 700	93.92	254	2.46	374	3.62
Western Europe	7 415	6 200	83.61	470	6.34	745	10.05
Eastern Europe	3 630	3 300	90.91	170	4.68	160	4.41
USSR	8.000	7 200	90.00	650	8.12	150	1.88
TOTAL	39 882	35 180	88.21	2 245	5.63	2 457	6.16

Source: R.J. Fantel, and others, Phosphate Availability and Supply: Minerals Availability Appraisal, (Washington, D.C., United States Bureau of Mines, 1987).

a/ On the basis of the three major end-uses.

Table IV.71. Largest phosphate companies in the North, 1989 a/

Country, region or economic grouping	Company
North America	
United States	Agrico Chemical Co.
	CF Industries Inc.
	Freeport McMoRan Chemical Co.
	Gardinier Inc.
	IMC Fertilizer Group Inc.
	TexasGulf Chemicals Co.
Canada	Esso Chemical
	Belledune Fertilizers
Western Europe	
Belgium	Société chimique Prayon-Rupel, S.A.
France	Société chimique de la grande paroisse, Soferti
Norway	Norsk-Hydro Azote
Netherlands	DSM Netstoffen
Spain	Fertilizantes Españoles, S.A.
Sweden	Boliden Kemi
Oceania	
Australia	Queensland Phosphate Ltd.
Other developed economies	
South Africa	Phosphate Development Corp.
	Chemfos Ltd.

Source: "1990 project survey", Engineering and Mining Journal, vol.191 (January 1990), pp.89-94.

a/ Not including companies in Japan because of lack of data.

Table IV.72. Largest phosphate companies in North America by stage of processing, 1988

Product	Company	Capacity (tonnes per year)	Percentage share
Phosphate rock	IMC Fertilizer Inc., Florida	15 873	30.25
	TexasGulf Chemicals Co., North Carolina	5 986	11.41
	Agrico, Florida	5 442	10.37
	Oxychem Ag Products Inc., Florida	4 989	9.51
	Mobil Mining & Minerals, Florida	4 263	8.12
	Seminole Fertilizer Corp., Florida	2 722	5.19
	Simplot, JR, Co., Idaho and Wyoming	2 063	3.93
	USS Agri-Chem (Sinochem), Florida	1 814	3.46
	Nu West Industries, Idaho	1 497	2.85
	C & G holdings Inc., Florida	1 361	2.59
Phosphoric acid a/	Agrico, Louisiana and Florida	1 660	14.73
	IMC Fertilizer Group Inc., Florida	1 542	13.68
	CF Industries Inc., Florida	1 279	11.35
	TexasGulf Chemicals Co., North Carolina	1 152	10.22
	Oxychem Ag Products Inc., Florida	1 016	9.01
	Gardinier Inc.	633	5.79
	Seminole Fertilizer Corp., Florida	566	4.83
	Farmland Industries Inc., Florida	544	4.83
	Royster Co., Florida	499	4.43
	Fort Meade chem (USS Agri), Florida	435	3.86
Ammonium phosphates	Agrico Chemical Co.	1 259	16.35
	IMC Fertilizer Group Inc.	1 152	14.96
	Seminole Fertilizer Corp.	649	8.42
	CF Industries Inc.	544	7.07
	Royster Co.	499	6.48
	Gardinier Inc.	431	5.59
	Farmland Industries Inc.	417	5.42
	TexasGulf Chemicals Co.	348	4.52
	Oxychem Ag Products Inc.	317	4.12
	ESSO Chemical, Canada	268	3.47

Source: Tennessee Valley Authority, North American Capacity Data (Muscle Shoals, Alabama, 1989).

a/ Wet-process phosphoric acid.

phoric acid for the major producers. Similarly, several producers of phosphate rock in the United States have increased their market power by forming a Phosphate Rock Export Association called Phosrock. While these two associations are not directly linked, two major transnational corporations, W R Grace and IMC Corporation are members of both. The two other members of Phoschem are Becker Industries and Royster Company. The Phoschem members together with Occidental Chemical Company supply more than 50 per cent of the phosphorous pentoxide exported from the United States. The extent to which these companies are active at different stages of processing is reflected in table IV.72.

Several major phosphate-producing companies abandoned production in 1986 following the bankruptcy of Beker Chemical, including W R Grace, Amax, USS Agri and Williams Co, while the rationalization which proceeded rapidly in the United States phosphate industry during 1986 set the scene for a recovery in revenues in 1987 and 1988. Companies such as IMC and Freeport have since then opted to undertake major investments. Participation of trading companies, such as CTIC and Cargill and Nu South, and even State importers, such as Sinochem of China, have helped to reverse industry contraction. Seminole and Florida Crushed Stone, which had acquired fertilizer facilities in the middle of the depression, decided to sell and take their profits.

In 1988 the following major company adjustments also occurred. Hookers Prairie plant of W R Grace was sold to Seminole, which later sold it to Argus fertilizer, a new company in the business. W R Grace also agreed to a deal with IMC to sell its half of the Four Corners mine, thus removing itself entirely from the phosphate business. Nu West industries set up two subsidiaries, Nu South and Nu Gulf, to operate plants purchased from Mississipi Chemical and Beker Chemical. Also in 1988, Estech was forced to close one of its phosphate plants because of depleted reserves.

The phosphate rock export agency Phosrock now includes most of the Florida and North Carolina exporters as members. Noranda joined in 1988 and TexasGulf joined in early 1989, leaving Estech as the only major exporter outside the ranks. In the United States, investment in new phosphate plants is expected to go down in the near future, despite current improved revenue levels. The net effect is that capacity levels currently the highest in the world are expected to fall slowly until the mid-1990s [14].

(b) *Largest phosphate companies in the South*

The developing world market for phosphate rock was stable before about 1960. Sales were made through large central organizations such as the *Comptoir des phosphates de l'Afrique du Nord* [15], whose dissolution in 1960 caused North African producers to market their output independently. The stability of the industry was also aided by the existence of entry barriers which prevented new export-oriented operations. In some cases, European fertilizer facilities were essentially captive markets for North African phosphate rock, because the equipment used in fertilizer manufacture was especially designed for North African phosphate rock. This factor and others resulted in considerable sales resistance to the new output of Senegal and Togo in 1961 and 1962. During the second half of the 1960s the gradual increase in the number of producing countries made the industry more competitive. Excess capacity added to competitive pressures as United States producers actively sought to expand exports. Moroccan exports were displaced in Western Europe; while in 1968, the United States briefly passed Morocco as the largest phosphate rock exporter in the world.

A list of some of the largest phosphate companies in the South is given in table IV.73. Over the past several decades Governments and private interests in developing countries have increased their ownership of world capacity. In Morocco, the Office Chérifien des Phosphates is wholly State-owned. The rock processor Maroc-Chimie S.A., owned principally by the Office Chérifien des Phosphates with minority foreign holdings, helps to diversify markets for finished products. In Senegal, Industries Chimiques du Sénégal is partially State-owned with foreign private shareholders. In Tunisia, the Groupe Chimique Tunisien, operates very large phosphate-rock local processing plants. It has foreign interests that help not only to raise capital but also to develop markets for products. In Jordan, the Jordan Fertilizer Industry Company controls most sales and exports of processed phosphate products. Other fertilizer complexes producing finished products are financed in part by foreign fertilizer companies such as Agrico. Sales agents and foreign financing of fertilizer plants tend to reduce Jordanian control.

Mineral specialists have recognized the significant increase in participation by developing-country companies in the phosphate market. While the overall participation of developing-country producers was only about 15 per cent in the late 1960s, the gap is slowly closing. Today, the developing countries of Africa, Asia and Latin America have the highest growth rate at 4.2 per cent per annum.

Table IV.73. The largest phosphate companies in the South, 1988

Country or region	Company
North Africa and West Africa	
Morocco	Office chérifien des phosphates
Senegal	Industries chimiques du Sénégal
Tunisia	Groupe chimique tunisien
Togo	Office togolais des phosphates
Western Asia	
Iraq	State Organization for Minerals
Jordan	Jordan Fertilizer Industry Company Ltd.
South-East Asia and Oceania	
Nauru	Nauru Phosphates Co.
Thailand	P & S Milling Co. Ltd.
Indian Subcontinent	
India	Hindustan Zinc Ltd.
Latin America	
Brazil	Fertilizantes Fosfatados, S.A.
Mexico	Inversionesy Minerales, S.A.
Peru	Empresa Minera del Peru

Source: "1990 project survey", Engineering and Mining Journal, vol.191 (January 1990), pp.89-94.

(c) *Significance of State-controlled industries*

In the United States and Canada, most phosphate fertilizer manufacturers are privately held companies. This contrasts with the growing governmental ownership found in other parts of the world. Altogether, about 75 per cent of the world industry is currently owned or controlled by the State, and virtually all of the growth in basic productive capacity throughout the world is occurring under some form of State ownership. In Morocco, where the phosphate industry has been nationalized for some time, output and distribution of phosphate rock is controlled by the State-owned Office Chérifien des Phosphates. Though other companies control domestic chemical processing of the rock, the Government may have various levels of ownership in those companies. The phosphate industry in Morocco will continue to be controlled by the Government, considering the size and richness of reserves available in the country.

In Senegal, the two major phosphate producer companies, Compagnie Sénégalaise des Phosphates de Taiba and Société Sénégalaise des Phosphates de Thies are 50 per cent State-owned, the remainder consisting of French and United States private shareholders.

In Jordan, Jordan Phosphate Mines Company, owned by the Government (80 per cent) and by Arab and foreign shareholders (20 per cent), controls all the mining and selling of phosphate rock in the country. In Tunisia, phosphate rock production and other processing plants are controlled by the State-owned Compagnie des Phosphates de Gafsa, by the Société Arabe des Engrais Phosphates et Azotes, which is owned by the Government of Tunisia (60 per cent) and the Abu Dhabi Development Fund (40 per cent), and by Industries Chimiques Mahgrébines. Considering the importance of the phosphate sector in the Tunisian economy, it is doubtful that the Government will relinquish ownership of the entire industry.

In Pakistan, fertilizer production is partly State-owned. The Bangladesh fertilizer industry is entirely State-owned, with the production and marketing controlled by the State-owned public sector corporations. The domestic fertilizer industry in Indonesia is entirely owned by the Government of Indonesia, and is managed by a State-owned corporation. The industry in the Islamic Republic of Iran and Kuwait is largely State-owned. The industry of Qatar is owned jointly by the State and by Norsk-Hydro of Norway. The industry of Turkey is partly State-owned and partly privately owned.

The most immediate impact of the growth of State-controlled enterprise on the phosphate industry is its possible influence on market structure. State-controlled enterprises may attempt to increase market power in the future, threatening the survival of private industries in the North. In the phosphate industry, however, factors that affect the agricultural and industrial consuming industries rather than privately held producers control the market, at least in the short to medium term. The growing diversity of the world fertilizer base has also made it difficult for any one State-controlled major producer country or group of countries to control supply.

3. *Capacity utilization and expansion plans*

There are approximately 112 phosphate rock manufacturing plants in the world today, with an achievable capacity of 173 million tonnes of phosphate production. Achievable capacity is an estimate of the sustained capacity, which is considerably less than the name-plate sustained capacity. Some phosphate mines have been closed because of over-supply. Given current demand, the level of an over-supply potential world-wide is about 9 per cent.

Regarding the distribution of capacity, table IV.74 shows that in 1988 about 51 per cent can be found in the North, about 27 per cent in the South and 22 per cent in centrally planned economies. Among individual regions, North America accounts for 32.3 per cent of total phosphatic fertilizer capacity, followed by Eastern Europe and the USSR (21.4 per cent), Western Europe (13 per cent) and Africa (12.8 per cent).

Table IV.74. World phosphate fertilizer capacity, 1987/88-1995
(Millions of tonnes of phosphorous pentoxide)

Region	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93	1995a/
North	18.30	18.30	18.23	18.23	18.23	18.23	17.70
North America	11.59	11.59	11.59	11.59	11.59	11.59	11.53
Western Europe	4.65	4.65	4.58	4.58	4.58	4.58	4.54
Oceania	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Other developed economies	1.76	1.76	1.76	1.76	1.76	1.76	1.33
South	9.77	10.02	10.02	10.02	10.02	10.17	12.56
Africa	4.59	4.59	4.59	4.59	4.59	4.59	5.21
Latin America	1.75	1.75	1.75	1.75	1.75	1.90	1.90
North Africa and Western Asia	1.95	1.95	1.95	1.95	1.95	1.95	2.54
East Asia	1.48	1.74	1.74	1.74	1.74	1.74	2.91b/
Centrally planned economies	7.77	7.98	8.29	8.57	8.60	8.72	9.78
Asiab/	0.10	0.10	0.17	0.32	0.34	0.46	1.02
Europe and the USSR	7.67	7.88	8.12	8.25	8.25	8.25	8.76
TOTAL	35.83	36.30	36.54	36.82	36.85	37.12	40.05
Operating rate (percentage)a/	71	73	71	71	80	80	80
Productiona/	25.6	26.6	26.7	27.1	30.7	31.2	32.0

Source: FAO/UNIDO/World Bank Working Group on Fertilizers.
a/ Estimates by Blue, Johnson & Associates, Menlo Park, California.
b/ Both East and South Asia combined.

As regards new phosphate-rock plant construction, the *Engineering and Mining Journal* ([16], pp.89-94), in its annual project survey for 1990, reports on projects in developing countries as follows: North Africa—four projects at $275 million; Western Asia—four projects at $325 million; Latin America—one project at $183 million; Asia—two projects; and Oceania—one project at $60 million. Table IV.75 reflects phosphate-rock capacity expansion plans reported in the survey. Apart from the scheduled projects with capital, projects by companies in Algeria, Egypt and the Syrian Arab Republic are also real possibilities. Still in their initial phases are the projects in Sri Lanka and Viet Nam.

New investment projects for the expansion of phosphoric acid capacity in developing countries are listed in table IV.76. Petrofertil of Brazil plans to expand its Itatiaia, Ceara, plant to produce 105,000 tonnes of P_2O_5 per year with investment amounting to $200 million. In Chile, Corfo will soon expand its

Table IV.75. Expansion plans for phosphate rock capacity, 1988-2000

Country	Company	Location	Project	Planned capacity (thousands of tonnes per year)	Investment (millions of dollars)	Start-up year
			Projects with capital			
Peru	Promotora Bayóvar	Bayóvar	Open-pit mine, plant	1 700	183	1990s
Morocco	OCPa/	Khouribga	Mine	1 200	100	1990
	OCPa/	Youssoufia	Mine, plant	4 200	150	1988/89
Togo	OTPb/	Kpeme	Mine, plant	1 000	400	1990s
Tunisia	Phosphates Gafsa	Gafsa	Mine	1 000	25	..
Jordan	Jordan Phosphate Mines	Shidiyah	Mine	3 000	25	1988
Turkey	Etibank	Samikan Mazidagi	Open pit mine, plant	750	300	1989
Nauru	Nauru Phosphate	Nauru	Plant	300	60	..
			Projects requiring capital			
Algeria	Ferphos	Djebel Onk	Mine, plant	6 000	..	1988/89
Egypt	Red Sea Phosphate	Abu Tartour	Underground mining	2 000	..	1988/89
Syrian Arab Republic	General Co. for Phosphates	Cadir el Hamal	Mine, plant	5 000	..	1989
Sri Lanka	State Mining and Mineral Development	Eppawala	Mine, plant	35	..	..
Viet Nam	Lao Cai	Lao Cai	Mine, plant	1 500	..	1990s

Source: "1990 project survey", Engineering and Mining Journal, vol.191 (January 1990), pp.89-94.
a/ Office chérifien des phosphates.
b/ Office togolais des phosphates.

Table IV.76. Expansion plans for phosphatic acid capacity, 1988-2000

Country	Company	Location	Project	Planned capacity (thousands of tonnes per year)	Investment (millions of dollars)	Start-up year
			Projects with capital			
Brazil	Petrofertil	Itatiaia, Ceara	Mine, plant	105	200	..
Chile	Corfo	Antofagasta	Mine, pla	100	24	..
Colombia	Ecominas	Boyaca	Mine, plant	100	250	..
Peru	Empresa Minera del Peru	Area 1, Bayóvar	Open-pit mine, plant	90	58	1990
Uganda	Sukulu Mines	Ticaf plant	Plant	80	100	1990
			Projects requiring capital			
Egypt	Misr Phosphate	Hamrawein	Mine, plant	1 200	..	1989
	Red Sea Phosphate	Abu Tartour	Underground mining	2 000	..	1988/89
Mauritania	Government	Bofal	Plant	2 000	..	1990
			Mine, plant	5 000	..	1989
Syrian Arab Republic	General Company for Phosphates	Cadir el Hamal	Mine, plant	5 000	..	1989
Sri Lanka	State Mining and Mineral Development	Eppawala	Mine, plant	35	..	..
Viet Nam	Lao Cai	Lao Cai	Mine, plant	1 500	..	1990s

Source: "1990 project survey", Engineering and Mining Journal, vol.191 (January 1990), pp.89-94.

Antofagasta phosphoric acid plant to reach 100,000 tonnes per year. Ecominas, at Boyaca in Colombia, is also planning to increase capacity to 100,000 tonnes per year with a total capital investment of $250 million. Less significant increases in phosphoric acid capacity are projected in Peru and Uganda with a combined total investment cost of $158 million. Egypt and Mauritania are planning substantial increases of their phosphoric acid plants at Hamrawein and Bofal, respectively, although funds for the two projects have not yet been allocated.

4. *Structure of the cost of production*

Table IV.77 shows average variable costs of production for all phosphoric acid plants, not including the cost of phosphate rock, in each of the major producing countries. Producers with the lowest costs are countries that have no domestic phosphate rock industry.

Table IV.77. Phosphoric acid: average cost for selected producers
(Dollars per tonne)

Country or region	1985	1989a/
Japan	117	..
Morocco	132	174.0
Republic of Korea	109	..
Tunisia	127	158.0
United States	128	132.5
North-Western Europe	130	171.3

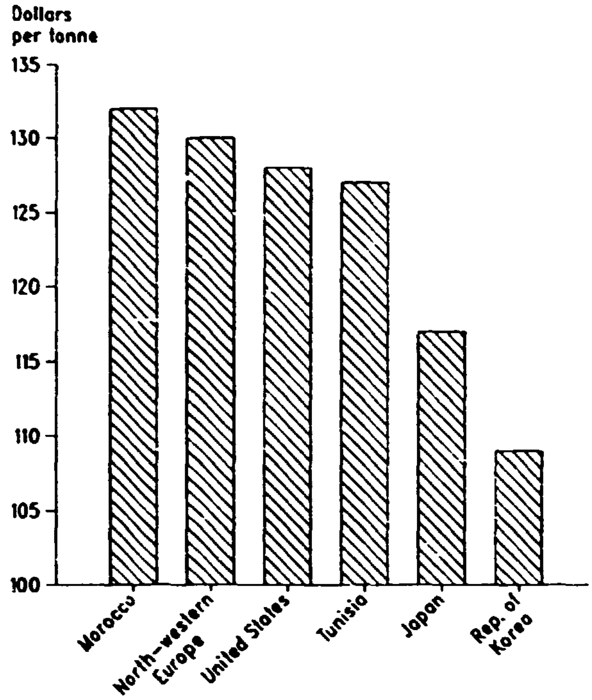
Source: R.J. Fantel, and others, Phosphate Availability and Supply: Minerals Availability Appraisal (Washington, D.C., United States Bureau of Mines, 1987).

a/ Cost forecast adjusted to take into account inflation trends between 1985 and 1989.

The Republic of Korea and Japan must import the phosphate rock required to produce phosphoric acid, but they are able to compete in the export market because they have relatively low production costs. Each of these countries has a relatively low-cost sources of sulphur, a major factor in producing phosphoric acid. As shown in figure IV.11, the average variable costs in Western Europe (excluding Spain) are the highest faced by major producers. European phosphoric acid plants have to import nearly all the phosphate rock they process. The degree to which these plants can remain competitive in the future will depend on their ability to negotiate favourable contracts for phosphate rock and sulphur.

Because the major consuming regions often are far from the producing areas, the cost of transport of phosphate rock and phosphate processed products is an important factor in determining the relative competitive position of alternative supplies. The cost of transport depends on the nature of the product as well as on the distance, on the size of load and vessel and on market conditions. That is, high-grade (for example, higher P_2O_5 content) material can be shipped for approximately the same cost as low-grade material, and is therefore cheaper (measured as cost per unit of P_2O_5 content) to ship [17].

Figure IV.11. Average cost of phosphoric acid for selected producers, 1985



Source: R. J. Fantel *et al.*, *Phosphate Availability and Supply. A Minerals Availability Appraisal* (Washington, D.C., United States Bureau of Mines, 1987).

Table IV.78 shows the distribution of the costs of production in the United States phosphate industry by processing stage. The raw material costs of phosphate rock and sulphuric acid are the two most significant components of phosphoric acid manufacturing costs in the United States. Average United States labour costs are relatively low, primarily because of the high degree of mechanization in United States plants. This may not be true of other major producers world-wide. Energy is not a significant component of the cost of production of phosphoric acid in the United States.

Table IV.78. Production costs in the United States phosphate industry by processing stage, 1988
(Dollars per tonne)

Cost components	Phosphate rock	Phosphoric acid	Diammonium phosphate	Granular triple superphosphate
Electricity	2.46	4.85	1.34	2.34
Reagents	0.87	0.98	0.58	0.38
Severance taxes	1.34	..	..	..
Employment costs	1.62	3.25	1.50	2.47
Maintenance	2.04	11.21	2.12	5.93
Mine and plant overhead	1.34	..	2.69	0.76
Depreciation	1.87	5.16	2.96	0.76
Depletion royalties	0.69	..	..	..
Sulphuric acid	..	99.71	0.44	..
Phosphate rock	..	74.25	..	9.14
Other taxes	0.29	0.71	0.37	0.63
Phosphoric acid	..	..	99.46	69.78
Anhydrous ammonia	..	..	24.62	..
Storage and shipping	..	..	2.91	2.78
TOTAL	15.81	216.90	143.42	100.32

Source: National Fertilizer Development Center, Production Cost Surveys (Muscle Shoals, Alabama, The Fertilizer Institute, 1987 and 1988).

since energy costs in its manufacturing plants are known to be well below the average for other regions, reflecting primarily the lower rates for available energy.

In the North, environmental legislation affecting fertilizer production and use has severely affected the cost of production. The industrial processes that produce fertilizer also produce liquid, solid and gaseous effluents that usually have to be treated to reduce their harmful effects on the environment. The use of double absorption in sulphuric acid plants, the removal of fluoride compounds, the safe disposal of phosphogypsum from phosphoric acid plants, and the removal of nitrogen oxides from nitric acid plants are typical examples of additional investments required to reduce effluents. In the EEC, consideration is also being given to limiting the use of some phosphate fertilizers containing high quantities of cadmium, a toxic metal that can enter the food chain.

5. *Processing in developing countries*

The processing of phosphatic fertilizers in developing countries is still at an early stage. Current fertilizer production and consumption conditions point to processing gaps in Africa, Asia and Latin America. The lack of availability represents a constraint in the application of phosphatic fertilizers. On the average, the dosages applied are lower than that required to obtain optimum productivity.

India has recorded substantial advances in production by utilizing new technologies and processes based on nitric acid decomposition of phosphate rock for phosphatic fertilizer manufacturing and different new formulations of complex fertilizers. As previously noted, the Government plays an important role in the fertilizer industry in India. In the private sector, there are joint ventures with United States transnational corporations and major Indian industrial groups, such as Zuari, owned by the United States Steel Corporation and the Birla Group, together with the Indian public. Two United States corporations, namely Chevron and International Minerals and Chemicals, own and operate a fertilizer plant with an Indian industrial group as a partner and with Indian public shareholding, while there is capital participation in another plant by a transnational corporation from the United Kingdom. A major fertilizer manufacturing company, Shriram Chemical Industries, is fully owned by an Indian industrial group, and the production of phosphatic fertilizers is almost fully owned and managed by Indian private-sector industry.

In Pakistan, the expansion of phosphatic fertilizer production has also involved transnational corporations, in partnership with the private sector. Indonesia has now built facilities for the production of phosphatic fertilizers in East Java. The Republic of Korea has also built new, privately-owned phosphatic fertilizer plants, including joint venture companies that are partly owned and managed by transnational corporations. The domestic production of Jordan is sufficient to enable it to export phosphate acid and phosphatic fertilizers.

The establishment and operation of chemical fertilizer plants in developing countries requires careful project planning and entails fairly complex contractual agreements and other relationships between the host country and foreign corporations involved in fertilizer production and related technology transfers. While the loan component of the large capital outlays necessary for fertilizer production can be provided largely through international financial institutions, part of the equity finance may have to be obtained from transnational corporations, often necessitating joint venture agreements between the parties concerned.

In addition, process technology and basic engineering designs have to be obtained from transnational corporations possessing the specialized expertise, both patented and non-patented [11]. Detailed plant engineering generally requires the involvement of specialized foreign engineering companies, although there is a considerable and growing domestic engineering capability in some developing countries, such as Brazil, India, Mexico and Republic of Korea.

Thus, despite the fact that transnational corporations may not operate through subsidiaries or majority equity holdings in fertilizer production in many developing countries, they nevertheless have been playing an increasing role at various stages of project planning and implementation.

6. *Technology and industry development*

(a) *The nature of processing*

The main processed phosphate products traded in the fertilizer market are the following: phosphate rock; diammonium phosphate (DAP), 18-46-0; monoammonium phosphate, (MAP), 11-52-0; granular triple superphosphate (GTSP), 0-46-0; merchant-grade orthophosphoric acid (MGA), 0-52-0; polyphosphoric (PPA), 0-68-0, or superphosphoric acid (SPA), 0-70-0; and ammonium polyphosphate solution (APP), 10-34-0, 11-37-0.

DAP, MAP and GTSP are solid products manufactured in large volumes and sold to mixers and dealers for blending and direct application; they are traded internationally. The acids (MGA, PPA or SPA) are produced and shipped as fluids to purchasers who use them as feedstocks in their own upgrading plants; acids also are shipped internationally. APP solutions are produced from PPA, usually by both basic producers and regional distributors and dealers, and are ultimately used for direct application and fluid solutions and suspensions.

The first stage of processing is the transformation of the run-of-mine ore to phosphate rock by beneficiation, drying, calcining and grinding or some combination of these steps. Not all of the steps are required in all cases. For example, several plants use processes that accept rock with only mining and beneficiation; the wet concentrate is fed directly to phosphoric acid production. Several other plants accept wet rock for wet grinding. Calcining is not necessary for the majority of rocks; when it is necessary it usually replaces drying, but can be a very costly step if required. In some cases, however, calcining is followed by wet beneficiation, then drying of the concentrate. Phosphate rock sold on the world market for further processing is mainly dried but not ground before shipment. It is usually considered uneconomic to ship wet rock, which has a moisture content of about 15 per cent.

Sulphuric acid is required for producing about 80 per cent of world output of phosphate fertilizer. Sulphurous materials used in fertilizers may be Frasch-mined elemental sulphur, recovered elemental sulphur or pyrite, or they may be obtained as by-products of smelter acid. Of these forms only Frasch-mined sulphur is energy-intensive; it requires large amounts of energy to superheat the water under pressure that is pumped into the sulphur-bearing formation to melt the sulphur, which is then pumped to the surface. Recovered sulphur is mainly that removed from natural gas and fuel oil. Pyrite ore is mined, usually by open-pit methods, and needs little beneficiation. In some cases, pyrite is a by-product of mining and beneficiation of non-ferrous sulphide ore. Recovery of the sulphur dioxide released in non-ferrous sulphide smelting operations (with copper, zinc and nickel, for example) is now mandatory in most countries to prevent atmospheric pollution.

About 60 per cent of world output of phosphate fertilizer is made from phosphoric acid. The most common fertilizer product is phosphoric acid produced by the wet-process method. The principal reaction involved in all wet-process phosphoric acid plants is the digestion by sulphuric acid of tricalcium phosphate, the primary constituent of phosphate ores. This results in the precipitation of gypsum and the formation of phosphoric acid in solution. Most phosphoric acid processes involve the digestion of the phosphate rock with sulphuric acid; in Europe there are some processes that utilize nitric acid for the digestion.

The strength of the phosphoric acid can be increased by evaporating water from it. At the evaporation stage, contaminants (in particular, iron, aluminium and magnesium oxides) can cause problems, since they tend to start precipitating out of the acid as a sludge, which is difficult to store, ship or handle. In addition, the precipitated contaminants develop as complex phosphate compounds containing large amounts of P_2O_5, reducing the grade of the acid produced.

The phosphoric acid will increase in quality through vacuum evaporation stages to approximately 30 to 45 per cent P_2O_5. These are only nominal strengths, but through clarification (removal of much of the sludge) will result in typical merchant-grade phosphoric acid (approximately 54 per cent P_2O_5), which is one of the most common products from a wet-process phosphoric plant. It has been more prevalent in recent years because it has fewer impurities; therefore, the acid can be shipped without large amounts of precipitated solids. Filter acid has a usual concentration of 28 per cent P_2O_5; merchant acid, 54 per cent; and superphosphoric acid, 70 per cent. Another concentration, at 42 per cent P_2O_5, should be considered, since it is sufficient to produce GTSP, DAP, and MAP by slurry processes. In the United States, a few plants use a hemihydrate process that produces filter acid at a concentration of 42 per cent P_2O_5 compared with the dihydrate process. Because hemihydrate processes are energy-saving, as shown in table IV.79, hemihydrate phosphoric acid plants represent a good option, especially in energy-deficient countries. Hemihydrate processes also have a capital cost that is somewhat lower than that of the dihydrate processes, and the product acid is relatively free from sludge-forming impurities.

Table IV.79. Comparison of energy use for processed phosphate products[a]

Product description	Energy input (gigajoules per tonne)	Energy input (gigajoules per tonne of P_2O_5)
Phosphate rock for direct application		
Mined, beneficiated, dried and ground (30 per cent P_2O_5)	1.21	4.03
Same as above but granulated	2.06	6.87
Mined and ground only (25 per cent P_2O_5)	0.53	2.12
Phosphoric acid, merchant-grade (54 per cent P_2O_5)		
Hemihydrate process	2.04	3.77
Dihydrate process	5.29	9.80
TSP, non-granular (46 per cent P_2O_5)		
Hemihydrate process	2.07	4.50
Dihydrate process	4.16	9.02
TSP, granular, slurry process (46 per cent P_2O_5)		
Hemihydrate process	2.25	4.89
Dihydrate process	4.43	9.43
DAP granular, 18-46-0		
Hemihydrate process	1.14	2.48
Dihydrate process	3.94	8.57
MAP granular, 11-52-0		
Hemihydrate process	1.17	2.17
Dihydrate process	4.46	8.26
SSP (20 per cent P_2O_5)[b]		
Non-granular	0.99	4.95
Granular	1.69	8.45

Source: M.S. Mudahar and T.P. Hignett, Energy and Fertilizer: Policy Implications and Options for Developing Countries (Muscle Shoals, Alabama, International Fertilizer Development Center, 1982).

a/ Not including energy for transport of raw materials or products; use of recovered sulphur assumed.

b/ SSP = single superphosphate. No addition of energy from sulphuric acid production.

The quality of phosphate rock for acid production is affected by the contained amounts of such deleterious materials as magnesium (MgO), iron and aluminium (Fe_2O_3 plus Al_2O_3), calcium (CaO) and chlorine. Other materials are also considered deleterious in the processing of phosphate rock for its many end-uses. These include fluorine (because of air pollution regulations in the United States), organic matter (because carbon dioxide levels of greater than 4 to 5 per cent can cause foaming in acid production) and trace metals (which also can cause the precipitation of sludges in acids). All these impurities can cause problems during the production of phosphoric acids, and tend to decrease the profitability of the operations by increasing costs. One chemical rock constituent that has recently become of major importance is cadmium, since relatively high cadmium values have been detected in fertilizer products and in phosphogypsum, which is a waste product in the manufacture of phosphoric acid.

Granular TSP is made by a two-step process that involves first making non-granular TSP, which is later used to make granular mixed fertilizers. Because the making of TSP involves drying and fine grinding of the rock, it is usually energy-intensive.

The great majority of ammonium phosphate plants use a slurry process in which the phosphoric acid is used at an average concentration of about 40 per cent P_2O_5. MAP may also be made in non-granular form for use in granulation of mixed fertilizers. Some plants produce granular MAP or DAP from merchant-grade acid (50 per cent), particularly when the acid is shipped from a distant source. Table IV.79 provides a comparison of energy use for processed phosphate steps involved in products. Energy use for phosphatic fertilizers can vary widely depending on the steps involved in phosphate rock preparation and on the phosphoric acid manufacturing process. The comparison shows that TSP is somewhat more energy-intensive than DAP or MAP, probably because the heat of reaction of ammonia with phosphoric acid is utilized to decrease energy use. However, the choice of the method used for preparing the phosphoric acid, dihydrate versus hemihydrate, gives the greatest opportunity for energy-saving.

(b) *Current technologies*

The major suppliers of technology for the manufacture of wet phosphoric acid, with a P_2O_5 concentration of around 30 per cent, are Dorr Oliver (United States), Fisons (United Kingdom), Nissan (Japan), Prayon (Belgium) and Rhône-Poulenc (France). Nissan employs the hemihydrate process, giving greater overall efficiency. Concentrated acid at around 50 per cent P_2O_5 is also produced by the hemihydrate route, with processes from Fisons, Nissan and Occidental Petroleum (United States).

The trend towards a wide range of mixed fertilizers has required high-analysis phosphate intermediates for granulation with ammonium nitrate or urea. Apart from phosphoric acid, MAP has become a major material for this purpose. The process technology has been developed by four fertilizer companies: Fisons, Gardi. .er, Norsk-Hydro, Scottish Agricultural Industries and Swift. The Minifos system of Fison has been widely adopted during the past 10 years.

(c) *Widespread application of new technologies*

A modified technology for phosphatic fertilizers developed recently, and which has the advantage of simplifying operations significantly, is wet-grinding of rock phosphate. A modified phosphoric acid technology has been developed in conjunction with Central Glass of Japan, generally known as the "Central Glass-Prayon Process", the recovery efficiency of which is higher than that of the original Prayon process. As regards ammonium phosphates, an interesting technology developed by the Tennessee Valley Authority of the United States is based on the melt granulation process and involves the use of a pipe reactor. In another development in Japan, a fluidized granulation process is used for the production of ammonium phosphate and mixed fertilizers in conjunction with pipe reactors.

(d) *Most active developing countries in research and development*

With a few notable exceptions, developing countries have not kept pace with the rapidly changing technological innovations that have characterized the fertilizer industry over the past decade, especially in energy conservation and large-scale, high technology process units. The most significant contributions have been made by State-owned organizations, such as those in India, which emphasize industrial energy conservation. Similar projects have been undertaken in Indonesia and Bangladesh. There is only one international institution dealing exclusively with fertilizer research and development and devoted to the needs of developing countries. That institution is the International Fertilizer Development Center, which was established after the 1974 World Food Conference, is financed internationally, in part by United Nations agencies, and has a Managing Board of Directors drawn from developing and developed countries. With a site adjacent to the Tennessee Valley Authority fertilizer research facilities at Muscle Shoals, Alabama, it has access to the process technology developed by the Authority, and can transfer it to developing countries without any cost for licences or basic know-how.

The Technology Division of the Center has been continuously working on improving the supply of raw materials in developing countries in Africa, Asia and Latin America. However, the Center has not yet developed special competence in the more complicated and costly aspects of process and basic engineering technologies at the heart of fertilizer manufacture. Most of the successful technological developments in process design, basic engineering and fabrication have come from a limited number of firms in developed market economies, under licences or other collaborative arrangements. Some of these technologies are available to manufacturers in countries, such as Brazil and India, where chemical and mechanical engineering are not yet as highly advanced as in developed countries. In recent years, with the rapid expansion of the fertilizer industry in developing countries, there has been increasing interest in acquiring the basic technology and engineering to build additional plants with limited assistance from process licensors in developed countries.

(e) *North-South shifts in competitiveness through applications of new technology*

There exists a significant degree of concentration in phosphatic fertilizers with a few corporations operating on a transnational basis. These corporations are from developed countries and are the sources of the most important technological advances currently or in the foreseeable future. World-wide, while many fertilizer companies have made frequent and important contributions, most of the accumulated know-how and current effort comes from widely diversified companies in which fertilizer manufacture may be a small component of total activities.

The continuing dependence of developing countries on a few corporations from developed market economies in respect of process technology, basic designs and engineering and supervision responsibilities at various stages of fertilizer manufacture poses an important question as to how such dependence can be significantly reduced. In most cases there has been inadequate transfer and absorption of technology in developing countries. Equipment and machinery are largely imported (except in Brazil, India and Mexico), and manufacturing facilities are heavily dependent on imports of spares and components. There is also almost total dependence on imports of catalysts, except in India.

While there is considerable potential for the growth of phosphatic fertilizer production in developing countries, the above-mentioned factors are detrimental to the expansion of further processing in developing countries and need to be effectively tackled to overcome current North-South imbalances and to improve the competitiveness of the South.

7. *Short- and medium-term industry outlook*

(a) *Consumption*

Phosphate will continue to play a major role in the fertilizer market. Over the short to medium term, the demand for phosphatic fertilizers is largely dependent on economic activity and agricultural policies in developed and developing economies. The International Fertilizer Institute estimates that consumption of phosphatic fertilizers will rise by 1 million tonnes over the next five years [18]. Other sources [19] do not foresee the international phosphate market being seriously short for any sustained periods during the 1990s. There may be brief periods of perceived shortages (logistical or inflation-induced) leading to short-term price run-ups during the next two to four years, and to somewhat higher price levels. However, there are enough new projects to enable the world markets to be for the most part adequately supplied. The most significant increases in fertilizer usage are expected to come from the less agriculturally developed regions world-wide. However, major consumption forecasts do not suggest a growth rate during the next 10 years much above that of the 1970-1986 period (about 7.6 per cent) in the South. Developed market economies are projected slowly to increase consumption at a rate of 1.8 per cent per annum up to the year 2000. While the main source of the expected growth in fertilizer consumption will come from crop area expansion in developed countries, growth in developing countries and centrally planned economies will be generated from increases in fertilizer applications per unit of crop area.

(b) *Production*

A World Bank study estimates that there is probably sufficient processing capacity for phosphates to meet world needs through the mid-1990s [20]. After correcting for present excess inventory, this capacity is not expected to satisfy demand much beyond the mid-1990s. Currently, world producers are operating at about 83 per cent of achievable capacity. It is important to note that even at full production in 1980, output reached only 92 per cent of achievable capacity; therefore, a balance by 1995 could be optimistic. Economic depletion will occur in all major producing countries, but is more acute and immediate in the United States.

Between now and the mid-1990s, about 4 million tonnes of new phosphate processing capacity will be required annually, much of it in China. The total investment needed for processing in that country will be about $4 billion. The phosphate industries of Jordan, Morocco and the USSR are also likely to expand steadily through the 1990s, and there could be some development in Australia, Egypt and Togo. In the United States, little new development is expected; the country will retain its position as the major producer and exporter of fertilizer, but its relative position is expected to decline significantly.

Table IV.80 shows the projected future phosphate rock production. New capacity will consist of the expansion of existing plants plus construction of new plants. Not all operations are suited for direct expansion because of various physical limitations. It is estimated that only about 37 per cent of the new capacity can be obtained by expansions. In 1990 very little "grass-roots" capacity is expected to be added owing to unfavourable prices and over-supply. Expansions of existing operations and inventory adjustments will be the most favoured method of meeting short-term demand. In the United States, capital expenditure will be designed essentially to maintain capacity at current levels, whereas African countries, and probably China as well, will almost double their capacity. The USSR must upgrade many Kola mines to maintain production, and thus capital expenditure will not raise output.

Table IV.80. Phosphate-rock supply forecasts a/

Producing country or region	1990		1995		2000		2005	
	Million tonnes	Percentage	Million tonnes	Percentage	Million tonnes	Percentage	Million tonnes	Percentage
United States	55.7	32.0	55.6	29.3	56.9	27.6	52.2	24.1
USSR	31.0	17.8	31.0	17.8	31.0	15.1	31.0	14.3
Morocco	30.8	17.7	33.9	17.8	48.6	23.6	64.3	29.6
China	12.0	6.9	18.0	9.5	18.0	8.7	18.0	8.3
Tunisia	9.0	5.2	12.0	6.3	12.0	5.8	12.0	5.5
Jordan	6.0	3.4	10.0	5.3	10.0	4.9	10.0	4.6
Australia Oceania	4.0	2.3	4.0	2.1	4.0	1.9	4.0	1.8
Israel	3.5	2.0	3.5	1.8	3.5	1.7	3.5	1.6
South Africa	3.4	2.0	3.4	1.8	3.4	1.7	3.4	1.6
Togo	2.4	1.4	2.4	1.3	2.4	1.2	2.4	1.1
Senegal	2.1	1.2	2.1	1.1	2.1	1.0	2.1	1.0
Rest of world	14.1	8.1	14.1	7.4	14.1	6.8	14.1	6.5
TOTAL	174.0	100.0	190.0	100.0	206.0	100.0	217.0	100.0

Source: Society of Mining Engineers, *Economics of Internationally Traded Minerals* (Littleton, Colorado, 1986).

a/ Based on achievable capacity.

The share of developing countries in phosphate production is expected to increase to 38 per cent by 2000. That of developed countries is expected to decrease by 4 per cent, while a similar trend is anticipated in the centrally planned economies [18]. Investments in production facilities in developing countries could exceed $36 billion by 2000. Half of the new phosphate processing capacity is likely to be built in China, and other developing countries with phosphate reserves are likely to make new investments. World phosphoric acid fertilizer capacity is expected to grow at 0.7 per cent per year up to the mid-1990s.

The prerequisites for fertilizer production include raw materials, utilities and infrastructural facilities, technical and managerial skills, capital and large domestic or external markets. Production of phosphoric acid on a large scale is generally associated with assured supplies of an adequate quantity of phosphate rock of consistent quality and of possibly imported sulphur. Such plants are usually built near the phosphate mines, for example in Morocco. Sulphur is an important raw material and major cost item in the production of phosphate fertilizers. The main suppliers of sulphur are Canada, Mexico, Poland, USSR and United States. Sulphur has been in relatively tight supply over the past few years, despite large stockpiles in Canada. Current projections indicate that there will be sufficient sulphur to meet needs through 1995 from existing and planned capacity.

(c) *Market equilibrium and prices*

Over the short term, phosphatic fertilizer prices are expected to continue to rise as a result of expected strong demand. Projected long-term phosphate prices should continue to increase up to 2000 because of expected higher crop prices, strong demand and movements in exchange and interest rates.

Because of economic and environmental constraints, one source estimates that production is not likely to exceed present capacity before 2005, at least in the United States. Most new phosphate demand will be in developing countries and centrally planned countries, where most investment in new phosphatic fertilizer capacity will take place. It also seems increasingly evident that new world capacity development will generally keep pace with expected market changes. Supply factors (as a function of capacity) should become less and less likely to contribute to market imbalance than demand factors. Thus, variations in demand (caused, for example, by weather-induced grain surpluses or shortages) are far more likely to determine the international balance of phosphatic fertilizer supply and demand than supply factors related to capacity.

E. Copper (ISIC 3720041)*

1. *Recent trends and current conditions*

The world copper-processing industry has historically been subject to market fluctuations in quantities and prices. More recently, structural changes in patterns of demand for materials have led to some stagnation in end-use. Environmental concerns about production have arisen and pressures have increased for recycling. Technology is playing an increased role on both the demand and the supply side of the markets in which copper is bought and sold.

After a prolonged period of low prices, international copper prices have increased dramatically since 1986, a result of strong demand increases and reduced capacities caused by industrial restructuring. However, the present copper price plateau of slightly over $1 per pound may not be exceeded, owing to the accumulation of stocks of unsold durable goods such as automobiles, and to postponed purchases by copper wire and brass mills. The previous fall and rapid rise of copper prices reflect the instability that the industry has recently faced, beginning with the oil crises of the 1970s. Copper prices have risen to a sharp peak and collapsed in 1974-1975, 1977-1978, 1980-1981, and 1985-1986.

The production of refined copper has increased every year since 1985, reflecting higher prices and increased economic activity during this period. Increases in secondary production also contributed to the upswing. Refineries throughout the world are estimated to have been operating at about 84 per cent capacity, with a range of between 81 and 91 per cent. The sharp increase in capacity utilization in the United States is due to higher concentrate and leach output. Other significant increases in utilization have occurred in Australia, Canada, Chile, Mexico and Spain. Major new expansions in refinery capacity are anticipated in Chile, Philippines, United States and Yugoslavia.

World demand for refined copper has risen slowly since the downturn experienced in the early 1980s. This growth has been attributed to both consumer demand and substantial capital expenditure in developed countries, particularly in Australia, Japan, United States and Western Europe. While exchange rate adjustments appear to be responsible for rising demand in NICs, structural factors are responsible for more permanent demand changes. These factors include the growth of industrial production, particularly in the capital goods sector, competition between copper and other conventional substitute materials such as aluminium and plastics, and competition arising from new technologies and materials such as fibre optics and superplastics [42].

(a) *Production of primary refined copper*

World production of refined copper increased by nearly 4 per cent in 1988 over the previous year, reaching 8.6 million tonnes. This figure is 16.5 per cent higher than the 1982 output, indicating a steady recovery in the copper industry from the slump of the early 1980s. Data on refined copper production of various countries ranked according to level of production are presented in table IV.81 and in figure IV.12. Concerning recent increases from 1987 to 1988, the United States had the second largest at 24.8 per cent, followed by Australia at 9.5 per cent, Spain at 8.4 per cent and Canada at 6.4 per cent. Mexico registered an exceptionally sharp increase of 82.3 per cent. Surprisingly, several notable decreases occurred, parti-

*UNIDO acknowledges the contribution made by B. Bochum, Department of Mineral Resource Economics, West Virginia University.

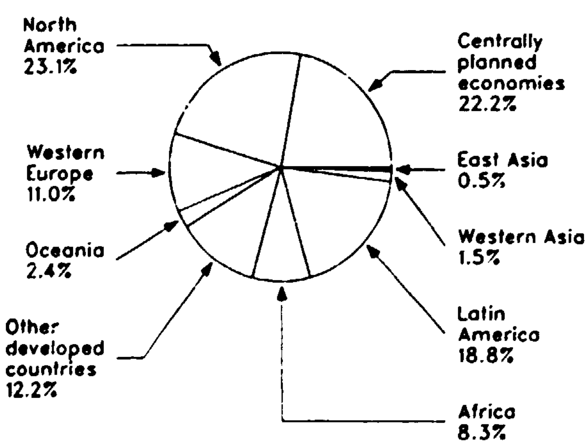
Table IV.81. World production of primary refined copper by region, 1988

Rank in 1988	Country, region or economic grouping	1988 production (thousands of tonnes)	Percentage change 1987-1988	Percentage change 1980-1988	Percentage share 1980	Percentage share 1988
1	United States	1 406.0	24.8	35.7	16.5	16.7
2	Chile	1 012.7	4.4	24.9	11.0	11.2
3	Japan	854.6	-1.9	-3.9	12.1	12.5
4	USSR	850.0	1.2	18.1	9.8	9.9
5	Canada	490.7	6.4	-2.9	6.9	5.7
6	Zambia	447.9	-9.8	-26.3	8.3	5.2
7	China	410.0	2.5	54.7	3.6	4.8
8	Poland	401.0	2.8	12.2	4.9	4.7
9	Belgium and Luxembourg	310.0	-10.4	1.7	4.1	3.6
10	Zaire	202.5	-3.6	40.6	1.9	2.4
11	Mexico	200.3	82.3	115.6	1.3	2.3
12	Australia	196.0	9.5	35.4	2.0	2.3
13	Germany, Federal Republic of	192.0	-1.6	2.1	2.6	2.2
14	Peru	179.4	-20.2	-21.8	3.0	2.1
15	Republic of Korea		8.3	124.1	1.0	1.9
16	Brazil		0.7	..	..	1.7
17	South Africa	148.0	-3.1	5.0	1.9	1.7
18	Spain	108.8	8.4	-21.6	1.9	1.3
19	Bulgaria	88.0	1.1	46.7	0.8	1.0
20	Yugoslavia	79.4	-19.6	-13.5	1.2	0.9
	North America	1 896.7	19.5	10.2	23.4	22.1
	Western Europe	906.0	-6.9	-2.3	12.6	10.6
	Oceania	196.0	9.6	35.3	2.0	2.3
	Other developed economies a/	1 002.6	-2.1	-2.7	14.0	11.7
	Africa	677.9	-7.0	-10.2	10.3	7.9
	Latin America	1 540.4	6.1	35.9	15.4	18.0
	North Africa and Western Asia	120.5	1.8	193.9	0.6	1.4
	East Asia	43.3	-7.9	..	0.2	0.5
	Other developing economies	..	..	..	..	..
	Centrally planned economies b/	2 180.2	2.1	22.7	21.6	25.5
	Total North c/	4 001.3	6.3	4.7	52.0	46.7
	Total South c/	2 382.1	1.5	22.8	26.4	27.8
	TOTAL	8 563.6	4.0	16.5	100.0	100.0

Source: United States Bureau of Mines, Minerals Yearbook (Washington, D.C., Department of the Interior, 1985, 1986 and 1988).
a/ Israel, South Africa, Japan.
b/ Estimates.
c/ Excluding centrally planned economies.

Figure IV.12. World production of primary refined copper, by region or economic grouping, 1988

Total: 8.56 million tonnes



Source: United States Bureau of Mines, *Minerals Yearbook* (Washington, D.C., Department of the Interior, 1985, 1986 and 1988)

cularly Peru at −20.2 per cent, Yugoslavia at −19.6 per cent, Sweden at −14.5 per cent, and Belgium and Luxembourg at −10.4 per cent. Since 1980, the strongest increases have taken place in Mexico at 115.6 per cent and China at 54.7 per cent. Major declines were recorded in the Federal Republic of Germany at −21.8 per cent, Brazil at −21.6 per cent, and Zambia at −26.3 per cent.

From table IV.82 it is difficult to find any clear trends concerning the extent to which the reported

Table IV.82. World production of secondary refined copper by region, 1988

Rank in 1988	Country, region or economic grouping	1988 production (thousands of tonnes)	Percentage change 1987-1988	Percentage change 1980-1988	Percentage share 1980	Percentage share 1988
1	United States	453.3	9.3	-12.0	33.1	26.5
2	Germany, Federal Republic of	234.4	14.5	26.0	12.0	13.7
3	USSR	149.0	1.4	10.4	8.7	8.7
4	Belgium and Luxembourg	124.2	-4.5	80.0	4.4	7.3
5	Japan	100.5	-8.1	-19.5	8.0	5.9
6	United Kingdom	75.0	9.8	-19.4	6.0	4.4
7	Yugoslavia	66.0	64.6	67.1	2.5	3.9
8	German Democratic Republic	62.0	1.6	87.9	2.1	3.6
9	Italy	60.4	0.7	-	0.7	3.5
10	Spain	50.0	-2.0	233.3	1.0	2.9
11	China	50.0	-	66.7	1.9	2.9
12	Brazil	38.0	-26.9	-39.7	4.0	2.2
13	Canada	38.0	26.7	-13.6	2.8	2.2
14	Austria	32.0	-2.7	-7.8	2.2	1.9
15	France	30.2	16.1	-18.4	2.4	1.8
16	Australia	26.7	-7.3	29.6	1.3	1.6
17	Sweden	22.0	83.3	76.0	0.8	1.3
18	Mexico	20.0	-1.0	100.0	0.6	1.2
19	Hungary	12.5	-	4.2	0.8	0.7
20	Romania	12.0	-	-50.6	1.6	0.7
	North America	491.3	10.5	-12.1	35.9	28.7
	Western Europe	706.2	10.9	39.3	32.6	41.3
	Oceania	26.7	-7.3	29.6	1.3	1.6
	Other developed economies	100.5	-8.1	-19.5	8.0	5.9
	Africa	4.0	..	100.0	0.1	0.2
	Latin America	58.0	-19.7	-20.5	4.7	3.4
	North Africa and Western Asia	..	..	..	..	..
	East Asia	10.0	..	25.0	0.5	0.6
	Other developing economies	..	..	..	..	..
	Centrally planned economies a/	313.4	1.7	24.9	18.3	16.8
	Total North	1 324.7	8.6	9.3	77.9	77.5
	Total South	72.0	-16.5	-13.2	5.3	4.2
	TOTAL	1 710.1	5.8	9.9	100.0	100.0

Source: United States Bureau of Mines, Minerals Yearbook (Washington, D.C., Department of the Interior, 1985, 1986 and 1988).
a/ Estimates.

production increases have changed the market shares of developed and developing countries. The refined market share of the North declined from 52 per cent in 1982 to 46.7 per cent in 1988, while the share of the South changed only slightly, from 26.4 per cent to 27.8 per cent. The developing countries of Latin America saw their share increase from 15.4 to 18.0 per cent, while that of Africa fell from 10.3 to 7.9 per cent.

The inability to increase output in other countries can be attributed not only to technical difficulties but also to strikes and shut-downs [21]. Disappointing performance by several mines, notably Ok Tedi, contributed to the rise in refined output being lower than expected in the United States, as did strikes and technical difficulties at smelters. The Horne smelter operated by Noranda started 1988 on strike, and in the autumn its output was again restricted by malfunctioning of the plant, while the Kidd Creek smelter operated by Falconbridge was temporarily closed for maintenance.

Production in Chile was 100,000 tonnes less than forecast, with serious technical problems at the new Codelco plant. Technical difficulties restricted Codelco metal output at the Chuquicamata plant. The achievement of full production by the La Caridad smelter continues to be hampered by technical and labour difficulties. In Peru, the smelter and mines of Centromin have suffered from lack of spare parts and serious strike action; in Taiwan Province, the Keelung smelter closed down for two months for maintenance; and production at the Cox Creek refinery was interrupted for seven weeks. Smelters in Japan not only reduced their cathode production by 25,000 tonnes, but also deliberately restricted additional feed purchases in order to avoid turning the concentrate market against them. Even so, they achieved an increase in production. In the United States, the production increase was helped by the reopening of the Garfield smelter and the new leaching operations. The increase reported for Zambia helped to return production to its 1985 level. Although mine production was in some cases less than expected, high prices in the past two years did ease scrap supplies and increased secondary production.

(b) *Production of secondary refined copper*

The production of refined copper from secondary sources (scrap) depends on the increase in the stock of scrap relative to that of refined copper. Over the long term, the proportion of secondary copper in the total refined copper supply has been increasing in developed countries, and will continue to do so in the future as the stock of scrap increases. The rate of increase, however, is small. Secondary copper represented 16.2 per cent of total refined supply in 1980, and rose only to 16.6 per cent in 1988. Increases in secondary copper production world-wide have risen by 16.7 per cent since 1982, but only 5.8 per cent since 1987. Because of the rationale of recycling, secondary production has been much larger in developed than in developing countries. Table IV.82 shows that the North had a secondary market share of 77.5 per cent in 1988 compared with only 4.2 per cent in the South.

Among developed countries, the United States and the Federal Republic of Germany are by far the largest producers, with refining increases of 9.3 and 14.5 per cent respectively between 1987 and 1988. The USSR, Belgium and Luxembourg and Japan are also large producers. The greatest production increases in 1987 were recorded by Sweden at 83 per cent, and Yugoslavia at 64.6 per cent. Only Brazil reported a strong decline of −26.9 per cent in output for that period. Since 1980 the sharpest increases have occurred in Spain at 233.3 per cent, Mexico at 100 per cent and the German Democratic Republic at 87.9 per cent.

(c) *Production of semi-manufactures*

The production of copper semi-manufactures concerns the activities of wire mills and brass mills. Wire mill products include communications wire and cable, building wire, magnet wire, power cables, apparatus wire and cordage, and automotive wire and cable. Brass mill products include strips, sheets and plates, mechanical wire, rods and bars, and plumbing and commercial tubes and pipes. To these can be added foundry and powder products.

Most production of semi-manufactures is concentrated in three main regions: North America, Western Europe and Japan. Owing to a lack of data for Eastern Europe and most developing countries, total world production cannot be estimated. Table IV.83,

Table IV.83. World production of copper semi-manufactures, 1980 and 1988
(Tonnes)

Country or economic grouping	Plates, sheets and strips	Rods, bars and sections	Tubes	Wire	Total
Benelux a/					
1980	16 522	5 877	27 305	306 081	355 785
1988 b/	12 208	2 486	21 464	319 162	355 320
Percentage change c/	-21.1	-57.7	21.4	-4.3	-0.1
Brazil					
1980	12 750	13 670	6 430	128 920	161 770
1988 b/	12 550	15 546	12 040	120 140	160 270
Percentage change	-1.6	13.7	84.3	-6.8	-0.9
France					
1980	30 271	14 184	56 454	360 094	461 003
1988	24 249	24 574	65 727	368 510	483 060
Percentage change	-19.9	73.2	16.4	2.3	4.8
Germany, Federal Republic of d/					
1980	69 989	30 022	74 383	482 065	657 017
1988	121 042	29 552	121 289	449 875	722 043
Percentage change	72.9	-1.6	63.1	-6.7	9.0
Italy					
1980	33 200	16 500	33 800	265 000	348 500
1988	69 000	12 700	58 500	275 000	415 200
Percentage change	107.8	-23.0	73.1	3.8	19.1
Japan d/					
1980	32 389	24 198	121 936	909 865	1 183 522
1988	189 187	35 914	197 566	1 028 088	1 450 755
Percentage change	484.1	48.4	62.0	13.0	22.6
Scandinavia e/					
1980	37 314	8 316	41 170	112 400	199 200
1988	65 002	10 423	47 471	120 000	242 896
Percentage change	74.2	25.3	15.3	6.8	21.9
Spain					
1980	4 381	5 770	15 161	82 910	108 222
1988	4 210	3 969	26 174	95 718	130 071
Percentage change	-3.9	-31.2	72.6	15.4	20.2
United Kingdom					
1980	34 027	6 714	69 355	250 105	360 201
1988	26 015	3 900	71 774	214 051	315 740
Percentage change	23.5	-41.9	3.5	-14.4	-12.3
United States					
1980	90 265	58 967	301 186	1 269 153	1 719 571
1988	112 490	65 320	390 090	1 472 363	2 040 263
Percentage change	24.6	10.8	29.5	16.0	18.6

Source: Metal Statistics (London, World Bureau of Metal Statistics), various issues.

a/ Belgium, Netherlands and Luxembourg.

b/ 1988 data not available.

c/ Change between 1980 and most recent year.

d/ Others included in total.

e/ Denmark, Finland, Norway and Sweden.

therefore, shows the level of production in 1988 by the major developed country producers and by Brazil, and the percentage change in production from 1980. Countries showing the largest percentage increase in production are Japan at 22.6 per cent, Scandinavia at 21.9 per cent and Spain at 20.2 per cent; losses are shown to have occurred in the United Kingdom at −12.3 per cent, Benelux countries at −0.1 per cent and Brazil at −0.9 per cent. The production of semi-manufactures is also growing fast in Turkey. Further information on tubes and pipes used principally in construction and plumbing appears in [22].

(d) *Trade in refined copper*

Because of their homogeneity, refined products are usually taken as a basis for the description of the world copper trade. Table IV.84 shows that exports of refined copper have grown only slightly since 1980 for both developed and developing countries. While exports from the United States have declined, export increases from Western Europe have accounted for the difference. However, the exports of Western Europe have not attained their level of 1980. Concerning export performance in 1986-1987, strong increases can be seen for Yugoslavia at 140.9 per cent, Australia at 22.1 per cent, United Kingdom at 19.3 per cent, United States at 17.9 per cent and the Federal Republic of Germany at 17.1 per cent. Among developing countries, Zambia shows an increase of 7.1 per cent and Chile of 3.5 per cent. The largest growth in exports since 1980 has occurred in Yugoslavia, Sweden and Australia.

World imports of refined copper appear to have grown more rapidly than world exports in 1986-1987, although trade remained in equilibrium. In that period, as reflected in table IV.85, refined copper imports increased by 13 per cent in Brazil, by 77 per cent in Indonesia, and by 143.4 per cent in Portugal. Among developed countries, the strongest import increases occurred in Finland at 65.2 per cent, Japan at 28.4 per cent and Greece at 22.9 per cent. In the period 1980-1987, substantial increases can be seen in Portugal at 149.6 per cent, Indonesia at 170 per cent, Japan at 54.7 per cent and India at 42.4 per cent.

Although the increases in refined copper imports shown for the United States do not appear to be large, imports rose, as a proportion of domestic consumption, from less than 10 per cent in the early 1970s to 24.3 per cent in 1987. This change is said to reflect the

Table IV.84. World exports of refined copper by region, 1980 and 1987

Rank in 1987	Country, region or economic grouping	1987 exports (thousands of tonnes)	Percentage change 1986-1987	Percentage change 1980-1987	Percentage share 1980	Percentage share 1987
1	Chile	942.6	3.5	23.8	23.1	28.3
2	Zambia	499.4	7.1	-18.7	18.6	15.0
3	Canada	288.8	-5.9	-13.8	10.2	8.7
4	Belgium and Luxembourg	253.6	6.6	-16.9	9.3	7.6
5	Zaire	204.9	-8.0	32.9	4.7	6.1
6	Peru	179.8	-6.8	4.5	5.2	5.4
7	Poland	161.6	-4.6	11.6	4.4	4.8
8	Philippines	119.3	-4.3	-	0.2	3.6
9	USSR	100.0	-	-28.6	4.2	3.0
10	Australia	83.5	22.1	60.9	1.6	2.5
11	Germany, Federal Republic of	63.1	17.1	-26.8	2.6	1.9
12	Japan	60.4	-13.1	-71.4	6.4	1.8
13	Sweden	43.6	8.5	114.8	0.6	1.3
14	Spain	42.5	-35.0	-35.9	2.0	1.3
15	United Kingdom	33.4	19.3	1.5	1.0	1.0
16	Yugoslavia	33.0	140.9	130.8	0.4	1.0
17	Norway	30.2	3.1	9.8	0.8	0.9
18	Austria	23.8	-2.1	-	0.6	0.7
19	China	22.3	-87.0	-	0.0	0.7
20	United States	17.9	20.1	4.1	0.5	0.5
North America		306.7	-4.7	-13.0	10.7	9.2
Western Europe		533.8	2.8	-9.7	17.9	16.0
Oceania		64.4	22.1	57.0	1.6	2.5
Other developed economies		142.4	-12.4	-53.8	8.2	3.7
Africa		704.3	2.2	-8.3	23.3	21.1
Asia		137.3	-5.8	-	0.2	4.1
Latin America		1 122.6	3.0	20.3	28.3	33.7
Other developing economies		19.1	39.4	33.6	0.4	0.6
Centrally planned economies		300.0	1.5	-2.0	9.3	9.0
Total North		1 048.7	-0.3	-17.2	38.5	31.5
Total South		1 983.3	2.3	15.2	52.3	59.5
	TOTAL	3 332.0	1.4	1.1	100.0	100.0

Sources: *Metal Statistics* (London, World Bureau of Metal Statistics), various issues. *Commodity Yearbook* (New York, United Nations Conference on Trade and Development, 1989).

Table IV.85. World imports of refined copper by region, 1980 and 1987

Rank in 1987	Country, region or economic grouping	1987 imports (thousands of tonnes)	Percentage change 1986-1987	Percentage change 1980-1987	Percentage share 1980	Percentage share 1987
1	United States	518.9	2.3	12.8	13.3	14.5
2	Germany, Federal Republic of	429.3	-9.2	-13.0	14.2	12.0
3	Italy	392.0	7.9	-0.4	11.3	11.0
4	France	356.9	5.4	-14.4	12.0	10.0
5	Japan	353.3	28.4	54.7	6.6	9.9
6	United Kingdom	239.9	-9.2	-11.8	7.8	6.7
7	Belgium and Luxembourg	126.0	-4.0	-21.3	5.3	3.5
8	Brazil	114.2	13.0	-45.1	6.0	3.2
9	Philippines	106.9	-	-	0.3	3.0
10	India	76.9	3.5	42.4	1.6	2.2
11	China	75.5	-55.9	-41.1	3.7	2.1
12	Sweden	51.3	-17.3	-32.9	2.2	1.4
13	Argentina	50.9	5.6	32.2	1.1	1.4
14	Hungary	42.0	14.8	21.7	1.0	1.2
15	Indonesia	32.4	77.0	170.0	0.3	0.9
16	Greece	30.6	22.9	23.9	0.7	0.9
17	Portugal	29.7	143.4	149.6	0.3	0.8
18	Finland	27.1	65.2	13.9	0.7	0.8
19	Singapore	27.0	-	-	-	0.8
20	Netherlands	25.0	4.6	16.8	0.6	0.7
North America		473.5	1.3	13.0	14.4	15.0
Western Europe		1 962.7	-1.6	-11.2	59.6	48.8
Oceania		2.6	100.0	15.4	0.1	0.1
Other developed economies		236.2	28.0	49.4	7.2	9.9
Africa		7.4	-	-	0.2	-
Asia		152.7	33.0	205.7	4.6	13.1
Latin America		255.4	9.0	-28.5	7.8	5.1
Other developing economies		31.9	-20.4	-46.1	1.0	0.5
Centrally planned economies		350.0	1.5	-14.3	10.6	8.4
Total North		2 675.0	2.3	-1.6	81.2	73.7
Total South		647.4	22.1	49.0	13.6	18.7
	TOTAL	3 472.4	2.5	8.4	100.0	100.0

Sources: *Metal Statistics* (London, World Bureau of Metal Statistics), various issues. *Commodity Yearbook* (New York, United Nations Conference on Trade and Development, 1989).

gradual loss of cost-competitiveness by United States industry over the past two decades. To some extent the loss of market power reflects a change in pricing policy from a period when United States producer prices were held below the level of the London Metal Exchange (LME) to deter substitution, until 1978 when producers adopted the New York Commodity Exchange price, which is highly correlated with the LME price. Since then, the United States producer price has at times exceeded the LME price.

An additional explanation of the loss of market power has been the impact of the dollar exchange rate on the price of copper and on the ability of the United States and other developed-country copper producers to compete effectively in world copper trade [23]. Exchange rates can affect relative production-cost-competitiveness, and the export position of a country can deteriorate, if other foreign producers devalue their currencies against the currency of that country. Likewise, cost-competitiveness can deteriorate if the costs of a particular country rise faster than the costs of its competitors. As an example, table IV.86

Table IV.86. Consumer price indexes for Canada, Chile, Peru and the United States
(1980=100)

Year	Consumer price index in domestic currencies				Consumer price index in United States dollars		
	Canada	Chile	Peru	United States	Canada	Chile	Peru
1980	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1981	112.4	119.7	175.4	110.4	109.7	119.7	120.1
1982	124.6	131.6	288.4	117.1	118.1	100.8	119.4
1983	131.8	167.4	609.0	120.9	125.0	82.8	108.0
1984	137.5	200.7	1 280.2	126.1	124.1	79.3	106.7
1985	143.0	262.3	3 372.0	130.5	122.4	63.5	88.8
1986	148.9	313.4	5 999.5	133.1	125.3	63.3	124.7
1987	155.4	375.7	1 115.0	137.9	138.7	64.2	203.4

Source: International Financial Statistics (Washington, D.C., International Monetary Fund), various issues.

summarizes consumer price index movements (reflecting changes in production costs) in the United States and its principal copper competitors, Canada, Chile and Peru.

Although the Canadian consumer price index has risen faster since 1980 than that of the United States, there has been very little difference in United States competitiveness with respect to Canada, after adjusting for exchange rate changes through 1984. In 1985, however, a 5 per cent appreciation of the United States dollar against the Canadian dollar more than offset slightly larger price increases in Canada, worsening United States competitiveness in relation to Canada. Consumer prices in Chile have risen considerably faster than in the United States, but when adjusted for exchange rate changes, United States competitiveness with respect to Chile deteriorated considerably. In Peru, prices have risen dramatically since 1980; by 1985, prices were more than 33 times their level in 1980. After adjusting for exchange rate changes, however, the consumer price index in Peru was 88.8, compared with 130.5 in the United States. Again, as in the case of Chile, currency devaluations in Peru had more than exceeded the difference in inflation rates between Peru and the United States. Although United States copper producing cost competitiveness *vis-à-vis* Peru worsened, the deterioration was less severe than in relation to Chile.

A final trade issue is the long-standing dispute between the EEC and Japan over Japanese tariffs on imports of refined copper [24]. First brought before GATT in 1982, this dispute came closer to resolution in 1987, when both parties requested the Director-General of GATT to mediate. The EEC contended that the high Japanese tariffs harmed EEC smelters by raising of the price of their refined copper in Japan and allowing Japanese smelters to dominate the concentrate market. As a first step towards resolution of the dispute, the Director-General appointed an independent investigator to establish the factual situation. Although similar or higher tariffs were applied in the Republic of Korea and Taiwan Province, progress was being made towards their elimination. The tariff in Taiwan Province was reduced in stages from 17.5 to 6.5 per cent in 1987-1988, and in the Republic of Korea it was reduced from 20 to 10 per cent over the same period.

(e) *Consumption of refined copper*

Copper possesses a number of valuable properties that make the metal and its alloys useful in nearly every industry [25]. It is often consumed in almost pure metallic form by the electrical industry in the manufacture of various products, such as generators, motors, electric locomotives, switchboards and telephone and telegraph equipment. In its alloyed form, major copper consumers include the construction, automobile, ammunition and shipbuilding industries.

Since copper is used mainly in the production of durable goods, its demand is largely based on the investment climate surrounding the industries producing such goods. With total investment in developed countries tending to fluctuate far more widely than total consumption, such a relationship introduces a high degree of instability into the durable goods market. Mention has been made of the dependence of consumption on the availability of substitutes, not only in regard to aluminium and conventional materials, but also to new engineering materials. Table IV.87 shows that world consumption of refined copper grew by 13.5 per cent between 1980 and 1988; these figures fail to reflect the sharp decline in consumption experienced in the early 1980s. Consumption stood at 10.6 million tonnes in 1988 compared with 10.5 million in 1987 and 9.4 million in 1980. Most of the refined consumption is shown to have taken place in the North, which accounted for some 62.7 per cent of world consumption in 1988, down only slightly from 65.6 per cent in 1980. Developed consuming countries with the largest share in 1988 were the United States at 20.8 per cent, Japan at 12.5 per cent, Federal Republic of Germany at 7.5 per cent, Italy at 4.2 per cent and France at 3.8 per cent. Among developing countries the Republic of Korea had a 2.5 per cent share and Brazil 2.2 per cent.

The sharpest increases in consumption in 1987-1988 took place in India at 13 per cent, Mexico at 11 per cent and Belgium and Luxembourg at 8.9 per cent. Over the longer term since 1980 the Republic of Korea

Table IV.87. World consumption of refined copper, 1980 and 1988

Rank in 1988	Country, region or economic grouping	1988 consumption (thousands of tonnes)	Percentage change 1987-1988	Percentage change 1980-1988	Percentage share 1980	Percentage share 1988
1	United States	2,210.5	3.5	18.3	19.9	20.8
2	Japan	1 330.7	3.6	14.9	12.4	12.5
3	Germany, Federal Republic of	797.5	-0.3	6.6	8.0	7.5
4	Italy	445.6	6.1	14.9	4.1	4.2
5	France	408.9	2.5	-5.7	3.6	4.8
6	United Kingdom	327.7	-	-19.9	4.4	3.1
7	Belgium and Luxembourg	317.8	8.9	4.6	3.2	3.0
8	Republic of Korea	266.3	2.8	217.0	0.9	2.5
9	Canada	238.5	2.7	14.3	2.2	2.2
10	Brazil	232.0	-10.3	-5.7	2.6	2.2
11	Spain	135.0	2.7	-0.4	1.4	1.3
12	Yugoslavia	131.0	5.7	6.9	1.3	1.2
13	India	130.0	13.0	68.4	0.8	1.2
14	Australia	128.8	3.9	2.1	1.3	1.2
15	Mexico	120.4	11.0	2.8	1.2	1.1
16	Sweden	104.6	6.4	..	..	1.0
17	Finland	73.7	-4.3	28.2	0.6	0.7
18	Turkey	70.0	-7.0	109.6	-0.4	0.7
19	Greece	44.0	12.8	25.7	0.4	0.4
20	Argentina	42.9	-32.8	-18.3	0.6	0.4
	North America	2 449.0	3.4	17.9	22.2	23.0
	Western Europe	2 751.5	2.6	2.2	28.7	25.9
	Oceania	130.6	4.1	1.6	1.4	1.2
	Other developed economies	1 330.7	-1.9	6.6	13.3	12.5
	Africa	29.4	5.8	-6.7	0.3	0.3
	Asia	641.6	-18.9	113.7	3.2	6.0
	Latin America	469.2	-15.3	-5.0	5.3	4.4
	Other developing economies	131.0	-5.7	6.9	1.3	1.2
	Centrally planned economies	2 346.3	-	-	-	22.1
	Total North	6 661.8	2.0	8.4	65.6	62.7
	Total South	1 621.2	-16.0	33.8	10.1	15.2
	TOTAL	10 629.3	2.0	13.5	100.0	100.0

Sources: Metal Statistics (London, World Bureau of Metal Statistics), various issues. Commodity Yearbook (New York, United Nations Conference on Trade and Development, 1989).

reports the strongest increase at 217 per cent, followed by Turkey at 109.6 per cent and India at 68.4 per cent.

In the United States, consumption in 1988 rose by 3.5 per cent over the 1987 level and 18.3 per cent over that of 1980. The demand for copper in its construction industry has been variable, with declines occurring near the end of the year. At the same time, copper demand for use in industry and in commercial building has been more stable. The demand for consumer durables and industrial electrical equipment has also been good. In Japan, however, the growth of demand for copper to be used in both electric wires and copper and brass mill products has been much stronger, owing to a long-delayed boom in consumer demand.

Consumption in Japan thus increased by 3.6 per cent in 1988 over the 1987 level, and by 14.9 per cent over that of 1980. In the Federal Republic of Germany demand fell by −0.3 per cent in 1987. Its increase of 6.6 per cent since 1980 is mainly due to increased activity in the automobile industry. Among developing countries, the rise in refined copper consumption was strongest in Asia, which recorded a 113.7 per cent increase in the period 1980-1988, with the Republic of Korea and India showing the highest growth rates.

(f) *Consumption of copper semi-manufactures*

To obtain a better understanding of the above-mentioned changes in refined copper consumption, it is necessary to examine both end-use substitution effects and recent changes in industries employing copper as an input. As reflected in table IV.88,

Table IV.88. Refined copper consumption by major end-uses in selected countries and regions, 1970 and 1983

Country or region and end-use	Consumption 1970 (thousands of tonnes)	Consumption 1983 (thousands of tonnes)	Percentage change 1970-1983	Percentage share 1970	Percentage share 1983
Western Europe[a]					
Electrical[b]	1 487	1 658	11.50	48.0	49.1
Construction	489	582	19.02	15.8	17.2
Transport	308	261	-15.26	9.9	7.7
General engineering	574	615	7.14	18.5	18.2
Domestic uses	240	262		7.8	7.8
Total	3 098	3 378	9.04	100.0	100.0
United States					
Electrical[b]	1,018	1,220	19.84	44.4	50.6
Construction	445	368	-17.30	19.4	15.2
Transport	196	178	-9.18	8.6	7.8
General engineering	460	478	3.91	20.1	19.7
Domestic uses	173	164	-5.20	7.5	6.7
Total	2 292	2 408	5.06	100.0	100.0
Japan					
Electrical[b]	624	769	23.24	55.3	52.1
Construction	90	122	35.55	8.0	8.3
Transport	169	228	34.91	15.0	15.4
General engineering	178	239	34.27	15.7	16.2
Domestic uses	68	118		6.0	8.0
Total	1 129	1 476	30.74	100.0	100.0
Brazil					
Electrical[b]	63	92	46.03	59.4	63.9
Construction	8	15	87.50	7.5	10.4
Transport	15	17	13.33	10.4	11.8
General engineering	15	8	-46.67	10.4	5.6
Domestic uses	5	12	140.00	4.7	8.3
Total	106	144	35.85	100.0	100.0

Source: K. Takeuchi and others, The World Copper Industry: its Changing Structure and Future Prospects (Washington, D.C., World Bank, 1987).

a/ Including Southern Europe.

b/ Including telecommunications.

electrical and electronic end-uses in Western Europe and Japan account for approximately 50 per cent of total consumption. Construction, transport and general engineering end-uses tend to be important in those countries and in others as well. Copper tubing plays an important role in construction. Copper use in consumer products tends to be about the same in Western Europe, the United States and Japan. In 1983, 49.1 per cent of consumption in Western Europe was for electrical end-uses, 17.2 per cent for construction, 7.7 per cent for transport, 18.2 per cent for general engineering and 7.8 per cent for domestic uses.

Although the long-term prospects for copper use in electrical products and telecommunications are good, the current outlook is less favourable. In the United States, investment in electrical generation and transmission has tapered off from past high levels in 1973 and 1974, and this trend is expected to continue. In

Japan, applications in the domestic telecommunications market have become saturated owing to the very high level of telephone ownership. In addition, 80 to 90 per cent of new large trunk telecommunications may be taken over by fibre optics. Consumption in cables, generating equipment, electrical installations and motors is also approaching near-saturation. In the Federal Republic of Germany, most of the past investment has been for rationalization, rather than the expansion of capacity. A continuation during the 1990s of the rapid growth of the past 15 years in its electrical industry will depend on expansion in the territory of the German Democratic Republic after unification of the two countries.

(g) *Replacement of copper by optical fibres*

A major factor affecting copper consumption is its replacement by other traditional materials or by modern engineering materials. The traditional materials competing with copper are aluminium, stainless steel, plastics (polyvinyl chloride), titanium, lead, cadmium and niobium. Aluminium has been increasingly substituted for copper in recent years. The new engineering materials of importance are superplastics, optical fibres and possibly superconducting materials. Fibre optics technology now offers a viable, if not superior, alternative to copper wire systems in telecommunications. Current technology makes the use of fibre optics in telecommunications a reality, and the economics of optical fibre systems suggests that the substitution may proceed rapidly. An examination of substitution possibilities is thus important for understanding how rapidly copper wire and cable consumption may decline [26].

Most substitution is likely to take place in the telephone network, but applications are not likely to proceed at an equal rate of penetration in all parts of the system. Telephone networks can conveniently be disaggregated into three general segments: the long-distance network, inter-office exchanges and the local feeder and distribution loop. In long-distance networks, the clear advantages of fibre optics technology suggests that the majority of the new routes will employ optical fibre cables. Possibilities for copper being used are currently strongest in the local feeder and distribution loop.

To forecast the volume of copper that will be displaced by optical fibres in wire and cable use, the rates of market substitution of fibre optic cables for copper wire must be considered. According to the World Bank [26], these rates were expected to vary between previous levels of 10 per cent in 1985 and 32 per cent in 1989 to a possible 70 per cent by 1995. The Bank also applied these rates to determine the loss in copper wire and cable consumption in the Federal Republic of Germany, France, Italy, Japan, United Kingdom and United States. On the basis on projected GDP growth rates for developed countries, expected to average about 3 per cent per annum between 1985 and 1995, the expected consumption losses are given in table IV.89. Of the total of 309,000 tonnes of copper displaced by optical fibres, the biggest losses are likely to occur in Japan and Italy, countries with the largest shares of copper consumption in both the telecommunications and electrical industries.

Table IV.89. Copper displaced by optical fibres in telecommunications in selected countries, 1983 to 1995
(Thousands of tonnes)

Year	France	Germany, Federal Republic of	Italy	Japan	United Kingdom	United States
1983	-	-	-	-	-	-
1984	2.5	1.8	3.1	4.9	0.9	1.2
1985	6.4	5.2	4.8	12.0	2.9	3.8
1986	11.9	9.0	11.6	20.4	5.6	7.9
1987	18.4	14.8	20.0	31.1	9.7	12.8
1988	24.9	21.1	28.0	41.6	14.6	18.9
1989	31.6	25.5	35.9	51.7	19.9	25.0
1990	36.1	31.5	43.0	60.7	25.2	31.6
1991	40.8	37.2	48.6	66.1	30.4	36.3
1992	43.4	39.3	52.5	70.4	34.6	40.3
1993	45.9	41.2	55.6	72.9	37.9	42.6
1994	47.8	50.8	57.8	74.5	40.5	43.9
1995	49.3	50.7	59.4	75.5	42.6	44.4

Source: Non Ferrous Metal Statistics (New York, American Bureau of Metal Statistics), various issues.

2. *Industry restructuring*

Broadly speaking, four different markets for copper can be distinguished according to the major industry processing stages; that is, the market for copper concentrates, for blister copper, for refined copper and for copper semi-manufactures [23]. This distinction is important for understanding the dynamic relationship between suppliers and customers in the international copper trade. It should also be recognised that each of these product categories has its own market structure in terms of the degree of flexibility of demand and supply, the degree of homogeneity of products and the characteristics of suppliers and customers.

Quality differences in copper concentrates and blister copper are distinctly greater than in refined copper. The mineral composition and assay of copper concentrates and blister copper differ from producer to producer, depending on the geology of the mines and the type of processing facilities involved. Also, with blister copper, the size of a given product differs depending on the habits of a particular producer. Thus, product differentiation among producers is stronger in the copper concentrates and blister markets than in the refined markets. Customers tend to have a preference for certain types of concentrates or blister copper over other types.

In contrast to concentrates and blister copper, refined copper is more standardized in quality and size. Refined copper is almost always easily interchangeable among different brands. The high degree of homogeneity of refined copper provides its customers with a greater flexibility in obtaining required materials.

Because of the high vertical integration of the world copper industry, any explanation of industry structure must begin with organization at the mining stage. While firm concentration has decreased historically at this stage, it remains high at the smelting and refining stages, concentration falls off again at the semi-fabrication stage. A large number of international copper firms are vertically integrated to some degree, but there appear to be relatively broad and active arm's-length markets between independent firms at each stage.

(a) *Largest companies in the North*

In 1948 the seven leading transnational copper-mining corporations, namely Kennecott Copper (United States), the Roan-AMC Group (United States), the Anglo-American Group (South Africa), Union Minière (Belgium) and International Nickel of Canada (INCO), accounted for 70 per cent of total market economy output, but by 1969 their share had dropped to 54 per cent [27]. By 1978, Newmont Mining (United States) and Asarco (United States) had replaced the Roan-AMC Group and Union Minière, with the seven largest companies accounting for 25 per cent of capacity. As shown in table IV.90, the 10 largest firms now account for only 28.3 per cent of capacity. The largest of the 10 are Métallurgie Hoboken, Asarco, Phelps Dodge, and Canadian Copper Refiners. These changes in market share can be attributed to the following five main factors [28]:

(a) Many new discoveries of major copper sources have occurred, most recently in the South Pacific (Australia, Indonesia and Papua New Guinea), the Province of British Columbia in Canada, Siberia and parts of Africa and Latin America;

(b) The possibility of geographical discovery has been aided by the diffusion of the mining technology needed to work very low-grade ore bodies successfully on a large scale. This includes the recent development of solvent leaching processes that permit copper recovery to be made from tailings;

(c) The pressure towards creating new sources of copper has come from the desire of smelting, refining and fabricating companies to integrate backwards to their own supplies or to finance the growth of small, new copper mines and be paid back in output. Financing from companies based in Japan, for instance, has played a major role in the multiplication of copper ventures over the past 15 years. Japanese companies have used contracts for copper metal or copper concentrates as collateral in providing capital between 1966 and 1973 for 13 new mines in eight countries. By 1975, 57 per cent of Japanese imports (414,000 tonnes) originated in projects financed in part by Japanese institutions. In addition, Japanese firms have developed new mines in Zaire and Malaysia using equity investments. Refiners and fabricators in the Federal Republic of Germany, led by the Norddeutsche Raffinerie-Metallgesellschaft AG group, have followed the same pattern in Africa and the South Pacific;

(d) Companies not traditionally associated with copper have diversified by forming or buying copper-mining companies;

(e) State-owned companies have become increasingly active in the industry as Governments of developing countries have attempted to obtain more control over the exploitation of their copper resources.

A number of United-States-based mining firms have some degree of vertical integration between the mining and refining stages. Anaconda, Phelps Dodge, Kennecott and Asarco all have large mines, smelters and refineries. In Japan, Nippon, Mumitomo, Mitsubishi and Mitsui are the major smelters and refiners, but their links to the mining stage are largely indirect. In Western Europe, Norddeutsche Raffinerie and Union Minière are the largest smelters and refinery groups, but they do not own mines.

The degree of integration in the United States, none the less, has never been exceedingly high. Whereas Anaconda, Phelps Dodge, Kennecott and Asarco had 17 per cent of the mining capacity of developed market economies in 1979, their collective refinery capacity was 22 per cent. Three other large United States-based copper companies, Amax, Cerro and Phelps Dodge, operate custom smelters and refineries to process the output of other producers who retain ownership but pay toll charges. Altogether, Amax,

Table IV.90. The largest copper-refining companies in the North, 1980 and 1988

Company and country	Capacity 1980 (thousands of tonnes)	Capacity 1988 (thousands of tonnes)	Percentage change 1980-1988	Percentage share 1980	Percentage share 1988
Metallurgie Hoboken (Belgium)	780.0	850.0	8.24	8.69	6.98
Asarco (United States)	522.4	413.6	-26.30	5.82	3.40
Phelps Dodge (United States)	446.2	380.9	-17.14	4.97	3.13
Canadian Copper Refiners (Canada)	435.4	371.9	17.07	4.85	3.05
Nippon Mining (Japan)	360.0	300.0	-20.00	4.01	2.46
Norddeutsche Raffinerie (Federal Republic of Germany)	240.0	230.0	-4.35	2.67	1.89
Onahoma Smelting and Refining (Japan)	234.0	234.0	0.00	2.61	1.92
Magma Copper (United States)	181.4	272.1	33.33	2.02	2.24
Kennecott Copper (United States)	423.6	206.8	-104.83	4.72	1.70
INCO (Canada)	179.6	179.6	-	2.00	1.48
TOTAL	3 802.6	3 438.9	-10.58	42.39	28.26

Source: Non Ferrous Metal Statistics (New York, American Bureau of Metal Statistics, various issues).

Asarco and Cerro operate 19 per cent of the smelting capacity and 32 per cent of the refining capacity in the United States, but hold only 5 per cent of the mining capacity in that country. At the same time, Duval, Cyprus and Cities Service have become large mining companies (Duval and Cyprus have capacities of 120,000 and 100,000 tonnes, respectively); without smelting or refinery facilities of their own, they thus rely on arm's-length market transactions (those taking place at open market prices rather than internal prices) for those services.

An arm's-length market for smelting and refining services is growing in developing countries [27]. For example, Southern Peru Copper Company, owned by Asarco, Cerro, Phelps Dodge and Newmont, produces blister copper, which is then refined by Minero Peru (Empresa Minera del Peru). In Papua New Guinea, the Rio Tinto Zinc mine sells its concentrates to non-affiliated smelters, with the exception of a small amount sold to a subsidiary in Spain.

Concentration is also relatively diffuse at the semi-fabrication stage of the international copper industry. Concentration ratios at almost all stages of copper milling and foundry operations have been declining. There is a high degree of vertical integration from the refining stage to the semi-fabrication stage, but the overlap is highly imperfect, again reflecting a broad arm's-length market. Altogether less than one half of all copper fabrication facilities are affiliated with copper producers. The ownership structure at this stage also appears to vary considerably from country to country. In some countries, such as Belgium and France, the principal copper semi-manufacturers and manufacturers are members of the same corporate group; while in other countries, such as the Federal Republic of Germany and the United States, there are a large number of semi-manufacturers and manufacturers that have no corporate interconnections.

(b) *Largest companies in the South*

Over the past several decades Governments and private interests in developing countries have increased their ownership of mines as well as unrefined and refined copper capacity. A recent assessment [29] of the more important of these ownership changes highlights the following: the acquisition by the Government of Chile of the properties and processing facilities held by Anaconda, Kennecott and Cerro in Chile; the acquisition by the Government of Zambia of a majority interest in Nchanga Consolidated Copper Mines and in Roan Consolidated Mines; and the acquisition by the Government of Zaire of the properties and processing facilities held by Union Minière du Haut Katanga.

Other instances of government or private interests increasing their participation in copper have occurred in Peru, where the Government has acquired the properties and processing facilities of the Cerro Corporation, and in Mexico, where government legislation designed to increase local participation in industry has resulted in private and public interests acquiring a majority interest in several previously foreign-owned copper companies. Prior to these nationalization programmes, the involvement of developing country governments and firms was relatively small. Some exceptions were government involvement in Chile (Empresa Nacional de Minera), India (Hindustan Copper) and Yugoslavia, and government-private ventures in Mexico and the Philippines.

Table IV.91 provides a ranking of the refined copper capacity of the 10 largest companies in the South. Together they account for only 23.2 per cent of total capacity. However, the concentration is fairly high if the share of the first four out of 10 is considered. Some 74.3 per cent is accounted for by four government enterprises, namely Zambia Consolidated Copper Mines, Companio de Cobra, Gecamines and Enami. Further comments on restructuring in the South are given below in section 3 on capacity utilization and expansion.

(c) *Significance of State-controlled industries*

Mineral specialists have come to recognize that State-controlled enterprises have become more prevalent in international mineral markets [29]. Such enterprises range from State-trading organizations and

Table IV.91. The largest copper refining companies in the South, 1980 and 1988

Company and country or area	Capacity 1980	Capacity 1988	Percentage change 1980-1988	Percentage share 1980	Percentage share 1988
	(thousands of annual tonnes)				
Zambia Consolidated Copper Mines	770.0	770.0	-	8.58	6.32
Compania de Cobra (Chile)	455.0	455.0	-	5.07	3.74
Gecamines (Zaire)	250.0	250.0	-	2.79	2.05
Enami (Chile)	150.0	622.0	314.67	1.67	5.11
Minero Peru (Peru)	135.0	188.5	39.63	1.51	1.55
Caraiba Metals (Brazil)	150.0	150.0	-	1.67	1.23
Sociedad Minera El Temente (Chile)	130.0	130.0	-	1.45	1.07
Hindustan Copper (India)	40.6	42.0	3.45	0.45	0.34
Taiwan Metal Mining (Taiwan Province)	-	50.0	-	-	0.41
Cobra de Mexico (Mexico)	71.6	165.0	130.45	0.80	1.36
TOTAL	2 152.2	2 822.5	31.15	24.00	23.20

Source: Non Ferrous Metal Statistics (New York, American Bureau of Metal Statistics, various issues.)

State-owned mineral industries to regulatory agencies that determine tariffs or exert control in the procurement of minerals. Their nature and impact varies according to whether they reside in developing or developed countries, or take the form of international agencies.

The most obvious impact of the growth of State-controlled enterprise on an industry such as copper would be to change market structure and hence price formation by increasing or decreasing the degree of competition [30]. Any increase in the size or number of State-controlled enterprises might infringe upon the survival of private industry. Such an increase would have to be accompanied by the actual exercise of any attained market power. Possibilities for producer and consumer cartels can also be increased, since public enterprises are better suited to enter into restrictive types of international commodity agreement. These enterprises could also lead to lower output and higher prices than could have been achieved otherwise, resulting in permanently higher production costs [29]. Greater mineral price instability may also arise because of the production inflexibility of State mineral enterprises. The possibility also exists that nationalized firms will break up and not re-establish certain chains of vertical integration.

The contemporary history of increased State ownership began in the late 1960s. In 1967, the Government of Zaire nationalized the properties of Union Minière du Haut Katanga, bringing all the copper operations of the country under the State-owned company, Gecamines. In the same year, the Government of Chile assumed a 51 per cent interest in the El Teniente Mine of the Bradem Copper Company, a wholly owned subsidiary of Kennecott Copper Corporation. This was followed in 1969 by an agreement whereby the Government acquired in 1970 a 51 per cent interest in the Chiquicamata and El Salvador properties of Anaconda. Nationalization of the Chilean copper industry was completed in 1971. In 1970, the Government of Zambia began to acquire the properties of the Anglo-American Corporation and of Roan Selection Trust. By 1979, Codelco (Chile), Gecamines (Zaire) and Zimco (Zambia) together accounted for 24.1 per cent of total mine capacity of the developed market economies.

If the nationalization of copper companies prior to 1976 is accepted as an action that was necessary for Governments to acquire resources for economic development, the recent completion of such action suggests that no further changes in market structure are likely to occur in the immediate future. The increases in ownership since 1980, reflected in table IV.91, are reasonably small, and since these increases have not led to market power in the form of price manipulation, it appears that any future structural impact that State-controlled enterprises might have on the market is limited. Even when the Intergovernmental Council of Copper Exporting Countries undertook its first cartel action in 1974 to influence prices, no copper price increases came about. To a large extent, the relegation of copper price formation to the LME also acts as a safeguard.

3. *Capacity utilization and expansion plans*

Because of the shorter construction periods for smelters and refineries than for mines, new projects and expansions are not announced far in advance [31]. Data on future capacity, even within a period of five years, are therefore unreliable. For this reason, and because significant data for the group of the former centrally planned economies are not available, only rough estimates of total planned capacity are possible. Table IV.92 shows that there were approximately 12.2 million tonnes of refining capacity at the end of 1988, up from 9 million tonnes in 1980. One source ([32], pp. 27-31) states that in 1988-1989 this capacity was utilized to produce refined copper at a rate equivalent to the utilization of 84 per cent of global mine capacity. This figure agrees with the range estimated by the United States Bureau of Mines [24]. Refinery capacity utilization is estimated at between 81 and 91 per cent and smelter capacity at between 77 and 80 per cent.

Regarding the distribution of capacity, table IV.92 shows that in 1988 about 30 per cent could be found in North and Central America, 16.25 per cent in Asia and Oceania (including Japan), 9.64 per cent in Africa, 14.52 per cent in Latin America and 12.35 per cent in Western Europe. Among individual countries, the United States accounted for 18.1 per cent of total refining capacity, followed by Chile (9.9 per cent).

Table IV.92. World copper-refining capacity, end of 1988

Region, country or area	Capacity 1980	Capacity 1988	Percentage change 1980-1988	Percentage share 1980	Percentage share 1988
	(thousands of tonnes)				
United States	2 414.2	2 202.0	-8.79	26.90	18.10
USSR	..	1 040.0	..	..	8.55
Japan	1 242.1	1 166.4	-6.09	13.85	9.58
Chile	765.0	1 208.0	57.91	8.53	9.93
Zambia	770.0	770.0	0.00	8.58	6.33
Canada	433.5	610.0	40.72	4.83	5.01
Belgium and Luxembourg	820.0	850.0	3.66	9.14	6.98
Germany, Federal Republic of	325.0	340.0	4.61	3.62	2.80
Poland	..	432.0	..	..	3.55
Peru	190.0	243.0	27.89	2.11	2.00
Zaire	250.0	250.0	0.00	2.79	2.05
Australia	210.0	230.0	9.52	2.34	1.89
South Africa	155.0	154.2	-0.52	1.73	1.26
Yugoslavia	150.0	150.0	0.00	1.67	1.23
Spain	170.0	184.0	8.23	1.89	1.51
Mexico	72.0	165.0	129.17	0.80	1.36
Brazil	150.0	150.0	0.00	1.67	1.23
Republic of Korea	130.0	200.0	53.85	1.45	1.64
United Kingdom	157.0	[illegible]	-17.83	1.75	1.06
Philippines	..	138.0	..	..	1.13
China	..	475.0	..	..	3.90
North America a/	2 847.7	2 812.0	-1.23	31.73	23.11
Western Europe a/	1 472.0	1 503.0	2.10	16.40	12.35
Africa a/	1 175.0	1 174.2	-0.10	13.11	9.64
Latin America a/	1 177.0	1 766.0	50.04	13.11	14.52
Asia a/	1 372.1	1 979.4	14.26	15.30	16.25
Centrally planned economies a/	..	1 622.0	..	..	13.30
TOTAL	8 970.0	12 169.0	35.66	100.00	100.00

Source: Non Ferrous Metal Statistics (New York, American Bureau of Metal Statistics, various issues).

a/ Based on data in table.

Japan (9.6 per cent), USSR (8.6 per cent), Belgium and Luxembourg (7 per cent), Zambia (6.3 per cent) and Canada (5.0 per cent).

Although developing countries have roughly the same share of mine capacity as developed countries, their share decreases when the proportion is examined at higher stages of copper processing. In 1988, the major copper-exporting developing countries accounted for 28.8 per cent of the refinery capacity of the develo[illegible]d market economies and for 35.1 per cent of their smelter capacity. The higher share of smelter production in developed countries is due to imports of concentrates and the use of copper scrap as a smelter input. In developing countries, scrap accounts for a very insignificant part of smelting and in most cases is nil.

The differences in the percentage of smelting and refinery capacity have been changing in recent years, and will presumably continue to do so if developing countries can manage to derive the economic benefits that come from increased copper processing. Although several developing countries, such as Mexico and Papua New Guinea, continue to export concentrates, many countries are exporting an increasing proportion of refined metal as compared with copper at other stages.

For example, in Peru, which exports over 60 per cent of its copper as blister copper and 35 per cent as refined metal, there are plans for building additional refining capacity. The copper industries in Chile and Zambia are integrated to a substantial degree. Virtually all the output of the Zambian mines is refined before export. Approximately 70 per cent of Chilean mine production is refined locally, the remainder being smelted locally and exported as blister copper. In Zaire, approximately 90 per cent of output is smelted locally, and 45 per cent is processed through to the refined stage.

Regarding new copper mine and plant construction, the following activities have been reported for 1990 ([33], pp. 89-94): North and Central America—five projects at $611 million; South America and the Caribbean—19 projects at $5,671 million, Europe—four projects at $559 million; Africa—one project at $700 million; Asia—five projects at $538 million; and Oceania—eight projects at $1,349 million. This yields a total of 42 projects at $9,428 million.

Information on smelter and refinery capacity expansion is also available ([33], pp.89-103). As part of the new investment projects listed in table IV.93, smelting and refining expansion is expected in Chile at Codelco plants at Chuquicamata, Caletones and Potrerillos and at ENAMI plants at Las Ventanas and Paipote; in the Republic of Korea at Onsan (although offset by a closure at Changhung); and at Port Kembla in Australia. A 25 per cent increase by Pasar in the Philippines is probable, but not yet confirmed, while the future of the small smelter in Taiwan Province is

Table IV.93. Survey of copper smelter and refinery expansions, 1990

Company	Location	Project	Planned copper capacity (tonnes per year)	Investment (millions of dollars)	Start	Project classification	Notes
Falconbridge	Timmins, Ontario Canada	smelter, refinery	80 321	60	1988	BD	Expansion from 52,655 tonnes per year
Paraibuna de Metals	Sao Luis, Brazil	smelter, refinery	100 000	150	1989	A	Also 50 tonnes per year of silver and 5 tonnes per year of gold
Codelco	Chuquicamata, Chile	solvent extraction electrowinning	250 000	280	1988	D	Includes leaching plant at Mina Sur open-pit mine
Enami	Paipote, Chile	smelter	130 000	26	1992	D	New converter and upgrading of oxygen and acid plant
Enami	Las Ventanas, Chile	smelter	160 000	67	1990	D	New acid and oxygen plant
Hudson Bay Mining	Flin Flon, Manitoba, Canada	smelter		130	..	E	Noranda reactor to be installed
Mitsubishi Metals	Texas City, Texas	smelter	150 000	200	1991	A	Concentrate from Latin American mines
						C	Concentrate from adjacent mine
Empresa Minera	Tintaya, Peru	smelter, plant	24 000				
Hierro Peru	Marcona, Peru			80	1988-1989	BC	Treatment of tailings and production of 3 000 tonnes per year
Outokumpu	Harjavalta, Finland	smelter, refinery	100 000	23		D	Expansion from 80 000 tonnes per year
Quimigal	Sines, Portugal	smelter, refinery	100 000	300		C	Feed from Neves Corvo; flash smelting
Bor Group	Bor, Yugoslavia	smelter	210 000	122	1990s	C	Feed from Bor Basin
Government	Sabah, Malaysia	smelter	50 000 a/	150		C	Copper concentrate from the Mamut field
Pasar	Philippines	smelter	170 000	50		CE	Expansion from 138 000 tonnes per year
Electrolytic Refining	Port Kembla, New South Wales	smelter	80 000	150	1990	D	Expansion to double capacity
Hindustan Copper	Khetri, India	smelter	31 000	10	1988	E	
Hindustan Copper	Ghatsila, India	refinery	20 000	9	1988	D	Expansion from 16 500 tonnes per year
National Iran Copper	Sarcheshmen, Islamic Republic of Iran	concentrator, smelter		153	1988	D	Expansion by 40 000 tonnes per year, plus 6 000 tonnes per year of cobalt

Source: "International project survey", Engineering and Mining Journal, vol.191, pp.89-94.

Notes: A New project under construction.

B Project included in development programme, on which which construction has not yet begun, and may require further financing.

C Project in the initial proposal stage.

D Expansion of current facilities.

E Routine capital expenditure to maintain capacity or modernize facilities.

a/ Blister copper.

said to be in doubt. In the United States new capacity is coming on stream at the San Manuel plant of Magma Copper, helping to offset the closure of the Douglas plant of Phelps Dodge, and the Bingham Canyon complex is reopening. Apart from the scheduled expansions, plans by Mitsubishi Metals for a new smelter in the United States with a capacity of between 100,000 and 120,000 tonnes are well advanced, while in Brazil a 100,000-tonnes plant at Mananhao and a 300,000-tonnes plant by CVRD at Azul are also real possibilities. The Paraibuna project in Brazil and the Pasar expansions are accompanied by similar increases in the refining capacities of the plants; Mitsubishi, however, will produce anodes only. In addition, a new 100,000-tonnes refinery is being built in Zaire at Luilu, and there are important expansions by Norddeutsche Raffinerie in the Federal Republic of Germany and by Falconbridge at Kristiansand, Norway.

4. *Nature of production costs*

Production costs are central to any analysis of the performance and structure of the world copper industry. However, the accurate assessment of these costs remains difficult, not only because of the lack of suitable data, but also because of obvious differences in accounting procedures between firms or between organizations making independent estimates. Any international copper cost comparisons made must thus be interpreted cautiously.

Among sources of cost information, the United States Bureau of Mines has provided publicly available estimates on a regular basis for the major copper-producing countries [24]. The most recent estimates, shown in table IV.94, feature total production costs as well as smelter refinery costs (which include costs of transport and of by-product and co-product smelting). Australia, Chile and Zaire are shown to have the

Table IV.94. Estimated copper-refining and total production costs
(January 1988 dollars per pound of refined copper)

Country and type of cost	Number of mines	Mine operating cost	Mill operating cost a/	Smelter and refinery cost b/	By-product credit	Net operating cost	Taxes c/	Cash costs	Recovery of capital d/	Total production cost c/, e/
Average annual production costs f/										
Australia	4	0.33	0.14	0.16	0.23	0.39	-	0.39	0.07	0.47
Canada g/	18	0.47	0.30	0.52	0.92	0.36	-	0.37	0.18	0.54
Chile	7	0.15	0.16	0.09	0.05	0.34	-	0.34	0.05	0.39
Peru	5	0.21	0.30	0.33	0.07	0.76	0.02	0.79	0.14	0.92
Philippines	7	0.28	0.37	0.24	0.49	0.39	0.04	0.43	0.10	0.53
United States	18	0.19	0.28	0.17	0.10	0.52	0.01	0.53	0.07	0.61
Zaire	4	0.27	0.14	0.29	0.25	0.45	0.01	0.46	0.03	0.48
Zambia	9	0.32	0.26	0.25	0.08	0.76	0.08	0.84	0.06	0.89
Other	40	0.35	0.36	0.28	0.42	0.57	0.01	0.59	0.15	0.74
Total number of mines and average costs e/	112	0.26	0.25	0.24	0.27	0.47	0.01	0.48	0.09	0.57
Life-of-the-mine production costs h/										
Australia	4	0.47	0.22	0.19	0.44	0.44	-	0.44	0.07	0.51
Canada g/	18	0.61	0.31	0.68	1.23	0.37	-	0.37	0.18	0.55
Chile	7	0.18	0.21	0.09	0.05	0.42	-	0.43	0.05	0.48
Peru	5	0.19	0.30	0.36	0.22	0.63	0.01	0.64	0.15	0.80
Philippines	7	0.24	0.31	0.24	0.28	0.52	0.03	0.55	0.10	0.65
United States	18	0.16	0.26	0.17	0.09	0.50	0.01	0.50	0.07	0.57
Zaire	4	0.29	0.15	0.25	0.19	0.51	0.01	0.52	0.03	0.54
Zambia	9	0.35	0.26	0.25	0.08	0.77	0.08	0.85	0.06	0.91
Other	40	0.28	0.34	0.28	0.34	0.56	0.02	0.58	0.16	0.74
Total number of mines and average costs e/	112	0.25	0.26	0.21	0.23	0.50	0.01	0.51	0.09	0.60

Source: K. Takeuchi and others, The World Copper Industry: its Changing Structure and Future Prospects (Washington, D.C., World Bank, 1987).

a/ Including copper recovery by leaching

b/ Including cost of transport and of by-product and co-product smelting.

c/ Taxes and production costs are at a rate of return of zero per cent and do not include taxes based on State or federal revenue.

d/ Cost average over the life of the machinery.

e/ Averages may not add precisely because of rounding.

f/ On the basis of annual production rates and ore grades in 1988.

g/ Including the Sudbury nickel-copper operations of INCO and Falconbridge.

h/ On the basis of life-of-the-mine production rates and ore grades; not necessarily reflecting 1988 grade and production.

lowest average total costs followed by Canada and the Philippines. Smelter refinery costs were lowest for Australia, Chile and the United States, followed by Zambia and the Philippines. Smelting costs include roasting, smelting, converting, fire refining and delivery of the blister copper to the refinery. Refinery costs include that of converting electro-refining blister copper or anode copper into high-grade cathodes, and of delivering the refined copper to the mill. Depending on location, transport costs can add considerably to process[illegible]s.

Other [illegible]ences in reported cost estimates are due not only to the technology involved, but also to the cost structure, which varies with factor input proportions [34]. For example, smelters can employ any of the following seven furnace technologies: conventional reverberatory; oxy-fuel reverberatory; electric; Inco flash; Outokumpu flash; Noranda continuous; and Mitsubishi continuous. The conventional reverberatory furnace is the most widely used smelter technology in the world, but it is also the poorest performer, using three times as much labour as the most labour-efficient process. With respect to energy, these furnaces consume larger quantities of fossil fuels than do furnaces using the other technologies, and require more electricity than all except the electric furnace. They also incur the heaviest charges for supplies. As for by-products, reverberatory operations produce less sulphur but more steam than most other processes. The use of oxygen-enriched combustion air in reverberatory furnaces is a variation practised to a limited extent. This modification improves factor productivity, but reduces the production of steam and sulphur by-products.

Compared with furnaces using conventional reverberatory technology, electric furnaces have 60 per cent higher labour productivity and partially substitute electricity for fossil fuels. Electricity use in electric furnaces is nearly double that of any other smelter technologies. Nor are any credits for steam production accrued by electric furnace facilities. The flash (Inco and Outokumpu) and continuous (Noranda and Mitsubishi) processes are generally the most efficient smelter technologies. Together they account for 44 per cent of copper production. Each requires roughly the same amount of labour (0.8 to 0.9 working hours per tonne of concentrate) and electricity (330 to 380 kilowatt-hours per tonne of concentrate). Gas and oil use is greater for the continuous processes, and sulphur and steam production vary among the different technologies.

Data regarding actual factor costs in the countries referred to above are difficult to obtain. For most of the countries, either delivery or labour is the largest cost component in refining. Individually these factors vary greatly; together they typically account for 60 to 6[illegible] per cent of gross refining costs. Energy and supplies account for 24 and 14 per cent of the gross cost, respectively. The major contributor to the energy component is electricity.

While the above data provide insights into the structure of factor costs, an equally important consideration is the major changes that have taken place in the trend of overall costs over the past decade. A variety of influences, most of them beyond the control of the industry, triggered the changes [23]. Some of the influences were the following: the steep rise in energy costs resulting from OPEC oil price increases in 1973 and 1978; tighter pollution control standards and their stricter enforcement, especially in developed countries; high inflation followed by high interest rates; and substantial and frequent exchange rate variations between the dollar and other major currencies.

The dynamic interplay of external influences and the vigorous efforts by copper producers to ensure their own survival have led to the application of cost-cutting measures and cut-backs or closures of uneconomic operations. In general, net operating costs fell from \$0.49 per pound (or 0.4536 kilogram) in 1975 to \$0.47 per pound in 1988. This reduction is best understood in terms of the cyclical behaviour of the copper industry, whereby losses in periods of low copper prices have been offset by profits in periods of high copper prices [23]. The recent prolonged period of low prices, however, appears to have forced producers to think of such prices as normal. Because copper is a homogeneous product, cost-competitiveness is the only way to survive. Because product prices are determined by market forces, a mere relative cost advantage over competitors in the copper industry does not guarantee that producers can cover their production costs. Therefore, in addition to striving for cost-competitiveness, producers have been forced to reduce absolute cost levels.

A final factor in achieving cost reductions is the greater emphasis placed on the efficiency of smelting and refining operations ([35], pp. 160-165). For integrated producers, mining and milling costs at many mines have appeared to reach a trough. With total production costs at many competing operations now only a few cents apart, small variations in smelting and refining costs have become increasingly important. For custom processors, the stimulus has been the low level of processing charges that they have experienced for concentrates and blister copper in recent years. Given that treatment and refining charges on concentrate, and refining charges on blister copper, rose sharply in 1988, producers anticipate a period of narrow margins. When that occurs, the survival of some custom operations could be in doubt unless their operating costs are reduced.

5. *Processing in developing countries*

Although developing countries have considerably increased their processing and refining of copper ores, there still exist gaps in capacity between the volumes of blister copper, refined metal and semi-manufactures currently produced and the volumes that could be produced if all concentrates were domestically processed. An attempt will now be made to estimate those gaps, following an approach based on a recent OECD study [36].

Although developing countries accounted for 50.2 per cent of world copper ore capacity in 1988, table IV.95 and figure IV.13 show that they achieved only 31.4 per cent of refined metal capacity. As a result, developing countries currently have the capacity to refine only 74.5 per cent of the concentrates they produce, leaving a gap in refined metal consumption that could potentially be filled by the expansion of domestic

Table IV.95. Copper mining, smelting and refining capacity, 1988
(Thousands of annual tonnes)

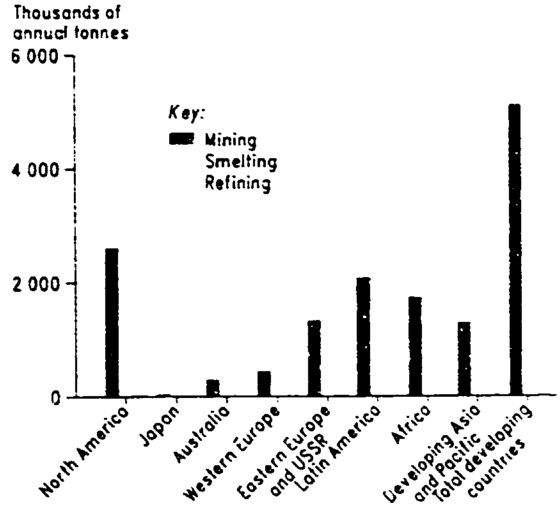
Country, area, region or economic grouping	Mining	Smelting[a]	Refining[a]
World	10 210	11 653	12 169
North America	2 619	2 320	2 812
Canada	929	629	610
United States	1 690	1 691	2 202
Western Europe	420	160	1 970
Japan	26	1 212	1 244
Australia	288	254	243
Eastern Europe and USSR	1 339	1 712	1 903
Latin America	2 099	1 833	1 661
Brazil	53	160	195
Chile	1 580	1 304	1 208
Mexico and Central America	329	274	174
Peru	457	362	252
Africa	1 731	1 364	1 074
South Africa	196	256	163
Zaire[b]	780	525	250
Zambia[b]	637	464	625
Developing countries of Asia and the Pacific	1 299	1 172	1 088
ASEAN			
Indonesia	130	-	-
Malaysia	-	-	-
Philippines	247	138	138
China	240	585	475
India	75	92	48
Papua New Guinea	250	-	-
Republic of Korea and Taiwan Province	3	185	175
TOTAL	5 129	4 369	3 823
Developing countries as percentage of world total	50.2	37.5	31.4

Source: M. Brown and B. McKern, Aluminium, Copper and Steel in Developing Countries (Paris, Organization for Economic Co-operation and Development, 1987).

a/ Including smelting and refining of scrap.

b/ A substantial part of mine production is processed hydrometallurgically.

Figure IV.13. Copper mining, smelting and refining capacity, 1988



Source: M. Brown and B. McKern, Aluminium, Copper and Steel in Developing Countries (Paris, Organization for Economic Co-operation and Development, 1987).

Table IV.96. Capacity gaps in processing of copper concentrates to produce smelted and refined copper, 1988[a]

Country, region or economic grouping	Additional annual capacity requirement (thousands of tonnes) Smelting	Refining
Latin America		
Brazil	55	100
Chile	276	96
Peru	95	110
Africa		
Zaire[b]	255	275
Zambia[b]	173	-
Asia and Oceania		
China	..	110
India	..	84
Indonesia	130	130
Malaysia	30	30
Papua New Guinea	250	250
Philippines	109	..

Source: M. Brown and B. McKern, Aluminium, Copper and Steel in Developing Countries (Paris, Organization for Economic Co-operation and Development, 1987).

a/ One tonne of copper concentrate is assumed per tonne of smelted and refined copper. Gaps are understated, especially for refining, to the extent that some existing capacity is committed to the processing of scrap.

b/ A substantial part of mining output is processed hydrometallurgically.

processing. Two of the bigger developing country producers already have largely integrated processing capacities. Chile has 15.5 per cent of world concentrate capacity, 11.2 per cent of world smelter capacity and 9.9 per cent of refinery capacity. Zambia has 6.2 per cent of concentrate capacity, 4 per cent of smelter capacity and 5.1 per cent of world refinery capacity.

Developing countries with the potential to undertake further processing of blister and refined copper are listed in table IV.96. One source ([35], pp.160-175), estimates that six or seven of these countries could contemplate investment in some 1.2 million tonnes of new smelting capacity and 1.6 million tonnes of refining capacity. However, one complication with gap analysis in the case of copper is that the available capacity data for refining, and to some extent for smelting, do not distinguish primary from secondary metal. Thus, to the extent that existing refining capacity is dedicated to scrap refining, gaps are understated. This bias applies mostly to more industrialized developing countries.

Another complication is whether appropriate technology could be deployed in developing countries to close the gaps. This does not seem to be a problem, however, since refining technology is readily available from a number of suppliers, and the major developments over the years have involved the casting stage. Continuous casting has been an important ad[illegible]ce, as was the development of the Asarco shaft [illegible] used for melting copper prior to casting. [illegible]ogies at the semi-fabrication stage are also [illegible]ly non-proprietary, with the important exception of the technologies developed for the continuous casting of wire rod. These technologies can, however, apparently be used without a continuing requirement for assistance from the supplier or any other enterprise. Continuous casting of wire rod is employed on a limited basis in developing countries, and to date has been used only in importing developing countries.

Most developing countries have some small-scale copper fabrication. All the bigger, more industrialized, developing countries have larger-scale units, especially for the fabrication of electrical wire and cables. OECD [36] has estimated that annual semi-fabrication on capacity in 1984 was approximately 1.1 million tonnes in developing countries of Asia, 750,000 tonnes in Latin America and 50,000 tonnes in Africa (excluding South Africa). More than three quarters of the total capacity of developing countries would be for wire-making, most of it located in the more industrialized developing countries.

Most developing-country production is for local consumption and exports of semi-manufactures and manufactures are very small, although statistics are incomplete and there are problems of definition. Moreover, most exports, especially if the copper content of finished manufactures are included, are not made by traditional copper producers, but rather by NICs such as Brazil, India and Republic of Korea, which are also net copper importers.

Because of the heterogeneity of products, processes and firms, it is very difficult to generalize about processing costs beyond what was said in the previous section. However, it is somewhat easier to generalize about the comparative advantage of primary copper exporters. These countries tend to be at a significant competitive disadvantage in relation to developed consuming countries in international freight and investment costs. A greater disadvantage concerns marketing costs and the need for close contact with consumers. On the other hand, developing exporting countries generally have lower labour costs which, for some products in some locations, may outweigh the other competitive disadvantages. Tariff and non-tariff barriers are significant. Nevertheless, OECD [36] believes that considerable growth in world trade in semi-fabricated and fabricated products is possible.

The extent to which developing countries will expand consumption sufficiently to absorb the potential increases has been considered in a recent World Bank study [37]. The basis for analysis is the material intensity-of-use, which reflects the number of tonnes of copper consumed per million constant dollars of GDP. Table IV.97 shows that although copper intensity-of-use has fluctuated in recent years in developing countries, an increase can be confirmed, particularly in Brazil, Republic of Korea and Turkey. Further analysis of the data also reveals that the net import share of copper semi-manufactures in domestic consumption has increased in India, Mexico, Republic of Korea and Turkey. While further information and analysis would be necessary to determine the need, economic efficiency, and comparative advantage of further copper processing in specific countries, the above-mentioned trends confirm a potential for further processing.

Whether such processing can be justified in terms of increasing processed exports, and hence greater value added, depends more on market competitiveness in relation to existing developed-country producers. Three types of problems appear to exist [29]. The first type involves problems of an institutional nature, such as tariff structures and existing commercial relationships between producers and consumers. The second type includes problems associated with commercialization. For some products, such as wire rod, vertical integration reduces trade prospects, while for others, the

Table IV.97. Copper intensity-of-use, 1960-1985 a/

Country	1960	1965	1970	1975	1980	1985	Range b/	Per capita GDP, 1980 (dollars)
India	-	0.66	0.47	0.25	0.48	0.55	3.58	240
Philippines	-	-	0.22	0.11	0.09	0.14	5.85	690
Turkey	0.20	0.26	0.39	0.40	0.59	1.12	6.02	1 470
Republic of Korea	-	0.12	0.27	0.64	1.35	2.37	64.70	1 520
Brazil	0.49	0.41	0.63	0.86	0.99	0.73	2.51	2 050
Mexico	0.42	0.54	0.55	0.52	0.63	0.58	1.89	2 090
Chile	0.92	4.27	0.96	1.40	1.56	0.96	5.17	2 150
South Africa	0.85	0.78	0.64	0.37	1.14	1.01 c/	1.94	2 300
Portugal	1.32	0.83	0.78	0.71	0.75	0.61	2.72	2 370
Yugoslavia	2.13	2.07	1.87	2.08	2.19	2.21	1.64	2 370
Argentina	0.32	0.34	0.24	0.31	0.34	0.33	2.00	9 890
Japan	1.27	1.11	1.25	1.00	1.09	0.94	1.57	9 890
United States	0.93	0.98	0.96	0.63	0.72	0.64	1.91	11 360
Sweden	1.41	1.14	0.85	0.81	0.85	0.82	2.02	13 520

Source: M. Radetki, State Mineral Enterprises (Washington, D.C., Resources for the Future, 1985).

a/ Consumption per unit of GDP.

b/ Ratio between maximum and minimum intensity value recorded each year during period.

c/ 1984 data.

diffuse nature of the market (for example, the large number of enterprises using copper wire) may make efforts to penetrate them costly. The third type pertains to potential competitiveness *vis-à-vis* producers in developed countries. For example, because of their greater distance from markets, export-oriented plants in developing countries may have to maintain a higher level of pipeline stocks to ensure a regular and uninterrupted supply of goods than would a plant in the country of consumption. There is, in addition, a need to establish and maintain adequate stocks of more sophisticated products near important markets in order to be able to service consumers at any time with any type of processed product. Other areas in which export-oriented plants may be at a disadvantage include technical servicing and access to needed spare parts for machinery and equipment.

6. *Technology and industry development*

Since the latter part of the 1970s, the copper industry has experienced a relatively long period of stagnation, some of it attributable to a slow-down in the economic growth rates of the major economies. However, some of the decline is also due to lagging technology and increased competition from engineering materials in certain end-uses. An important problem is that copper producers have viewed technological innovation strictly in the context of mining and beneficiation. The resultant innovations have consisted mainly in adaptions of other types of technology to mining, and in this respect the producers have been reasonably successful.

There are, however, a number of new technologies that can be applied at the smelting and refining stages not only to improve efficiency but also to reduce harmful sulphur dioxide emissions. One recent study ([38], pp. 1271-1273) has ranked new smelting technologies and systems according to their potential importance, as follows: flash smelting; continuous smelting (Noranda/Mitsubishi/Outokumpu); fugitive control; solvent extraction (electrowinning); CLEAR process (hydrometallurgy); refractories (increased on-stream time, better maintenance and improvements in corrosion-erosion characteristics); CYMET process (hydrometallurgy); improved precious metals recovery; cogeneration of power from smelting; advanced by-product recovery system; and AMAX blast furnace smelting. It should be noted also that there are two hydrometallurgical processes for sulphuride concentrates, namely the Cuprex extraction process (CMEP), and GCM—Great Central Mines process. Both are chloride-based. CMEP is the only hydrometallurgical process shown to have consistently produced cathode-grade copper, though in granular form.

Copper produced in nearly all smelting processes and in some hydrometallurgical processes contains impurities and by-products. The above-mentioned study [37] also ranked four of the most significant refining technologies as follows: automation of tank house operations; periodic current reversal; fluid-bed electrode; and electrode-slurry process.

Among other new processing technologies, some attention has been given to continuous processes, but the latest technologies have had little commercial application to date ([35], pp.160-165). The WORCRA process devised by Consolidated Rio Tinto of Australia has not proved commercially viable, and development is not continuing. A newer SENKEN process has been proposed, operating at rates exceeding 2,000 tonnes per day per reactor. This process is said to be capable of smelting much coarser feed than flash smelting. Two other processes, KIVCET and the TBRC have value for special feedstocks only. Klockner-Humboldt-Deutz developed its CONTOP process. The process employs an oxygen-fed high-temperature cyclone reactor that produces a high-grade matte, which is then top-blown to remove slag, followed by continuous converting and refining in a separate stationary tow-blown furnace, to produce anode-grade metal. The process is now also seen as an efficient way of raising capacity and reducing operating costs at existing smelters. CONTOP cyclones are now operating successfully at Padabora (South Africa) and Chuquicamata (Chile), and Asarco plans to rebuild its El Paso smelter using this technology. The Q-S process developed by Queneau and Schuhmann is still under development. It feeds dry concentrates to a rotary sloping kiln, and combustion is progressively controlled by the admission of oxygen and coal.

Power metallurgy has emerged as a source of new and viable copper manufacturing processes with advantages over conventional ingot metallurgy practice. A new process developed by Gorham International was expected to produce fully dense powder-metallurgy parts at lower cost than either sintering or sintering combined with hot isostatic pressing. Advantages claimed for the pressure-assisted sintering process are equipment costs that were considerably lower than those incurred with other processes, shorter cycle times than other processes, a very narrow density scatter band, and better dimensional control than with conventional sintering.

Technological innovations are also important for the further expansion of copper in a variety of industry sectors and end-uses. Prospects for change in copper applications have recently been analysed by the International Copper Research Association [39], which has suggested that applications of new technology could lead to new market opportunities for copper in heat pumps, solar power, desalination facilities and electric vehicles. Solar power is a promising area, with passive systems the main area for growth during the next 20 years. The use of copper solar radiator systems in the United States consumes more than 10,000 tonnes annually and is growing slowly. Since large-scale solar electric generation plants are not considered economically viable, heat pumps are being used more extensively in heating and cooling buildings. In a few years over one third of new homes are expected to be equipped with heat pump facilities, and the total market in the United States will exceed 1 million units.

Desalination and other marine applications account for about 100,000 tonnes of copper alloys per year. The largest applications continue to be ship propellers and condenser tubes for heat exchangers in coastal power-generating plants. Desalination plants remain a long-term opportunity for copper. Copper usage is also expected to increase in copper alloy tooling, in fabrication of aerospace and automobile advanced composite structures, in power handling systems, in electronically controlled devices used in automated machinery, in supplying power for lasers and in superconducting devices.

7. *Environmental aspects of copper processing*

Copper processing can have significant adverse impacts on air quality, surface- and ground-water quality and surrounding soil. Concerning air quality, uncontrolled copper-smelting processes involve the emission of large quantities of particulate matter, trace elements and sulphur oxides, all having adverse effects on human health. Sulphur dioxide (SO_2), and the sulphates and sulphuric acid aerosols it forms in the atmosphere, can be lung irritants and aggravate asthma. Estimates of the magnitude of health risks and the influence of SO_2 and secondary pollutants from all emission sources range from 0 to 50,000 premature deaths per year in the United States and Canada [34]. Sulphur dioxide emissions from smelters also have been linked to visibility degradation and acid deposition.

Fugitive emissions from furnaces and converters can cause health problems in the work place and result in elevated levels of toxic pollutants such as lead and arsenic in the immediate vicinity of the smelter. Generally, employees are exposed to the highest concentrations of toxic elements because they work in enclosed areas. However, contamination of the soil surrounding a smelter is also of concern. Fortunately, toxic metals are present only in very small concentrations in most copper ores.

To control copper smelter pollution, the problem must be considered at all pyrometallurgical processing stages [34]. Most control methods involve collecting the gases and converting the SO_2 to some other product. The characteristics of the gases dictate the type of control technology, which in turn determines the kind of by-products produced. For example, pollution-abating acid plants require a relatively high (at least 4 per cent) SO_2 concentration in the off-gas for economical operation and compliance with pollution limitations. Roasters, flash furnaces, electric furnaces continuous smelting furnaces and converters all produce gases that can be treated in an acid plant. Weak gases, such as those from reverberatory furnaces and fugitive emissions, must be treated by different means.

Acid plants have proven to be popular in the United States. The technology is well proven and is the least expensive method of smelter SO_2 control. Sulphuric acid is used in solution mining, and is the most common form in which other industries consume sulphur; thus it can be a saleable by-product rather than a waste product. However, markets for non-leaching applications of sulphuric acid generally are a considerable distance from the smelters in the United States, and the resulting transport costs can turn the by-product credit into a deficit. Moreover, it is often cheaper for industrial consumers to buy sulphur and produce the sulphuric acid themselves than to purchase acid produced elsewhere.

In some countries, such as Japan, a very high level of SO_2 control is achieved by copper smelters as part of a government policy to provide sulphuric acid for industrial de lopment. In developing regions, such as the copper-producing countries of Africa and Latin America, there are few industrial markets for acid, and SO_2 control is minimal.

The imposition of environmental regulations on copper processing can affect the nature of the production technology employed, and thus the efficiency or profitability of a plant [34]. In the United States, for example, limitations on SO_2 emissions have resulted in the replacement of reverberatory smelting furnaces with flash or continuous furnaces that can employ acid plant technology. While SO_2 control requires large capital investment, the technologies employed improve efficiency in copper recovery. Similarly, although installing liners and other controls to prevent copper leaching solutions from contaminating ground water adds to the cost of solution mining, these controls also mean greater recovery of the copper-laden solution.

Given these trade-offs, and the fact that each copper operation is unique, it is extremely difficult to estimate the cost of environmental regulation. Industry sources in the United States have estimated that the additional cost to domestic copper producers of full compliance with the Clean Air Act may eventually amount to $0.15 per pound (0.4536 kilogram) of copper. Some government analysts suggest that, while the costs of full compliance at reverberatory smelters may well be over $0.12 per pound because of operating characteristics that make SO_2 capture difficult, the cost at newer smelters may be as low as $0.03 per pound, with an average for all United States operations of $0.09 per pound [34].

The significance of this cost for industry competitiveness depends on the cost of the domestic and international operations to which it is compared. In the early 1980s, when the average net domestic production cost was $0.92 per pound, the average cost of air quality control was 10 per cent of the total cost. Today, the average net production cost has dropped to around $0.47 per pound, making air quality control about 19 per cent of the cost. Because detailed data on environmental controls at foreign smelters are not available, it does not suffice simply to subtract $0.09 per pound from the United States cost (or add it to foreign costs) in order to compare international differences in pollution control costs [34].

Except in Japan, smelter emissions are controlled, if at all, only to the extent that sulphuric acid is needed at an associated leaching project. Copper smelters in other countries capture up to 35 per cent of the input sulphur, on average only about 20 per cent of the present level of control in the United States. Japanese smelters achieve 95 per cent control as part of a government policy to subsidize sulphuric acid production. Information on the costs of acid production in other countries is not available. One comparison [40] made between Canada, Chile, Peru and the United States on the basis of incomplete information about their level of control, suggested that a balancing of environmental standards would make the United States more competitive with Canada and Chile, but not with Peru.

8. *Short- and medium-term outlook*

The world copper industry is currently recovering from a malaise which began in the late 1970s. The causes of the downturn can be seen both in the creation of substantial over-capacity in that period, and in the secular decline of world demand. These problems became more aggrevated during the 1982-1984 recession. Special problems exist for developing countries, not only because of the continuing debt crisis, but also because of related difficulties of obtaining foreign exchange for plant maintenance and modernization. During the past two years, however, the industry has experienced an upturn. The period of rationalization has led to increased profits, and the improved conditions are expected to continue.

(a) *Consumption*

After a sharp decline in the early 1980s, the consumption of refined copper by developed countries has recently increased. This change, together with production gaps that largely triggered the copper price boom of 1987-1989, was unexpected. Although long-term implications should not be drawn from a two-year upturn, it nevertheless calls for a reassessment of the post-1973 trend towards sharply declining intensity of output of metals. Some of the causes of the recent increases in copper consumption are only beginning to be understood [41]. The most fundamental of these causes, the increased production of metal-intensive capital goods, may point to a future for copper consumption that is not altogether as bleak as previously expected, at least for the medium term.

Most of the major copper-consuming countries participated in the 1985-1988 demand increases, which applied to almost all lines of copper production. The net increase in consumption between 1985 and 1988 was about equally divided between developed and developing countries. The centrally planned economies had virtually no change. Growth was particularly strong in Brazil, Canada, Chile, China, France, Federal Republic of Germany, Italy, Japan, Republic of Korea, Mexico and Taiwan Province.

The most unusual aspect of the 1985-1988 increase in consumption has been that growth in the developed countries, measured in terms of GDP, continues to be only moderate. Their copper consumption increased almost at the same rate as that of GDP from 1985 to 1988, even when the GDP growth rate was slightly below average. In developing countries, copper consumption grew at a slightly lower growth rate between 1985 and 1988. This behaviour represents a significant departure from past relationships. The main reason appears to be that the copper-intensive industrial and capital goods branches have done better than the rest of the economy in the United States, Japan, Italy, and several other developed countries.

There are also indications that technology and tastes may now be working in favour of copper, with expansion anticipated for data communications and cable television. Another factor is the partial restoration of the position of copper as against aluminium in the building wire market. Still another is the penetration of copper into the market for tubing in competition with steel and aluminium. On the other hand, the replacement of copper by materials such as plastics, ceramics and optical fibres is likely to continue.

Over the short to medium term, the demand for copper is largely contingent on economic activity in the developed and developing market economies. It is too early yet to learn what the impact might be on world copper consumption of the changes in Eastern Europe. In balancing the above factors, major consumption forecasts do not suggest a growth rate during the next 10 years above the approximately 2 per cent per year of the 1970-1984 period. Given the range of judgemental factors in projecting copper demand and of forecasts based on econometric models, it is not easy to provide a precise estimate of the consumption growth rate in developed countries. A consensus figure often cited in forecasts of future capacity and prices over the next 10 years is approximately 1.7 per cent [41].

(b) *Production*

The 1980s witnessed surprising changes in the structure and economics of copper production. The changes may be grouped under the following four headings: the closure or modernization of inefficient units; the emerging importance of solvent extraction and the electrowinning process; exchange rate adjustments by major copper-exporting countries; and consolidation of ownership through mergers and acquisitions. Stimulated largely by low prices during this period, the changes eventually resulted in cost savings to different degrees for different producers in the countries concerned, thus altering their competitive position in the world market. As noted in the discussion of operating costs in section 4 above, the changes have greatly modified the operations and structure of the copper industry.

The high capacity-utilization rates of 1988 and 1989 suggest that the modifications have reduced much of the excess capacity, particularly the high-cost and inefficient capacity. The previous analysis of currently planned smelting and refining projects suggests a relatively slow rate of capacity expansion. Up to 1995, increases are not likely to total more than 10 million tonnes of capacity at all stages, an expansion probably resulting from the implementation and start-up of the planned large-scale projects. Investment in new mines and expansion of existing ones have been taking place at a substantially reduced pace. This will affect capacity availability in the 1990s. The criteria for new investment have become much more stringent than in the 1970s. The fact that the industry refused to reactivate idled capacity during the price boom of 1987-1988 reflects its cautious outlook for the future.

Capacities beyond 1995 will be determined by investment decisions yet to be made. Although there is no lack of potential areas that could be developed, the decision to do so may be constrained by the slow market conditions expected to prevail through the early 1990s. These capacity considerations suggest that over the next 10 years the annual growth rate in refined copper production will not exceed 1.5 per cent.

(c) *Market equilibrium and prices*

Future prospects for copper prices and industry expansion depend on the relative growth rates of copper consumption and production, estimated at 1.7 per cent and 1.6 per cent, respectively. On the subject of projected market equilibrium, the World Bank [42] anticipates that capacity expansions are likely to be significantly slower in the second half of the 1990s, so that markets might return to a more balanced supply and demand condition by 2000. Concerning geographic shifts in capacity, Chile has not only become the largest producer in the world (excluding the USSR), but is projected to account for the bulk of the increase in world capacity over the next decade. The relative decline of production in Zaire and Zambia, both of whose production is entirely State-owned, and the projected new foreign private investment in copper mining capacity in Australia, Chile and Papua New Guinea signal the re-emergence of transnational corporations in the world copper industry. The bulk of the copper output of Peru is currently produced by such corporations, and if that country is to develop its rich resources in line with the growth in world demand, it must also depend heavily on new foreign direct investment.

Given the expected growth rates in refined copper consumption and production, world capacity and demand should remain more or less in balance by the mid-1990s. Prices may need to increase substantially, and one source suggests a level of more than $1 per pound (in constant 1985 dollars) in order to provide the necessary incentive to replace depleted mines and to build sufficient capacity to meet future growth in world consumption. Since 1987, prices have exceeded this level, but the present market balance suggests that even higher prices may be needed before production begins to expand.

F. Ironmaking (ISIC 371010)*

Iron plays a pivotal role in steelmaking. It is the primary raw material for the steelmaker and will continue to be so. Yet the supply of iron is a major long-term problem for steelmakers. The production of iron ore is a process that has been known, in essence, for centuries, and which has reached a state of considerable sophistication. The modern blast furnace, which is the primary ironmaking tool, is both a highly developed and a highly efficient item of equipment. It is also massively expensive, it depends on other highly capital-intensive support equipment, and it works best on a very large scale. This causes problems for steelmakers, who cannot forec. t precisely the future demand pattern for steel, but have to commit long-term finance to ironmaking.

The following review of ironmaking will examine this problem as it affects both developed and developing countries. To place the problem in context, recent trends in production and capacity utilization are examined. Most of the review, however, is concerned with basic technologies of ironmaking. Examples will be gi en of how ironmaking problems have been tackled in different locations, of what geographic sources of raw materials are available, and of variations in iron and steel demands. Attention will also be given to developments in blast-furnace technology and cokemaking, to energy and environmental considerations and to alternative types of iron units and smelting reduction involving new ironmaking technologies that may offer long-term solutions to ironmaking problems.

*UNIDO acknowledges the contribution made by B. Cooper, Editor, *Steel Times International*.

1. *Recent trends and current conditions*

(a) *Iron and steel production*

Growth in the production of pig-iron and steel has been sluggish in recent years. The data on world pig-iron production contained in table IV.98 shows that very little change in output occurred in 1987-1988 among the countries featured in figure IV.14. The USSR is clearly the largest producing country, with Japan a close second. Next come China, United States and Federal Republic of Germany. As shown in table IV.99, the same countries dominate world steel production, with the United States closer to Japan in terms of quantity of output.

Table IV.98. Major pig-iron-producing countries, 1987-1989

Rank in 1989	Region, country, area or economic grouping	Production (millions of tonnes) 1987	1988	1989	Percentage share 1987	1988	1989	Percentage change 1987-1989	1988-1989
1	Japan	73.4	79.3	80.2	14.6	14.[illegible]	20.9	9.2	1.1
2	China	56.1	56.9a/	57.0a/	11.2	10.7	14.9	1.6	0.2
3	United States	43.9	50.5	50.5	8.7	9.5	13.2	14.9	-0.1
4	Germany, Federal Republic of	28.1	31.9	32.8	5.6	6.0	8.5	16.6	2.7
5	Brazil	21.3	23.6	19.5	4.2	4.4	5.1	-8.4	-17.3
6	France	13.4	14.8	15.1	2.7	2.8	3.9	12.5	1.8
7	Republic of Korea	11.1	12.6	14.8	2.2	2.4	3.9	33.7	17.8
8	United Kingdom	11.8	13.1	12.6	2.4	2.5	3.3	6.7	-3.9
9	India	10.9	11.7	12.2	2.2	2.2	3.2	11.5	3.8
10	Italy	11.3	11.4	11.7	2.3	2.1	3.1	3.9	3.0
11	Belgium and Luxembourg	10.5	11.7	11.7	2.1	2.2	3.0	11.2	-0.2
12	Canada	9.7	9.5	10.3	1.9	1.8	2.7	6.0	8.2
13	South Africa	6.[illegible]	6.1	6.5	1.3	1.1	1.7	2.7	6.1
14	Australia	5.6	5.7	6.1	1.1	1.1	1.6	8.6	6.7
15	Taiwan Province	3.7	5.7	5.9	0.7	1.1	1.5	58.4	2.8

Table IV.98. (Continued)

Rank in 1989	Region, country, area or economic grouping	Production 1987	Production 1988	Production 1989	Percentage share 1987	Percentage share 1988	Percentage share 1989	Percentage change 1987-1989	Percentage change 1988-1989
		(millions of tonnes)							
16	Spain	4.8	4.6	5.7	1.0	0.9	1.5	19.2	24.3
17	Netherlands	4.6	5.0	5.2	0.9	0.9	1.4	12.6	3.6
18	Austria	3.5	3.7	3.8	0.7	0.7	1.0	8.6	2.7
19	Turkey	4.1	4.4	3.5	0.8	0.8	0.9	-15.1	-20.9
20	Mexico	3.7	3.6	3.3	0.7	0.7	0.8	-12.2	-9.7
21	Other Africa	3.0	3.0	3.0a/	0.6	0.6	0.8	-	-
22	Yugoslavia	2.9	2.9	2.9	0.6	0.5	0.8	-	-
23	Sweden	2.3	2.5	2.6	0.5	0.5	0.7	14.8	5.6
24	Finland	2.1	2.2	2.3	0.4	0.4	0.6	8.6	3.6
25	Argentina	1.8	1.6	2.2	0.4	0.3	0.6	20.0	35.0
26	Chile	0.6	0.8	0.7	0.1	0.2	0.2	13.3	-15.0
27	Other Latin America	0.5	0.5	0.5a/	0.1	0.1	0.1	-	-
28	Venezuela	0.5	0.5	0.5	0.1	0.1	0.1	-2.0	-2.0
29	Portugal	0.5	0.5	0.4	0.1	0.1	0.1	-24.0	-24.0
30	Norway	0.4	0.4	0.3	0.1	0.1	0.1	-32.5	-32.5
31	Czechoslovakia	9.8	9.8a/	..	2.0	1.8	..	..	..
32	Poland	10.0	10.0a/	..	2.0	1.9	..	..	..
33	Bulgaria	1.7	1.7a/	..	0.3	0.3	..	..	..
34	Hungary	2.1	2.1a/	..	0.4	0.4	..	..	..
35	German Democratic Republic	2.7	2.8a/	..	0.5	0.5	..	..	..
36	Romania	9.5a/	9.5a/	..	1.9	1.8	..	..	..
37	USSR	113.9	114.0a/	..	22.7	21.5	..	..	..
	Total b/	211.3	323.8	231.3	42.1	61.0	48.6	9.5	-28.6
	Total c/	149.7	149.9a/	150.0a/	29.8	28.3	31.5	0.2	0.1
	EDC	85.0	93.0	95.1	16.9	17.5	20.0	11.9	2.3
	Total	502.1	530.6	476.4	100.0	100.0	100.0	-5.1	-10.2

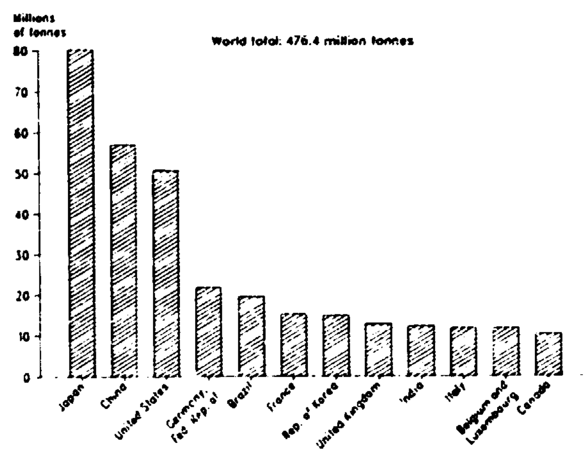
Source: International Iron and Steel Institute, Western World Cokemaking Capacity (Brussels, 1989).

a/ Estimated.

b/ Centrally planned economies.

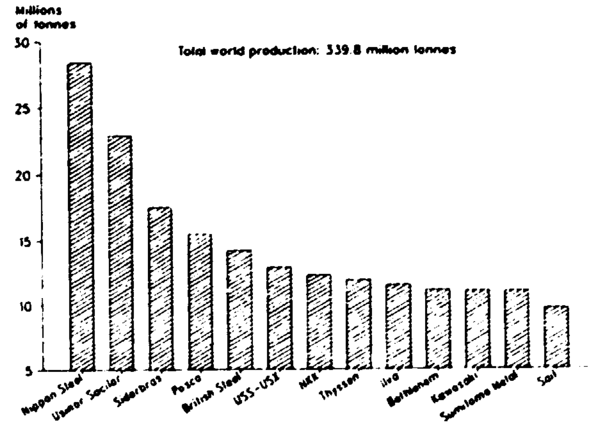
c/ Market economies.

Figure IV.14. Major pig-iron-producing countries, 1989



Source International Iron and Steel Institute *Western World Cokemaking Capacity* (Brussels, 1989)

Figure IV.15. World's leading steelmaking companies, 1989



Source International Iron and Steel Institute *World Steel in Figures* (Brussels, 1989)

(b) *Major steelmaking companies*

Steelmaking is dominated by 14 large companies, with all other companies shown in table IV.100 generating only a fraction of the output of the largest. These 14 companies each have an output close to or greater than 10 million tonnes of steel per annum. The share of the most important companies is featured in figure IV.15. The top four produce more than 15 million tonnes per year. At the top, Nippon Steel produced 28.4 million tonnes in 1989 and Usinor produced 22.9 million tonnes.

(c) *Production capacity and utilization rates*

Production capacity figures are given in table IV.101 for steelmaking-grade direct-reduced iron in the major producing countries. Venezuela and Mexico appear to

[illegible]

Rank in 1989	Country, area or economic grouping	Production 1983	Production 1988	Production 1989	Percentage share 1983	Percentage share 1988	Percentage share 1989	Percentage change 1983-1989	Percentage change 1988-1989
		(millions of tonnes)							
1	USSR	152.5	163.0	160.7	[illegible]	[illegible]	[illegible]	5.4	-1.4
2	Japan	97.2	105.7	107.9	[illegible]	[illegible]	14.7	11.0	2.2
3	United States	76.8	90.7	88.9	[illegible]	[illegible]	11.6	15.8	-2.0
4	China	40.0	59.4	61.3	[illegible]	[illegible]	6.0	53.2	3.2
5	Germany, Federal Republic of	35.7	41.0	41.2	5.2	5.3	5.4	14.8	-
6	Italy	21.8	23.7	25.1	3.2	3.0	3.3	15.1	5.9
7	Brazil	14.7	24.7	25.0	3.2	3.2	2.2	70.1	1.2
8	Republic of Korea	11.9	19.1	21.9	2.8	2.4	1.8	84.0	14.7
9	Other countries	13.4	21.4	21.2	2.7	2.7	2.0	58.2	-0.9
10	France	17.6	19.1	19.3	2.5	2.4	2.7	9.7	1.0
11	United Kingdom	15.0	19.0	18.8	2.4	2.4	2.3	25.3	-1.1
12	Canada	12.8	15.2	15.5	2.0	1.9	1.9	21.1	2.0
13	Czechoslovakia	15.0	15.4	15.5	2.0	2.0	2.3	3.3	0.6
14	Poland	16.2	16.9	15.2a/	1.9	2.2	2.4	-6.2	-10.1
15	India	10.2	14.3	14.4	1.8	1.8	1.5	41.2	0.7
16	Romania	12.6	1.5	13.5a/	1.7	1.9	1.9	7.1	-6.9
17	Spain	13.0	11.9	12.7	1.6	1.5	2.0	-2.3	6.7
18	Belgium	10.2	11.2	10.9	1.4	1.4	1.5	6.9	-2.7
19	South Africa	7.2	8.8	9.4	1.2	1.1	1.1	30.6	6.8
20	Taiwan Province	5.0	8.3	8.7	1.1	1.1	0.8	74.0	4.8
21.	German Democratic Republic	7.2	8.1	7.9	1.0	1.0	1.1	9.7	-2.5
22	Turkey	3.8	8.1	7.8	1.0	1.0	0.6	105.3	-3.7
23	Mexico	7.0	7.8	7.7	1.0	1.0	1.1	10.0	-1.3
24	Democratic People's Republic of Korea	6.1	6.8	6.9	0.9	0.9	0.9	13.1	1.5
25	Australia	5.7	6.4	6.6	0.8	0.8	0.9	15.8	3.1
26	Netherlands	4.5	5.5	5.7	0.7	0.7	0.7	26.7	3.6
27	Sweden	4.2	4.8	4.7	0.6	0.6	0.6	11.9	-2.1
28	Austria	4.4	4.6	4.7	0.6	0.6	0.7	6.8	2.2
29	Yugoslavia	4.1	4.5	4.5	0.6	0.6	0.6	9.8	-
30	Argentina	2.9	3.6	3 9	0.5	0.5	0.4	34.5	8.3
31	Luxembourg	3.3	3.7	3.7	0.5	0.5	0.5	12.1	-
32	Venezuela	2.4	3.7	3.5	0.4	0.5	0.4	45.8	-5.4
33	Hungary	3.6	3.6	3.5	0.4	0.5	0.5	-2.8	-2.8
34	Finland	2.4	2.8	2.9	0.4	0.4	0.4	20.8	3.6
35	Bulgaria	2.8	2.9	2.8	0.4	0.4	0.4	-	-3.4
	TOTAL	663.4	779.9	782.5	100.0	100.0	100.0	18.0	0.3

Source: International Iron and Steel Institute, Western World Cokemaking Capacity (Brussels, 1989).
a/ Estimated.

Table IV.100. Leading steelmaking companies of the world, 1988-1989

Rank in 1989	Company	Production 1988	Production 1989	Production share 1988	Production share 1989	Percentage change 1988-1989
		(millions of tonnes)				
1	Nippon Steel	28.3	28.4	8.5	8.4	0.1
2	Usinor Sacilor a/	19.4	22.9	5.8	6.7	18.0
3	Siderbras	17.0	17.5	5.1	5.1	2.8
4	USS Posco	13.1	15.5	3.9	4.6	18.5
5	British Steel	14.7	14.2	4.4	4.2	-3.3
6	USS (USX Corp.)	14.1	12.9	4.2	3.8	-8.4
7	NKK	12.0	12.3	3.6	3.6	2.0
8	Thyssen	12.1	11.9	3.6	3.5	-1.6
9	Ilva	11.8	11.5	3.5	3.4	-3.0
10	Bethlehem	11.7	11.1	3.5	3.3	-5.2
11	Kawasaki	10.8	11.0	3.3	3.2	1.7
12	Sumitomo Metal	11.8	11.0	3.5	3.2	-6.8
13	Sail Steel India	8.3	9.7	2.5	2.8	16.6
14	LTV Steel	9.5	7.7	2.9	2.3	-19.3
15	Arbed	7.1	7.0	2.1	2.1	-2.2
16	Iscor	6.5	7.0	2.0	2.1	6.6
17	Dofasco	4.5	6.6	1.4	1.9	45.0
18	Kobe Steel	6.5	6.5 b/	1.9	1.9	-0.2
19	Broken Hill Co.	6.0	6.3	1.8	1.8	4.8
20	China Steel	5.8	6.1	1.8	1.8	4.5
21	Hoogovens	5.3	5.4	1.6	1.6	2.7
22	Inland	5.6	5.0	1.7	1.5	-9.4
23	National Steel Corp.	4.9	4.9	1.5	1.4	-
24	Krupp Stahl	4.3	4.6	1.3	1.4	7.4
25	Voest Alpine	4.4	4.6	1.3	1.3	3.2
26	Peine Salzgitter	4.1	4.5	1.2	1.3	9.8
27	Cockerill Sambre	4.6	4.5	1.4	1.3	-2.6
28	Armco	4.5	4.4	1.3	1.3	-2.0
29	Sindermex	4.2	4.2	1.3	1.2	-0.2
30	Hoescht	4.1	4.1	1.2	1.2	1.5
31	Stelco	4.6	4.1	1.4	1.2	-11.3
32	Ensidesa	3.3	4.0	1.0	1.2	23.5
33	Kloeckner	3.4	3.6	1.0	1.1	8.1
34	Mannesmann	4.3	3.6	1.3	1.1	-16.3
35	Nisshin Steel	3.3	3.5	1.0	1.0	6.2
36	Tokyo Steel	3.4	3.4	1.0	1.0	-0.3
37	Sidor	3.2	3.0	1.0	0.9	-0.6
38	SSAB-Svenskt	3.0	2.9	0.9	0.8	-2.7
39	Rouge Steel	2.8	2.6	0.8	0.8	-5.4
40	Nucor	2.0	2.6	0.6	0.8	30.0

Table IV.100 continued

Rank in 1989	Company	Production 1988 (millions of tonnes)	Production 1989 (millions of tonnes)	Production share 1988	Production share 1989	Percentage change 1988-1989
41	North Star	2.3	2.6	0.7	0.8	14.7
42	Wierton	2.8	2.6	0.9	0.8	-9.2
43	Rautaruukki	2.3	2.4	0.7	0.7	6.1
44	Co-Steel	2.2	2.4	0.7	0.7	10.0
45	Gerdau	2.0	2.4	0.6	0.7	20.0
46	Tata Iron and Steel	2.3	2.3	0.7	0.7	-
47	United Engineering Steel	2.2	2.3	0.7	0.7	4.5
48	Wheeling-Pittsburgh	2.3	2.3	0.7	0.7	-1.3
49	Nakayama Steel	2.2	2.2	0.7	0.6	-
50	Somisa	1.8	2.1	0.5	0.5	15.7
	TOTAL	332.5	339.8	100.0	100.0	2.2

Source: International Iron and Steel Institute, World Steel in Figures (Brussels, 1989).

a/ Including figures for Saarstahl (1988 production: 2.77 million tonnes).

b/ Including a full year of production from Algoma.

Table IV.101. Capacity and production of steelmaking-grade direct-reduced iron by country, 1989
(Thousands of tonnes per year)

Rank	Country	Capacity Total	Capacity Percentage share	Production Total	Production Percentage share	Capacity utilization (percentage)
1	Saudi Arabia	800	3.3	1 210	7.9	151.3
2	Qatar	400	1.6	530	3.5	132.5
3	Argentina	930	3.8	1 170	7.6	125.8
4	Egypt	720	3.0	820	5.4	113.9
5	USSR	1 670	6.9	1 700	11.1	101.8
6	Germany, Federal Republic of	400	1.6	350	2.3	87.5
7	Brazil	310	1.3	260	1.7	83.9
8	United States	400	1.6	290	1.9	72.5
9	Canada	1 000	4.1	710	4.6	71.0
10	Mexico	3 030	12.5	2 130	13.9	70.3
11	India	600	2.5	400	2.6	66.7
12	South Africa	1 360	5.6	890	5.8	65.4
13	Indonesia	2 000	8.2	1 300	8.5	65.0
14	Venezuela	4 500	18.5	2 440	15.9	54.2
15	Myanmar	40	0.2	20	0.1	50.0
16	Malaysia	1 250	5.2	570	3.7	45.6
17	Peru	120	0.5	50	0.3	41.7
18	Libyan Arab Jamahiriya	550	2.3	90	0.6	16.4
19	Iraq	1 470	6.1	200	1.3	13.6
20	Nigeria	1 020	4.2	130	0.8	12.7
21	Iran (Islamic Republic of)	730	3.0	40	0.3	5.5
22	Trinidad and Tobago	800	3.3	..	..	..
23	New Zealand	170	0.7	..	..	..
	TOTAL	24 270	100.0	15 300	100.0	63.0

Source: International Iron and Steel Institute, press release, 18 January 1990.

have the greatest capacity, but their capacity utilization rates are low. Indonesia has the next highest capacity, with also a low utilization rate. The lowest rate for any country appears for the Islamic Republic of Iran. When examining the capacity and production totals for the various countries, capacity utilization can be attributed not only to economic and technological but also to political factors.

2. *Technological trends*

The input-output relationship between ironmaking and steelmaking should be explained before describing the major technologies. The steelmaking process consists literally of the process by which pig-iron or scrap is refined and the correct alloying constituents added to achieve liquid steel. This steel is then cast into a solid form for rolling and processing. But in general parlance, steelmaking encompasses the entire process from iron ore to the rolled product. The whole process involves the following steps: ironmaking; hot-metal pretreatment; primary steelmaking; ladle (secondary) steelmaking; casting; and rolling. There is, however, another main route to steel, from scrap, through the electric arc furnace, to casting and rolling. The other routes, which are of such limited importance as to warrant little attention, will be mentioned where appropriate.

The second route, as can be seen, does not depend on iron (hot metal) as a raw material. Known as the electric-arc-furnace route, it accounts for just over 30 per cent of the total steel made in developed market economies, and about the same in the steel-making developing countries and areas. It is used by Argentina, Brazil, Chile, Mexico, Venezuela, India, Republic of Korea and Taiwan Province. It also accounts for approximately the same level of steel output in the countries of Eastern Europe and the USSR. The other 70 per cent of steel produced in developed market economies is made through a process known generically as the oxygen converter process, many variations of which exist. This process takes molten pig-iron (hot metal) and scrap as its charge materials, and can consume up to 30 per cent of its charge weight in the form of scrap without having to resort to additional fuel. The oxygen converter itself requires no fuel since it relies on the carbon in the hot metal to react with blown oxygen in an exothermic reaction to provide energy. However, if scrap levels above 30 per cent are used, there is usually insufficient carbon to enable temperatures to be maintained during steelmaking.

There is another process which has vanished almost completely in developed market economies and has never been substantially employed in the developing countries, but which still contributes to overall steel-making in Eastern Europe and China. This is known as the open-hearth process, in which virtually any form of iron input can be consumed, be it hot metal, pig-iron, scrap or any combination thereof. Today most countries want to abandon this obsolete and energy-inefficient method of making steel.

In terms of input-output ratios, it is a reasonable estimate that for every 100 tonnes of steel made in the world, 46 tonnes are derived from scrap, either through the electric arc furnace, oxygen converter or open hearth furnace, and 52 tonnes are derived from hot metal (liquid iron). The odd 2 per cent is supplied by a product called direct-reduced iron which, although it holds a very small share of the total iron market, is an interesting and increasingly important material. It will be discussed in detail later, especially since its production is concentrated in certain developing countries.

(a) *Blast-furnace dependence on coke*

In terms of production technology, the biggest problem facing steelmakers is finding a ready supply of iron, even though the blast furnace has been developed to a peak of operating efficiency to produce iron from iron ore and coke as the main charge materials. But half the problem of the blast furnace lies with its demand for coke, a product that is made from metallurgical-quality coal in coke ovens. The ironmaker is continually trying to reduce dependence on coke and has had considerable success in this direction, although ultimately there must always be a certain consumption of coke in the conventional blast furnace. This is due to the triple function that coke performs in the blast furnace, serving as a fuel for heating, a reducing agent for converting iron ore to iron (albeit through the intermediary of carbon monoxide) and a mechanical support for the stack of burden material in the furnace. The latter must maintain adequate permeability for the reaction gases, while controlling the descent of the burden.

Coke ovens have an operating life of around 30 years, and a recent survey by the International Iron and Steel Institute found that "of the coke ovens operating in the United States at present, 55 per cent are more than 25 years old. Moreover, with an overall average oven age of over 22 years, further large-scale closures of cokeries in the United States are foreseeable" [43]. At the end of 1988, when the survey was made, the age profile of coke ovens in the EEC showed that 65 per cent of all ovens were more than half-way through their expected life, and that the average age of ovens had increased dramatically since the previous survey in 1984. Developed countries are at a disadvantage in that there is a tendency for their plant to be older than that of newly developing steelmaking countries. They are facing a real problem over what to do to ensure a coke supply for the next two or three decades of ironmaking, and indeed further into the future.

A whole new ironmaking strategy may be required, but it unfortunately does not yet exist. Established ironmakers are working not only on completely new technologies for the long-term production of iron, but on shorter-term methods of extending coke-oven life and reducing coke consumption in the blast furnace. Both of these latter developments are merely putting off the day when existing cokemaking facilities can no longer be satisfactorily maintained, and long-term investment capital will need to be spent on new coke-oven batteries.

However, new batteries are being built in certain locations, and major modification work is being done on existing batteries, driven not only by a need to supply coke to the furnaces, but also by increasingly strict legislation on environmental control. For not only is the coke oven a necessary evil, it has also been a dirty and environmentally unacceptable piece of equipment. New technologies have greatly improved the environmental acceptability of coke ovens, and much is being done in Europe and in the United States to reduce coke-oven emissions in order to bring existing coke ovens up to the standard of new ones.

Given the apparent undesirability of both blast furnaces and coke ovens, it is perhaps surprising that the latest integrated iron and steel plants in the world, the Kwangyang works of Posco in the Republic of Korea and the Baoshan Works in China, have opted for this conventional technology. But the basic problem is that steelmaking engineers have not yet managed to come up with anything better.

(b) *Improving blast-furnace performance*

The past 10 years have seen dramatic improvements in blast-furnace performance in terms of coke consumption, total energy consumption, productivity and useful life. These efforts have been driven by high energy costs and an uncertain steel market which reflects directly on to the iron suppliers. The steel industry during the past 10 years has also undergone extensive rationalization in manufacturing facilities involving the removal of large amounts of aging capacity. The blast furnaces left operating are thus newer and larger in capacity.

The operation of a furnace reflects the basic principle of economies of scale: that is, the larger it is, the better it works. Large blast furnaces currently have internal working volumes in the order of 4,000 cubic metres, and a daily output of 10,000 tonnes of hot metal. However, those ironmakers who do not have the advantage of large new furnaces have still been able to improve their furnace productivity and efficiency by implementing many modifications. The following are examples of typical modifications:

(a) Improved control over burden preparation to ensure a consistent quality of iron ore and coke. A blast furnace that is run consistently is one that can be accurately controlled and can reach high productivity by virtue of running smoothly. Iron quality also depends on smooth running of the furnace;

(b) Improved process control. This requires the use of internal probes, gas analysis and computerization, including the use of artificial intelligence in the most up-to-date systems;

(c) Better burden distribution. This means the adoption of bell-less tops which can be made to place the burden where it is needed to ensure even gas permeability and steady burden descent;

(d) Injection of pulverized or granulated coal through the tuyères to reduce coke consumption by replacing it partially with less expensive non-coking coals. Levels of injection of 150 kilograms per tonne of hot metal have regularly been achieved in Europe, replacing coke on a kilogram for kilogram basis. The United States is now adopting this technology as it has become proven. With the injection of additional oxygen it is possible to push injected coal rates up to a limit which has not yet been determined, but it is thought that it may be possible to replace at least 50 per cent of coke with coal;

(e) Better energy recovery from top gas and from using the high top pressures employed in modern furnaces to drive turbines. The blast furnace and coke ovens together are an integral part of the energy cycle of an integrated plant, providing both electricity and fuel gases for other parts of the plant. Indeed, some plants have become suppliers of energy to the market at times when they have excess energy. Currently, the original source of this energy is largely tied up in coal which is converted to coke, making it inherently

difficult to find alternatives to the blast-furnace and coke-oven route, since the energy balance would be greatly altered:

(f) Longer campaign lives achieved through the use of improved refractory and cooling systems. Since the campaign life of a previous-generation blast furnace might have been up to eight or 10 years, there was considerable time in which refractory and cooling technology could be advanced. The techniques used today will enable campaign lives of up to 15 years to be achieved, since not only are better systems built into the furnace at reline times, but it has become possible to make ongoing repairs to the inside lining without having to stop production for long periods. This is a result both of automated gunning systems that can work inside the furnace, and of the development of rapid blow-down and start-up operating procedures that would not have been possible with early refractory systems;

(g) Alternative forms of heat energy have been used in blast furnaces as they have become economic. Prior to coal injection, both oil and gas injection were used in different locations. Both of these methods are currently economically fashionable. Recent work with plasma torches, particularly in France, where nuclear power provides some of the cheapest electricity in Europe, has yielded promising results, but is obviously not applicable in many locations. It is also worth mentioning the use of charcoal in blast furnaces in Brazil, where charcoal has been readily available as a coke substitute and its application in blast furnaces has reached a sophisticated level. However, environmental restrictions are likely to stop further growth of this technology.

These modifications have contributed to the following productivity improvements over the past decade: an increase from 1.4 to 2.2 tonnes per day of output of hot metal per cubic metre of furnace; fuel rate reductions from 550 to 490 kilograms per tonne of hot metal; and improved quality through reducing the silicon content of hot metal from 1 to 0.6 per cent. These are only recent improvements. The blast furnace has been the primary ironmaking tool for centuries and is a finely tuned production unit. Where a dozen furnaces used to supply iron to the steelshop, the modern steelmaker will rely on one blast furnace to provide a guaranteed annual supply of more than 3 tonnes of hot metal. That single furnace in many cases is the only source of hot metal, and the steelshop has often to look elsewhere for its iron supply. It is also likely to have stockpiled material to meet its orders until the blast furnace can be relined and brought up to date, a job that can take around four months for a complete rebuild on a large furnace. In developed market economies this scenario is no longer rare.

(c) *Taking the blast-furnace option*

Unless specific reasons relating to natural resources make it necessary to do otherwise, the blast furnace will still be chosen as the best way to produce iron for steelmaking. This can be exemplified by the case of Pohong Iron and Steel Company in the Republic of Korea. In 1989 the company became the fourth largest steel producer in the world with an output of 15.5 million tonnes, while the Republic of Korea became the sixth largest pig-iron producer with 14.8 million tonnes. This iron production is entirely due to Pohong Iron and Steel, and demonstrates the dependence of NICs on pig-iron as a raw material for steel. Not surprisingly, a relatively new industrial economy is short of the recycling scrap that is available in mature economies. The company is currently entering the fourth expansion of its new Kwangyang Works in the south of the country, with one third of its blast furnaces producing 2.8-million-tonnes-per-year due for commissioning at the end of 1990, and the building of a fourth furnace of similar size scheduled for blowing-in at the end of 1992. Total steel output from the works will then reach 11.4 million tonnes per year. For this level of output there is nothing that will compare with the modern blast furnace for iron production. Classic economic arguments about raw material availability being a natural industrial advantage have been disproved in the past by Japan, which is the second largest steelmaking country in the world after the USSR, and they continue to be disproved by the Republic of Korea, which has to import all of its iron ore and coking coal, and yet still remains one of the lowest-cost steel producers in the world.

By coming late to a mature industry the Republic of Korea has the advantages of a well-tried and highly developed technology that can be installed in a state-of-the-art form by experienced developed-country contractors who compete to ensure that the customer is offered competitive prices on contracts, while chasing the few orders that are available throughout the world.

The only other major new blast-furnace building project in the world is currently in progress at the new integrated works of Baoshan, near Shanghai in China. This massive project was started in the early 1980s with technology and plant supplied by Austria, Belgium, France, Federal Republic of Germany, Japan, United Kingdom and United States. The first blast furnace was supplied by Nippon Steel of Japan, and the second one of the same internal volume of 4,063 cubic metres is being built largely by Chinese contractors. It is scheduled for completion by the end of 1990, and will add a further 3 million tonnes of ironmaking capacity to Baoshan Works.

(d) *Direct-reduced iron and market outlets*

Iron from the blast furnace is in liquid form and is produced on site for steelworks. If processing is not interrupted, it remains liquid right through to casting as steel through continuous casters or ingots. Certain production problems arise when iron is cast solid and has to be remelted in the steelworks, but that is rare. A very small proportion of blast-furnace iron is also cast into foundry pig-iron, but the percentage is so small as to be statistically insignificant. Liquid pig-iron is thus not a traded commodity; at temperatures of around 1,500° C and in batch sizes of up to 350 tonnes, transport is nearly impossible, except internally. There is, however, another form of iron that is produced in solid form from iron ore without ever going through the liquid stage. This is known as direct-reduced iron, a highly metallized material (typically over 90 per cent) that is produced by means of direct-reduction technology without the use of the blast furnace. Because it is produced as a solid and in a granular form it can be transported and easily remelted and is therefore suitable as a marketable commodity. It represents a small proportion of total world-wide ironmaking, but it is becoming increasingly relevant as a high-quality substitute for scrap in electric-arc furnaces and basic-oxygen-furnace converters. Much direct-reduced iron is made on site for adjacent steelworks or local consumption and does not seek a market. In favourable locations throughout the world, however, direct-reduced iron is now being produced for export markets and will continue to increase its share of total iron production.

Direct-reduced iron will thus find markets in developed countries where the supply of scrap is becoming ever more contaminated with elements that are hard to remove in the steelmaking process, such as copper and other heavy metals, or elements that cause environmental problems during their removal, such as lead and zinc. The need for higher-quality iron units will be felt particularly by those electric-arc-furnace operators who are attempting to move their product range further into that covered by the integrated producers, in particular the flats market of strip and plate. This movement is particularly strong in the United States, where in 1989 the world saw the start-up of the first thin-slab casting and rolling mill by an electric-arc-furnace operator. Despite initial problems with the plant, Nucor has plans to build a second mill of the same type, and other United States mini-mills are quickly moving into the market. The only other planned commercial thin-slab mini-mill is in Taiwan Province.

3. *International location of direct-reduced iron facilities*

The current international market for direct-reduced iron has been estimated at around 10 million tonnes, but available merchant production capacity has been very limited. Recent moves in Venezuela will capitalize on this shortfall, by increasing the availability of merchant direct-reduced iron in the form of hot-briquetted iron, which is a compacted version of direct-reduced iron. This makes it more suitable for transport since density is increased, while the risk of spontaneous combustion through re-oxidation from the atmosphere is removed. This product is thus made safe to handle and store and more convenient to carry and melt down. Direct-reduced iron production operations in a sample of countries are reviewed below. The capacity utilization rates presented in table IV.101 were examined earlier, and they demonstrate clearly how actual production falls well behind installed capacity.

(a) *Venezuela*

With 2.7 million tonnes of direct-reduced iron output in 1989, Venezuela is the leading country in the world for direct-reduced iron production. This is a result of its unique combination of natural resources which have made the direct-reduction and electric-arc-furnace route the pre-eminent method of steel production. The mineral and energy wealth of Venezuela is concentrated in a remarkable area known as Guayana, at the confluence of the Orinoco and Caroni rivers. The Orinoco gives direct access to the sea for 80,000-tonne ships, while the fast-flowing Caroni has been harnessed by the Guri dam to provide 10,000 megawatts of electrical power. Two billion tonnes of high-quality iron ore deposits lie within 125 kilometres of the river confluence and natural gas fields, while reserves of 2.74 trillion cubic metres are within 150 kilometres to the north. Natural gas provides the key ingredient for the production of direct reduced iron in Venezuela, since it is a low-cost fuel and reductant for making iron from iron ore. It removes the need to depend on coke, and has been the force behind the development of a whole new range of iron-producing technologies. The Venezuelan steel industry depends on direct-reduced iron and some imported scrap for its entire supply of iron units to produce 3.5 million tonnes of steel per annum. The scrap input is in fact an anomaly, since the nationalized steelmaker, Sidor (even equipped with facilities to produce direct-reduced iron), is unable to make enough to satisfy its own requirements. As can be seen from table IV.101, direct-reduced-iron capacity utilization in Venezuela is only 54 per cent, because of the inability of Sidor to make use of its direct-reduced-iron facilities.

This situation, however, is changing as Sidor increases production for its own use, and as new merchant direct-reduced-iron facilities come on stream. In February 1990, a new 830,000-tonne merchant hot-briquetted iron plant was commissioned, and is intended to supply direct-reduced iron to the United States as its prime customer. Initially, it will also find a domestic market, as Sidor works up its own capacity. Venezuela is recognized as the world's prime location for direct-reduced-iron production, and three other merchant direct-reduced-iron plants are in the pipeline. The first, scheduled to come on stream in October 1990, is a privately owned project that will produce 300,000 tonnes of merchant hot-briquetted iron and 300,000 tonnes for use in its own steel plant. The second is still a paper project for the production of 400,000 tonnes of hot-briquetted iron for export only, while the third and most ambitious is a 2-million-tonne direct-reduced iron project, one half of whose production will be for export and one half for consumption by a new electric-arc slab casting shop. The slabs produced will all be for export. Initial operation is scheduled for 1994, by which time it is estimated that the production of direct-reduced iron by Venezuela will have risen to some 8.1 million tonnes, confirming the production leadership of that country.

(b) *Malaysia*

Although relatively small by comparison with that of Venezuela, the only other merchant hot-briquetted iron plant in the world is located in Malaysia. Natural gas supplies again have been the deciding factor in building a direct-reduced-iron plant, but all iron ore used by the plant is imported, and the product is virtually all exported.

(c) *Mexico*

Mexico was the first country to produce direct-reduced iron, and is a close second to Venezuela in production. One of the two dominant gas-based direct-reduced-iron technologies was developed in Mexico and specifically designed to suit the resources of that country. However, unlike in Venezuela, direct-reduced iron is used for only a minor part, less than 30 per cent, of steel production in Mexico, with blast furnaces providing most of the iron units.

(d) *Argentina*

Gas-based direct-reduced iron production of 1.17 million tonnes played a significant role in the 3.9 million tonnes of steel output of Argentina, with blast furnaces providing around 2 million tonnes of iron, the remainder being made from scrap steel.

(e) *India and South Africa*

India and South Africa are rarely grouped together, yet in the field of direct-reduced iron it is reasonable to do so, since they are the two main locations for coal-based direct-reduced iron in the world. This technology provides a product similar to that of gas-based technology, but it relies on non-coking coal for the reductant. Both countries have vast reserves of coal, but not all of it is of metallurgical quality. Thus they have adapted their technologies to the use of lower-quality coal. In South Africa the direct-reduced iron is consumed at the plant where it is produced, while in India many of the direct-reduced-iron plants are providing a merchant commodity for consumption by local electric-arc shop operators. India has no ready supplies of scrap, so the combination of an available consumer and a technology that can absorb local low-grade ores and coals has led to the creation of the market.

(f) *Qatar and Saudi Arabia*

Qatar and Saudi Arabia, two relative newcomers to the steelmaking world, have capitalized on their natural gas resources to make direct-reduced iron for domestic and local export markets.

(g) *Union of Soviet Socialist Republics*

The USSR, the world's biggest iron and steelmaker, has only a small interest in direct-reduced iron for its natural gas fields at Staryy Oskol. Using United States technology and plants built by contractors from the Federal Republic of Germany, it has been successful in the production of direct-reduced iron for many years, operating its plant to more than 100 per cent capacity utilization. However, a total output of 1.7 million tonnes, all of which is consumed by the electric-arc smelting shop in-plant, is small compared with the annual figure of over 160 million tonnes of steel production in the USSR.

(h) *Other countries*

There are other successful producers of direct-reduced iron, notably in Canada, Egypt, Federal Republic of Germany, Indonesia and Trinidad and Tobago, where capacity is being well used, but the quantities produced amount to little in global terms. Plants have been less successful in the United Kingdom, where a direct-reduced iron plant was built in the early days of North Sea gas but never commissioned. In New Zealand a coal-based technology was developed specifically to suit the type of iron ore found in that country, but it has had technical operating difficulties compounded by financial problems and ownership battles.

4. *The outlook for smelting reduction*

As pointed out earlier, direct-reduced iron makes only a small contribution to global iron supply, and though it is likely to grow, it can only supplement bulk iron production as currently produced through the blast furnace. But if the blast furnace is not a satisfactory answer to the problems of ironmaking in the long term, or even in the medium term, then what is the solution? This question is being addressed by many ironmakers and plant suppliers in developed countries, and a technology that has become generically known as smelting reduction is being developed in many research projects. Smelting reduction processes are being designed to offer advantages from the following points of view:

(a) Costs. The processes will operate economically with smaller unit sizes than blast furnaces, and are therefore more flexible and cheaper to apply. They are being designed to employ non-coking coal in the majority of cases, thus doing away with the need to invest in coke ovens or to buy ready-made coke;

(b) Inputs. The processes can tolerate lower-quality iron-ore feed material and are being designed to operate with a variety of ore configurations; that is, lump, fines, pellets or sinter.

Of the processes under active development, two different kinds are currently in use. The operations involve a reactor that is fed with coal and oxygen, displaying some features in common with the hearth of a blast furnace or with an oxygen converter. In the first category, the aim is to divide the functions of the blast furnace into reduction and smelting. This is achieved through the use of twin vessels, one for each reaction, which are connected for gas and solid transfer. In the other category, the process is more like using a steelmaking converter with a liquid bath, but the ore reduction occurs in this bath rather than in a prereduction shaft.

At the beginning of the 1990s research and development have been conducted on probably two dozen smelting reduction methods, most of which are either at an early stage of research or already more or less mothballed. More esoteric systems based on plasma technology, which is being used for ferro-alloy production in Sweden, or other methods involving high electrical consumption have been mentioned recently.

The most important developments in the smelting reduction field may be summed up as follows:

(a) After successful pilot plant operations in the Federal Republic of Germany for many years at rates corresponding to an output of 60,000 tonnes a year, the first Corex commercial plant was built at Pretoria, South Africa, by Iscor and started up in 1989. After initial problems and modifications, the plant is now running at its planned nominal capacity of 300,000 tonnes a year using local ores and coals. The hot metal produced is said to be equivalent to blast-furnace iron and is now being used in the Iscor arc-furnace steel shop. Surplus gas is being used as a fuel within the mill;

(b) The major steel companies in Japan, Nippon Steel, Kawasaki, NKK, Kobe and Sumitomo, are all active in ironmaking research. Kawasaki has built a prereduction pilot plant at its Chiba works and a melting plant at Yawata, while NKK plans to build in 1990 a 500-tonnes-per-day pilot plant for stainless steel production;

(c) In Australia, CRA Ltd. is building a 300,000-tonnes-per-year plant on the basis of work done jointly in the Federal Republic of Germany with Kloeckner. The so-called Hismelt process is a single bath process which operates with injected ore fines and coal;

(d) In the Netherlands, under the sponsorship of the European Coal and Steel Community, the converted blast-furnace process has been jointly developed by the Netherlands steelmaker Hoogovens and British Steel, but it remains at the pilot stage. It is designed to use as much existing hardware as possible in converting a blast-furnace process into a two-stage reduction and smelting operation;

(e) In the United States, a joint development sponsored by the Department of Energy and co-ordinated by the American Iron and Steel Institute has been proposed to come up with a one-stage steelmaking route. Most of the United States integrated operators are involved and are watching developments closely.

The future of smelting reduction technology is the cause of much deliberation in the ironmaking world. There seems to be a growing niche for medium-sized production lines of around 0.5 million to 1 million tonnes per year, where blast furnaces and coke ovens are not justifiable. There is also a growing concern, for financial and environmental reasons, about rebuilding coke ovens, and this concern will become more acute in the coming years. The United States may well be the first location where the smelting reduction process is used in commercial operations on a substantial scale, followed by Japan and Europe.

The iron and steel industry is faced with a classic mature industry problem. The market is established and relatively stable, but there remains over-capacity world-wide. As developing countries bring new plant and capacity on stream, the global problem of over-production becomes exacerbated to the benefit of local economies. In a highly capital-intensive business, established producers in developed countries must think hard about their long-term investment. Ironmaking thus remains central to their concerns.

G. Forging industry: (ISIC 371007)*

Technological innovations aid product competition

Forging consists of taking a piece of steel known as a slug and heating it until it becomes malleable. It is then shaped by dies brought together more or less rapidly by devices using impact or pressure. The semi-finished steel products used for forging are generally round or square bars, known as billets, which are formed either by rolling ingots or by continuous casting, with or without rolling. These semi-finished products are cut up into slugs by sawing or shearing depending on the desired thickness. Their weight and length are calculated to make them suitable for forging a specific item.

The types of steel processed are carbon steels or ordinary steels, low-grade alloyed steel or strong alloy steels. There are strict rules for deciding which grades of steel are appropriate for a given piece. The criteria include stress analysis, data on the environment in which the piece will be used, the size and shape of the piece, ease of machining, the mechanical characteristics sought and the heat treatment to be applied.

A wide range of steel grades are used to produce forged pieces. Intensive research and development have resulted in more resistant steels. The forging and treatment processes themselves enhance the quality of the steel so that it can meet various customer requirements. Micro-alloys have also been developed over the past 15 years, particularly in the Federal Republic of Germany. These alloys render heat treatment unnecessary or simplify the process, thereby reducing costs.

It takes a great deal of pressure to ensure that the slug fills the cavities in the moulds. These cavities carry the form that the slug is to take in reverse. This shaping is achieved by impact or pressure. When the impact method is applied, instruments known as drop hammers or drop stamps are used. A falling mass which can weigh up to several tonnes provides the impact. Presses exert a much slower and more progressive force on the slug than drop hammers. Shortages of skilled workers and the need for high-volume consistent components have led to a growing tendency in factories to replace drop forges with presses. Billet mills are sometimes used to outline the shape of long slugs before forging with presses or drop forges.

A work station is generally made up of several machines. First a shearing machine provides slugs for one or more pieces of forging equipment. Shearing can take place when the metal is hot or cold. A drop hammer or a press is then used to shape the pieces and a flash trimmer removes the excess metal from the seam lines. These flashes inevitably occur because of the need to fill all these cavities in the dies. The work station can also include a billet mill or mechanization and automation equipment. Once the flash has been trimmed, the part may be heat-treated, finished and inspected. The parts manufactured by forging vary in weight from one gram to a few tonnes. The force

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required to forge the latter and the cost of equipment means that heavy parts are hammer-forged in small quantities.

Recent economic trends in production and deliveries are examined below. Technological developments in forging and forming metallurgy and engineering are reviewed. Examples are provided for a variety of countries, and the industry outlook is sketched in the conclusions.

1. Recent trends and current conditions

(a) *Production and consumption*

Production in the international forging industry decreased from 1980 to 1986, but in 1987 the decline stabilized. Table IV.102 shows that a sharp recovery

Table IV.102. Production of drop-forging industries by country, 1980-1988 [a]

Country	Production 1980	1987	1988	Percentage change 1987-1988	Euroforge[b] percentage share 1988
	(thousands of tonnes)				
Germany, Federal Republic of	831.3	782.5	866.1	10.7	45.76
United States and Canada	514.7	712.1	800.8	12.5	17.7
Italy	556.5	328.1	351.1	7.0	18.55
United Kingdom	295.3	222.8	261.4	17.3	13.8
France	208.6	154.8	173.3	12.0	9.15
Spain	134.2	143.8	152.9	6.3	8.07
Sweden	69.5	66.6	71.3	7.1	3.76
Belgium	13.7	14.6	16.3	11.6	0.86
Euroforge total[c]	2 109.1	1 713.2	1 892.4	10.5	100.00

Source: Data provided by Euroforge and the national association in the individual countries shown.

a/ Employment estimates for 1988: Federal Republic of Germany, 25,500; Italy, 13,000; United Kingdom: 10,500 France: 5,600; Spain: 4,500; and Belgium, 500.

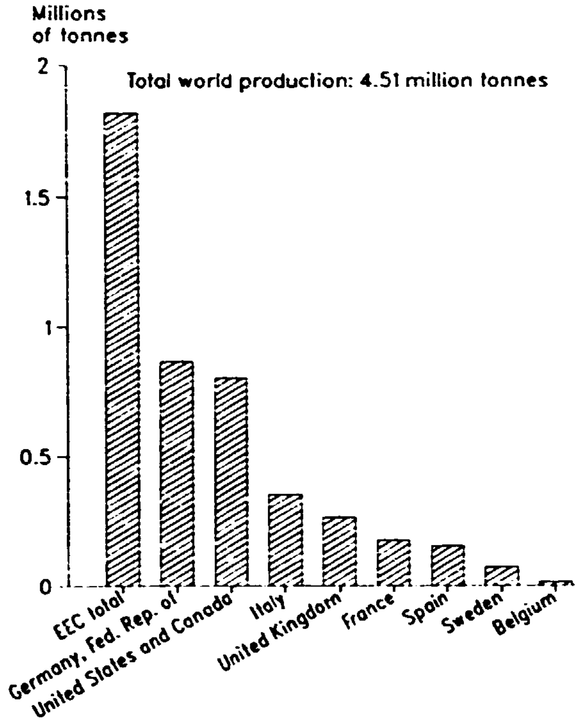
b/ Euroforge is an organization of individual European forging industry associations, comprising seven countries, namely, Belgium, France, Federal Republic of Germany, Italy, Spain, Sweden and United Kingdom. The secretariat, currently based in the Federal Republic of Germany, rotates among member national associations. Statistics from Euroforge member associations are presented here, with figures for the United States and Canada given for comparison only. The totals given are for Euroforge only, and do not represent global production levels.

c/ Excluding the United States and Canada.

had occurred, for the first time in many years. As shown in figure IV.16, the Federal Republic of Germany is the largest producer, with the combined total of the United States and Canada becoming smaller over the past decade. Forging industries in all EEC countries have made constant efforts to improve productivity by purchasing more efficient machinery, by extending the induction heating process, by mechanizing and robotizing work stations and by introducing CAD and CAM techniques. Such moves had become inevitable because of advances made in this direction by competing production techniques and customer pressure for lower prices.

In the most efficient and productive companies, investment levels have achieved a turnover of 10 per cent or more. Investments and productivity gains

Figure IV.16. Production of drop-forging industries by country or economic grouping, 1988



Source: National industry associations

combined with customer pressure have driven production costs down. However, the metal used accounts for at least 35 per cent of costs, and this is virtually impossible to reduce. The rest of the cost price is made up of labour (45 per cent), energy (8 per cent) and various other costs (12 per cent). These percentages vary widely according to the weight and grade of the metal used as well as the treatment and the shape of the piece to be produced. Production costs have also been reduced as a result of technical advances such as improved yields, the use of new, high-output equipment and the manufacture of lighter, higher-precision parts.

Regarding consumption trends, forged parts are used in all industries, including the automotive, aeronautics, shipbuilding, machine-building, mechanical engineering and electricity (traditional and nuclear power stations) industries. As shown in table IV.103, the

Table IV.103. Shipments of the European independent forging companies by industrial branch, 1988

Industrial branch	Deliveries (thousands of tonnes)	Percentage share
Automotive	1 022.6	56.2
Agricultural machinery	171.6	9.4
Mechanical constructions	167.5	9.2
Mining machinery	45.7	2.5
Railway	42.5	2.3
Aerospace	7.1	0.4
Other	364.1	20.0
TOTAL	1 821.1	100.0

Source: Euroforge.

automotive industry is by far the biggest consumer. Deliveries of European independent forging companies show that the automotive market represent 56.2 per cent of the total. Agricultural machinery accounts for 9.4 per cent and mechanical constructions for 9.2 per cent. All other end-use markets have a much smaller share. Concerning automotive uses in individual countries, it accounts for 73.5 per cent in the Federal Republic of Germany, 61 per cent in Spain, 48 per cent in the United Kingdom, 44 per cent in Italy and 37 per cent in France. Belgium is the only country where the forging industry does not supply the automotive industry. The same phenomenon of the dominance of the automotive industry can be noted in Japan and, to a lesser extent, in the United States. The forging industry is therefore very susceptible to the technical options adopted by the automotive industry, the efforts of which even spill over into other industries.

With respect to employment trends, the forging industry work-force has generally shrunk as a result of the slack market and the mechanization of production. This trend has not continued over the past two years because of an improved economic climate. However, forging, which used to be essentially a labour-based industry, is becoming mechanized and its labour force must undergo certain revisions.

(b) *Major structural and geographical changes*

Most companies are specializing more and more in specific products to be able to produce at the lowest possible prices. Specialization gives companies both an edge over competition and long-lasting control of the market niche they have chosen. Some companies have developed warm forging, at temperatures below the normal 1,250° C. More and more companies are using CAD and CAM techniques. These methods allow them to optimize their product and to achieve the maximum strength-to-weight ratio.

Many companies are family-owned and -operated businesses, which have built their success on the quality of their products. Others are subsidiaries of the steel industry, which uses them as a means of testing and selling its products. However, the number of these subsidiaries has decreased as a result of denationalization, particularly in the United Kingdom and France. The industry also includes independent and captive forges. It is important to note that the former may be subsidiaries of steel companies, whereas the latter are amalgamated with larger groups, especially in the automotive industry. As a general trend, the number of forging companies has declined over the past 20 years.

In the Federal Republic of Germany, 150 companies produce what amounts to one of the highest national production levels in the world. There are many large companies, such as Thyssen, Gerlach and Peddinghaus, in that country. In the United Kingdom, the largest company is United Engineering and Forging (formerly GKN), which accounts for 50 per cent of United Kingdom production. The other important groups are Firth Rixson, INCO Group and Cameron Iron Works.

In Belgium, 10 companies, four of which have forging as their main business, operate in the industry. All 10 companies are small- or medium-size businesses. They are spread over the country, but more clustered in places like Charleroi and Liège, which used to be the centres of heavy industries such as mining and steel. The decline in certain customer industries such as coal, steel and railways, and competition from other manufacturing methods have led to a substantial reduction in the number of forging companies, while the surviving companies specialize in other high-potential industries, such as mechanical engineering, lorries and aeronautics.

In Spain, out of the 40 companies that make up the forging industry only eight have more than 150 employees, five have between 100 and 150, nine 50 to 100, and 18 less than 50. The geographical spread is as follows: Basque territory—30; Catalonia—4; Aragon—2; Madrid—1; Galicia—1; and other regions—2. The largest companies are Patricio Echeveria SA, La Farga Casanova SA, Forgas de Villalba SA (Gekanor Group) and Forgas de Galicia SA.

In France, the industry is made up of 72 companies. Three groups, one of which was formed only recently, dominate. The groups include Ascometal, Forges Stephanoises and Forges de Courcelles. Forging companies are spread over the following regions: Ardennes—25; Loire—6; eastern France—14; and other regions—27.

In Italy, most companies are located in the north in Piedmont around Turin, in Lombardy in the Como area, in Varese and Bresci, and in Venetia and Emilia (Bologna). The largest companies are Teksid (Fiat subsidiary, 90 per cent of whose production goes to the car industry), the Erber Group, Riganti and Casartelli. In Lombardy, 10 per cent of the companies account for 50 per cent of production, and, except for Teksid, they are all family businesses.

(c) *The EEC and the forging industry in 1992*

The European closed-die forging industry has a total annual production of approximately 2 million tonnes and employs about 60,000 people. It is an industry of mainly small- and medium-sized enterprises, with many of the individual companies being family-owned. The most important customer industries have been mentioned in connection with table IV.103. Most forgings produced in Europe are supplied to European customers. There is a strong belief that the European industry will be affected by the further unification of the EEC in 1992.

To gauge the impact of this change on the forging industry, each company must analyse its own situation and make a comprehensive assessment of its position. From this, an appropriate strategy can be developed. Thus, for instance, a decision can be taken to adopt the strategy of the technological and economic market leader in a certain segment of the market. Other companies will confine themselves to a niche strategy, restricted to the national market, from which a future European strategy can evolve, if determined specialization and a strong competitive position are achieved. The question will frequently arise whether a company has the ability to expand or whether it will have to specialize further in order to be competitive in an expanded market. With growing competition in the domestic market, small- and medium-sized forging companies face continually rising pressure. Improved productivity performance, accelerated product innovation, shorter development periods, higher flexibility in delivery ("just in time"), increasing demands on quality, and the more and more computer-aided interrelation of all working processes within the company can only be handled by outstanding managers and specialists.

For many years forging companies in Europe have held their ground in competitive terms both within Europe and in international markets. There are already forging companies that export over 50 per cent of their total production. But in future, European forging companies will have to be prepared for even stiffer competition, because the technical trade barriers existing today will be lifted, making products more interchangeable, and because of locational problems. European forging companies should, however, be conscious of their strengths and be prepared to exploit them. Among these strengths, their products and the technology and logistics used in production are highly innovative, and their proximity to customers permits efficient and flexible service and delivery.

With the concepts of just-in-time deliveries, and "zero-defect quality", which is demanded by the automotive industry and in an increasing number of other industries, European forging companies must use the most modern manufacturing methods and materials. The high demands of customers can only be met by using computers in construction and development, quality control, production planning and controlling systems, data storage and data communications. Moreover, every forging company must consider the question of transnational corporation and strategic alliances. To remain abreast of conditions in Europe, a forging company should make use of the information provided by the EEC Commission, trade associations and federations, as well as other advisory bodies. These groups can assist on all questions concerning the EEC, and can help to find suitable partners for co-operative work.

(d) *International forging congresses*

On an international basis, a forging congress is now held once every three years to reflect and report on world-wide developments in the forging industry and further support technical advances in the field. In recent years, for example, international congresses have been held in the Federal Republic of Germany, United Kingdom, United States and, most recently, in India. The next congress will meet in Italy. The concept of arranging international meetings within the forging industry arose in Europe in the period after the Second World War, and had the aim of furthering mutual understanding and fostering a greater sense of unity.

From the outset the congresses were held in three-year cycles, each time at a different location in Europe. Very soon these European congresses grew into international congresses with a world-wide reach, and they began to be held outside Europe; for example, in the United States or in India. The markets of the forging industry developed in this period from being initially largely domestic to European and then finally becoming international. Hand in hand with this development there was an emergence of competition among forges, at first in Europe and later on a world-wide scale. The nature, content, location and time-cycle for these international congresses remain vital considerations for the industry world-wide.

2. *Technological trends in forging and forming metallurgy and engineering*

In recent years the forging industry has witnessed significant progress with micro-alloyed steels, aluminium-lithium alloys, titanium alloys with improved creep resistance and nickel-based superalloys. To obtain the best results, thermo-mechanical treatments, hot-die and isothermal forging and semi-solid state forging are among the technologies that have attracted the attention of innovative manufacturers. These technologies and the extension of powder forging and metal composite applications are likely to be at the forefront of forging development in the 1990s.

Leading plant and equipment manufacturers are responding to these changes and developing machines and techniques to cope with the parallel advances in materials technology, the demands for closer-to-form products and the continual quest for productivity improvements. Rotary forging developments, including aero-engine discs and high-rate hot-forging machines for automotive components, not previously produced by this technique, are examples of recent advances in forging equipment design, elaboration and manufacture. Altogether, these innovations are aimed at offsetting the threat to the international forging industry of competitive processes and components. A summary is given below of individual developments in various countries with an identifiable forging industry.

(a) *Belgium*

Since 1986, the industrial economy of Belgium has passed through two very contrasting stages of development, first during 1987 and second during the years 1988 and 1989. In the first stage, the country witnessed a substantial deceleration of economic growth, which in fact reflected a rather depressed economic climate internationally. As a result, the GNP of Belgium grew by only 1.3 per cent in 1987, much below the 2.8 per cent in 1986. Although economic activity was less dynamic than in 1986, the rate of inflation was still moderate and unemployment remained low. Belgian industry, in particular, was confronted with the following two major problems: a sharp dip in demand, mainly in the home market; and a steep fall in the price of steel products. This second factor had several consequences for the Belgian industry, including the following:

(a) Stabilization of average-cost prices in the steel processing industry, despite an increase in wage costs of 4.9 per cent;

(b) Stagnation or even deflation in the selling prices of products and, as a result, a reduction in manufacturing turnover. For the preliminary processing industry as a whole, the effect of the drop in steel prices was a 5 per cent reduction in turnover.

The forging industry in 1987 was thus faced with adverse economic conditions. Its turnover was affected by the fall in raw material prices, and tonnages remained stable at around the 1986 level. But there was also a positive element; the percentage of exports rose to account for more than half the total sales.

In the second stage of development covering 1988 and 1989, the economic situation of the national industry improved. Despite the sombre prospects following the market crash of October 1987, 1988 was unexpectedly the best year for Belgian economic growth in 10 years, with a GNP growth rate of 4.1 per cent. In addition, unemployment fell from 10.3 per cent in 1987 to 9 per cent in 1988, with inflation remaining low at 1.2 per cent against 1.6 per cent in 1987. It appears that the driving force behind the development of the Belgian economy in 1988 was industrial investment which, after increasing by 7 per cent in 1987, further rose by 11.5 per cent in 1988.

Against this background, the forging industry registered excellent results in 1988 with an improvement in activity estimated at more than 20 per cent (in tonnage and value). At the same time, sales prices began to revive following strong growth in steel product services. In fact, 1988 was a year of strong recovery in raw material prices, which consequently improved turnover in the forging industry. However, most companies in the industry also encountered longer delivery periods in obtaining steel supplies.

Because this growth extended into 1989, the Belgian national economy has been characterized by a continued high rate of investment, an acceleration of private consumption, and a decline in unemployment. The principal branches of the Belgian industry, and notably the preliminary processing of metal, have thus recorded sustained activity thanks to the stabilization of demand at a high level.

In the forging industry in particular, the economic situation has been encouraging, because of strong demand from industries such as heavy vehicles, civil aeronautics, building and civil engineering. Figures for the first half of 1989 fully confirm this encouraging situation as deliveries, expressed in tonnes, were up by 10 per cent compared with the same period of 1988. In value terms, deliveries rose by 35 per cent, which shows that price readjustments, which began in 1988, continued through 1989.

(b) *Brazil*

The Brazilian forging industry, in spite of problems caused by constant inflation, was able to maintain production in the past three years at either the same level, or somewhat above the level, of the previous period. The significant increase of exports in 1989 and 1988 also brought about increased employment, reaching some 24,000 in 1989. The most recent statistics on forging output are provided in table IV.104. During this period, the Brazilian forging industry continued promoting the application of new technology among its members, contributing to quality improvement and better competitiveness.

Table IV.104. Forging output in Brazil, 1988

Steel forging production	Shipments (thousands of tonnes)	Value (millions of dollars)
Drop forging, press and upset forging		
Deliveries from forging industry a/	235	788.2
In-house production of the automotive industry a/	230	748.4
In-house production of other industries (manufactures of armatures, hand tools, machine tools etc.) a/	5	40.2
Flanges	19	35.1
Cold forging, total of which:		
Deliveries from cold-forging industry a/	3	13.7
In-house production of the end-user industry	..	..
Open-die forging		
Ring rolling a/	9	17.3
Other open-die forging (excluding forging of steel bar, semi-finished products and railway rolling stock) a/	4	10.3

Source: Brazilian Forging Association.
a/ Accurately estimated.

(c) *China*

According to the China Forging Industry Association, the forging industry is a very important national industry, providing inputs to the entire spectrum of manufacturing, especially to the automotive, aerospace, agriculture and construction equipment, ordnance, mining, railway and petrochemical industries. Since the Second World War, the forging technology of China has achieved considerable progress. Examples are the large steel forging facilities in operation, such as the Eumuco forging presses, GFM precision forging machines, Hatebur hot formers, Thyseen Wagner ring rolling mills, the Siempelkamp screw press and Smeral pneumatic and hydraulic hammers. Yet in comparison, China still lags behind developed countries in forging production, not only in terms of quality but also in quantity and variety. Moreover, most of the machinery and equipment now being used in factories is outdated, and in many cases, the process applied still depends on the manual skills of the workforce. However, renovation and transformation have been proceeding through technology upgrading, equipment renewal and productivity growth. There is every indication that the annual increasing demand for advanced metal-forming technology will hold in the forseeable future, such as that for precision forging machines, machines and equipment for closed-die forgings, sheet-metal-forming presses, presses for cold and warm forgings, turnkey projects for complete installations and modernization of existing plant.

In the wake of the modernization drive, as shown in table IV.105, the total volume of forging production, which includes open-dye, impression-dye and ring-rolled forgings, reached 2 million tonnes in 1988. Future progress depends on the development of steel and car production in China. For example, the metallurgical industry is making efforts to produce over 70 million tonnes of steel a year by 1995, compared with 59.43 million tonnes in 1988. This means an increase in annual steel output of 20 million tonnes. In 1988, 37,000 automobiles were produced in China. This figure is expected to reach 700,000 in the year 2000. The forging industry has thus been preparing a long-range plan However, the prospects of constructing new plants like the No.2 Heavy Machinery Works and the No.2 Automobile Works are remote.

Table IV.105. Steel forging output in China, 1988

Production	Shipments (thousands of tonnes)
Drop forging	
In-house production of the automotive industry	162.0
In-house production of tractors and internal combustion engines	80.0
Railway rolling stock	155.0
Other industries	356.2
Open-dye forging	
Hydraulic press forging	262.0
Ring rolling	56.0
Open-dye forging	1 035.5
TOTAL	2 106.0

Source: China Forging Industry Association.

given the financial resources of the country. Development, therefore, will depend on the expected renovation and expansion of existing forging plants in China.

(d) *France*

During the decade 1970-1980, production of the French forging industry remained stable, at just above 200,000 tonnes per annum. From 1980 to 1983, it fell sharply to 141,000 tonnes, and then picked up slightly each year, until 1988 when it reached 173,000 tonnes. This is equivalent to production in the decade 1970-1980, if the systematic weight reduction in manufacturing parts is taken into account. If the production of captive automotive forges is added, then the tonnage in 1988 amounted to 302,000 tonnes.

The most decisive factor in the development of the forging industry in France is the technical options and production volume of the automotive industry. In a given year, it represents 30 to 40 per cent of forging activity; this can be increased to 40 to 50 per cent if the tonnages delivered for transmission gears are added. Direct deliveries to the automotive industry dropped from 70,000 tonnes in 1980 to 46,000 tonnes in 1983, rising afterwards to 52,000 and 56,000 tonnes in 1986 and 1988, respectively. This level is not likely to be maintained for economic and structural reasons, the former relating to a reversal in economic trends and the latter involving technical advances that could entail further change and product substitution. Such conditions have previously worked against the industry. In other markets, substitution is less manifest than in the car industry. Since 1986, forging output to other industries has experienced an upturn as follows: farm machinery, from 15,000 to 19,000 tonnes; public works equipment, from 15,000 to 19,000 tonnes; mining equipment, from 2,000 to 3,000 tonnes; and transmission gears, from 16,000 to 18,000 tonnes. In contrast, the level of deliveries has remained stable or declined in industrial valves (8,000 tonnes), mechanical engineering (11,000 tonnes) and railways (down from 9,000 to 7,000 tonnes).

In France, the price rises in steel imposed on the forging industry during the past two years caused considerable difficulties, since it has been practically impossible to pass these rises on in full to the largest customers of the industry. There has also been a reduction in the period of payment to 30 days, which has worsened the cash position of the forging companies.

(e) *Federal Republic of Germany*

An indication of the quantity and value of shipments made in 1988 can be obtained from table IV.106. On

Table IV.106. Shipments of steel forgings in the Federal Republic of Germany, 1988

Steel forging production	Shipments (thousands of tonnes)	Value (millions of dollars)
Drop forging, press and upset forging:a/	1 271.1	6 983.8
Shipments of forging industryb/	865.1	5 930.2
Home production of the automotive industryc/	305.0	2 107.2
Home production of other industries (armatures, tools, machineries etc.)a/	100.0	702.4
Flangesa/	87.9	636.7
Other pipe connectors and end piecesa/	43.8	652.2
Cold forginga/	132.7	1 164.2
- Shipments of cold forging industrya/	68.7	603.4
- Home production of the end consumer industriesc/	64.0	561.9
Open die forginga/	295.0	2 107.7
Ring rollinga/	97.1	643.8
Other open-dye forging (without forged steel bars, semi-finished products and rolling railway material)a/	197.9	1 423.9

Source: Industrieverband Deutscher Schmieden (Forging Industry Association of the Federal Republic of Germany) and the Euroforge Secretariat.

a/ Exact figures provided.

b/ Accurately estimated.

c/ Roughly estimated.

the basis of the expansion in the automobile industry, growth rates of output in the forging industry of the Federal Republic of Germany was 2 per cent in 1986, −3 per cent in 1987, 7 per cent in 1988 and 5 per cent in 1989. In 1989, the greatest-ever production volume was realized by the industry. Several new developments in the industry accounted for this progress, including:

(a) Introduction of statistical process control into the forging process;

(b) Production of even more finely tolerated forged components, dispensing wholly or partially with further machining;

(c) Working in co-operation with the customer's engineers, designing the form of forged components with attention focused on later loads in order to ensure that maximum load-bearing capacity is achieved with minimum weight and use of material;

(d) Further development of CAD software specific to forging, with improved transfer to the CAM phase;

(e) Reduction of costs for heat-treatment of forged components through the use of new steel materials.

The forging industry in the Federal Republic of Germany is confident that its endeavours will make an appreciable improvement to compete against substitution by a variety of different materials and processes in the forged components area.

(f) *India*

The past five years have witnessed a revolution in the automobile industry of India. A new generation of vehicles, including heavy, medium and light commercial vehicles, passenger cars and two- and three-wheelers, are now to be seen on Indian roads. What is significant is that the technological growth in the automotive sector has relied heavily on foreign participation, mainly that of Japan. Today all of the large Japanese vehicle producers have established manufacturing facilities in India in collaboration with local partners. Besides automobiles, various other uses of forgings such as defence, railways, nuclear energy, aerospace etc. have also made use of new technology. The net result has been a stepped-up demand for close-tolerance forgings, which require either minimum or no machining allowance. An idea of forging production for the major markets or end-uses in India in recent years can be obtained from table IV.107.

Table IV.107. End-use markets for forging production in India
(Thousands of tonnes)

Markets	1986-1987	1987-1988	1988-1989
Automotive (including off-highway equipment)	110.4	122.2	136.7
Industrial plant and machinery	18.8	22.1	28.7
Agricultural tractors and implements	24.5	26.3	35.2
Railways	5.7	6.8	8.1
Cold forgings	18.7	21.3	26.5
Others (including exports)	9.8	14.6	21.9

Source: Association of Indian Drop Forging and Stamping Industries.

Forging industry output has risen together with the benefits of upgraded technology. While until a few years ago the production of medium and large forging units in the country amounted to about 150,000 tonnes annually, it rose to about 210,000 tonnes in 1988. In addition, small-scale sector in India has forging units with a fixed capital investment of less than $350 million. Many small-scale units are in operation all over the country, predominantly catering to the higher demand for low technology and low-value items. The production of these units amounts to as much as 30 per cent of the total forging output. In addition, some of the large original equipment manufacturers have their own captive forge shops through which they meet their internal forging requirements. The Indian forging industry is fairly large and well diversified, and is now meeting almost the entire demand of forged products in the country, thus contributing to the import-substitution effort.

As in the case of forging industries in other countries, customer demands are changing in favour of high-performance, low-weight and cost-effective products. New manufacturing technologies and processes emphasize, for example, precision casting, powder metallurgy, plastics and composites as alternatives to forgings. According to the Association of Indian Drop Forging and Stamping Industries, the Ford Motor Company has reduced the steel content in its cars by about 31 per cent during the past few years by adopting newer technologies and incorporating products made out of plastics, composites and sintered materials.

(g) *Japan*

According to the Japan Forging Industry Association, the forging production volume of Japan recorded steady progress between 1987 and 1989. Output was 1.73 million tonnes in 1986 and 1.79 million tonnes in 1987, and with a production volume of 2.05 million tonnes, a new record was achieved in 1988. This was due to an unprecedented boost from the domestic economy in 1988, brought about by increases in personal consumption, plant and equipment investment and housing construction, as a result of the strong national government policy of stimulating domestic demand. Table IV.108 provides data on the shipments of drop, press and upset forging products to various end-use markets in 1988. However, a certain amount of uncertainty exists for the forging industry. For example, the automobile industry, which represents 63 per cent of the whole market of the forging industry, established production bases in overseas countries several years ago, and has been steadily increasing production. The Japanese forging industry is thus uncertain as to how Japanese automobile manufacturers in countries overseas will procure forged products in the future. Uncertainty also exists with regard to prices. Major industries using forged products were seriously affected by the two oil crises of 1973 and 1981, and by the rapid appreciation of the yen following the conference of the five major industrialized countries in 1985. This forced them to impose severe price reductions on the forging industry over a long period. As a consequence, sales prices have been showing a slight downward trend, which is also of great interest to the forging industry in Japan.

Another area of industry concern is the employee environment. Compared with other branches of the machinery industry, the occupational environment of the forging industry is very poor and the work involved is more physically demanding. This makes it extremely difficult for the industry to attract new employees, particularly younger people, and the average age of employees thus increases. To resolve this issue, the Japanese industry has begun to introduce mechanization in the manufacturing process of forged products to the greatest extent possible. This has entailed the use of automation and labour-saving machinery. At the same time, the industry recognizes that it can improve factory layout and the maintenance of natural green areas.

The structure of the Japanese forging industry comprises mainly medium and small enterprises that operate as sub-contractors. These small firms are in a rather weak position with regard to all aspects of employment in particular the work-force, facilities and funds. Nevertheless, the trade association believes that forging is an industry that has a great responsibility

Table IV.108. Shipments of drop, press and upset forgings by end-use markets in Japan, 1988

End-use markets	Ferrous		Non-ferrous		Total		Tonnage Percentage
	Million yen	Tonnes	Million yen	Tonnes	Million yen	Tonnes	
Industrial machinery and engineering material	534.6	320 260	9.8	1 254	544.4	321 514	15.6
Machinery for mining, road building and construction	243.2	172 304	0.3	36	243.5	172 340	8.4
Agricultural machinery and fishery	108.7	55 849	0.2	15	108.9	55 864	2.7
Tools	39.3	13 449	0.02	-	39.3	13 449	0.7
Automobile	2 219.6	1 293 216	84.6	7 330	2 304.2	1 300 546	63.3
Commercial cars and bicycles	71.6	52 724	11.6	661	378.4	53 385	2.6
Railways	32.5	17 575	0.2	9	32.6	17 584	2.1
Ships and harbour installation	64.9	43 569	3.4	370	68.2	43 939	2.1
Aeroplanes	47.4	1 213	25.3	590	72.7	1 803	0.1
Other	125.4	71 480	35.1	2 791	160.4	74 271	3.6
TOTAL	3 487.0	2 031 639	170.4	13 056	3 657.4	2 054 695	100.0

Source: Japan Forging Industry Association.

and an important role in the machinery industry. Thus, the industry intends to concentrate on cost reduction, technical improvement and new product development, largely in co-operation with end-using industries. Some of the technological means that will be used to achieve this goal include the following:

(a) The production of "net-shape" or "near-net-shape" forged products at the lowest possible cost;

(b) The establishment of an efficient production and control system to respond to the just-in-time method;

(c) Reduction in weight of forged products.

The application of these technologies implies the increased use of personal computers, new lubrication materials and methods, heating technology and devices for the forging process, including non-thermal refined steel and aluminium forging.

(h) *The Philippines*

Only two firms currently offer steel forging services, with a combined capacity of 10,600 tonnes. The bigger company, ANI Phils. Forge Inc., is a wholly-owned subsidiary of Australia National Industries, producing steel forgings for the automotive, mining, agricultural and heavy equipment industries. The forging presses of the company have a capacity of 2,500 and 1,300 tonnes, with upsetters of six-inch and four-inch capacities and drop hammers of from 30 hundredweights to 7 hundredweights. There is also one company with foreign investment capabilities wanting to construct a forging and roll-forming plant with a capacity of 15,000 tonnes. The precondition, however, is for them to export 70 per cent of their products and to allocate only 30 per cent for local consumption, according to the Metals Industry Research and Development Centre of the Philippines.

(i) *Spain*

In the past three years, the economy of Spain has expanded with GDP increases of 3.5 per cent per annum and with increases in consumer demand of 10 per cent per annum. Inflation has also fallen by nearly a half compared with the previous period, from 8.3 per cent in 1986 to 4.6 per cent in 1987 and 4.8 per cent in 1988. Concerning the forging industry, deliveries of drop forgings increased by approximately 12.8 per cent in 1986, 4.7 per cent in 1987 and 6.3 per cent in 1988, reversing the descending trend of previous years. This change, which is reflected in Table IV.109, is a result of increased demand in the automotive industry.

Table IV.109. Forging output in Spain, 1988

Steel forging production	Shipments (thousands of tonnes)	Deliveries (millions of dollars)
Drop forging, press and upset forging a/	152.9	295.3
Deliveries from forging industry a/	152.9	295.3
In-house production of the automotive industry a/	..	..
In-house production of other industries (manufactures of armatures, hand tools, machine tools etc.)	..	..
Cold forging	4.7	8.4
Deliveries from cold forging industry b/	3.9	8.4
In-house production of the end-user industry c/	0.8	-
Open die forging b/	25.4	49.1
Ring rolling b/	2.6	4.4
Other open die forging (excluding forging steel bar, semi-finished products and railway rolling stock) b/	22.3	44.6

Source: Spanish Forging Industry Association.
a/ Exact figures provided.
b/ Accurately estimated.
c/ Roughly estimated.

the main customer of the forging industry. Automobile production has gone up by about 40 per cent since 1986, reaching 1,722,261 units in 1988. Other vehicles produced in that year included 28,847 lorries, 66,000 vans and 47,997 off-highway vehicles. Strong domestic demand at the same time increased vehicle imports in 1988, with a market share of about 33 per cent in cars and about 40 per cent in lorries.

Other branches such as mining, public works, construction and railways have also increased their demand for forgings. Agricultural machinery and shipbuilding have both remained at levels more or less unchanged, whereas defence deliveries and pipeworks have been declining. Similarly, several closures occurred in the steelmaking industry.

After remaining unchanged in 1986-1987, prices started to increase by about 25 per cent in 1988. Even with the increased deliveries, there remains a strong level of competitiveness. Total employment has been reduced by 15.8 per cent in the past three years, being now around 4,263 employees, a figure that better matches the needs of the industry.

New investments occurred in 1986-1987, with the introduction of CAD systems, the updating of quality procedures and new heating equipment. Quality control and more highly-trained management have also been introduced.

(j) *Sweden*

Since 1986, the structure of the Forging Group in Sweden (Swedeforge) has undergone several essential changes. Ovako Steel, the largest manufacturer of engineering steels in Scandinavia, has acquired the two largest forging companies, Kilsta Smide and the forge of Volvo Company. The group now comprises a total of 14 members. The total production of forging in Sweden was 65,800 tonnes in 1986. In 1987, it increased to 66,600 tonnes and in 1988 to 70,300 tonnes. Further details on forging output for 1988 appear in table IV.110. Inputs to the domestic

Table IV.110. Forging output in Sweden, 1988

Steel forging production	Deliveries (thousands of tonnes)	Value (millions of dollars)
Drop forging, press and upset forging		
Deliveries from forging industry	71.3	143.9
In-house production of the automotive industry	..	..
In-house production of other industries manufactures of armatures, hand tools, machine tools etc.)	..	..

Source: Sveriges Mekan Forbund.

automotive industry (Volvo and Saab-Scania) reflect the steady growth in the production of forgings; they constituted 85 per cent of the tonnage output of the Swedish die-forging industry in 1988.

Despite increasing production, the Swedish die-forging industry has problems with profitability, mainly because of the rapid increase of steel and alloying prices since 1986. Increasing imports of low-priced forged goods into Sweden has also helped to keep prices down. Investments in the forging industry during this period have been about 4 per cent of turnover. A major part of these investments covered replacements of old equipment, without increasing the production capacity. Some of the investments related to the improved manufacture of dies, particularly the introduction of CAD/CAM. Other efforts at technological innovation related to better quality-control capability and statistical process control, quality control in purchasing materials and dies and in die manufacture, process control and short lead times for forging dies and prototype dies.

(k) *United Kingdom*

In 1986, forging demand in the United Kingdom reached an all-time low. However, activity in the United Kingdom forging industry has showed remarkable improvement since 1987, and this has been sustained through 1988 and well into 1989, as reflected in table IV.111. Following the upsurge in mid-1987, the total for that year reached 223,000 tonnes, a 28 per cent increase. Most of this increase was due to improvements from closures and rationalization. One very notable feature of the past two or three years has been the establishment of Japanese automotive manufacturing in the United Kingdom. Nissan is already producing vehicles; Toyota has committed itself to producing vehicles by 1991; and a third possibility exists with Mazda. Honda already has close links and joint ventures with the Rover group. Other automotive plants in the United Kingdom are United-States-owned and one is French-owned.

Another substantial contributory factor during 1987 to the improved performance of the independent forging industry has been the decision by two of the largest motor manufacturers in the United Kingdom to close their in-house forging facilities, with the result that a considerable tonnage became available to be met by the independent industry. Thus output in 1988 continued along the same pattern to over 261,000 tonnes, a 17 per cent increase. The rate of acceleration in 1989 has not been quite so rapid, and end-of-year figures are still not available. The best estimate is that 1989 will result in an output of 280,000 tonnes, considerably above the low of 1986. It is significant that exports of forgings from the United Kingdom, which now account for almost 20 per cent of total production, have been rising during the past three years at a faster rate than production as a whole. The fact that United Kingdom forgings are competitive in overseas markets is a sure indication of the new-found efficiency and price competitiveness of United Kingdom forges after the harsh years of recession.

With regard to new investments, United Engineering and Forging, the largest group of forging companies in the United Kingdom has made substantial investments in new computer-integrated die shop facilities and the installation of computerized numerical-control machining centres to supply mechanical components. There has also been investment in an additional 6,000-tonne press and a new 4,000-tonne dedicated press line for spindle forgings. Another of its plants specializing in the manufacture of automotive connecting rods has invested in new high-speed specialist hammers, incorporating techniques for improved weight control, consistency and closer-to-tolerance forgings.

Table IV.111. Deliveries of closed-die steel forgings by BFIA members in the United Kingdom 1985-1989

Market area	1985		1986		1987		1988		1989	
	Tonnes	Percentage	Tonnes	Percentage	Tonnes	Percentage	Tonnes	Percentage	Tonnes	Percentage
Mobile equipment										
Cars and light vans	43 836	21.30	37 605	21.60	48 832	21.90	55 815	21.40	65 384	24.09
Commercial vehicles	48 124	23.40	32 083	18.50	37 999	17.10	42 020	16.00	32 258	11.88
Tractors (wheeled)	23 148	11.20	19 183	11.00	25 620	11.50	29 417	11.30	25 277	9.31
Earth-moving (tractor, crawler)	7 587	3.70	6 717	3.90	6 580	3.00	6 489	2.50	4 070	1.50
Mechanical handling and engineering	2 614	1.30	3 119	1.80	3 362	1.40	4 950	1.90	3 524	1.30
Miscellaneous mobile	8 897	4.30	6 572	3.80	10 420	4.70	11 070	4.20	10 038	3.70
TOTAL	134 206	65.20	105 279	60.60	132 812	59.60	149 661	57.30	140 551	51.78
Agricultural machinery	2 458	1.20	2 320	1.30	7 482	3.40	6 994	2.70	7 725	2.85
Mining	7 429	3.60	6 781	3.90	6 328	2.80	5 242	2.00	9 402	3.46
Railways	839	0.40	1 013	0.60	1 774	0.80	2 028	0.80	1 990	0.73
Industrial engines	1 973	1.00	1 714	1.00	2 185	1.00	2 098	0.80	1 696	0.62
Pipeline	4 349	2.10	2 811	1.60	3 137	1.40	2 566	1.00	10 380	3.82
Aircraft	3 187	1.50	3 492	2.00	2 813	1.30	2 589	1.00	4 370	1.61
Mechanical engineering	7 363	3.60	6 364	3.70	5 561	2.50	9 894	3.80	5 046	1.86
Government sector	1 721	0.80	1 648	0.90	1 594	0.70	1 085	0.40	2 246	0.83
Other	14 195	6.90	13 678	7.90	24 001	10.80	31 286	11.90	35 962	13.25
Direct exports	28 217	13.70	28 708	16.50	35 163	15.70	47 907	18.30	52 084	19.19
TOTAL	205 937	100.00	173 808	100.00	222 850	100.00	261 350	100.00	271 452	100.00

Source: British Forging Industry Association.

Although the automotive industry, which includes cars, commercial vehicles and agricultural vehicles, still accounts for almost two thirds of total forging output, it is interesting to note that this industry is gradually losing its percentage share, while others, for example, machinery, industrial engines and general mechanical engineering, are increasing. The aerospace industry is also important, and although the United Kingdom's tonnage of steel forgings for this industry is small, it is estimated that total deliveries to the aircraft industry, consisting of steel, aluminium, titanium and nickel alloys, represent between 15 and 20 per cent of the total national industry turnover. In addition, the current airline re-equipment programme is likely to have strong growth certainly over the next decade.

Table IV.112. Forging output in the United States and Canada, 1988

Steel forging production	Shipments (thousands of tonnes)	Value (billions of dollars)
Drop forging, press and upset forging		
Deliveries from forging industry[a]	882 668	1.7
In-house production of the automotive industry	..	..
In-house production of other industries (manufactures of armatures, hand tools, machine tools etc.)	..	..
Open-die forging		
Ring rolling	..	..
Other open-die forging (excluding forging of steel bar, semi-finished products and railway rolling stock)[a]	273 474	0.6

Source: Forging Industry Association of the United States.

a/ Exact figures provided.

(l) *United States and Canada*

After several difficult years for the entire metalworking community, a resurgence of economic activity has taken place in the United States and Canada. Over the past three years the dollar volume of total forging industry sales has risen from $2.4 billion to $2.75 billion, a 15 per cent increase. Even more significant are the ferrous tonnages for custom impression-die forgings, which represent the largest segment of the North American forging industry. From 1986 to 1988 this tonnage increased by 36 per cent from 649,000 to 883,000 tonnes. Dollar volume for this increase was up 25 per cent, which demonstrates the competitive factors existing in the market. Further data on the output of separate products appear in table IV.112. Offshore imports of ferrous forgings continue to hold a strong position, taking an estimated 33 per cent of an expanding United States and Canadian market in 1988. While that share is down from the high of 36 per cent recorded for 1986, Canadian forging producers have expanded their ferrous forging output by 14 per cent.

Significant efforts have been made by the Forging Industry Association to upgrade existing technical education courses for employees, including the course entitled "Basic principles of forging die design", and in statistical process control and production planning and controlling systems. In addition, two new courses have been created; namely, "First-line supervisory development" and "Computer-aided engineering". The Forging Industry Association feels that these will continue to make a positive contribution to improvements within the forging industry. Hence there seems reason to believe that the forging industry in the United States and Canada will continue to recover.

(m) *Euroforge*

As noted earlier, Euroforge is a European federation comprising forging associations from seven countries: Belgium, France, Federal Republic of Germany, Italy, Spain, Sweden and the United Kingdom. The European forging industry ranks first among developed market economies before those of Japan and the United States. The main client of this basic industry, with a production of about 3 billion European Currency Units (ECUs) in 1988, is the automotive industry, which consumes more than 50 per cent of total production. Many vital parts of cars, for instance, steering and transmission parts, are forged. Technical innovation and strong competition from other techniques helped to cut costs while production increased in 1987 and 1988. Denmark, Greece, Ireland, Netherlands and Portugal, although members of the EEC, are not mentioned in this context since they have no sizeable forging industry.

3. *Medium- and long-term outlook*

Most forging companies are caught up in a trend towards specialization that started several years ago for technical and economic reasons. This specialization is based on different factors such as the shape and volume of the piece, the size of the order, the customer and the manufacturing methods. In certain applications alloy steels are replacing lower-quality grades. Parts are also being given more and more complex shapes and they tend to be lighter.

The medium-term prospects will depend directly on the technological options adopted by the automotive industry. Technological changes may well result in some new customers opting for forged products, even though other techniques have been used in their place elsewhere. If these technological changes are not realized, competition between the different manufacturing techniques will go on.

The long-term prospects of technical and economic competition from other manufacturing techniques has spurred forging firms to ever-greater advances. In some countries, such as the Federal Republic of Germany and Belgium, they have to maintain a tonnage production that has stabilized over the years, while elsewhere firms are trying to keep production from falling. The forging market is open to penetration from rival techniques and the struggle that has been going on is far from over. In the sub-contracting business, where relations with customers are paramount, a certain geographical proximity has always been a factor. Imports from as far afield as Brazil are now beginning to appear on the scene and other countries may well have designs on the European market. The forging industry, however, has taken a number of measures in respect of quality, productivity, service and costs to meet these challenges. Concerning the implications of the EEC market after 1992, more competition will be faced by the European forging industry; however, considerable additional opportunities will arise. Those companies which analyse and exploit the opportunities as well as the risks, and which develop a strategy for the future, will in all probability benefit.

H. Petroleum refining (ISIC 3530)*

Growing demand and changing product specification

Market conditions for the world refining industry showed a marked improvement in 1989, extending into the early months of 1990. For the first time since the crude oil price upheavals of 1973, there are signs that the upturn in the economics of the refining industry will be more than temporary. The main factors behind the improvement are as follows: significantly increased demand for refined products, which has pushed up plant utilization rates; and product prices that have been generally firm, while crude oil prices have been low enough to give positive margins. Growing demand for unleaded petrol is a continuing contributor to higher yields, and there has been a notable strength in most product prices.

1. *Price and profit conditions*

Squeezed between OPEC crude prices and competitive product prices, oil refining has been a distressed industry for most of the past 17 years. Problems stemmed from the oil price rises of the early 1970s, which came at a time when refiners were expanding sharply to meet anticipated growth of demand. The demand slump which followed the price rises left the industry with a huge surplus of distillation capacity. Refiners accordingly competed to process the incremental barrel and were happy to do so as long as the selling price of marginal barrels covered the direct costs of crude, fuel, catalysts and wear and tear. Refinery runs, therefore, remained high, although demand was slack, and product prices were low, reflecting the underlying surplus.

What changed in the course of 1989 is that utilization rates for conversion facilities, used to crack fuel oil into light products, increased to near maximum, and this trend is holding into 1990. With refinery throughput effectively limited by the capacity of conversion facilities, refiners have for once not been able to oversupply the market. Light-product prices have therefore remained high, despite periods of relatively low prices for crude oil and cracker feed. The result has been positive and at times substantial margins for upgraded refineries. This has been true in all three of the world's main refining centres, namely Rotterdam and Antwerp, the Houston area and Singapore. Calculations show that since the beginning of 1989 margins have ranged from some $0.80 per barrel to a very satisfactory $4 per barrel in the United States, with a range of $0.30 per barrel to $3.50 per barrel for an upgraded refinery in Western Europe [44]. Table IV.113 provides a comparison of price levels and the price ratios of refined products to crude from 1980 to 1989.

Refineries in oil-producing countries, mostly constructed in the late 1970s and early 1980s, shared in the strong margins, although it is likely that they benefited less than facilities located nearer the centres of demand. Transporting refined products is more costly than transporting crude as product tankers, which

*UNIDO acknowledges the contribution of M. Quinlan, Editor, *Petroleum Economist*.

Table IV.113. Oil and refined product prices, 1980-1989

Product	1980	1985	1988	1989 b/	Percentage change 1980-1989	Percentage change 1988-1989
	(dollars per tonne)					
Price levels						
Crude oil a/	252.07	192.58	109.12	129.41	18.6	-48.7
Premium gasoline	369.75	273.12	176.22	209.85	19.1	-43.2
Gasoil (light fuel oil)	306.00	240.15	134.73	153.10	13.6	-50.0
Heavy fuel oil (3 per cent sulphur)	169.75	51.34	68.47	83.82	22.4	-50.6
TOTAL	1 097.75	857.19	488.54	576.18	17.9	-47.5
Price ratios						
Premium/crude	1.47	1.42	1.61	1.62	18.6	48.7
Gasoil/crude	1.21	1.25	1.23	1.18	-4.1	-2.5
Fuel oil/crude	0.67	0.78	0.63	0.65	3.2	-3.0
TOTAL	3.35	3.45	3.47	3.45	3.0	-0.6

Source: International Energy Agency, Energy Prices and Taxes (Paris, Organisation for Economic Co-operation and Development, 1990).

a/ Brent API 32 except for 1980, which is Arab Light API 34.

b/ Including fourth quarter estimate.

Table IV.114. Refinery distillation capacity, throughput, output and capacity utilization, 1984-1987

Region or country and item	1984	1986	1987	Percentage change 1984-1987	Percentage change 1986-1987
	(thousands of tonnes)				
North America					
Capacity	1 077 101	1 005 641	1 036 661	-3.8	3.1
Throughput	839 769	846 332	862 291	2.7	1.9
Output	840 306	843 338	852 640	1.5	1.1
Utilization rate	78.0	83.7	82.2	5.4	-1.8
Europe					
Capacity	888 512	826 782	822 087	-7.5	-0.6
Throughput	652 907	667 678	660 918	1.2	-1.1
Output	640 225	657 180	649 920	1.5	-1.1
Utilization rate	72.1	79.5	79.1	9.7	-0.5
Africa					
Capacity	133 537	136 964	137 036	2.6	0.1
Throughput	93 463	98 261	96 786	3.6	-1.5
Output	86 697	90 935	91 969	6.1	1.1
Utilization rate	64.9	66.1	67.1	3.4	1.5
Asia					
Capacity	865 850	867 800	863 620	-0.3	-0.5
Throughput	610 687	645 437	656 226	7.5	1.7
Output	593 825	611 368	625 987	5.4	2.4
Utilization rate	68.6	70.5	72.5	5.7	2.8
Latin America					
Capacity	212 391	202 864	212 596	0.1	4.8
Throughput	154 057	157 054	154 423	0.2	-1.7
Output	149 537	153 398	149 906	0.2	-2.3
Utilization rate	70.4	75.6	70.5	0.1	-6.7
Oceania					
Capacity	41 609	41609	41 609	0.0	0.0
Throughput	31 394	29 327	30 063	-4.2	2.5
Output	30 270	29 442	29 728	-1.8	1.0
Utilization rate	72.7	70.8	71.4	-1.8	0.8
USSR					
Capacity	610 000	631 000	613 000	0.5	0.0
Throughput	501 550 a/	502 000 a/	503 625 a/	0.4	0.3
Output	460 390	461 334	472 053	2.5	2.3
Utilization rate	75.5	75.3	77.0	2.0	2.3
World					
Capacity	3 829 000	3 694 660	3 726 609	-2.7	0.9
Throughput	2 883 827	2 946 089	2 964 332	2.8	0.6
Output	2 801 250	2 846 994	2 872 203	2.5	0.9
Utilization rate	73.2	77.1	77.1	5.3	0.0

Source: Energy Statistics Yearbook 1987 (United Nations publication, Sales No. E/F.89.XVII.10).

a/ Estimated by the Statistical Office of the United Nations Secretariat.

need to meet shallower draught limits, are smaller than the very large and ultra-large crude carriers that ship crude between deep-water ports. On the other hand, the producing countries benefit from having relatively modern and generally large refineries, and in some countries gas is made available as a process fuel at an artificially low price. The exact position of the operators in producing countries therefore varies from refinery to refinery.

Two factors are behind the increased load of conversion facilities. Increased demand for refined products, a reflection of strong economic growth in many countries, has had its greatest impact on consumption of transport fuels—gasoline, diesel and jet kerosene. At the same time, sharply growing sales of unleaded petrol in Western Europe and the United States are forcing refiners to squeeze more octanes from their throughput, by cracking reforming, alkylation and isomerization, to make up for the boost that lead additives used to provide. If a downturn in major economies can be avoided, the signs are that the trends will be similar. Hence the view in the industry that the improvement in trading conditions is more than temporary.

2. *Capacity utilization*

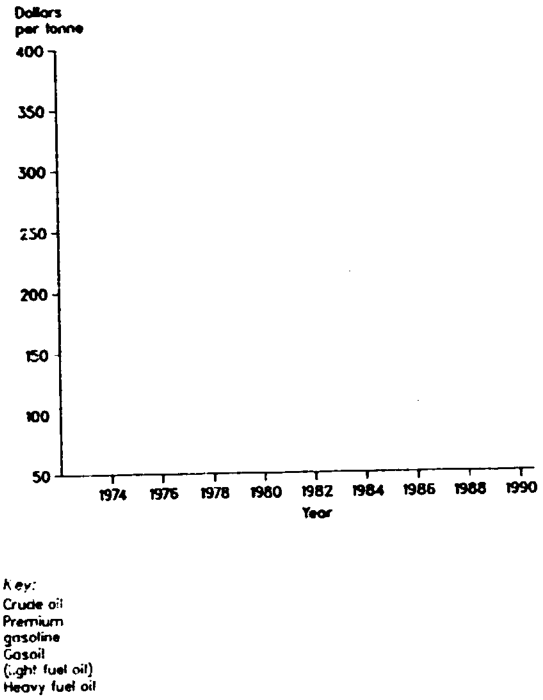
Operational statistics for the refining industry confirm the recent upturn. Data for 1987 (comprehensive 1989 figures are not yet available) show that utilization of distillation capacity increased from 73 per cent in the previous year to 76 per cent in Western Europe, and from 83 to 84 per cent in the United States. In East Asia, where buoyant economies are behind the fastest-growing oil products market in the world, utilization increased from 73 to 76 per cent. Further data on capacity, throughput, output and utilization appear in table IV.114. Figure IV.17 shows price variations on the Rotterdam spot market over the period 1974-1989. Although the regional average figures indicate a continuing surplus of capacity, the signs are that refineries with adequate upgrading facilities, in the main owned by the major international companies, are working at significantly higher loadings. Shell reports that its distillation capacity world-wide has been operating at a remarkable 91 per cent utilization rate, while British Petroleum says its distillation facilities have been running at an 87 per cent rate [44]. Data on loadings of conversion facilities is scarce, but British Petroleum reported 94 per cent utilization during 1988 and Chevron 89 per cent [44].

Subsequent consumption growth has given a further lift to utilization rates, which in the United States, according to the American Petroleum Institute, are now rising towards effective capacity. Taken together with the continuing rise in imports of refined products into the United States, it is being forecast that the largest oil market in the world will soon need a substantial addition to its refining capacity.

Data on refinery construction projects indicate that such additions are not in prospect for the United

Figure IV.17. Oil and refined product prices, 1974-1989

(Rotterdam spot prices)



Source: International Energy Agency

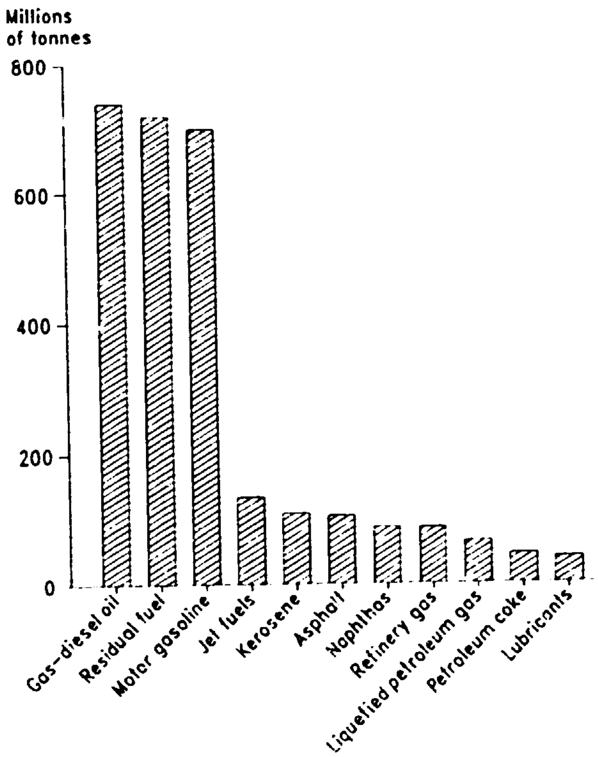
States, but rising demand in that country is stimulating capacity growth elsewhere. In particular, projects in the Caribbean and South America are aimed at the United States market. Coastal has plans for a new refinery on the site of the old Exxon refinery at Aruba; another new refinery at Aruba is under study; and Venezuela is pursuing a new project. Interestingly, these refineries will produce, among other products, fuel oil for the United States market, giving a boost to the trade which led to the development of United States offshore refineries in post-war years, but which declined in the early 1980s owing to the fall in demand in the United States. United States imports of residual fuel are rising sharply as a result of higher demand by electricity utilities. The advantages which led to the growth of Caribbean refining in proximity to the Gulf of Mexico and the United States coast, access to local and Western Asia crudes and competitive operating costs still apply, which makes a resurgence in regional importance seem highly likely.

Perceptions of a shortage of refining capacity, together with more satisfactory margins, seem to be behind a brake on the willingness of United States refiners to sell interest in their operations to the State companies of oil-producing countries. Up to now, however, the main focus of attention for the producers has been Western Europe, where margins are usually lower and where companies are more willing to sell stakes in their operations. This applies particularly to refineries without substantial upgrading facilities, which have been operating at much lower margins than those mentioned above. Kuwait, Libyan Arab Jamahiriya and Mexico have refining and marketing ventures of some years standing in Western Europe, while Venezuela has interests in the United States, and Saudi Arabia has acquired a stake in Texaco downstream operations in the United States. The OPEC member most keen to act now is Nigeria, which is seeking to acquire equity stakes in four United States and two Western European refiners with which it has processing links. While United States refiners are concerned about tight distillation capacity, it is the availability of octane capacity which preoccupies Western European operators.

3. *Recent trends in refinery products*

Changes have occurred in recent years concerning the relative importance of refinery products in total refinery output, as shown in figure IV.18. Further data are provided in table IV.115. The growing

Figure IV.18. World output of refined products, 1987



Source: *Energy Statistics Yearbook 1987* (United Nations publication, Sales No. E/F.89.XVII.10)

enthusiasm of Western European motorists for unleaded petrol has coincided with an increase in total petrol demand, placing high-octane streams at a premium and pushing up the price of methyl tertiary butyl ether (MTBE), the main octane improver for unleaded petrol. Although unleaded petrol already accounts for a high share of the total petrol market in some countries, notably in the Federal Republic of Germany (now nearing three quarters of total sales), Austria, Switzerland and Scandinavia, sales are still expanding elsewhere. The industry expects that some two thirds of petrol demand in Western Europe will be unleaded by the mid-1990s, sharply increasing the demand for octanes at the refinery [44].

There is another development increasing the pressure on octane units in Western Europe, namely the introduction of premium-grade unleaded in a number

Table IV.115. World output of refined products, 1984-1987

Product	1984	1986	1987	Percentage share 1987	Percentage change 1986-1987	Percentage change 1984-1987
	(thousands of tonnes)					
Gas-diesel oil	717 883	742 342	739 282	25.7	-0.4	3.0
Residual fuel	748 976	712 282	718 875	25.0	0.9	- 4.0
Motor gasoline	661 285	689 527	698 690	24.3	1.3	5.7
Jet fuels	116 572	127 977	133 587	4.7	4.4	14.6
Kerosene	11 674	110 795	107 949	3.8	-2.7	824.7
Asphalt	97 482	100 478	103 810	3.6	3.3	6.5
Naphthas	80 970	83 083	86 299	3.0	3.9	6.6
Refinery gas	78 302	83 317	85 174	3.0	2.2	8.8
Liquefied petroleum gas	60 669	62 110	64 793	2.3	4.3	6.8
Petroleum coke	39 102	42 952	44 029	1.5	2.5	15.6
Lubricants	38 145	37 956	39 129	1.4	3.1	2.6
Petrol	4 060	4 289	4 026	0.1	-6.1	-0.8
White spirit	2 681	2 739	2 687	0.1	-1.9	0.2
Subtotals a/						
Non-energy products	279 596	280 840	297 692	10.4	6.0	6.5
Energy products	2 521 654	2 556 154	2 574 511	89.6	0.7	2.1
TOTAL	2 801 250	2 846 994	2 872 203	100.0	0.9	2.5

Source: Energy Statistics Yearbook 1987 (United Nations publication, Sales No. E/F.89.XVII.10).

a/ Subtotals contain more products than that included in the column sum.

of countries. In line with the EEC directive, Eurograde unleaded of 95 research octane number is being made available throughout the EEC. However, in the course of 1989 and early 1990, a number of companies have begun marketing a 98 octane "Eurosuper" grade, first in the Federal Republic of Germany, and subsequently in France and the United Kingdom. The product seems to be meeting a demand, with Federal Republic of Germany sales of premium unleaded nearing 50 per cent of total unleaded sales [44].

In the United Kingdom, British Petroleum says it expects its Super Green to find a niche market, mainly among users of high-performance cars. However, in the United States, where there is a wider choice of gasoline octane ratings than in Western Europe, market analysts know that consumers will pay a premium to buy a higher grade than their vehicle actually needs, hence there is a likelihood that unleaded premium will develop into a significant product for West European refiners. In consequence, there are forecasts that the average octane rating of Western European gasoline will increase progressively, from some 92 octane at present to 93 by 1995 and higher values afterwards.

Producers of MTBE in the oil-producing countries as well as in Western Europe and the United States will be the main beneficiaries, with prices already having reached record levels. Industry data shows that the Western European spot price for MTBE increased from about 1.5 times the price of motor gasoline during most of 1988 to a ratio of 1.8 in 1989. High prices for MTBE will spur new construction projects, so that prices are likely to moderate when additional capacity is on stream.

For refiners in East Asia, strong demand growth held off what could otherwise have been a battle for increased market shares. New refineries in the NIC's had been seen as a threat to the export refiners of Singapore, but the strength of demand has allowed the new refineries to find a market, while allowing the Singapore operators to run at nearly full capacity. This is all the more remarkable in view of the large flow of refined products from the new Western Asia refineries to East Asia.

The next challenge for the Singapore operators is likely to come from Japan, whose refiners have been subject to government controls that are being eased and which are due to be lifted completely by 1995. With capacity of just over 4.3 million barrels per day and utilization running at less than 75 per cent, the Japanese operators have the potential to win overseas sales. First, however, they will need to invest heavily in conversion facilities. Fifteen of the country's 39 refineries are without catalytic cracking facilities, and capacities of crackers in use are often small in relation to distillation capacity. Reforming capacity is also low, and there are only a dozen octane units, for alkylation and isomerization, in operation. This configuration reflects the relatively high demand for fuel oil in Japan, where the product accounts for 34 per cent of total refined product sales, against some 20 per cent in Western Europe at present. The importance of fuel oil to Japanese refiners is greater even than these figures reflect, as large volumes of naphtha, kerosene and petrol are imported for the domestic market. Product imports are increasing strongly, following the phased lifting of trade restrictions on petroleum products.

4. *Investment prospects and capacity adjustment*

The need for continuing investment is a feature of the industry, regardless of location. The main factors involved are as follows: the changing structure of demand for refined products, changing specifications for products, and new environmental considerations. There is also the changing importance of the refining industry within the world oil industry. Moreover, in the longer term, the industry will need to react to the expected increase in the average gravity of world crude oil production and the corresponding increase in sulphur content.

(a) *Product demand*

The changing structure of demand for refined products, in particular the steep decline in consumption of fuel oil at a time when consumption of petrol has continued to increase, is the most fundamental of the challenges facing the industry. Table IV.116 provides recent figures on refinery product consumption for the major developing regions. The trend is in no sense new, as it was evident that there was a substantial imbalance between the output slate of a conventional refinery and the demand slate of the market as long ago as the mid-1970s. Countries with practical alternatives to fuel oil in electricity generation and industrial use, such as the United States, had acted on the imbalance even earlier.

But what continues to surprise the industry is the extent to which the trend away from the heavy end of the barrel, and in favour of light products, has run. Even after a decade of expensive oil, followed by a few years of moderate prices, consumers are still finding

Table IV.116. Consumption of refined products by developing regions, 1980-1987

Region and product	1980	1986	1987	Percentage share 1987	Percentage change 1986-1987	Percentage change 1980-1987
	(thousands of tonnes)					
Africa						
NGL/LPG	1 836	3 135	3 382	3.8	7.9	84.2
Naphtha	32	39	51	0.1	30.8	59.4
Motor petrol	13 455	16 698	17 053	19.2	2.1	26.7
Aviation fuels	3 909	3 880	4 141	4.7	6.7	5.9
Kerosene	4 136	5 769	6 176	6.9	7.1	49.3
Gas-diesel oil	19 559	23 831	23 973	26.9	0.6	22.6
Residual fuel	15 250	18 016	18 498	20.8	2.7	21.3
Other products	3 920	4 914	4 696	5.3	-4.4	19.8
Refinery fuel	2 855	3 638	3 696	4.2	1.6	29.5
Subtotal	64 952	79 920	81 939	92.1	2.5	26.2
Bunkers	6 883	7 305	7 060	7.9	-3.4	2.6
Total	71 835	87 225	88 999	100.0	2.0	23.9
Asia						
NGL/LPG	3 551	7 668	8 352	2.8	8.9	135.2
Naphtha	11 774	17 728	18 262	6.1	3.0	55.1
Motor petrol	23 881	33 110	35 900	12.0	8.4	50.3
Aviation fuels	7 237	9 369	10 062	3.4	7.4	39.0
Kerosene	18 125	20 115	20 688	6.9	2.8	14.1
Gas-diesel oil	58 028	75 099	84 006	28.2	11.9	44.8
Residual fuel	85 329	74 799	76 559	25.7	2.4	-10.3
Other products	24 157	22 075	21 974	7.4	-0.5	-9.0
Refinery fuel	9 178	10 937	10 938	3.7	-	19.2
Subtotal	241 190	270 900	286 786	91.6	5.9	18.9
Bunkers	7 319	10 978	11 540	3.9	5.1	57.7
Total	248 509	281 878	298 326	100.0	5.8	20.0
Latin America						
NGL/LPG	11 037	18 314	18 679	8.2	2.0	69.2
Naphtha	3 766	7 182	7 637	3.4	6.3	102.8
Motor petrol	44 668	43 797	44 365	19.5	0.9	-0.7
Aviation fuels	6 568	6 626	7 016	3.1	5.9	6.8
Kerosene	6 783	5 523	5 476	2.4	-0.9	-19.3
Gas-diesel oil	49 040	50 127	52 248	23.0	4.2	6.5
Residual fuel	56 538	51 112	54 102	23.8	5.8	-4.3
Other products	12 476	18 109	18 966	8.3	4.7	52.0
Refinery fuel	12 036	10 263	10 758	4.7	4.8	-10.6
Subtotal	202 912	211 053	219 247	96.4	3.9	8.1
Bunkers	8 708	7 557	8 133	3.6	7.8	-6.6
Total	211 620	218 610	227 380	100.0	4.0	7.4
Middle East						
NGL/LPG	1 830	6 229	6 457	4.7	3.7	252.8
Naphtha	541	1 463	1 736	1.3	18.7	220.9
Motor gasoline	12 973	19 047	19 760	14.4	3.7	52.3
Aviation fuels	5 713	6 219	6 575	4.8	5.7	15.1
Kerosene	6 016	8 655	8 864	6.5	2.4	47.3
Gas-diesel oil	25 986	35 864	39 337	28.7	9.7	51.4
Residual fuel	18 026	28 197	29 315	21.4	4.0	62.7
Other products	6 711	10 390	10 875	7.9	4.7	62.0
Refinery fuel	5 189	6 589	6 721	4.9	2.0	29.5
Subtotal	82 985	122 653	129 640	94.7	5.7	56.2
Bunkers	16 495	9 458	7 282	5.3	-23.0	-55.9
Total	99 480	132 111	136 922	100.0	3.6	37.9
World a/						
NGL/LPG	..	147 487	155 609	8.2	5.5	..
Naphtha	..	83 083	86 299	4.5	3.9	..
Motor petrol	..	688 023	701 883	36.9	2.0	..
Aviation fuels	..	87 816	92 867	4.9	5.8	..
Kerosene	..	106 326	107 780	5.7	1.3	..
Gas-diesel oil	..	712 182	728 369	38.3	2.3	..
Residual fuel	..	618 727	29 315	1.3	-95.3	..
TOTAL	..	2 443 644	1 902 122	100.0	-22.2	..

Source: International Energy Agency, World Energy Statistics and Balance, 1971-87 (Paris, Organisation for Economic Co-operation and Development, 1989).

Note: LPG = liquefied petroleum gas; NGL = natural gas liquids.

a/ World totals include other regions. Data for 1980 not available.

opportunities for investing in order to buy less. Relatively inexpensive oil of the past few years seems not to have discouraged spending on conservation, and oil seems to have recovered little of the market share it has lost to other fuels. Only in the transport branch is there no practical alternative to oil-derived fuels. Although fuel consumption per vehicle-kilometre has improved very significantly since the mid-1970s (and further substantial improvements can be expected as a result of the introduction of ceramic engine components and lean-burn engines), volume sales in this branch have continued to increase.

(b) *Changing product specification*

Oil refiners must therefore face up to continuing investments in upgrading facilities, particularly catalytic crackers, to convert their surplus fuel oil into petrol. In Western Europe, in particular, the refining industry has been spending heavily on upgrading since the mid-1970s (United States refiners already had a substantial volume of cracking capacity). Such investments have been very attractive financially; the "cracking margin" (the difference between the spot price of fuel oil and the spot price of gasoline) has been in the range of $100-$200 per tonne for much of this time, giving a strong cash-flow which has easily covered construction, finance and operating costs. With the financial standing of upgrading projects well established, finance has become readily available.

But the sharp growth in upgrading capacity has had an impact on the economics of upgrading operations. On the positive side, with many large projects now completed and engineering aspects regarded as less challenging than in the early days, the construction business has become much more competitive in tendering for new projects. This has brought the capital costs down sharply. Typically, a 25,000-barrel-per-day catalytic cracker in Western Europe might now be constructed for $200 million or less, whereas a similar facility brought on stream in the early 1980s might have cost as much as $500 million in current value terms [44]. This reduction, together with generally shorter construction times, has had a substantial impact on project rates of return.

Less positive was the progressive reduction in the cracking margin, evident until 1989, when demand increased to meet supply. As more capacity came into use, the price of fuel-oil cracker feed firmed; at the same time, the price of petrol eased, and cracking profits became less exciting. As noted, this is not now a problem, but if demand should ease again it is a trend to watch for.

Positions also differ regionally. The United States, with its historically strong demand for petrol and its availability of indigenous natural gas for heating, has led the way in the installation of upgrading capacity and now has no shortage. Western Europe has seen an investment boom and major projects are now completed, most recently the catalytic cracker at the Mongstad refinery of Statoil. Shell is now operating its Hycon unit at Rotterdam, describing it as the first of a new generation of conversion facilities. At a capital cost of $585 million, it converts 4,000 tonnes per day of residual fuel oil entirely into distillates. Also at Rotterdam, Esso has a Flexicoker in operation, converting 32,000 barrels per day of heavy residue into light product (70 per cent of the yield) and coke (30 per cent). The regional emphasis seems to be shifting to East Asia, where upgrading projects are in the engineering stage at the Singapore refineries.

(c) *Environmental considerations*

Tightening environmental controls on refinery operations (as distinct from product controls) are another influence on investment. In the United States and Western Europe, regulations governing air, water quality and noise have been made progressively more stringent, and in some countries, notably the Netherlands and Belgium, are about to become even more severe. Esso in Antwerp, for example, explains that it has had to burn low-sulphur fuel oil for many years and now has to use a mix of fuel oil, fuel gas and bought-in natural gas in order to comply with sulphur emission limits. Refiners accept the need for environmental controls, but they are concerned about the disparity in regulations between one country and the next. Operators in Rotterdam, for example, feel themselves disadvantaged in shared export markets compared with those in, for example, Singapore, where restrictions are less onerous. The Singapore operators are also envied for their lower wage-rates (particularly compared with levels in the Netherlands), which also give an edge in shared export markets.

Refiners are also having to face and adjust investments to meet changing specifications for refined products. In part these are the result of more stringent controls on the environmental impact of petroleum use, but there are signs that the oil companies are planning to place more emphasis on product quality in order to secure their markets from exports by new producers. In North America, there is a move towards unleaded petrol for 100 per cent of sales and a diesel sulphur limit of 0.05 per cent by 1994. Australia and New Zealand are expected to follow the lead of Western Europe.

Lower limits for sulphur in diesel fuel take away some flexibility from the refinery operator, as it becomes necessary to run a higher proportion of low-sulphur crudes in the distillation intake. Eventually, however, additional desulphurization capacity is likely to be built. The installation of "three-way" catalytic converters on cars will accelerate the shift towards unleaded petrol, as such vehicles can only run on unleaded, and vapour emission limits on petrol components generally result in good octane qualities.

(d) *New role of the refining industry*

In addition to the forces for change discussed above, there is the changing position of the refining industry within the world oil industry. From beginnings as separate producing, refining and marketing companies, the oil majors grew into integrated firms, and by the 1960s and early 1970s regarded refining operations almost as a service to their profitable upstream and marketing ventures. But the events of 1973 forced a change to this pattern; having lost control over much of their oil following OPEC action during that year, they sought to regain refining as a profit centre in its own right. The industry accordingly de-integrated to a considerable degree, with products transferred between operating companies at arms-length prices (equivalent to open market values) and corporate management of operating companies given much more control over their production than previously.

The effect of this has been to expose the refining industry to competition, which now comes from government-owned refineries built by producing countries, as well as from the independent oil refineries, much more than had been the case in the 1970s. Some major companies, therefore, have been following a strategy of disinvestment in refining. British Petroleum, for example, has said it is happy to be a "deficit refiner", buying-in any additional products it needs to supply its marketing outlets. It is not yet clear whether improved financial returns in the industry have led to a reassessment of this position.

5. *Medium- and long-term outlook*

There are, however, signs that increasing trade in refined products will be a feature of the industry in future years. This is because of a regional imbalance between supply and demand. Consumption of refined products is increasing significantly, for example, in Western Europe and the United States, but very little new refinery capacity is being constructed in these areas. Capacity data published anually in the September issues of the *Petroleum Economist* shows that 44 per cent of capacity under construction or firmly planned is accounted for by export plants in Western Asia. Some 28 per cent of new capacity is in East Asia, where demand growth is strong, and 18 per cent is in the Caribbean and South America. Since under 5 per cent of new capacity is in the United States and less than 2 per cent in Western Europe, these areas will certainly be importing more.

In total, there are 149.1 million tonnes per year of new capacity under construction or firmly planned. This represents an increase of 5.5 per cent on existing world capacity of 2,816 million tonnes per year in non-centrally-planned economies, and might be thought a considerable expansion. The world total in non-centrally-planned economies, however, includes a number of refineries that have for many years run at much less than their full capacity, and others that are too old or unsophisticated to produce a full range of the products most in demand.

The new capacity data can give an indication of the likely shift in the distribution of world refining capacity in non-centrally-planned economies [44]. With 217 million tonnes per year of capacity in operation and 65 million tonnes per year planned, Western Asia will have a total of 282 million tonnes per year, equivalent to just under 10 per cent of the total in non-centrally-planned economies. East Asia, with 442 million tonnes per year planned and 501 million tonnes per year in place, will have 18 per cent of the total, while the Caribbean and South America area, with 27 million tonnes per year planned and 375 million tonnes per year in place, will have 14 per cent. This leaves Western Europe, with less than 3 million tonnes per year planned and 698 million tonnes per year in place, with 24 per cent, and the United States, with 7 million tonnes per year planned and 890 million tonnes per year place, with 30 per cent. Africa, where 7 million tonnes per year is planned and 135 million tonnes per year exist, will have 5 per cent of the total.

I. Engineering plastics (ISIC 3560)*

Growing markets but danger of over-capacity

1. *Current situation*

(a) *Hierarchy of products*

High-value speciality materials in the form of engineering and high-performance plastics are increasingly finding their way into global applications in industries such as automotive manufacturing, aerospace, defence, general machinery and consumer goods. These materials form the apex of a production pyramid of general plastics materials which have been growing in profile since the 1940s. The development of these materials has been based on their superiority in substituting for older materials such as metals, glass, paper, ceramics and others. Advantageous properties offered by plastics include their light weight, resistance to corrosion, toughness and easy processibility.

Nearly 95 per cent of thermoplastics consumption in the world is made up of the standard polymers: low- and high-density polyethylene, polyvinyl chloride, polypropylene and polystyrene. They are priced at under $2 per kilogram. Some speciality uses have been developed in this field, such as high-density polyethylene gasoline tanks and window frames from polyvinyl chloride. Reinforced polypropylene and ultra-high-molecular-weight polyethylene are also now classified as engineering polymers and will be considered in more detail below.

The main concern in the present review is with the main group of engineering polymers, including polyamide, polycarbonate, polyacetal, polyphenylene oxide and polyester. They are distinguished from the previous group by their high performance in terms of strength and heat resistance. The price range for these products, which did not become established until the 1960s, varies from $2 to $5 per kilogram. They can be modified through the addition of a variety of fillers and reinforcing materials and by alloying or blending with different polymers.

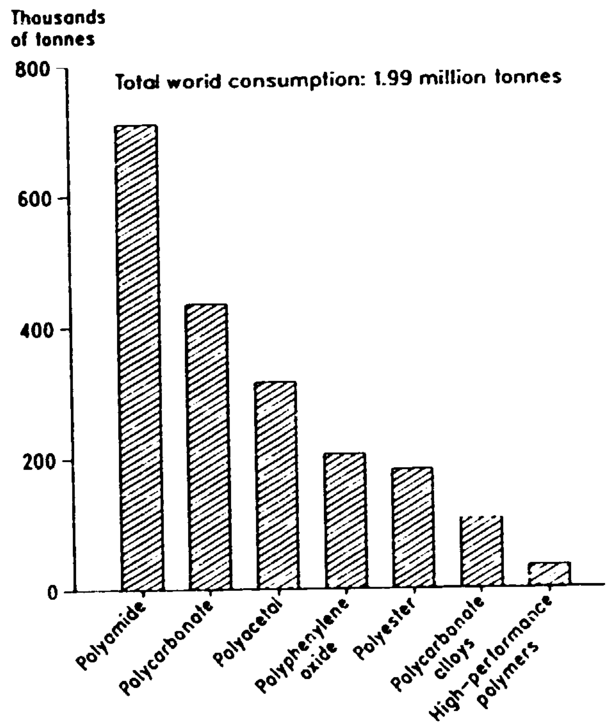
In a higher price and performance bracket than these are the high-performance polymers which stand out through their ability to retain mechanical and electrical properties even at high temperatures (above 200° C). They are flame-resistant and come in the price range of $50 per kilogram and above. Materials include polyacrylate, polysulphone, polyether sulphone, polyether imide, polyphenylene sulphide, liquid crystal polymers, fluoropolymers, polyimide and polyetherketone. These materials can be further divided according to their amorphous or crystalline state and consequent properties. Because of the hardness of crystalline polymers they are harder wearing and more resistant to chemical erosion and heavy load. They are thus preferred for machinery and in the automotive sector. Amorphous polymers do not shrink or warp and have higher aesthetic value. They are used for household goods, computer casing etc.

The higher-value end of the engineering polymers business is of a very small volume. Sales of materials launched in the 1980s such as polyether imide, polyetherketone and liquid crystal polymers amounted to only a few hundred tonnes. Sales of products first marketed in the 1970s, such as polyphenylene sulphide and polyether sulphone amounted to a few thousand tonnes. The sales numbers are higher for polymers launched in the 1960s, such as polyphenylene oxide and polyester, and again for polyamide, polyacetal and polycarbonate products of the 1950s.

(b) *Production and consumption*

In 1988 world consumption of all thermoplastics was nearly 70 million tonnes. Sales of the standard polymer, including low-density polyethylene, high-density polyethylene, polypropylene and polyvinyl chloride, but excluding polystyrene, amounted to 10 million tonnes or more. The consumption of engineering polymers, however, amounted to only 2 million tonnes in 1988 or roughly 3 per cent of all thermoplastics. As shown in figure IV.19, the largest market sector is currently in polyamide or nylon 6 and nylon 66, since this material makes a good alloy blend with other plastics such as acrylonitrile butadiene styrene and polyester. High-performance plastics have only a small share of 2.5 per cent of the overall plastics markets. Among these plastics, the largest single market is for polyphenylene sulphide, with about 14,000 tonnes.

Figure IV.19. World consumption of engineering and high-performance polymers, 1988

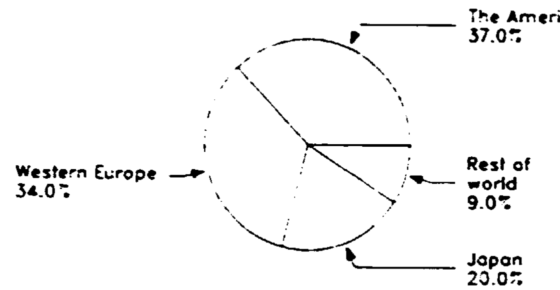


Source: Hoechst, Federal Republic of Germany

On a regional basis, figure IV.20 shows that the production of engineering polymers is spread between Europe and the United States, with one third each, and Japan and the rest of the world accounting for the rest. It can thus be clearly seen that the materials have achieved great penetration in the highly developed economies, a consequence of applications in high-technology industries.

*UNIDO acknowledges the contribution made by Lyn Tattum, Editor-in-Chief, *Chemicalweek International*.

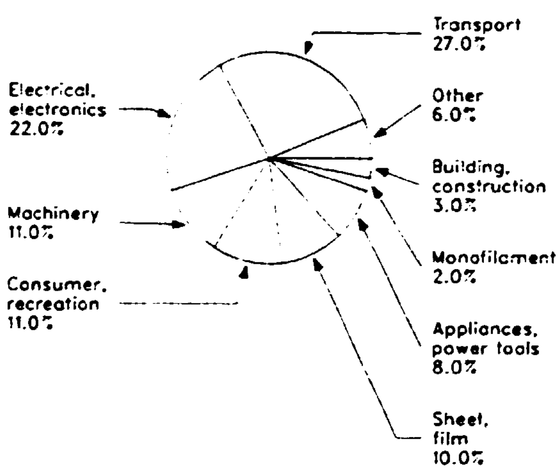
Figure IV.20. World consumption of engineering polymers, by region, 1988



Source Hoechst, Federal Republic of Germany

The main end-uses of engineering polymers are in industrial applications and the transport (primarily automotive), electrical, electronics and machinery industries, thanks mainly to their good mechanical and electrical properties, their chemical resistance and their durability. Some estimates of the percentage distribution of these end-uses are provided in figure IV.21. Transport with a 27 per cent share and

Figure IV.21. World consumption of engineering polymers, by end-use, 1988



Source Hoechst Federal Republic of Germany

electrical and electronics applications with a 22 per cent share are by far the largest. Roughly an even share of 10 per cent is allocated to the machinery and industrial, consumer and recreational, sheet and film, and appliance and power-tool markets. Monofilaments constitute only 2 per cent.

The transport and automotive industries exemplify the range of applications. In Western Europe, automobiles contain an average of 80-100 kilograms of plastic per vehicle, depending on the size of the car. Most of this is to be found in the interior trim. The main materials used are polypropylene, acrylonitrile butadiene styrene and polyurethane, each accounting for about one quarter of the total. Others include polyphenylene oxide and polystyrene. Polypropylene is being used in increasing quantities. For example, in the case of Mercedes-Benz, polypropylene usage has risen from 0.6 kilograms per car in 1968 models to 20.6 kilograms per car in 1985 models. In Fiat cars, polypropylene usage rose from 1.1 kilograms per car in 1965 to 31.9 kilograms per car in 1983. But this subsequently fell back to 22.1 kilograms per car in 1986. Much of this increased use has been due to the need to reduce the weight of automobiles and consequently their fuel consumption.

For producers of plastics the polymer high-value branch is important; it has been expanding from 8 to 10 per cent a year against fairly slow growth prospects for the plastics industry as a whole. In general, plastics demand is more closely linked to economic development, with growth curves tending to flatten in the short term, as economies recede from their fast growth rates of the late 1980s. Concern for the environment and problems of waste plastic disposal are also dampening demand.

It may be noted that development prospects for plastics are greatest in the South, where infrastructure and basic economic development is at an earlier stage. On the other hand, these countries, with some exceptions, offer the least opportunity in the near term for engineering plastics associated with advanced industrial development.

2. *Manufacturing capacity in developing countries*

Developing countries are not yet highly significant in the engineering polymers industry, though many have become the focus for general plastics production because of indigenous feedstocks such as gas. However, several major companies from developed market economies have ambitious plans for development in Asia. Of the $500 million to be spent world-wide by Du Pont in the early 1990s, $100 million will be in the Republic of Korea, Singapore and Japan. Meanwhile, investments in these countries and in Brazil as well appear to have stimulated over-capacity in certain product areas to be discussed below.

(a) *Republic of Korea*

One country which has stood out in plans for production is the Republic of Korea. Plans have been announced for a joint venture between Enichem Tecnoresine of Italy and Kumho Petrochemical of the Republic of Korea for the production of 20,000 tonnes of polycarbonate using Italian technology. The unit will be at Yeochon and will be the first polycarbonate plant in the Republic of Korea. Kumoto Petrochemical has also set up several joint ventures aimed at taking its petrochemicals business downstream, and has plans to produce the polycarbonate intermediate bisphenol A with Shell and polyamide in co-operation with Monsanto of the United States.

Other companies from developed market economies have various compounding facilities in the Republic of Korea. Akzo of the Netherlands built a compounding facility for engineering plastics based on local raw materials supplied by Kohap, a manufacturer of polyester and polyamide fibres. The investment has been inspired by the strong growth in the automotive and electronics industries in Asia. Du Pont is also building a compounding plant in the Republic of Korea on the basis of material to be supplied from Singapore. More recently, General Electric has been reviewing plans to build a polycarbonate unit with Lucky of Seoul, as growth in the United States market appears to have slowed.

(b) *Singapore*

Singapore is to become the focus of a major investment in East Asia by General Electric Plastics of the United States. It proposes to build a 100,000-tonne acrylonitrile butadiene styrene plant by 1992, to be followed by a 50 per cent expansion by 1995. In addition, it will also install polycarbonate compounding facilities. A polybutylene terephthalate project first slated for Spain could be relocated to Singapore. Following investment plans for the nylon intermediate adipic acid, Du Pont may go ahead with downstream investments for engineering plastics based on nylon. In the Jurong industrial estate it is already building for Delrin a $26-million finishing plant using engineering polymers supplied from the United States.

(c) *Taiwan Province*

Hoechst of the Federal Republic of Germany is making a major investment in Taiwan Province through its joint venture Taiwan Engineering Plastics. It is to produce 20,000 tonnes of acetyls.

(d) *Brazil*

BASF of the Federal Republic of Germany is negotiating a technology transfer agreement with the Brazilian Mariani group, which is planning to operate a polyamide derivatives plant through its subsidiary Nitrocarbono. Brazil has also become the focus for several polypropylene investments, some of which could be used in the engineering plastics sphere, when the demand of local industry and consumers builds up sufficiently. Hoechst is also planning a new polyacetals plant in Brazil.

3. *Capacity utilization and expansion plans*

Over-supply is already becoming an issue for several of the engineering plastics regarded only a few years ago as having great profit potential. In polycarbonate, for example, over-supply is now a reality and ambitious expansion plans threaten to exacerbate this. A world capacity in 1989 of 586,000 tonnes can be contrasted against demand of 435,000 tonnes, leaving producers with operating rates of around 74 per cent. Despite growth rate forecasts of 7 per cent a year, operating rates could fall to 71 per cent by 1994, because of planned additional capacity totalling 1.2 million tonnes. As shown in table IV.117, Bayer, the largest producer of polycarbonate in Europe, announced in late 1988 a massive investment plan to increase global capacity by 60 per cent to 270,000 tonnes by 1994.

For polyacetal, the forecast over-capacity could force operating rates down to 80 per cent by 1992, as capacity rises to 550,000 tonnes from 380,000 tonnes in 1988. As suggested in figure IV.22 the increase is partly due to seven new market entrants adding a total of 102,000 tonnes of capacity in Brazil, Republic of Korea, Singapore, Taiwan Province and United States.

The supply and demand picture for the small-volume polyphenylene sulphide is not encouraging. World-wide capacity was 22,000 tonnes in 1989, or 31,000 tonnes including compounding capacity. But the market stood at only 14,000 tonnes, representing a 45 per cent operating rate. In table IV.118, polyphenylene sulphide capacity is forecast to rise to 45,000 tonnes by 1992.

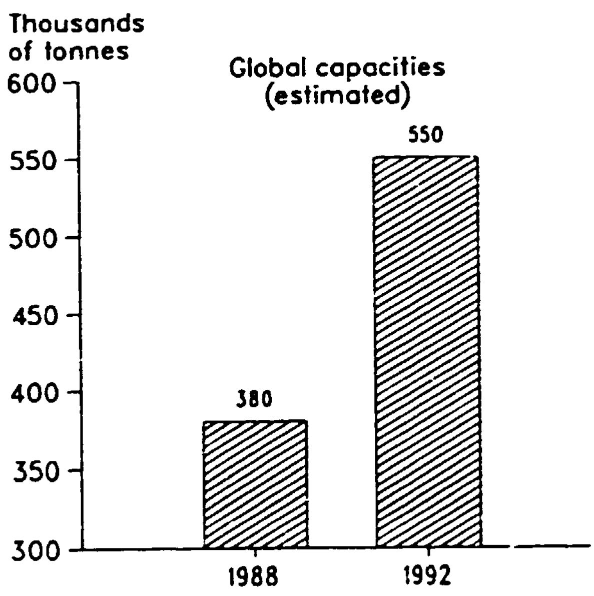
In liquid crystal polymers, where the global market stood at under 300 tonnes in 1988, there were already 20 suppliers, as shown in figure IV.23. For polyetherketone, with a market of 350 tonnes in 1988, capacity in Europe and the United States alone was set to increase from 1,250 tonnes in 1988 to 2,000 tonnes by 1992.

Table IV.117. Manufacturing capacity of polycarbonate in 1988 and forecast for 1994

Region or country and company	Capacity 1988 (thousands of tonnes)	Capacity 1994 (thousands of tonnes)	Percentage share 1988	Percentage share 1994	Start-up date
Europe					
Bayer[a]	100	146	17.4	12.2	1990 - 1991
General Electric[b]	90	255	15.4	21.4	1992 + 1994
ENI	17	17	2.9	1.4	
Dow	-	30	-	2.5	1990
DSM	-	40	-	3.4	1990
United States					
General Electric	190	244	32.4	20.5	1990
Mobay	73	173	12.5	14.5	1994
Dow	13	103	2.2	8.6	1992
Japan					
Taijin	35	35	6.0	2.9	
Mitsubishi Gas	25	45	4.3	3.8	1989
Mitsubishi Kasei	15	15	2.6	1.3	
Idemitsu	10	30	1.7	2.5	1989
Sumitomo	-	20	-	1.7	1991
General Electric	-	40	3.4	-	1991
TOTAL	568	1 193	100.0	100.0	

Source: Frost and Sullivan, New York.
a/ Further 24,000 tonnes scheduled after 1994-1995.
b/ Further 176,000 tonnes scheduled after 1994-1995.

Figure IV.22. Polyacetal manufacturing capacity forecast for 1992



Source Hoechst, Federal Republic of Germany

Table [illegible]. Manufacturing capacity of polyphenylene sulphide in 1988 and forecast for 1994[a]

Region or country and company	Capacity 1988 (thousands of tonnes)	Capacity 1994 (thousands of tonnes)	Percentage share 1988	Percentage share 1994	Start-up date
Japan					
Phillips Toray	7.5	10.0	30.5	22.4	1992[b]
Kureha	3.0	3.0	12.2	6.7	
Tophren	3.6	4.0[c]	14.6	8.9	
Toso Susteel	3.0	3.0	12.2	6.7	
Idemitsu	pp[d]	5.0[c]	-	11.2	1992[b]
United States					
Phillips	7.5	9.0	30.5	20.1	1992[b]
HCC	-	3.0	-	6.7	1992[b]
Europe					
Bayer	pp[d]	4.0	pp[d]	8.9	1990
Phillips Ciba Geigy	-	3.7	-	8.3	1992
TOTAL	24.6	44.7	111.8	100.0	

Source: Frost and Sullivan, New York.

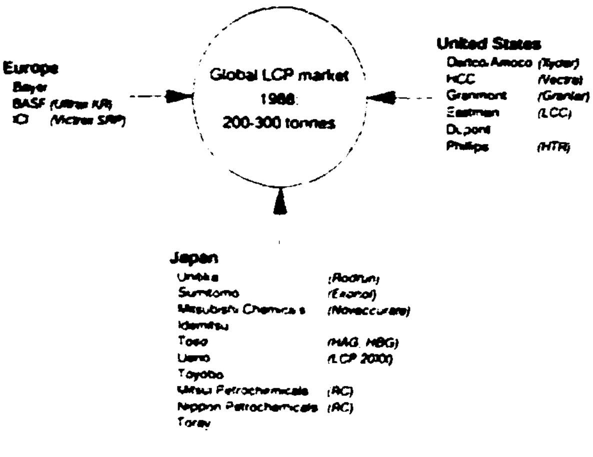
a All figures for base polymer, not compounded material. Companies compounding polyphenylene sulphide not included.

b Expected.

c Estimate.

d pp = pilot plant, with a capacity of less than 1,000 tonnes.

Figure IV.23. Liquid crystal polymers (LCP): current market, suppliers and trade names



Source: Hoechst, Federal Republic of Germany.

Note: LCP consumption of microwave utensils not included in total.

With respect to regional expansion, General Electric Plastics is planning a new complex in Spain to produce polyester and polycarbonate, enticed by local grants from the Government of Spain. As of early 1990, however, that investment has been under review in the light of weakening demand from the United States automobile industry and a possible relocation to Singapore.

Himont of Italy has built a new plant at Ferrara to produce a wide range of engineering plastics using its new "Catalloy" technology for making engineering polymers based on polypropylene. Other polypropylene manufacturers are upgrading their technologies to move in a similar direction.

DSM of the Netherlands is hoping to build a 40,000-tonne polycarbonates plant at Groningen in co-operation with Idemitsu of Japan. The move would mark the entry of DSM into the polycarbonates business. Local environmental opposition, however, has hampered plans, and the final go-ahead may not occur until late 1990.

Dow Chemical has also decided to enter polycarbonates production in Europe, chosing its Stade site in the Federal Republic of Germany as its preferred location. The company has an overall $200-million investment programme designed to increase production of engineering plastics in Europe.

Bayer, meanwhile, is developing a major engineering plastics production complex at Antwerp, including plans for polycarbonates. It was due to bring on stream in early 1990 the first commercial polymerization unit for polyphenylene sulphide in Europe. Capacity will be 4,000 tonnes of straight resins or 8,000 tonnes of compound filled with fibreglass.

Another planned location for many plastic companies is Japan, which sets the design and product specifications for many end-users around the world. Previously, four Japanese producers, Teijin, Mitsubushi Gas Chemical, Mitsubishi Chemical and Idemitsu, supplied the Japanese market. All the major engineering plastics producers have manufacturing in place or ambitions in Japan.

In the United States, most companies are expanding in line with market requirements. In particular, new compounding plants are being added to existing resin facilities. However, the current trend appears to be that United States companies are spreading their investments overseas.

4. *Short- and medium-term outlook*

Overall market growth rates are put at between 5 and 10 per cent depending on product and source of estimate. A market research company, Frost and Sullivan of the United States, says that demand for engineering polymers in Europe will increase by a third to 1.2 million tonnes by 1993. The value of this production would increase from $3.8 billion to $5 billion. The largest-volume product will be acrylonitrile butadiene styrene, but its limited scope for technical development will allow growth of only 19 per cent to 488,000 tonnes. Polyamides are likely to grow by 43 per cent to 314,000 tonnes because of strong demand for speciality products. Polycarbonates use may increase by 43 per cent to 174,000 tonnes. Polyacetals, now used as replacement for metal in domestic plumbing parts, may see usage increase by 31 per cent to 122,000 tonnes.

In the United States, demand for all engineering polymers is forecast to grow by 14 per cent to 1.45 million tonnes by 1990, with the market value increasing by $1 billion to $4.5 billion. The largest end-user will be the automotive industry, with demand forecast at 296,000 tonnes. The highest growth rates are likely to be in the electronic and electrical industry, with sales projected to jump from 82,000 tonnes to 123,000 tonnes. Acrylonitrile butadiene styrene, again showing the highest volume but slowest growth, will see sales rise to 50,000 tonnes during the period. Highest growth rates are expected in the smaller-volume products.

Regarding the allocation of investment between North and South, the development of end-use markets will probably dictate location of production. Thus, for the relatively small-volume engineering plastics, the development of the automobile and electrical and electronics industries will be major factors. Frequently, investments in these higher-value-added products are made at sites where plastic materials and their intermediates are already produced. Traditionally, this has been in the North.

However, the increasing number of petrochemical and plastics complexes in the South will serve as an incentive to locate engineering polymer plants close to feedstock sources. Recently, environmental considerations have also been hampering investment plans in the North. It is likely, therefore, that towards the year 2000 the North-South production imbalance in these high-technology materials will begin to correct itself.

Most investment is likely to be through technology transfer from the North, probably in joint-venture companies and projects. Transnational corporations from the United States, Europe and Japan already have a strong lead in research and development, and various stages in the production of engineering plastics and intermediates are already covered by patents.

A feature of the 1990s may be the growing number of patent disputes, as companies attempt to keep rival producers out of their markets. A recent example involved a case between Phillips Petroleum of the United States and a polyphenylene sulphide patent challenge from Hoechst of the Federal Republic of Germany and Kureha of Japan. Phillips won, but agreed to grant licences for manufacture of polyphenylene sulphide in the United States to the other two companies. They are also allowed to make polyphenylene sulphide compounds and certain other varieties world-wide, except in Japan. In return, the firms in the Federal Republic of Germany and Japan have granted Phillips corresponding licences.

J. Consumer and industrial tissue paper (ISIC 3419)*

Further growth fosters investment in developing countries

Any analysis of the consumer and industrial tissue paper industry must begin with an admission that very little information on the subject exists. This situation is characteristic of a highly competitive industry, where the battle for a share of the market is often fierce, with the result that production, prices and capital investment data are often hard to obtain. Not only must estimates be made for the data, but it is difficult to establish the definition of what is, and what is not, consumer and industrial tissue, as systems of definition vary internationally. The following classification has been adopted in the present survey:

(a) Consumer tissue is paper used to make such retail end-products as handkerchiefs, toilet paper, kitchen towels and serviettes;

(b) Industrial tissue is paper bought directly by factories, restaurants, offices, hotels etc. Speciality tissue, cigarette tissue and medical tissue products are excluded, although it is difficult to separate such data from the two major categories.

When a classification of products is made according to end-use, tissue falls into two main categories: sanitary and the rest. Sanitary tissue is, by far, the dominant one. In the United States, for example, it is about 98 per cent of total output, and it includes bathroom and facial tissue, towelling, napkins, base stock for sanitary articles, wadding and industrial wipes. The rest includes base stock for waxing and wrapping.

1. *Recent trends in consumption, production, prices and trade*

Generally speaking, trends in consumption for consumer and industrial tissue have been similar to those for all paper and paper-board. Production or output in this industry is frequently used as an indicator of consumption, and the annual increases in the output of tissue world-wide from 1983 to 1988 have averaged 4.7 per cent, compared with 5.4 per cent for the total output of paper and paper-board. Table IV.119 shows the strong increase in production,

Table IV.119. World production of tissue paper, 1985-1988

Rank in 1988	Region or economic grouping	Production (thousands of tonnes) 1985	1988	Percentage share 1985	1988	Percentage change 1985-1988
1	North America	4 929	5 424	43.5	42.3	10.0
2	Western Europe	2 537	2 830	22.4	22.1	11.5
3	Japan	1 089	1 281	9.6	10.0	17.6
4	Latin America	1 064	1 113	8.7	9.4	4.2
5	Asia a/	508	700	4.5	5.5	37.8
6	Eastern Europe b/	516	546	4.6	4.3	5.8
7	Asia c/	296	466	2.6	3.6	57.4
8	Other developed	284	330	2.6	2.5	16.2
9	Africa	113	134	1.0	1.0	18.6
	North	9 355	10 411	82.5	81.2	11.3
	South	1 985	2 413	17.5	18.8	21.6
	TOTAL	11 340	12 824	100.0	100.0	13.1

Source: Pulp and Paper International, *Fact and Price Book* (London, Miller Freeman Publications, 1990).

a/ Centrally planned economies.

b/ Including an estimate of 250,000 tonnes for the USSR for both 1985 and 1988.

c/ Developing market economies.

and hence consumption, that took place between 1985 and 1988. As would be expected, the largest consuming regions are North America, Western Europe and Japan. As in 1988, production in 1989 is again expected to have reached a record level.

Recent trends in world prices are impossible to judge with any accuracy, but prices are generally likely to have been increasing in face of rising demand. In the largest market, the United States, the price index from the Bureau of Labour Statistics shows a fairly steady increase since the 1970s, though price increases

*UNIDO acknowledges the contribution made by Peter Sutton, Editor, *Pulp and Paper International*.

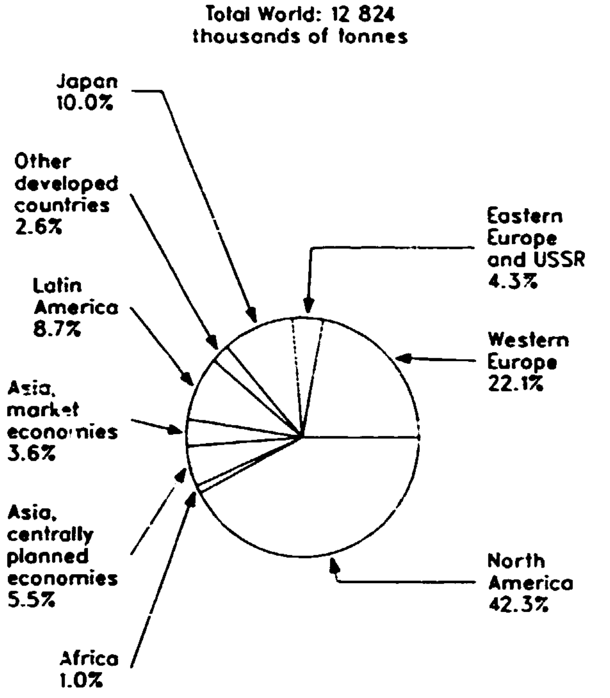
appear to have accelerated in the past two years. With 1982 as the base year corresponding to 100, the index was 106.6 in 1985 and 109.1 by 1987, but 117.3 by the end of 1988 and 124.4 by mid-1989. Across product sectors, price increase of toilet tissue and towels lead the way, the increases for facial tissue and napkins being slightly less.

World production of tissue paper has been increasing year after year for at least the past 10 years. This is true for most of the 10 largest country producers, as shown in table IV.120. The main reason is increasing consumer demand for tissue products, as the consumption of tissue is an indicator of consumer affluence. There are signs of market saturation in some of the leading producing countries, such as the United States. In the case of Western Europe, consumption in 1988 rose to 3.15 million tonnes in 1988, up 4.4 per cent from the previous year, according to the European Tissue Symposium based at Stockholm. A regional breakdown of world production in 1988 is given in figure IV.24.

Hence producers are looking towards developing countries for new markets. Rather than exporting, they are more likely to set up local subsidiaries making tissue and converting it to the end product. This is more attractive than exporting it from the home country, partly because of transport costs. Table IV.121 provides a perspective on tissue volume in developing countries. China currently has the largest market, followed by Mexico and Brazil.

With a few exceptions such as Sweden, there is little international trade in tissue rolls, but somewhat more in finished tissue products. At any rate, the trend volume still is not comparable to that of newsprint or kraft liner tonnage, though the value per tonne is much higher. Therefore, the effect of instability of exchange rates has probably not had a major effect on the top producer countries. The ranking of the major tissue-exporting countries is provided in table IV.122. Sweden and Italy are clearly the largest. Among the major importing countries featured in table IV.123, the United Kingdom is clearly the largest, followed by Italy, Federal Republic of Germany, and Belgium.

Figure IV.24. World production of tissue paper, by region or economic grouping, 1988



Source: Pulp and Paper International, *Fact and Price Book* (London, Miller Freeman Publications, 1990).

2. *Major companies at the global level*

(a) *World's largest companies*

Several of the world's leading companies producing tissue also manufacture other paper grades, and in some cases pulp as well. For this reason, it is not possible to determine the value of the sales and profits generated by tissue production alone. Table IV.124 and figure IV.25 provide a ranking of the world's largest tissue paper companies, but only in terms of their total pulp, paper and converting sales. The three

Table IV.120. World's 10 largest tissue paper producer and consumer countries, 1988

Rank	Country	Production: Total (thousands of tonnes)	Production: Percentage share	Rank	Country	Consumption: Total (thousands of tonnes)	Consumption: Percentage share
1	United States	4 968	50.6	1	United States	4 985	50.9
2	Japan	1 281	13.0	2	Japan	1 281	13.1
3	Germany, Federal Republic of	746	7.6	3	Germany, Federal Republic of	727	7.4
4	China	700	7.1	4	China a/	700	7.1
5	Canada	456	4.6	5	United Kingdom	528	5.4
6	United Kingdom	439	4.5	6	Canada	417	4.3
7	Mexico	359	3.7	7	Brazil	314	3.2
8	Brazil	323	3.3	8	France	305	3.1
9	Sweden	287	2.9	9	Mexico	285	2.9
10	Italy	264	2.7	10	USSR	250	2.6
	TOTAL	9 823	100.0		TOTAL	9 792	100.0

Source: Pulp and Paper International, Fact and Price Book (London, Miller Freeman Publications, 1990).

a/ Estimates.

Table IV.121. Five largest tissue paper producer and consumer countries in the South, 1988

Rank	Country	Production: Total (thousands of tonnes)	Production: Percentage share	Rank	Country	Consumption: Total (thousands of tonnes)	Consumption: Percentage share
1	China	700	40.3	1	China[a]	700	43.1
2	Mexico	359	20.7	2	Brazil	314	19.3
3	Brazil	323	18.6	3	Mexico	285	17.5
4	Republic of Korea	197	11.3	4	Republic of Korea	199	12.2
5	Venezuela	159	9.1	5	Venezuela	128	7.9
	TOTAL	1 738	100.0		TOTAL	1 626	100.0

Source: Pulp and Paper International, Fact and Price Book (London, Miller Freeman Publications, 1990).
a/ Estimates.

Table IV.122. Tissue paper exports from major trading countries, 1985-1989

Rank in 1988	Country	Volume 1985 (thousands of tonnes)	Volume 1988 (thousands of tonnes)	Percentage share 1985	Percentage share 1988	Percentage change 1985-1988
1	Sweden	122	143	19.8	17.4	17.2
2	Italy	43	133	7.0	16.2	209.3
3	Germany, Federal Republic of	50	97	8.1	11.8	94.0
4	Belgium	83	86	13.5	10.5	3.6
5	Mexico	19	79	3.1	9.6	315.8
6	Canada	56	68	9.1	8.3	21.4
7	Finland	82	63	13.3	7.7	-23.2
8	Austria	47	49	7.6	6.0	4.3
9	United States	16	37	2.6	4.5	131.3
10	France	35	21	5.7	2.6	-40.0
11	Norway	7	20	1.1	2.4	185.7
12	United Kingdom	1	9	0.2	1.1	800.0
13	Netherlands	16	9	2.6	1.1	-43.8
14	Spain	32	4	5.2	0.5	-87.5
15	Denmark	6	3	1.0	0.4	-50.0
	TOTAL	615	821	100.0	100.0	33.5

Source: Pulp and Paper International, Fact and Price Book (London, Miller Freeman Publications, 1990).

Table IV.123. Tissue paper imports of major trading countries, 1985-1989

Rank in 1988	Country	Volume 1985 (thousands of tonnes)	Volume 1988 (thousands of tonnes)	Percentage share 1985	Percentage share 1988	Percentage change 1985-1988
1	United Kingdom	79	98	14.9	15.4	24.1
2	Italy	64	78	12.1	12.2	21.9
3	Germany, Federal Republic of	78	76	14.7	11.9	-2.6
4	Belgium	47	70	8.9	11.0	48.9
5	Mexico	44	60	8.3	9.4	36.4
6	Canada	51	54	9.6	8.5	5.9
7	Finland	31	44	5.9	6.9	41.9
8	Austria	56	41	10.6	6.4	-26.8
9	United States	21	29	4.0	4.6	38.1
10	France	15	25	2.8	3.9	66.7
11	Norway	15	22	2.8	3.5	46.7
12	United Kingdom	20	18	3.8	2.8	-10.0
13	Netherlands	6	14	1.1	2.2	-133.3
14	Spain	1	5	0.2	0.8	400.0
15	Denmark	1	3	0.2	0.5	200.0
	TOTAL	529	637	100.0	100.0	20.4

Source: Pulp and Paper International, Fact and Price Book (London, Miller Freeman Publications, 1990).

largest companies, James River, Kimberly-Clark and Scott Paper, are located in the United States.

In general, the sales and profits of the leading companies have been increasing in recent years, and this trend seems likely to continue because of the recent spate of mergers and acquisitions in the industry. The bigger companies consequently have not only the largest sales incomes, but also a more global approach to the market. The three top tissue companies are also the second, third and fourth top companies in the world in pulp and paper production (listed by sales from pulp, paper and board only). Only International Paper is bigger.

(b) *South's largest companies*

Because of a lack of sales data, it is difficult to list the biggest producers in the South, but some estimates can be made on the basis of production capacity. Table IV.125 lists some of the major tissue-making companies, though not necessarily all the largest ones, according to their estimated current capacity. San Cristobal SA de CV Productos and Kimberly-Clark de Mexico are clearly the largest companies. Several of the major tissue-producing companies in the South are subsidiaries of the top North American companies Kimberly-Clark and Scott. This is a key feature of the tissue business in the South. However, the subsidiaries must be placed in perspective, since there are also independent companies listed in table IV.125.

3. *Manufacturing capacity of developing countries*

Limited data are available for providing a perspective on manufacturing capacity, consumption, production and exports in developing countries. Table IV.126 suggests that five countries and areas have by far the largest capacity: Mexico, Brazil, Republic of Korea, Venezuela and Taiwan Province. The per capita consumption in these countries and areas, however, does not follow the same order, suggesting that trade is necessary to reconcile the domestic balance sheet. The exceptions are Venezuela and Kuwait, with per capita consumptions of, respectively, 6.8 and 6.2 kilograms per head.

4. *Capacity utilization and capacity expansion plans*

Capacity utilization rates are now relatively high in most developed countries and in developing countries of Asia. As suggested in table IV.127, utilization rates were higher in 1988 than in 1980. This confirms the previously stated view of recent strong growth in the tissue-making industry.

Table IV.128 provides data on committed capital investment projects expected to start up during the period 1990-1993, and which will result in increased production capacity for tissue paper. Separately listed are the totals for projects in an advanced planning stage and likely to proceed. It is common for some existing and aging machines at a tissue mill to shut down when the new unit starts up. These figures, therefore, are the net increase in capacity that will result from the investments. The possible permanent shut-down of capacity unconnected with new investment is not taken into account.

Table IV.124. World's largest tissue paper companies in terms of sales from pulp, paper and converting operations only, 1988

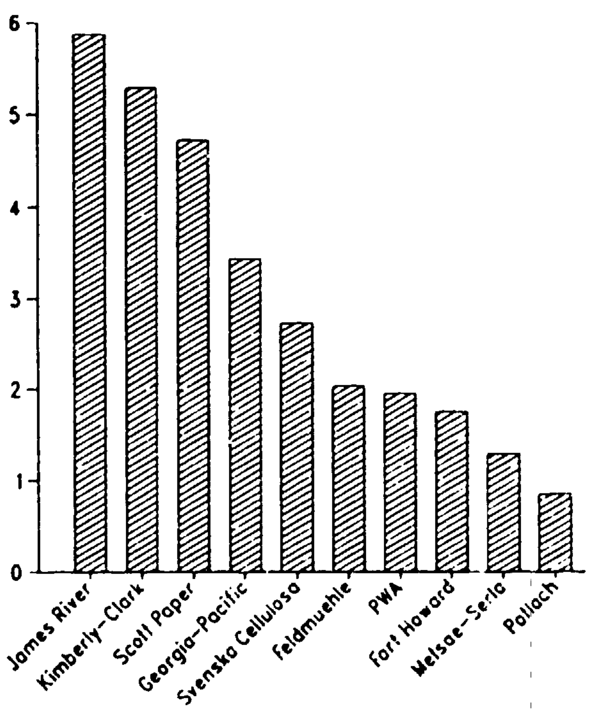
Rank	Company	Country	1988 sales (millions of dollars)	Percentage share	Percentage change over previous year	Net profits after tax (millions of dollars)	Marginal profit/ consolidated sales (percentage)	Percentage change over previous year
1	James River	United States	5 871.8	18.7	15.2	500.6	8.5	21.8
2	Kimberly-Clark	United States	5 286.2	16.9	9.9	378.6	7.0	16.4
3	Scott Paper	United States	4 726.2	15.1	14.7	591.4	12.5	20.1
4	Georgia-Pacific	United States	3 436.0	11.0	22.3	467.0	4.9	2.0
5	Svenska Cellulosa	Sweden	2 725.6	8.7	40.3	330.7	9.7	45.6
6	Feldmuehle	Germany, Federal Republic of	2 034.5	6.5	8.0	207.8	9.1	11.3
7	PWA	Germany, Federal Republic of	1 949.0	6.2	14.1	166.6	8.5	39.6
8	Fort Howard a/	United States	1 757.7	5.6	13.4	157.7	9.0	7.7
9	Metsae-Serla	Finland	1 292.2	4.1	18.3	167.6	9.2	204.8
10	Potlatch	United States	852.3	2.7	15.4	184.7	17.0	21.0
11	Kaysersberg	France	618.7	2.0	1.7	71.4	9.9	29.5
12	Sarrio	Spain	330.9	1.1	10.0	22.9	6.0	-19.5
13	Pope and Talbot	United States	291.6	0.9	32.6	53.7	10.4	9.6
14	British Tissue	United Kingdom	189.1	0.6	6.4	38.1	18.1	74.9
		TOTAL	31 361.8	100.0	..	3 338.8	..	..

Source: Pulp and Paper International, *Fact and Price Book* (London, Miller Freeman Publications, 1990).

Note: Some of these companies make other paper grades, and some also make pulp. In some cases, tissue is only a small part of their total sales of paper and paperboard. For companies ranked 8, 13 and 14, the figures are for tissue production only.

a/ These are 1987 results. Owing to a leveraged buyout in August 1988, the company did not release annual sales and earnings in that year.

Figure IV.25. World's top 10 producers of tissue paper: sales from pulp, paper and converting operations only, 1988



Source Pulp and Paper International, *Fact and Price Book* (London, Miller Freeman Publications, 1990)

Table IV.125. Major tissuemaking companies in the South, 1988

Company	Country or area	Estimated production capacity (thousands of tonnes per year)	Estimated production capacity: Percentage share
San Cristobal SA de CV Productos	Mexico	136	19.7
Kimberly-Clark de Mexico	Mexico	97	14.0
Taiwan Scott Paper	Taiwan Province	57	8.2
Industrias Klabin do Parana de Celulose	Brazil	40	5.8
Yuen Foong Yu	Taiwan Province	40	5.8
Fábricas de Papel Loreto y Pena Pobre	Mexico	36	5.2
Santa Therezinha	Brazil	35	5.1
Sangyong Paper	Republic of Korea	35	5.1
Elisas J. Curi	Brazil	25	3.6
Kimberly-Clark do Brasil	Brazil	24	3.5
SK Corporation	Taiwan Province	22	3.2
Toprak Kagit Sanayii	Turkey	22	3.2
COPA (Joint venture of Scott and Caemi)	Brazil	20	2.9
COPAPA	Brazil	18	2.6
Volta Grande de Paper	Brazil	18	2.6
Scott Paper	Malaysia	18	2.6
Hsing Lee Paper Corporation	Taiwan Province	18	2.6
Samjung Pulp	Republic of Korea	17	2.5
Dong Shin Paper Manufacturing	Republic of Korea	14	2.0
	TOTAL	692	100.0

Source: Pulp and Paper International, *Fact and Price Book* (London, Miller Freeman Publications, 1990).

Table IV.126. Tissue-paper manufacturing capacity in developing countries, 1988

Region, country or area	Capacity (000' of tonnes)	Capacity Percentage share	Consumption (000' of tonnes)	Consumption Percentage share	Production (000' of tonnes)	Production Percentage share	Exports (000' of tonnes)	Exports Percentage share	Per capita consumption Kilograms	Per capita consumption Percentage share
Latin America										
Mexico	432	18.2	285	13.8	359	17.2	79	54.9	3.4	8.2
Brazil	384	16.2	314	15.2	323	15.5	9	6.3	2.2	5.3
Venezuela	177	7.5	128	6.2	159	7.6	31	21.9	6.8	16.3
Columbia	86	3.6	69	3.3	73	3.5	4	2.8	2.3	5.5
Argentina	53	2.2	44	2.1	44	2.1	-	0.0	1.4	3.4
Western Asia										
Turkey	39	1.6	21	0.5	27	1.3	8	5.6	0.4	1.0
Kuwait a/	7	0.3	12	0.6	6	0.3	-	-	6.2	14.9
Jordan b/	5	0.2	14	0.7	3	0.1	-	-	3.0	7.2
Iran (Islamic Republic of)	6	0.3	6	0.3	4	0.2	-	-	0.1	0.2
Africa										
Kenya c/	5	0.2	10	0.5	5	0.2	-	-	0.4	1.0
Nigeria c/	10	0.4	45	2.2	5	0.2	-	-	0.4	1.0
Tanzania, United Republic of b/	9	0.4	12	0.6	4	0.2	-	-	0.5	1.2
Zimbabwe	5	0.2	3	0.1	4	0.2	1	0.7	0.3	0.7
Asia d/										
Republic of Korea	205	8.7	199	9.6	197	9.4	1	0.7	4.7	11.3
Taiwan Province	120	5.1	119	5.8	109	5.2	6	4.2	6.0	14.4
Malaysia c/	35	1.5	31	1.5	33	1.6	5	3.5	1.9	4.6
Thailand c/	36	1.5	55	2.7	30	1.4	-	-	1.0	2.4
Asia e/										
China a/	750	31.6	700	33.9	700	33.6	-	-	0.6	1.4
TOTAL	2 374	100.0	2 067	100.0	2 085	100.0	144	100.0	41.6	100.0

Source: Pulp and Paper International, Fact and Price Book (London, Miller Freeman Publications, 1990).

a/ Estimated capacity and consumption.

b/ Estimated consumption.

c/ All estimates.

d/ Market economies.

e/ Centrally planned economies.

Table IV.127. Tissue-making capacity utilization

Region, country or area	Capacity 1980	Capacity 1988	Production 1980	Production 1988	Utilization rate Percentage 1980	Utilization rate Percentage 1988	Percentage change 1980-1988
	(thousands of tonnes)						
North America							
Canada	396	515	368	454	93	88	-5.4
United States	4 493	5 103	3 968	4 967	88	97	10.2
Western Europe							
Germany, Federal Republic of a/	636	794	515	746	81	94	16.0
United Kingdom a/	518	457	435	439	84	96	14.3
Sweden b/	260	315	224	287	86	91	5.8
Italy b/	152	311	128	264	84	85	1.2
France a/	197	260	185	250	94	96	2.1
Spain b/	135	234	124	219	92	94	2.2
Eastern Europe and USSR a/							
USSR c/	123	266	100	250	81	94	16.0
Yugoslavia	74	122	61	111	82	91	11.0
Poland	110	118	96	110	87	93	6.9
Czechoslovakia	44	45	41	45	94	100	6.4
Romania c/	21	33	20	30	97	91	-6.2
Other developed countries							
Japan	1 084	1 408	900	1 281	83	91	9.6
Australia d/	131	141	115	127	88	90	2.3
New Zealand	44	71	38	60	86	85	-11.5
South Africa d/	84	133	82	110	98	83	-15.3
Israel	12	34	12	33	97	96	-1.0
Total North	8 514	10 360	7 412	9 783	87	94	8.0
Latin America a/							
Mexico	184	432	184	359	100	83	-17.0
Brazil	297	384	267	323	90	84	-6.7
Venezuela	143	177	103	159	72	90	25.0
Colombia	46	86	38	73	82	85	3.7
Argentina	54	53	38	44	70	83	18.6
Western Asia a/							
Turkey	10	39	8	27	79	69	-12.7
Kuwait	-	7	-	6	-	86	-

Table IV.127 continued

Region, country or area	Capacity 1980	Capacity 1988	Production 1980	Production 1988	Utilization rate: Percentage 1980	Utilization rate: Percentage 1988	Percentage change 1980-1988
	(thousands of tonnes)						
Jordan	-	5	-	3	-	60	-
Iran (Islamic Republic of	16	6	5	4	31	67	116.1
Africa[d/]							
Kenya[d/]	2	5	2	5	100	100	-
Nigeria[d/]	-	10	-	5	-	50	-
United Republic of Tanzania	-	9	-	4	-	44	-
Zimbabwe[d/]	2	5	2	4	100	80	-20.0
Asia[a/]							
China[c]	606	750	515	700	85	93	9.4
Republic of Korea	73	205	57	197	78	96	21.3
Taiwan Province	72	120	59	109	82	91	11.0
Malaysia[d/]	15	35	8	33	55	94	70.9
Thailand[d/]	21	36	8	30	87	83	-4.6
Total South	1 541	2 364	1 294	2 085	84	88	4.8
TOTAL	10 055	12 724	8 706	11 868	171	182	6.4

Source: Pulp and Paper International, Fact and Price Book (London, Miller Freeman Publications, 1990).

a Capacities for both years are derived from an operating rate for the entire paper and board industry in each year.

b Capacity for 1980 is derived from an operating rate for the entire paper and board industry in that year.

c/ All estimates.

d Production and capacity in 1988 estimated.

e/ Capacity in 1980 estimated.

Table IV.128. Tissue paper: net capacity additions from new capital investment, 1990-1993
(Thousands of tonnes per year)

Item	Europe	North America	Latin America	Asia[a/]	Australasia	Africa
Committed projects	281 (61)	135 (100)	..	77 (68.8)	25 (100)	- -
Planned projects	180 (39)	- -	..	35 (31.3)	- -	12 (100)
TOTAL	461 (100)	135 (100)	..	112 (100.0)	25 (100)	12 (100)

Source: Pulp and Paper International, Fact and Price Book (London, Miller Freeman Publications, 1990).

Note: Figures in parentheses are percentage share.

a/ Including Western Asia.

5. *Short- and medium-term industry outlook*

Excess capacity has plagued the European tissue industry in recent years, at least according to producer association reports. There are signs that the growth in demand in Western Europ particularly in the Northern countries, is slowing down and may be nearing the saturation point. But this has not yet had a noticeable effect on capital investment planning. According to one recent report from the European Tissue Symposium, which has members in 16 Western European countries, the gap between installed capacity and production was about 200,000 tonnes per year at the end of 1988. Plans for new tissue paper machines and complete new mills are expected to increase this over-capacity to 350,000 tonnes per year by 1994.

In addition to excess capacity, the European Tissue Symposium foresees an overall slow-down in consumption growth of between 2 and 3 per cent per year by 1994. Consumption in 1988 was 3.15 million tonnes, up 4.4 per cent following previous increases. These are all signs that the fight for market share in Europe is going to become even tougher. However, there is hope in the comparatively low per capita consumption in the Mediterranean countries. The average for the 16 European Tissue Symposium member countries was 8.8 kilograms in 1988, but in Italy the figure was 8.5 kilograms, in France 7.9 kilograms, in Spain 5 kilograms and in Portugal 4.6 kilograms.

K. Paper and board for corrugated boxes (ISIC 341131-341137)*

Industry downturn in some countries

Casemaking materials or container board is the second largest branch of the world paper and board industry by tonnage but not by value. In the present review the focus will be on the following main grades of packaging paper and board used to make corrugated boxes or casemaking materials: kraft liner made from virgin fibre and test liner made from recycled fibre; and fluting, again both virgin and waste-based. As far as possible, packaging paper for sacks, bags and carton board are not considered. However, some of the publicly available figures used here include some carton board with linerboard

1. *Trends in production, consumption, prices and trade*

Trends in the production and consumption of materials to make corrugated boxes are an indicator of the economic progress of a country, simply because the output and trade of many goods depends directly on the use of boxes to package them for shipment. Regarding the measurement of consumption, the industry practice is to use output or production or a surrogate. The world production of paper and board for corrugated boxes has been setting new records every year since 1983. Table IV.129 provides data on production increases in different countries since 1985, and a regional breakdown for 1988 is given in figure IV.26.

The related consumption increases are reflected in the prices of these products, which have, in general, gradually increased over the past three years, although there are exceptions. Taking the price of unbleached kraft liner as a bench-mark, the United States export price to Europe has increased by about 65 per cent from the end of 1985 to the end of 1989. For United States shipments of liner to South-East Asia, the increase has been about 90 per cent; to Japan it has

*UNIDO acknowledges the contribution made by Peter Sutton, Editor, *Pulp and Paper International*

Table IV.129. World production of paper and board for corrugated boxes, 1985-1988

Rank in 1988	Country, region or economic grouping	Production 1985 (thousands of tonnes)	Production 1988 (thousands of tonnes)	Percentage share 1985	Percentage share 1988	Percentage change 1985-1988
1	North America	21 665	25 335	43.3	42.2	16.9
2	Western Europe	5 980	15 604	19.2	19.3	21.2
3	Japan	5 829	7 103	11.7	11.8	21.9
4	Asia, a/ b/	3 345	4 378	6.7	7.3	30.9
5	Eastern Europe and USSR	4 082	4 172	8.2	6.9	2.2
6	Western Asia	2 107	3 525	4.2	5.9	67.3
7	Latin America	2 431	2 832	4.9	4.7	16.5
8	Other developed countries	852	965	1.7	1.6	13.3
9	Africa	128	151	0.3	0.3	18.0
	North	42 008	49 183	84.0	81.9	17.1
	South	8 011	10 886	16.0	18.1	38.9
	TOTAL	50 019	60 069	100.0	100.0	20.1

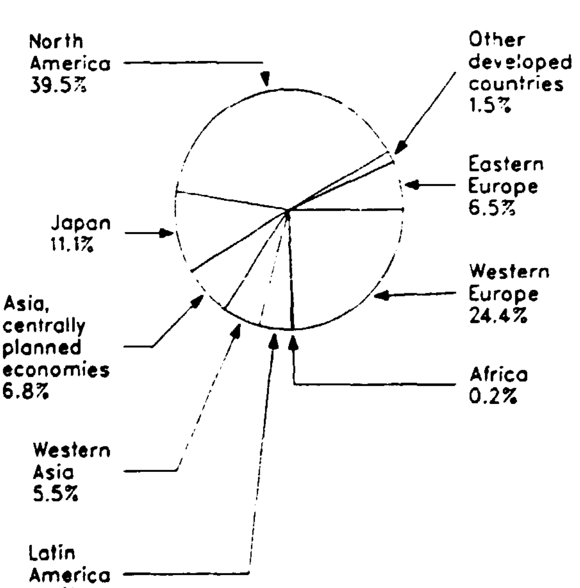
Source: Pulp and Paper International, Fact and Price Book (London, Miller Freeman Publications, 1990).

a/ Centrally planned economies.

b/ Data for China include total output of packaging paper and board, not necessarily only corrugated box material.

Figure IV.26. World production of paper and board for corrugated boxes, by region or economic grouping, 1988

Total: 60.1 million tonnes



Source Pulp and Paper International, *Fact and Price Book* (London, Miller Freeman Publications, 1990)

been about 30 per cent, and to China, about 70 per cent (mid-1989 figures). These are substantial increases, but it must be remembered that casemaking prices crashed in 1985 compared with 1984 levels. For example, comparing the end-1989 to the end-1984, instead of end-1985, export price to Europe gives a much lower increase of just 20 per cent. The United States is not only the world's largest producer, but also the biggest exporter of kraft liner.

Among the waste-based test-liner grades, which are not traded internationally as much as kraft liner, prices in the Federal Republic of Germany, a major producer and consumer, fell and then recovered over the same period, so that the net rise was only about 10 per cent. In Japan, the main domestic linerboard products, which contain about 40 per cent recycled fibre, actually declined in price by about 13 per cent. This was largely the result of production over-capacity, which outweighed substantial rises in the production of corrugated boxes.

Another major product is the corrugating medium, which is the paper that forms the central part of a brown box. It is corrugated and used to separate the inner and outer layers of linerboard. Semi-chemical corrugating medium is the best grade because it is made from virgin wood pulp, which has greater strength. In the United States, the price of semi-chemical medium increased by about 60 per cent from the end of 1985 to mid-1989. In Europe, the price of semi-chemical medium in the Federal Republic of Germany increased by about 7 per cent from mid-1986 to end-1989. By contrast, the price of waste-based corrugating medium increased by nearly 20 per cent over the same period.

All 10 of the world's largest producing countries increased output from 1985 to 1988, and probably also in 1989, primarily as a result of increased domestic and export demand. There is little or no sign of government support, with the exception of China and the USSR. Table IV.130 shows that the United States is by far the largest producer, followed by Japan and China. These countries are also the largest consumers. The relative ranking of the five largest producer and consumer countries in the South is provided in table IV.131, which shows China to be by far the largest in both categories.

The export performance of the major producing countries is reflected in table IV.132. One crucial

Table IV.130. World's 10 largest producer and consumer countries of paper and board for corrugated boxes, 1988

Rank	Country or area	Production: Thousands of tonnes	Production: Percentage share	Rank	Country or area	Consumption: Thousands of tonnes	Consumption: Percentage share
1	United States	23 354	48.2	1	United States	21 457	45.1
2	Japan	7 103	14.7	2	Japan	7 239	15.2
3	China[a]	4 370	9.0	3	China	4 866	10.2
4	USSR	3 200	6.6	4	USSR	2 710	5.7
5	Canada	1 977	4.1	5	Germany, Federal Republic of	2 575	5.4
6	France	1 967	3.9	6	France	2 278	4.8
7	Germany, Federal Republic of	1 818	3.8	7	United Kingdom	1 924	4.0
8	Sweden	1 767	3.6	8	Italy	1 601	3.4
9	Brazil	1 508	3.1	9	Canada	1 507	3.2
10	Taiwan Province	1 494	3.1	10	Taiwan Province	1 471	3.1
	TOTAL	48 462	100.0		TOTAL	47 624	100.0

Source: Pulp and Paper International, Fact and Price Book (London, Miller Freeman Publications, 1990).

a Data for China include total output for packaging paper and board, not necessarily only corrugated box materials.

Table IV.131. Five largest producer and consumer countries of paper and board for corrugated boxes in the South, 1988

Rank	Country or area	Production: Thousands of tonnes	Production: Percentage share	Rank	Country or area	Consumption: Thousands of tonnes	Consumption: Percentage share
1	China a/	4 370	46.7	1	China a/	4 866	51.5
2	Brazil	1 508	16.1	2	Taiwan Province	1 471	15.6
3	Taiwan Province	1 494	16.0	3	Republic of Korea	1 212	12.8
4	Republic of Korea	1 160	12.4	4	Brazil	1 062	11.2
5	Mexico	834	8.9	5	Mexico	835	8.9
	TOTAL	9 366	100.0		TOTAL	9 446	100.0

Source: Pulp and Paper International, Fact and Price Book (London, Miller Freeman Publications, 1990).

a/ Data for China include total output for packaging and board, not necessarily only corrugated box materials.

Table IV.132. Exports of paper and board for corrugated boxes, 1985-1988

Rank in 1988	Country	Exports 1985 (thousands of tonnes)	Exports 1988 (thousands of tonnes)	Percentage share 1985	Percentage share 1988	Percentage change 1985-1988
1	United States	1 695	2 108	31.4	30.4	24.4
2	Sweden	1 237	1 463	22.9	21.1	18.3
3	Finland	512	589	9.5	8.5	15.0
4	Canada	423	542	7.8	7.8	28.1
5	Brazil	186	446	3.4	6.4	139.8
6	Germany, Federal Republic of	386	365	7.1	5.3	-5.4
7	Netherlands	171	329	3.2	4.7	92.4
8	France	224	325	4.2	4.7	45.1
9	Austria	191	259	3.5	3.7	35.6
10	China a/	130	155	2.4	2.2	19.2
11	Norway	82	117	1.5	1.7	42.7
12	United Kingdom	56	70	1.0	1.0	25.0
13	Japan	79	68	1.5	1.0	-13.9
14	Italy	4	46	0.1	0.7	1 050.0
15	Belgium	21	45	0.4	0.6	114.3
	TOTAL	5 397	6 927	100.0	100.0	28.3

Source: Pulp and Paper International, Fact and Price Book (London, Miller Freeman Publications, 1990).

a/ 1985 estimated.

factor affecting their performance has been the instability of exchange rates, notably in Brazil, Canada, Finland, South Africa, Sweden and United States, with the greatest impact having been felt in Europe. The main trading currency for kraft liner sales is the United States dollar, and United States exports to all the major markets in Europe and Asia are traditionally paid for in that currency, which is also likely to be used by European suppliers when trading outside Europe. But within Europe, local currencies are used in most markets, including that of the Federal Republic of Germany. An important exception is the United Kingdom, where all sales from whatever supplier are currently in dollars, though there have been unsuccessful attempts by European suppliers to introduce prices in pounds sterling in the past.

Concerning the influence of exchange rates, the strength of the United States dollar in late 1985 was one reason why European suppliers moved away from selling in dollars throughout Europe to the current practice of selling mostly in local European currencies. Since then, the dollar exchange rate has brought temporary market advantages in both the United States and Europe. The United Kingdom market, where liner is sold only in dollars, complicates the Europe-wide situation even further. In recent times, the long decline in the value of the dollar against most key European currencies gave the United States the advantage, so that prices could not be increased in Europe without previous increases in the United States. European kraft liner is normally sold at a higher price than United States liner because of its higher quality. A further difference which has become more important recently is the European ability not only to meet shorter delivery times, but also to be more consistent in meeting them.

The world's largest importing countries are ranked in table IV.133. The Federal Republic of Germany is the largest importer, with the United Kingdom and France next in importance.

Table IV.133. Imports of paper and board for corrugated boxes, 1985-1988

Rank in 1988	Country	Imports 1985 (thousands of tonnes)	Imports 1988 (thousands of tonnes)	Percentage share 1985	Percentage share 1988	Percentage change 1985-1988
1	Germany, Federal Republic of	921	1 121	22.1	21.3	21.72
2	United Kingdom	711	867	17.1	16.5	21.94
3	France	562	732	13.5	13.9	30.25
4	China a/	550	651	13.2	12.4	18.35
5	Italy	412	586	9.9	11.9	42.23
6	Netherlands	286	334	6.8	6.4	16.8
7	Belgium	232	307	5.6	5.8	32.33
8	Japan	178	225	4.3	4.3	26.40
9	United States	105	207	2.5	3.9	97.14
10	Canada	38	72	0.9	1.4	89.47
11	Austria	70	60	1.7	1.1	-14.29
12	Norway	63	46	1.5	0.9	-26.98
13	Finland	22	32	0.5	0.6	45.45
14	Sweden	16	17	0.4	0.3	6.25
	TOTAL	4 166	5 257	100.0	100.0	26.19

Source: Pulp and Paper International, Fact and Price Book (London, Miller Freeman Publications, 1990).

a/ 1985 estimated.

Table IV.134. World's largest producers of paper and board for corrugated boxes in terms of sales from pulp, paper and converting operations only, 1988

Rank	Company	Country	1988 sales (millions of dollars)	Percentage share of sales	Percentage change over previous year	Net profits after tax (million of dollars)	Marginal profit consolidated sales	Percentage change over previous year
1	International Paper	United States	8 197.0	17.4	17.8	754.0	7.9	85.3
2	Stone Container	United States	3 641 0	7.7	22.6	489.9	13.1	63.3
3	Great Northern Nekoosa	United States	3 588.1	7.6	38.6	516.9	14.4	50.9
4	Weyerhaeuser	United States	3 525.0	7.5	17.7	980.0	9.8	13.8
5	Georgia-Pacific a/	United States	3 436.0	7.3	22.3	467.0	4.9	2.0
6	Honshu Paper	Japan	2 933.2	5.8	6.2	30.4	0.9	3.6
7	Svenska Cellulosa	Sweden	2 725.6	5.8	40.3	330.7	9.7	45.6
8	Daishowa Paper	Japan	2 437.9	5.2	5.8	222.7	8.5	16.9
9	Jefferson Smurfit	Ireland	2 368.8	5.0	22.4	273.5	11.0	47.7
10	Union Company	United States	2 052.3	4.4	14.5	295.1	11.1	42.3
11	Rengo	Japan	1 976.5	4.2	6.7	33.5	1.6	79.6
12	PWA	Germany, Federal Republic of	1 949.0	4.1	14.1	166.6	8.5	39.6
13	Temple-Inland	United States	1 429.1	3.0	13.7	199.2	11.2	40.9
14	La Cellulose du Pin	France	1 319.8	2.8	34.0	66.1	4.0	120.1
15	Williamette Industries	United States	1 174.7	23.4	2.5	161.1	9.4	32.8
16	Assi b/	Sweden	1 124.7	2.4	7.2	147.7	13.3	19.1
17	Reedpack	United Kingdom	1 015.3	2.2	5.6	125.6	9.1	26.8
18	Sappi	South Africa	814.3	1.7	67.5	270.6	28.9	71.1
19	Amcor	Australia	771.6	1.6	1.9	153.8	6.8	24.8
20	Klabin c/	Brazil	694.9	1.5	1 056.0	84.9	12.2	1 171.6
		TOTAL	47 174.8	100.0				

Source: Pulp and Paper International, Fact and Price Book (London, Miller Freeman Publications, 1990).

Note: Most of these companies make other paper and paper board grades and some also make pulp. But in most cases container board is a major part of their total sales of paper and paper board.

a/ Georgia-Pacific acquired Great Northern Nekoosa in early 1990.

b/ 100 per cent State ownership.

c/ The exchange rate used was that of 31 December 1988, rather than the IMF average used in other cases. This is because of the legal requirements of the accountancy system in Brazil.

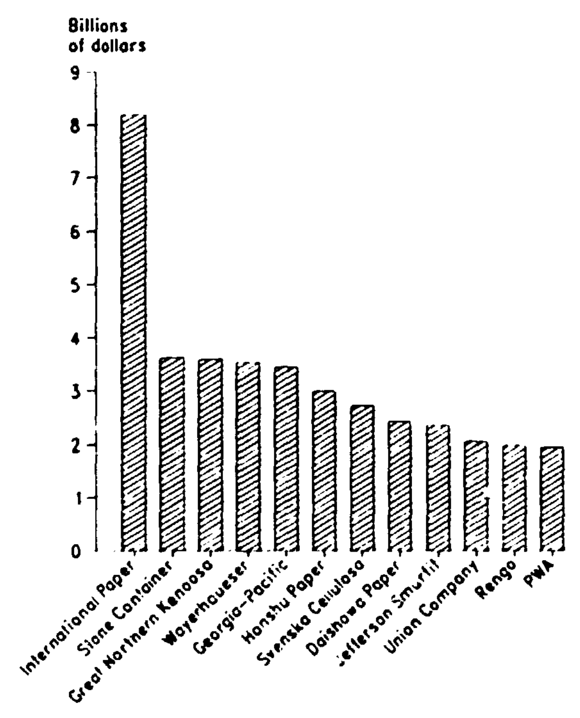
2. *Major companies at the global level*

(a) *Largest companies in the North*

As reflected in table IV.134 and figure IV.27, the main producers of paper and board for corrugated boxes increased sales and profits in 1988, thanks to effective demand with no significant over-supply. These increases probably continued for many producers in the first part of 1989, but began to decline in the fourth quarter. Many of the same companies may have lower profits in 1990. The largest United States companies not only enjoyed a healthy domestic market, but also had more export orders than they could meet. Again there are signs that both types of demands receded as 1989 progressed. So far in 1990, the growth in demand has slowed down from that of the previous year, but it is still positive, up about 5 per cent in Europe compared with 1989, and at about the same level in the United States. Unfortunately, this has not stopped the erosion of kraft liner prices in both markets in 1990.

The lower sales increase and profit margin for the three leading Japanese companies may reflect the continuing production over-capacity of the industry in Japan. The poor results from two of the big producers in Taiwan Province may be the result of large capital investment in new equipment. Unfortunately, this capacity may be coming on stream at a time when the growth in domestic demand is easing off from high levels of previous years.

Figure IV.27. World's largest producers of paper and board for corrugated boxes: sales from pulp, paper and converting operations only, 1988



Source Pulp and Paper International, *Fact and Price Book* (London, Miller Freeman Publications, 1990)

Like other parts of the paper industry, there has been a spate of mergers and acquisitions among several companies in the container board business in North America and Western Europe. This has not only reduced the number but increased the size of the largest companies, in general making them stronger and more focused. It has added to the development of a global market for container board.

A recent report by the Finnish consultant Ekono gives some of the current trends among companies in the industry. The top 10 North American producers of container board accounted for about 75 per cent of the total production of casemaking materials in 1989, whereas the corresponding figure for Western Europe is only 45 per cent. North Americans are also strongly integrated in the boxmaking business, with the top 10 accounting for some 58 per cent of total North American corrugated capacity, while their European counterparts only have about a 26 per cent share of corresponding capacity.

(b) *Largest companies in the South*

Output of container board in South-East Asia, Ekono has reported, is almost as high as in Western Europe, but the industry differs structurally from those mentioned above. The top 10 Asian container board producers, mostly Japanese companies, accounted for only about 30 per cent of total Asian output in 1989. In general, the Asian container board industry is far less concentrated and integrated into box manufacturing than its North American and European counterparts. The vast majority of container board producers are small and not integrated. In addition, working conditions are often poor and equipment is old. But the small converter is still a major factor in the booming Asian market for container board. The average size of the 10 largest companies in the South is reflected in table IV.135.

Capacity in the Asian market is rapidly expanding. There may be periods of over-capacity ahead, notably in Taiwan Province and the Republic of Korea. This also adds to the already severe shortage of the necessary fibre, both pulp and recycled waste paper and board. This is one reason why Asian and Australian companies are looking for further investment opportunities in North America and Oceania to guarantee a fibre supply.

3. *Manufacturing capacity in developing countries*

Estimates of manufacturing capacity in developing countries and areas are provided in table IV.136, together with consumption, production, exports and per capita production. The largest capacity can be found in Brazil and Mexico in Latin America and in India, Republic of Korea and Taiwan Province in Asia. These same countries and areas, however, do not display the highest per capita consumption. This difference perhaps reflects the overall manufacturing capacity of a particular country as well as the size of its population relative to that manufacturing activity. Taiwan Province thus has the largest per capita consumption at 73.9 kilograms per head, while Israel has 31.5 kilograms, Republic of Korea 28.4 kilograms, and Kuwait 25.8 kilograms per head.

4. *Capacity utilization and expansion plans*

Capacity utilization rates were very high in most countries in 1988, up from lower rates in 1980, as shown in table IV.137. The rates are surprisingly low in Japan and Italy. Table IV.138 shows that capacity utilization is highest in the South in those countries and areas which are also important manufacturers, such as Brazil and Taiwan Province. Like Japan, the Republic of Korea appears to have over-invested in casemaking capacity. As in most of the pulp, paper and paper board business, the market for container board and corrugating medium tends to suffer from periodic swings from over-capacity to under-capacity and back again. A healthy market balance leads producers to invest in new equipment, which usually means higher capacity. When this occurs at about the

Table IV.135. Largest companies of the South in terms of sales from pulp, paper and converting operations only, 1988

Rank	Company	Country or area	1988 sales (millions of dollars)	Percentage share	Percentage change over previous year	Net profits after tax (millions of dollars)	Marginal profit/ consolidated sales	Percentage change over previous year
1	Klabin a/	Brazil	694.9	26.8	1 056.0	84.9	12.2	1 171.6
2	CMPC	Chile	462.3	17.8	13.5	149.9	29.5	83.5
3	Yuen Foong Yu Paper	Taiwan Province	329.5	12.7	5.7	64.4	19.5	54.4
4	Chen Loong	Taiwan Province	276.0	10.6	-1.3	6.7	2.4	-78.7
5	Ballapur Industries	India	268.7	10.3	40.7	30.6	8.4	105.3
6	SEKA b/	Turkey	226.1	8.7	81.1	21.7	9.7	53.1
7	Venepal	Venezuela	223.2	8.6	81.7	21.7	9.7	53.1
8	Ban Yu Paper Mill	Taiwan Province	115.6	4.5	-16.0	4.5	3.9	-84.5
		TOTAL	2 596.3	100.0	1 260.8	384.4	95.3	1 357.8

Source: Pulp and Paper International, Fact and Price Book (London, Miller Freeman Publications, 1990).

Note: Most of these companies make other paper and paper board grades, and some also make pulp. But in most cases, container board is a major part of their total sales of paper and paper board.

a/ The exchange rate used was that of 31 December 1988, rather than the IMF average used in other cases. This is because of the legal requirements of the accountancy system in Brazil.

b/ 100 per cent State ownership.

Table IV.136. Casemaking-materials manufacturing capacity in developing countries, 1988

Region, country or area	Capacity ('000' of tonnes)	Capacity Percentage share	Consumption ('000' of tonnes)	Consumption Percentage share	Production ('000' of tonnes)	Production Percentage share	Exports ('000' of tonnes)	Exports Percentage share	Per capita consumption Kilogrammes	Per capita consumption Percentage share
Latin America										
Brazil	1 644	10.6	1 062	8.4	1 508	12.3	466	42.4	7.4	2.9
Mexico	1 080	7.0	835	6.6	835	6.8	57	5.2	9.8	3.9
Argentina	449	2.9	363	2.9	364	3.0	1	0.1	11.5	4.5
Chile a/	190	1.2	151	1.2	143	1.2	7	0.6	11.8	4.7
Venezuela b/	125	0.8	113	0.9	113	0.9	-	-	6.0	2.4
Colombia b/	106	0.7	89	0.7	90	0.7	1	0.1	2.9	1.1
Western Asia										
Turkey	457	2.9	356	2.8	347	2.8	59	5.4	6.6	2.6
Iran (Islamic Republic of)	232	1.5	180	1.4	65	0.5	-	-	3.4	1.3
Israel	60	0.4	140	1.1	58	0.5	-	-	31.5	12.4
Kuwait c/	17	0.1	50	0.4	16	0.1	-	-	25.8	10.2
Jordan	9	0.1	24	0.2	5	-	-	-	6.1	2.4
Africa										
South Africa d/	710	4.6	420	3.3	600	4.9	200	18.2	12.4	4.9
Zimbabwe	35	0.2	34	0.3	32	0.3	-	0.3	3.7	1.5
Algeria d/	35	0.2	60	0.5	25	0.2	-	-	2.5	1.0
Nigeria d/	50	0.3	80	0.6	25	0.2	-	-	0.8	0.3
Morocco	26	0.2	51	0.4	24	0.2	-	-	2.1	0.8
Asia e/										
Taiwan Province f/	1 575	10.1	1 471	11.7	1 494	12.2	83	7.6	73.9	29.2
Republic of Korea	1 590	10.2	1 212	9.6	1 160	9.5	-	-	28.4	11.2
India d/	1 000	6.4	850	6.7	750	6.1	-	-	1.0	0.4
Indonesia	308	2.0	191	1.5	246	2.0	66	6.0	1.1	0.4
Asia g/	5 830	37.5	4 866	38.6	4 370	35.6	155	14.1	4.4	1.7
TOTAL	15 528	100.0	12 598	100.0	12 270	100.0	1 098	100.0	253.1	100.0

Source: Pulp and Paper International, *Fact and Price Book* (London, Miller Freeman Publications, 1990).
a/ All packaging paper and board.
b/ Linerboard only.
c/ Consumption estimated.
d/ All figures estimated.
e/ Market economies.
f/ Capacity estimated.
g/ Centrally planned economies.

Table IV.137. Capacity utilization of casemaking companies in the North, 1980-1988

Region or country	Capacity 1980 (thousands of tonnes)	Capacity 1988 (thousands of tonnes)	Production 1980 (thousands of tonnes)	Production 1988 (thousands of tonnes)	Utilization rate 1980 (percentage)	Utilization rate 1988 (percentage)	Percentage change 1980-1988
North America							
Canada	1 818	2 043	1 588	1 952	87	96	10.3
United States	18 922	23 817	16 180	23 528	86	96	11.6
Western Europe a/							
Sweden	2 459	1 767	2 115	1 767	86	100	16.3
Germany, Federal Republic of b/	1 384	1 934	1 121	1 818	81	94	16.0
France b/	1 502	1 945	1 412	1 867	94	96	2.1
Italy	1 367	1 206	1 148	1 061	84	88	4.8
Spain	932	1 293	857	1 127	92	98	6.5
United Kingdom b/	1 051	1 174	883	1 127	84	96	14.3
Eastern Europe c/							
USSR d/	3 106	3 404	2 516	3 200	81	94	16.0
Yugoslavia	335	368	275	335	82	91	11.0
Poland	260	309	226	287	87	93	6.9
Czechoslovakia	196	216	184	216	94	100	6.4
Hungary	154	134	152	134	99	100	1.0
Other developed countries							
Japan e/	6 100	8 356	5 063	7 103	83	85	2.4
Australia d/	525	611	460	550	88	90	2.3
New Zealand	223	361	192	307	86	85	-1.2
South Africa d/	433	723	424	600	98	83	-15.3
Israel d/	47	60	46	58	97	96	-1.0
TOTAL f/	40 814	49 721	33 694	47 177	83	95	14.5

Source: Pulp and Paper International, *Fact and Price Book* (London, Miller Freeman Publications, 1990).
a/ 1980 capacities are based on an operating rate for the entire paper and board industry in each country.
b/ 1988 capacities are based on an operating rate for the entire paper and board industry in each country.
c/ Both capacities are based on an operating rate for the entire paper and board industry in each country.
d/ All figures estimated.
e/ Capacity estimated.
f/ 18 leading producing countries only.

Table IV.138. Capacity utilization of casemaking companies in the South, 1980-1988

Region or country	Capacity 1980 (thousands of tonnes)	Capacity 1988	Production 1980 (thousands of tonnes)	Production 1988	Utilization rate 1980 (percentage)	Utilization rate 1988	Percentage change 1980-1988
Latin America							
Brazil	884	1 644	796	1 508	90	92	2.2
Mexico	658	1 000	658	834	100	77	-23.0
Argentina	274	449	192	364	70	81	15.7
Chile[b]	26	190	24	143	90	75	-16.7
Venezuela[c/d]	155	125	112	90	72	72	0.0
Africa							
Zimbabwe[e]	15	35	14	32	93	91	-2.2
Algeria[c]	17	35	13	32	76	91	19.7
Nigeria[c]	10	50	7	35	70	50	-28.6
Morocco	22	26	20	24	91	92	1.1
Western Asia							
Turkey	125	457	99	356	79	76	-3.8
Iran (Islamic Republic of)[d]	50	232	29	65	40	28	30.0
Kuwait	-	17	-	16	-	94	-
Jordan	5	9	5	5	100	56	-44.0
Asia							
China[b]	1 332	5 830	1 239	4 370	93	75	-19.4
Taiwan Province	768	1 575	630	1 494	82	95	-15.9
Republic of Korea	659	1 590	514	1 160	78	73	-6.4
India[c]	635	850	450	750	71	88	23.9
Indonesia	64	308	54	246	85	80	-5.9
TOTAL	5 699	14 502	4 847	11 514	85	79	-7.1

Source: Pulp and Paper International, Fact and Price Book (London, Miller Freeman Publications, 1990).

a/ In most cases, capacities are derived from an operating rate of the entire paper and board industry in each country. The exceptions, those for which an operating rate of the casemaking branch only is available, are Iran (Islamic Republic of), Republic of Korea and Turkey.

b/ All packaging paper and board.

c/ Linerboard only.

d/ All figures estimated.

e/ 1980 figures estimated.

same time, a period of over-supply will occur. If this coincides with a fall in demand, there can be a severe decline in prices, with production shutting down to reduce stocks and, at worst, companies going out of business.

Regarding capacity expansion plans, table IV.139 provides the totals for committed capital investment projects scheduled to start up during the period 1990-1993 and which will result in increased production capacity for casemaking materials. Separately listed are the totals for projects in an advanced planning stage and likely to come to fruition. The figures represents the net increase in capacity that will result from investment. The possible permanent shut-down of capacity unconnected with new investment is not taken into account, although some existing and aging machines at board mills will probably shut down when new units start up.

As mentioned earlier, direct foreign investment is increasing mainly as a result of continuing mergers and acquisitions. This is making the container board market more global. However, although there is more foreign investment in the container board market, the share of foreign ownership is generally still quite limited. Most domestic markets world-wide are dominated by domestic producers, if there are any.

Direct foreign investment in the European container board industry is increasing, largely in anticipation of the planned Single Market among the member countries of the EEC. Nordic producers, particularly Swedish companies, and North Americans are seeking to establish themselves in the EEC mainly by buying producers there. This is also true for the buyers of container board, the corrugators and boxmakers. In North America, direct foreign investment is limited. The most notable example is the Jefferson Smurfit Group from Ireland, which has rapidly established itself by acquisitions in the 1980s. It is now looking for a greater market share in Europe, and is one of the few companies from the North to have acquired and operated companies in this industry in Latin America. As previously noted, direct foreign investment has also been initiated in North America by Asian and Australasian companies seeking more secure fibre supplies or wanting to produce container board, some of it for export back to the home market of the investor.

In recent years there has been little evidence of direct government involvement in the industry. Some cases of financial subsidy have occurred, and some companies are State-owned. There have been occasions, for example in Japan, when the Government has tried to organize a planned reduction of over-capacity through the closure of aging production lines. The most common involvement probably is through import taxes to protect domestic producers. For such a major traded product as linerboard there may be

Table IV.139. Casemaking materials: net capacity additions from new capital investment, 1990-1993
(Thousands of tonnes per year)

Item	Europe	North America	Latin America	Asia[a]	Australasia	Africa
Committed projects	1 000 (64.9)	420 (100)	- -	430 (80.4)	130 (46.4)	..
Planned projects	540 (35.1)	- -	240 (100)	105 (19.6)	150 (53.6)	..
TOTAL	1 540 (100.0)	420 100	240 (100)	535 (100.0)	280 (100.0)	..

Source: Pulp and Paper International.

Note: Figures within parentheses are percentage shares.

a/ Including Western Asia.

some justification for this. There have been signs that during times of weak demand, some producers in the North have attempted to export their over-capacity to the South, notably to the South-East Asian markets, bringing down prices there.

In the South, a limited domestic market is not commonly a problem for producers of casemaking materials, though it may be becoming so in Taiwan Province and in the Republic of Korea, where producers have been dependent on the growth of exports of products that need packaging. Raising sufficient capital for new investment is a problem anywhere. For some companies in the South, particularly in Asia, finding a good supply of fibrous raw material is a problem.

5. *Technological trends*

Advanced technology is widely used by the major producers of casemaking materials, North and South. CAD/CAM in the design of mills and machinery is fairly common. Most medium-size and large mills will have some level of computer control of production lines, frequently at a very high level of sophistication, with mill-wide computer process control bringing together factors such as power generation, waste treatment, the production process itself, as well as direct order input and administration.

Flexible manufacturing is becoming more widespread in the North, with the recognition that not only is consistently high quality required, but also flexibility in meeting demands that may vary from one customer to the next. This is part of the process of adaptation by the industry to being demand-driven, not supply-driven.

Biotechnology and genetic engineering are being used at the fibrous raw material end to produce quick-growing trees for pulpwood. Some Brazilian pulp producers have been at the forefront in this development.

Technology need not be a major bottle-neck for expanding production capacity, especially in developing countries. Many examples can be found there of small producers running old production lines or second-hand ones bought from the North, using locally gathered waste paper and board as the main raw material. At this level, technology is not a major problem, but for a large mill, advanced technology to produce board of consistently high quality is necessary to be competitive. This may be a problem, added to that of skilled labour, for companies aspiring to join the major league.

6. *Short- and medium-term outlook*

Prices have been adversely affected by the unfavourable short-term outlook for the producers of casemaking materials world-wide. However, this phenomenon has followed a period of record growth for the industry. While a downturn seems to have started, there are few signs that it will be long and deep. The underlying trend in the medium-term is toward a continued increase in the demand for boxes made of corrugated paper-board.

L. Leathermaking and shoemaking machinery (ISIC 3824)*

Technological changes feature computerization and automation

The world leathermaking and shoemaking machinery market has increasingly made use of more advanced technology. Most of this development has taken place in what can be viewed as the traditional European leather and footwear countries. Italy is usually considered to have about half the world business in tannery machinery. Other important producing countries are France, Federal Republic of Germany, and Spain. Other countries producing some tannery machinery include Finland, Netherlands, Switzerland and United Kingdom. In Asia, the leading tannery-machinery-producing area is Taiwan Province, although machinery is also produced in China, India, Indonesia, Japan, Republic of Korea and Thailand. There is also some production in North and South America. Sophisticated tannery machinery production is essentially restricted to Europe, with France, Federal Republic of Germany, Italy and Spain taking the lead in technological innovation. Developing countries restrict their production to simpler tannery machinery such as wooden drums and paddles, although they do emulate European designs. Some joint venture arrangements already exist between European and Indian and Chinese companies, but they are not widespread.

The older developed countries such as the United Kingdom made a major contribution in originating and developing the first leathermaking machines, but as leathermaking has migrated to Southern Europe and subsequently to Asia, the production of new leathermaking machinery has become far more diversified geographically. Some manufacture of tannery equipment remains in the United Kingdom, but today the industry is clearly dominated by Italy, which offers a wealth of competing machines. Other significant producing countries are China, France, Federal Republic of Germany and Spain, with isolated specialist producers in Australia, Finland, Netherlands, New Zealand, Switzerland and United States. Japan has a reasonably long tradition in leathermaking machinery production, but has not been a significant world contender. However, the emergence of a growing tanning industry in Asia has seen concomitantly the development of leathermaking machinery in India, Republic of Korea, Taiwan Province and Thailand. Initially, this has been based on simpler machines, often copied from models designed in developed market economies, but joint ventures are also known and provide a springboard for further development. It is highly likely that while European countries will remain the leading source of leathermaking machinery for many years to come, Asian countries will develop their own industry and at some point challenge the European countries.

Before outlining the various specific developments that have taken place in leathermaking machinery in recent years, it is appropriate to mention the general trend in development. This has been to refine existing equipment to produce the types of leather currently in

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demand by the following means: more efficiently and more productively linking them where possible; combining more than one operation in one machine; and introducing labour-saving devices such as automatic stackers and hide hoists. Additionally, growth in the production of upholstery leather has seen the development of equipment able to process whole hides rather than just first sides.

The computer has wrought a revolution in leathermaking both in the availability of fine controls on individual machines and also in process control systems that can extend from simple water batching and heating to totally integrated control making it possible to oversee much of the leathermaking process. The stage of fully automated leathermaking has not yet been reached, but considerable progress along the path has been made.

1. *Technological trends*

A few year ago it would have been relatively easy to point to evolutionary developments in shoemaking technology, indicating the main lines of progress. But this is no longer easy. There has been an explosion of developments in technology embracing shoe construction, shoemaking materials and components, plant organization and micro-computer innovation. It is also difficult to anticipate specific developments in automated shoemaking because of current shifts in the location and methods of production, the effects of emerging environmental protection legislation and unpredictable fashion changes.

(a) *Leather preparation*

The machine most clearly associated with the leather industry is the drum. This is used for a wide variety of operations from chemically removing the hair from the hide or skin to tanning, colouring, lubricating with fat-liquor and even softening the leather in an operation referred to as drumming. Although the drum looks remarkably like its forebears of a hundred years ago, it has been transformed from a simple rotating wooden barrel to a twentieth-century high-technology piece of equipment that is precision-engineered, actuated by electromechanical means, equipped with sophisticated process instrumentation, microprocessor-programmed and -controlled and even, if required, linked to individual personal computers.

Among the most important developments in wooden drums are the systems that allow rapid discharge as well as recirculation of processing liquors. This operation is often achieved through hollow axles to external compartments that enable the liquor to be screened and cleaned and its temperature, pH value and chemical strength to be monitored and adjusted. Such a development has enabled the underlying chemical parameters to be maintained at their optimum level, while design changes inside the drum have greatly improved the mechanical action between the hide and liquor. Instead of the drum being smooth-sided, it is now usually fitted with pegs that tend to stretch and draw the hides, thereby increasing the efficiency of the chemical reactions. The movement of the hides over and past the pegs as the drum rotates has been linked to a steeplechase rather than to a slalom.

It is estimated that the drum is still used to process over 90 per cent of global hide production, but alternative systems have been developed which bring a variety of benefits. Instead of being made of wood, these newer vessels are usually of stainless steel or polymer. There is the hide processor, based on the rotating cement mixer, as well as a variety of Y-compartment mixers, usually in stainless steel, which employ an arrangement of shelves to cause the hides and skins to roll as the mixer rotates. These vessels also incorporate recirculation facilities and are claimed to need less water and chemicals for a given hide load. While they provide easier loading, one stated disadvantage is their heat loss. The most recent development in tanning technology is a through-feed machine in which the skin is passed through a bath of liquor while the tanning chemicals are injected into the skin under pressure. This is still at the prototype stage, but it does open up the possibility of individual treatment of skins as well as through-feed operation.

Traditionally, the drum was loaded and its operating sequence overseen by the tan-yard supervisor. The first steps towards automation came with punched card systems some two decades ago. These controlled running and stopping times, reversing slow running and generating signals for the addition of water and chemicals, correcting temperatures and opening and closing valves. More recently, the development of the microcomputer has made possible a degree of sophistication and instant control that was impossible even a few years ago. Tailor-made computer control systems are now common, with a move towards integrated stock control of chemicals, so that system costs, production tallies and a host of other management data are readily available.

Fleshing, the operation to remove pieces of fat and flesh from the under-side of the skin or hide, has changed little over the years. Recent developments, however, involve the wider use of through-feed machines rather than return-feed machines. There has also been a move towards perfecting a pre-fleshing machine to be used with woollen sheepskins in New Zealand to remove sufficient fat and meat matter and to present a flat smooth surface to the wool-shearing machine.

One important operation in the tannery is the splitting of hides. The hide is inserted on one side of the machine and it comes out in two layers on the other. The operation is performed by a continually sharpened band-knife progressing across the width of the hide. While there has been little fundamental development, the advent of microprocessor control has permitted much easier programming and monitoring of splitting thickness as well as continuous digital read-out.

Shaving machines are at a stage of development similar to that of splitting machines. The move is again towards through-feed action and microprocessor control to bring about a much greater degree of accuracy and instant thickness change. The vibration or chatter that some shaving machines can produce and which can cause ribbing is now more clearly understood and can usually be brought under control by changing one or more of the mechanical parameters. Following the tanning operation the hide or skin is sammied, an operation designed to remove much of the surplus liquid. Originally, a wringer-type machine was employed, and such a design is still popular in North America. But there is a move toward through-feed machines together with greater sophistication in spreading the leather to avoid pleats as it is passed under the rollers.

One of the most important operations in leathermaking is that of drying after sammying and setting to dispose of the free and combined water still in the leather. The need is to dry as slowly yet as efficiently as possible, while ensuring that the leather remains soft and flexible. Natural air drying is traditionally considered the best method, but for the modern factory, air-flow drying in one of its varied forms has become the generally preferred method. One refinement of recent years has been the so-called dehumidification drying concept developed in France, which embraces a closed-circuit energy recovery system using heat pumps. This combines precise control of drying conditions with thermal energy savings.

Other approaches to drying include the use of infrared radiation, high frequency bombardment or microwave energy. The latter method is the most recent entrant into the field. The concept is extremely attractive because the water can, in theory, be evaporated off without raising the temperature of the leather, thus retaining its inherent characteristics of softness. Models introduced in 1989 are of through-feed design, but they have yet to make an impact in the tannery. In contrast, the vacuum-drying principle by which leathers are slicked and subjected to a vacuum process between heated plates has proven to be immensely popular in Europe. Multi-table machines that go up to five levels are common, and mechanical devices to slick out the leather have started making their appearance.

It is common, when drying leathers, to toggle or to stretch them to prevent any loss of area. Originally a manual operation, toggling machines have become increasingly sophisticated to reduce labour inputs. This has generally led towards a horizontal-conveyor toggling approach, although a horizontal-membrane stretch concept has been introduced more recently. In the membrane stretch design the leathers are placed on a membrane and another membrane is brought into close contact from above. The membranes are then stretched outwards, taking the leather with them as heat is applied to dry off excess moisture.

It is probably true that most leather is still given its finish, colour and protective coatings using a spray machine. A variety of configurations have been developed to achieve the most even deposition of finish, and devices to shut off the delivery of finish, when there is no leather underneath, are commonplace. However, it is usual for such machines to use solvent finishes, and in the environment-conscious world of the 1990s the leathermaking industry is exploring other finishing possibilities that are efficient in their use of chemicals, yet safe and effective. Roll-coating, which is rather like a conventional printing operation, is one such increasingly popular alternative, not least because it can deposit in one pass the same thickness as three or four passes on a spraying machine. Water-based finishes obviate the fire and health risks posed by solvent finishes. Roll-coating will probably continue to make inroads into conventional finishing techniques.

The final tannery operation before dispatching the leather is to measure its surface. Area measurement is a perennial source of disagreement between the tanner and his customer. A pin-wheel measuring machine, a design that is decades old, is considered the most accurate type ever devised, and is often used as the arbiter in case of disputes. But the past decade has seen the development of electronic systems in which the leather is automatically measured as it is passed under a bridge, in whatever units are required, the pieces being counted piece by piece, with total area based on a predetermined programme. Both through-feed and return-feed designs are available and can often lead to rolling, batching and bundling devices, again to a preselected programme.

Hides and skins are heavy and unwieldy items which are usually processed through the tannery in a batch. One of the most useful developments in recent years, has been the automatic staking machine which can be fitted at the outlet of virtually any production machine to collect and batch (in the chosen configuration of flesh to flesh or flesh to grain) the required number of hides or skins for progression to the next operation. It is a device that has contributed considerably to efficiency in the leathermaking process.

(b) *Basic shoemaking techniques*

The traditional material for making shoes is leather, and the early machines employed mechanical methods of cutting, slicing, shaping and assembling jobs previously carried out by hand. Traditional shoemaking, which is distinctive through its complexity and emphasis on treating each shoe as an individual item, still exists, but it is a specialized craft and has been largely superseded by newer, mass production arrangements. These employ simpler construction methods, new shoemaking materials and new technology.

A major new trend in shoemaking is to employ assembly operations utilizing pre-produced components. The use of automated machinery is increasing, as is the use of pick-and-place robots and linking mechanisms. This places a new emphasis on consistently accurate materials, proportions, measurements and components. However, the technology of shoemaking still involves having a stack of foot-shaped formers, the last, over which the upper is draped and constructed and to which the sole is joined. Traditionally this operation was done by stitching through a welt, a strip of leather sewn around the periphery of the upper, although nails and screws were not uncommon for additional security.

One of the first major developments in shoemaking machinery was occasioned through the move from a stitched sole to an injected-on or stuck-on sole. In the former the shoe upper is placed on a metal last on a carousel machine and the polymer sole is squirted into a split-mould cavity where it solidifies before the complete shoe is ejected. This type of construction is ideal for large-scale production and has resulted in the emergence of high-production machines capable of producing solings in a variety of polymers and colours and in different material densities for different functional needs.

The stuck-on technology requires that a unit sole be pressed on to the upper, but this operation has not been significantly developed. However, automated roughing and cementing machines and operations have emerged. To ensure a good mechanical board to the shoe upper, it is often required to rough the lasted margin; that is, the part of the upper to which the sole will be bonded. This operation is now totally automated, and the latest development is machines that can rough shoe styles and which have a sole that folds around the upper sidewall roughers.

One of the most complex shoemaking operations mentioned above is lasting. Here, a flexible, two-dimensional material, the shoe upper, is converted into a semi-rigid three-dimensional shape. This has long been a mechanical operation, but recent developments have seen an increasing degree of sophistication, so that precise draughting forces can be exerted for the shoe being lasted. Computer control has made it possible for machines to recognize whether it is a left or right shoe being lasted, and for shoe recognition data to be transmitted from one lasting machine (the forepart laster) to another (the seat and side laster). In essence, the skilled manual intervention of the operator has been progressively diminished to the point where an unskilled operator can undertake the work.

The other area of shoemaking technology where considerable technological development has occurred is in stitching work. From the days when an operator held various upper components together and stitched them into a whole, sewing-machines have developed to the point where a variety of sewing-machine designs are available and can undertake a variety of related operations as well as specific tasks. As an example, sewing-machines can automatically back-tack, cut off thread, simultaneously sew two rows of thread and change the density of sewing, if required. A considerable amount of shoemaking upper assembly is carried out on sewing-machines in which the upper component, functional and decorative, is held together in a template and placed under a sewing head, where a pre-programmed stitch path is followed. This is a well-established technology, but developments have appeared recently, making it possible to input stitching data direct from computer-held design data.

Another shoemaking operation that is also being directly affected by advances in microprocessor technology is cutting. Traditionally, upper materials were cut or "clicked" by hand. Swing beam presses were subsequently introduced, later to be complemented by travelling head presses in which layers of material were fed on a conveyor under a cutting head moving across the direction of travel. The latest development is for the computer to decide the nesting of the components to achieve maximum materials utilization and then to proceed to cut out the components automatically. Related to this operation is the cutting of leather. Being a natural material from a living animal, full-grain leather often has surface disfigurations and imperfections. These can easily be avoided when uppers are cut out by hand, but the solution has proved somewhat intractable when translated into a machine operation. Current attempts to solve the problem involve identifying the surface imperfections and then nesting upper components towards a representation of the leather on a screen. When the nesting is complete, it is "locked" into the computer, and cutting can take place automatically with no further manual intervention. Such machines were introduced into commercial production in 1989.

(c) *Moving the shoe assembly*

Over the past two decades, mechanized shoemaking has been organized on a track system in which the progressively assembled shoes are carried around on pegs and lifted from the track by operatives to perform the next operation. This is a logical system combining a fair degree of flexibility in production and construction methods with reasonable throughput, but demanding a good long run of particular styles to justify the established set-up. In order to improve productivity and to shorten the work, a "rink" system has been devised in which the shoemaking machines, for instance, from insole attaching to the last through to sole pressing, are arranged in a horseshoe. Instead of an operator being assigned to a specific operation, the throughput of the rink is the responsibility of the team that undertakes a variety of tasks around the rink, as required. The team also inspects its own work.

The success of the rink in shoemaking has been prodigious. It is not unusual for productivity, measured as shoe output per operator, to jump by at least 20 per cent. Rejects have been virtually eliminated and higher quality in production is achieved, all within a far smaller floor area. The rink owes virtually nothing to new shoemaking technology, being more a direct function of the standard methodology of production. More recently, even further developments have been spawned to make the rink more efficient. These include coolers to lower the temperature of the last quickly (so that they can be returned promptly into production) and also compact, high-rise dryers to maintain throughput without taking up more floor space.

(d) *Computer-aided design*

The most far-reaching development in shoemaking without a shadow of doubt is CAD; it has the potential to form the basis of a revolution that will inevitably lead to fully automated production. The work started in earnest during the 1970s, when efforts were expended on mathematically mapping the contour of a last, a highly involved and complex operation. This was followed by the development of micro-computers and laser and water-jet cutters, which lend themselves to microprocessor control. Finally, there arose the need for shoe manufacturers to respond more rapidly than ever to new fashion trends.

When all these possibilities and motivations were pressed upon shoe manufacturers, CAD was born. Its most popular application to date has been to provide a technology for engineering shoe patterns for a full range of shoe sizes. Briefly, it is now possible to design a shoe, if required, on the computer screen, and thus to draw up the components which can then be produced instantly for the full size range by means of a laser, water-jet or reciprocating blade cutter. Pattern engineering along these lines is now common practice in Europe, North America and elsewhere. Companies are beginning to explore the possibilities of designing shoes on the screen in three dimensions, changing heel heights, toe shapes and the colour and texture of the upper materials at the touch of a button.

The latest development in this technology is for the computer-generated data on stitching lines to be directly downloaded from the CAD station to the production machines on the shop floor. Such developments are still rare, but there are examples of applications in Mexico, Republic of Korea and United Kingdom. The use of the technique is bound to grow simply because of the few hours with which it now becomes possible to move from the design to the production stage. Previously, this part of the production process could easily have taken months. Some manufacturers are also using the pattern engineering technology to produce shoe components for the small-volume ends of the shoe size range. It provides a fast and convenient way of making small quantities of shoes without affecting mainstream production.

These steps are leading to computer-integrated manufacture (CIM), the consequences of which are immense. Using the established global telecommunications network, it is now possible to design shoes in Paris, to produce the patterns and samples in Milan, and to have the footwear produced in East Asia. All of this can be done within hours and days using data generated at the design stage and fed, where required, throughout the world. It would seem that the next stage of development is for shoemaking machinery to be tailored in harmony with this new technology rather than for shoemaking machinery to be further developed in isolation of the opportunities offered by the combination of CAD and CIM.

(e) *Environmental considerations*

A newer pressure being experienced by the leathermaking industry is that of environmental protection. This has been felt traditionally in developed countries, where effluent discharge regulations are increasingly severe, but the pressure is now spilling over into developing countries and NICs. Additionally, environmental protection is being extended to embrace solvent discharge, and this is having an impact on various leathermaking operations. A prime example is the roller-coating machine, which can easily use low-solvent and no-solvent finishes, giving it an edge over finishes used in a conventional spraying machine. Ultraviolet curing of leather finishes where no solvent is employed provides a related example of how technology and hence leathermaking machinery may be influenced by environmental legislation.

2. *Shoemaking machinery in Italy*

Italy is without doubt the leading producer of both shoemaking and leathermaking machinery. The production of such machinery dates back to the beginning of the twentieth century for tannery equipment, but the major phase of growth occurred after the Second World War and has continued into the 1990s. The tanning machinery branch consists of around 55 companies employing 1,800 people and generating an annual turnover of $240.3 million in 1989 (provisional) and a forecast turnover of $275.3 million in 1990. About 70 per cent of production is for export to such important markets as China, Spain, USSR and Venezuela. In 1988, the EEC purchased Italian leathermaking machinery to the value of $31.3 million, while Asia bought equipment worth nearly $40.8 million and Central and South America nearly $15.3 million. The distribution of Italian leathermaking machinery exports in 1989 is given in table IV.140. The majority of tanning machinery manufacturers are members of the Association of Tanning Machinery Constructors (CIMACO) based in Milan. Their role is to promote, in collaboration with the National Institute for Foreign Trade, the activities of associated industries on world markets through exhibitions, market surveys, trade missions and conferences.

ASSOMAC, the Italian shoemaking machinery manufacturers association, estimates that Italy produces shoemaking and leathermaking machinery (there is no breakdown between the two categories) to the value of $728.3 million annually. On the basis of tannery machinery production estimates obtained from CIMACO, shoemaking machinery production in Italy is worth around $473.4 million annually. ASSOMAC estimates that Italy has around 60 per cent of the global market for shoemaking machinery, worth approximately $801.2 million. The Italian figures exclude sales of injection moulding machinery, which are substantial, but include spare parts. As shown in table IV.141, the main Italian markets are France, Federal Republic of Germany, Japan, Portugal, Spain, United States and USSR. In 1988 the USSR took plant to the value of $145.7 million, including tannery machinery.

Table IV.140. Export distribution of Italian-made machines and equipment for the preparation and working of leather, hides and furs, 1989

Importing country or area	Equipment costs (thousands of dollars)	Percentage share 1989	Percentage change 1988-1989
USSR	32 432	29.0	134.4
Spain	7 981	7.1	-44.3
Brazil	5 298	4.7	347.8
Republic of Korea	5 127	4.6	56.4
Germany, Federal Republic of	4 676	4.2	81.0
United States	4 463	4.0	10.5
Bulgaria	4 172	3.7	999.9
Japan	4 087	3.7	83.7
Mexico	4 062	3.6	122.3
China	3 984	3.1	-72.9
France	3 492	3.1	30.9
Nicaragua	3 427	2.6	999.9
Portugal	2 925	2.6	-36.7
Hong Kong	2 892	2.6	-31.3
Egypt	2 892	2.4	667.1
Yugoslavia	2 693	2.4	71.1
India	2 629	2.3	-27.6
Indonesia	2 539	2.2	74.3
United Kingdom	2 405	1.9	33.5
Netherlands	2 144	1.7	-11.8
Thailand	1 939	1.5	36.4
Argentina	1 714	1.2	6.1
Pakistan	1 353	1.1	-34.4
Taiwan Province	1 271	1.1	-60.6
Venezuela	1 186	1.1	-87.2
TOTAL	111 783	100.0	

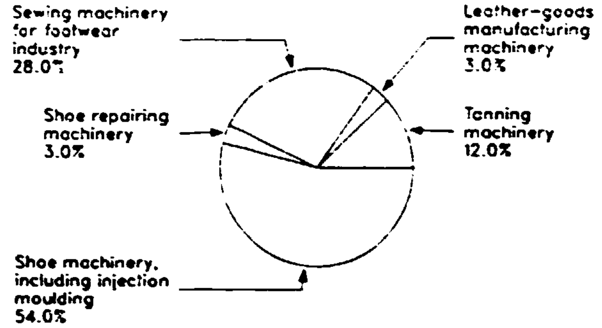
Source: Association of Tanning Machinery Constructors (Milan).

Table IV.141. Export distribution of Italian-made machines and equipment for footwear manufacture and repairs, 1989

Importing country or area	Equipment costs (thousands of dollars)	Percentage share 1989	Percentage change 1988-1989
USSR	52 227	33.6	372.3
Portugal	13 171	8.5	26.6
United States	8 414	5.4	14.8
Spain	7 964	5.1	9.6
Japan	7 715	5.0	-10.9
France	7 158	4.6	37.7
Germany, Federal Republic of	6 567	4.2	54.2
Hong Kong	5 586	3.6	4.2
Mexico	5 391	3.5	182.7
United Kingdom	4 758	3.1	-9.0
Thailand	4 512	2.9	94.4
India	4 301	2.8	-42.0
China	3 468	2.2	-10.8
South Africa	2 376	1.5	7.3
Indonesia	2 720	1.7	130.0
Greece	2 671	1.7	-16.3
Singapore	2 224	1.4	170.1
Venezuela	2 049	1.3	72.5
Yugoslavia	1 993	1.3	-1.5
Brazil	1 975	1.3	232.5
North Yemen	1 817	1.2	307.7
Colombia	1 731	1.1	120.2
Australia	1 481	1.0	6.3
Switzerland	1 662	1.1	7.0
Turkey	1 377	0.9	-6.4
TOTAL	155 308	100.0	

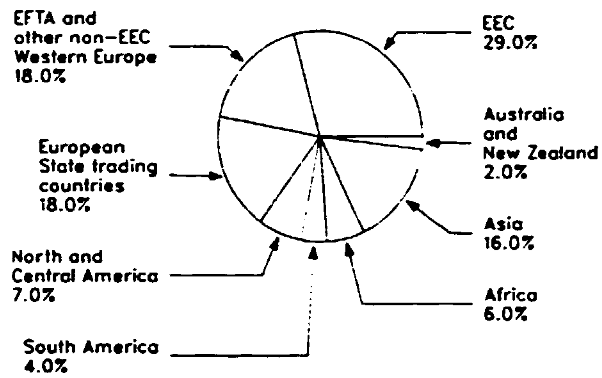
Source: Association of Tanning Machinery Constructors (Milan).

Figure IV.28. Leathermaking and shoemaking machinery sales in the Federal Republic of Germany, 1988



Source: German Machinery and Plant Manufacturers Association

Figure IV.29. Exports of leathermaking and shoemaking machinery by the Federal Republic of Germany: country shares based on 1987-1990 averages



Source: German Machinery and Plant Manufacturers Association

3. *Shoemaking in the Federal Republic of Germany*

The second most important shoemaking machinery producer is the Federal Republic of Germany, with an estimated production (including injection moulding equipment) of approximately $242 million. The Federal Republic of Germany has a major shoemaking and leathermaking machinery industry represented by its own association, the German Association of Shoe and Leather Machinery Manufactures, which is a division of the German Machinery and Plant Manufacturers Association. The shoe and leather machinery manufacturers association includes 28 companies, and the country's annual production of shoemaking and leathermaking machinery is valued at approximately $245 million. Of the total leathermaking machinery produced, as reflected in figure IV.28, injection moulding equipment accounts for 54 per cent, footwear sewing-machines for 28 per cent, tanning machinery for 12 per cent, and leather-goods manufacturing machinery and shoe repair machinery for 3 per cent each. As shown in figure IV.29, approximately 95 per cent of output is exported to 110 countries. About 29 per cent is sold within the EEC; 18 per cent goes to EFTA and other Western European countries; 18 per cent is sent to European countries with State trading organizations; and 16 per cent goes to Asia. North and Central America take 7 per cent, Africa 6 per cent, and South America 4 per cent.

4. *Markets for leathermaking machinery*

(a) *Production and consumption*

The production of leather is essentially stable because of the limited availability of raw material, and this, in turn, restricts the demand for new leathermaking machinery. The trend is for the high-labour-cost countries to invest in high-productivity equipment that achieves high quality without excessive demands on the work-force. One type of this sophisticated control equipment can undertake all the routine operations, from adding water to drums, to checking and adjusting liquor temperature and pH, revolving drums, and stopping the cycle when the production sequence is finished. Such equipment, produced mainly in Switzerland and to a lesser extent in the United Kingdom, is selling well around the world.

The total value of the leathermaking machinery business is expected to be of the order of $582.7 million in 1990, on the assumption that the Italian industry has about half the world-wide business. With the continuing move of leathermaking to Asia, demand from Asia should remain on the increase, although the highly sophisticated leathermaking industry in Europe will continue to purchase the most expensive machinery.

The opening-up of Eastern Europe will also, it is anticipated, generate a more sophisticated leathermaking industry in such countries as Czechoslovakia, Poland, USSR and Yugoslavia, and in the territory of the former German Democratic Republic after unification of the two German States, each in its turn engendering higher demand. Major countries and areas in Asia include China, Hong Kong, India, Indonesia and Pakistan. Estimates of the level of new tanning machinery exports are given in table IV.142. Among individual countries, China is the largest exporter, followed by Spain and Venezuela. At the regional level China is also the principal exporter with Central and South America second.

Table IV.142. Tanning machinery exports in 1988

Rank	Exporting region, area or economic grouping	Exports (millions of dollars)	Percentage share
1	China	15.5	11.6
2	Spain	15.1	11.4
3	USSR	14.6	14.0
4	Venezuela	9.7	7.3
5	Portugal	4.9	3.7
6	Hong Kong	4.4	3.3
7	United States	4.3	3.2
8	India	3.8	2.9
9	France	2.8	2.1
10	Germany, Federal Republic of	2.7	2.0
	Asia	42.9	32.3
	EEC	33.5	25.2
	Other Europe	28.1	21.1
	Central and South America	16.0	12.0
	North America	6.2	4.7
	Africa	5.3	4.0
	Oceania	0.9	0.7
	Others	0.2	0.2
	TOTAL	132.9	100.0

Source: Association of Tanning Machinery Constructors (Milan).

A significant feature of international trade in leathermaking machinery is for redundant machinery from tanneries that have closed down in Europe and the Americas to be rented and shipped to developing countries. Such machinery sells at about half the price of equivalent new machinery. Developing countries are not likely to invest in such sophisticated equipment as their European counterparts because: first, they do not have the same urgent need to automate their operations; secondly, they often lack the resources to maintain the machinery in peak condition; and thirdly, such equipment is very expensive and its price cannot always be justified.

(b) *Industry outlook*

There is a move towards a concentration of independent leathermaking machinery companies, particularly in Italy where at least one major group has been forming. This move will contribute towards higher investment in research and development for machinery design and construction, although it will most probably result in less choice for the buyer. Research associations in Europe, principally in France, Federal Republic of Germany, Italy and United Kingdom have made a major contribution towards leathermaking machinery developments by being in a position to assess ideas advanced by the machinery manufacturers. For example, microwave drying of leather has been described by the Tanners School at Reutlingen as an "instant" tanning method. In a similar vein, CSIRO in Australia has contributed significantly to leathermaking machinery development, working closely with an Italian drum manufacturer to assess and develop new hide unhairing processes.

Future prospects for the machinery industry are satisfactory. The constraint on raw material supplies will always restrict leathermaking production, and recent additional restrictions on growth include the "green" movement, which makes leathermaking increasingly difficult in regions such as Europe, as well as animal rights protestors who could well come to regard leather as an unacceptable material, if they feel that animal welfare is not being given a high enough priority.

5. *Markets for shoemaking machinery*

(a) *Production and consumption*

World footwear output was estimated at 9,705 million pairs in 1987, and is projected to increase to 11,362 million pairs by the year 2000. Over half this production (51 per cent) is manufactured in Asia, including Western Asia, followed by Eastern Europe (18 per cent), Western Europe (12.5 per cent), South America (9 per cent) and North and Central America (6.5 per cent). As the trend is towards mechanized production of footwear, these percentage shares of global production can be considered a rough guide to where the market is for shoemaking machinery. However, the picture is seriously distorted by the considerable quantity of shoemaking machinery produced in Asia by local manufacturers but not appearing in the statistics. In addition, Brazil, for instance, prohibits a considerable amount of imports; thus shipments of such machinery are sometimes not recorded.

Global production of shoemaking machinery has an estimated value of $80.1 million, of which Italy is reckoned to account for a 60 per cent share. The other major shoemaking machinery country is the Federal Republic of Germany, with an approximately 25-30 per cent share. The United Kingdom probably accounts for about 15 per cent. An annual investment of 2 per cent of turnover is considered, by some observers, as a reasonable estimate of what shoemaking companies spend annually on new shoemaking plant and equipment.

There is a continuing move of shoemaking around the world as it gravitates to the lowest-labour-cost countries and areas with an adequate infrastructure for the production of and international trade in shoes. Thus, in the Republic of Korea and Taiwan Province there is a move towards higher-value net production (also a way of circumventing import restrictions to developed market economies on the basis of pairage), while new shoemaking plants are rapidly opening up in China, Indonesia and Thailand.

(b) *Industry outlook*

Current shoemaking trends plus the expanding market for footwear and new shoemaking technology means that there is generally growing and buoyant demand for new shoemaking machinery. The higher-labour-cost countries tend to invest in the most sophisticated equipment, but with the need to respond quickly to this challenge, producers in Eastern Europe and Asia are considering the purchase of such equipment. This trend applies equally to CAD, which can translate new shoe designs into production in a matter of hours.

The general outlook for the shoemaking machinery industry is good. Shoemaking operations will become increasingly de-skilled, with a continuing shift towards automated production. Western Europe and the United States are expected to remain the leaders in the design and production of new shoemaking machinery in the short to medium term, simply because computer technology is featured so prominently in the equation. The markets for the equipment, however, will be increasingly found in the main shoemaking countries in Asia.

M. Soft drinks (ISIC 3134)

Recent changes in brand sales and ownership patterns

There is no internationally agreed definition of the term soft drinks and methods of data computation in the industry are not uniform. It is therefore difficult to make direct comparisons between soft-drinks industries in different countries. In the United States, for instance, the term soft drinks refers to carbonated drinks only, while in Europe it includes all kinds of water, juices and other non-alcoholic drinks containing sugar and flavouring substances. Where possible, consistent definitions are applied in the present review.

For soft-drinks sales world-wide, the 1980s have been a decade of unparalleled growth which is only now beginning to slow down or decline sharply in some places. From established markets in the United States, the home of Coca-Cola and Pepsi-Cola and Western Europe, demand has spread to the former centrally planned economies of Eastern Europe and the USSR and to developing countries, where the easy availability of soft drinks is seen as one of the keys to, and a sign of, increasing prosperity.

1. *Production and consumption*

Table IV.143 provides global soft-drinks production figures. Production rose from 46.5 billion litres in 1980 to 55.3 billion litres in 1987. The 1987 level marked a 3.4 per cent increase over that of 1986. Geographically, the soft-drinks industry of Western Europe remained the largest producer with approximately 21 and 21.4 billion litres (or 16.2 and 16.4 billion litres for the EEC) in 1986 and 1987, respectively, thus accounting for about 39.3 and 38.7 per cent of total world production. While Asia ranked second in 1987, with about 14.8 million litres of soft drinks, it is worth noting that Africa experienced a remarkable production increase of 70.8 per cent during the period 1980-1987.

Table IV.143. World production of soft drinks, 1980-1987

Region, country, or economic grouping	Production (billions of litres) 1980	1986	1987	Percentage share 1980	1986	1987	Percentage change 1986-1987	1980-1987
Africa	2.4	3.8	4.1	5.2	7.1	7.4	7.9	70.8
America								
North	7.6	7.4	7.9	16.3	13.8	14.3	6.8	3.9
South	5.9	7.1	7.1	12.7	13.1	12.8	1.4	20.3
Asia	6.8	8.0	8.1	14.6	15.0	14.6	1.2	20.6
Europe	19.3	21.0	21.4	41.5	39.3	38.7	1.9	10.9
EEC	15.3	16.2	16.4	32.9	30.3	29.7	1.2	16.0
EFTA	1.1	1.4	1.5	2.4	2.6	2.7	7.1	50.0
Eastern Europe	2.5	2.9	2.9	5.4	5.4	5.2	-	30.0
Other Europe	0.4	0.5	0.6	6.9	0.9	1.1	20.0	7.2
USSR	3.5	5.0	5.3	7.5	9.3	9.6	6.0	36.4
Oceania	1.0	1.3	1.3	2.2	2.4	2.4	-	51.4
TOTAL	46.5	53.5	55.3	100.0	100.0	100.0	3.4	18.9

Source: Industrial Statistics Yearbook 1986 (United Nations publication, Sales No. E/F.89.XVII.15), vol.2.

Because of the difficulty of obtaining data on international soft-drinks production and consumption, the approach taken here is to generate an impression of major market movements by examining available data for a few countries. An additional problem of differentiating between soft-drinks production, consumption, sales and shipments exists. Thus, information on any one of these variables in one country or a group of countries is used as a measure of industry or market activity.

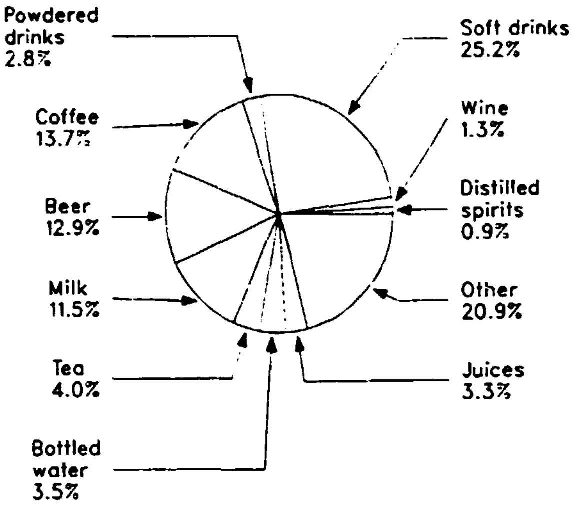
Table IV.144 shows 1987 comparative consumption patterns for various drinks in selected countries. In most countries, soft drink ranks second to beer in per capita consumption. Per capita consumption of soft drinks is highest in the United States and Australia. Figure IV.30 shows the market share for soft drinks and other beverages in the United States.

Table IV.144. Beverage consumption in selected countries and areas, 1987
(litres per capita)

Country	Beer	Wine	All spirits	Soft drinks
Australia	114.0	21.2	1.3	75.0
Brazil	12.2	23.0	10.0	33.0
Canada	80.0	7.4	2.7	70.0
Hong Kong	20.0	1.0	7.1	41.0
Indonesia	0.7	0.3	0.2	0.7
Japan	40.0	0.8	2.6	65.5
Philippines	15.3	-	2.6	16.0
Republic of Korea	19.0	-	-	10.0
Singapore	22.5	1.7	5.6	62.0
Taiwan Province	33.0	-	-	43.0
Thailand	3.4	-	-	8.9
United States	97.5	9.0	2.7	75.1
Venezuela	58.3	1.9	2.1	47.0
Zimbabwe	15.2	-	-	3.7

Source: International Marketing Data and Statistics 1990 (London, Euromonitor Publications, 1990).

Figure IV.30. Market shares for soft drinks and other beverages in the United States, 1988



Source: Beverage Industry, February 1989.

In the United States, carbonated drinks and bottled water were the main gainers in 1988 (the latest year for which figures are available), with per capita consumption up 4.1 per cent to 173.3 litres and 12.2 per cent to 24.2 litres, respectively. As shown in table IV.145, the per capita consumption of soft drinks and other beverages rose from 415 litres per capita in 1966 to 530 litres in 1986.

The market share held by soft drinks relative to other beverages is given in table IV.146. The soft-drinks market share increased from 19.5 per cent in 1982 to 25.2 per cent in 1988. The share of bottled water increased from 1.8 per cent in 1982 to 3.5 per cent in 1988.

Overall, 1988 beverage consumption in the United States continued to follow the pattern of the decade. Twenty years ago, carbonated drink consumption stood at 94.3 litres per capita behind milk at 96.9 litres, coffee at 140 litres and tap water at 242.3 litres. In the last decade alone, carbonated products have seen an annual growth of 3.7 per cent, spurred on by the growth of colas and diet drinks.

The introduction of new products appeared to be of less significance. The main new product entry in 1988 in the United States was a ginger ale-like version of a leading lemon-lime drink, which failed to make any significant impact. Even the popular and fairly new cherry-flavoured drink segment appeared to stumble in 1988, suggesting that it was a passing fad. Juice-added soft drinks also did badly in 1988, losing market share.

Fruit juices as a product have not been as popular in the United States as in Western Europe, perhaps solely because of the high consumption of carbonated drinks. They have a "mornings-only" image, and since peaking at 29.5 litres per capita in 1983, juice consumption has declined by 27.9 per cent. Moreover, for the third time in the decade, the Florida citrus crop was badly hit by frost in December 1989, slashing the anticipated juice yield. Nevertheless, Florida still accounts for 70 per cent of the citrus juice produced in the United States. Ironically, Brazil was anticipating a bumper crop, but with so much already committed to Europe, it was doubtful whether Brazil would be able to fill the United States shortfall.

Bottled water has been one of the successes of the decade in the United States, with an average annual growth rate of 11.1 per cent. Largely the result of successful marketing campaigns, all segments, from flavoured seltzers (mineral water) and effervescent water to imported pure mountain spring water, have become increasingly popular. Originally, consumers bought it as a replacement for tap water, but it is now being used as a drink in its own right. In the United States it also fits in with the trend toward a more healthy diet. In Europe, bottled water has likewise shown massive increases, partly arising from increasing

Table IV.146. Comparative market shares for soft drinks and other beverages in the United States, 1982-1988
(Percentage)

Beverage	1982	1987	1988	Change in share 1987-1988	Change in share 1982-1988
Soft drink	19.5	24.2	25.2	1.0	5.7
Coffee[a]/	14.6	13.9	13.7	-0.9	-0.9
Beer	13.4	13.1	12.9	-0.2	-0.5
Milk	11.0	11.3	11.5	0.2	0.5
Tea[a]/	4.1	4.0	4.0	0.0	-0.1
Bottled water	1.8	3.1	3.5	0.4	1.7
Juices	3.7	3.4	3.3	-0.1	-0.4
Powdered drinks	3.3	3.0	2.8	-0.2	-0.5
Wine[b]/	1.2	1.3	1.3	0.0	0.1
Distilled spirits	1.0	0.9	0.9	0.0	-0.1
Total	73.6	76.2	79.1	2.9	5.5
Imputed tap water consumption[c]/	26.4	21.8	20.9	-4.1	-5.5
TOTAL	100.0	100.0	100.0		

Source: Beverage Industry, February 1989.
a/ Coffee and tea data are based on a three-year moving average.
b/ Including wine coolers beginning in 1984.
c/ Including all other beverages.

Table IV.145. Per capita consumption of soft drinks and other beverages in the United States, 1966-1986
(litres per person)

Beverage	1966	1970	1975	1980	1985	1986
Soft drinks	72.2	85.8	99.6	129.3	154.2	159.1
Coffee[a]/	141.4	134.9	124.7	103.6	97.5	95.6
Beer	62.4	69.9	81.6	91.9	90.0	90.7
Milk	90.7	87.3	85.1	78.6	76.4	77.5
Tea[a]/	15.1	19.7	27.6	27.6	27.6	27.6
Bottled water	-	-	4.5	10.2	17.0	18.9
Juices	23.8	24.6	25.7	26.1	23.4	23.1
Powdered drinks	-	-	18.1	22.7	23.4	22.3
Wine[b]/	3.8	4.9	6.4	7.9	9.1	9.1
Distilled spirits	5.7	6.8	7.6	7.6	6.8	6.4
TOTAL	415.4	433.9	480.9	505.0	525.4	530.3

Source: Beverage Industry, February 1989.
a/ Coffee and tea data are based on a three-year moving average to counter balance inventory swings, thereby portraying consumption more realistically.
b/ Including wine coolers beginning in 1984.

concern about the pollution of local water supplies. However, the recent discovery of small quantities of benzene in one of the market leaders, Perrier, in the United States (and subsequently other countries as well) led to a mass temporary withdrawal of this brand from the market, and may result in a downturn in the market as a whole.

According to estimates by the Commission of the European Communities, in 1986 total soft-drinks production in the EEC was nearly 15 billion litres. Looking at Western Europe as a whole (the EEC plus Scandinavia, Austria and Switzerland), however, four major types of soft drink (carbonates, still, juice and water) rose by an average of 4 to 5 per cent between 1983 and 1988, giving an overall increase of 26 per cent. The Federal Republic of Germany is the largest consumer of soft drinks in Europe on a per capita basis (78 litres in 1986), compared with 68 for Belgium and 60 for the Netherlands. Portugal was one of the lowest at 24 litres per capita.

In the United Kingdom, the market for carbonates and concentrates (used in the production of a still drink by the consumer) expanded by 10 per cent in the three years up to 1989, reaching a market value of £3.4 billion in 1989. Although some of this growth is attributed to new product launches, it is the brand leaders that have considerably increased their sales. Low-calorie products have been a major growth area in both carbonates and concentrates, and 1989 saw the launch of caffeine-free diet coke, the first national caffeine-free cola brand. In fact, colas dominate the carbonates market, accounting for 43 per cent of sales, and are the fastest-growing sector.

Concentrate sales were falling, first because they lacked the image of carbonates, and secondly because an ingredient commonly used in them, namely tartrazine, became linked with hyperactivity in children. Since then, tartrazine has been removed and higher juice contents have been introduced, thereby upgrading the product.

Most Eastern European countries have recorded substantial increases in consumption. Bottled water rose by 9.4 per cent over the period 1988-1989, carbonated drinks by 5.9 per cent, still drinks by 9.5 per cent, juice by 6.8 per cent and syrups by 2.4 per cent.

The annual consumption of soft drinks in Australia also increased in 1989, with production rising by 7.6 per cent. In fact, per capita consumption has risen from 64.2 litres to 94.87 litres over the past 10 years.

Consumption of carbonated soft drinks in South Africa reached 1.2 billion litres in 1986, slightly below the 1985 level, with a per capita consumption of 40 litres. Coca-Cola has the largest market share with 65 per cent, followed by Sparletta with 19 per cent, Schweppes with 6 per cent and Pepsico with 4 per cent. Mineral water consumption is minimal, consisting mostly of imported European brands.

Turning to East Asia, annual production of carbonated soft drinks in Japan dropped from 2.9 billion litres in 1985 to 2.7 billion in 1985. Although colas occupy a sizeable portion of the market, 33 per cent, table IV.147 shows that sales of carbonated soft drinks have been declining, with some consumers switching to canned coffee drinks, canned Oolong tea drinks and mineral water.

Table IV.147. Sales of carbonated soft drinks by brand in Japan, 1984-1987

Brand	1984	1986	1987[a/]	Percentage share 1987	Percentage change 1986-1987
	(thousands of cases)[b/]				
Lemon:					
Kirin lemon	19 400	16 700	17 000	20.1	1.8
Mitsuya cider[c/]	18 200	16 900	17 200	20.1	0.6
Ribbon citron	2 100	1 800	1 800	2.1	0.0
Other	12 016	10 311	10 436	12.3	1.2
Total	51 716	50 000	45 711	54.9	1.6
	(422 000)	(373 000)	(379 000)		
Lemon-lime:					
Sprite	28 400	27 000	27 500	32.5	1.9
Melinda lemon lime	1 150	950	900	1.1	-5.3
Seven-Up	900	800	1 000	1.2	25.0
Suntory lemon	1 500	1 200	1 200	1.4	0.0
Others	10 329	7 918	7 513	8.9	-5.1
Total	42 279	37 868	38 113	45.1	0.6
	(345 000)	(309 000)	(311 000)		
TOTAL[b/]	93 995	83 579	84 559	100.0	1.2
	(767 000)	(682 000)	(690 000)		

Source: Times Spirits Monthly Statistics, July 1987, and Japanscan, October 1987.

Note: Figures in parentheses are thousands of litres.

a/ Estimates.

b/ One case = 340 ml x 24 bottles = 8.16 litres.

c/ Ciders refer to lemonade in Japan.

The market for soft drinks in South-East Asia is now valued at more than $1 billion, with consumption climbing to 3.8 billion litres. A study by IMES, a United-Kingdom-based market research company, covering Indonesia, Malaysia, Philippines, Singapore and Thailand, estimates that the fastest-growing sectors of the soft-drinks industry are sweet non-carbonated drinks and bottled mineral water, sales of which grew by 80 per cent in the four years up to 1986. However, most of the total of 3.3 billion litres of soft drinks consumed is accounted for by carbonated products, the market share of which grew by 50 per cent during the four-year period in Thailand, but was stable in Singapore and slightly down in the Philippines. However, their sales dropped by 26.5 per cent in Malaysia and by 45 per cent in Indonesia.

2. *Major companies and brands*

The three countries where corporate market power and brand loyalty play a strong role are Japan, United Kingdom and United States. Over the past three years, the suppliers of carbonates and concentrates in the United Kingdom (Mentel) have gone through an intense phase of concentration. Two dominant groups have linked to Coca-Cola and Pepsico. In January 1987, Coca-Cola formed a joint company with Schweppes called Coca-Cola and Schweppes Beverages, of which 51 per cent is owned by Cadbury Schweppes and 49 per cent by Coca-Cola. The new company opened a

£6.5 million soft-drinks complex at Wakefield, England, in 1989, the biggest plant of its type in Europe.

The second giant group was formed when Britvic Soft Drinks bought the chief interests of Beecham Soft Drinks, forming a company called Britvic Coronas, but subsequently reverting to its former name. The main brands are Pepsi, Diet Pepsi, Britvic, Corona and Seven-Up. A.G. Barr of Scotland, which leads a group of independent soft-drinks companies that are expanding from their regional bases, acquired Mandora, and is spending £6 million on plant improvements.

The market for fruit juice in the United Kingdom was estimated to be worth £835 million in 1989. Its rapid growth was fuelled by an increasingly health-conscious public, with a desire for convenience foods and new tastes. Gerber Foods Manufacturing is the leading supplier of cartoned long-life own-label juice in the United Kingdom, but at the end of 1989 it moved into the chilled-juice sector for the first time. It spent £4.3 million on a new plant at Bridgwater, Somerset, building what is claimed to be the biggest of its type in Europe, capable of producing 1 million cartons a day. Combibloc and Tetra Pak cartons continue to enjoy immense success in the United Kingdom and Europe as a whole, and Tetra Pak, which accounts for 90 per cent of the aseptic market, sold 54 billion cartons world-wide, the equivalent of 10 cartons for every person in the world.

In the United States, concentration within the soft-drinks industry has continued since 1988. A list of the 50 largest soft-drinks companies is provided in table IV.154 in the appendix to the present section. The percentage market shares held by the top four companies in 1987 are shown in table IV.148 for their top brands. Coca-Cola is the leader with a 34.3 per cent share, followed by Pepsi-Cola with 26.5 per cent, Hicks and Haas with 7.7 per cent and Royal Crown Cola with 1.6 per cent. The continued change in concentration is reflected in table IV.149.

Table IV.148. Market shares of top four soft-drinks companies and 10 most important soft drinks in the United States, 1987

Rank	Parent company and brand	Market share (percentage)
	Coca-Cola	
1	Classic Coke	19.8
3	Diet Coke	7.7
6	Sprite	3.5
9	Caffeine-free Coke	1.7
10	"New" Coke	1.6
	Total	34.3
	Pepsi-Cola	
2	Pepsi	18.8
4	Diet Pepsi	4.8
8	Mountain Dew	2.9
	Total	26.5
	Hicks and Haas	
5	Dr. Pepper	4.3
7	Seven-Up	3.4
	Total	7.7
	Royal Crown Cola	
10	RC	1.6
	TOTAL	70.1

Source: Beverage Digest.

Table IV.149. Changes in market share of the three largest soft-drinks companies in the United States, 1986-1987

Company	Market share (percentage) 1986	1987	Percentage change 1986-1987
Mainstream companies			
Coca-Cola	39.9	40.3	0.4
Pepsi-Cola	29.8	30.2	0.4
Hicks and Haas a/	11.6	12.1	0.5
Total	81.3	82.6	1.3
Niche companies			
Royal Crown	3.1	2.9	-0.2
Canada Dry b/	2.5	2.1	-0.4
Orange Crush	1.1	0.9	-0.2
Shasta	0.8	0.6	-0.2
Total	7.5	6.5	-1.0
Total	88.8	89.1	0.3
All other companies	11.2	10.9	-0.3
TOTAL	100.0	100.0	

Source: Beverage Digest and United States Industrial Outlook 1989 (Washington, D.C., United States Department of Commerce, 1989).

a/ Including Dr. Pepper, Seven-Up, A and W (root beer) and Squirt brands.

b/ Including Sunkist brands.

The market share by each of the niche companies decreased, though only slightly, between 1986 and 1987. Share increases were reported by Coca-Cola, from 39.9 to 40.3 per cent, Pepsi-Cola, from 29.8 to 30.2 per cent, and Hicks and Haas, from 11.6 to 12.1 per cent. By any measure of comparison, the United States market still has an extremely high degree of concentration. The top three companies took 81.3 per cent of the market in 1986 and 82.6 per cent in 1987.

Table IV.148 shows how the market share is divided among the 10 major brands of soft drinks. Classic Coke is shown to be in first place with a 19.8 per cent share, Pepsi in second with 18.8 per cent and Diet Coke in third with 7.7 per cent. The captive bottling network of the two largest cola franchise organizations, Coca-Cola and Pepsi-Cola, continued to grow by acquiring selected independent franchises and by investing in others. It is estimated that the captive franchise bottling networks represent more than 40 per cent of the total branded output of the franchisers.

The Japanese market is comparable to other markets in its shift towards brand sales in bottled waters. A slow-down can thus be observed in the sales of major soft drinks by brand. As already shown in table IV.147, sales of lemon carbonated soft drinks fell from 422 million litres in 1984 to 373 million litres in 1986, and only recovered slightly to reach 379 million litres in 1987. Similarly, lemon-lime drink sales fell from 767 million litres in 1984 to 682 million litres in 1986, and stabilized at 690 million litres in 1987.

Although soda water constitutes only a small portion of the Japanese beverage market, table IV.150 reflects trend similar to that described above, but the adjustment has been more pronounced. Soda water sales thus show a continuing decline from 174.8 million litres in 1984 to 97.2 million litres in 1987.

Table IV.150. Sales of soda water by brand in Japan, 1984-1987

Brand	1984	1986	1987a/	Percentage share	Percentage change 1986-1987
	(thousands of cases)				
Fanta club soda	5 300	3 200	2 900	32.2	-9.4
Suntory soda	2 200	1 500	1 300	15.0	-11.2
Kirin tansanb/	1 900	1 200	1 050	14.4	-13.3
Ribbon tansanb/	1 400	800	700	11.7	12.5
Canada Dry soda	1 430	900	800	8.9	-11.1
Wilkinson tansan	1 000	550	500	8.8	-1.3
Belinda club soda	800	450	400	5.6	-9.1
Other	2 156	1 521	1 350	4.4	-11.1
TOTAL	16 186	10 121	9 000	100.0	-11.1
	(174 809)	(109 307)	(97 200)		

Source: Vines Spirits Monthly Statistics, July 1987.
Note: Figures in parentheses are thousands of litres.
a/ Estimates.
b/ Tansan means carbonic acid in Japanese.

Changes in market share by the major companies involved in producing mineral water have been almost negligible in the past two years. Table IV.151 shows that Suntory Ltd. held the largest share at 40.2 per cent, followed by Kirin at 8 per cent, Hoorinai at 5.2 per cent and Nikka at 3.4 per cent.

3. *Short-term outlook*

Because of lack of information, forecasts beyond 1989 are not available. Table IV.152 thus reflects the forecast global sales for 1989. Sales are expected to have been worth $35.6 billion in the United States, $3.1 billion in the United Kingdom, $2.3 billion in the Federal Republic of Germany, $2.0 billion in France, $1.9 billion in Italy and $0.8 billion in Japan. The United States is shown to have the largest market share at 77.9 per cent, followed by the United Kingdom at 6.9 per cent and the Federal Republic of Germany at 5.1 per cent. Data for 1989 are also provided in figure IV.31.

A more detailed set of forecasts is available only for the United States and only at the aggregate soft drinks level. As shown in table IV.152, however, forecasts are

Table IV.151. Sales of mineral water by company and brand in Japan, 1984-1987

Company	Brand	1984	1986	1987a/	Percentage share	Percentage change 1986-1987
		(thousands of cases)				
Suntory Ltd.	Suntory	3 600	3 300	3 500	40.2	6.1
Kirin	Kirin Brewery	680	700	700	8.0	-
Hoorinai	Fuji	400	400	450	5.2	12.5
Nikka	Nikka Whisky	400	300	300	3.4	-
Nunobiki Kosen Sho	Nunobiki	130	140	170	2.0	21.4
Canada Dry Japan	Canada Dry	170	120	130	1.5	8.3
Nippon Suishitsu	Kenkyusho No.1	115	100	100	1.1	-
Nippon Kosen Inryo	Crystal Cherry	90	75	80	0.9	6.7
Elm Water	Elm	40	30	30	0.3	-
Aporon Bottling	Shirayama	50	45	45	0.5	-
Nagoya Sampack	Yoro	16	10	10	0.1	-
Shiraishi Kosan	SPA	35	31	35	0.4	12.9
Koya Mineral Foods	KOYA	25	25	30	0.3	20.0
Gensen Kan	Shingen	40	40	50	0.6	25.0
Other	Other	2 634	2 544	3 070	35.3	20.7
	TOTAL	8 425	7 640	8 700	100.0	13.9
		(91 000)	(82 500)	(93 950)	-	

Source: Vines Spirits Monthly Statistics, July 1987.
Note: Figures in parentheses are thousands litres.
a/ Estimates.

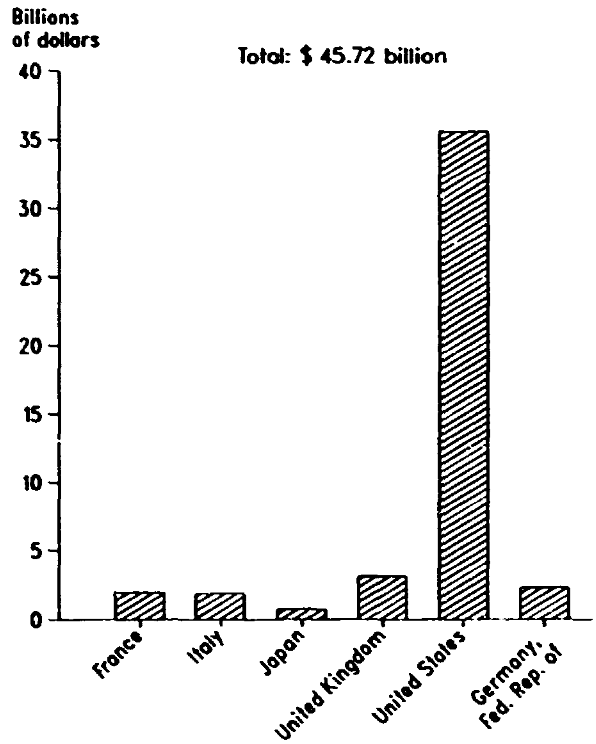
restricted to only a few of the included variables. Table IV.153 shows an 8 per cent increase in the total value of soft-drinks shipments by industry between 1988 and 1989.

Table IV.152. Soft-drinks sales in selected countries, 1984 and 1989

Country	Market size 1984 (millions of dollars)	Market size 1989a/ (millions of dollars)	Percentage share 1989	Percentage change 1984-1989
United States	30 700	35 600	77.9	16.0
United Kingdom	2 588	3 139	6.9	21.3
Germany, Federal Republic of	2 160	2 320	5.1	7.4
France	1 673	2 000	4.4	19.5
Italy	1 357	1 898	4.2	39.9
Japanb/	686	763	1.7	11.2
TOTAL	39 164	45 720	100.0	16.7

Source: Beverage Industry, June 1986.
a/ Forecast; in 1984 constant prices.
b/ Shipments only.

Figure IV.31. Forecast of global soft-drinks sales, by countries, 1989



Source: *Beverage Industry*, June 1986

Table IV.153. Trends and forecasts of bottled and canned soft-drinks shipments in the United States, 1985-1989

Item	1985	1987a/	1988b/	1989c/	Percentage change: Compound annual 1972-1986	Compound annual 1981-1988	Annual 1987-1988	Annual 1988-1989
Industry data								
Value of shipments (million dollars)d/	19 358	21 992	23 500	25 380	10.0	6.2	6.9	8.0
Value of shipments (million 1982 dollars)	17 924	19 566	20 453	21 600	2.3	3.3	4.5	5.8
Industry price change (percentage) e/	1.1	2.3	..	..	..	..	..	..
Total employment (thousands)	106	101 -	99.6	..	-1.2	-2.7	-1.4	..
Production workers (thousands)	37.2	35.1	34.9	..	-1.8	-3.6	-0.6	..
Average hourly earnings (dollars)	9.1	10.25	10.48	..	8.2	7.0	2.2	..
Product Data								
Value of shipments (million dollars)f/	18 100	20 497	21 973	23 731	10.4	7.5	7.2	8.0
Value of shipments (million 1982 dollars)	16 760	18 236	19 124	20 197	2.6	4.6	4.9	5.6
Trade Data								
Value of imports (thousand dollars)	120	135	177	..	37.1	23.5	31.1	..
Ratio of imports to new supplyg/	0.007	0.007	0.008	..	..	14.9	14.3	..
Value of exports (thousand dollars)	21.7	39.7	15.0	..	16.0	-10.9	-62.2	..
Ratio of exports to shipments	0.001	0.002	0.001	..	-	-19.7	-50.0	..

Source: United States Department of Commerce and Department of Labour; Bureau of Labour Statistics (BLS). Estimates and forecasts by ITA.

a/ Estimates except for exports and imports.
b/ Estimates.
c/ Forecasts.
d/ Value of all products and services sold by the bottled and canned soft drinks industry.
e/ The percentage change in prices is calculated from previous year to current year using the annual average published by the United States Bureau of Labour Statistics.
f/ Value of all industry products classified with those of the bottled and canned soft drinks industry.
g/ New supply is the sum of product shipments plus imports.

Table IV.154. The 50 largest beverage companies in the United States, 1987

Rank	Company and headquarters	1987 sales (dollars)	Percentage share	Principal beverage subsidiaries	Principal product categories
1	The Coca-Cola Company (Atlanta)	7 658 300	16.0	Coca-Cola USA, Coca-Cola Foods,	Soft drinks, citrus juices fruit drinks
2	Anheuser-Busch Companies, Inc. (St. Louis)	6 781 000	14.1	Anheuser-Busch Inc.	Beer, beer imports
3	PepsiCo, Inc. (Purchase, New York)	4 099 400	8.5	Pepsi-Cola Company, Pepsi-Cola International	Soft drinks, bottled water
4	The Seagram Company Ltd. a/ (Montreal, Canada)	3 815 480	8.0	House of Seagram, Seagram Classics Wine Company, Seagram International	Distilled spirits, wine, coolers, mixers
5	Coca-Cola Enterprises, Inc. (Atlanta)	3 329 134	6.9	Coca-Cola Bottling Companies	
6	Philip Morris Company Inc. (New York)	3 200 000	6.7	Miller Brewing Company, General Foods Corporation	Beer, wine coolers, drink mixes, fruit drinks
7	John Labatt Ltd. (London, Canada)	1 673 584	3.4	Labatt Brewing Company, Chateau-Gai, Johanna Farms, Holiday Juice	Beer, wine, wine coolers, fruit juices, fruit drinks
8	The Stroh Brewery Co. (Detroit)	1 500 000	3.1	Brewing Division, Stroh Foods	Beer, coolers, soft drinks
9	Hiram Walker-Gooderham & Worts Ltd. b/ (Walkerville, Canada)	1 350 000	2.8	Hiram Walker & Sons, Corby Distilleries, Maidstone Wine & Spirits, Frederick Wildman & Sons, Callaway Vineyard & Winery, Maker's Mark Distillery	Distilled spirits, wine
10	The Molson Companies, Ltd. (Toronto, Canada)	1 137 340	2.4	Molson Breweries of Canada Ltd., Martlet Importing Company, Santa Fe Beverage Company (joint venture)	Beer, coolers, beer imports
11	Adolph Coors Company (Golden, Colorado)	1 133 339	2.4	Brewing Division	Beer
12	G. Heileman Brewing Company c/ (LaCrosse, Wisconsin)	1 100 000	2.3	Brewing Division	Beer
13	Brown-Forman, Inc. (Louisville)	1 063 754	2.2	Brown-Forman Beverage Company Black Bush Import Company, Brown-Forman Import Company, Brown-Forman International Ltd., Canadian Mist Distillers Ltd., Early Times Distillers Company, Jack Daniel Distillery	Distilled spirits, wine, wine coolers
14	E&J Gallo Winery (Modesto, California)	1 050 000	2.2		Wine, wine coolers
15	McKesson Corporation d/ (San Francisco)	956 800	2.0	McKesson Wine and Spirits, Bottled Water Division, Carlton Importing	Distilled spirits, wine, bottled water, beer imports
16	Monickman Group (Pennsauken, New Jersey)	750 000	1.6	Beverage Capital Corporation, Canada Dry Potomac Corporation, Royal Crown Bottling, Galler Seven-Up Bottling, Pepsi-Cola Bottling of New York, Canada Dry Bottling, Seven-Up Bottling, Pepsi-Cola National Brands, Canada Dry Delaware Valley, Coors Distributing Company of New York	Soft drinks, beer
17	Tropicana Products, e/ Inc. (Bradenton, Florida)	745 000	1.6		Citrus juices

Rank	Company and Headquarters	1987 sales (dollars)	Percentage share	Principal beverage subsidiaries	Principal product categories
18	Ocean Spray Cranberries, Inc. (Plymouth, Massachusetts)	735 804	1.5		Fruit drinks, juice cocktails
19	Coca-Cola Bottling Company of New York, Inc. (Greenwich, Connecticut)	726 000	1.5		Soft drinks
20	Dr. Pepper/Seven-Up Companies[f] (Dallas)	725 000	1.5	Seven-Up Company, Dr. Pepper Company, Premier Beverages, Inc.	Soft drinks
21	General Cinema Corp. (Chestnut Hill, Massachusetts)	674 728	1.4	General Cinema Beverages	Soft drinks
22	IC Industries, Inc. (Chicago)	605 000	1.3	Pepsi-Cola General Bottlers, Inc.	Soft drinks
23	American Brands, Inc. (Old Greenwich, Connecticut)	599 400	1.2	Jim Beam Brands Company	Distilled spirits
24	Procter & Gamble Company (Cincinnati)	595 000	1.2	Crush International, Ben Hill Griffin Citrus	Soft drinks, fruit juices
25	TCC Beverages, Ltd. (Toronto, Canada)	566 000	1.2		Soft drinks
26	Bacardi Imports, Inc. (Miami)	515 000	1.1		Distilled spirits
27	S&P Company (Corte Madera, California)	485 000	1.0	Falstaff, General, Pearl and Pabst Brewing Companies	Beer
28	Johnston Coca-Cola Bottling Group, Inc. (Chattanooga)	481 000	1.0	Central States Coca-Cola, Coca-Cola Bottling Companies, Mid-States and Blue-grass Coca-Cola Bottling Companies	Beer Soft drinks
29	Westinghouse Electric Corporation (Pittsburgh)	466 350	1.0	Westinghouse Beverage Group	Soft drinks
30	Coca-Cola Bottling Company (Niles Illinois)	425 000	0.9	Coca-Cola Bottling Companies	Soft drinks
31	Coca-Cola Bottling Company Consolidated (Charlotte, North Carolina)	354 414	0.7	Coca-Cola Bottling Companies	Soft drinks
32	Ben E. Keith Company (Dallas)	350 000	0.7		Beer
33	Royal Crown Cola Company (Rolling Meadows, Illinois)	325 000	0.7		Soft drinks
34	National Beverage Corporation (Fort Lauderdale)	310 000	0.6	Shasta Beverages, Faygo Beverages	Soft drinks
35	Citrus World, Inc. (Lake Wales, Florida)	265 000	0.6		Citrus juices
36	Coca-Cola Bottling Group-Southwest, Inc. (Dallas)	260 000	0.5	Coca-Cola Bottling Companies	Soft drinks
37	Buffalo Rock Company, Inc. (Birmingham)	250 000	0.5	Pepsi-Cola Bottling Companies	Soft drinks
38	Beverage Management, Inc. (Columbus)	245 000	0.5	Seven-Up, Royal Crown and Canada Dry Bottling Companies	

Table IV.154 (continued)

Rank	Company and Headquarters	1987 sales (dollars)	Percentage share	Principal beverage subsidiaries	Principal product categories
39	Quaker Oats Company (Chicago)	242 500	0.5	Grocery Specialities Division (Gatorade) Food Service Division (Ardmore Farms)	Fruit drinks, Fruit juices
40	Kemmerer Bottling Group, Inc. (Joliet, Illinois)	231 000	0.5	Seven-Up Bottling Company of Indiana	Soft drinks
41	Welch Foods (Concord, Massachusetts)	221 898	0.5		Fruit juices, fruit drinks
42	All American Bottling Corporation (Coral Gables, Florida)	217 000	0.5	Seven-Up Bottling Companies Royal Crown Beverage Company, RC/Canada Dry Bottling RC/Seven-Up/Dr. Pepper Bottling	Soft drinks
43	RJR Nabisco, Inc. (Winston-Salem, North Carolina)	205 000	0.4	Del Monte USA	Fruit juices, fruit drinks, drink mixes
44	Sunkist Group, Inc. (Darien, Connecticut)	200 000	0.4	Sunkist Brands, Inc.	Citrus juices, fruit drinks, bottled water
45	Coca-Cola Bottling Company, United, Inc. (Birmingham)	198 000	0.4	Coca-Cola Bottling Companies	Soft drinks
46	Canandaigua Wine Company, Inc. (Canandaigua, New York)	171 319	0.4	Bisceglia Brothers Wine Company, Batavia Wine Cellars, Richards Wine Cellars, Tenner Brothers, Widmer's Wine Cellars	Wine, wine coolers, wine imports
47	Campbell Soup Company (Camden, New York)	170 000	0.4	Beverage Business Unit, Juice Bowl Products, Inc.	Vegetable juice, fruit juices
48	Philadelphia Coca-Cola Bottling Company (Philadelphia)	166 000	0.3		Soft drinks
49	Tree Top, Inc. (Selah, Washington)	163 000	0.3		Fruit juices
50	Castle & Cooke, Inc. (Los Angeles)	150 000	0.3	Dole Food Company	Fruit juices
	TOTAL	47 965 743	100.0		

Source: Beverage World, July 1988, pp.51-56.

a/ Seagram completed acquisition of Martell S.A. and Tropicana Products, Inc. in June 1988.

b/ Acquired by Allied-Lyons PLC in November 1987

c/ Acquired by Bond Corporation Holdings Ltd. (Australia) in September 1987.

d/ McKesson sold its Wine and Spirits Division to a management group in April 1988.

e/ Acquired from Beatrice Company by Seagram Company Ltd. in April 1988.

f/ Listed separately in Beverage World top 50 companies in 1987, with Dr. Pepper ranking 33 and Seven-Up, 42. The companies officially merged in April 1988.

REFERENCES

Chapter I

1. Asian Development Bank, *Asian Development Outlook 1990* (Manila, 1990).
2. Alexandratos Nikos, *World Agriculture: Toward 2000* (Rome, Food and Agriculture Organization of the United Nations, 1988).
3. United Nations Development Programme, *Human Development Report 1990* (New York, Oxford University Press, 1990).
4. *World Development Report 1988* (Washington, D.C., World Bank, 1989).
5. United Nations Educational, Scientific and Cultural Organization, *Statistical Yearbook 1989*, (Paris, 1989).
6. Foreign direct investment flows to developing countries: recent trends, major determinants and policy implications (PPD.167).

Chapter II

1. "Shaking up Detroit", *Business Week*, 14 August 1989.
2. "Haunting clouds of uncertainty: East Germany's people and industry", *Financial Times*, 23 February 1990.
3. "East Germany machine output could triple", *Financial Times*, 7 March 1990.
4. "Next steps in the Hungarian economic reform", *Eastern European Economics*, vol. 27, No. 5 (Fall 1989).
5. Ron Cooper, "Soviet Union, much venture, little gained", *Euromoney*, February 1990.
6. "Recent trends in foreign direct investment flows to European CMEA countries" (PPD 152).
7. J. B. G. Tilak, "Economic slowdown and educational recession in Latin America", *IDS Bulletin*, vol. 20, No. 1 (1989).
8. "Third world: exports to West Germany on the increase", *North-South News Service*, 22 March 1990.
9. Economist Intelligence Unit, *Argentina*, Country Report No. 2 (London, 1990).
10. World Bank, *World Development Report 1987* (New York, Oxford University Press, 1987).
11. J. N. Bhagwati, "Poverty and public policy", *World Development*, vol. 16, No. 5 (May 1988).
12. T. N. Srinivasan, "External sector in development: China and India, 1950-1989", *American Economic Review*, vol. 80, No. 2 (May 1990).
13. W. A. Stoever, "Foreign collaborations policy in India: a review", *Journal of Development Areas*, vol. 23, No. 4 (July 1989).
14. Amiya Kumar Bagchi, "An economic policy for the new government", *Economic and Political Weekly*, vol. 25, No. 6 (1990).
15. James Clad, "Indian Ministers at odds over economic strategy", *Far Eastern Economic Review*, 1 March 1990.
16. I. J. Ahluwalia, "Industrial growth in India: performance and prospects", *Journal of Development Economics*, vols. 23-24 (1986).
17. P. A. Petri, "Korea's export niche: origins and prospects", *World Development*, vol. 16, No. 1 (January 1988).
18. Chuji Kikutani, "Dynamic Development", *Journal of Japanese Trade and Development*, No. 6, 1989.
19. Ministry of Science and Technology, *Report on the Survey of Research and Development in Science and Technology* (Seoul, 1988).

Chapter III

1. *Industry and Development: Global Report 1988/89* (United Nations publication, Sales No. E.89.III.E.5).
2. United Nations Environment Programme, *Safeguarding the World's Water*, Environmental Brief No. 6. (Nairobi, 1988).
3. D. M. Tates and P Reynold, "The regional context of industrial water demand forecasting in Canada", *International Symposium on Water Resources Management in Industrial Areas*, vol. 1 (Lisbon, Laboratorio Nacional de Engenharia Civil, 1981).
4. J. Muelschlegel, *Drinking and Industrial Water Demands in the Netherlands* (Laxenburg, Austria, International Institute for Applied Systems Analysis, 1979).
5. *The Demand for Water* (United Nations publication, Sales No. E.76.II.A.1), 1976.
6. Paul R. Ehrlich and others, *Ecoscience: Population, Resources and Environment* (San Francisco, W. H. Freeman and Co. 1977).
7. *The Economist*, 2 September 1989.
8. Organisation for Economic Co-operation and Development, *The State of the Environment 1985* (Paris, 1985).
9. M. J. Chadwick and others, eds., *Environmental Impacts of Coal Mining and Utilization* (Oxford, Pergamon Press, 1987).
10. Energy Information Administration, *Manufacturing Energy Consumption Survey: Changes in Energy Efficiency, 1980-1985* (Washington, D.C., January 1990).
11. H. Hotelling, "The economics of exhaustible resources", *Journal of Political Economy*, vol. 34 (1931).

12. H. J. Barnett and C. Morse, *Scarcity and Growth* (Baltimore, Johns Hopkins University Press, 1963).

13. P. S. Dasgupta and G. Heal, "The optimal depletion of exhaustible resources", *Review of Economic Studies*, Symposium issue (1974).

14. J. Stiglitz, "Growth with exhaustible resources", *Review of Economic Studies* (1974).

15. T. C. Koopmans, "Some observations on optimal economic growth and exhaustible resources", in *Economic Structure and Development*, H. C. Bos, ed. (Amsterdam, North-Holland, 1973).

16. V. K. Smith, ed., *Scarcity and Growth Reconsidered* (Baltimore, Johns Hopkins University Press, 1979).

17. D. Pearce, A. Markyanda and E. Barbier, *Blueprint for a Green Economy* (London, Earthscan, 1989).

18. A. V. Kneese and J. L. Sweeny, eds., *Handbook of Natural Resource and Energy Economics* (Amsterdam, North-Holland, 1985).

19. V. S. Vatakuri and R. V. Lama, *Environmental Engineering in Mines* (Cambridge, Cambridge University Press, 1986).

20. National Research Council, *Renewable Resources for Industrial Materials* (Washington, D.C., National Academy of Sciences, 1976).

21. D. W. Pearce and J. Rose, *The Economics of Natural Resource Depletion* (London, Macmillan, 1975).

22. F. A. Smith, "Waste material recovery and reuse", in *Population, Resources, and the Environment*, vol. 3, Research Reports of the Commission on Population Growth and the American Future (Washington, D.C., Government Printing Office, 1972).

23. Walter Labys and L. Waddel, "Transmaterialization: technology and material demand cycles", *Materials and Society*, vol. 12, No. 1 (1988).

24. Organisation for Economic Co-operation and Development, *Energy Balances of OECD Countries, 1970-1983* (Paris, 1984).

25. A. Hamza and J. Galiup "Assessment of environmental pollution in Egypt: case-study of Alexandria Metropolitan Area", *Water Quality Bulletin*, vol. 7, No. 2 (Geneva, World Health Organization, 1982).

26. A. P. Economopoulos, "Rapid wastewater inventories and their use in environmental planning", in *Management of Industrial Wastewater in Developing Countries*, D. Stuckey and A. Hamza, eds (Oxford, Pergamon Press, 1982).

27. World Health Organization, *Hazardous Waste Management Policy Guidelines and Practices* (Copenhagen, 1982).

28. *The Safe Disposal of Hazardous Wastes*, vol. I (Washington, D.C., World Bank, 1989).

29. Kosnonti Statiszitikai Hivatal, *The State and the Protection of the Environment* (Budapest, 1986).

30. B. Piaseck and J. Gravander, "The missing links: restructuring hazardous waste controls in America", *Technical Review*, October 1985.

31. Environmental Protection Agency, *The Toxics Release Inventory, 1987* (Washington, D.C., Government Printing Office, 1989).

32. F. A. Uriarte, Jr., "Hazardous waste management in ASEAN: with emphasis on small and medium industries", in *Hazardous Waste Management*, S. Maltezou and others, eds. (London, Tycooly, 1989).

33. *Industry and Development: Global Report 1988/89* (UNIDO publication, Sales No. 88.III.E.6).

34. United Nations Environment Programme, *Hazardous Chemicals*, Environmental Brief No. 4 (Nairobi, 1989).

35. Urzad Wojewozki, ed., "Report on the state of the environment for the Katowice Province" (Katowice, 1981) (mimeograph).

36. Jan Kapala and Henryk Herman, "Air pollution in the Katowice Province—sources and hazards", *Environmental Protection Engineering*, vol. 13, Nos. 3-4 (1987).

37. "Big cleanup", *Business Week*, 19 March 1990.

38. R. Kucharski and E. Marchwinska, "Exposure of edible and pasture plants and consumers in the Katowice District" (Katowice, Institute of Environmental Protection, 1990) (mimeograph).

39. E. Marchwinskia and others, "stezennie kadmu I olowiu W Probkach Ziemniakow Z Roznych Rejonow Polski", *Roczn*, vol. XXXV, No. 2 (1983).

40. B. Reynolds, "Wastes from the high-tech industry", *Proceedings of 33rd Ontario Industrial Waste Conference, 15-18 June 1986* (Ontario, Ministry of the Environment, 1986).

41. T. L. Foeke, "Waste minimization in the electronics production industries", *Waste Management*, vol. 38, No. 3 (March 1988).

42. Department of Commerce, *Survey of Current Business* (Washington, D.C., June 1980).

43. C. Leiper and U. E. Simonis, "Environmental damage—Environmental expenditures: statistical evidence on the Federal Republic of Germany", *International Journal of Social Economics*, vol. 15 (1988).

44. Organisation for Economic Co-operation and Development, *Environmental Policy and Technical Change* (Paris, 1985).

45. Data Resources Incorporated, "The macro-economic impact of federal pollution control programs: 1978 assessment", report submitted to the United States Environmental Protection Agency and the Council on Environmental Quality (Washington, D.C., 1979).

46. *Special Study on Economic Change: Hearing Before the Joint Economic Committee of the United States*, (Washington, D.C., Government Printing Office, 1978), part 2.

47. Organisation for Economic Co-operation and Development, *Macro-economic Evaluation of Environmental Programmes* (Paris, 1982).

48. Ingo Walter, *Studies in International Environmental Economics* (New York, Wiley-Interscience Publications, 1976).

49. Organisation for Economic Co-operation and Development, *The Macro-economic Impact of Environmental Expenditure* (Paris, 1985).

50. D. Schaefer and C. Stahmer, "Input-output model for the analysis of environmental protection activities", *Economic Systems Research*, vol. I, No. 2 (1989).

51. G. Christiansen and R. Haveman, "Public regulations and the slowdown in productivity growth", *American Economic Review*, vol. 71, No. 2 (May 1981).

52. Myrick A. Freeman, *Benefits of Air and Water Pollution Control: a Review and Synthesis of Recent Estimates*, report prepared for the United States Council on Environmental Quality (Washington, D.C., Government Printing Office, 1979).

53. Ingo Walter, *International Economics of Pollution* (London, Macmillan, 1975).

54. Organisation for Economic Co-operation and Development, *Macro-Economic Evaluation of Environmental Programmes* (Paris, 1978).

55. D. Huisingh, "Cleaner technologies through process modifications, material substitutions and ecologically based ethical values", in *UNEP Industry and Environment*, January—March 1989.

56. R. P. Campbell and W. M. Glenn, *Profit from Pollution Prevention* (Toronto, Pollution Probe Foundation, 1982).

57. J. C. Chazelon, *Les techniques propres dans l'industrie française* (Paris, *La société objective*, 1982).

58. R. P. Bringer and S. Zoss, *An Environmental Program that Works* (St. Paul, Minnesota, 3M, 1984).

59. L. C. Gardner and D. Huisingh, "Waste reduction through material and process substitution", *Hazardous Waste and Hazardous Materials*, vol. 4, No. 2 (1987).

60. M. Royston, *Pollution Prevention Pays* (Elmsford, New York, Pergamon Press, 1979).

61. Economic Commission for Europe, "Compendium on low- and non-waste technology" (ENV/WP.2/5/Add.63).

62. United Nations Environment Programme and Ministry for Research and Technology of the Federal Republic of Germany, *Final Proceedings of the International Symposium on Clean Technologies*, Bonn, 7-18 October 1985 (Paris, 1985).

63. Susan T. Johnnie, "Waste reduction in Hewlett-Packard, Colorado Springs Division, printed circuit board manufacturing shop", *Hazardous Waste and Hazardous Materials*, vol. 4, No. 1 (1987).

64. T. Nunno and others, *Toxic Waste Minimization in the Printed Circuit Board Industry* (Park Ridge, New Jersey, Noyes Data Corporation, 1988).

65. Economic Commission for Europe, "Rotalyt-Alutop", in "Compendium on low- and non-waste technology" (ENV/WP.2/5/Add.24).

66. Economic Commission for Europe, "Compendium on low- and non-waste technology", vol. V (ECE/ENV/36).

67. Economic Commission for Europe, "Preparation of moulding sands containing reclaimed sands (ENV/WP.215/Add.15).

68. Economic Commission for Europe, "Recovery and purification process for pyridine from effluent from the production of semi-synthetic antibiotics from penicillin", in "Compendium on low- and non-waste technology" (ENV/WP.2/5/Add.131).

69. D. Huisingh and others, *Proven Profits from Pollution Prevention* (Washington, D.C., The Institute for Local Self-Reliance, 1986).

70. Barry I. Castleman, "The export of hazardous factories to developing nations", *International Journal of Health Services*, vol. 9, No. 4 (1979).

71. Thomas N. Gladwin and Ingo Walter, *Multinationals under Fire: Lessons in the Management of Conflict* (New York, John Wiley, 1980).

72. Organisation for Economic Co-operation and Development, *Control of Chemicals in Importing Countries: Proceedings of the Seminar on the Control of Chemicals in Importing Countries* (Paris, 1981)

73. Annie Street and James E. Zorn, "Toward controlling the international movement of hazardous products, *The Corporate Examiner*, July 1983.

Chapter IV

1. *Fearnleys Review 1989* (Oslo, Fearnresearch, 1990).

2. Lloyd's Register of Shipping, *Statistical Tables 1989* (London, 1990).

3. *Fearnleys World Bulk Fleet* (Oslo, Fearnresearch, February 1990).

4. Commission of the European Communities, *Panorama of EC Industry 1989* (Luxembourg, 1988).

5. Lloyd's Register of Shipping, *Annual Survey of Merchant Ships*, (London, 1990).

6. *US Maritime Reporter and Engineering News*, December 1989.

7. Simpson, Spencer and Young Research Services Ltd., *Annual Shipping Review*, 1989 (London, 1989).

8. Wharton Econometric Forecasting Associates, *World Coal Trade in the 1990s, Trade Patterns and Prices* (London, 1989).

9. Ocean Shipping Consultants, *Seaborne Grain Trade and Transport to 2000* (Chartsey, 1989).

10. Department of Commerce, *A Competitive Assessment of the U.S. Textile Machinery Industry* (Washington, D.C., January 1987).

11. *Fertilizer Supplies for Developing Countries: Issues in the Transfer and Development of Technology* (United Nations publication, Sales No. E.85.II.D.2).

12. *International Trade in the Fertilizer Sector: Implications for Developing Countries* (United Nations publication, Sales No. E.84.II.D.17).

13. W. F. Stowasser, "Phosphate rock", *Mineral Facts and Problem* (Washington, D.C., Bureau of Mines, 1985).

14. "Phosphate rock", *Metals and Minerals Annual Review*, (London, The Mining Journal Limited, 1989).

15. T. G. Langton, *Investment and Capacity Fluctuations in the Phosphate Rock Fertilizer Industries* (College Park, Pennsylvania, Pennsylvania State University Press, 1986).

16. "1990 project survey" *Engineering and Mining Journal*, vol. 191, No. 1 (January 1990).

17. R. J. Fantel and others, *Phosphate Availability and Supply: a Minerals Availability Appraisal* (Washington, D.C., Bureau of Mines, 1987)

18. *Price Prospects for Major Primary Commodities*, vol. II, (Washington, D.C., World Bank, 1988).

19. Blue, Kohnson and Associates, *Fertilizer Industry Basics* (Menlo Park, California, 1989).

20. W. R. Bush, ed., *Economics of Internationally Traded Minerals* (Littleton, Colorado, Society of Mining Engineers, 1986).

21. M. Y. Thompson, "Copper", *Mining Annual Review* (1989).

22. P. T. Foley, "International copper demand patterns: the case of plumbing tube", in *Economics of Internationally Traded Minerals*, W. R. Bush, ed. (Littleton, Colorado, Society of Mining Engineers, 1986).

23. K. E. Porter, and P. R. Thomas "International competitiveness of United States copper production, 1981-87", *Mineral Issues* (Washington D.C., Bureau of Mines, 1989).

24. "Copper", *Minerals Yearbook* (Washington, D.C., Bureau of Mines, 1985, 1986 and 1988).

25. J. L. Jolly, "Copper", *Minerals Facts and Problems* (Washington, D.C., Bureau of Mines, 1985).

26. C. S. Tan, *Fibre Optics and the Copper Industry* (Washington, D.C., World Bank, 1986).

27. Centre on Transnational Corporations, "Transnational corporations in the copper industry" (ST/CTC/21).

28. *The Processing and Marketing of Copper: Areas for International Co-operation* (United Nations publication, Sales No. E.84.II.D.24).

29. M. Radetzki, *State Mineral Enterprises* (Washington, D.C., Resources for the Future, 1985).

30. W. C. Labys, "The growth of public enterprise and its impact on mineral trade", in *World Trade in Metals and Minerals*, W. R. Bush, ed. (Littleton, Colorado, Society of Mining Engineers, 1986).

31. W. Gluschke, J. Shaw, and B. Varon, *Copper: the Next Fifteen Years* (Dordrecht, Netherlands, Reidel B. V., 1979).

32. R. Goldie, and R. Maiman, "Red metal exemplified trend", *The Northern Miner Magazine*, No. 14.(1989).

33. "1990 Project Survey", *Engineering and Mining Journal*, vol. 191, No. 1 (January 1990).

34. Office of Technology Assessment Copper: *Technological Competitiveness* (Washington, D.C., Government Printing Office, 1988).

35. M. A. Cook, "Copper smelting and refining: the cold wind of competition begins to blow," *Natural Resources Forum*, vol. 13, No. 2 (1989).

36. M. Brown, and B. Mckern, *Aluminium, Copper and Steel in Developing Countries* (Paris, Organisation for Economic Co-operation and Development, 1987).

37. M. Radetzki and K. Takeuchi *Growth Patterns in Copper Consumption in Industrializing Countries*. (Washington, D.C., World Bank, 1989).

38. L. J. Sous, "Assessment of projected technological innovations in the United States copper industry", *Mining Engineering*, vol. 35 (1983).

39. International Copper Research Association *Technology and Copper Demand* (New York, 1988).

40. Congressional Research Service *The Competitiveness of American Metal Mining and Processing*, (Washington, D.C., Government Printing Office, 1986).

41. R. Mikesell, *The Global Copper Industry* (London, Croom-Helm, 1988).

42. K. Takeuchi and others, *The World Copper Industry: its Changing Structure and Future Prospects*, (Washington, D.C., World Bank, 1987).

43. International Iron and Steel Institute, *Western World Cokemaking Capacity* (Brussels, 1989).

44. *Petroleum Economist* (London, various issues).