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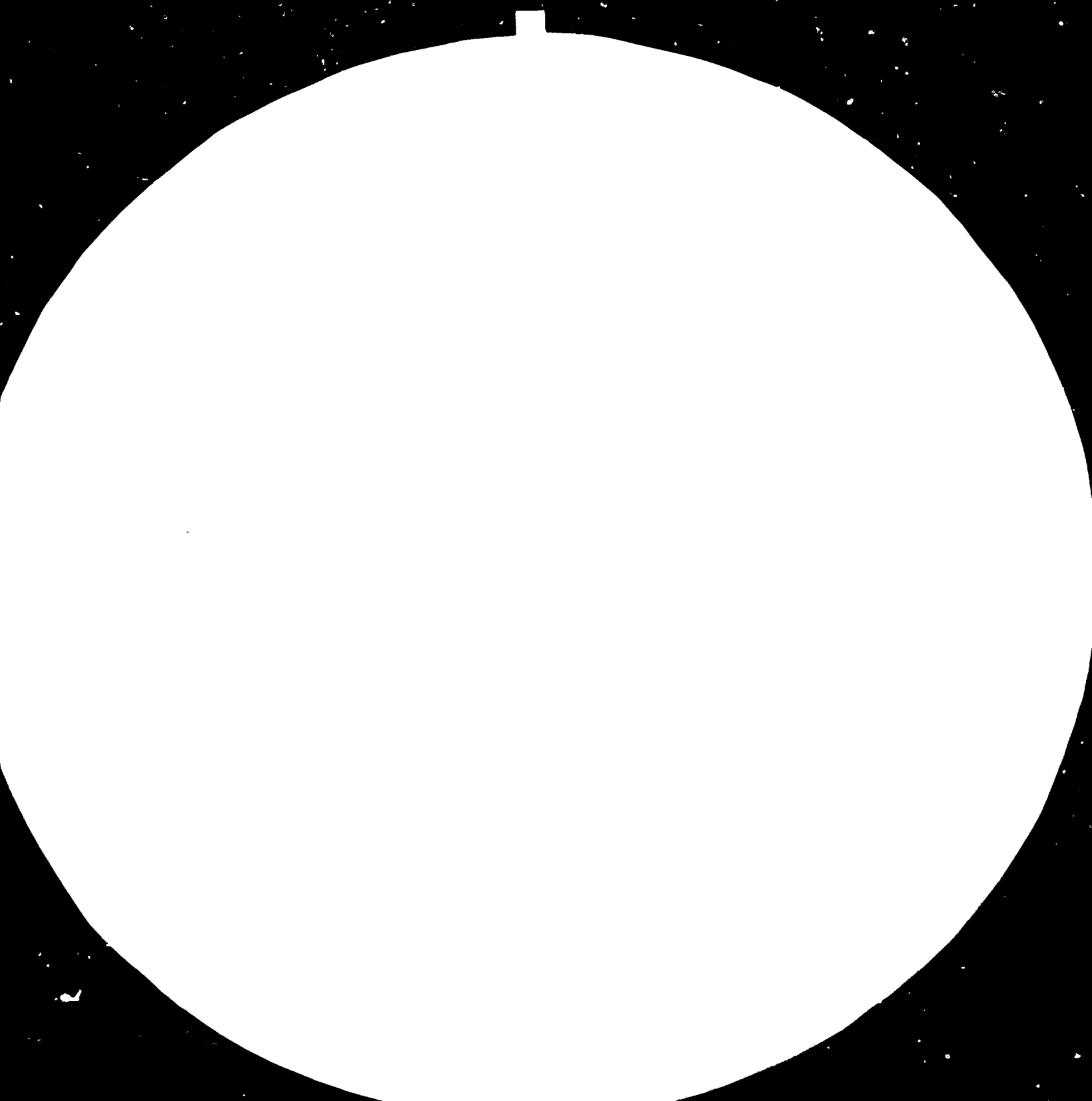

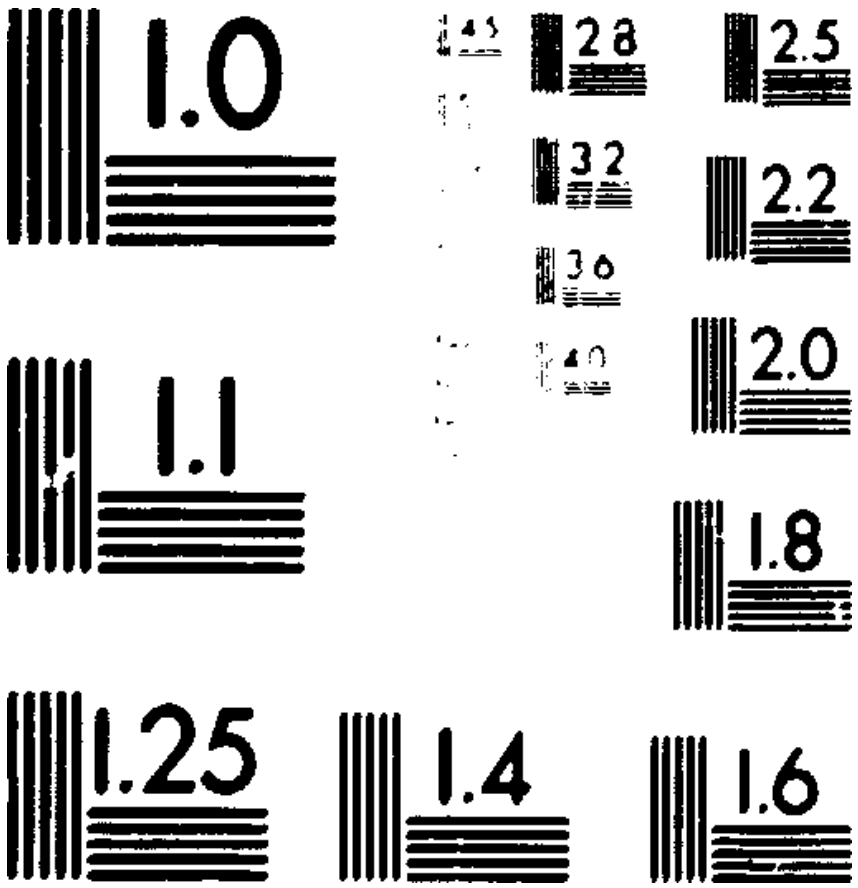

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WORLD NON-ELECTRICAL MACHINERY

LES MACHINES NON ELECTRIQUES DANS LE MONDE

LA MAQUINARIA NO ELECTRICA EN EL MUNDO

ABSTRACT / SOMMAIRE / EXTRACTO

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ABSTRACT

This publication focuses on the production of machine tools, an important subsector of the non-electrical machinery industry. The world-wide structure of firms in this subsector is analysed, both from a long-term perspective and with regard to recent developments. The importance of trade performance and changes in comparative advantage is stressed. In this connection, the growth of world exports and their changing composition receive particular attention.

The machine tools produced by the subsector are surveyed in terms of type, purpose and size. A basic distinction according to type is that between metal-cutting and metal-forming machines. In 1980, metal-cutting machines accounted for about three quarters of world machine-tool production in terms of gross value. With regard to purpose, machine tools can consist of general-purpose (i.e. universal) as well as special-purpose items. The former are designed for producing small batches of different workpieces, while the latter are intended for large-batch production of a single type of workpiece in a sequence of operations. Finally, machine tools may be described in terms of size, which in turn depends on the sizes of the components to be produced. Large machines are complex and the demand for them is limited; hence, their production and use are still confined to the developed countries. Producers in the developing countries are primarily concerned with small, low-cost, universal machines because the production technology is relatively simple and domestic requirements for machine tools are not sophisticated.

In the period 1966-1981, gross world output (at current prices) increased more than four-fold, while the value of exports rose by an even greater amount. The industry's highly cyclical nature was made apparent by production slow-downs in 1971, 1976 and 1981. In several of the major producing countries, these fluctuations may be attributed to changing patterns of investment in equipment. Thus, the industry's problems are more than a reflection of cyclical forces; they are also the result of the general slow-down in world economic activity. A second salient characteristic is the steady rise in exports as a percentage of world production—from 28 per cent in 1966 to 43 per cent in 1981. This trend, which is explored in detail, promises to figure prominently in the industry's future development.

The developing countries play only a modest role in world production and exports of machine tools, and their share did not increase significantly during the period 1966-1980. Users of machine tools in those countries are heavily dependent on suppliers in developed countries, and the policies adopted with regard to the machine-tool industry by the Governments of the developed countries therefore have important consequences for industrial progress in the developing countries.

The production of machine tools is technically complex and requires heavy initial investment in design and testing. Markets are diverse and economies of scale do not lend themselves to the production of many types of tools. Another

obvious limitation on small and specialized manufacturers is that they cannot enjoy economies of scale in innovative activities, and thus they do not have the resources needed for large-scale research and development. Moreover, it is often risky for a small firm to invest heavily in developing sophisticated machines. All of these factors have inhibited the growth of the industry in the developing countries.

The publication concludes by focusing on recent experiences of producers of machine tools in the developing countries. It examines successful initiatives, as well as some less successful ones. The prospects for this important subsector throughout the 1980s are considered in the light of global trends and recent experience.

SOMMAIRE

La présente publication s'attache à la fabrication des machines-outils, important sous-secteur de l'industrie des machines non électriques. Elle analyse la répartition mondiale des entreprises, tant dans une perspective à long terme que selon sa récente évolution. Elle souligne l'importance des résultats commerciaux et des modifications de l'avantage comparé. A cet égard, la croissance des exportations mondiales et le changement de leur composition retiennent l'attention.

Les machines-outils fabriquées dans ce sous-secteur sont présentées par type, fonction et taille. Quant au type, on distingue essentiellement entre machines à tailler et machines à façonner. En 1980, les premières formaient près des trois quarts de la production mondiale en valeur brute. Quant à leur fonction, les machines-outils peuvent être soit universelles, soit spéciales. Les premières sont conçues pour produire de petits lots de pièces différentes, tandis que les autres sont destinées à la production de masse d'une même pièce par une succession d'opérations. Enfin, on peut décrire les machines-outils d'après leur taille, qui à son tour dépend de celle des éléments qu'elles doivent produire. Les grosses machines sont complexes et leur demande reste limitée : seuls les pays développés en produisent et en utilisent. Les fabricants des pays en développement s'occupent essentiellement de petites machines universelles et bon marché, car la technologie de la production est relativement simple, de même que les besoins intérieurs en machines-outils.

Au cours de la période 1966-1981, la production mondiale brute (aux prix courants) a plus que quadruplé, la valeur des exportations s'élevant encore davantage. Le caractère fortement cyclique de l'industrie ressort des baisses de sa production enregistrées en 1971, 1976 et 1981. Dans plusieurs des grands pays producteurs, ces fluctuations peuvent s'attribuer au changement des schémas d'investissement en biens de capital. Ainsi, les problèmes de l'industrie ne sont pas seulement l'effet de forces cycliques; ils résultent aussi du ralentissement général de l'activité économique mondiale. Autre caractéristique marquante, les exportations s'élèvent régulièrement, en pourcentage de la production mondiale, passant de 28 % en 1966 à 43 % en 1981. Cette tendance, exposée en détail, promet de s'affirmer dans l'évolution future de l'industrie.

Les pays en développement ne jouent qu'un rôle modeste dans la production et l'exportation de machines-outils, où leur part n'a pas sensiblement augmenté au cours de la période 1966-1980. Les utilisateurs y dépendent étroitement de fournisseurs installés dans les pays développés dont, par suite, les politiques nationales à l'égard de cette industrie ont d'importantes conséquences pour le progrès industriel dans les pays en développement.

La fabrication des machines-outils est d'une technique complexe et exige de gros investissements initiaux dans les études et les essais. Les marchés sont divers et les économies d'échelle ne se prêtent pas à la production de nombreux types d'outils. Autre limitation manifeste qui s'impose aux petits fabricants

spécialisés, ils ne peuvent bénéficier d'économies d'échelle dans les activités novatrices et ainsi ne disposent pas des ressources requises pour des recherches et un développement d'envergure. De plus, il est souvent risqué pour une petite entreprise d'investir fortement dans la mise au point de machines complexes. Tous ces facteurs ont entravé la croissance de l'industrie dans les pays en développement.

La publication conclut en s'attachant aux activités récentes des fabricants de machines-outils dans ces pays. Elle examine les initiatives heureuses, ainsi que d'autres qui l'ont été moins. Elle présente les perspectives de cet important sous-secteur pendant toutes les années 80 à la lumière des tendances globales et de l'expérience récente.

EXTRACTO

Esta publicación se centra en la producción de máquinas herramientas, importante subsector de la industria de maquinaria no eléctrica. Se analiza la estructura de las empresas del subsector en el mundo entero, en una perspectiva de largo alcance y en relación con los hechos más recientes. Se subraya la importancia del rendimiento de esta industria y la evolución de la ventaja relativa. A este respecto se presta especial atención al incremento de las exportaciones en el mundo y al cambio de los elementos que las integran.

Las máquinas herramientas producidas por este subsector se estudian por tipos, usos y tamaños. Una distinción básica en función del tipo es la que se hace entre máquinas para corte de metales y máquinas de conformar metales. En 1980, las máquinas para corte de metales representaban aproximadamente las tres cuartas partes de la producción mundial de máquinas herramientas en cuanto a valor bruto. Por lo que se refiere a su uso, las máquinas herramientas pueden ser de uso general (es decir, universal), y para usos especiales. Las primeras están concebidas para producir pequeñas series de piezas diferentes, mientras que las últimas se destinan a la producción de grandes series de un solo tipo de piezas mediante una sucesión de operaciones. Por último, las máquinas herramientas pueden clasificarse según su tamaño, que a su vez depende del tamaño de los componentes que hayan de producir. Las grandes máquinas son complejas y su demanda es reducida; en consecuencia, su producción y empleo todavía están limitados a los países desarrollados. Los productores de los países en desarrollo se interesan principalmente por las máquinas universales, pequeñas y de bajo costo, pues la tecnología de producción es relativamente simple y no se requieren máquinas herramientas complejas.

En el período 1966-1981 la producción bruta mundial (a precios corrientes) se cuadruplicó con creces y el valor de las exportaciones se elevó en una proporción aún mayor. El descenso de la producción en los años 1971, 1976 y 1981 puso de manifiesto el carácter sumamente cíclico de esta industria. En varios de los principales países productores estas fluctuaciones pueden atribuirse a la evolución de las características de la inversión en equipo. Así pues, los problemas de la industria son algo más que un reflejo de ciertas fuerzas cíclicas; son también el resultado de la reducción general de la actividad económica mundial. Una segunda característica notoria es el continuado aumento del porcentaje de las exportaciones con relación a la producción mundial, que pasó del 28% en 1966 al 43% en 1981. Parece que esa tendencia, que se estudia detenidamente, predominará en el futuro desarrollo de esta industria.

Los países en desarrollo cumplen sólo un modesto papel en la producción y exportación mundial de máquinas herramientas, y su participación no aumentó significativamente en el período 1966-1980 Los usuarios de máquinas herramientas en esos países dependen básicamente de los abastecedores de los

países desarrollados, y en consecuencia las políticas que adopten los gobiernos de los países desarrollados con respecto a la industria de máquinas herramientas tienen importantes repercusiones en el progreso industrial de los países en desarrollo.

La producción de máquinas herramientas es técnicamente compleja y requiere grandes inversiones iniciales en diseño y ensayos. Los mercados son muy distintos y las economías de escala no se prestan de por sí a la producción de muchos tipos de herramientas. Otra evidente limitación que afecta a los pequeños fabricantes y a los fabricantes especializados es que no cuentan con economías de escala en las actividades de innovación, y en consecuencia no disponen de los recursos necesarios para la investigación y el desarrollo en gran escala. Más aún, para una pequeña empresa suele ser arriesgado hacer grandes inversiones con miras a la producción de máquinas complejas. Todos estos factores han impedido el crecimiento de esta industria en los países en desarrollo.

La publicación termina con el examen de las experiencias recientes de los productores de máquinas herramientas en los países en desarrollo. Se da cuenta de algunas inicitavias fructíferas y de otras que no lo son tanto. Las perspectivas de este importante subsector a lo largo del decenio de 1980 se analizan a la luz de las tendencias y de los últimos datos mundiales.

WORLD NON-ELECTRICAL MACHINERY

An empirical study of the machine-tool industry

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna

WORLD NON-ELECTRICAL MACHINERY

An empirical study of the machine-tool industry

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EXPLANATORY NOTES

Regional classifications, industrial classifications, trade classifications and symbols used in the statistical tables of this survey, unless otherwise indicated, follow those adopted in the United Nations Statistical Yearbook.

The following classification of economic groupings is used in the text and in most tables, in conformity with the classification adopted by the Statistical Office of the United Nations Secretariat: "Developing countries" includes all countries, territories, cities or areas in the Caribbean area, Central and South America, Africa (other than South Africa), the Asian Middle East (other than Israel) and East and South-East Asia (other than Japan). "Developed market economies" includes North America (Canada and the United States of America), Europe (other than Eastern Europe), Australia, Israel, Japan, New Zealand and South Africa. "Centrally planned economies" includes Bulgaria, Czechoslovakia, the German Democratic Republic, Hungary Poland, Romania and the Union of Soviet Socialist Republics. Unless otherwise specified, "world" excludes Albania, China, the Democratic People's Republic of Korea, Mongolia and Viet Nam. In some tables the classification may differ slightly from that given above, depending on the source cited.

Throughout this publication, the following 13 developing countries and areas are considered as newly industrializing countries and areas (NICs); Argentina, Brazil, Colombia, Egypt, Hong Kong, India, Malaysia, Mexico, the Philippines, the Republic of Korea, Singapore, Thailand and Turkey (for definition, see *Industry in a Changing World* (United Nations publication, Sales No. E.83.II.B.6)).

Countries are generally arranged in the order adopted in the *Statistical Yearbook*. Inclusion of a particular country or area in, or its exclusion from, any economic or geographical grouping has been dictated by considerations of the availability of comparable data in statistics of the United Nations and other international agencies.

"Manufacturing" includes the industry groups listed in Major Division 3 of the International Standard Industrial Classification of All Economic Activities (ISIC) (United Nations publication, Sales No. 71.XVII.8) throughout this volume, unless otherwise indicated.

Dates divided by a hyphen (1960-1965) indicate the full period involved, including the beginning and end years.

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

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

Annual rates of growth or change refer to annual compound rates, unless otherwise specified.

In tables:

Apparent arithmetical discrepancies, such as details and percentages that do not add precisely to totals, are owing to rounding of the basic data or to differences in rounding of numbers known to different degrees of precision;

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

A dash (—) indicates that the amount is nil or negligible;

A blank indicates that the item is not applicable;

A minus sign before a figure (−2) denotes a deficit or decrease, except as indicated;

The names of countries are those in current official use.

The following abbreviations are used in this volume:

United Nations organizations

UNCTAD	United Nations Conference on Trade and Development
UNIDO	United Nations Industrial Development Organization
GATT	General Agreement on Tariffs and Trade

Other organizations

EEC	European Economic Community
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of Petroleum Exporting Countries

Economic and technical abbreviations

c.i.f.	cost, insurance, freight
FMS	flexible manufacturing system
f.o.b.	freight on board
GDP	gross domestic product
IIT	intra-industry trade
ISIC	International Standard Industrial Classification
LDC	less developed country
MVA	manufacturing value added
NC	numerical(ly) control(led)
n.e.s.	not elsewhere specified
NIC	newly industrializing country or area
R and D	research and development
RCA	revealed comparative advantage
SITC	Standard International Trade Classification
TNC	transnational corporation

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Part One

The Non-Electrical Machinery Branch

Introduction

The non-electrical machinery branch of industry makes engines and turbines, agricultural machinery, industrial machinery and office machines including computing machines.[1] Since the industrial revolution at the beginning of the nineteenth century, the branch has played a crucial role as a supplier of capital goods for production activities and, consequently, for world industrial development. In response to increasing demand, the branch has developed continuously, increasing production, diversifying its products and improving their quality. On the technical side, this expansion has been made possible by the development of machine tools and continuous research and development (R and D) in the branch.

The developing countries, recognizing the importance of non-electrical machinery as the basic means of industrial development, have also attached growing importance to this branch, aiming initially at import substitution and at possible future exports. Several developing countries, particularly among the newly industrializing countries and areas (NICs), have had some success producing less-sophisticated agricultural, textile, food-processing, metalworking and office machinery. They are increasingly competitive in world markets because of their low labour costs, and this has created increasing pressure for adjustment in the developed countries. However, world-wide production capacity in this branch is still concentrated in a few highly industrialized, developed countries and the contribution of the developing countries to world production and exports is minimal. This is due largely to the slow development of production technology and office modernization in the local user industries, and to the limited capability for product development and rationalization of production in this branch in the developing countries. The branch is characterized by the need for continuous product development. In addition, the general problems of administration and management in non-electrical machinery businesses caused by fluctuations in demand, and difficulties in exporting and market penetration, also make the development of viable indigenous production activities in this branch in the developing countries less easy.

The examination of the general characteristics of the branch in chapter I will show why the industry is so concentrated in a limited number of developed countries and what factors determine their comparative advantage in this field. It is important to understand this before going on to investigate the recent growth of production and exports and the changes in their distribution between countries in chapters II and III.

[1] Throughout this publication, the industries which produce non-electrical machinery are considered to be those classified by the International Standard of Industrial Classification (ISIC) under the code number 382.

I. General characteristics of the non-electrical machinery branch

A. Diversity of products and small scale of operations

The products produced in the non-electrical machinery branch are very diverse in several respects. Market structure and length of production run vary according to the type of product. For example, the production of chemical machines, machine tools, wood-working machines, food-processing machines, dies, tools and jigs is usually based on small production runs, while large-scale production is normal for engines and turbines, construction machines, small office machines, agricultural machines and ball- and roller-bearings. Furthermore, many types of industrial machines are produced on specific orders from customers. Hence, even in large establishments, multiple-production runs for small-batch production are common, except for a few products such as small office equipment and hand tools. In the case of parts and components, production is usually in small batches of multiple-products, carried out by small- and medium-size establishments who are all in competition with one another. These firms are closely connected with their customers through subcontracting or subsidiary-parent relationships. Technical collaboration between them and the customers (parent firms) is extremely important to the latter to ensure that standardization requirements are met and to enable them to make frequent changes in their product models.

Reflecting these characteristics, the branch consists typically of a few large firms and many small- and medium-size firms that are highly specialized in a narrow range of products. In fact, the concept of economy of scale is often no relevant for production in this branch. A study showed that, in the United States of America, labour productivity in the agricultural machinery industry increased as firm size increased, but the reverse was the case for machine tools, dies, tools, jigs, and textile machinery.[1]

Both in Japan and in the United States, the average number of employees per establishment in the branch was less than fifty.[2] Furthermore, in the majority of developed countries, the average size of firm decreased in the 1970s in terms of both number of employees and value added. This was partly due to the increasing fragmentation of production processes and product specialization which was part of the adjustment process in these countries brought about by increasing competition in both domestic and overseas markets for non-electrical machinery.

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[1]See Howard Pack, "Fostering the capital goods sector in LDCs", *World Development*, vol. 9, No. 3 (1981), p. 228.

[2]Based on data supplied by the Statistical Office of the United Nations Secretariat.

B. Factor intensity

Probably the most important characteristic of production in the non-electrical machinery branch is its technological intensity. Compared to the average for all manufacturing, the non-electrical machinery branch is R-and-D-intensive and manpower-intensive, but non capital-intensive. Continuous R and D effort and efficient use of human resources are essential for the development of this branch and the maintenance of its competitive position in the world market. Owing to their relative advantage in this respect, a few highly industrialized countries have, since the beginning, enjoyed a predominant position in world production of non-electrical machinery. At the same time, as is shown in the following chapter, the fact that, in this industry, production is less capital-intensive and that scale economy is not relevant, has encouraged a growing emphasis on the development of some less sophisticated kinds of production in the developing countries. Particularly in recent years, the increasing need for a reduction in costs in the developed countries has encouraged producers of non-electrical machinery in those countries to make more effort to transfer certain production processes to the developing countries.

Automated production has been one of the major concerns among manufacturers in the developed countries both in order to reduce costs and to increase productivity. The desire for automation accelerated around the mid-1950s when international trade started increasing rapidly along with the gradual removal of trade barriers. Increasing price competition, the decreasing availability of labour and the consequent wage increases necessitated the introduction of labour-saving machinery with higher productivity. Reflecting this demand from machinery users, production of automated machinery started increasing rapidly with continuous innovation. For example, both in the United Kingdom of Great Britain and Northern Ireland and in the United States of America, the proportion of automated machinery in total machinery deliveries increased, in terms of value, from around 10 per cent in the mid-1950s to almost 30 per cent in the mid-1970s.[3] This tendency was further accelerated from the late 1970s onwards, particularly in the engineering industries. (This aspect will be discussed in more detail in part two.) As a consequence, the relative importance of product research related to automatization and labour-saving has been increasing in R and D activities in the branch. Thus, current industrial restructuring has led to a substantial shift in the technological and commercial aspects of this sector.

The relative factor intensities in an industry are difficult to measure precisely. To give a crude comparison between the non-electrical machinery branch and all other manufacturing, table 1 shows value added per employee, wage bill per employee and non-wage value added per employee for selected countries, the values for non-electrical machinery being expressed as a ratio of those in total manufacturing. For most of the countries, relative wage bill per

[3] For details, including the definition of the degree of automaticity, see R. W. Coombs, "Innovation, automation and the long-wave theory", *Futures*, vol. 13, No. 5 (October 1981), pp. 364-366.

Table 1. Relative factor intensities in the production of non-electrical machinery in selected countries, 1970 and 1978

(In ratio to the same factor intensity in total manufacturing)

Country	Relative value added per employee		Relative wages and salaries per employee		Relative non-wage value added per employee	
	1970	1978	1970	1978	1970	1978
Developed market economies						
Germany, Federal Republic of	0.837	0.852[a]	1.075	1.067[a]	0.659	0.679[a]
Italy	1.029	1.094	1.108	1.051	0.973	1.123
Japan	1.141	1.047	1.235	1.192	1.097	0.958
Sweden	0.908	0.941	1.050	1.022	0.752	0.868
United Kingdom	1.002	1.011	1.072	1.047	0.926	0.960
United States	1.006	1.026	1.117	1.112	0.906	0.965
Centrally planned economies						
Czechoslovakia	1.080	1.003	1.093	1.091	1.068	0.959
Hungary	1.072	1.025	1.107	1.044	1.059	1.018
Developing countries						
Brazil	1.032	...	1.475	...	0.899	...
Chile	0.484	0.636[a]	0.994	1.180[a]	0.369	0.521[a]
Colombia	0.853	0.669	1.093	0.956[a]	0.773	0.603
India	1.085	1.405[a]	1.137	1.339[a]	1.039	1.476[a]
Republic of Korea	0.571	0.942	0.918	1.223	0.455	0.837
Singapore	0.825	0.990	1.005	1.140	0.723	0.914
Turkey	0.992	0.824[a]	1.230	1.115[a]	0.909	0.648[a]

Source: Based on data supplied by the Statistical Office of the United Nations Secretariat.
[a] 1977.

employee is greater than unity. This implies that the branch is relatively skill-intensive. On the other hand, relative non-wage value added per employee is smaller than unity in most cases, which results from the fact that the branch is less capital-intensive.

Table 2 compares the non-electrical machinery branch and the manufacturing sector as a whole in respect of relative R and D expenditure and manpower. At least in the developed market economies, the high R and D expenditure and manpower intensities in the branch are obvious. A substantial amount of R and D expenditure and manpower, including the number of scientists and engineers in the branch, is involved in computer-related fields. For example, in the United States, the EEC countries and Japan, 70 per cent, 40 per cent and 30 per cent respectively of total R and D expenditure in the branch is for computer-related work.[4]

[4] Derived from data provided in the Organisation for Economic Co-operation and Development (OECD), *Trends in Industrial R and D, 1967-1975* (Paris, 1975).

Table 2. Measures of R and D intensity in non-electrical machinery and in total manufacturing in selected developed market economies, 1975[a]

Country or area	*R and D expenditure in relation to gross output*			*R and D manpower in relation to total number of employees*			*Number of research scientists and engineers in relation to total number of employees*		
	Machinery[b] (percentage)	*Total manufacturing (percentage)*	*Ratio of machinery to total manufacturing*	*Machinery[b] (percentage)*	*Total manufacturing (percentage)*	*Ratio of machinery to total manufacturing*	*Machinery[b] (percentage)*	*Total manufacturing (percentage)*	*Ratio of machinery to total manufacturing*
EEC countries[c]	1.99[d]	1.50	1.325[d]	2.30	2.30	1.133	0.81	0.61	1.332
Japan	1.49	1.22	1.219	2.94	2.76	1.062	1.58	1.29	1.228
United States	3.21	2.26	1.418	. . .	. . .	. . .	2.65	2.02	1.307

Source: Based on data given in OECD, *Trends in Industrial R and D, 1967-1975* (Paris, 1979); data supplied by the Statistical Office of the United Nations Secretariat and estimates by the UNIDO secretariat.

[a] All calculations were based on data in current dollars.

[b] Non-electrical machinery including professional and scientific equipment, photographic and optical goods (ISIC 382 and 385).

[c] Excluding Luxembourg.

[d] Estimates.

C. Factors determining location of production

R and D capacity

As seen in the previous section, the production of non-electrical machinery is characterized by intensive R and D and technology. This means that one of the most important factors determining the location of production is R and D capability.

World R and D activities are concentrated in highly industrialized developed countries. In the OECD member countries as a whole, around $5.8 billion were spent in 1975 for R and D activities in the non-electrical machinery branch, which was 13 per cent of that year's total R and D expenditure in the entire manufacturing sector in these countries. Of the $5.8 billion, the United States, EEC countries and Japan accounted for 55 per cent, 30 per cent and 10 per cent, respectively.[5] As for the number of scientists and engineers employed, the United States, EEC countries and Japan accounted for 56 per cent, 24 per cent and 18 per cent, respectively.[6] Comparing these figures to their corresponding shares in value added, 33 per cent, 43 per cent and 16 per cent, world R and D effort and available manpower resources appear to be highly concentrated in these few industrialized countries. However, among these highly industrialized countries, the type of R and D differs from country to country. Some countries' R and D is expenditure-oriented and that of others is manpower-oriented. Furthermore, the relative importance of sources of R and D funds differs from country to country. For example, among major developed market economies, government contribution was substantial in the Federal Republic of Germany and, to a lesser extent, in Canada, Italy and Sweden. Funds from abroad were significant in Canada. In Japan, R and D was almost entirely financed by the private sector (see table 3).

The development of microcircuits together with the growing need to reduce costs in the developed countries resulted in the rapid development of computerized industrial machinery for automation in the 1970s. Industrial robots and numerically controlled machine tools have become "programmable" or "flexible". Market competitiveness became tough due to stagnant world demand and to the emergence of several NICs in the non-electrical machinery market. In order to survive in these technological and market conditions, the developed countries have been increasingly required to invest in R and D, although investment in R and D is becoming increasingly costly and is often not connected with immediate profits. During the period 1967-1975, taking OECD countries as a whole, the real increase in R and D expenditure and manpower in the non-electrical machinery branch was not as remarkable as in some other industries (see table 4). However, table 5 shows that, taking the countries separately, several major producers such as Canada, the Federal Republic of Germany, Italy, Japan and Sweden, recorded remarkable increases

[5] Estimates based on data provided in OECD, *op. cit.*

[6] This includes those employed in the branch of professional and scientific equipment, photographic and optical goods (ISIC 385), where the relative importance of R and D is small compared to non-electrical machinery as a whole.

either in R and D expenditure or manpower or both. On the other hand, the United Kingdom recorded substantial decreases in these, which resulted, as seen later, in the declining share of that country in the world market for non-electrical machinery.

Table 3. Sources of funds for R and D in non-electrical machinery[a] in selected developed market economies, 1975

(Percentage)

Country	*Private*	*Government*	*Foreign*	*Total*
Canada	65	13	22	100
France	91	7	2	100
Germany, Federal Republic of	79	20	1	100
Italy	85	15	—	100
Japan	99	1	—	100
Sweden	90	10	—	100
United Kingdom	87	8	5	100
United States	91	9	—	100

Source: OECD, *Trends in Industrial R and D, 1967-1975* (Paris, 1979), p. 50.

[a]Non-electrical machinery including professional and scientific equipment, photographic and optical goods (ISIC 382 and 385).

Table 4. Real trends in R and D in manufacturing, OECD countries, 1973 and 1975

(1967 = 100)

	R and D expenditure		*R and D manpower*[a]		*Research scientists and engineers*	
Industry	*1973*	*1975*	*1973*	*1975*	*1973*	*1975*
Aircraft (including other aerospace products)	75	70	. . .	. . .	77	72
Electrical machinery (including computers)	120	117	116	133	117	123
Chemicals (excluding rubber and plastic products)	115	125	106	110	113	121
Other transport equipment	149	135	149	162	136	145
Non-electrical machinery; professional and scientific equipment; photographic and optical goods (excluding computers)	110	110	117	118	126	133
Basic metals; metal products except machinery	102	110	89	88	99	103
Food, beverages and tobacco; textiles and leather products; rubber and plastic products	116	124	99	101	105	114
Wood and cork products; paper products; non-metallic mineral products; miscellaneous manufactures	128	131	115	121	132	141

Source: OECD, *Trends in Industrial R and D, 1967-1975* (Paris, 1979), pp. 29-66.

[a]Excluding the United States.

Table 5. Trends in R and D in the combined branches of non-electrical machinery[a] in selected developed market economies, 1967-1975

Country	*R and D expenditure*	*Number of research scientists and engineers*	*R and D manpower*
Austria	***	---	***
Belgium	-	*	**
Canada	***	**	**
Denmark	***	--	**
Finland	***	***	***
France	*	*	-
Germany, Federal Republic of	*	***	***
Ireland	***	***	***
Italy	***	**	***
Japan	***	***	**
Norway	***	***	***
Sweden	**	***	*
United Kingdom	--	--	--
United States	*	*	---

Source: OECD, *Trends in industrial R and D in selected OECD member countries, 1967-1975* (Paris, 1979), pp. 53 and 79-82.

Key: *** 50 per cent or more increase
** 25-49 per cent increase
* 3-24 per cent increase
- 3-24 per cent decrease
-- 25-49 per cent decrease
--- 50 per cent or more decrease

[a]In this case, computers, professional and scientific equipment, and photographic and optical goods are excluded.

The general lack of manpower and R and D infrastructure in the developing countries is the most serious restriction on the development of indigenous production of non-electrical machinery. The development of the non-electrical machinery industries in these countries has, instead, been initiated by the international spread of technical know-how, exported in the forms of patents and licences, and of direct foreign investment by established producers in the developed countries. In this, as in the case of other engineering industries, transnational corporations (TNCs) play an important role, particularly in the fields of assembly and parts production.[7]

The low capability for R and D in this branch in the developing countries not only restricts the rapid expansion of the branch but also affects to some extent the efficiency of the entire domestic economy. The main source of advantage in the developing countries is the low cost of labour.[8] In addition,

[7]Given the cost of research and the relative lack of trained manpower, it is likely that for the developing countries a quick result can be achieved more cheaply by licensing.

[8]It is commonly recognized that low labour cost is the main comparative advantage in the developing countries. However, an obvious question is whether the per capita wage level relative to labour productivity in the developing countries is lower than that in the developed countries. For example, labour productivity in the textile-machinery firms in India and the Republic of Korea was estimated to be at the most 20 to 40 per cent of that in the developed countries. On the other hand, average wages in these firms were less than 10 per cent of those in the developed countries. Thus, even if the difference in per-employee capital cost is excluded from the calculation, labour costs in the developing countries are substantially lower than those in the developed countries. Owing to this cost advantage and to a shortage of investment funds, producers in the developing countries tend to choose more labour-intensive production to minimize costs (Pack, *loc. cit.*, pp. 231-237).

raising the level of employment is one of the most important policy goals in most developing countries. Therefore, the adoption of labour-intensive processes with labour-intensive machinery is more appropriate in these countries, although this is not fully recognized by either the countries' users or producers of machinery. The machinery produced in the developed countries is, in general, labour-saving. Machinery users in the developing countries often import these labour-saving machines which have a much higher capacity than actually needed. Furthermore, most major domestic machinery producers in developing countries produce, under licensing or patent agreements with firms in the developed countries, identical or similar machines to those produced in the developed countries without adapting them to more labour-intensive use. This is partly because of strong government protection against imports resulting in monopolistic production in the domestic market and an unwillingness to be innovative in design, and partly due to the absence of experienced manpower and other general R and D infrastructure. Even if R and D manpower exists, import-substitutive industries in the developing countries tend to attach importance to cost reduction (process research) but not to design improvement (product research). (This is discussed further in relation to machine tools in part two.) This, in turn, discourages the manufacturers in user industries from improving production technology and, thus, does not stimulate their demand for machines.

Some NICs do attempt design modifications to reduce the capital-labour ratio in user industries. For example, several Argentine firms produce food-processing machines that are less mechanized than those produced in the developed countries for the same purpose. Similar examples can also be seen in Brazil and India. However, these are rather exceptional cases. Most major firms producing non-electrical machinery in the developing countries carry out licensed production of unaltered machinery and do not modify their initial designs when the licensor does.[9] This has important consequences. Continuous design improvement in the developed countries while the developing countries continue to produce older versions of machines tends to give the developed countries a technical dominance in which the machines produced in their countries are less expensive to use regardless of relative factor costs. Thus, the effect of intensity of innovation in non-electrical machinery offers a somewhat different picture from that of the goods included in the product-cycle model (e.g., consumer durables).

Nevertheless, the developing countries have continued to increase their share in world output as well as in world exports of non-electrical machinery on the basis of low labour costs and strong government protection. They have mostly concentrated on the production of parts and components and on assembly of standardized machines with lower technological requirements. For other types of machines, the developed countries are still predominant in the world market and competing among themselves on the basis of product development.

[9]Two loom producers in India offer an example. In 1974, one produced a Swiss automatic loom of the late 1950s and early 1960s; the second a semi-automatic loom according to a 1950 Japanese design. (For more detail, see Pack, *loc. cit.*, pp. 237-244.)

Industrial linkage

Industrial-linkage development is another important determinant of comparative advantage in the developed countries. The world's leading countries in non-electrical machinery production also enjoy the benefits of having strong engineering industries relevant to the branch. For example, in 1975, the non-electrical machinery branch itself, the iron and steel industry and the electrical-machinery industries contributed 26 per cent, 11 per cent and 5 per cent respectively of Japanese gross output of non-electrical machinery.[10] Thus, the existence of these industries as efficient suppliers of direct inputs to the production of non-electrical machinery is particularly important. Among these, one can assume a growing importance of the electrical-machinery industry as a direct input supplier to the non-electrical machinery branch in recent years as a result of the increasing application of electronics in non-electrical machinery. In any case, in the developed countries, the development of the non-electrical machinery industry has depended greatly upon the existence and development of these other supporting industries.

Another advantage of industrial linkage in the developed countries is the existence of an efficient subcontracting network which tends to reduce costs and improve technology. Small firms concentrating on large-batch production of selected parts or components common to a large number of users obtain the benefits of cost reduction through full utilization of special-purpose machine tools and of increasing technical competence through specialization. In the developing countries, subcontracting is still in its infancy although an increasing emphasis has been attached to it in recent years. For example, despite efforts to foster a subcontracting system in the late 1960s, the largest machine-tool-producing firm in India purchased only 10 per cent of its inputs outside the firm. A comparable figure for a producer in Western Europe was 40 per cent.[11]

In the developing countries as well as in very small developed countries, opportunities for expansion of the branch are generally limited by the lack of efficient support from the rest of the economy in these countries. Therefore, the branch's dependence on the import of required inputs is much higher, particularly in the production of final goods.[12] For these countries, the fields in which comparative advantage may exist are really limited to the fields of labour costs and government policies.

Size of domestic demand

Finally, the existence of sufficient domestic demand is also an important factor. As seen earlier, economy of scale plays an important role in increasing productivity of the kind of standardized non-electrical machines in which the

[10]Based on the 1975 input-output table for Japan presented in *Japan Statistical Yearbook* (Statistics Bureau, Prime Minister's Office, 1980), pp. 530-537.

[11]Pack, *loc. cit.*, p. 233.

[12]Even in those direct input industries existing in a developing country, the prices of their products are often higher than those of corresponding imports because of government protection, inefficiency in production or small production runs in those industries.

developing countries could have a comparative advantage. But many developing countries as well as small developed countries are at a disadvantage in the production of these machines, even though the production is not technology- or skill-intensive but labour-intensive, because of their small domestic markets. Thus, they can only produce viably for export. This is aggravated by the fact, frequently seen in the developing countries, that strong protectionist measures (such as import restrictions, tax and non-tax incentives) provided by Governments encourage the establishment of firms whose production capacity exceeds actual demand. Thus, lack of opportunity for large-batch production together with technical and managerial inefficiencies in production result in a capacity utilization of often less than 50 per cent. Production is then saddled with high fixed costs. Consequently, they seek to export or to diversify their product range in order to reduce the excess capacity regardless of the initial purpose of production. This, however, is not an easy task. The designs of machines which meet the requirements of domestic customers often differ from those which meet the requirements of export markets. At the same time, technical and economic feasibility limits diversification of production to a narrow range of products, unless there are additional protectionist measures. In any case, a change in their strategy requires an alteration in their production structures. In part two, this aspect will be discussed in more detail in the case of machine tools.

In summary, R and D capability, the existence of efficient supporting industries and the existence of sufficient domestic demand are critically important in achieving world competitiveness and, thus, are essential for the development of the branch in any country. The field in which relative labour cost is the most important factor determining comparative advantage is limited to the production of standardized machines, parts and components for which product development is less important. These factors change over the years.

The changes in comparative advantages in the international markets and the consequent changes in world distribution of production capacity and exports are investigated in the following two chapters.

II. World production and structural change

A. World distribution of production capacity

Traditionally, world production capacity of non-electrical machinery has been concentrated in the established industrial centres. Until the early 1950s, the traditional suppliers of non-electrical machinery, such as Germany, the United Kingdom and the United States, shared the world market among themselves. In the 1950s, however, the production capacity of non-electrical machinery started spreading rapidly from one developed country to another and, at the same time, world trade in non-electrical machinery started expanding rapidly with the removal of trade barriers. The 1960s saw the emergence of new international competitors. These countries, such as Canada, Italy, Japan, the Union of Soviet Socialist Republics and several European centrally planned economies rapidly increased their capacity to produce and export during the decade. Consequently, the production shares of the traditional suppliers declined substantially.

In the 1970s, another phase of expansion took place in several NICs. This reflected these countries' increasing efforts towards self-reliance in the field of capital goods and the promotion of export industries, including those producing parts and components for capital goods. This was greatly encouraged by the growing world-wide integration of engineering industries through the "fragmentation of production processes" in which transnational corporations played an important role.[1] At the same time, following on from the imitation of foreign technology, production with indigenous technology was also emerging in some of these countries in limited fields of agricultural, food-processing and textile machinery, and office equipment, stimulated by government-sponsored R and D. As a consequence, the developed countries' price competitiveness declined rapidly in world markets for these relatively less sophisticated types of machinery as well as for machine parts and components. This led to further product specialization between the developed countries and the developing countries. Production lines in the non-electrical machinery industries in the developed countries shifted to highly technology-intensive fields in which the developed countries could sustain a comparative advantage, while less technology-intensive and more labour-intensive parts of the production process were transferred to the developing countries, taking advantage of their lower wage costs. Reflecting the nature of a lower technology requirement, the type of assembly established in the developing countries was mostly single-production runs for mass production of standardized products. This shift often coincided with the continuing shift of the corresponding machinery-user industries to the

[1] See *World Industry in 1980* (United Nations publication, Sales No. E.81.II.B.3), p. 149.

developing countries (e.g., the textile industry, the food-processing industry and other light industries).

Nevertheless, since all of the factors determining world competitiveness mentioned in chapter I favour location in the developed countries, the production of non-electrical machinery is still highly concentrated in these countries. Although demand for industrial machinery has been increasing rapidly,[2] the contribution of the developing countries as a whole to world non-electrical machinery production is very small.

Figure I shows the growth of production and the changes in the world distribution of value added at constant prices in the non-electrical machinery branch since 1963. During the period 1963-1979, world net output of the branch increased 2.6-fold, slightly faster than that of total manufacturing value added (MVA) in the sixteen years. In 1963, the shares of the developed market economies, the centrally planned economies and the developing countries were 83 per cent, 15 per cent and 2 per cent, respectively. This distribution was basically unchanged until 1970. However, among the developed countries, a remarkable transition occurred in world leadership in terms of production share during the 1960s. By 1970, the share of Japan had increased dramatically while that of the traditional producers (France, the Federal Republic of Germany, the United Kingdom and the United States) had decreased.

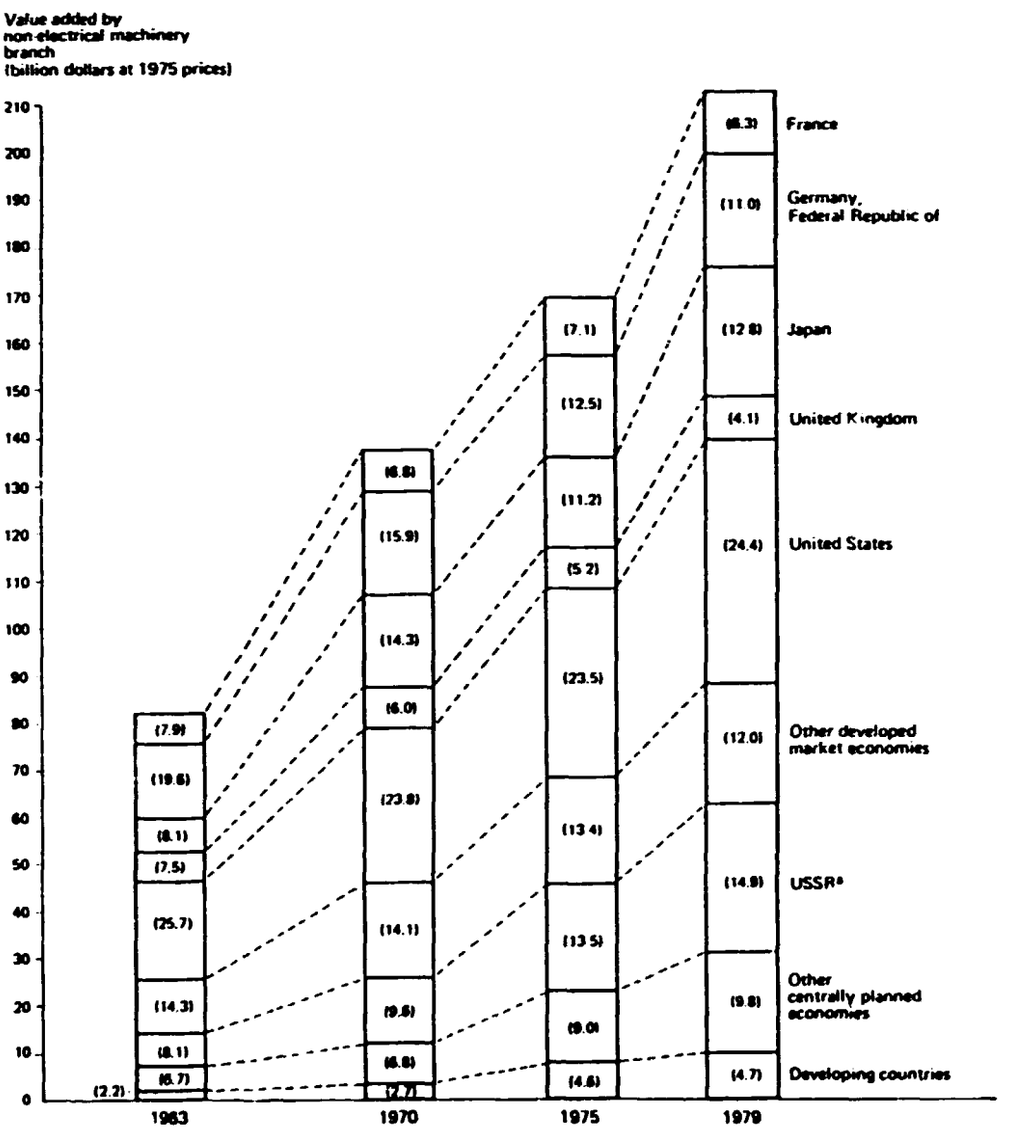
During the period 1970-1979, production growth in the developed market economies slowed down while that in the centrally planned economies and the developing countries continued to increase rapidly. Consequently, the share of the developed market economies declined from 81 per cent to 71 per cent while the shares of the centrally planned economies and the developing countries increased substantially from 16 per cent to 25 per cent and from 3 per cent to 5 per cent, respectively. However, concentration of world production in the hands of a few large producers was reduced only slightly. In 1979, six countries (France, the Federal Republic of Germany, Japan, the United Kingdom, the USSR and the United States) accounted for 74 per cent of world net production, compared to their combined shares of 77 per cent in 1963 and 76 per cent in 1970. Four countries (the Federal Republic of Germany, Japan, the USSR and the United States) accounted for 63 per cent in 1979, compared to 62 per cent in 1963, and 64 per cent in 1970.

Net production in the developing countries increased 5.6-fold during the period 1963-1979, with an acceleration during the first half of the 1970s. As seen in figure II however, only a few developing countries contributed to this growth, production being highly concentrated in those few countries. The major contributors during the 1960s were Argentina, Brazil, India and Mexico. During the first half of the 1970s, they were Brazil, Mexico, Peru and a few Asian countries such as the Islamic Republic of Iran, the Republic of Korea, Singapore and Turkey. (See also table 19 in the annex to part one.) In 1963, Argentina, Brazil, India and Mexico accounted for 74 per cent of total net output produced by the developing countries. During the period 1963-1970, these four countries' share increased to 78 per cent. In 1975, their share still

[2] A study has suggested that income elasticities of demand for agricultural machinery, office machines and metal-working machinery were considerably higher in the developing countries (Romeo M. Bautista, "Import demand for capital equipment in the Philippines", *Weltwirtschaftliches Archiv*, vol. 116, No. 3 (1980)).

remained at 78 per cent. Brazil's share increased from 18 per cent in 1963 to 42 per cent in 1975 as a result of a dramatic growth in net production, particularly in the early 1970s. In 1975, two South American countries, Argentina and Brazil, accounted for 57 per cent of total net production of non-electrical machinery in the developing countries, compared to their combined share of 45 per cent in 1963. Considering that the total share of the developing countries in world net output is small, the predominance of these

Figure I. World distribution of net manufacturing output in non-electrical machinery (ISIC 382), by country and economic grouping, 1963, 1970, 1975 and 1979

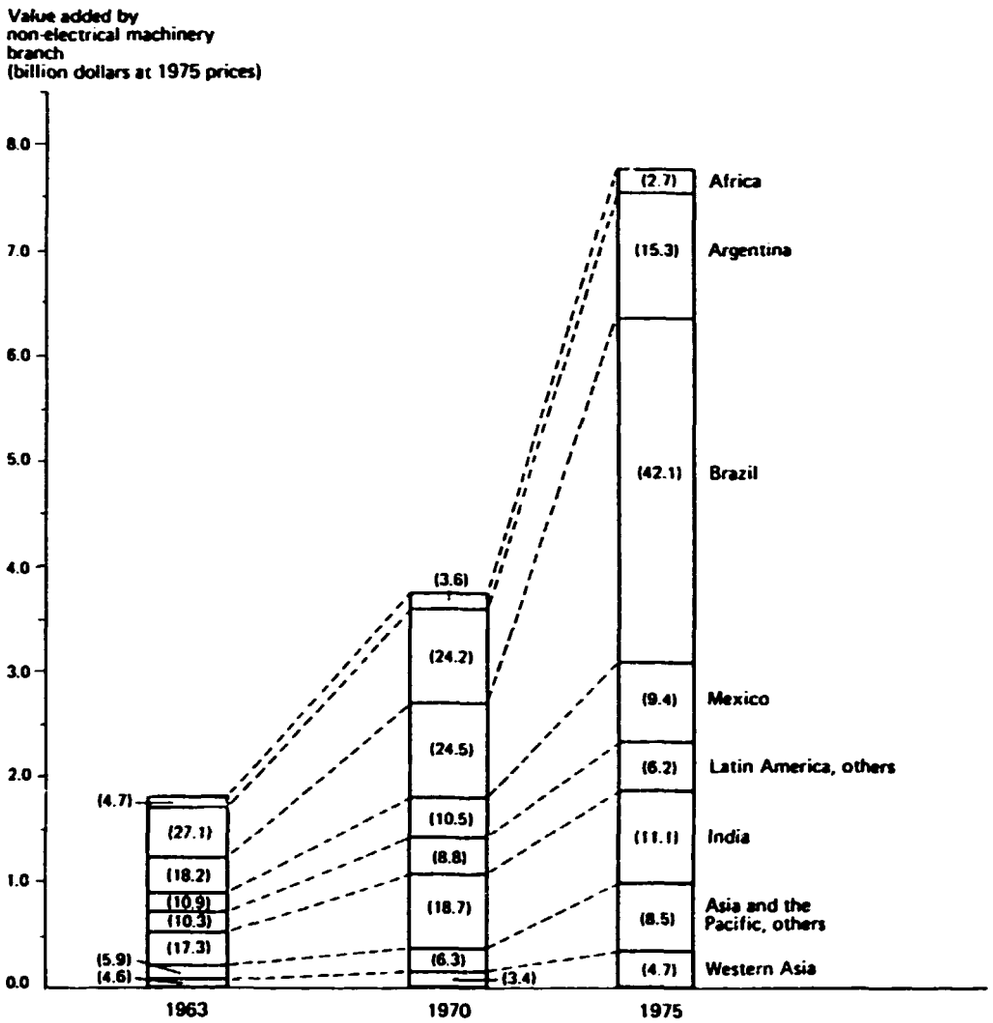


Source: Based on data supplied by the Statistical Office of the United Nations Secretariat and estimates by the UNIDO secretariat.

Note: Figures in parentheses are the branch's percentage share of world value added.

[a]Crude estimates.

Figure II. Growth and distribution of net manufacturing output in non-electrical machinery (ISIC 382) among developing countries and regions, 1963, 1970 and 1975



Source: Based on data supplied by the Statistical Office of the United Nations Secretariat and estimates by the UNIDO secretariat.

Note: Figures in parentheses are the percentage share of each developing country or region in the total value added by the non-electrical machinery branch.

few countries reflects the fact that production is non-existent or negligible in most of the other developing countries. During the latter half of the 1970s, however, the combined share of the four leading producers (Argentina, Brazil, India and Mexico) was reduced to 74 per cent due to the rapid production expansion in several other NICs such as the Republic of Korea and Singapore.

The growth of net output in the non-electrical machinery branch is, of course, related to the level of investment in the branch. Table 6 shows annual averages of gross capital formation as a percentage of value added and annual growth rates of value added in selected countries. Taking six selected developed market economies in the 1970s, the ratio of investment to value added tended

Table 6. Average annual growth rate of net output and ratio of gross fixed-capital formation to net output in the non-electrical machinery branch in selected countries within economic grouping, 1963-1978

(Percentage)

Country	Real average annual growth rate of value added[a]			Average annual ratio of gross fixed capital formation to net output[b]		
	1963-1969	1969-1975	1975-1978	1964-1969	1970-1975	1976-1978
Developed market economies						
France	4.41	5.75	1.47	11.57	4.53	3.85
Germany, Federal Republic of	2.90	0.52	1.67	10.14	10.52	7.84[c]
Italy	5.16	3.82	5.40	...	12.23	10.15
Japan	17.02	3.63	7.84	11.39	10.55	5.34
United Kingdom	4.26	1.42	−1.22	...	6.57	7.34
United States	8.65	4.65	7.27	5.58	5.59	6.53
Developing countries						
Brazil	17.03	29.23	2.62	8.24	13.73[d]	...
Colombia	6.63	11.74	14.45	12.72	7.35	...
Mexico	15.06	7.43	6.04	...	4.92	...
Republic of Korea	10.27	22.21	33.09	17.07[e]	21.99	48.19
Singapore	2.43	28.85	5.70	13.76	30.98	23.01
Turkey	6.93	23.80	3.47	24.09	...	14.28

Source: Based on data supplied by the Statistical Office of the United Nations Secretariat and on estimates by the UNIDO secretariat.

[a] Based on constant 1975 dollars.

[b] Based on current dollars.

[c] 1976-1977.

[d] 1970-1974.

[e] 1967-1969.

to decrease in France, the Federal Republic of Germany, Italy and Japan, while that in the United Kingdom and the United States tended to increase. The capital coefficient varies widely from country to country. The United States achieved one of the fastest growth rates in production although the investment level in the country was relatively low. The relatively high capital coefficient in the United States was probably a result of the country's outstanding R and D investment (see table 2). Among the six selected developing countries, the Republic of Korea and Turkey recorded a high investment ratio in the 1960s, while Brazil, the Republic of Korea and Singapore recorded high investment ratios in the 1970s in relation to their starting points. The changes in the growth of production in these countries were closely related to the changes in the level of investment, although the capital coefficient differs from country to country. The incremental capital-output ratio (ICOR)[3] in the period 1970-1975,

[3] The ratio of the value of investment to the incremental value of net output. Here, the average ICOR was derived as the ratio of the average annual investment per unit of net output to the average annual growth rate of net output.

was relatively low (which implies a relatively high capital coefficient) in the three Latin American countries, compared to that in the two Asian countries, the Republic of Korea and Singapore. This can be explained by the fact that the two Asian countries were newcomers, and the capital coefficient in the early stage of development is generally low because of the small proportion of equipment investment in relation to total capital invested.

B. Changing importance of the branch in the manufacturing sector

The share of a country in world net output of non-electrical machinery can be compared to that country's share in world total manufacturing net output. The degree of specialization of a developed country in non-electrical machinery production relative to other developed countries is shown in table 18 in the annex. This was measured by the ratio of the country's share in total net output of non-electrical machinery in the developed countries to the country's share in total manufacturing value added in the developed countries. This ratio is called simply "the relative specialization index".[4] Similarly, the relative specialization index for each developing country within the group of developing countries is shown in table 19 in the annex.

Among the developed countries, the variation in the specialization index increased during the period 1963-1979.[5] Thus, non-electrical machinery was a dynamic growth industry only in a certain number of countries (11 out of the 28 developed countries sampled had an index exceeding 1.0). On the other hand, because of the high level and growth of Brazilian non-electrical machinery production, the index for most of the other developing countries decreased during the period. In 1975, only five countries (or 8 per cent) of the 65 developing countries sampled recorded an index exceeding 1.0, compared to 12 countries (or 22 per cent) of the 55 developing countries sampled in 1963. In 1975, 71 per cent of the developing countries had an index of less than 0.5 compared to 59 per cent in 1963.

Table 7 summarizes the relationship between growth in the non-electrical machinery branch and that in the manufacturing sector. While a comparison of absolute growth rates between the country groupings indicates the change in each group's share in world net output of non-electrical machinery, relative growth indicates the change in the share of non-electrical machinery in total manufacturing value added (MVA) in each of the groupings.[6] In the developed market economies as a whole, the branch lost its position as a dynamic growth industry in the late 1970s due to world-wide cutbacks in equipment investment

[4]Alternatively, the relative specialization index can be defined as the ratio of the share of non-electrical machinery in total MVA for the country to the share of non-electrical machinery in total MVA for the country group. (See footnote *b* to table 18.)

[5]The coefficient of variation increased from 0.51 in 1963 to 0.55 in 1979.

[6]Relative growth refers to growth in the branch relative to growth in the whole manufacturing sector.

Table 7. Growth and relative growth of net output in the non-electrical machinery branch, by economic grouping, 1963-1978[a]

	Growth rate (percentage)			*Relative growth index[b]*		
Economic grouping	*1963-1970*	*1970-1975*	*1975-1978*	*1963-1970*	*1970-1975*	*1975-1978*
Developed market economies	6.99	3.58	4.38	1.195	1.072	0.810
Centrally planned economies	8.20	8.82	7.77	1.120	1.035	1.392
Developing countries[c]	10.33	16.14	5.06[d]	1.402	2.025	0.891[d]
Africa	8.78	9.78	7.53[d]	1.320	1.775	0.891[d]
Asia	9.88	12.42	10.91	1.302	1.463	1.357
Latin America	10.63	17.73	2.41	1.450	2.208	0.553

Source: Based on data supplied by the Statistical Office of the United Nations Secretariat and estimates by the UNIDO secretariat.

[a]Data based on 1975 dollars.

[b]Relative growth index was defined as the ratio of growth rate of value added in the non-electrical machinery to that in the manufacturing sector as a whole.

[c]The number of developing countries included differs slightly from year to year, and from period to period.

[d]1975-1977.

and a faster recovery in other manufacturing branches.[7] In the centrally planned economies, the branch was a dynamic growth industry throughout the period 1963-1978, with an increase in its relative growth in the late 1970s resulting from a slowdown of growth in other manufacturing branches. In the developing countries, both the absolute growth and the relative growth in the branch were remarkably high until the middle of the 1970s, but dropped drastically in the late 1970s. This was due largely to the changing growth share of the predominant producer, Brazil. However, regional differences in growth are remarkable. While the branch lost its position of a dynamic growth industry in developing Africa and Latin America in the latter half of the 1970s, the branch in developing Asia continued to keep a high level of growth relative to the growth in the rest of the world as well as to the growth of MVA within the region. Thus, the branch in both developing Asia and the centrally planned economies was an important source of industrial growth throughout the period 1963-1978.

As the result of the high relative growth in the non-electrical machinery branch, the share of the branch in MVA increased substantially both in the developed countries and the developing countries during the 1960s. In the 1970s, the share decreased slightly in the developed countries, while, in the developing countries, the share increased despite a declining trend in the latter half of the 1970s (see table 8). The decrease in the relative importance of the branch in the developed countries in the 1970s may be explained partly by the

[7]Capital-goods industries in general and the non-electrical machinery industry in particular are the first industries that suffer from economic recession and perhaps the last ones to recover from it. In 1979, production of non-electrical machinery grew faster again than total MVA in this economic grouping, because of world-wide economic recovery and increases in retooling demands in various economic sectors.

high sensitivity of non-electrical machinery production to changes in economic conditions. In the developing countries, however, it is more often the case that structural change is brought about or accelerated through government initiative.[8]

Table 8. Share of non-electrical machinery (ISIC 382) in total manufacturing value added, by economic grouping, 1963, 1970 and 1978[a]

(Percentage)

	Economic grouping[b] (number of countries included)					
	Developed countries (29)			*Developing countries (58)[c]*		
Measurement	*1963*	*1970*	*1978*	*1963*	*1970*	*1978*
Unweighted average	8.4	8.6	8.6	1.5	1.6	2.3
Weighted average	10.7	11.6	11.4	2.5	3.3	5.1

Source: Based on data supplied by the Statistical Office of the United Nations Secretariat and estimates by the UNIDO secretariat.

[a]Based on constant 1975 dollars.

[b]An identical country sample was used in the calculations for 1970 and 1978, but the composition of the sample for 1963 was slightly different.

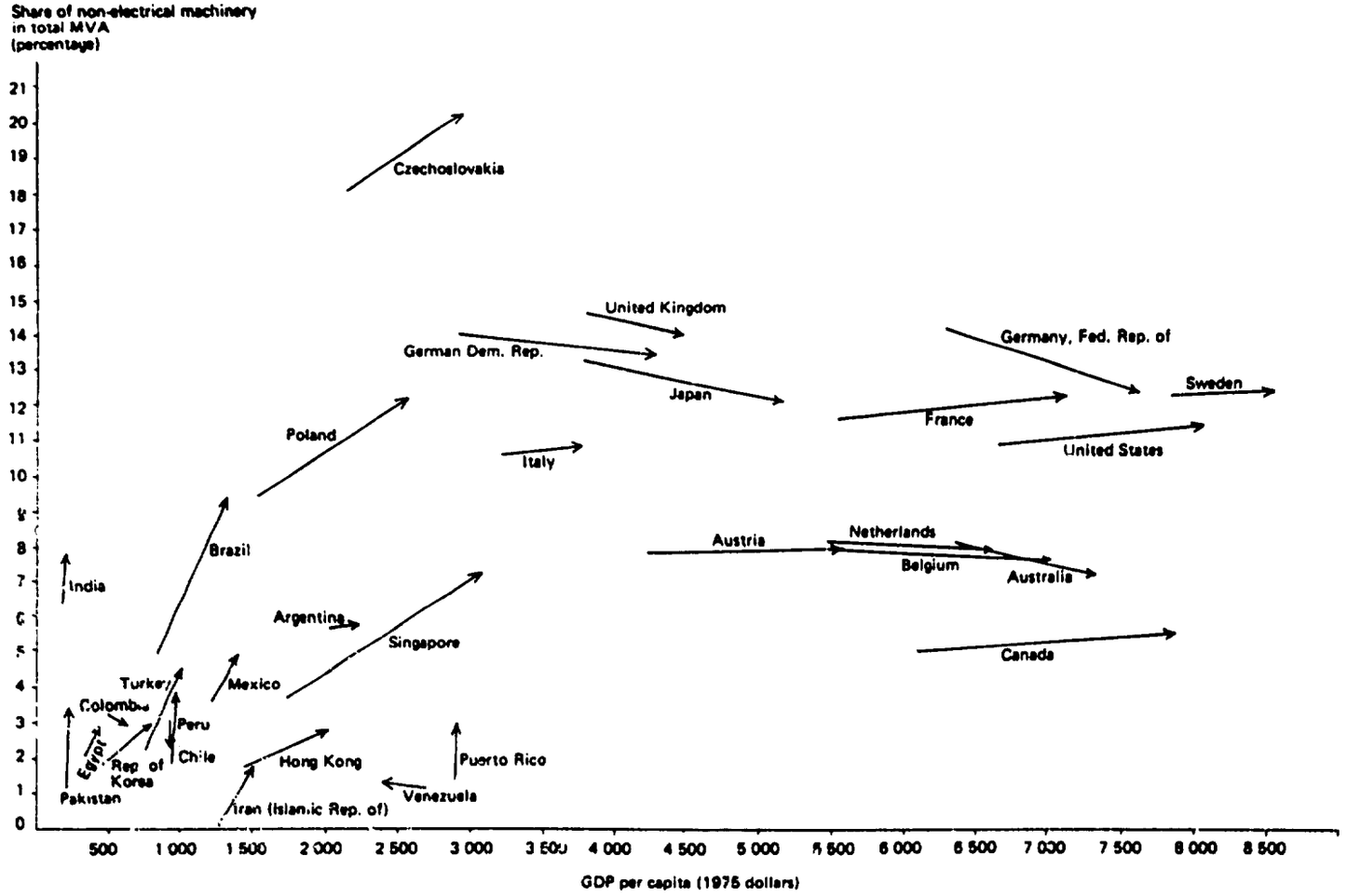
[c]For 1978, the number of countries included was 47.

C. Pattern of development

The results of previous studies suggest the hypothesis that the share of the branch in total MVA changes over the course of development, and that development of the branch depends on market size. As seen in figure III, in the period 1970-1978, lower income countries tended to record a rapid increase in the branch share while higher income countries did not. Furthermore, the level of the branch share appears to be higher in larger countries than in smaller countries at each income level. This hypothesis was tested with cross-country regression analysis on several functional relationships between the endogenous variable, the share of non-electrical machinery in total MVA, and the two exogenous variables, per capita gross domestic product (as a proxy for the stage of development) and population size (as a proxy for market size). The sample consisted of 92 countries for which relevant data for at least the late 1970s were available. Five different functional forms were tested for fit of data

[8]For example, the Republic of Korea has focused on selected target industries in each of its economic development plans since 1962 and, consequently, the relative importance (i.e. share in total MVA) of those industries has increased during the respective planning periods. Following cement and textiles (1962-1966), oil refining, synthetic fibres and electrical machinery (1967-1971), and steel, electronics and shipbuilding (1972-1976); non-electrical machinery (in addition to steel, electronics and petrochemicals) was assigned to be a target industry in the Fourth Plan (1977-1981). In the category of non-electrical machinery, machine tools were given particular emphasis. The Fourth Plan envisaged a 3.9-fold increase in net output of non-electrical machinery, in real terms, from the 1975 level, or an annual growth of 25 per cent during the period 1975-1981 (*Asian Research Bulletin*, 31 May 1981, pp. 802-803).

Figure III. Changes in per capita GDP and in the share of non-electrical machinery in total MVA for the fifteen largest producers in each group, developed countries and developing countries and areas, 1970-1978[a]



Source: Based on data supplied by the Statistical Office of the United Nations Secretariat and the Office of Development Research and Policy Analysis of the United Nations Secretariat and estimates by the UNIDO secretariat.

[a]For several developing countries, the terminal year is earlier than 1978 but not earlier than 1975.

and statistical significance. Out of these, the following estimated equation was selected as giving the best fit:

$$v = -24.207 + 2.422 \ln y + 1.218 \ln N + e, \; R^2 = 0.58$$

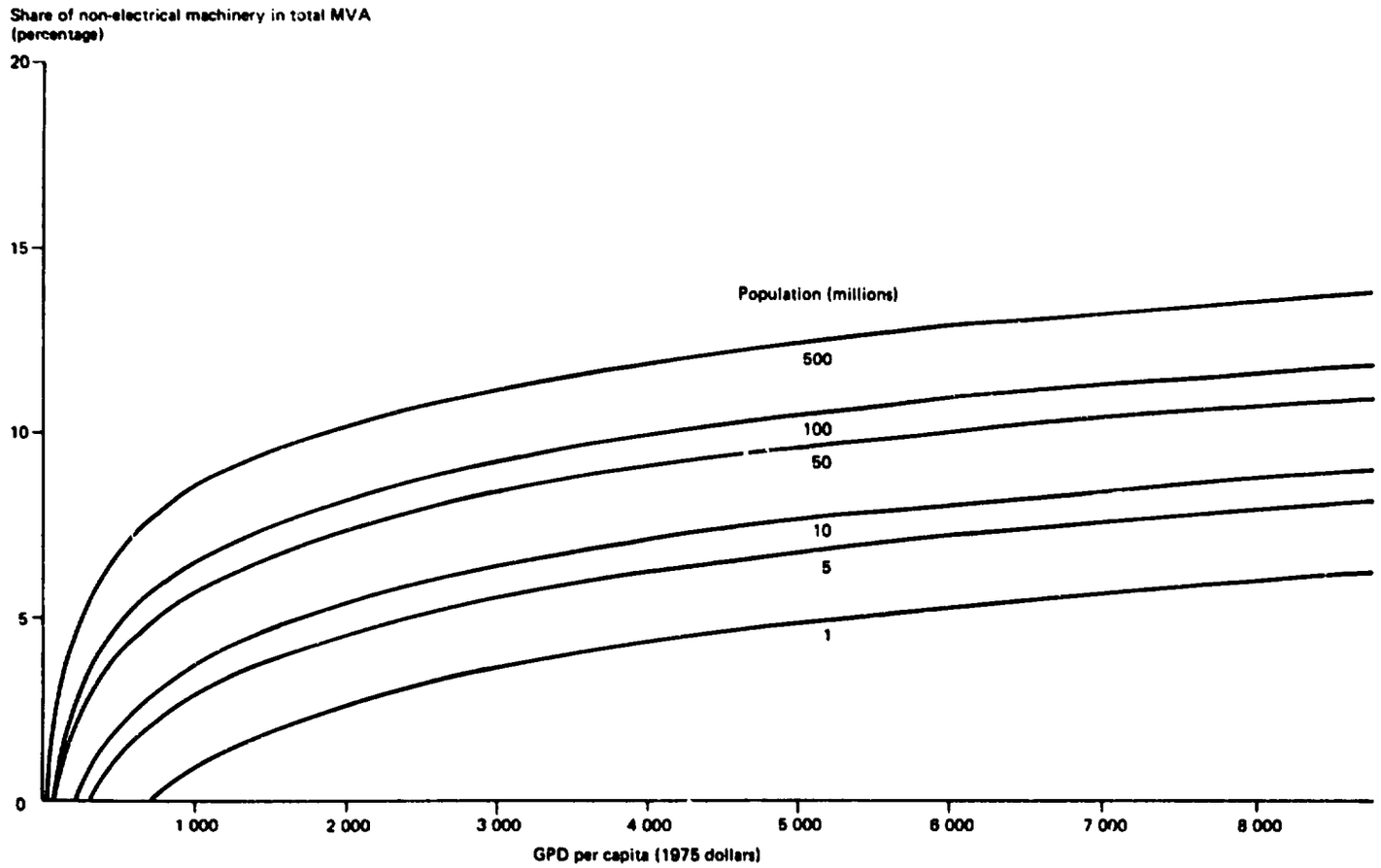
where v is the share of non-electrical machinery in total MVA, y is per capita GDP in 1975 dollars, N is population size, and e is residual. The estimates for the two coefficients were statistically significant, and hence, the two independent variables explain much of the variation in the branch's share of MVA.

Figure IV shows the estimated growth paths at selected population sizes. After reaching a certain level of development and market size, the share of non-electrical machinery in total MVA increases as per capita GDP or population size increases. However, the effects of the level of development and of the size of population diminish gradually as their levels increase. This is due partly to the fact that, at an early stage of development, the branch starts growing rapidly to achieve import substitution. While production is for import substitution, the industry is often under strong government protection and free to grow rapidly. Unlike the demand for many consumer durables, internal demand for non-electrical machinery is, to a certain extent, proportionate to the size of the economy. Therefore, after the level of economically viable import substitution is achieved, the main growth possibilities become market expansion, replacement demand in the domestic market and exports. Thus, the relative growth tends to decline and become closer to unity, although technological innovation may stimulate internal and external demand and consequently the branch may continue to be a growth industry.

In the previous section, relative specialization in individual countries was measured by comparing the share of a country in world non-electrical machinery production to its share in total world manufacturing production, or by comparing the branch share in total MVA in each country with the corresponding share in total MVA in a subset of countries (i.e., the developed countries or the developing countries). The relative level of development of the branch in individual countries is measured more systematically by comparing the actual share v with the expected share $\hat{v}$ derived from the average growth path. A derivation from the expected share $v - \hat{v} = e$ can be attributed to country-specific idiosyncrasies or to comparative advantage, independent of the stage of economic development and the market size.

Table 20 in the annex to part one presents actual and expected shares of non-electrical machinery in MVA and the ratio between them in each of the 92 countries listed. There tend to be large deviations between actual and expected shares in the developing countries, particularly in the smaller ones. The large variation in the ratio of actual to expected share among small developing countries, in which the scope for import substitution is generally limited, may be explained partly by the large differences in the development level of export industries which depend heavily on foreign investment in these countries. Also, in a small developing country where the relative importance of the branch is small, establishment of a large- or even medium-size factory causes a drastic increase in the branch share, but this share increase is not necessarily continuous thereafter. Thus, the branch share does not tend to increase uniformly. On the other hand, most of the countries of the Organization of Petroleum Exporting Countries (OPEC) recorded a substantial

Figure IV. Estmated patterns of structural change in the non-electrical machinery branch (ISIC 382) at given population sizes



Source: Estimates based on data supplied by the Statistical Office of the United Nations Secretariat and the Office of Development Research and Policy Analysis of the United Nations Secretariat and estimates by the UNIDO secretariat.

downward deviation. For these countries, per capita GDP may not be a good proxy for the level of development.

To summarize, in 1978, six out of the 29 developed countries sampled recorded actual shares exceeding their expected shares by more than 50 per cent and four countries recorded actual shares falling short of their expected shares by more than 50 per cent. Out of the 63 developing countries sampled, 14 recorded actual shares 50 per cent or more higher than their expected shares and 22 countries recorded actual shares 50 per cent or more lower than their expected shares. These figures show that divergence from the expected results is far greater in the developing than in the developed countries in this branch.[9]

As seen earlier, the non-electrical machinery branch is relatively technology-intensive, and thus requires a large amount of R and D expenditure per unit of output and a large number of R and D personnel (including scientists and engineers) per unit of manpower in comparison with corresponding averages in total manufacturing. R and D capability (including available manpower) increases, in general, as development of the economy proceeds. However, in practice, endowment of these branch-specific factors of production differs from country to country even at the same level of economic development as measured by per capita GDP. In addition to this, differences in the degree of development of a complex of supporting industries as a result of industrial linkages, and differences in the strength of protectionist measures among countries, also contribute to a deviation of actual from expected share.[10]

[9]The coefficient of variation (i.e., standard deviation divided by mean) of the sample for the ratio of actual share to expected share in 1978, was 1.84 in the case of the developing countries, compared to 0.51 in the case of the developed countries.

[10]See Frank Weiss and Frank Wolter, "Machinery in the United States, Sweden and Germany—An assessment of changes in comparative advantage", *Weltwirtschaftliches Archiv*, 1975, pp. 295-298.

III. Trade performance and changes in comparative advantage[1]

The changes in world distribution of production capacity for non-electrical machinery was an important consequence of the changing comparative advantage of countries in non-electrical machinery in the international market, which in turn was determined by various factors mentioned earlier. In this chapter, the changes in comparative advantage among countries in the international market and the consequences of these for intra-industry trade in non-electrical machinery are investigated.

A. Growth and distribution of world exports

In 1963, world exports of non-electrical machinery totalled about 17 billion dollars, 57 per cent of which was accounted for by the three biggest exporters, the Federal Republic of Germany, the United Kingdom and the United States. In the 1960s, several other recently industrialized developed countries such as Canada and Japan emerged as vigorous competitors in the world market for non-electrical machinery. In the 1970s, Japan continued to increase its share, while the shares of the United Kingdom and the United States continued to decline (see table 9). During this decade, several less industrialized developed countries such as Spain and some NICs such as Brazil and Singapore emerged in the world market as additional competitors in the field of less sophisticated machinery on the basis of their lower labour costs.

The share of the developing countries in world exports of non-electrical machinery increased rapidly from their very low level in the early 1960s. In 1979, exports from the developing countries as a whole accounted for 2.1 per cent of world non-electrical machinery exports. This, however, was much smaller than these countries' share in world exports of all manufactures, which was 8.8 per cent.[2] This was partly due to the fact that the establishment and the growth of the non-electrical machinery industry in the majority of the developing countries was geared to import substitution rather than to exports, while many other manufacturing industries, including other engineering industries in those countries, were export-oriented, often being involved in the

[1]Throughout this chapter, non-electrical machinery is the set of products which is classified into the category of division code 71 of the Standard International Trade Classification (SITC, Revision 1) which is approximately concordant with ISIC 382.

[2]Based on data given in *A Statistical Review of the World Industrial Situation, 1981* (UNIDO/IS.292, February 1982), p. 10.

Table 9. Share of non-electrical machinery exports in world trade, by economic grouping and country, 1963, 1970, 1975 and 1979

(Percentage)

Exporter	*1963*	*1970*	*1975*	*1979*
Developed market economies, total	85.0	87.8	87.0	86.8
France	4.8	5.9	7.2	7.1
Germany, Federal Republic of	19.6	20.0	19.7	19.1
Italy	4.7	6.5	5.9	6.1
Japan	2.1	5.3	6.6	9.1
Switzerland	3.4	3.2	3.2	3.3
United Kingdom	14.3	10.3	9.2	8.8
United States	23.7	22.0	20.3	18.2
Others	12.4	14.6	14.9	15.1
Centrally planned economies, total	14.4	11.3	11.3	11.1
Developing countries, total	0.6	1.0	1.7	2.1
World, total	100.0	100.0	100.0	100.0
		(billion dollars)		
Total value of world exports	16.8	38.2	102.7	184.3

Source: Based on data given in United Nations, *Bulletin of Statistics on World Trade in Engineering Products*, various issues; data supplied by the Statistical Office of the United Nations Secretariat; and estimates by the UNIDO secretariat.

global strategies of transnational corporations (TNCs) as seen in the production of parts and components and assembly in the electrical machinery and automobile industries in those countries.

Furthermore, as can be seen in table 10, the developing countries' exports were highly concentrated in a few NICs. In 1978, seven countries and areas, namely Argentina, Brazil, Mexico, Hong Kong, India, the Republic of Korea and Singapore, accounted for 86 per cent of the total exports from the developing countries. Also, as seen in the substantial increase in these seven countries' share during the period 1963-1978, the increase in the share of the developing countries in world exports depended almost entirely on the growth of exports from these seven countries. Among these seven countries, the growth in the contribution of Brazil was most significant.

Table 11 summarizes the relationship between growth of exports of non-electrical machinery and that of total manufacturing exports during the period 1963-1978. In the developed market economies, non-electrical machinery was no longer a high export-growth area throughout the period, while in the developing countries and the centrally planned economies, non-electrical machinery was a high export-growth item. The relative growth of exports of non-electrical machinery in the developing countries declined substantially in the 1970s. Nevertheless, non-electrical machinery exports continued to be an important source of export growth in these two economic groupings. In 1978, the share of non-electrical machinery in total manufacturing exports in the developing countries and the centrally planned economies was 4.8 per cent and 25.8 per cent, respectively, compared to their corresponding 1963 figures of 3.0 per cent and 22.3 per cent.

Table 10. Share of exports of non-electrical machinery in total exports from developing countries, by country or area within region, 1963, 1970, 1975 and 1978

(Percentage)

Exporter	*1963*	*1970*	*1975*	*1978*
Africa, total	18.4	7.6	2.7	1.6
Latin America, total	23.0	47.0	46.2	47.1
Argentina	7.2	12.5	12.2	8.4
Brazil	8.6	16.6	24.3	27.9
Mexico	6.2	12.9	7.2	8.0
Others	1.0	5.0	2.5	2.8
Western Asia, total	2.5	7.0	5.6	4.8
Other Asia and the Pacific, total	56.1	38.4	45.6	46.4
Hong Kong	4.2	3.8	5.6	9.7
India	7.1	9.6	7.8	6.5
Republic of Korea	0.3	2.2	4.3	6.7
Singapore	33.7	16.1	21.4	18.9
Others	10.8	6.7	6.5	4.6
Developing countries, total	100.0	100.0	100.0	100.0
		(billion dollars)		
Total value of exports from developing countries	0.10	0.38	1.73	3.02

Source: United Nations, *Bulletin of Statistics on World Trade in Engineering Products*, various issues; data supplied by the Statistical Office of the United Nations Secretariat; and estimates by the UNIDO secretariat.

Table 11. Growth elasticities[a] in non-electrical machinery exports, by economic grouping, 1970-1978

Economic grouping	*1963-1970*	*1970-1978*
Developed market economies	0.953	0.964
Developing countries	1.301	1.112
Centrally planned economies	1.021	1.117

Source: Based on data given in the United Nations, *Bulletin of Statistics on World Trade in Engineering Products;* data supplied by the Statistical Office of the United Nations Secretariat; and data given in *A Statistical Review of the World Industrial Situation, 1980* (UNIDO/IS.214, February 1981), p. 7.

[a]Elasticities are defined as the ratio of annual average growth rates of exports of non-electrical machinery (SITC 71) to the corresponding rates for manufacturing (SITC 5-8 less 68).

The types of products which contributed most to the growth of exports differed between the developed market economies and the developing countries. This will be discussed in the following section which deals with the differences in the comparative advantage of each product between the two economic groupings. The contributions of non-electric power-generating machinery (SITC 711) and office machines (SITC 714) were much higher in the developing

countries than in the developed market economies, while metalworking machinery (SITC 715) and textile and leather machinery (SITC 717) contributed more in the developed market economies (see table 12). Differences in skill and technology requirements and in degree of product standardization between the product groups may partly explain the differences between the two economic groupings in the proportion contributed by each product group to the growth of exports of non-electrical machinery.

Table 12. Percentage contribution of product groups to the growth of exports of non-electrical machinery, by economic grouping, between 1970 and 1978

Product group	*SITC code*	*Economic grouping*	
		Developed market economies	*Developing countries*
Power-generating machinery, other than electric	711	16.1 (15.6)	23.7 (22.9)
Agricultural machinery	712	6.6 (6.6)	6.1 (5.7)
Office machines	714	10.5 (11.0)	20.3 (20.3)
Metalworking machinery	715	5.9 (6.3)	2.7 (2.8)
Textile and leather machinery	717	4.4 (5.4)	3.4 (3.8)
Machines for special industries	718	13.6 (13.3)	12.4 (12.6)
Machinery and appliances, n.e.s.	719	42.8 (41.8)	31.4 (31.7)

Source: Based on data supplied by the Statistical Office of the United Nations Secretariat.

Note: $\Delta X_i^j / \Delta X_i^m$ as a percentage, where ΔX designates the difference between the 1970 and 1978 levels of exports, i stands for a country group, j stands for a product group, and m is non-electrical machinery (SITC 71). Figures in parentheses are the percentage shares of non-electrical machinery in total exports in 1978.

The changing comparative advantages in the two economic groupings resulted in changing patterns in their trade. During the 1970s, there was a significant shift in the destination of exports of non-electrical machinery from both the developed market economies and the developing countries. The importance of both the developing countries and the centrally planned economies as importers from the developed market economies increased significantly, while the importance of the developed market economies as importers decreased because of the relatively slow economic growth in this group. On the other hand, the pattern of exports from the developing countries shifted gradually from trade between themselves towards exports to the developed market economies, based on the advantage of low labour costs. Thus, the growth of world exports of non-electrical machinery in the 1970s depended substantially on an increasing inter-group trade between the developed market economies and the developing countries (see table 13).

Exports from the developed market economies to the developing countries in 1978 depended largely on the product groups SITC 717 (textile and leather machinery) and SITC 718 (machines for special industries). This reflected the structural depression in their user industries in the developed market economies together with faster growth in their user industries in the developing countries. On the other hand, the developed market economies were very important as a

Table 13. Changes in the destination of exports of non-electrical machinery, by economic grouping, 1970-1978

(Percentage)

Economic grouping as source of exports	Year	Destination of exports			
		World	Developed market economies	Developing countries	Centrally planned economies
Developed market economies	1970	100.0	72.2	23.3	4.6
	1978	100.0	61.6	31.7	6.7
Developing countries	1970	100.0	33.8	65.7	0.4
	1978	100.0	45.1	54.5	0.4

Source: Based on data supplied by the Statistical Office of the United Nations Secretariat.

destination for exports of non-electric power-generating machinery (SITC 711) and office machines (SITC 714) from the developing countries (data not shown).

Import penetration of the developing countries into the developed market economies was significant in the 1970s. The share of the developing countries in the total value of the developed market economies' imports of non-electrical machinery increased from 0.7 per cent in 1970 to 2.4 per cent in 1978. In particular, in the total value of imports of non-electric power-generating machinery and of office machines, the shares of the developing countries reached 4.0 per cent and 5.0 per cent respectively in 1978.[3] For example, in the United States, which is the largest export market for non-electrical machinery produced in the developing countries, the percentage share of imports in total apparent consumption of office machines increased from 4.1 per cent in 1967 to 12.3 per cent in 1976, of which the percentage change due to exports from the developing countries was 24 per cent. In the case of metalworking machinery, the percentage share of imports in apparent consumption increased from 4.1 per cent to 5.7 per cent, where the developing countries' contribution to the change was 25 per cent.[4]

The increasing penetration by the developing countries of the international market for non-electrical machinery was a consequence of changing comparative advantage between the developed countries and the developing countries. The effect of changes in comparative advantage has been particularly dynamic in the field of non-electrical machinery because, along with increasing competitiveness, the importance of technological factors such as capability for product development and improvement of manufacturing technology has been increasing for certain types of machinery, while the importance of relative labour costs has been increasing for other types of machinery. In the following section, the recent changes in comparative advantage and their effects on intra-industry trade at the SITC 3-digit level are investigated.

[3] Based on data supplied by the Statistical Office of the United Nations Secretariat.

[4] Ho Dac Tuong and Alexander J. Yeats, "Market disruption, the new protectionism, and developing countries: A note on empirical evidence from the United States", *The Developing Economies*, June 1981, pp. 114-115, table III.

B. Changing comparative advantage and intra-industry trade[5]

This section attempts to provide a rough impression of recent changes in the comparative advantage of different product groups within the category of non-electrical machinery between the two economic groupings, the developed market economies and the developing countries.

The type of product in which the developing countries had a relatively large and growing export trade was likely to be highly standardized products, parts and components. The type of product in which the developed countries sustained a high comparative advantage was likely to be that characterized by rapid product development. It can be expected that, in this type of technology-intensive product, comparative advantage tends to shift rapidly from one developed country to another according to technological initiative and innovation in these countries. Through this adjustment process, capacity to export non-electrical machinery spreads into more countries with increasing product specialization and differentiation even within very narrow product ranges. A predictable consequence of this is growing intra-industry trade.

Different types of exports are important to different countries. One of the widely used measures for indicating a country's "revealed" comparative advantage (RCA) in a given product is the country's export-performance ratio for the product. This approach assumes that the pattern of trade reflects inter-country differences in relative cost as well as non-price factors such as those mentioned earlier.[6] For a given period, the export-performance ratio, or the index of RCA, indicates the relative success of a given product in the world export market, that is, the share of the product in the country's total exports of manufactures in relation to world exports of that product as a share of world trade in manufactures.[7] For example, a value of 1.5 indicates that the product's share in a country's exports of manufactures is 50 per cent larger than the corresponding world totals. The RCA index was calculated on the basis of two-year averages for the periods 1970-1971 and 1978-1979 for each of the seven product categories of non-electrical machinery at the SITC 3-digit level in the countries for which relevant data were available. The results of the calculation are presented in table 21 in the annex to part one. The RCA index shows a wide range of variation from 1.0, the "normal" value which indicates conformity with the world pattern. It should be noted that the absolute values of the index as well as their changes must be regarded with caution in the case of those countries in which exports of resource-based commodities account for a large part of total manufacturing exports (e.g., exports of refined petroleum in OPEC countries).

Table 14 summarizes the results of the RCA index presented in annex table 21 into averages and dispersions within each of four defined economic

[5]Intra-industry trade (IIT) is defined as the simultaneous export and import of products within a given industry.

[6]For details, see Bela Balassa, "Trade liberalization and revealed comparative advantages", *The Manchester School of Economics and Social Studies*, vol. 33, No. 1 (1965), pp. 103-106.

[7]In symbols, the RCA index is

$$(X_i^j / X_i^m)/(X_w^j / X_w^m),$$

where j is the commodity, m is total manufacturing, i is the country, w stands for world and X is value of the export flow.

Table 14. Averages of the RCA index for different product groups of non-electrical machinery, by economic grouping, 1970-1971 and 1978-1979

Product group	SITC code	Period	Economic grouping[a]			
			Industrially mature market economies[b]	*Recently industrialized market economies*[c]	*NICs*[d]	*Other developing countries*[e]
Power-generating machinery, non-electric	711	1970-1971	0.83 (0.68)	0.33 (1.69)	0.15 (1.45)	0.26 (3.30)
		1978-1979	0.87 (1.23)	0.38 (1.23)	0.40 (1.44)	0.07 (1.52)
Agricultural machinery	712	1970-1971	0.97 (0.59)	0.39 (0.93)	0.09 (1.65)	0.15 (1.61)
		1978-1979	1.01 (0.47)	0.52 (0.70)	0.24 (1.55)	0.13 (2.27)
Office machines	714	1970-1971	0.83 (0.71)	0.36 (1.21)	0.31 (1.34)	0.02 (1.29)
		1978-1979	0.82 (0.72)	0.37 (0.89)	0.43 (1.06)	0.07 (2.19)
Metalworking machinery	715	1970-1971	1.08 (0.82)	0.30 (1.34)	0.09 (1.26)	0.02 (1.98)
		1978-1979	1.00 (0.88)	0.52 (1.16)	0.16 (1.03)	0.03 (1.82)
Textile and leather machinery	717	1970-1971	1.10 (1.15)	0.31 (1.47)	0.14 (1.02)	0.02 (1.10)
		1978-1979	1.14 (1.24)	0.46 (0.96)	0.17 (0.96)	0.02 (1.10)
Machinery for special industries	718	1970-1971	1.03 (0.37)	0.26 (1.11)	0.17 (1.50)	0.24 (1.69)
		1978-1979	1.07 (0.37)	0.33 (0.95)	0.20 (1.17)	0.16 (1.50)
Machinery and appliances, n.e.s.	719	1970-1971	1.13 (0.32)	0.30 (0.63)	0.15 (1.16)	0.10 (2.16)
		1978-1979	1.12 (0.32)	0.41 (0.78)	0.20 (0.79)	0.09 (1.96)

Source: Based on the data presented in table 21 in the annex.

Note: Figures in parentheses are coefficients of variation.

[a]For each product group, the countries included were common between the two periods. However, country samples differ slightly from product group to product group.

[b]Industrially mature market economies include: Austria, Belgium, Denmark, France, Germany, Federal Republic of, Italy, Luxembourg, Netherlands, Norway, Sweden, Switzerland, United Kingdom and United States.

[c]The remaining developed market economies are classified here as recently industrialized market economies.

[d]See explanatory notes.

[e]For each product group, the number of countries included differs slightly due to the non-availability of relevant data. It appears, however, that most of the countries excluded because export data were not available did not export any product that was classified in the product group. Taking this into account, the average RCA index for this economic grouping tends to be significantly overestimated.

groupings. In each of the seven product groups, comparative advantage appears to increase as the level of economic development increases. For none of the seven product groups was there any clear evidence of shifting comparative advantage in favour of the developing countries in general during the 1970s, although average RCA indices for NICs increased significantly in all the product groups during the period. This is probably because non-electrical machinery is very diverse and the SITC 3-digit-level classification of non-electrical machinery is still too broad to identify shifts of comparative advantage between economic groupings. It is possible that, in many highly industrialized countries, the loss in comparative advantage in standardized products in a given product group was entirely offset by an increase in comparative advantage in technology-intensive products in the same group because of technological innovation. In fact, in some of the product groups, average RCA indices for the industrially mature market economies even increased. The most important fact, however, was that comparative advantage

in several, though not all, developed market economies declined, while those of several NICs increased remarkably, as seen in table 21 (annex). This was particularly pronounced in non-electric power-generating machinery, agricultural machinery and office machines.

Table 15 also analyses data presented in table 21 in the annex. As can be seen, the mean value of the RCA index for the seven product groups in all the developing countries listed as well as in all the less industrialized developed countries listed is below 1.0, indicating that none of these countries has a comparative advantage as yet in non-electrical machinery as a whole, although the mean RCA index increased significantly in all of these selected countries during the 1970s. The countries which have a comparative advantage in non-electrical machinery as a whole are still only a few of the more industrialized developed countries, among whom some recorded a further increase in the average value and others recorded a declining average.

Table 15. Distribution of RCA in exports of non-electrical machinery[a] in selected countries and areas, 1970-1971 and 1978-1979

	1970-1971		*1978-1979*	
Country or area	*Mean RCA index*	*Coefficient of variation*	*Mean RCA index*	*Coefficient of variation*
Leading developed market economies				
France	0.86	0.11	0.85	0.17
Germany, Federal Republic of	1.44	0.33	1.37	0.29
Italy	1.16	0.26	0.98	0.33
Japan	0.66	0.42	1.00	0.27
Switzerland	1.75	0.91	1.88	0.96
United Kingdom	1.52	0.26	1.35	0.23
United States	1.48	0.35	1.51	0.42
Developed market economies, comparative sample				
Greece	0.02	0.86	0.03	0.97
Israel	0.14	0.53	0.29	0.55
Portugal	0.16	0.56	0.22	0.88
Spain	0.63	0.60	0.76	0.45
Yugoslavia	0.33	0.58	0.71	0.45
Leading newly industrializing countries and areas				
Argentina	0.36	0.92	0.40	0.64
Brazil	0.57	0.82	0.74	0.55
Colombia	0.16	0.64	0.26	0.43
Hong Kong	0.04	0.82	0.25	2.02
India	0.18	0.79	0.33	0.63
Mexico	0.26	1.20	0.49	1.24
Republic of Korea	0.08	1.00	0.14	0.75
Singapore	0.32	0.89	0.39	0.58

Source: Based on data presented in table 21 in the annex.

[a]Among the seven product groups shown in tables 14 and 21.

The coefficient of variation of the RCA index among the seven product groups indicates the degree of concentration of exports in a few product groups within the category of non-electrical machinery in relation to the pattern of world exports. Except in Switzerland, the dispersion of the RCA index among the product groups in the leading developed market economies was smaller than in the remaining selected countries. Furthermore, with a few exceptions, the dispersion tended to decrease in large countries and to increase in small countries in the 1970s, regardless of their levels of development.

Export diversification is not the only salient consequence of changing comparative advantage. Intra-industry trade became increasingly dominant in world trade in non-electrical machinery as international division of labour in the industry increased due to shifts in comparative advantage and disadvantage. Thus, specialization within each product group in the category of non-electrical machinery has proceeded much faster than in other categories of highly standardized products including many non-durable consumer goods. In the non-electrical machinery industry, as well as in other engineering industries, comparative advantage in some products is determined mainly by the technological level, while that of other products is influenced largely by the relative labour cost. Therefore, intra-industry trade reflects the heterogeneity of the product groups in which it is measured. This suggests that the degree of intra-industry trade should decrease and that the RCA index should be more pronounced when product groups are broken into narrower ranges (e.g., product groups classified at the SITC 5-digit level).

The measure of intra-industry trade (IIT) used in the present study is directly based on the share of net exports (i.e., value of exports minus value of imports) in total value of trade (i.e., value of exports plus value of imports).[8] Table 21 in the annex presents, instead of the IIT index, the percentage ratio of net exports to total trade in order to serve not only as an implicit form of the IIT index[9] but also as an indicator of the degree of export dominance (or import dominance) of trade in the seven product groups.

Table 16 (also based on data from table 21) shows a clear positive correlation between intra-industry trade and the level of development in each of the seven products. This is due to the fact that product specialization and differentiation increase in the process of industrialization. However, there was an interesting trend in intra-industry trade in the 1970s. In all seven product groups, intra-industry trade decreased, on average, in the more industrialized developed countries, while it increased in all product groups, on average, in the less industrialized developed countries and the NICs. This was due to the fact that, among the more industrialized developed countries, disparities in trade in non-electrical machinery increased in such a way that the export dominance increased in some countries while the import dominance increased in other

[8] In symbols, the index of IIT is defined as follows:

$$IIT_{ij} = (1 - \frac{|X_{ij} - M_{ij}|}{X_{ij} + M_{ij}}) \times 100$$

where i stands for a country, j is a product group, X is exports and M is imports (see Herbert Grubel and P. J. Lloyd, *Intra-industry Trade: The Theory and Measurement of International Trade in Differentiated Products* (London, MacMillan, 1975), p. 21).

[9] By this definition, a value of the IIT index can be derived simply by subtracting the absolute value of the percentage net export ration from 100.

Table 16. Average intra-industry trade[a] in different product groups of non-electrical machinery, by economic grouping

(Percentage)

Product group	*SITC code*	*Period*	*Economic grouping*			
			Leading developed market economies[b]	*Developed market economies, comparative sample*[c]	*NICs*[d]	*Other developing countries*
Power generating machinery, non-electric	711	1970-1971	71.64	22.73	12.63	11.16
		1978-1979	67.55	31.60	30.09	7.79
Agricultural machinery	712	1970-1971	53.81	18.40	12.29	9.56
		1978-1979	53.10	31.63	25.49	4.58
Office machines	714	1970-1971	79.91	24.99	30.39	4.75
		1978-1979	79.20	33.12	43.25	3.22
Metalworking machinery	715	1970-1971	64.80	25.91	8.52	5.56
		1978-1979	59.43	30.73	14.59	5.79
Textile and leather machinery	717	1970-1971	58.62	18.79	11.75	9.46
		1978-1979	57.36	36.67	16.33	4.26
Machines for special industries	718	1970-1971	64.93	11.02	8.45	12.87
		1978-1979	56.42	23.60	18.04	10.60
Machinery and appliances, n.e.s.	719	1970-1971	68.43	21.17	12.00	4.53
		1978-1979	60.17	35.65	19.38	5.20

Source: Based on data presented in table 21 (annex).

[a]For a definition of the measure of intra-industry trade, see footnote 8.

[b]France, Germany, Federal Republic of, Italy Japan, Switzerland, United Kingdom and United States.

[c]Greece, Israel, Portugal, Spain and Yugoslavia.

[d]See explanatory notes.

countries due to the shifts of comparative advantage among these countries. On the other hand, in the less industrialized developed market countries and in the NICs, increasing comparative advantage and a consequent increase in exports in certain fields of each product group reduced the import dominance in their trade in that product group. In the developing countries other than the NICs, while imports increased at a fast pace as industrialization proceeded, exports increased at a slower pace. Thus, these countries were left behind in terms of changing comparative advantage in the world export market.

Among the seven product groups, office machines recorded the highest intra-industry trade because of the highly diverse nature of the group whose products range from a large variety of parts and components and simple typewriters to large electronic computers.

Table 17 summarizes the results of the calculation of the measure of intra-industry trade at a more specific product level (i.e., product groups at the SITC 4-digit level). In the developed market economies, intra-industry trade was extensive in all of the 19 selected product groups. However, intra-industry trade was relatively low for dairy-farm machines, agricultural tractors, typewriters and cheque-writing machines, calculating and accounting machines, statistical machines, sewing machines, printing and bookbinding machines, powered tools, n.e.s., and bearings, compared to the remaining product groups.

Table 17. Intra-industry trade in selected product groups of non-electrical machinery at the SITC 4-digit level, by economic grouping, 1978-1979

(Number of countries)

Product group	SITC code	Selected developed market economies (20)[a]		Selected developing countries (30)[b]	
		IIT index[c]		IIT index[c]	
		between 0.25 and 0.50	between 0.50 and 1.00	between 0.25 and 0.50	between 0.50 and 1.00
Agricultural machinery for preparing and cultivating the soil	7121	6	12	5	4
Agricultural machinery for harvesting, threshing and sorting	7122	4	13	1	5
Dairy-farm machines	7123	4	9	0	2
Tractors, other than road tractors	7125	4	7	4	5
Typewriters and cheque-writing machines	7141	4	6	5	0
Calculating and accounting machines (including computers)	7142	4	8	1	5
Statistical machines	7143	6	8	1	4
Metalworking machine tools	7151	5	11	3	3
Textile machinery	7171	7	11	0	2
Leather machinery (excluding sewing machines)	7172	7	11	4	1
Sewing machines	7173	5	6	6	3
Paper mill and pulp mill machinery and other machinery for the manufacture of paper articles	7181	4	13	2	1
Printing and bookbinding machinery	7182	3	10	1	0
Food-processing machinery (excluding domestic)	7183	7	12	2	3
Heating and cooling equipment	7191	5	12	3	2
Pumps and centrifuges	7192	3	14	4	1
Mechanical handling equipment	7193	4	14	3	1
Powered tools, n.e.s.	7195	10	10	2	0
Ball, roller or needle-roller bearings	7197	3	10	0	1

Source: Based on data supplied by the Statistical Office of the United Nations Secretariat.

[a] Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Federal Republic of, Ireland, Israel, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, United States and Yugoslavia.

[b] The thirteen NICs plus Bahrain, Chile, Congo, Costa Rica, El Salvador, Ivory Coast, Kenya, Kuwait, Liberia, Madagascar, Morocco, Pakistan, Senegal, Tunisia, United Republic of Cameroon, Upper Volta and Venezuela.

[c] For definition of the IIT index, see footnote 8.

These product groups are considered to be relatively less heterogeneous or relatively well standardized.

In general, very few developing countries that trade in non-electrical machinery were involved in substantial intra-industry trade. In these countries, the product groups in which intra-industry trade was relatively high were agricultural machinery except for dairy-farm machines (i.e., SITC 7121, 7122 and 7125), calculating and accounting machines, and sewing machines.

Vertical forms of intra-industry specialization between the developed countries and the developing countries initiated by TNCs explain, at least partly, the increasing intra-industry trade of the developing countries as well as, to a much lesser extent, the developed countries. In certain fields of non-electrical machinery production (e.g., labour-intensive processes), TNCs which are based in the developed countries have become more inclined to look abroad in response to changes in comparative advantage, and it has often been the case that they have transferred a part of their production process to the developing countries. Thus, as with exports of other engineering products, TNCs play an important role in the growth of exports of non-electrical machinery from the developing countries. Exports by subsidiaries of TNCs take a large share in engineering exports from the developing countries, and a large part of their exports is intra-firm transfer. As international vertical integration of the non-electrical machinery industries proceeds, completely assembled final products constitute a declining share in total world trade in the branch.[10]

Tariff and non-tariff barriers are not usual forms of government intervention in the non-electrical machinery industry in developed countries. Instead, the most prevalent forms are technical and financial assistance in the field of R and D, directed at altering patterns of production and trade. In addition, government purchases and support for exports are also substantial. On the other hand, as mentioned earlier, tariff protection is widely applied in the developing countries where the objective of the domestic non-electrical machinery industry is import substitution. This aspect will be further investigated in part two.

To summarize, world production as well as exports of non-electrical machinery will continue to be dominated by the developed countries in the 1980s because of their technological advantage and consequent rapid development of products and manufacturing technologies. However, certain labour-intensive processes will continue to be transferred to the developing countries and import substitutive production of standardized machinery will grow even faster in those developing countries with large domestic markets. Among the developed countries, increasing competition to expand market shares may lead to the emergence of protectionism, and the differences in relative costs of production between them will encourage and accelerate direct investment in overseas production, rather than the export of home-produced goods.

In order to understand the characteristics and the trends in growth of the non-electrical machinery branch, more concrete and detailed investigations are made in part two, taking the machine-tool industry as typical of capital-goods production.

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[10]For more details, see, for example, G. K. Helleiner, "Manufactured exports from less developed countries and multinational firms", *Economic Journal*, March 1973, pp. 21-47.

Annex

ADDITIONAL TABLES

Table 18. Distribution of value added in the non-electrical machinery branch and relative specialization among selected developed countries, 1963, 1970 and 1979[a]

	Share within the group of developed countries (percentage)			*Relative specialization index[b]*		
Country	*1963*	*1970*	*1979*	*1963*	*1970*	*1979*
Australia	1.75	1.11	0.81	0.090	0.709	0.643
Austria	0.63	0.67	0.71	0.670	0.681	0.698
Belgium	0.94	0.94	0.88	0.652	0.690	0.671
Canada	1.02	1.11	1.37	0.390	0.438	0.537
Czechoslovakia	2.12	2.20	3.15	1.625	1.554	1.782
Denmark	0.68	0.72	0.67	1.111	1.171	1.226
Finland	0.55	0.50	0.56	1.039	0.891	1.038
France	8.85	8.00	8.14	1.053	1.014	1.081
German Democratic Republic	2.61	2.55	3.03	1.262	1.212	1.176
Germany, Federal Republic of	22.06	18.64	14.28	1.426	1.236	1.088
Greece	0.08	0.04	0.04	0.371	0.179	0.130
Hungary	0.73	0.65	0.50	1.099	0.967	0.648
Ireland	0.03	0.02	0.02	0.190	0.140	0.140
Israel	0.09	0.09	0.10	0.555	0.449	0.410
Italy	4.93	4.16	4.15	0.976	0.918	0.958
Japan	9.07	16.80	16.54	0.879	1.144	1.102
Luxembourg	0.07	0.05	0.04	0.867	0.689	0.671
Netherlands	1.62	1.44	1.23	0.796	0.712	0.666
New Zealand	0.07	0.08	0.06	0.287	0.343	0.279
Norway	0.37	0.34	0.39	0.636	0.614	0.842
Poland	1.24	1.70	3.59	0.727	0.802	1.078
Portugal	0.01	0.08	0.09	0.035	0.237	0.228
South Africa	0.60	0.44	...	1.027	0.713	0.532[c]
Spain	0.48	0.57	0.57	0.354	0.297	0.250
Sweden	1.75	1.77	1.56	1.044	1.067	1.152
United Kingdom	8.42	7.06	5.28	1.240	1.263	1.239
United States	28.88	27.93	31.65	0.896	0.947	1.023
Yugoslavia	0.38	0.37	0.57	0.519	0.450	0.478

Source: Based on data supplied by the Statistical Office of the United Nations Secretariat and estimates by the UNIDO secretariat.

[a] All calculations were based on data in dollars at 1975 prices.

[b] Defined as $(V_i^{382}/V_G^{382})/(V_i^3/V_G^3) = (V_i^{382}/V_i^3)/(V_G^{382}/V_G^3)$, where V_i^{382} and V_i^3 are value added in non-electrical machinery and total manufacturing value added, respectively, for country i, and V_G^{382} and V_G^3 are those for the developed countries as a whole.

[c] 1978.

Table 19. Distribution of value added in the non-electrical machinery branch and relative specialization among developing countries and areas, 1963, 1970 and 1975[a]

	Share within the group of developing countries and areas (percentage)			*Relative specialization index[b]*		
Country or area	*1963*	*1970*	*1975*	*1963*	*1970*	*1975*
Africa						
Algeria	0.17	0.18	0.29	0.349	0.282	0.409
Angola	...	0.01	0.01	...	0.128	0.093
Benin	...	0.02	0.01	...	0.661	0.347
Congo	...	0.01	0.01	...	0.354	0.362
Egypt	1.72	0.89	0.71	0.958	0.574	0.503
Ethiopia	—	—	—	—	—	—
Gabon	...	0.01	0.02	...	0.134	0.316
Ghana	0.01	0.01	0.01	0.026	0.028	0.016
Kenya	0.13	0.14	0.05	0.611	0.582	0.192
Libyan Arab Jamahiriya	...	0.05	0.03	...	0.335	0.154
Madagascar	—	—	—	—	—	—
Mauritius	0.01	0.01	0.02	0.035	0.076	0.182
Morocco	1.10	0.81	0.53	0.938	0.805	0.556
Mozambique	0.03	0.04	0.04	0.143	0.128	0.224
Namibia	—	0.01	—	0.263	0.305	0.189
Nigeria	0.05	0.06	0.11	0.072	0.061	0.102
Rwanda	—	—	—	—	—	—
Somalia	—	—	—	—	—	—
Sudan	0.06	0.05	0.04	0.131	0.141	0.119
Uganda	0.01	0.01	0.02	0.020	0.027	0.049
United Republic of Cameroon	0.05	0.09	0.04	0.251	0.395	0.206
United Republic of Tanzania	0.06	0.07	0.03	0.447	0.459	0.160
Zaire	0.47	0.35	0.16	1.518	1.362	0.655
Zambia	0.29	0.21	0.14	1.239	0.763	0.530
Zimbabwe	0.53	0.54	0.42	1.061	1.009	0.772
Total Africa	4.69	3.57	2.69			
Latin America						
Argentina	27.14	24.21	15.33	2.078	1.697	1.161
Barbados	...	0.02	0.03	...	0.863	1.028
Bolivia	0.02	0.02	0.02	0.228	0.121	0.102
Brazil	18.19	24.52	42.13	1.110	1.472	2.085
Chile	4.36	2.19	0.86	1.444	0.877	0.571
Colombia	1.00	1.80	0.89	0.517	0.948	0.466
Costa Rica	0.09	0.15	0.09	0.428	0.591	0.354
Dominican Republic	—	—	0.01	—	0.007	0.020
Ecuador	0.04	0.02	0.03	0.138	0.054	0.062
El Salvador	0.02	0.02	0.02	0.092	0.095	0.079
Guatemala	0.11	0.07	0.04	0.206	0.168	0.098
Guyana	—	—	—	—	—	—
Honduras	—	—	—	—	0.042	0.039
Mexico	10.92	10.51	9.37	1.337	1.061	0.958
Panama	0.02	0.01	0.01	0.085	0.075	0.069
Paraguay	0.08	0.04	0.04	0.421	0.276	0.295
Peru	1.40	1.27	1.70	0.577	0.518	0.733
Puerto Rico	0.99	0.79	1.09	0.397	0.435	0.590
Trinidad and Tobago	0.21	0.17	0.12	0.846	0.446	0.546
Uruguay	0.69	0.34	0.13	0.725	0.464	0.243
Venezuela	1.30	1.85	1.07	0.206	0.331	0.284
Total Latin America	66.58	68.00	72.98			

Table 19 *(continued)*

Country or area	Share within the group of developing countries and areas (percentage)			Relative specialization index[b]		
	1963	1970	1975	1963	1970	1975
Western Asia						
Cyprus	0.11	0.09	0.03	1.388	1.013	0.416
Iraq	0.81	0.59	0.45	1.906	1.325	0.810
Kuwait	...	0.08	0.07	...	0.183	0.200
Lebanon	...	...	0.02	...	...	0.128
Turkey	3.71	2.64	4.09	0.936	0.660	0.898
Total Western Asia	4.63	3.40	4.66			
Other Asia and the Pacific						
Bangladesh	...	...	0.05	...	...	0.130
Burma	0.02	0.02	0.01	0.068	0.073	0.042
Fiji	...			...	0.095	0.304
Hong Kong	0.88	0.80	0.78	0.580	0.491	0.447
India	17.29	18.72	11.12	1.466	1.899	1.405
Indonesia	0.27	0.24	0.39	0.187	0.195	0.251
Iran (Islamic Republic of)	0.15	0.11	1.69	0.030	0.024	0.311
Malaysia[c]	0.79	0.89	0.61	0.832	0.846	0.593
Pakistan	0.62	0.56	0.84	0.285	0.291	0.587
Philippines	0.71	0.84	0.56	0.238	0.320	0.220
Republic of Korea	1.68	1.19	1.69	1.424	0.520	0.444
Singapore	1.07	0.82	1.45	1.968	1.100	1.739
Sri Lanka	0.06	0.29	0.10	0.180	0.868	0.321
Thailand	0.56	0.51	0.36	0.337	0.330	0.209
Total other Asia and the Pacific	24.10	24.99	19.65			

Source: Based on data supplied by the Statistical Office of the United Nations Secretariat and estimates by the UNIDO secretariat.

[a]See footnote *a* to table 18.

[b]See footnote *b* to table 18.

[c]West Malaysia only.

Table 20. Actual and expected shares of non-electrical machinery (ISIC 382) in total manufacturing value added, by country and area, 1970 and 1978

Country or area	Share of non-electrical machinery in total manufacturing value added					
	Actual (percentage)		Expected[a] (percentage)		Ratio of actual to expected share	
	1970	1978	1970	1978	1970	1978
Developed market economies						
Australia	8.20	7.31	8.49	8.97	0.966	0.815
Austria	7.88	8.00	6.85	7.53	1.150	1.062
Belgium	7.98	7.69	7.80	8.42	1.023	0.913
Canada	5.06	5.66	9.03	9.77	0.560	0.579
Denmark	13.54	14.04	7.52	7.99	1.801	1.757
Finland	10.31	12.17	6.66	7.14	1.548	1.704

Country or area	Share of non-electrical machinery in total manufacturing value added: Actual (percentage) 1970	Actual (percentage) 1978	Expected[a] (percentage) 1970	Expected[a] (percentage) 1978	Ratio of actual to expected share 1970	Ratio of actual to expected share 1978
France	11.73	12.42	9.85	10.52	1.191	1.181
Germany, Federal Republic of	14.29	12.52	10.36	10.86	1.379	1.153
Greece	2.07	1.69	4.98	5.94	0.416	0.285
Ireland	1.62	1.76	4.26	4.84	0.380	0.364
Israel	5.19	5.10	4.98	5.71	1.042	0.893
Italy	10.62	10.78	8.61	9.04	1.233	1.192
Japan	13.24	12.12	9.81	10.69	1.350	1.134
Luxembourg	7.97	7.99	3.93	4.43	2.074	1.804
Malta	0.73	0.65	—	1.19	(high)	0.546
Netherlands	8.24	8.00	8.16	8.71	1.010	0.918
New Zealand	3.97	2.75	5.52	5.84	0.719	0.471
Norway	7.10	9.05	6.88	7.69	1.032	1.177
Portugal	2.74	2.56	4.33	5.04	0.633	0.508
South Africa	8.25	6.04	5.38	5.87	1.533	1.029
Spain	3.44	3.53	7.29	8.06	0.472	0.438
Sweden	12.35	12.63	8.46	8.69	1.460	1.453
United Kingdom	14.61	14.02	9.02	9.45	1.620	1.484
United States	10.96	11.63	11.99	12.54	0.914	0.927
Yugoslavia	5.21	5.46	4.76	5.80	1.095	0.941
Centrally planned economies						
Czechoslovakia	17.97	20.26	5.94	6.81	3.025	2.975
German Democratic Republic	14.02	13.48	6.91	7.87	2.029	1.713
Hungary	11.19	7.97	4.71	5.80	2.376	1.374
Poland	9.28	12.10	6.15	7.50	1.509	1.613
Developing countries or areas						
Algeria	0.93	2.10[b]	3.86	4.58[b]	0.241	0.459[b]
Argentina	5.57	5.74	6.49	6.81	0.858	0.843
Bangladesh	. . .	0.64[d]	0.90	1.01[d]	. . .	0.634[d]
Barbados	2.83	5.08	0.30	0.42	9.433	12.095
Benin	2.17	1.71[d]	—	—	(high)	(high)[d]
Bolivia	0.40	0.50[d]	0.71	1.25[d]	0.563	0.400[d]
Brazil	4.84	9.34	5.94	7.39	0.815	1.264
Burma	0.24	0.26	—	—	(high)	(high)
Chile	2.88	2.24	3.39	3.58	0.850	0.626
Colombia	3.11	2.82	2.79	3.72	1.115	0.758
Congo	1.16	1.79[d]	—	—	(high)	(high)[d]
Costa Rica	1.94	1.75[d]	1.21	1.75[d]	1.603	1.000[d]
Cyprus	3.33	2.03	1.24	1.40	2.685	1.450
Dominican Republic	0.02	0.11	1.15	2.33	0.017	0.047
Ecuador	0.18	0.30[d]	1.14	2.19[d]	0.158	0.137[d]
Egypt	1.89	2.77	2.27	3.26	0.833	0.850
El Salvador	0.31	0.39[d]	0.23	0.63[d]	1.348	0.619[d]
Ethiopia	—	—[d]	—	—		
Fiji	0.31	1.56[c]	0.08	0.71[c]	3.875	2.197[c]
Gabon	0.44	1.56[d]	1.93	3.58[d]	0.228	0.436[d]
Ghana	0.09	0.08[d]	1.90	1.86[d]	0.047	0.043[d]
Guatemala	0.55	0.49[d]	1.37	1.86[d]	0.401	0.263[d]
Guyana	—	—[d]	—	—[d]		
Honduras	0.14	0.17[c]	—	—[c]	(high)	(high)[c]

Table 20 *(continued)*

Country or area	Share of non-electrical machinery in total manufacturing value added: Actual (percentage) 1970	Actual (percentage) 1978	Expected[a] (percentage) 1970	Expected[a] (percentage) 1978	Ratio of actual to expected share 1970	Ratio of actual to expected share 1978
Developing countries or areas (continued)						
Hong Kong	1.61	2.59[c]	3.50	4.42[c]	0.460	0.586[c]
India	6.24	7.70	3.84	4.29	1.625	1.795
Indonesia	0.64	1.02[c]	2.51	3.44[c]	0.255	0.296[c]
Iran (Islamic Republic of)	0.08	1.72	5.53	6.24	0.014	0.276
Iraq	4.35	4.00[d]	3.92	4.37[d]	1.110	0.915[d]
Kenya	1.91	0.48	0.29	0.97	6.586	0.495
Kuwait	0.60	0.99[d]	7.54	6.81[d]	0.080	0.145[d]
Lebanon	...	0.63[d]	2.82	2.57[d]		0.245[d]
Libyan Arab Jamahiriya	1.10	0.76[d]	6.88	6.03[d]	0.160	0.126[d]
Madagascar	—	—	0.07	0.04	—	—
Mauritius	0.25	0.51[c]	—	0.40[c]	(high)	1.275[c]
Mexico	3.48	4.80	6.12	6.77	0.569	0.709
Morocco	2.64	2.79[b]	2.38	3.12[b]	1.109	0.894[b]
Mozambique	0.42	1.11[d]	1.47	1.13[d]	0.286	0.982[d]
Namibia	1.00	0.93[d]	1.49	1.64[d]	0.671	0.567[d]
Nigeria	0.20	0.50[d]	3.72	4.35[d]	0.054	0.115[d]
Pakistan	0.95	3.27[c]	1.77	2.10[c]	0.537	1.557[c]
Panama	0.25	0.30	1.41	1.94	0.177	0.155
Paraguay	0.91	1.47	0.20	1.36	4.550	1.081
Peru	1.70	3.66[b]	3.84	4.24[b]	0.443	0.863[b]
Philippines	1.05	1.53	2.53	3.39	0.415	0.451
Puerto Rico	1.43	2.91[d]	4.69	4.87[d]	0.305	0.598[d]
Republic of Korea	1.71	2.89	3.00	4.73	0.570	0.611
Rwanda	—	—[d]	—	—		
Singapore	3.61	7.20	3.11	4.66	1.161	1.545
Somalia	—	—[d]	—	—		
Sri Lanka	2.85	1.67[c]	0.20	0.83[c]	14.250	2.012[c]
Sudan	0.46	0.59[d]	1.47	1.64[d]	0.313	0.360[d]
Thailand	1.08	1.03[d]	2.19	2.94[d]	0.493	0.350[d]
Trinidad and Tobago	1.46	2.78[c]	2.74	3.38[c]	0.533	0.822[c]
Turkey	2.17	4.42	4.48	5.48	0.484	0.807
Uganda	0.09	0.73[d]	0.78	0.70[d]	0.115	1.043[d]
United Republic of Cameroon	1.30	0.79[b]	0.95	1.74[b]	1.368	0.454[b]
United Republic of Tanzania	1.51	0.79[d]	—	—	(high)	(high)[d]
Uruguay	1.52	1.42[b]	2.75	2.88[b]	0.553	0.493[b]
Venezuela	1.09	1.18	6.17	6.23	0.177	0.189
Zaire	4.47	3.24[d]	0.28	0.30[d]	15.964	10.800[d]
Zambia	2.51	2.12	0.79	1.16	3.177	1.828
Zimbabwe	3.31	3.52	1.08	1.11	3.065	3.171

Source: Based on data supplied by the Statistical Office of the United Nations Secretariat and estimates by the UNIDO secretariat.

[a] Expected shares *(v)* were calculated by the following estimated regression equation,

$$v = -24.207 + 2.422 \ln y + 1.218 \ln N$$

where v is the expected share of non-electrical machinery in MVA, y is GDP per capita and N is population.

[b] 1977.

[c] 1976.

[d] 1975.

Table 21. Selected indicators of export performance, by country within product group, 1970-1971 and 1978-1979[a]

Country or area	Percentage share in world total exports[b]		RCA index[c]		Percentage ratio of net exports to total trade[d]	
	1970-1971	1978-1979	1970-1971	1978-1979	1970-1971	1978-1979
A. Power generating machinery, non-electric (SITC 711)						
Algeria	...	0.001	...	0.024	...	−99.839
Argentina	0.070	0.101	0.151	0.216	−76.684	−64.121
Australia	0.225	0.132	0.216	0.154	−84.557	−85.148
Austria	1.078	0.713	0.833	0.489	25.983	3.749
Bahrain	0.017	0.008	0.187	0.039	−85.011	−74.976
Bangladesh	...	—	...	0.002	...	−99.757
Barbados	—	—	0.004	—	−99.057	−99.999
Belgium	1.586	1.554	0.321	0.332	−44.403	−46.421
Belize	...	0.001	...	0.086	...	−83.802
Brazil	0.063	1.458	0.109	1.438	−91.109	8.943
Brunei	—	—	0.015	—	−99.934	−99.970
Canada	11.225	6.125	1.965	1.534	−3.585	−21.517
Chile	0.008	—	0.021	0.001	−95.738	−99.598
Colombia	0.003	0.020	0.037	0.205	−98.954	−89.597
Congo	0.001	0.001	0.127	0.386	−94.786	−85.655
Costa Rica	—	0.002	0.004	0.043	−99.564	−94.761
Cyprus	...	0.002	...	0.065	...	−87.329
Czechoslovakia	...	0.299	...	0.236	...	55.438
Denmark	1.064	0.730	0.763	0.586	−23.447	−7.914
Dominican Republic	...	0.003	...	0.078	...	−89.045
Egypt	—	—	0.001	0.004	−99.722	−99.571
El Salvador	0.001	—	0.012	0.002	−97.370	−99.703
Fiji	—	—	—	—	−99.987	−99.982
Finland	0.114	0.204	0.110	0.196	−77.639	−61.726
France	6.233	8.561	0.803	0.980	2.005	9.808
French Guiana	0.002	—	4.566	0.374	−70.387	−99.605
Germany, Federal Republic of	14.793	18.866	0.933	1.160	53.112	58.046
Greece	0.001	0.003	0.004	0.008	−99.700	−98.313
Guadeloupe	—	0.001	0.013	0.149	−98.078	−93.234
Guatemala	0.001	—	0.017	0.003	−96.717	−99.697
Guyana	—	0.001	—	0.066	−99.997	−88.008
Honduras	—	—	—	0.001	−99.990	−99.868
Hong Kong	—	0.052	—	0.049	−99.940	−83.653
India	0.143	0.326	0.227	0.695	−63.507	−15.649
Indonesia	...	0.047	...	0.253	...	−91.261
Ireland	0.003	0.087	0.009	0.146	−97.841	−56.297
Israel	0.024	0.082	0.117	0.329	−85.839	−66.161
Italy	3.613	3.919	0.590	0.584	5.852	4.573
Ivory Coast	0.006	0.013	0.135	0.162	−90.533	−86.740
Jamaica	...	—	...	—	...	−99.886
Japan	5.610	10.286	0.576	0.936	28.919	70.008
Kenya	...	—	...	0.006	...	−99.193
Kuwait	0.011	0.014	0.063	0.047	−61.104	−57.430
Liberia	0.002	—	0.967	0.121	−93.528	−96.092
Madagascar	0.002	0.001	0.071	0.077	−94.357	−96.644
Malaysia	0.034	0.037	0.104	0.073	−87.469	−87.210
Malta	—	—	—	0.002	−99.935	−99.658
Martinique	—	—	0.031	0.061	−98.851	−96.990
Mexico	0.302	0.633	0.779	1.913	−66.347	−36.256
Morocco	0.001	—	0.017	0.001	−98.952	−99.935

Table 21 *(continued)*

Country or area	Percentage share in world total exports[b] 1970-1971	Percentage share in world total exports[b] 1978-1979	RCA index[c] 1970-1971	RCA index[c] 1978-1979	Percentage ratio of net experts to total trade[d] 1970-1971	Percentage ratio of net experts to total trade[d] 1978-1979
A. Power generating machinery, non-electric (SITC 711) (continued)						
Netherlands	2.281	1.907	0.457	0.369	−24.380	−22.313
New Zealand	0.019	0.014	0.047	0.045	−91.845	−94.613
Nicaragua	...	—	...	—	...	−99.993
Norway	0.358	0.321	0.356	0.382	−56.173	−41.100
Oman	...	—	...	0.028	...	−97.472
Pakistan	0.005	0.002	0.023	0.011	−97.043	−97.209
Philippines	—	0.001	0.001	0.006	−99.944	−99.551
Portugal	0.022	0.011	0.055	0.039	−88.551	−92.895
Republic of Korea	0.042	0.152	0.120	0.109	−91.140	−87.619
Reunion	—	—	0.014	0.026	−98.191	−96.398
Saudi Arabia	...	0.012	...	0.048	...	−97.669
Senegal	0.009	0.003	0.166	0.099	−79.553	−88.931
Singapore	0.188	0.467	0.372	0.439	−61.096	−40.596
Spain	0.279	0.710	0.283	0.466	−75.405	−34.148
Sri Lanka	...	—	...	0.001	...	−99.735
Sweden	2.397	2.438	0.786	0.946	−7.364	10.252
Switzerland	2.042	2.220	0.855	0.877	33.523	24.783
Syrian Arab Republic	...	0.028	...	0.752	...	−75.035
Thailand	—	0.005	0.003	0.020	−99.888	−98.658
Trinidad and Tobago	0.006	0.002	0.030	0.012	−84.570	−95.289
Tunisia	0.001	0.005	0.015	0.057	−98.645	−96.197
Turkey	—	0.011	—	0.087	−99.991	−97.441
United Kingdom	17.246	13.581	2.010	1.872	49.134	33.712
United Republic of Cameroon	0.028	0.002	0.732	0.070	−34.448	−95.560
United Republic of Tanzania	...	—	...	0.001	...	−99.979
United States	28.897	24.703	1.834	1.863	26.007	26.228
United States Virgin Islands	0.001	—	0.010	0.001	−97.160	−96.937
Upper Volta	—	—	0.058	0.029	−96.816	−99.052
Uruguay	...	0.008	...	0.123	...	−45.681
Venezuela	0.037	—	0.083	0.001	−92.864	−99.920
Yugoslavia	0.373	0.436	0.524	0.705	−36.906	−50.469
B. Agricultural machinery (SITC 712)						
Algeria	...	—	...	—	...	−99.995
Argentina	0.250	0.416	0.540	0.894	−39.879	−15.302
Australia	0.644	0.462	0.617	0.542	−42.143	−65.408
Austria	0.681	1.194	0.526	0.821	−42.470	−9.586
Bahrain	0.005	0.004	0.052	0.018	−56.738	−81.281
Bangladesh	...	—	...	—	...	−99.914
Barbados	—	—	0.021	—	−98.722	−99.962
Belgium	4.120	4.573	0.833	0.980	42.542	28.148
Belize	...	0.004	...	0.398	...	−59.141
Brazil	0.074	1.224	0.129	1.206	−89.585	45.007
Canada	7.560	6.076	1.325	1.523	−21.511	−35.183
Chile	...	0.002	...	0.006	...	−98.941
Colombia	0.022	0.041	0.282	0.417	−90.469	−83.408
Congo	0.002	—	0.342	0.002	−87.589	−99.780

Country or area	*Percentage share in world total exports*[b]		*RCA index*[c]		*Percentage ratio of net exports to total trade*[d]	
	1970-1971	*1978-1979*	*1970-1971*	*1978-1979*	*1970-1971*	*1978-1979*
Costa Rica	0.004	0.006	0.107	0.144	−96.448	−95.555
Cyprus	...	0.003	...	0.081	...	−89.236
Czechoslovakia	...	3.693	...	2.913	...	3.966
Denmark	2.123	1.958	1.524	1.572	6.865	−6.218
Dominican Republic	...	0.001	...	0.013	...	−98.752
Egypt	—	—	—	0.001	−99.874	−99.906
El Salvador	0.002	0.005	0.037	0.110	−95.935	−91.520
Fiji	...	—	...	0.001	...	−99.945
Finland	0.326	0.426	0.315	0.406	−71.902	−54.019
France	6.276	5.981	0.809	0.686	−16.851	−20.866
French Guiana	—	0.001	1.005	1.518	−81.145	−94.846
Germany, Federal Republic of	14.221	16.118	0.897	0.991	56.030	55.584
Greece	0.007	0.004	0.037	0.011	−98.457	−99.363
Guadeloupe	—	—	0.001	0.017	−99.921	−98.962
Guatemala	—	0.001	0.002	0.022	−99.856	−98.712
Guyana	—	—	—	—	−99.998	−99.996
Hong Kong	—	—	—	—	−99.922	−99.725
India	0.030	0.067	0.047	0.144	−96.536	−48.477
Indonesia	...	0.015	...	0.076	...	−91.708
Ireland	0.059	0.166	0.161	0.278	−91.893	−85.870
Israel	0.031	0.062	0.153	0.252	−91.904	−82.201
Italy	6.492	8.440	1.061	1.256	35.519	56.427
Ivory Coast	0.007	0.014	0.154	0.173	−96.612	−93.280
Jamaica	...	—	...	0.001	...	−99.773
Japan	3.738	8.686	0.383	0.796	34.403	68.630
Jordan	...	—	...	0.014	...	−99.110
Kenya	0.001	0.001	0.010	0.021	−99.682	−99.037
Kuwait	0.002	0.004	0.013	0.015	−63.198	−95.893
Liberia	0.001	—	0.291	0.166	−98.029	−98.544
Madagascar	0.003	—	0.151	0.002	−94.489	−99.960
Malawi	0.003	0.003	0.291	0.391	−93.172	−94.104
Malaysia	0.023	0.010	0.070	0.020	−87.906	−93.314
Malta	...	0.017	...	0.453	...	7.500
Martinique	0.004	0.001	0.649	0.127	−79.181	−93.074
Mexico	0.026	0.070	0.068	0.212	−97.458	−80.500
Morocco	0.002	—	0.034	—	−98.787	−99.979
Netherlands	1.945	2.310	0.389	0.448	−6.001	−15.192
New Zealand	0.112	0.168	0.276	0.536	−82.496	−63.709
Nicaragua	—	—	—	0.003	−99.982	−99.742
Norway	0.589	0.670	0.587	0.788	−48.782	−35.919
Pakistan	0.001	0.001	0.002	0.005	−99.833	−99.866
Philippines	—	0.002	0.001	0.009	−99.975	−98.677
Portugal	0.039	0.026	0.098	0.088	−92.601	−94.029
Republic of Korea	0.008	0.028	0.021	0.020	−84.593	−76.387
Reunion	—	0.001	0.002	0.047	−99.717	−95.445
Saudi Arabia	...	0.017	...	0.071	...	−96.281
Senegal	0.016	0.004	0.347	0.101	−62.921	−86.799
Singapore	0.012	0.053	0.024	0.050	−54.471	−43.260
Spain	0.346	1.027	0.349	0.684	−64.733	−26.718
Sri Lanka	...	—	...	0.002	...	−99.887
Sweden	3.004	2.393	0.984	0.929	21.079	14.415
Switzerland	0.249	0.382	0.104	0.151	−64.253	−54.117
Syrian Arab Republic	...	0.002	...	0.062	...	−99.060
Thailand	—	0.004	0.002	0.013	−99.932	−99.102

Table 21 *(continued)*

Country or area	Percentage share in world total exports[b]		RCA index[c]		Percentage ratio of net exports to total trade[d]	
	1970-1971	1978-1979	1970-1971	1978-1979	1970-1971	1978-1979
	B. Agricultural machinery (SITC 712) (continued)					
Trinidad and Tobago	0.010	—	0.047	0.002	−79.483	−99.160
Tunisia	—	0.001	0.001	0.017	−99.982	−98.951
Turkey	0.001	0.013	0.003	0.109	−99.599	−85.536
United Kingdom	18.594	11.546	2.167	1.591	76.974	43.073
United Republic of Cameroon	0.010	0.022	0.256	0.499	−90.245	−90.357
United Republic of Tanzania	...	—	...	—	...	−99.994
United States	27.966	24.879	1.776	1.877	39.321	29.619
United States Virgin Islands	0.001	0.001	0.007	0.004	−94.475	−54.409
Upper Volta	—	—	0.048	0.140	−99.113	−95.437
Uruguay	...	0.009	...	0.134	...	−91.422
Venezuela	0.016	0.023	0.035	0.057	−97.917	−97.031
Yemen	...	—	...	0.153	...	−99.839
Yugoslavia	0.405	0.561	0.568	0.906	−60.305	−39.546
Zambia	...	—	...	—	...	−100.000
	C. Office machines (SITC 714)					
Algeria	...	—	...	0.001	...	−99.966
Argentina	0.505	0.278	1.090	0.596	−26.791	−25.160
Australia	0.054	0.248	0.052	0.292	−96.359	−83.170
Austria	0.169	0.287	0.130	0.197	−75.608	−68.895
Bahrain	0.001	0.002	0.014	0.010	−75.249	−89.184
Bangladesh	...	—	...	0.001	...	−99.149
Barbados	—	0.003	0.001	0.301	−99.866	−67.997
Belgium	1.135	1.296	0.230	0.278	−44.145	−39.321
Belize	...	0.003	...	0.383	...	−11.423
Brazil	0.635	0.847	1.117	0.836	−44.770	−12.527
Canada	3.342	3.469	0.586	0.869	−38.433	−27.510
Chile	0.003	0.002	0.008	0.011	−97.363	−97.469
Colombia	0.008	0.009	0.111	0.089	−94.219	−88.736
Congo	—	—	0.059	0.005	−93.699	−99.595
Costa Rica	...	—	...	—	...	−99.925
Cyprus	...	0.002	...	0.054	...	−81.638
Czechoslovakia	...	0.658	...	0.519	...	−43.789
Denmark	0.447	0.389	0.321	0.312	−58.250	−61.493
Dominican Republic	...	—	...	0.006	...	−97.772
Ecuador	...	0.004	...	0.074	...	−92.033
Egypt	...	—	...	—	...	−99.974
El Salvador	0.001	—	0.019	0.002	−92.433	−99.069
Finland	0.026	0.102	0.025	0.097	−93.303	−78.221
France	8.001	8.420	1.031	0.965	−17.440	−7.680
French Guiana	—	—	0.009	0.713	−99.954	−91.287
Germany, Federal Republic of	15.564	13.259	0.981	0.815	6.255	−3.225
Greece	—	0.001	—	0.002	−99.976	−99.069
Guadeloupe	—	0.002	0.012	0.267	−97.480	−81.974
Guyana	—	—	—	0.007	−99.901	−92.520
Hong Kong	0.053	1.571	0.055	1.489	−77.306	−6.157

Country or area	Percentage share in world total exports[b]		RCA index[c]		Percentage ratio of net exports to total trade[d]	
	1970-1971	1978-1979	1970-1971	1978-1979	1970-1971	1978-1979
India	0.068	0.013	0.108	0.028	−24.851	−72.429
Indonesia	...	0.002	...	0.009	...	−97.357
Ireland	0.061	1.862	0.170	3.117	−77.036	16.625
Israel	0.038	0.091	0.192	0.365	−80.644	−71.731
Italy	8.093	5.301	1.321	0.789	25.433	−0.347
Ivory Coast	0.001	0.001	0.012	0.016	−97.673	−95.972
Jamaica	...	—	...	—	...	−99.837
Japan	8.114	10.445	0.836	0.954	3.520	43.507
Kenya	—	—	—	0.001	−99.995	−99.733
Kuwait	0.002	0.005	0.011	0.016	−92.603	−94.665
Liberia	—	—	0.129	0.001	−97.215	−99.938
Madagascar	0.001	—	0.067	0.003	−91.099	−99.818
Malaysia	0.012	0.028	0.035	0.058	−85.207	−78.779
Malta	0.019	0.009	1.356	0.258	14.694	−24.989
Martinique	—	0.002	0.040	0.240	−97.709	−85.970
Mexico	0.078	0.209	0.203	0.630	−84.871	−57.010
Morocco	0.002	0.002	0.033	0.031	−95.395	−93.264
Netherlands	3.348	3.177	0.670	0.615	−8.447	−15.130
New Zealand	—	0.001	0.001	0.003	−99.879	−99.381
Norway	0.115	0.365	0.114	0.359	−77.492	−55.929
Oman	...	—	...	0.026	...	−95.466
Pakistan	—	0.002	—	0.013	−99.884	−92.382
Philippines	—	0.006	0.002	0.025	−99.704	−94.833
Portugal	0.133	0.171	0.337	0.599	−43.092	−22.395
Republic of Korea	0.097	0.465	0.271	0.332	−42.812	−21.142
Reunion	0.001	0.001	0.057	0.071	−89.039	−90.483
Saudi Arabia	...	0.002	...	0.009	...	−99.151
Senegal	0.001	0.001	0.027	0.028	−86.257	−89.713
Singapore	0.196	0.570	0.401	0.539	−24.415	−7.678
Spain	0.495	0.677	0.504	0.447	−61.238	−59.128
Sri Lanka	...	—	...	—	...	−99.955
Sweden	3.747	2.982	1.227	1.157	6.989	−4.211
Switzerland	1.399	1.220	0.585	0.479	−24.857	−35.639
Syrian Arab Republic	...	—	...	—	...	−99.963
Thailand	—	0.027	—	0.101	−99.978	−73.366
Trinidad and Tobago	0.002	0.001	0.010	0.004	−89.683	−96.671
Tunisia	—	—	0.001	0.004	−99.639	−98.179
Turkey	...	—	...	—	...	−99.946
United Kingdom	9.121	10.449	1.063	1.440	−14.859	−11.529
United Republic of Cameroon	0.001	—	0.024	0.011	−93.712	−98.011
United States	35.011	31.930	2.221	2.409	48.262	43.685
United States Virgin Islands	—	—	—	—	−99.693	−98.370
Upper Volta	—	—	0.014	0.008	−97.208	−98.503
Uruguay	...	—	...	0.003	...	−99.293
Venezuela	0.007	0.001	0.016	0.002	−97.889	−99.821
Yugoslavia	0.042	0.092	0.059	0.149	−90.098	−82.065
D. Metalworking machinery (SITC 715)						
Argentina	0.109	0.165	0.237	0.354	−88.271	68.752
Australia	0.165	0.092	0.158	0.107	86.430	86.456
Austria	1.199	1.512	0.927	1.039	15.524	2.464
Bahrain	—	0.001	0.004	0.007	95.218	89.592

Table 21 *(continued)*

Country or area	Percentage share in world total exports[b]		RCA index[c]		Percentage ratio of net exports to total trade[d]	
	1970-1971	1978-1979	1970-1971	1978-1979	1970-1971	1978-1979
	D. Metalworking machinery (SITC 715) (continued)					
Bangladesh	...	0.001	...	0.013	...	−97.625
Barbados	...	—	...	0.001	...	−99.748
Belgium	2.195	1.841	0.445	0.395	−18.915	−13.593
Belize	...	—	...	0.007	...	−80.045
Brazil	0.179	0.342	0.315	0.336	−85.248	−84.610
Canada	1.123	1.512	0.197	0.379	−70.640	−40.828
Chile	—	0.013	—	0.057	−99.879	−82.274
Colombia	0.002	0.025	0.020	0.256	−99.085	−81.731
Congo	—	0.001	0.003	0.255	−98.498	−71.703
Costa Rica	—	0.001	—	0.028	−99.995	−97.682
Cyprus	...	0.002	...	0.076	...	−92.239
Czechoslovakia	...	5.106	...	4.034	...	18.895
Denmark	0.574	0.551	0.412	0.442	−18.416	−11.100
Dominican Republic	...	0.001	...	0.034	...	−90.564
Ecuador	...	0.002	...	0.046	...	−97.386
Egypt	—	—	—	—	−99.941	−99.985
El Salvador	0.001	0.001	0.015	0.013	−93.177	−97.571
Fiji	—	—	—	—	−99.701	−99.950
Finland	0.028	0.187	0.027	0.180	−95.224	−46.685
France	5.921	5.983	0.763	0.685	−22.471	13.973
French Guiana	—	—	0.199	0.113	−93.937	−94.331
Germany, Federal Republic of	34.602	32.364	2.181	1.990	60.350	65.443
Greece	0.001	0.009	0.005	0.028	−99.690	−96.840
Guadeloupe	—	—	0.002	0.002	−98.564	−99.609
Guatemala	—	—	0.001	—	−99.593	−99.922
Guyana	...	—	...	0.001	...	−99.066
Hong Kong	0.062	0.046	0.064	0.044	−58.148	−82.338
India	0.126	0.200	0.200	0.427	−79.518	−56.669
Indonesia	...	0.001	...	0.007	...	−99.234
Ireland	0.002	0.078	0.007	0.131	−98.107	−65.224
Israel	0.024	0.030	0.119	0.122	−95.272	−89.036
Italy	8.966	8.165	1.464	1.217	16.702	46.785
Ivory Coast	0.001	0.002	0.012	0.021	−98.342	−95.481
Jamaica	...	—	...	0.003	...	−96.006
Japan	5.032	15.728	0.518	1.446	−11.904	80.660
Jordan	...	—	...	0.005	...	−99.764
Kenya	—	0.001	0.006	0.009	−99.447	−98.978
Kuwait	0.011	0.008	0.066	0.026	−54.046	−88.115
Madagascar	—	—	0.004	0.003	−98.867	−99.819
Malaysia	0.006	0.005	0.019	0.010	−95.575	−96.767
Martinique	0.001	—	0.095	0.059	−87.830	−89.224
Mexico	...	0.013	...	0.046	...	−97.960
Netherlands	1.177	0.914	0.235	0.177	−36.724	−33.718
New Zealand	0.005	0.026	0.012	0.082	−97.271	−76.504
Nicaragua	...	—	...	—	...	−99.781
Norway	0.073	0.067	0.073	0.079	−84.514	−80.505
Oman	...	—	...	0.011	...	−96.187
Pakistan	0.003	0.004	0.011	0.021	−97.128	−92.175
Panama	0.001	—	0.079	—	−92.374	−99.970
Philippines	...	0.001	...	0.002	...	−99.700

Country or area	*Percentage share in world total exports*[b]		*RCA index*[c]		*Percentage ratio of net exports to total trade*[d]	
	1970-1971	*1978-1979*	*1970-1971*	*1978-1979*	*1970-1971*	*1978-1979*
Portugal	0.062	0.046	0.158	0.160	−77.525	−80.004
Republic of Korea	0.010	0.095	0.027	0.068	−97.846	−95.864
Reunion	—	—	0.001	0.036	−99.849	−88.641
Saudi Arabia	...	0.009	...	0.037	...	−97.036
Senegal	0.001	0.001	0.012	0.016	−86.892	−93.409
Singapore	0.040	0.271	0.079	0.255	−85.831	−46.890
Spain	1.291	2.169	1.313	1.431	−31.007	24.697
Sri Lanka	...	—	...	—	...	−99.987
Sweden	2.591	2.311	0.850	0.896	−12.438	17.655
Switzerland	8.083	8.635	3.384	3.409	52.858	67.600
Syrian Arab Republic	...	0.002	...	0.047	...	−97.801
Thailand	—	0.001	—	0.005	−99.958	−99.434
Trinidad and Tobago	0.001	—	0.004	0.001	−93.586	−99.500
Tunisia	—	0.001	0.006	0.007	−99.259	−99.375
Turkey	0.001	0.002	0.004	0.015	−99.864	−99.700
United Kingdom	10.645	6.442	1.241	0.888	32.287	2.637
United Republic of Cameroon	—	0.001	0.013	0.029	−94.680	−96.736
United States	15.479	9.605	0.982	0.725	49.840	−6.885
United States Virgin Islands	—	—	—	..	−98.082	−98.431
Upper Volta	—	—	0.008	0.001	−98.050	−99.775
Uruguay	...	0.001	...	0.015	...	−96.704
Venezuela	0.009	0.009	0.019	0.021	−98.158	−98.952
Yugoslavia	0.327	0.761	0.459	1.228	−66.962	−55.765
E. Textile and leather machinery (SITC 717)						
Algeria	...	0.001	...	0.012	...	−99.927
Argentina	0.022	0.047	0.048	0.101	−96.207	−91.300
Australia	0.065	0.090	0.062	0.104	−92.145	−86.439
Austria	0.619	0.806	0.479	0.555	−41.724	−25.111
Bahrain	0.011	0.001	0.120	0.006	−19.871	−90.467
Belgium	2.451	3.076	0.496	0.659	1.820	13.098
Belize	...	0.001	...	0.060	...	−66.864
Brazil	0.188	0.470	0.328	0.465	−85.790	−61.492
Canada	0.813	0.682	0.142	0.171	−56.682	−59.875
Chile	0.005	0.023	0.013	0.100	−97.788	−92.165
Colombia	0.021	0.040	0.280	0.412	−94.937	−90.560
Congo	—	—	0.067	0.030	−76.633	−98.916
Costa Rica	0.001	—	0.022	0.005	−98.648	−99.673
Cyprus	...	0.002	...	0.064	...	−95.346
Czechoslovakia	...	6.854	...	5.415	...	58.650
Denmark	0.629	0.507	0.451	0.407	−0.694	−8.214
Dominican Republic	...	0.001	...	0.033	...	−96.212
Ecuador	—	0.001	0.020	0.015	−99.767	−99.748
Egypt	0.001	—	0.002	0.001	−99.832	−99.993
El Salvador	0.003	0.001	0.048	0.026	−96.697	−98.600
Finland	0.195	0.079	0.186	0.075	−56.481	−75.229
France	5.902	5.855	0.760	0.672	−1.996	6.801
Germany, Federal Republic of	31.181	29.348	1.965	1.805	68.040	68.616
Greece	0.003	0.006	0.014	0.019	−99.581	−99.124
Guadeloupe	—	—	0.002	0.003	−99.415	−99.480
Guatemala	0.001	—	0.010	0.005	−99.116	−99.616

Table 21 *(continued)*

Country or area	Percentage share in world total exports[b]		RCA index[c]		Percentage ratio of net exports to total trade[d]	
	1970-1971	1978-1979	1970-1971	1978-1979	1970-1971	1978-1979
E. Textile and leather machinery (SITC 717) (continued)						
Guyana	...	—	...	0.010	...	−96.240
Hong Kong	0.087	0.104	0.089	0.098	−91.079	−89.736
India	0.318	0.216	0.501	0.461	−29.648	−51.679
Indonesia	...	0.001	...	0.006	...	−99.878
Ireland	0.032	0.140	0.087	0.235	−90.782	−73.213
Israel	0.008	0.137	0.040	0.549	−97.689	−58.654
Italy	8.928	8.771	1.458	1.304	29.629	28.154
Ivory Coast	—	0.002	0.009	0.028	−98.737	−97.383
Jamaica	...	—	...	0.005	...	−97.792
Japan	12.082	14.256	1.244	1.305	51.805	76.929
Jordan	...	0.001	...	0.046	...	−97.415
Kenya	0.001	—	0.029	0.006	−97.335	−99.818
Kuwait	0.002	0.012	0.012	0.042	−78.505	−68.929
Liberia	—	—	0.164	0.008	−91.394	−99.317
Madagascar	—	—	0.010	0.001	−99.502	−99.997
Malaysia	0.011	0.008	0.034	0.016	−93.076	−95.972
Malta	...	—	...	0.001	...	−99.952
Martinique	—	—	0.009	0.011	−98.872	−98.365
Mexico	0.014	0.038	0.037	0.114	−98.930	−97.205
Morocco	0.002	—	0.028	0.001	−99.146	−99.983
Netherlands	1.407	1.870	0.282	0.362	−17.182	0.038
New Zealand	0.008	0.089	0.020	0.284	−96.661	−61.720
Norway	0.056	0.110	0.056	0.127	−78.350	−63.357
Oman	...	—	...	0.006	...	−99.132
Pakistan	0.021	0.008	0.088	0.047	−97.424	−97.493
Panama	0.001	--	0.054	0.001	−95.999	−99.929
Philippines	0.028	0.023	0.129	0.093	−92.466	−95.451
Portugal	0.064	0.101	0.161	0.353	−91.565	−84.226
Republic of Korea	0.036	0.360	0.100	0.256	−97.431	−83.883
Reunion	—	—	0.001	0.008	−99.754	−97.318
Saudi Arabia	...	0.005		0.019	...	−97.734
Senegal	...	0.001	...	0.038	−97.457	−92.755
Singapore	0.065	0.213	0.166	0.200	−72.043	−34.176
Somalia	—	—	0.030	0.018	−97.039	−99.952
Spain	1.087	1.647	1.110	1.088	−29.394	6.233
Sri Lanka	...	—	...	0.003	...	−99.722
Sweden	1.193	1.369	0.391	0.531	21.900	30.983
Switzerland	11.626	14.125	4.867	5.564	74.830	75.971
Syrian Arab Republic	...	0.001	...	0.037	...	−99.730
Thailand	—	0.006	0.002	0.020	−99.959	−98.565
Trinidad and Tobago	0.002	0.002	0.011	0.012	−87.831	−93.439
Tunisia	0.001	0.005	0.023	0.062	−98.185	−96.174
Turkey	0.014	0.013	0.091	0.099	−95.841	−97.735
United Kingdom	12.300	7.754	1.434	1.069	39.930	19.822
United Republic of Cameroon	0.002	0.002	0.065	0.058	−95.456	−96.977
United Republic of Tanzania	...	—	...	0.011	...	−99.960
United States	8.692	7.452	0.550	0.562	−23.399	−22.206
United States Virgin Islands	0.001	—	0.005	--	−96.218	−99.731

Country or area	Percentage share in world total exports[b]		RCA index[c]		Percentage ratio of net exports to total trade[d]	
	1970-1971	1978-1979	1970-1971	1978-1979	1970-1971	1978-1979
Upper Volta	—	—	0.040	0.029	−97.762	−99.280
Uruguay	...	—	...	0.005	...	−99.709
Venezuela	0.007	0.001	0.017	0.003	−98.630	−99.693
Yugoslavia	0.111	0.422	0.155	0.682	−87.840	−68.439
F. Machines for special industries (SITC 718)						
Argentina	0.112	0.085	0.244	0.182	−83.178	−81.540
Australia	0.567	0.357	0.544	0.416	−72.689	−72.237
Austria	1.242	1.793	0.961	1.233	−11.367	16.098
Bahrain	0.016	0.157	0.173	0.742	−63.977	−28.096
Bangladesh	...	—	...	—	...	−99.980
Barbados	0.001	—	0.088	0.031	−90.848	−95.877
Belgium	2.859	3.782	0.578	0.811	−4.409	22.694
Belize	...	0.029	...	3.233	...	29.467
Brazil	0.266	0.529	0.466	0.521	−78.972	−32.531
Canada	2.306	2.511	0.403	0.629	−55.997	−45.369
Chile	0.001	0.004	0.002	0.017	−99.777	−97.809
Colombia	0.010	0.017	0.139	0.175	−97.113	−90.936
Congo	0.002	0.001	0.334	0.157	−81.471	−91.893
Costa Rica	—	—	0.008	0.010	−99.673	−99.636
Cyprus	...	0.008	...	0.265	...	−83.998
Czechoslovakia	...	2.253	...	1.778	...	1.285
Denmark	1.531	1.289	1.099	1.035	3.230	7.860
Dominican Republic	...	0.010	...	0.236	...	−82.761
Ecuador	—	0.001	0.007	0.028	−99.932	−99.353
Egypt	0.002	—	0.005	0.003	−98.660	−99.944
El Salvador	0.003	0.001	0.051	0.033	−94.189	−97.855
Fiji	—	—	—	0.007	−99.996	−99.194
Finland	1.010	1.026	0.972	0.975	−16.206	17.223
France	6.937	8.419	0.894	0.965	12.455	24.656
French Guiana	0.001	—	1.452	0.113	−87.891	−99.368
Germany, Federal Republic of	23.900	21.137	1.510	1.500	56.078	59.160
Greece	0.005	0.014	0.024	0.042	−99.272	−95.899
Guadeloupe	0.002	0.001	0.132	0.149	−94.866	−93.779
Guatemala	—	0.001	0.007	0.010	−99.514	−99.591
Guyana	—	0.004	0.005	0.208	−99.836	−83.109
Honduras	—	—	0.001	—	−99.976	−100.000
Hong Kong	0.011	0.009	0.011	0.009	−94.062	−96.338
Iceland	0.002	0.003	0.109	0.101	−94.904	−91.450
India	0.042	0.128	0.067	0.274	−91.241	−70.335
Indonesia	...	0.020	...	0.111	...	−96.196
Ireland	0.034	0.226	0.092	0.380	−92.475	−62.370
Israel	0.017	0.009	0.085	0.035	−92.335	−94.633
Italy	5.703	5.346	0.931	0.797	29.362	33.766
Ivory Coast	0.009	0.038	0.202	0.472	−89.644	−74.690
Jamaica	...	0.004	...	0.066	...	−79.588
Japan	4.336	6.707	0.449	0.616	28.254	66.300
Jordan	...	—	...	0.017	...	−99.794
Kenya	0.001	0.003	0.012	0.047	−99.572	−97.971
Kuwait	0.099	0.087	0.358	0.294	−54.010	−81.807
Liberia	0.003	0.002	1.571	1.001	−97.132	−98.260
Madagascar	0.013	0.003	0.628	0.368	−77.728	−91.401
Malaysia	0.089	0.048	0.278	0.097	−87.034	−93.213

Table 21 *(continued)*

Country or area	Percentage share in world total exports[b] 1970-1971	1978-1979	RCA index[c] 1970-1971	1978-1979	Percentage ratio of net exports to total trade[d] 1970-1971	1978-1979
F. Machines for special industries (SITC 718) (continued)						
Malta	—	—	0.001	0.003	−99.948	−99.296
Martinique	0.001	0.001	0.149	0.081	−96.048	−96.205
Mexico	0.010	0.058	0.026	0.175	−98.769	−91.153
Morocco	0.001	—	0.014	0.005	−99.572	−99.794
Netherlands	2.458	2.431	0.492	0.470	−14.760	−5.128
New Zealand	0.012	0.021	0.029	0.067	−95.800	−86.595
Norway	0.422	0.363	0.422	0.429	−51.225	−61.770
Oman	...	0.011	...	0.986	...	−81.347
Pakistan	0.002	0.003	0.008	0.015	−99.336	−98.111
Panama	0.016	—	0.960	—	−84.519	−99.980
Philippines	0.001	0.014	0.007	0.057	−99.694	−96.746
Portugal	0.034	0.008	0.087	0.027	−90.254	−97.027
Republic of Korea	0.011	0.124	0.031	0.088	−96.769	−81.914
Reunion	0.001	0.001	0.045	0.059	−97.303	−95.931
Saudi Arabia	...	0.140	...	0.573	...	−92.181
Senegal	0.018	0.005	0.383	0.131	−46.724	−93.991
Singapore	0.484	0.843	0.950	0.792	−65.801	−34.883
Spain	0.380	0.826	0.389	0.545	−73.359	−18.381
Sri Lanka	...	0.005	...	0.077	...	−87.330
Sweden	3.782	3.534	1.239	1.371	27.277	38.376
Switzerland	2.766	2.973	1.158	1.171	7.398	35.455
Syrian Arab Republic	...	0.013	...	0.341	...	−92.370
Thailand	0.001	0.008	0.007	0.030	−99.553	−96.951
Trinidad and Tobago	0.015	0.017	0.072	0.114	−92.632	−86.860
Tunisia	—	0.021	0.008	0.268	−99.460	−89.464
Turkey	0.005	0.003	0.029	0.028	−99.369	−98.951
United Kingdom	12.948	10.363	1.509	1.428	43.179	31.569
United Republic of Cameroon	0.007	0.004	0.181	0.162	−89.667	−95.909
United Republic of Tanzania	—	—	0.001	—	−99.980	−100.000
United States	25.458	24.614	1.616	1.857	68.790	54.164
United States Virgin Islands	0.008	0.005	0.069	0.015	−67.633	−23.879
Upper Volta	0.001	0.002	0.366	0.607	−94.303	−84.563
Uruguay	...	0.002	...	0.039	...	−95.212
Venezuela	0.034	0.019	0.079	0.047	−94.988	−98.636
Yemen	...	0.004	...	3.623	...	−97.692
Yugoslavia	0.098	0.262	0.138	0.424	−89.689	−76.063
Zambia	0.001	0.001	0.004	0.010	−99.725	−97.722
G. Machinery and appliances, not elsewhere specified (SITC 719)						
Algeria	...	—	...	0.001	...	−99.996
Argentina	0.095	0.206	0.204	0.442	−83.816	−53.701
Australia	0.298	0.262	0.286	0.308	−75.008	−72.044
Austria	1.510	1.802	1.168	1.240	−13.912	−2.981
Bahrain	0.021	0.036	0.226	0.182	−71.128	−64.760
Bangladesh	...	—	...	—	...	−99.967
Barbados	—	—	0.002	0.002	−99.851	−99.782
Belgium	2.367	2.055	0.479	0.441	−25.639	−20.647

Country or area	Percentage share in world total exports[b]		RCA index[c]		Percentage ratio of net exports to total trade[d]	
	1970-1971	1978-1979	1970-1971	1978-1979	1970-1971	1978-1979
Belize	...	—	...	0.027	...	−94.918
Brazil	0.108	0.359	0.189	0.354	−89.852	−67.855
Brunei	...	—	...	—	...	−99.999
Canada	1.909	1.583	0.333	0.397	−52.058	−45.741
Cape Verde	...	—	...	0.650	...	−88.781
Chile	0.007	0.019	0.016	0.082	−97.923	−89.699
Colombia	0.018	0.029	0.241	0.294	−93.591	−86.588
Congo	—	—	0.077	0.077	−97.086	−98.549
Costa Rica	0.005	0.005	0.124	0.125	−91.296	−92.186
Cyprus	...	0.011	...	0.333	...	−75.511
Czechoslovakia	...	3.653	...	2.885	...	4.541
Denmark	2.013	1.870	1.445	1.501	9.924	16.599
Dominican Republic	...	0.001	...	0.031	...	−96.378
Ecuador	—	0.004	0.018	0.082	−99.787	−96.953
Egypt	0.020	0.002	0.062	0.014	−85.738	−99.504
El Salvador	0.005	0.003	0.100	0.068	−81.721	−92.864
Ethiopia	—	—	—	0.008	−99.999	−99.713
Fiji	—	—	0.001	0.001	−99.834	−99.860
Finland	0.560	0.909	0.537	0.871	−44.697	−0.357
France	7.508	8.721	0.967	0.999	−3.491	14.715
French Guiana	—	0.001	0.363	1.084	−98.365	−91.829
Germany, Federal Republic of	25.206	24.938	1.589	1.534	55.496	57.343
Greece	0.008	0.028	0.042	0.087	−97.982	−91.333
Guadeloupe	0.001	0.001	0.044	0.133	−97.365	−94.462
Guatemala	0.001	0.001	0.008	0.012	−98.614	−98.641
Guyana	—	0.001	—	0 038	−99.998	−94.687
Honduras	—	—	—	—	−99.993	−99.997
Hong Kong	0.056	0.070	0.058	0.067	−76.857	−80.692
Iceland	—	—	0.002	0.011	−99.836	−99.046
India	0.077	0.122	0.122	0.260	−89.460	−75.353
Indonesia	...	0.008	...	0.045	...	−98.099
Ireland	0.116	0.272	0.318	0.456	−68.836	−42.813
Israel	0.059	0.100	0.293	0.402	−82.229	−66.782
Italy	8.037	8.373	1.312	1.246	25.749	46.474
Ivory Coast	0.003	0.012	0.062	0.150	−96.744	−92.430
Jamaica	...	0.001	...	0.017	...	−96.172
Japan	5.769	10.300	0.595	0.942	38.145	70.431
Jordan	—	0.001	0.007	0.119	−99.822	−98.456
Kenya	0.001	0.002	0.012	0.026	−99.282	−98.394
Kuwait	0.026	0.033	0.152	0.111	−85.709	−89.720
Liberia	0.003	—	1.175	0.123	−94.017	−98.564
Madagascar	0.002	0.001	0.073	0.112	−95.765	−96.567
Malawi	—	—	0.013	—	−99.025	−99.983
Malaysia	0.037	0.087	0.114	0.176	−85.648	−75.396
Malta	0.001	0.001	0.050	0.031	−96.757	−94.642
Martinique	0.001	0.001	0.077	0.138	−97.295	−94.041
Mexico	0.270	0.112	0.697	0.339	−70.417	−85.887
Morocco	0.001	—	0.011	0.003	−99.440	−99.891
Netherlands	2.945	2.956	0.590	0.572	−25.474	−11.757
New Zealand	0.034	0.049	0.084	0.156	−87.473	−74.849
Nicaragua	0.002	0.002	0.035	0.039	−93.666	−88.052
Nigeria	...	—	...	—	...	−100.000
Norway	0.626	0.557	0.624	0.652	−43.175	−38.545
Oman	...	0.012	...	1.061	...	−85.832

Table 21 *(continued)*

Country or area	Percentage share in world total exports[b] 1970-1971	Percentage share in world total exports[b] 1978-1979	RCA index[c] 1970-1971	RCA index[c] 1978-1979	Percentage ratio of net exports to total trade[d] 1970-1971	Percentage ratio of net exports to total trade[d] 1978-1979
G. Machinery and appliances, not elsewhere specified (SITC 719) (continued)						
Pakistan	0.003	0.005	0.012	0.030	−98.764	−96.647
Panama	—	—	0.029	—	−99.145	−99.985
Paraguay	...	—	...	—	...	−99.987
Philippines	0.001	0.011	0.006	0.048	−99.646	−96.127
Portugal	0.098	0.070	0.249	0.243	−75.992	−78.725
Republic of Korea	0.008	0.129	0.024	0.092	−98.222	−89.648
Reunion	0.001	0.001	0.024	0.066	−97.862	−95.508
Saudi Arabia	...	0.035	...	0.142	...	−98.039
Senegal	0.004	0.001	0.091	0.039	−86.936	−96.214
Singapore	0.133	0.503	0.260	0.474	−71.901	−42.682
Somalia	0.001	—	0.462	0.135	−84.005	−99.353
Spain	0.462	0.953	0.471	0.629	−68.200	−24.024
Sri Lanka	...	—	...	0.005	...	−99.305
Sweden	4.597	3.468	1.506	1.345	16.080	17.513
Switzerland	3.080	3.787	1.289	1.493	5.022	31.463
Syrian Arab Republic	...	0.004	...	0.098	...	−97.816
Thailand	0.002	0.012	0.015	0.043	−99.275	−95.761
Trinidad and Tobago	0.005	0.004	0.023	0.029	−92.508	−96.402
Tunisia	0.001	0.003	0.022	0.044	−98.799	−97.987
Turkey	0.001	0.003	0.008	0.024	−99.586	−98.926
United Kingdom	10.147	8.224	1.182	1.133	33.587	20.273
United Republic of Cameroon	0.005	0.002	0.128	0.073	−91.858	−97.831
United Republic of Tanzania	—	—	—	—	−99.999	−99.995
United States	21.767	16.684	1.380	1.259	59.467	38.108
United States Virgin Islands	0.002	0.003	0.014	0.009	−96.640	−63.518
Upper Volta	—	—	0.100	0.157	−96.022	−94.897
Uruguay	...	0.005	...	0.076	...	−87.083
Venezuela	0.030	0.010	0.066	0.025	−96.153	−99.122
Yemen	...	—	...	0.292	...	−99.528
Yugoslavia	0.313	0.524	0.440	0.845	−69.731	−60.889
Zambia	—	—	0.001	—	−99.833	−99.999

Source: Based on data supplied by the Statistical Office of the United Nations Secretariat.

[a] All figures are unweighted annual averages. However, for 1978-1979, figures for the following countries and areas refer to 1978 only: Barbados, Belize, Cape Verde, Chile, Congo, Czechoslovakia, Ecuador, Fiji, Honduras, India, Kuwait, Liberia, Mexico, Nigeria, Oman, Somalia, Syrian Arab Republic, United Republic of Tanzania, Virgin Islands (U.S.) and Zambia.

[b] Percentage share in total value of exports from the countries listed in the table.

[c] Index of revealed comparative advantage. For the definition, see chapter III, footnote 8.

[d] In symbols, $100 \times (X_i^j - M_i^j)/(X_i^j + M_i^j)$, where: i is the country, j is the product group and X and M are the values of exports and imports, respectively.

Part Two

The machine-tool industry

Introduction

The machine-tool[1] industry is an old industry which emerged simultaneously with the development of engineering industries and with industrialization in general. More specifically, it can be said that the pace of development of machine tools governed the pace of industrial development. The history of machine tools can be traced back some 200 years. Before that time, the potential of any kind of power-driven machinery could not be realized simply because the tools available were not adequate for producing commercially usable engines. In 1776, the first real machine appeared. This machine was the steam engine which had been invented 10 years earlier by James Watt. Watt had been working with the idea for several years, but had not been able to build a successful engine because he could not produce a piston to fit a cylinder closely enough to be steam-tight and so produce power. John Wilkinson solved the problem by inventing a horizontal boring mill with a boring bar supported outside the work and thus independent of the irregularities of the rough casting. This was the first effective machine tool which made the manufacture of full-scale engines possible at last. Thus, as has usually been the case with all machine tools, the demand existed before the tool. This invention was the essential technological factor underlying the industrial revolution which followed in the United Kingdom. During the next 50 years, the engineering industries, particularly in industrial machinery, grew very fast on the basis of continuous innovation and invention. Its development was dependent upon that of the machine-tool industry. Thus, a mechanized economy was established which permitted a wide range of manufactured products to be produced much faster and more cheaply, thereby stimulating demand for the products. This in turn required quick development of new types of machine tools and all the basic types of machine tools had been developed by the end of the nineteenth century.

The share of machine tools in total manufacturing output is negligible, and even in the output of non-electrical machinery, it is much less than 10 per cent in most countries. However, in terms of a country's development, machine tools play a crucial role. Directly or indirectly they produce all manufactures and many primary products. In order to produce machinery, unit parts are first produced by processing iron and steel and other materials. The parts are then assembled. In this whole process, the making of the parts by machine tools is the most important section in terms of number of production runs and in the sense that it largely determines the quality of the final products. As production of any machine used in the economy depends heavily on machine tools, it is evident that the machine tool is the basis of our whole mechanized society.

[1]Throughout part two, "machine tools" refers to metalworking machine tools. In simple terms, a machine tool is a power-driven machine designed to cut or shape metal.

Because of this and the increasing competitiveness of markets for engineering products, there has been a continuous demand from the engineering industry that machine tools should be developed and improved to give higher precision and productivity, new applications and easier handling.[2] Through this process, machine tools have become very diverse. It is said that currently there exist about 3,000 different types of machine tools, for each of which there are many variations matching particular users' requirements for performance in terms of size, precision, speed, automaticity, efficiency etc. Thus, the industry's importance is in its role as supplier of equipment of the required quality and quantity to the engineering industries which, in turn, are vital to all economic and industrial development. The role of the industry in generating and diffusing new production technology has made it of central concern to Governments in many developed countries as well as several developing countries such as the newly industrializing countries or areas (NICs).

[2]The high pace of product development towards more sophisticated machine tools is implied in the rapid increase in their prices. For example, during the ten years from 1967 to 1977, the wholesale price index of machine tools in the United States increased by 113 per cent, compared to the 88 per cent increase in that of durable goods as a whole (based on data provided in National Machine Tool Builders' Association, *Economic Handbook of the Machine Tool Industry, 1978-1979* (McLean, Virginia, 1979)).

IV. Overview of the machine-tool industry

A. General characteristics

Machine tools may be classified into several broad categories according to their types, functions, sizes etc. A basic differentiation according to type is between the two broad categories of metal-cutting and metal-forming machines. In 1980, metal-cutting machines accounted for about three quarters of world machine-tool production in terms of gross value.[1]

Machine tools may be also classified into the two groups, numerically controlled (NC) machine tools and manually controlled machine tools. Although the share of NC machine tools in world machine-tool production is still very small in terms of number, their share in terms of value has become considerable.[2] However, the production as well as consumption of NC machines is concentrated in developed countries because of the technical complexity of their production and because a strong factory organization and programming and tooling services are prerequisites for their use.

Machine tools are also often classified into the two categories, general-purpose machines (or universal machines) and special-purpose machines, according to their functions. General-purpose machines are designed to produce small batches of several different workpieces while special-purpose machines are designed for large-batch production of a single type of workpiece in a sequence of operations. The former, which are the majority in machine-tool production and used in most engineering workshops, are supplied as standard products for sale from stock. On the other hand, production of the latter is usually based on specific orders received from customers. A transfer machine for mass production of automobile components is a typical example of a special-purpose machine tool.

Although there is no clear dividing line or functional difference, machine tools may be classified into the two groups, large machines and small machines. Size of machine is closely related to the size of component to be produced. A typical example of a large machine is that used in the aerospace industry which requires large high-precision components.[3] A machine-tool factory usually

[1] Based on the data provided in *American Machinist*, February 1982, p. 109. Unless otherwise stated, all references to values in this part are based on current prices. These were converted to United States dollars at the respective year's average rate for commercial transactions to facilitate cross-country comparisons and aggregations. It should be noted that changes in the relative value of currencies reduce the comparability of the data. For example, the revaluation of the currency of a country against the United States dollar inflates the corresponding United States dollar figures for that country.

[2] In 1978, NC metal-cutting machine tools accounted for 2.7 per cent of total metal-cutting machine-tool production in terms of number but 24.0 per cent in terms of gross value in France, the Federal Republic of Germany, Italy, Japan, the United Kingdom and the United States.

[3] For example, a gantry milling machine for aircraft production has a 90-feet long by 14-feet wide bed. The price of this machine is almost two million dollars (*Iron Age*, 29 August 1977, p. 84).

produces several kinds of machines of about the same size for various economic reasons. Large machines are usually complex and demand for them is limited. Hence, their production and consumption is concentrated in industrialized countries. The development of the machine-tool industry in the developing countries has been predominantly in the field of small and low-cost universal machines because their production technology is relatively simple and they meet general domestic demand. The machine tools which are currently used in developing countries are generally of low power, 3 hp or less.

The output of the machine-tool industry is consumed almost exclusively by the engineering industries (i.e., industries classified in ISIC 381-385) including the machine-tool industry itself. In the United States, for example, a very large engineering firm has more than 10,000 machine tools. In 1978, the engineering industries in Japan purchased 96 per cent of all the domestically produced machine tools. The non-electrical machinery industry and the automobile industry in particular were the two most important customers whose purchases together accounted for 78 per cent of total domestic supply in 1979 (see table 22). Thus the demand for machine tools depends heavily on the investment behaviour of these engineering industries which in turn depends on the domestic- and export-market conditions for their engineering products.

The high value added per unit of output indicates two further important characteristics of the machine-tool industry, that it is highly skill-intensive and that the fabrication process has a high degree of complexity. In both Japan and the United States, for example, the ratio of value added to gross output in the industry was significantly high compared to the average in the non-electrical machinery branch which, in turn, was much higher than the average for total manufacturing.[4] On the other hand, as seen in these two countries, labour

Table 22. Domestic market structure for machine tools produced in Japan, 1963, 1970 and 1979[a]

(Percentage)

Source of domestic demand	*1963*	*1970*	*1979*
Basic-metals industry	5.1	5.1	2.1
Metal products except machinery	[b]	[b]	3.7
Non-electrical machinery	43.4	43.9	46.3
Electrical machinery	7.5	6.2	7.6
Automobiles	21.8	28.9	32.0
Other transport equipment	4.4	4.9	3.0
Precision instruments	5.7	4.1	4.5
Other manufactures	[b]	[b]	1.3
Other domestic demand	12.1	6.6	0.9
Total	100.0	100.0	100.0

Source: Based on data provided by Japan Machine Tool Builders' Association.

[a] Based on orders received at current prices.

[b] Included in "other domestic demand".

[4] The high value added to gross output ratio in the machine-tool industry compared to that in the non-electrical machinery industry as a whole is partly due to the fact that the fragmentation of the production process in the latter industry has advanced less than in many other machinery industries, particularly those carrying out mass production of multiple-product production.

productivity in the industry is relatively low, which reflects the labour-intensive nature of the industry (see table 23).

Reflecting the relatively small-batch production of diverse products, small- and medium-scale operations are dominant in the industry. Firms employing more than 2,000 persons are rather exceptional. Furthermore, large firms tend to diversify their production lines to produce not only machine tools but also other products. In leading machine-tool producing countries like the Federal Republic of Germany, Japan, the United Kingdom and the United States, the number of firms in this branch ranges between 500 and 1,000 with small firms predominating. In 1978, three-quarters of the 450 firms in the Federal Republic of Germany had less than 25 employees and only 15 firms employed more than 1,000 persons.[5] In the United Kingdom, 60 per cent of the 983 firms employed 10 or fewer persons and only 17 firms employed more than 500 persons.[6]

Furthermore, the degree of concentration in the industry is relatively low compared to other engineering industries. For example, in the United States the four largest firms account for only around 20 per cent of total output of machine tools in the country. Similar figures apply in other leading countries.[7] In developing countries, however, a few large firms tend to dominate domestic production and exports.

Another characteristic is that most firms are highly specialized in the production of one type or a few types of machine tools and produce a small quantity of customized products according to orders received.[8] There are several reasons for this. Firstly, the market for machine tools is limited to engineering industries and is small, but machine tools are diverse. Therefore, scale economies are not possible in the production of most types of machine tools. Secondly, as in the case of many other capital goods, demand for

Table 23. The ratio of value added to gross output, and per-employee value added in the metal-cutting machine-tool industry in Japan and the United States, 1976

Country	*Ratio of value added to gross output (percentage)*	*Ratio compared to that in the non-electrical machinery industry (index)*	*Ratio compared to that for average of total manufacturing (index)*	*Per-employee value added (dollars)*	*PVA compared to the average in the non-electrical machinery industry (index)*	*PVA compared to the average for total manufacturing (index)*
Japan	49.3	1.11	1.47	13 243	0.81	0.89
United States	66.6	1.24	1.55	28 642	0.98	0.99

Source: Based on data provided by Japan Machine Tool Builders' Association; National Machine Tool Builders' Association, United States; and the Statistical Office of the United Nations Secretariat.

[5] *American Machinist*, February 1978, p. 85.

[6] Information given by the Machine Tool Trade Association, London.

[7] For the smallness of firms and the low concentration in the machine tool industry, see, for example, A. Daly and D. T. Jones, "The machine tool industry in Britain, Germany and the United States", *National Institute Economic Review*, No. 92, May 1980, pp. 55-57; OECD, *NC Machine Tools, Their Introduction in the Engineering Industries* (Paris, 1970), pp. 32-34.

[8] The number of machine tools produced by a firm ranges from less than ten to a few hundred at most, depending on the kind of product. Large machine tools are often produced as single items.

machine tools fluctuates widely following economic conditions and this requires flexibility in adjusting production in the industry. Thirdly, the development of skills and market awareness benefit from product specialization.

Machine tools are technically complex and require a large initial overhead investment in design and testing. An obvious disadvantage for small and specialized machine-tool manufacturers is that they can less easily support investment in innovation than larger firms. Actually, many small firms are below the critical size for innovation. They do not have the resources needed to carry out the large amount of R and D work required, particularly in the fields of NC and electronics applications. Production of a NC machine tool costs, in general, several times more than production of a non-NC machine tool. It is often too risky for a small firm to make such a large investment in developing NC machines or other sophisticated machines. Moreover, the highly cyclical demand for machine tools aggravates the risk. In order to reduce these disadvantages, there has been a tendency in the developed countries to concentrate production. This has been, in most cases, among larger firms. In general, successful firms tend to become larger and less specialized while the others remain small or disappear through mergers or closures.

Close technological collaboration between machine-tool producers and users in product development and innovation is indispensible to ensure that machine tools meet the technological requirements of users. For example, automobile producers may prepare instructions for their tooling needs in the form of models, engineering blueprints or computer control tapes. Consequently, the machine-tool producers must co-ordinate their R and D and capital-investment programmes with the automobile producers' changing requirements. The small-scale and specialized structure of the machine-tool industries makes it difficult for them to initiate rapid development in machine tools. Instead, technological development by major machine-tool users tends to affect the size and organization of machine-tool firms.

This need for close technological co-operation between the suppliers and users of machine tools results in the location of machine-tool firms close to their customers. For example, in the United States, more than one-half of the machine-tool shops are located in the north-central region, with more shops in the State of Michigan than in any other state. These shops primarily supply the automobile industry. On the other hand, the numerous workshops in the State of California primarily supply the aerospace industry.[9]

A similar pattern can also be observed in a broader comparison such as that between countries. The two most essential determinants of location in the machine-tool industry are the existence of sufficient demand and a comparative advantage in machine tools in the world market. A country's comparative advantage is determined by several factors such as the accumulation of technology, the availability of manpower, R and D capability, the availability of economically and technologically suitable input materials, the existence of auxiliary industries etc., as described in part one. Because most of these factors are present in a limited number of developed countries in which the engineering

[9]Thomas G. Marx, "Technological change and the structure of the machine-tool industry", *MSU Business Topics*, vol. 27, No. 1 (1979), p. 41.

industries are highly developed, the production and export of machine tools is highly concentrated in these few developed countries. The existence of well-developed engineering industries in those countries provides a large domestic market for the machine tools produced. On the other hand, the production and exports of machine tools in the developing countries as a whole are negligible. Except in some newly industrializing countries and areas (NICs), current levels of demand for machine tools in the developing world are, in general, insufficient for economic local production. In the NICs, however, the increasing amount of imports of machine tools generated by the rapid development of domestic engineering industries has stimulated emphasis on local production of certain types of machine tools for import substitution. In spite of factor endowments in the user industries different from those in the developed countries, the machine tools which are currently produced in the developing countries are, in many cases, those originally designed for the developed countries. Production of modified or indigenous machine tools which meet local technological requirements is still in the primary stage and is limited to a few countries.

There is a tendency towards product specialization among the developed countries. Product specialization depends heavily on external factors such as the development of upstream-linked industries and demand structure in the country. For example, the highly advanced electronics industries in Japan and the United States provide a comparative advantage in the production of NC machine tools in these countries. Equally important is the specific demand structure for machine tools in a country. Not only the size and the technical level but also the product pattern of the machine-tool industry are determined by the structure of the domestic engineering industries and, to a lesser extent, by specific demands from principal export markets. For example, the machine-tool industry in Switzerland specializes in high precision machines for watch and other precision equipment manufacture. In Sweden, the specialization is in the field of ball-bearing production. The great variety of machine tools, particularly of sophisticated machine tools, produced in the Federal Republic of Germany reflects the diversity of the products produced in that country's engineering industries. In the United Kingdom, production of less sophisticated standard machines is more typical, following the requirements of the less innovative domestic engineering industries (which are characterized by mass production of consumer durables) and of demand from Commonwealth countries, the United Kingdom's principal export markets. In Japan, the quick response to the changing requirement for automatization in the large automobile industry and in small- and medium-scale engineering workshops resulted in rapid specialization in small, low-cost NC machines. In the United States, until recently, the large domestic markets for almost all types of machine tools enabled the machine-tool industry to produce all types of machine tools, including huge machines for the aerospace industry, in optimum size batches without depending on exports. This is reflected in the fact that the degree of product specialization even in large firms is considerably higher in the United States than that in firms in Europe and Japan. The product specialization in different types of machines in these countries has had important consequences in the performance of their machine-tool industries in the 1970s, which will be discussed later.

B. Technological development and trade consequences from the beginning of the twentieth century to the mid-1960s

From the beginning of the machine-tool industry until the early twentieth century, the United Kingdom dominated world markets, the early growth of demand in its domestic machinery industries having stimulated innovation and technological development. From that point on, Germany and the United States began to overtake the United Kingdom. After this first period of growth during the era of the industrial revolution, there was a second dramatic expansion of world machine-tool production during the First World War stimulated by wartime demand. For example, in the United States, output of machine tools increased in value from 49 million dollars in 1914 to 212 million dollars in 1919. Production in Germany and the United Kingdom grew rapidly as well. However, there was a basic difference between the United Kingdom and the other two countries in the expansion of this period. The United Kingdom concentrated on the production of its traditional lathes, while the other two diversified their products. This characteristic difference contributed significantly to the declining share of the United Kingdom and the increasing shares of the other two countries in the world machine-tool market in the first half of the twentieth century.

A remarkable innovation was made in the early twentieth century. Until that time, carbon steel had been the basis of the cutting tools and this had gradually become the ultimate factor limiting productivity. At the same time there was an increasing requirement from users for speed and efficiency in machine tools. The new material which took the place of carbon steel was "high-speed steel". The introduction of this material spurred further progress in machine-tool design. Following high-speed steel, the next major advance was achieved in the early 1930s with the introduction of carbide cutting tools in Germany. Today, this material is the most widely used cutting-tool material.

The development of machine tools in terms of both quality and quantity during this period was also a consequence of requirements from user industries. In the United States, mass production of consumer durables including automobiles started in the early twentieth century, much earlier than in Europe, and this generated a large domestic market for machine tools. The emergence of the United States in this field was based on the large-scale development of special-purpose machine tools with interchangeable standardized parts suitable for mass production of consumer durables, rather than on the heavier custom-designed machine tools for producing industrial machinery, railway equipment and ships that were the basis of the British machine-tool industry. Domestic demand in the United States for machine tools was further expanded during the inter-war period when the rapid development in the ordnance industries required increasing supplies of high-precision special-purpose machine tools for mass production. During this period as well as the next post-war period, the aircraft industry expanded rapidly with increasing technological sophistication and this required supplies of many complicated parts produced with great accuracy. Consequently, many new high-precision machine tools were designed for this purpose. In the 1950s and the 1960s, consumer-durable industries (e.g., those producing automobiles and electrical appliances) increased their importance as trigger industries for special-purpose machine tools designed for

mass production. Almost the entire domestic demand for machine tools was filled by the domestic machine-tool industry and, consequently, imports were minimal until the late 1960s.

The basis for the German challenge was the creation of a strong system of technical education. This strong skill base in engineering technology led to a leading position in all kinds of advanced machinery including advanced machine tools. The education system was further reinforced by successful rationalization in the inter-war period.[10]

The increasing requirement of the engineering industries for higher precision and automatization led to a revolutionary new development, that of numerically controlled machine tools (NC machine tools). NC systems are units which convert symbols on punched cards, or data on magnetic tape into electric pulses that control the various mechanical functions of the machine tools. An important advantage of numerical control is that there is no need to stop the machinery to make adjustments every time there is a change in the size of workpiece or the tool used. Once the tape (or cards) carrying the control instructions (or the programme) has been prepared, no further adjustment of machine handling is needed. This avoids the waiting periods which occupy 80-95 per cent of the time it takes to produce a finished item by non-NC machine tools, reduces human error and increases the uniformity of products. Furthermore, the prepared tape can be stored for future use or dispatched to other places. In addition, the ability of NC machines to produce parts of complicated design provides users with greater design freedom and production flexibility. The shortened production time reduces the number of spare parts which users must stock and allows users to incorporate last-minute design changes into the parts. This advantage is particularly great in high-risk or uncertain markets with long production lead times such as the automobile industry where the ability to go from the initial design of a new model to production as fast as possible is essential in order that the customers' tastes will not have changed by the time the new model arrives in the showroom.[11]

Commercial production of NC machine tools first began in the United States[12] in the mid-1950s, encouraged by various circumstances in the country such as the high wage level and the necessity for small-batch production of items with high accuracy, particularly in the aircraft and ordnance industries. Owing to the improvement in electronics technology from solid-state electronics to integrated circuits in the 1960s, the first electronic-control machine tools were developed. This resulted in a considerable expansion of NC machine production in the 1960s. In 1966, output of NC machines was already about 15 per cent of the value of total gross output of machine tools in the United States, although, in terms of number, it accounted for only one per cent of total

[10]For details, see, for example, Daly and Jones, *loc. cit.*, pp. 59-63.

[11]Marx, *loc. cit.*, pp. 42-43.

[12]A technique for automatic control of general-purpose machine tools was first developed in Germany during World War II for use in the ordnance industry. The first NC milling machine was developed in the United States in 1952. The first commercial NC machine tool was shown at the National Machine Tool Show in the United States in 1955. The Federal Government of the United States then placed the first order for NC machine tools for use primarily in the aerospace industry on government-sponsored projects (Marx, *loc. cit.*, p. 46). Industrial production of NC machines started in the early 1960s in Europe and in the mid-1960s in Japan (OECD, *NC Machine Tools . . .*, p. 39).

machine-tool production.[13] Numerically controlled machines, however, were generally used only in the aerospace industry. The widespread diffusion of their use only took place in the 1970s.

From the beginning of the twentieth century to the middle of the 1960s, the trade shares of the world's leading countries in this field were relatively stable. Germany, after 1955 the Federal Republic of Germany, and the United States dominated world machine-tool exports supported by their technological superiority and large production capacities.[14] (See table 24.) In the period after the Second World War, production capacity spread gradually to other developed countries along with the rapid growth of equipment investment in their engineering industries. After these countries had developed their production sufficiently to replace imports, some of them emerged in world markets as vigorous new international competitors. Nevertheless, in 1965 the combined share of the four leading exporters, the Federal Republic of Germany, the United States, the United Kingdom and Switzerland in total world machine-tool exports (excluding exports from the centrally planned economies) was still as large as 86 per cent. If exports from the centrally planned economies are included, these four countries accounted for two-thirds of world exports. In 1965, the top seven exporters of machine tools and their estimated shares in total world exports including those from the centrally planned economies were: Germany, Federal Republic of (30%), the United States (18%), the United Kingdom (10%), Czechoslovakia (10%), Switzerland (9%), German Democratic Republic (6%) and Italy (6%).[15] Thus, until the mid-1960s, technological superiority determined, almost exclusively, the comparative advantage of a country in the world machine-tool market.

Table 24. Share of world exports of machine tools, selected developed market economies, 1913-1965[a]

Year	*France*	*Germany*[b]	*Italy*	*Switzerland*	*United Kingdom*	*United States*
1913	—	48	—	—	12	33
1921	—	30	—	—	14	35
1937	—	48	—	5	7	35
1955	4	32	3	13	12	29
1965	5	30	6	9	10	18

Source: Daniel T. Jones, "The metalworking machine tool industry in Western Europe and government intervention", first draft of a paper prepared for the European Research Centre (University of Sussex, April 1980); *American Machinist*, 16 January 1967.

[a]Total world exports exclude those from centrally planned economies.

[b]Data from 1955 on refer to the Federal Republic of Germany only.

[13]*Ibid.*, p. 39.

[14]Throughout the period, exports were more marginal to the United States' machine-tool industry than to that of Germany.

[15]Based on data presented in *American Machinist*, 16 January 1967, p. 131.

V. Growth and spread of world production and exports since the mid-1960s

A. World production and exports

In the 1970s, the growth of world machine-tool production was somewhat slower than that of other non-electrical machinery. The world gross output of machine tools increased only 1.9-fold in nominal terms during the period 1970-1978, compared to a 2.4-fold increase in gross output of non-electrical machinery as a whole.[1] This reflects the highly sensitive nature of machine-tool production to world economic conditions. Similar trends were recorded in most of the individual developed countries for which relevant data are available. Table 25 shows that, out of 19 developed countries (16 developed market economies and three centrally planned economies),[2] 12 countries recorded a reduction in the share of machine tools in total gross output of non-electrical machinery. By contrast, in four out of the five developing countries listed, the share of the machine-tool industry increased.

Reflecting the highly sensitive nature of machine-tool demand to general economic conditions, the growth of world machine-tool output showed large cyclical fluctuations and was greatly influenced by the performance of the few leading countries (see table 26 and figure V). The cyclical trend in aggregated world output more or less matched the trends in output of the nine major countries, although the degree of fluctuation differed from country to country. This can be explained partly by the increasing effect of world economic conditions on the performance of individual countries' engineering industries.

Another general world trend in the machine-tool industry was the increasing importance of exports. Except for three years, 1967, 1973 and 1980, export growth exceeded production growth. Consequently, the ratio of exports to output increased from 28 per cent in 1966 to 43 per cent in 1981 with the highest ratio of 49 per cent in 1979. As will be seen later, this was the consequence of increasing international specialization between countries in the production of different types of machine tools. World exports of machine tools were also dependent on the performance of the few leading exporters, as can be seen by a comparison between table 26 and figure VI.

During the 1970s, the fluctuations in production in the leading countries were closely related to the equipment investment in the automobile industries in those countries. Particularly in Japan and the United States, where both export

[1]Based on data supplied by the Statistical Office of the United Nations Secretariat and on data presented in table 25.

[2]The centrally planned economies refer to those in Europe and the USSR. Centrally planned economies in other areas are classified in the group of developing countries.

dependency and import dependency in machine tools were small compared to other major countries, the contribution of investment in the domestic automobile industry to the growth of machine-tool production was considerable (see figure VII).

Thus, demand for machine tools is a basic indicator of the trend in industrial-equipment investment and varies according to changes in the overall economic situation within a country and in the international market. Hence, the growth pattern of the machine-tool industry is marked by more pronounced fluctuations than other industries.

Table 25. Share of machine tools in total gross output of non-electrical machinery in selected countries, 1970-1971 and 1977-1978[a]

(Percentage)

Country	*1970-1971*	*1977-1978*
Developed market economies		
Australia	1.4[b]	0.6
Austria	3.6	4.0
Canada	1.4	1.4
Denmark	1.3	2.2
Finland	—	0.4
France	4.4	2.4
Germany, Federal Republic of	9.3	5.8
Italy	9.7	7.5
Japan	4.8	3.2
Netherlands	2.5	1.5[c]
Portugal	13.9	4.8
Spain	18.6	13.5[d]
Sweden	3.2	2.5
United Kingdom	4.0	2.7
United States	2.0	2.0
Yugoslavia	6.5	5.8
Centrally planned economies		
Czechoslovakia	3.8	2.5
Hungary	2.0	9.4
Poland	0.6	0.8
Developing countries		
Brazil	2.4	3.2[c]
India	3.3[b]	3.9[c]
Republic of Korea	—	6.0
Singapore	—	2.4
Turkey	2.2[b]	1.7[c]

Source: American Machinist, various issues; OECD, *The Engineering Industries in OECD Member Countries, 1975-1978* (Paris, 1980); data provided by the Statistical Office of the United Nations Secretariat; and estimates by the UNIDO secretariat.

[a] All calculations were based on data in current dollars.

[b] 1970 only.

[c] 1976-1977.

[d] 1977 only.

Table 26. Growth of world gross output and exports of machine tools, 1966-1981[a]

Year	Gross output		Exports	
	Value (million dollars)	*Annual growth rate (percentage)*	*Value (million dollars)*	*Annual growth rate (percentage)*
1966	5 598	9.1	1 544	14.7
1967	6 150	9.9	1 681	8.9
1968	6 175	0.4	1 872	11.1
1969	7 008	13.5	2 163	15.5
1970	7 816	11.5	2 620	21.1
1971	7 859	0.5	2 670	1.9
1972	8 423	7.2	3 023	13.3
1973	11 033	31.0	3 876	28.2
1974	12 705	15.2	4 856	25.3
1975	13 685	7.7	5 855	20.6
1976	13 583	−0.7	5 969	1.9
1977	15 176	11.4	6 700	12.2
1978	18 638	22.8	8 382	25.1
1979	22 989	23.3	11 337	35.3
1980	26 826	16.7	11 489	1.3
1981[b]	26 470	−1.3	11 400	−0.8

Source: Based on *American Machinist*, various issues; United Nations, *Bulletin of Statistics on World Trade in Engineering Products*, various issues; data supplied by the Statistical Office of the United Nations Secretariat; and estimates by the UNIDO secretariat.

[a]Based on current dollars.

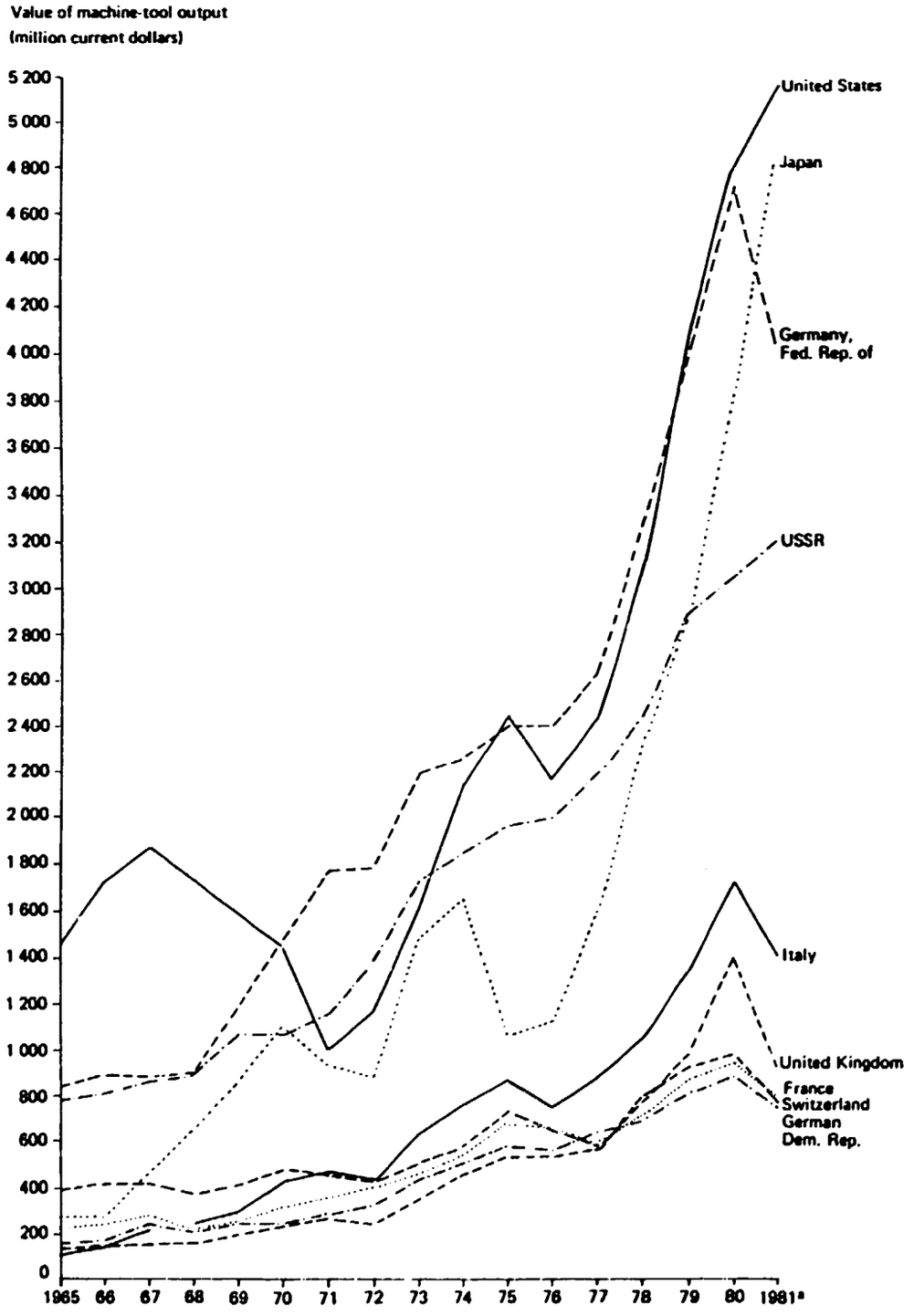
[b]Estimated.

Another characteristic of this industry is that the delivery times for machine tools tend to be long. It is common for delivery times to exceed one year in the case of large machines. This results in a backlog of orders which tides the industry over periods of declining orders. It is for this reason that the large drop in world machine-tool production occurred in 1976, somewhat later than the start of the world economic recession.

Figure VIII shows the changes in percentage annual growth rates of world gross output of machine tools, world gross fixed investment in engineering industries,[3] world net output in engineering industries, and world total value added (world aggregated GDP), all based on current dollars, during the period 1969-1978. These growth rates appear to be highly correlated to each other as indicators. It may be noticed, however, that the fluctuations of net output in the engineering industries were larger than those of world total value added (a proxy for world economic conditions), which reflects the high sensitivity of demand for engineering products to the world economic situation. During the period 1970-1977, the growth rate of gross fixed investment in the engineering industries was higher than that of machine-tool demand, except for two years (1973 and 1975). The general tendency for machine-tool demand to be a decreasing proportion of the engineering industry's gross fixed investment in

[3]Here, as throughout this publication, "engineering industries" are taken to be all those industries involved in the manufacture of fabricated metal products, machinery and equipment included in the International Standard Industrial Classification (ISIC) 38.

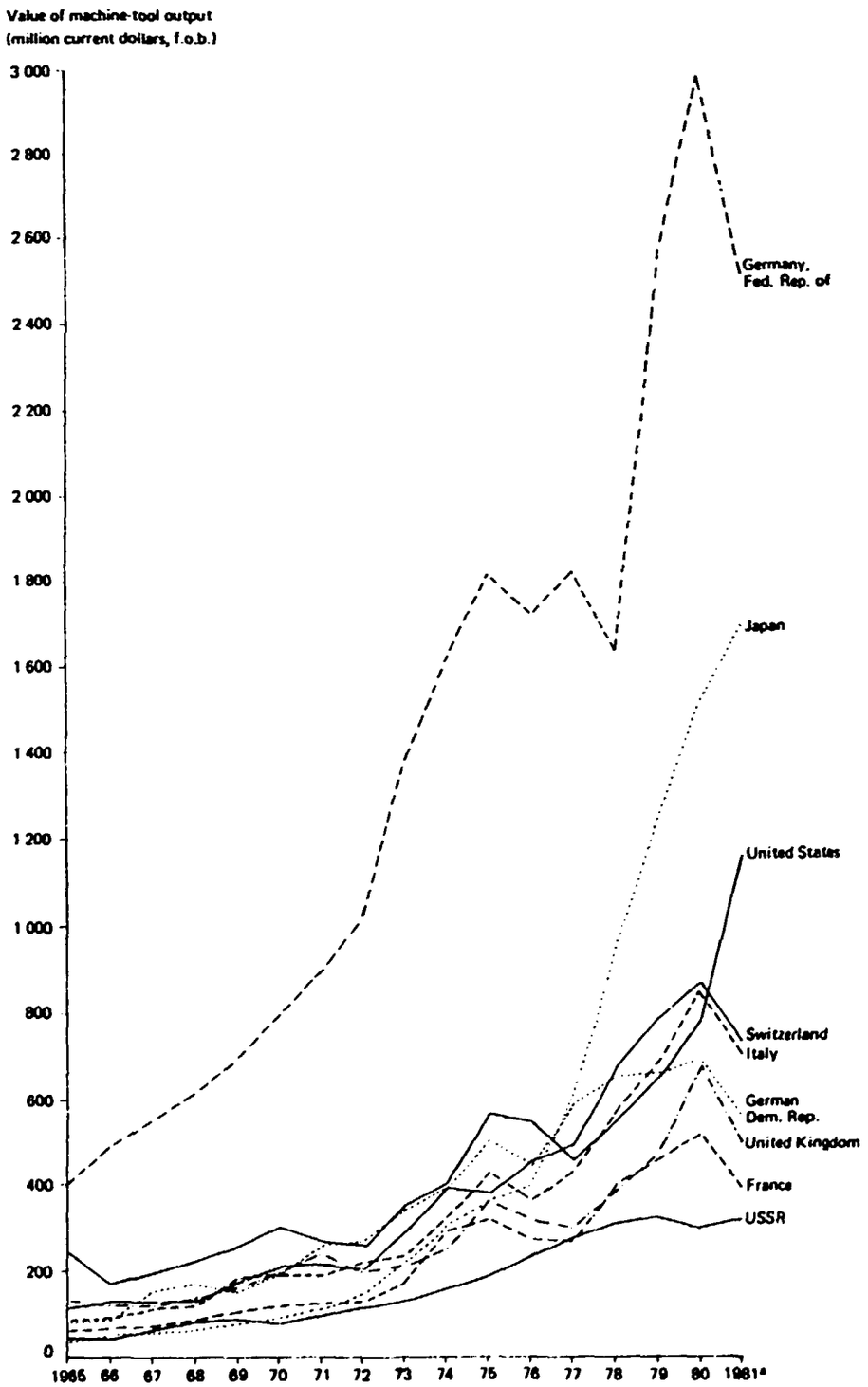
Figure V. Changes in machine-tool output of the nine leading producers, 1965-1981



Source: American Machinist, various issues.

[a]Estimated.

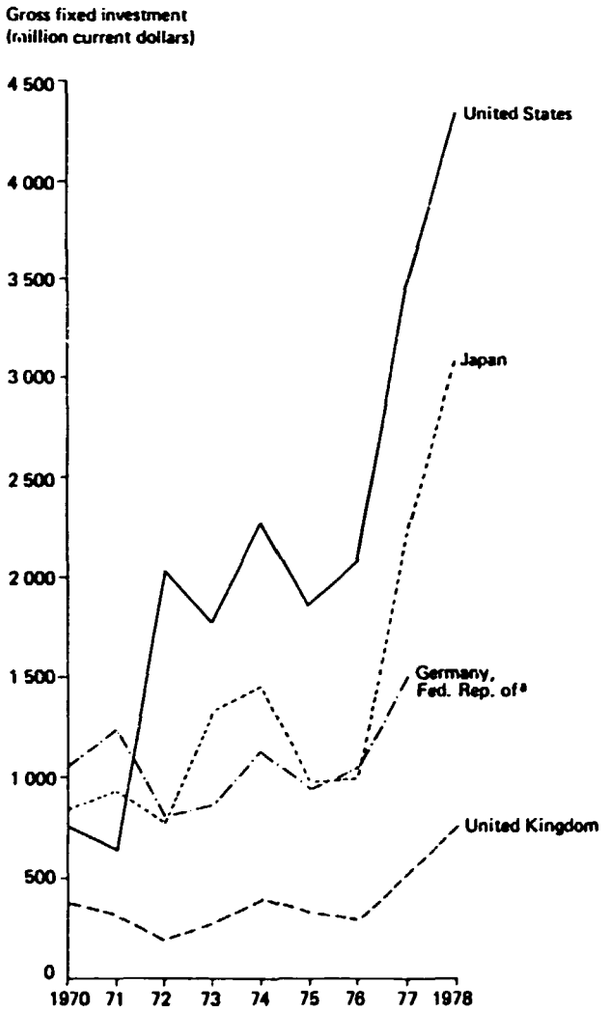
Figure VI. Changes in machine-tool exports from the nine leading exporters, 1965-1981



Source. *American Machinist*, various issues.

[a]Estimated.

Figure VII. Gross fixed investment in machinery and equipment in the automobile industry in selected countries, 1970-1978

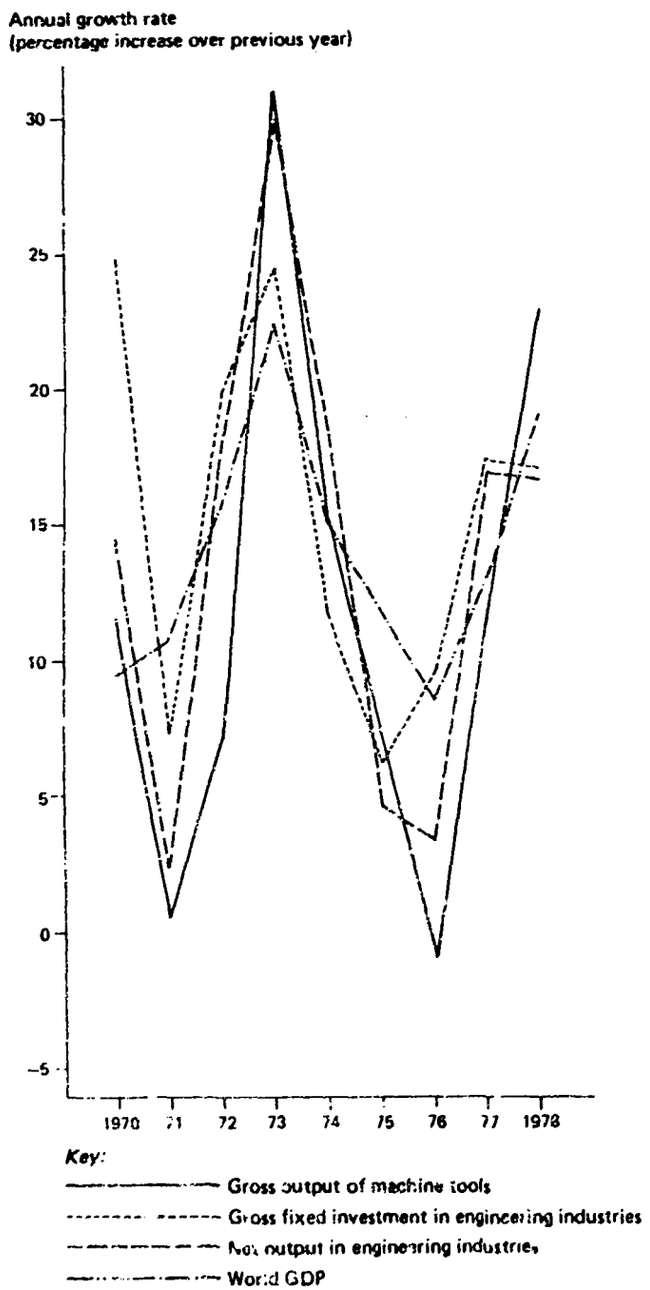


Source: Data supplied by the Statistical Office of the United Nations Secretariat.

[a]Data for the Federal Republic of Germany not available after 1977.

Figure VIII. Annual world growth rates of gross output in the machine-tool industry, gross fixed-capital formation and net output in engineering industries, and world GDP, 1969-1978[a]

(Percentage)



Source: Based on data supplied by the Statistical Office of the United Nations Secretariat and the Office of Development Research and Policy Analysis of the United Nations Secretariat and data given in *American Machinist*, various issues.

[a]Nominal growth rates based on current dollars.

terms of current price may be explained partly by rapid increases in the cost of building materials compared to the price of machine tools.

In 1978, however, production of machine tools recorded a much higher growth rate than those of both gross fixed investment and net output in the engineering industries. This was mainly due to the increasing demand for retooling in engineering industries, particularly in small-scale workshops needing labour-saving processes, and in the automobile industry where further automatization and a shift toward production of energy-saving cars were required. In 1978, the ratio of gross fixed investment to value added in the engineering industries was 13 per cent which was almost the same as for the manufacturing average in that year, whereas the ratio of machine-tool production to the engineering industries' gross fixed investment was 17 per cent.[4]

Data for the real growth of world machine-tool production were not available. However, the following data may give an indication of the real growth of world machine-tool production in recent years.

The world's two largest producers of machine tools, the Federal Republic of Germany and the United States recorded a fall of real gross output by about 20 per cent between 1970 and 1977.[5] France's real output in 1978 was about 15 per cent lower and the United Kingdom's about 40 per cent lower than their respective 1970 levels.[6] In the United States, the average wholesale price of machine tools increased 1.9-fold during the period 1970-1977.[7] Assuming the same price increase in world gross output, no substantial increase was made in world production during the period.

Changes in employment in the machine-tool industry reflect the production trend as does the rate of growth of labour productivity.[8] Table 27 shows the changes in employment in the industry in France, the Federal Republic of Germany, Italy, Japan, the United Kingdom and the United States, which together accounted for around 60 per cent of world total output of machine tools throughout the period 1966-1979. In these countries, the decline in employment in the industry was remarkable, particularly after the mid-1970s. As mentioned earlier, one of the most pronounced structural characteristics of the machine-tool industry is the predominance of small-scale firms which produce small quantitites of products based on specific orders from users. For these firms, a decrease in orders results directly in labour cuts. It should also be noted that, in recent years, increasing difficulty in shedding labour together with uncertainty about future demand has made producers hesitant to employ additional workers even if their business shows recovery. For example, in Japan, the production recovery due to increasing exports in the later 1970s did not generate a proportionate increase in employment. Instead, the production

[4]Estimates based on data supplied by the Statistical Office of the United Nations Secretariat; and *American Machinist*, various issues.

[5]Daly and Jones, *loc. cit.*, p. 54.

[6]Daniel T. Jones, "The metalworking machine tool industry in Western Europe and government intervention", first draft of a paper prepared for the European Research Centre (University of Sussex, April 1980).

[7]Based on data presented in the National Machine Tool Builders' Association, *op. cit.*

[8]There does not appear to have been, on average, any significant increase in labour productivity in the industry in major machine-producing countries during the period 1967-1977.

Table 27. Changes in employment in the machine-tool industry in selected countries, 1960-1977

(1970 = 100)

Year	*France*	*Federal Republic of Germany*	*Italy*	*Japan*	*United Kingdom*	*United States*
1960	...	85.8	...	70.5	92.0	81.0
1966	85.1	90.0	...	68.5	92.9	108.0
1970	100.0	100.0	100.0	100.0	100.0	100.0
1973	103.4	...	...	91.9	74.3	86.7
1975	103.1	...	...	83.1	75.6	88.6
1977	82.0	98.6	98.6	65.4	71.5	84.4

Source: National Machine Tool Builders' Association, *1978-1979 Economic Handbook of the Machine Tool Industry* (United States, 1979); OECD, *NC Machine Tools, Their Introduction in the Engineering Industries* (Paris, 1970); Daniel T. Jones, "The metalworking machine tool industry in Western Europe and government intervention", first draft of a paper prepared for the European Research Centre, University of Sussex, April 1980.

increase was achieved mainly by additional investment in labour-saving and high-productivity equipment and by an increase in subcontracting. In Japan, the output of machine tools increased by 36 per cent in terms of number of machines, or 73 per cent in terms of weight, between 1977 and 1980, while employment in the industry increased by only 5 per cent.[9]

In the late 1970s, in response to rapid growth in retooling demand in the automobile and other engineering industries, world machine-tool production recovered substantially from the drastic falls of the mid-1970s (see table 26). However, as major retooling programmes were gradually completed in the user industries, growth of world production of machine tools decelerated in the early 1980s. World production of machine tools is estimated to have dropped by 10 per cent or more in 1981 compared to 1980.

B. Technological development and changes in world distribution of production and export capacity

Policy in the engineering industries in developed countries has changed gradually due to increases in labour costs and the need for increasing competitiveness in world markets in view of the emergence of newly industrializing countries and areas (NICs). There has been a shift away from capacity expansion to retooling in order to reduce production costs through saving labour and increasing efficiency. Consequently, demand for automated machines tools such as NC machines has increased in many engineering fields while the growth of demand for conventional or standard machines for mass production has slowed down in the developed countries. Reflecting this, numerical control became the single most important trend in machine-tool design in the 1970s. The development of NC technology was made primarily outside the machine-tool industry. The aerospace and automobile industries,

[9]Based on data provided by the Ministry of International Trade and Industry, Japan.

which are important customers for NC machine tools, played leading roles in this development. The development of NC machines was further accelerated in the mid-1970s as microcircuits were developed in the field of electronics and applied increasingly in the control systems of machine tools.[10] For example, in 1975 when the first microelectronically controlled NC unit was introduced, the share of NC lathes in the total value of output of lathes in seven selected countries (France, Germany, Federal Republic of, Italy, Japan, Sweden, United Kingdom and United States) was 28 per cent. By 1980, it had increased to 54 per cent (see table 28). Thus, the substitution of NC lathes for conventional lathes has become a general trend in the developed countries.[11]

Table 28. Production of lathes in seven selected countries,[a] 1975-1980

Year	*Value of output (million dollars)*		*Share of NC lathes in value of total output of lathes (percentage)*
	Total lathes	*NC lathes*	
1975	1 590	445	28.0
1976	1 555	498	32.0
1977	1 758	626	35.6
1978	. . .	938	. . .
1979	2 825	1 310	46.4
1980	3 531	1 906	54.0

Source: ECLA/IDB/IDRC/UNDP research programme, *Technical Change and Technology Policy: The Case of Numerically Controlled Lathes in Argentina*, Working Paper No. 44 (Buenos Aires, March 1982), p. 3.

[a] France, Germany, Federal Republic of, Italy, Japan, Sweden, United Kingdom and United States.

[b] At current prices.

As microelectronically controlled NC units were developed and the need increased in the engineering industries for multi-function machines which would reduce production time and ensure great accuracy in the machined components, a new type of NC machine called a "machining centre" was invented. Machining centres are NC machine tools which allow the execution of a number of operations such as milling, drilling, boring and attaching screws without repositioning the workpiece. They are equipped with automatic-transfer controls which make it possible to change automatically between a great variety of tools. This makes the use of machining centres particularly suitable for plants in which a large variety of products is produced in small batches.

Microcircuits brought about a substantial reduction in the cost of the control units as they were standardized and produced on a large scale.

[10] The NC machine guided and controlled by computer is generally called a "computer numerical-control" (CNC) machine.

[11] A number of major lathe producers in several NICs such as Argentina, Brazil, India, the Republic of Korea and Taiwan Province, China have also recently attempted to switch their production over from conventional lathes using imported NC units.

Programming and maintenance have also become much easier. These two factors together have accelerated the growth of demand for NC machines from small engineering workshops.

An important consequence of the development of NC technology has been the changing comparative advantage between various countries. The remarkable development of NC machines and the consequent expansion of their production was only achieved in a limited number of developed countries where technological innovativeness and a strong electronics industry already existed. The reason is that, in the development and design of NC machines, mechanical know-how is less important than the ability to find electronic and electrical solutions. The high quality of the control unit (i.e., the electronic part) is essential in relation to the functional behaviour of the part and the servo-mechanism in terms of reliability and durability. Consequently, the design of the mechanical part is much influenced by the development of the control unit. The design process is, therefore, much more sophisticated than that of conventional machines. Machine tools are no longer designed by inventive mechanical engineers alone but by a team with a multidisciplinary approach using electrical engineering and electronic, small computer and servo techniques. The development of NC machines depends also on the degree of enthusiasm in the domestic engineering industries for the introduction of new production technologies into their production lines since there must be a close technological linkage between the machine-tool producers and users.

Only a few developed countries have met these conditions and could carry out a rapid expansion of their machine-tool industries in the latter half of the 1970s to take advantage of the rapid growth in demand for NC machines. Thus, there was an increasing tendency for comparative advantage in machine tools to be even more concentrated in a few developed countries, leaving not only the developing countries but also many developed countries behind.

The dramatic development of NC machines resulted in a change in manufacturing concepts in the engineering industries in the developed countries which widened the technological gap between them and the developing countries that remained relatively backward in computer applications and micro-electronics technology. The development of NC machines saved the machine-tool industry in the few leading developed countries from the recession and the increasing availability of these machines enabled their engineering industries to cope with the vigorous challenge of developing countries in the international market for engineering products.

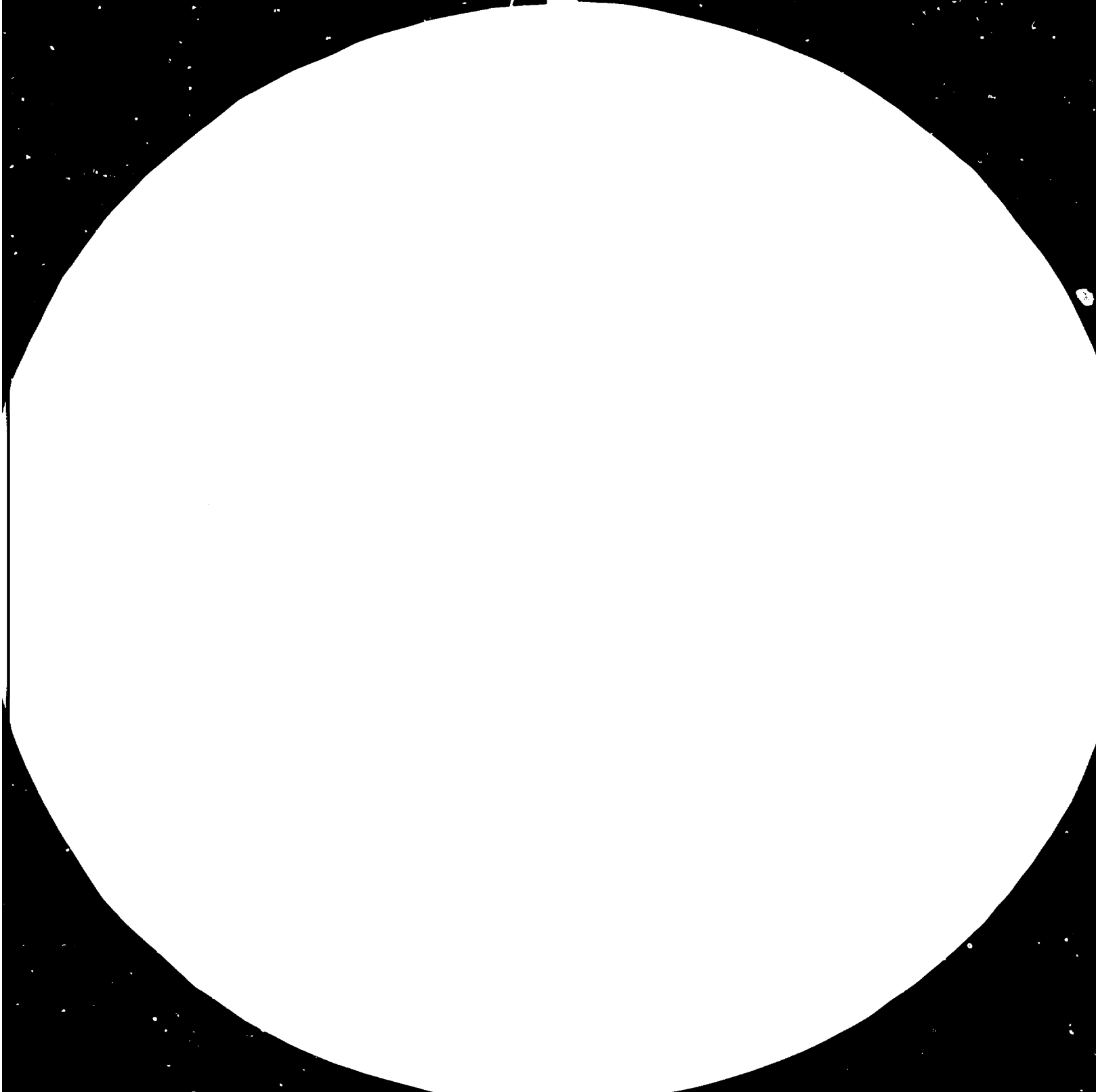
Another important consequence of the development of NC machines in these countries was that, as the share of NC machines in total output of machine tools increased, the ratio of value added to gross output in the machine-tool industry decreased. This was due to the fact that, except in very large companies, NC units are usually produced by firms outside the machine tool industry, and a NC unit comprises around 15-20 per cent, on average, of the selling price of a NC machine.[12]

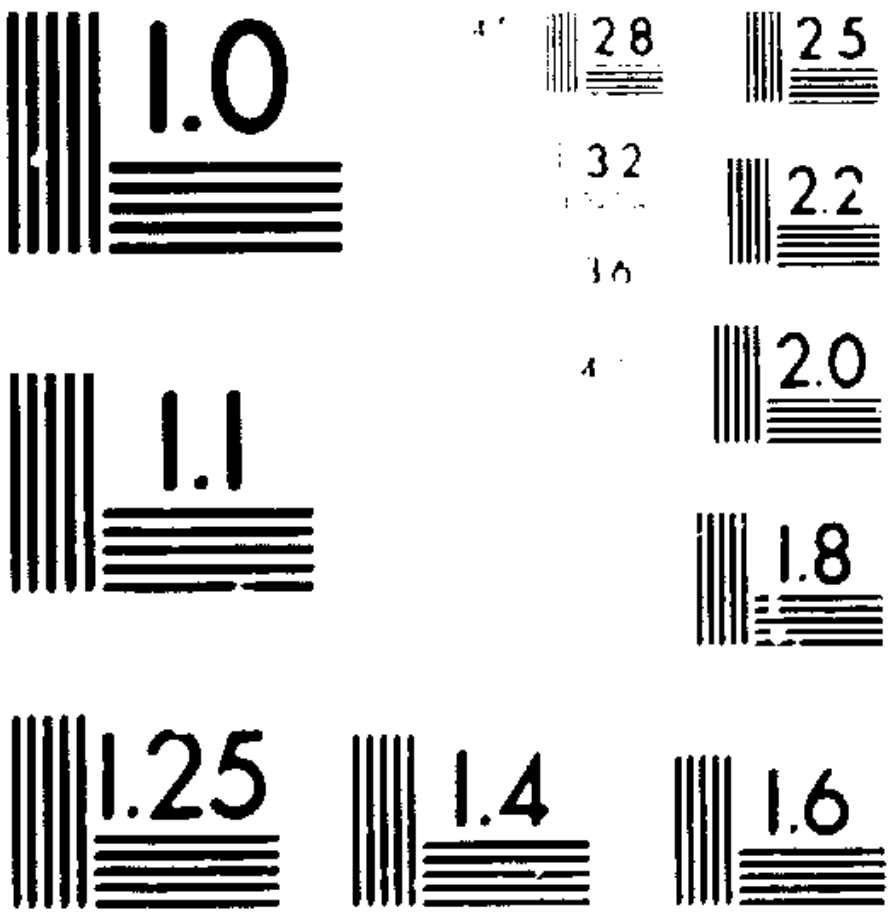
During the period 1966-1981, the share of the developed market economies in world machine-tool output remained in a narrow range between 70 and 75 per cent, except in the two years 1976 and 1977 when the machine-tool

[12] "It is electronics firms and not traditional machine-tool firms that are capturing leading shares of the world market for the most automated machine tools" (Jones, *op. cit.*, p. 26).


84.08


.23





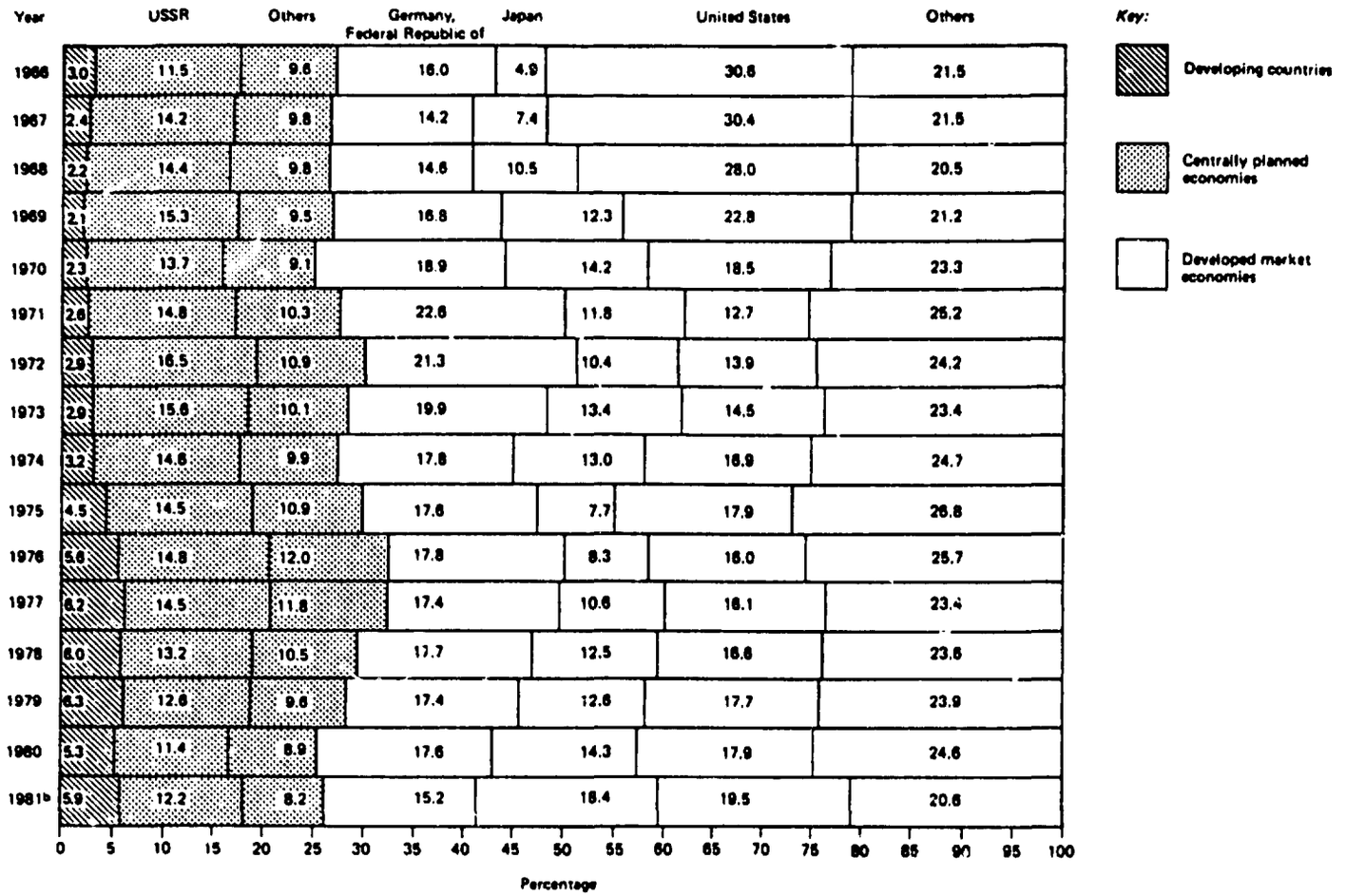
industry in the developed market economies suffered most seriously from the world-wide economic stagnation. On the other hand, during the mid-1970s the share of the developing countries increased remarkably from their previous 3 per cent level up to 6 per cent at the expense of the developed market economies and continued to remain at the 6 per cent level until 1981. The share of the centrally planned economies remained at 25 per cent until 1975, increased slightly in 1976 and then started declining as the production in the developed market economies recovered (see figure IX). However, at the individual country level, remarkable transitions in world leadership in production occurred during these fifteen years as a result of the change in the nature of machine-tool demand in the developed countries and significant differences in innovativeness. Japan increased its share from an average of 6.2 per cent in 1966-1967 to 13.4 per cent in 1979-1980, while the shares of the United Kingdom and the United States decreased from 7.1 to 4.8 per cent, and from 30.5 to 17.8 per cent respectively. The share of the Federal Republic of Germany increased slightly from 15.1 to 17.5 per cent over the same period. The share of the USSR declined slightly from 14.4 to 12.0 per cent. (See table 43 in the annex to part two for details.)

The changes in world production shares were, to a large extent, a consequence of these countries' export performances. The share of Japan in world total exports of machine tools increased from 3.4 per cent in 1966-1967 to 12.6 per cent in 1979-1980, while those of the Federal Republic of Germany, the United Kingdom and the United States decreased from 32.2 to 25.9 per cent, from 7.5 to 5.7 per cent, and from 11.4 to 7.9 per cent respectively. Consequently, Japan became the world's second largest exporter of machine tools following the Federal Republic of Germany, while the United Kingdom and the United States lost their leading positions in world export markets. (See figure X and table 43 in the annex).

C. Market penetration and changes in comparative advantage

International trade in machine tools has been on the increase. In 1981, the share of exports in world machine-tool production was 43 per cent in terms of value, compared to 28 per cent in 1966 (see table 26). There are a number of reasons for the increase. First, while engineering industries have been spreading rapidly in the world, machine-tool production has been concentrated in a limited number of countries. Second, in machine-tool producing countries, capacity utilization has become increasingly difficult because of the economic downturn, and consequently machine-tool producers have increasingly sought customers abroad. Third, diversification and technological progress have proceeded rapidly in the engineering industries which has accelerated the growth of demand for highly sophisticated machine tools, but, for both economic and technical reasons, no country can produce all of the machine tools that are required by its domestic machine-tool users. International markets have become more competitive due to the emergence of new international competitors and import-substitution industries have been established in the countries which used to be good customers. This has forced exporting

Figure IX. World distribution of gross output of machine tools,[a] by selected country within economic grouping, 1966-1981

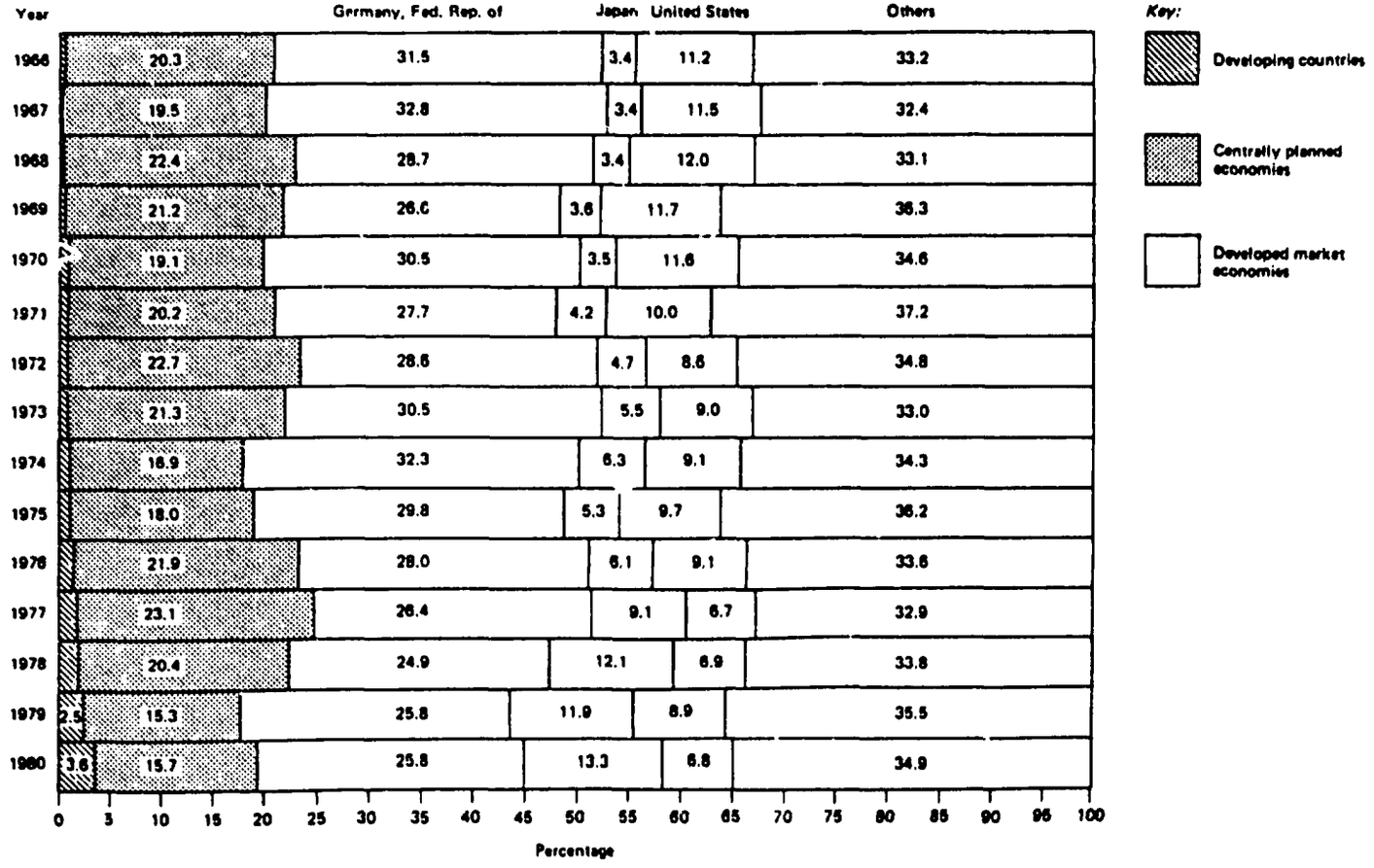


Source: Based on data provided in *American Machinist*, various issues, and estimates by the UNIDO secretariat.

[a] At current prices.

[b] Estimated.

Figure X. World distribution of machine-tool exports, by selected country within economic grouping, 1966-1980



Source: Based on United Nations, *Bulletin of Statistics on World Trade in Engineering Products*, various issues; data supplied by the Statistical Office of the United Nations Secretariat; and *American Machinist*, various issues.

countries into increased specialization in products in which they have a comparative advantage in order to survive in the international market. Finally, there has been a progressive reduction in tariff barriers in many countries which has also encouraged international trade in machine tools.

Consequently, even in the major machine-tool producing countries, not only exports but also imports of machine tools have become significant. In most of the developed countries, both the share of exports in production and the share of imports in consumption have shown an increasing trend, although the degree of dependence on trade (either imports or exports) differs from country to country.

One of the more widely used methods of assessing export performance is that of revealed comparative advantage (RCA) which was introduced in part one. However, RCA measurement does not cover market penetration. Performance and changes in the competitiveness of the machine-tool industry in individual countries in home and overseas markets can be measured by changes over time in the penetration of the home market by imported goods and in the proportion of the domestic machine-tool industry's products which are exported. The penetration of the home market by imported goods (or import dependency) is often measured by the ratio of imports to domestic demand (or domestic apparent consumption). However, this does not take account of the extent of a domestic industry's involvement in exports. If the domestic industry is able to recoup domestic losses through foreign sales, the penetration by imports should be smaller than where no export expansion occurs. This leads to the adoption of a measure of the penetration by imports (or disruption of the industry) which takes the ratio of imports to total supply, that is, the ratio of imports to the sum of domestic gross output and imports. The ratio reduces as exports increase. Given a positive inflow of imports, the increment of the ratio exceeds unity if gross output decreases. Therefore, if the increment of the ratio exceeds unity, it will be judged that market disruption in the industry has occurred.[13]

Similarly the ratio of exports to gross output, which is commonly adopted, ignores the extent to which imports of the same products are finding their way into the country. Therefore, instead of this, the ratio of exports to the sum of gross output and imports (or total demand) will be used to measure the industry's trade performance.

Table 44 (annex, part two) shows the two ratios (in percentages) for 35 machine-tool producing countries in four selected periods. Dependence on both imports and exports varies widely from country to country as well as from year to year. However, on average, the following general tendencies can be observed during the period 1966 to 1980.

The share of exports in total demand, or export proportion, tended to increase in all of the three economic groupings. (See table 29 which summarizes the information from table 44.) In 1966-1967, only six out of 19 developed market economies recorded an export proportion exceeding 40 per cent, while in 1979-1980, 11 out of 18 countries did so. In particular, France, Japan, Spain and Sweden achieved a remarkable increase in export proportion. Among the seven centrally planned economies, the number of countries with an export proportion exceeding 40 per cent increased from one to two. A rapid increase

[13]For details, see Tuong and Yeats, *op. cit.*, pp. 107-110.

Table 29. Export and import proportions of machine tools, by economic grouping, 1966-1967 and 1979-1980[a]

(Percentage)

Economic grouping[b]	Ratio of exports to the sum of gross output and imports		Ratio of imports to the sum of gross output and imports	
	1966-1967	1979-1980	1966-1967	1979-1980
Developed market economies (17)[c]	27.6	39.4	40.7	41.0
Centrally planned economies (7)	24.0	31.6	35.9	40.4
Developing countries (8)	1.3[d]	15.3	71.4[d]	52.2

Source: Data presented in table 44 in the annex.

[a]Equal-weighted averages.

[b]Numbers in parentheses indicate the number of countries sampled in each grouping.

[c]Finland, New Zealand and South Africa are excluded.

[d]Gross output and exports for Singapore and Taiwan Province, China were considered as nil.

in export proportion was seen in Czechoslovakia and the German Democratic Republic. In the developing countries, four countries or areas (Argentina, India, Singapore and Taiwan Province, China) recorded an export proportion of 10 per cent or more in 1979-1980 whereas no countries had done so in 1966-1967.

With regard to the share of imports in total supply, or import proportion, not only the level but also the trends vary widely from country to country, partly because the level of imports depends considerably on domestic demand which fluctuates according to the country's overall economic situation. The import proportion in the Federal Republic of Germany, the German Democratic Republic, the USSR and the United States tended to increase from the relatively low levels of 1966-1967 (i.e., import penetration occurred). In Italy and Japan, the import proportion continued to decrease. Of the major developing countries and areas involved in machine-tool production, those in Asia (China excluding Taiwan Province, India, the Republic of Korea, Singapore and Taiwan Province, China) reduced their import proportion significantly while those in Latin America (Argentina and Brazil), where import substitution had already progressed to a relatively high level by the late 1960s, tended to increase their import proportion.

A change in the difference between the two ratios (i.e., a change in the ratio of net exports to the sum of output and imports or to the total supply) implies a change in the country's comparative advantage in the international market for machine tools. During the 1970s, six developed market economies, Australia, Denmark, South Africa, the United Kingdom, the United States and Yugoslavia recorded a reduction in the ratio of net exports to total supply, while the 14 remaining developed market economies recorded an increase. Most dramatic was the increase recorded by Japan. Among the seven centrally planned economies, only Czechoslovakia and Romania recorded an increase in the net-export to total-supply ratio. Among the seven major developing countries, Argentina was the only country in which the ratio did not increase. The increase recorded by Taiwan Province, China was comparable to that recorded by Japan. According to this measure (the ratio of net exports to total

supply or to total demand), the world's four strongest suppliers of machine tools in 1979-1980 were Switzerland, the Federal Republic of Germany, the German Democratic Republic and Japan, in that order.

As seen earlier, the machine-tool industry is an old industry but highly technology-intensive. Continuous product development characterizes the industry as an unstandardized industry. Comparative advantage in such a field tends to exist in a few highly developed countries because it is determined mainly by the availability of human resources and the capacity for innovation. Recalling the strong relationship between machine-tool producers and users in the field of R and D and particularly in design, comparative advantage in machine tools and that in engineering products in general are interdependent. Countries that have a technologically advanced machine-tool industry have, to a certain extent, a comparative advantage in engineering products as a whole. On the other hand, countries that depend on importing advanced machine tools tend to experience a certain delay in the diffusion of the latest machining technology and, thus, have a comparative disadvantage in engineering products.

As several developing countries emerged in the world machine-tool market in the 1970s, comparative costs became more important in determining the comparative advantage of a country's exports of certain types of machine tools. Consequently, the product range of the industry in which comparative advantage exists in the developed countries has been narrowed to those machines whose production is technology-intensive. This, together with declining demand for less advanced machines in the domestic market, has increased the pressure on the developed countries' machine-tool industries to make structural adjustments.

The index of revealed comparative advantage (RCA)[14] in machine tools indicates the relative success of a country's machine tools in the world export market. This is determined by differences in price and non-price factors among countries. The RCA index figures which are presented in table 45 in the annex do not include exports from the centrally planned economies because data on their exports of manufactured products as a whole is lacking. Thus, world totals of machine-tool exports and of manufactured goods exports exclude the exports from the centrally planned economies. While the data for exports that have been used so far referred only to the countries in which the production of machine tools was significant, data for exports from additional countries have been incorporated into tables 45 and 46 in the annex. In several developing countries which appear in these tables, no production capacity for machine tools appears to exist. Therefore, exports from these countries can be considered as re-exports or exports of used machine tools.

In the export of machine tools, differences in RCA between the few leading developed countries and the rest are large. No developing country has a RCA in machine tools as a whole. Within the whole branch of non-electrical machinery, the product group of machine tools has been one of the slowest to produce a shift of RCA from the developed countries to the developing countries.

[14]For the definition, see chapter III, footnote 7.

In 1970-1971, only five countries (the Federal Republic of Germany, Italy, Spain, Switzerland and the United Kingdom) recorded an RCA index exceeding 1.0, the "normal" value. Of these, Switzerland recorded an outstanding value of 4.0, followed by the Federal Republic of Germany (2.2). Of the remaining 18 developed market economies, 12 countries recorded an index of less than 0.5, showing a clear comparative disadvantage. None of the 41 developing countries sampled recorded an index exceeding 0.5. In fact only eight developing countries showed a significant value of 0.05 or more.

Between 1970-1971 and 1978-1979, the index decreased in almost half of the 23 developed countries with a general tendency towards 1.0. Among the five countries that had recorded an RCA index exceeding 1.0 in 1970-1971, only Spain increased its index, while the United Kingdom turned into a country having no comparative advantage in machine tools. The increase in the index for Japan was dramatic. The increases for Yugoslavia and Austria were also considerable. In 1978-1979, Switzerland (4.0) and the Federal Republic of Germany (1.9) still kept their high comparative advantage, followed by Spain (1.6), Japan (1.4), Italy (1.3), Austria (1.1) and Yugoslavia (1.1).

The average unit price of exports of machine tools suggests their average degree of sophistication. An increase in unit price implies an increase in the average degree of sophistication of the machine tools although it is also influenced by changes in exchange rates and cost reductions. At least for the developed market economies, an increase in the unit price of exports, implying an increase in the degree of sophistication, contributed significantly to their changing RCA. Without a single exception, all the countries that recorded an increase in the RCA index between 1970 and 1979 to a level exceeding 1.0 (e.g., Austria, Japan, Spain and Yugoslavia) also recorded the fastest increases in the unit price of exports during the same period. The two countries that sustained a very high RCA index, despite a slight decrease (e.g., the Federal Republic of Germany and Switzerland) recorded a rapid increase in the unit price of exports as well (see table 30).

During the same period, 32 countries, including all the major exporters, out of the 41 developing countries recorded an increase in the index. However, none of these countries managed to reach the value of 0.5 in 1978-1979. In 1978-1979, the highest index was 0.472 recorded by India.

Table 31 summarizes these changes in the RCA index by economic grouping.[15] The developed market economies are divided into four subgroups according to the size of population and the length of history of manufacturing development. The developing countries are divided into two groups, the NICs and other developing countries. From this summary, certain features emerge. First, RCA showed a positive relation to the length of development history, particularly in 1970-1971. Second, in all groups except for the industrially mature developed market economies, RCA tended to increase more rapidly in those countries whose RCA had been relatively low in 1970-1971 than in those whose RCA was already relatively high. Third, for the developed market economies, RCA varied more widely among the small countries than among the large countries. Fourth, on average the NICs had a higher RCA than the

[15] The centrally planned economies are excluded due to lack of data.

Table 30. Average unit value[a] of machine-tool exports in selected countries, 1970-1971 and 1978-1979

Country	Export unit value (thousand dollars)		Ratio of export unit value to import unit value	
	1970-1971	1978-1979	1970-1971	1978-1979
Argentina	2.46	4.50	0.56	0.55
Austria	3.23	10.70	1.03	1.10
Belgium and Luxembourg	2.51	6.43	0.94	0.78
Brazil	1.63	3.88	0.41	0.37
Denmark	1.94	5.10	0.61	0.70
France	3.44	8.69	1.01	0.99
Germany, Federal Republic of	3.88	11.60	1.33	1.36
Italy	2.89	7.15	0.94	1.12
Japan	2.32	7.37	0.51	0.58
Netherlands	2.67	5.56	0.98	0.72
Portugal	1.65	3.91	0.62	0.55
Republic of Korea	1.92[b]	3.60	...	0.48
Spain	1.55	4.86	0.46	0.48
Sweden	3.11	6.35	0.99	0.72
Switzerland	6.23	22.07	1.80	2.27
United Kingdom	2.64	6.54	0.70	0.74
United States	...	6.08[c]	...	1.15[c]
Yugoslavia	1.92	6.01	0.59	0.63

Source: Data provided by the Statistical Office of the United Nations.

[a] Price per metric ton.

[b] 1970 only.

[c] 1978 only.

Table 31. Average RCA index by economic grouping, 1970-1971 and 1978-1979

Economic grouping[a]	1970-1971		1978-1979	
	Average RCA index	Coefficient of variation	Average RCA index	Coefficient of variation
Industrially mature developed market economies:				
large (5)[b]	1.316	0.387	1.094	0.447
small (7)[c]	0.969	1.309	0.996	1.271
Recently industrialized developed market economies:				
large (4)[d]	0.676	0.728	1.147	0.410
small (7)[e]	0.075	1.042	0.104	0.462
NICs (13)[f]	0.082	1.472	0.159	1.122
Other developing countries (28)	0.019	2.781	0.028	2.289

Source: Based on data presented in table 45 in the annex.

[a] Numbers in parentheses indicate the number of countries in each group or subgroup. The centrally planned economies are omitted due to lack of relevant data.

[b] France, Federal Republic of Germany, Italy, United Kingdom and United States.

[c] Austria, Belgium and Luxembourg, Denmark, Netherlands, Norway, Sweden and Switzerland.

[d] Canada, Japan, Spain and Yugoslavia.

[e] Australia, Finland, Greece, Ireland, Israel, New Zealand and Portugal.

[f] For definition, see explanatory notes.

small recently industrialized developed market economies. Finally and most importantly, without exception, all of the large recently industrialized developed market economies increased their RCA and, on average, the increase was remarkable.

D. Intra-industry trade

As mentioned earlier, no country can economically produce all the kinds of machine tools that are required by its domestic users. Moreover, as import substitution progresses and therefore the need to export increases, machine-tool producers tend to specialize further in a limited range of products in which they have a comparative advantage. Thus, changes in comparative advantage (or disadvantage) have encouraged an international division of labour in machine-tool production, for example, the production of advanced machine tools in the developed countries and that of less sophisticated standard machine tools in the developing countries. The increasing product differentiation and specialization among countries has resulted in growing and very significant intra-industry trade (IIT).[16] Another important factor affecting the intra-industry trade in machine tools is economy of scale which particularly affects countries with small domestic markets including most developing countries. It should be noted, however, that the above points only apply in the context of free trade. In several developing countries where the machine-tool industry is under tariff protection to encourage import substitution, intra-industry trade tends to be smaller than would otherwise be the case.

Figures for the ratio of net exports (exports minus imports) to total trade (exports plus imports), which correspond implicitly to the IIT index, are shown in table 46 in the annex. These figures refer to machine tools as a whole and do not distinguish between different types of machine tools, although machine tools are very heterogeneous, as mentioned earlier. Broadly speaking, the highly industrialized developed countries export advanced machines and import standard machines, while the reverse is true for the NICs and the less industrialized developed countries. However, product specialization in exports differs from country to country. Intra-industry trade in the machine-tool industry is, to a large extent, a result of factor proportions varying more within than across industries as defined by the data categories.

A country's success in exports depends heavily upon that country's specific specialization in products for export. As mentioned earlier, almost all of the developed countries' imports of machine tools are from other developed countries and the share of imports from the developing countries is minimal. Among the developed countries, some countries export relatively high-price machines and import relatively low-price machines while others export relatively low-price machines and import relatively high-price machines. For example, in 1978-1979, the average per-ton price of machine tools exported by Japan was only 58 per cent of that of machine tools imported by the country, which reflects the country's trade pattern of exporting low-cost machines and importing highly sophisticated ones. By contrast, the average unit price of Switzerland's exports was more than 100 per cent higher than that of the

[16] For a definition, see chapter III, footnotes 5 and 8.

country's imports. For the developing countries and for the less industrialized developed market economies such as Portugal, Spain and Yugoslavia, per-ton prices of exports were considerably lower than those of imports (see table 30).

The average per-ton price may imply the degree of sophistication of the machine tools, but not their average size. Per-ton prices of large machines may be lower than those of small machines even if the degree of sophistication is more or less the same. Per-unit prices of exports and imports of machine tools were available for only a few countries. In 1978, the average per-unit price of machine tools exported by the United States was $2,987, two and a half times higher than the per-unit cost of the country's imports. On the other hand, in India, the average per-unit price of exports in the same year was $307, which was a mere 3 per cent of the unit cost of imports.

As mentioned in part one, intra-industry trade, like comparative advantage, is an important consequence of the restructuring process. Table 32 indicates the existence of a clear positive relationship between the level of intra-industry trade in machine tools and the level of economic development. This reflects the fact that as economies develop, product differentiation (by quality and performance of machines) and specialization in narrow product lines also develop.[17] However, contrary to expectation, IIT tended to decrease between 1970-1971 and 1978-1979 in the less mature developed market economies, the centrally planned economies and the developing countries other than the NICs. For the first of these groups, the decrease in average IIT was due to a considerable decrease in the IIT of Portugal, where the intra-industry trade deficit increased, and of Spain, where the intra-industry trade balance improved remarkably. In the group of seven centrally planned economies, four countries

Table 32. Average intra-industry trade[a] in machine tools, by economic grouping, 1970-1971 and 1978-1979[b]

(Percentage)

Economic grouping[c]	*1970-1971*	*1978-1979*
Industrially mature developed market economies (18)	54.1	56.4
Recently industrialized developed market economies (comparative sample) (6)[d]	26.7	25.4
Centrally planned economies (7)	62.6	61.6
NICs (13)	9.0	16.9
Other developing countries (15)[e]	4.1	3.4

Source: Based on data presented in table 46 in the annex and *American Machinist*, various issues.

[a]For a definition of the measure of intra-industry trade, see chapter III, footnotes 5 and 8.

[b]Equal weighted averages.

[c]Numbers in parentheses indicate the number of countries included in each grouping.

[d]Greece, Israel, Portugal, South Africa, Spain and Yugoslavia.

[e]Countries for which exports were not reported are excluded.

[17]Trade data for machine tools (SITC 7151) do not include parts and components of machine tools.

recorded a decrease in IIT as the result of increasing import dominance, although in the German Democratic Republic, export dominance increased. In the group of 15 developing countries other than the NICs, only four relatively more industrialized countries within this group (Ivory Coast, Kenya, Pakistan and Tunisia) recorded an increase in IIT. In the remaining 11 countries sampled, exports were generally negligible and could not catch up with a rapid increase in imports. In these countries, neither production capacity nor export capacity as yet existed at a significant level, and imports, which were also small, fluctuated widely from year to year. Thus their IIT tended also to fluctuate yearly.

IIT in the centrally planned economies was, on average, exceptionally large. This is probably because product specialization was already well advanced due to the strong industrial allocation scheme among these countries.

For several leading exporters of machine tools, their intra-industry trade was not large and, moreoever, showed a decreasing trend, although many of these countries are highly developed and industrialized, for example, the German Democratic Republic, the Federal Republic of Germany, Japan and Switzerland. This was the result of their outstanding export performances together with slow growth in import demand. In these countries, structural adjustment was achieved relatively smoothly within the machine-tool industry towards NC and other advanced machines for which world demand grew rapidly. It can also be said that these countries had more of a tradition of product differentiation and specialization in these types of machines and that therefore adjustment pressures on their industry were small. Starting with a technological lead, the intra-industry trade balance in these countries improved further and, in 1979, the intra-industry trade surplus as a percentage of their total trade (imports plus exports) increased to more than 60 per cent and, consequently, the IIT index became less than 40 per cent (see table 47 in the annex).

Intra-industry trade between the developed countries and the developing countries was small although it tended to increase in a limited number of countries. The developed countries' trade with the developing countries was mainly exports while the developing countries' trade with the developed countries was mainly imports. During the 1970s, out of 22 developed market economies sampled, 16 countries increased IIT with the developing countries. Nevertheless, their IIT with the developing countries was still small compared to their IIT with the developed countries. In 1979, only six of the 22 countries recorded IIT with the developing countries exceeding 10 per cent. These six countries were Austria, Canada, Greece, Israel, New Zealand and the United States, among these Austria, Israel and New Zealand showed a deficit in intra-industry trade with the developing countries.

IIT between the 35 developing countries sampled and the developed countries (developed market economies and centrally planned economies) during the 1970s showed the following features. No developing country recorded an export dominant intra-industry trade with either the developed market economies or the centrally planned economies. There was a general tendency towards increasing IIT with both the developed market economies and the centrally planned economies. However, for most of the 35 countries, increase in IIT with the other two economic groupings was either insignificant

or non-existent. India and Singapore were the only exceptions. In 1978-1979, India's IIT index with both the developed market economies and with the centrally planned economies was around 30 per cent, and Singapore's IIT index with the developed market economies was 40 per cent.

Thus, intra-industry trade in machine tools between the developed countries and the developing countries is limited to a very few countries. Most developing countries are left behind in the increasing international division of labour, a concept still confined to the developed countries so far as machine tools as finished products are concerned.

E. Recent experiences of the machine-tool industry in Japan, the United Kingdom and the United States

These three countries have been selected for further analysis to demonstrate certain recent growth patterns in the machine-tool industry in leading countries. Japan is a typical case where success in overcoming the mid-1970s' crisis in the industry was achieved by changing over from a domestic-market-oriented policy to exports, adapting to the changing demand structure with active R and D and product specialization. The United States is a country where the traditionally inward-looking industry suffered from a large drop in domestic demand in the mid-1970s and could not make a quick structural adjustment to the changing requirements of machine-tool users. The United Kingdom is a typical case where comparative advantage in the type of machine tools traditionally produced by the country has been decreasing and where structural and technical difficulties have occurred in shifting the production lines towards more advanced and more competitive machines.

Japan

As in many other countries, the years 1975 and 1976 were probably the worst years in the history of the Japanese machine-tool industry. In these two years, large adjustment pressures arose in the industry. Machine-tool producers had to give up mass production and lay off substantial numbers of their workforce or, in the worst cases, had to close down or sell off their factories. Some firms, even large ones, went bankrupt. Nevertheless, most major firms did not relax their R and D efforts in developing new products, especially NC machines, in order to cope with the changing demands from their user industries. They also changed their basic strategy dramatically from an inward-looking one to export promotion, involving a series of opening up of overseas sales affiliates during that time. At the same time, many foreign ventures closed down their businesses and withdrew from the country because of sluggish local demand. Efforts to adjust, particularly in the automobile industry and in small- and medium-scale engineering industries, stimulated a demand for machine tools. Supported also by the existence of a strong electronics industry as an upstream-linked industry, tool production started to grow rapidly in Japan. Particularly remarkable was the expansion of production capacity for NC

machine tools, especially for low-cost NC lathes and machining centres. The rapid development of NC technology and the expansion of production capacity in the country resulted also in a dramatic expansion of exports in the late 1970s, which, in turn, brought about further increases in production capacity and consequent cost advantages for the country.

Until the mid-1970s, Japan's production growth had been led by the growth in domestic demand with exports playing a buffer role when domestic demand was stagnant. However, as retooling programmes designed to save labour in small- and medium-scale engineering industries and to cater for the shift in production towards energy-saving automobiles and airliners got under way in the United States and European automobile and aerospace industries in the second half of the 1970s, Japanese exports of machine tools, particularly of NC machines, started expanding rapidly, taking up the excess production capacity created in the mid-1970s by the sharp fall in domestic demand.[18] As table 33 shows, until the mid-1970s, the growth of domestic consumption and the growth of exports were negatively correlated, but the rapid export growth in the late 1970s was irrespective of the domestic consumption level, and, at the same time, export dependency started increasing rapidly.

Japanese fortunes depended on several factors. First, the strong automobile industry could initiate rapid technological development of machine tools towards automation and increased efficiency. Second, through volume runs, product standardization and labour-saving operations, production costs per

Table 33. Machine tools in Japan: share of exports in gross output, and annual growth rates of apparent consumption and exports, 1966-1980[a]

(Percentage)

Year	*Share of exports in gross output*	*Annual growth rate of consumption*	*Annual growth rate of exports*
1966	19.2	−10.2	47.3
1967	12.7	76.3	10.3
1968	9.9	60.2	9.1
1969	9.1	27.3	23.4
1970	8.2	28.7	16.4
1971	12.0	−17.8	23.2
1972	16.3	−13.8	25.6
1973	14.6	64.9	51.9
1974	18.7	3.7	43.5
1975	33.9	−42.3	0.7
1976	35.4	−2.5	17.6
1977	38.5	33.6	68.2
1978	48.7	21.8	66.5
1979	42.7	39.2	33.0
1980	39.8	39.1	12.6

Source: *American Machinist*, various issues.

[a]Based on current dollars.

[18]Quick model changes and frequent development of new models in the Japanese as well as in the United States automobile industry compared to other countries have certainly had a large effect in stimulating the demand for machine tools.

unit of output were reduced.[19] Third, the world market for the type of machines (i.e. small low-cost NC lathes and machining centres which small engineering firms could afford to buy), which Japan was proceeding to develop fast, was less competitive and, moreover, expanding rapidly. Fourth, world-wide sales and after-service networks were already well established either by the machine-tool producers themselves or by giant trading firms.[20] Fifth, machine-tool producers were able to deliver quickly, due largely to product standardization. Finally, and probably most importantly, there was a strong linkage between the electronics industry, particularly the NC-unit industry and the machine-tool industry. The geographical closeness and the historically strong design links between NC-unit producers and machine-tool builders created great cost and technology advantages in the production of NC machines. This certainly accelerated the specialization in NC machines in the country's machine-tool industry as well as consequent demand for them.

In 1980, there were at least seven producers of NC units in Japan. Of these, by far the most important one was the world's largest NC-unit producer. This firm accounted for some 60 per cent of total production of NC units (in terms of number) in the country.[21] From 1970 to 1975, the firm's production of NC units fluctuated up and down between 958 and 3,031 units, but from 1975 onwards, the firm's production increased steadily every year, reaching a provisional total in 1981 of 22,000 units. In 1979, this firm sold 14,235 units compared to a corresponding figure of 4,000 units for the largest European producer. However, of the 4,000 units sold by the European producer, 2,500 were in fact produced by the Japanese company, for which the European company had the distribution rights in Europe. The Japanese firm's production in 1978 of some 9,500 NC units is reckoned to represent about 40 per cent or more of world total output in that year. Mainly due to this firm's contribution, Japanese production of NC units increased more than 10-fold between 1975 and 1980 and reached about 28,000 units. This production capacity was significantly larger than domestic demand in 1980 which was around 22,000 units.[22]

Through mass production and aggressive technological innovation, the unit price of NC units produced by the largest Japanese producer has been substantially reduced. Bulk procurement of NC units by machine-tool producers reduces the cost of NC units even further.[23] It can be said that the

[19]Unit costs in Japan were estimated to be only half of those in the United States (*American Machinist*, December 1981, p. 51).

[20]Many of the machine-tool producers in Japan started exporting their products through trading companies in the 1960s taking advantage of a well-established world network of these companies. However, as exports increased, they found that the effectiveness of the trading companies was limited, particularly in the field of technical services. In order to overcome this problem the producers started establishing their own sales and service networks in potential overseas markets. Today, the Japanese machine-tool industry has its own network of distributorships, agencies and licenses covering some 130 cities abroad (Machine Tool Builders' Association of Japan).

[21]Japan Machine Tool Builders' Association.

[22]Estimate based on data provided by Japan Machine Tool Builders' Association and the Ministry of International Trade and Industry, Japan.

[23]For a firm buying about 1,000 NC units per annum, the rebate can be as large as 35 per cent (ECLA/IDB/IDRC/UNDP, *Technical Change and Technology Policy: The Case of Numerically Controlled Lathes in Argentina*, Working Paper No. 44 (Buenos Aires, March 1982), p. 14).

availability of cheap NC units has made possible the rapid development of design concepts as well as the reduction of production costs of NC machine tools.

The cost structure of production of NC machines differs significantly from that of production of non-NC machines. The direct labour content in NC-machine production is usually much smaller while the cost of components plays a larger role. Hence, wage costs lose a lot of their significance in determining overall production costs when a producer changes over to the design and production of NC machines, but the ability to acquire components at a low price is of great importance. For example, the NC unit accounts for some 15-25 per cent of the cost of NC lathe production. The largest item of cost of the NC unit is depreciation for development costs. Thus, for NC machines as for other advanced machine tools, labour costs are not significant as a determinant of comparative advantage.

The heavy dependence of Japan's machine-tool industry on the large NC-unit producer itself indicates the weakness of the country's machine-tool industry in the long run. Although the importance of NC equipment as a part of machine tools is increasing, most Japanese machine-tool producers do not produce their own NC units, whereas many machine-tool producers in other leading countries, particularly in the United States, do produce their own NC units. In Japan, dependence on the external supply of NC units creates a lack of electronics know-how among the producers of machine tools.

Nevertheless the existence of an innovative electronics industry, strongly promoted by the Government and closely linked to the machine-tool industry, has given Japan a considerable advantage in developing complex manufacturing systems such as a combination of robotics, automatic-transfer machines and machine tools or so-called flexible manufacturing systems (FMS), which stimulate the development of the machine-tool industry. The recent development of FMS will be investigated in chapter IV.

NC-machine production requires substantial R and D and also a distribution and service network. Maintenance and repair of NC machines is technically much more difficult than that of simple non-NC machines. For most customers the electronic unit is an apparatus of unknown internal design and the users tend to rely more on the service network of the supplier.

In acquiring components, R and D, and distribution and service networks, economies of scale are very important. The success of the Japanese NC-lathe industry in the late 1970s was probably partly due to advantages of size. In 1978, the largest Japanese firm produced 950 NC lathes, four times the number of units produced by the largest lathe firm in France, the Federal Republic of Germany, Italy or the United Kingdom. The average production of the next four largest lathe firms in Japan was 525 units in 1978 while the comparable figure for the four European countries ranged between 35 and 210 units.[24]

With these technological, cost and structural advantages, the share of NC machines in total output of metal-cutting machine tools increased from 17 to 50 per cent between 1975 and 1980 and the share of NC machines in total exports of metal-cutting machine tools increased from 13 to 64 per cent in the

[24]ECLA/IDB/IDRC/UNDP, *op. cit.*, p. 13.

same period.[25] It was, therefore, the dramatic growth of NC machine exports which triggered off the growth of Japanese machine-tool production in the late 1970s.

The most important item among Japanese NC machine tools in both production and exports is NC lathes which in 1980 accounted for 45 per cent of gross output and 58 per cent of the country's exports of NC metal-cutting machine tools. From 1975 to 1980, output of NC lathes increased ten-fold in terms of value and nine-fold in terms of number of units. This growth rate was much faster than that of other major producers and as a result Japan has become the world's largest producer of NC lathes (see table 34). During the period 1976-1980, exports of NC lathes achieved an eight-fold growth in terms of value. In 1980, Japan exported 6,592 units of NC lathes while importing only 12 NC lathes.[26] The European and United States' NC-lathe markets were heavily penetrated by external competitors and particularly by Japan. The increase in the Japanese share in total consumption of NC lathes in France, the Federal Republic of Germany, Italy, Sweden, the United Kingdom and the United States is shown in table 35. Almost half of the NC lathes purchased in 1980 in the market consisting of these six countries were produced in Japan, although in terms of value their share was only 27 per cent.

The growth of production and exports of machining centres in Japan was even more dramatic. During the four years 1976-1980, gross output increased ten-fold in terms of number and eight-fold in terms of current value, with a considerable reduction in price. Exports increased 22-fold in terms of number and 14-fold in terms of value. This growth was particularly remarkable in 1979 and 1980. In 1980, machining centres accounted for 33 per cent of gross output and 36 per cent of exports of NC metal-cutting machine tools in Japan.

Table 34. Production of NC lathes in selected countries, 1975 and 1980

	Value (million current dollars)		*Number of units*	
Country	*1975*	*1980*	*1975*	*1980*
Japan	66	673	1 359	12 036
United States	213	481	1 640	2 751
Other countries[a]	166	752	1 535[b]	5 137[b, c]

Source: ECLA/IDB/IDRC/UNDP, *Technical Change and Technology Policy: The Case of Numerically Controlled Lathes in Argentina*, Working Paper No. 44 (Buenos Aires, March 1982), pp. 6-7.

[a] France, Federal Republic of Germany, Italy, Sweden and United Kingdom.

[b] Excluding Italy.

[c] Estimate.

[25] Based on data provided by the Ministry of International Trade and Industry, and the Ministry of Finance, Japan.

[26] The Ministry of Finance, Japan. Japan exports low-cost NC lathes and imports high-cost NC lathes. In 1980, the average price of exported NC lathes was 15.3 million yen compared to that of imported NC lathes which was 31.4 million yen.

Table 35. Share of Japanese products in total consumption of NC lathes in six selected countries,[a] 1975-1980

(Percentage)

Year	*In terms of number of units*	*In terms of current value*
1975	12.6	5.6
1976	22.1	9.0
1977	29.0	14.2
1978	34.8	21.0
1979	41.7	24.3
1980	45.5	26.5

Source: ECLA/IDB/IDRC/UNDP, *Technical Change and Technology Policy: The Case of Numerically Controlled Lathes in Argentina*, Working Paper No. 44 (Buenos Aires, March 1982), p. 8.

[a]France, Federal Republic of Germany, Italy, Sweden, United Kingdom and United States.

The largest importer of Japanese NC machines is the United States followed by the EEC countries. In 1980, 47 per cent of Japanese NC-lathe exports went to the United States and 29 per cent went to EEC countries. Of Japanese exports of machining centres, 44 per cent went to the United States and 32 per cent to EEC countries.[27]

The rapid growth of exports of NC machines is, to a large extent, due to two factors. First, while machine-tool producers in the United States and major European countries have been concentrating on large and sophisticated models, Japanese producers have concentrated on small, low-cost, high-performance machines intended for small users in the developed countries.[28] In this field, they have met little direct competition in the international market. Second, this type of Japanese machine has met the requirements of small engineering workshops in the United States and Western Europe who wanted to retool to reduce costs, and the demand from these users has increased rapidly. The increasing specialization in low-cost NC machines in the Japanese machine-tool industry relative to other major countries is reflected in tables 34 and 36.

Nevertheless, there have been unfavorable changes in export market conditions for Japanese products since the beginning of the 1980s. First, the majority of the prospective users of small NC machines in the United States and Europe have already completed their retooling programmes and demand growth in these markets has slowed down. Second, several machine-tool producers in the United States, who had previously concentrated on the production of large machines, are moving into the production of small machining centres and other small NC machines in response to the change in domestic demand structure. In Western Europe, the conversion to NC

[27] *Customs Statistics* (Tokyo, The Ministry of Finance).

[28] The low price of machinery in general and of machine tools in particular produced in Japan is related to a difference of philosophy between Japanese producers and their competitors. Japanese producers have emphasized cost reduction through mass production while, traditionally, European and American machine-tool builders have emphasized performance. Moreover, it is often the case that Japanese producers offer substantial discounts on their NC lathes during market penetration and this contributes to the lower price of Japanese machines.

Table 36. Production of NC metal-cutting machine tools, share in total output of metal-cutting machine tools and average unit price in selected countries, 1967 and 1978

	Production			*Percentage share in total output of metal-cutting machine tools*			*Average unit price (thousand dollars)*
	Number (thousands)	*Value (million dollars)*		*In terms of number*	*In terms of value*		
Country	*1978*	*1967*	*1978*	*1978*	*1967*	*1978*	*1978*
France	0.8	9	158	1.9	4.4	22.0	198
Germany, Federal Republic of	2.4	30	420	1.7	5.1	12.8	175
Italy	0.7	12	109	1.8	6.8	10.3	156
Japan	7.3	6	568	5.3	1.7	24.3	78
United Kingdom	1.0	20	109	1.9	6.1	14.2	109
United States	5.9	285	745	2.3	20.8	24.1	126
Total	18.1	362	2 109	2.7	12.0	24.0	117

Source: OECD, *NC Machine Tools, Their Introduction in the Engineering Industries* (Paris, 1970), p. 36; *American Machinist*, various issues; and Daniel T. Jones, "The metalworking machine tool industry in Western Europe and government intervention", first draft of a paper prepared for the European Research Centre, University of Sussex, 18 April 1980.

machines has been slower than in Japan or the United States and concern about the growing imports of NC machines from Japan is becoming stronger. Third, since the formation of the export cartel in January 1978 in Japan in order to fix the minimum export price of NC lathes and machining centres for 15 developed market economies, the price competitiveness of Japanese NC machines has been gradually diminishing.[29] Fourth, as a measure to secure markets and realize cost advantages in production and shipment, Japanese NC-machine producers have increasingly established subsidiaries to produce locally in the United States[30] and have formed joint enterprises or concluded licensing agreements with European producers. All of these factors have resulted in a slow-down in the growth of Japanese exports of machine tools in the last years, 1980 to 1982.

The United States

As was seen in figure X, the United States has been gradually losing its leading position in world machine-tool exports. The country's share in world output of machine tools also decreased, with annual fluctuations, from the mid-1960s to the mid-1970s due to the generally stagnant state of domestic demand (see figure IX). In the United States, the retooling boom started in the latter half of the 1970s, centred on the automobile and aereospace industries.

[29] *Sumitomo Bank Review* (Tokyo), vol. 22, No. 6 (1981), pp. 5-6; and *Fuji Bank Bulletin* (Tokyo), vol. 32, No. 8 (1981), pp. 178-179.

[30] Regarding the cost advantage of producing in the United States, a major Japanese machine-tool producer who opened a subsidiary in the United States in the mid-1970s stated that: "The costs of labour and materials in the United States are much cheaper than they are in Japan. Many machine-tool components produced in Japan are under United States license and thus much more expensive. For example, a simple drive belt that costs two dollars in the United States might cost 16 dollars in Japan" (*Iron Age*, vol. 222, No. 32 (27 August 1979), p. 78).

However, the capacity of the country's machine-tool industry to supply the domestic market could not catch up with the increasing demand. Imports of machine tools began to grow faster than domestic supply and thus the country's import dependence increased (see table 37). In 1978, the United States became a net importer of machine tools for the first time in its history. In the following years, both the import dependence and the trade deficit in machine tools increased further.

Table 37. Consumption growth and trade dependence in machine tools in the United States, 1966-1981[a]

(Percentage)

Year	Growth of apparent consumption	Share of imports in apparent consumption	Share of exports in gross output
1966	31.7	8.2	10.1
1967	10.5	9.6	10.4
1968	−10.1	9.5	13.0
1969	−9.9	10.4	15.9
1970	−15.4	10.4	21.1
1971	−35.4	11.0	2[illegible].8
1972	24.6	11.1	22.2
1973	39.1	11.8	21.8
1974	38.2	11.2	18.7
1975	12.1	14.4	23.2
1976	−11.8	16.4	25.2
1977	45.4	14.2	18.5
1978	14.8	23.2	18.7
1979	37.6	23.4	16.0
1980	19.6	24.4	16.3
1981[b]	2.8	26.9	22.3

Source: Based on data provided in *American Machinist*, various issues; and data provided by the Statistical Office of the United Nations Secretariat.

[a]Based on current dollars.

[b]Estimates.

The machine-tool industry in the United States has been basically inward-looking and exports have played the role of a buffer against domestic demand fluctuations. Although the proportion of exports has tended to increase during the last fifteen years, producers in the country's machinery industries in general and in its machine-tool industry in particular, have remained dependent on the vast domestic markets and have not been active in penetration into overseas markets. This has resulted in larger annual fluctuations in machine-tool output (almost entirely due to cyclical domestic demand fluctuation) than in other major countries where the machine-tool industry was more dependent on exports. Furthermore, the inward-looking attitude of the machine-tool producers has made it harder to recognize recent trends towards fundamental changes in the structure of the world machine-tool market. This has led to delays in product development to meet changing demand overseas.

Import penetration into the United States market has been increasing steadily. In this, Japan has played a major part. Japan's good fortune lay in the

fact that, just when her machine-tool producers started promoting exports to take up the large excess production capacity generated by sluggish domestic demand in the mid-1970s, the retooling boom started in the United States where domestic production capacity had shrunk considerably during the stagnation in the late 1960s and the early 1970s. Also, the Japanese type of machine tool (i.e., low-cost NC machines including small machining centres) which exactly met the needs of American producers were not then available in the United States. A machine-tool user in the United States noted at the time that the vigorous Japanese penetration started:

> "As a matter of policy, we would like to buy nothing but United States-made machine tools. Unfortunately, this is not always possible, particularly in the area of smaller machines, machines in the under-100,000-dollars-a-piece category."[31]

Japanese producers soon established a good reputation in the United States market for the quality of their products and services, and for their delivery times. In machine tools, once a country achieves market penetration and a substantial share of another country's market, it is extremely difficult for other competitors to come in. In 1981, the share of Japan in the value of United States imports of machine tools was 49 per cent compared to the corresponding figure of 21 per cent in 1976. Among other major exporters to the United States, the increase in the share of Taiwan Province, China in American imports of machine tools was also remarkable, rising from 4 per cent in 1976 to 7 per cent in 1981. On the other hand, the share of the Federal Republic of Germany, traditionally the largest exporter to the United States, declined from 29 per cent in 1976 to 14 per cent in 1981 (see table 38).

Table 38. Major exporters' shares in total value of United States machine-tool imports, 1976 and 1981

(Percentage)

Country or area	*1976*	*1981*
China (Taiwan Province)	4	7
Germany, Federal Republic of	29	14
Italy	5	4
Japan	21	49
Switzerland	9	6
United Kingdom	10	11

Source: Data provided by the Statistical Office of the United Nations Secretariat.

In 1980, the apparent consumption of NC machines in the United States was about 13,500 units, a dramatic increase from 7,000 units in 1979. The 1980 level of consumption in terms of number of units was probably as high as that in Japan where, in 1980, the apparent consumption of NC machines for metal-cutting alone was 11,800 units.[32] However, the commodity balance in NC

[31] *Iron Age*, vol. 222, No. 32 (27 August 1979), p. 76.

[32] The diffusion rate of NC machines in Japan, in terms of number of units, appears to be substantially higher than in the United States, although comparable data are not available.

machines differed widely between the two countries. In 1980, the United States produced about 10,000 NC machines (for both metal-cutting and metal-forming) of which 1,300 (or 13 per cent) were exported, while it imported 4,800 machines (97 per cent of which were from Japan). Thus, 36.6 per cent of American consumption was supplied by imports, 34.4 per cent of which came from Japan. In Japan, the output of NC machines for metal-cutting alone was 21,700 units, more than twice the United States output of NC machines including these for metal-forming. Of the Japanese output, 9,960 (or 46 per cent) were exported. On the other hand, Japan imported a mere 80 machines for metal-cutting which was 0.7 per cent of its consumption in that year.[33]

The vigorous challenge which foreign machine-tool producers are presenting to domestic producers in the United States market in recent years was clearly recognized in a recent speech of the president of the National Machine Tool Builders' Association in that country:

> "The traditional relationship between backlogs in the United States industry and imports has changed. Usually, sales of foreign machine tools in this country follow the cycle of United States machine-tool backlogs, dropping off sharply soon after lead times shrink to acceptable levels. However, in the last cycle, imports did not drop when United States backlogs fell. Instead they continued to grow."[34]

After they had established a market share in the United States, several foreign producers started direct investment there in order to enjoy the country's cost advantages. The largest cost in building a complex machine tool comes in the final stage of assembly and in the addition of electric components. A firm of producers in the Federal Republic of Germany, that has been building machine tools in the United States through subcontractors, said that they could reduce the cost of producing a given machine by at least 25 per cent by manufacturing in the United States rather than in the Federal Republic of Germany although the cost of materials in the United States was substantially higher. A recent study suggests that, by 1985, 13 per cent of United States domestic machine-tool demand will be supplied by foreign-owned firms producing machines within the country.[35]

Traditionally, government protection and intervention in the country's machine-tool industry in all fields including R and D has been almost non-existent in the United States. However, the above-mentioned situation has created, for the first time, signs of protectionist moves, particularly against the import of Japanese automated machine tools.[36]

The United Kingdom

In spite of government support of the machine-tool industry to the extent of some £100 million during the period 1966-1978, the United Kingdom's machine-tool industry did not perform well during the 1970s. Real output in

[33] Based on data reported in *American Machinist*, February 1982, p. 107; and by the Ministry of International Trade and Industry, and the Ministry of Finance, Japan.

[34] *Iron Age*, vol. 222, No. 32 (27 August 1979), p. 74.

[35] *Ibid.*, pp. 76 and 79.

[36] Jones, *op. cit.*, p. 25.

1979 was 22 per cent lower than in 1968 and over a third lower than the peak level in 1970. Employment in the industry also fell from 72,100 persons in 1968 to 56,000 persons in 1978.[37] Imports became increasingly important in domestic consumption and accounted for about half of consumption in 1981 compared to a little over a quarter in 1966. On the other hand, as a result of the sluggish growth of domestic consumption, the share of exports in gross output increased from around 30 per cent in 1966 to over 50 per cent in 1981. This export growth was, however, much slower than that in many other machine-tool producing countries.[38] (See table 39 and table 43 in the annex.)

Table 39. Consumption growth and trade dependence in machine tools in the United Kingdom, 1966-1981[a]

(Percentage)

Year	*Growth of apparent consumption*	*Share of imports in apparent consumption*	*Share of exports in gross output*
1966	14.1	26.5	29.3
1967	10.4	32.0	28.2
1968	−23.3	31.8	36.9
1969	2.2	28.0	39.3
1970	16.4	33.1	43.2
1971	−14.8	34.8	51.4
1972	0.8	34.3	46.2
1973	31.3	35.7	42.0
1974	24.1	40.9	42.8
1975	9.2	41.0	49.8
1976	−5.7	44.1	49.5
1977	−9.9	45.3	51.1
1978	39.0	47.2	49.8
1979	54.5	53.2	47.2
1980	19.1	46.4	48.3
1981[b]	−37.7	48.8	53.3

Source: Based on data provided in *American Machinist*, various issues; and data provided by the Statistical Office of the United Nations Secretariat.

[a]Based on current dollars.

[b]Estimates.

The decline of the United Kingdom in both world production and world exports of machine tools was due basically to stagnant demand in the country and to the technical inferiority of the country's machine-tool industry which resulted in a loss of competitiveness in international markets. Both the slow growth of machine-tool purchases and the slow pace of technical innovation in machine tools were, in turn, related to the generally weak engineering industries

[37]Anne Daly, "Government support for innovation in the British machine tool industry: a case study", in *Industrial Policy and Innovation*, C. Carter, ed. (London, National Institute of Economic and Social Research, 1981), pp. 60-61.

[38]In 1977, the British machine-tool industry set itself a target of exporting 60 per cent of its output by 1980 (*American Machinist*, February 1978, p. 86). However, in spite of sluggish domestic demand, the export share had only increased to 53 per cent in 1981.

in the country. The most important user of machine tools in the country is the automobile industry. As is well documented, the automobile industry in the United Kingdom has been losing competitiveness in both home and international markets. The growth of automobile production in terms of numbers has been slow[39] and the pace of model changes has been much slower than in Japan or the United States. The aircraft industry, another important user of sophisticated machines (including NC machines), was also relatively unsuccessful in the post-war period. The lack of innovation leading to reduced competitiveness in the country's engineering industries is a major problem in developing NC and other advanced machines, and is contributary to the lack of innovativeness in the country's machine-tool industry in general.[40] This in turn resulted in too much specialization in volume production of less sophisticated standard machines for which domestic demand was decreasing[41] and which have been increasingly subject to severe competition from less industrialized developed countries such as Spain, Poland and Yugoslavia as well as from several developing countries and areas such as India, Singapore and Taiwan Province, China which have been doing well in the international market on the basis of lower wage costs.

Another important reason for the technical inferiority of the United Kingdom's machine-tool industry is the shortage of qualified manpower in the country's engineering industries in general and in its machine-tool industry in particular. Observers pointed out that this was largely due to the failure of the Government's irresolute attempt to imitate the training infrastructure of the Federal Republic of Germany. This, together with the relatively low capital investment and the existence of too many small-scale firms in the industry, resulted in relatively low labour productivity in the country's machine-tool industry.[42] In 1977, per-employee gross output of machine tools in the United Kingdom was $13,800, much lower than the corresponding figures of $49,800 in Japan, $48,700 in the United States, $31,500 in the Federal Republic of Germany and $27,500 in France.[43]

In order to overcome these technical and structural problems and to promote the development of more sophisticated machines, particularly NC machines, the Government of the United Kingdom, unlike the Governments of the Federal Republic of Germany and of the United States, has employed various measures to encourage R and D and the diffusion of NC and other advanced machines in the user industries. These included the NC machines

[39]From 1970 to 1979, the number of passenger cars produced in the United Kingdom decreased by 31 per cent compared to a 94 per cent increase in Japan, a 52 per cent increase in France, a 27 per cent increase in the United States, and a 12 per cent increase in the Federal Republic of Germany (based on data supplied by the Statistical Office of the United Nations Secretariat).

[40]This resulted in the low rate of diffusion of NC machines. In 1976, only 0.43 per cent of all machine tools then in use in the country's metalworking industries were NC machines. (*Metalworking Production*, February 1981, p. 11.)

[41]This can be seen in table 39. Even in the years when domestic consumption decreased, the share of imports in consumption increased, which suggests a substantial decrease in the domestic demand for United Kingdom-produced machine tools, most of which were standard machines.

[42]For details, see Daly and Jones, *loc. cit.*, pp. 55-62.

[43]National Machine Tool Builders' Association, *op. cit.*

trial-period scheme, the pre-production order scheme and various financial supports for product development such as the provision of a 25 per cent subsidy of the cost of developing and launching new machine tools, and 15-20 per cent grants for projects to modernize and expand capacity (the Industry Act of 1972). During the period 1975-1979, about £30 million were allocated in grants to encourage new product development.[44]

In spite of active government support, the country's machine-tool industry did not have any remarkable success in the development of advanced machines and consequently did not succeed in reducing the country's comparative disadvantage. The United Kingdom's traditional pattern of trade in machine tools, that is, exporting standard machine tools to less industrialized countries than itself and importing high-performance and high-precision advanced machine tools, remained basically unchanged in the 1970s. This can be seen in a comparison between the unit value of exports and that of imports (see table 31). In Japan also, the average value of imports substantially exceeded that of exports. However, Japanese exports consisted mainly of NC machines and the average per-ton price of machine tools exported was higher than that in the United Kingdom. In NC machines, the United Kingdom's inferiority is also considerable. The United Kingdom was the first country in Europe to adopt NC machines[45] and the share of NC machines in total output of machine tools increased rapidly from 2.8 per cent in 1966 to 9.6 per cent in 1971. However, this initial advantage in NC-machine production did not last long. In the 1970s, the development of NC machines slowed down as is seen in the very slow increase in the share of NC machines in total output of machine tools to 18 per cent in 1981.[46] This was a substantially lower proportion than in Japan or the United States in that year.

One of the main reasons why the government support schemes were unsuccessful was that the development of new machine tools, in the United Kingdom often carried out by universities, was without reference to product demand. A study has pointed out that the absence of co-operation between suppliers and users in developing new machine tools was one of the main reasons for the lack of success of the promotion efforts.[47] The absence of such co-operation is partly due to the users' conservativeness. Most British users are unwilling to buy a newly developed machine or to use a new technique until it has been proved to be good elsewhere, which gives certain foreign machine-tool producers a great advantage.[48] Another reason was probably the over-emphasis on larger-scale operations which were viable only for mass production of standardized machines.

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[44]Daly and Jones, *loc. cit.*, p. 62; and Jones, *op. cit.*, p. 24.

[45]"The United Kingdom started using NC units in 1957, followed by France in 1958. In 1960, the value of the output of NC machines in the United Kingdom was 2.6 million dollars, far ahead of the rest of the European countries and Japan (OECD, *NC Machine Tools . . .*, pp. 36 and 39).

[46]Daly, *op. cit.*, p. 61; and the Machine Tool Trade Association, *British Machine Tool Industry and Trade, Basic Facts, 1982* (London, 1982), p. 3.

[47]"Especially in an industry such as machine tools, technical progress is not confined to the results of laboratory work and highly-trained personnel are needed at all levels for a firm to be successful" (Daly, *op. cit.*, p. 66).

[48]*Metalworking Production*, February 1981, p. 16.

F. Structural adjustments within the machine-tool industry in the developed countries since the mid-1970s

As mentioned earlier, the rapid growth of NC-machine production in relation to the growth of conventional-machine production in the developed countries was primarily the result of the changing structure of demand for machine tools in these countries. More specifically, the growth of demand for machine tools to expand capacity has been generally very slow with further deceleration after the mid-1970s. By far the greater part of the demand in the latter half of the 1970s and early 1980s was for rationalization of production to cut costs and to improve quality. Another important reason for the rapid diffusion of NC machines was the considerable reduction in price of these machines due to the reduction in price of the NC units through volume runs. This made NC machines available even to small firms. Equally important, the remarkable reduction in size of NC devices enabled ever faster design development of machine tools.

The unbalanced growth between different types of machines was also a consequence of the changing structure in the engineering subsector. For example, the world-wide depression in the shipbuilding and basic-metal industries resulted in a depression in the production of large special-purpose machines, while the recovery of the automobile and several other consumer-durable industries resulted in a booming production of small NC machines.

The depression among both the producers and users of large special-purpose machine tools for heavy industry and the declining competitiveness of the developed countries in less sophisticated machines, has created an increasing adjustment pressure on the machine-tool industry in the developed countries. In order to maintain their share of the domestic market as well as their comparative advantage in export markets, the developed countries must shift their production lines towards sophisticated machines embodying a large degree of human skill.[49] This is the reason why the Governments of the developed countries have been making every effort to foster and promote the production of advanced machine tools, particularly NC machines.

This adjustment process has, however, resulted in greater disparities not only between the developed countries, as mentioned earlier, but also between machine-tool producing firms within individual developed countries. This was due to the extreme difficulty of shifting production factors within the industry and to the limited capacity for developing new products which require advanced technology. These difficulties arise from the structural characteristics of the industry, namely, the smallness and the extreme specialization of individual firms. In practice, corporate performance has shown an increasing polarization within the industry in many developed countries. Some firms have been enjoying booming business, while others have been compelled to sell off assets and discharge workers or to merge with a strong firm. This has depended on the type of machines they produce and not on the firm size. This was particularly pronounced in the Japanese machine-tool industry in which firms producing small NC machines have been prospering with record sales and

[49] "This is an industry in which the advanced countries should be able to maintain a comparative advantage" (Jones, *op. cit.*, p. 16).

profits, irrespective of their size or the length of their business history. Thus, many small firms and newcomers had a chance of success so long as they were producing the right machine tools. The increasing opportunities for small firms and newcomers were the consequence of:

(a) The change in customer demand from the high-priced machines generally produced by the large leading companies, which often have unnecessarily high precision and quality, to those that are "reasonably" priced and have the "exact" degree of precision required;

(b) The narrowing technological gap between the leading established companies and the newcomers due to the development of NC systems which eliminate the need for the mechanical gears that determined the precision level.[50]

However, in the early-1980s, there were already signs of disparities between firms even in the field of NC machines. Some NC machine-producing firms continued to increase their sales while others started to decline, depending on their technological and sales capabilities. The life cycle of machine tools has become shorter as the engineering industries have become more advanced. Although machine tools have reached a high level of maturity and reliability, the requirement from the engineering industries for even more advanced performance calls for continuous R and D efforts by machine-tool producers who would otherwise fall behind in the increasingly competitive market.

As both producers and users move towards the development of machine tools as part of a computer-controlled system (such as the FMS), it becomes increasingly difficult, financially and technically, for small firms to carry out R and D work on product development. In an engineering field such as this with high rates of product development, R and D work must explore a wide range of potential applications. The amount of non-profit-making work is therefore great. For small firms producing or wanting to start producing NC machines, the risk is further increased by the possibility of unexpected developments in electronics and NC systems, which are likely to happen elsewhere in larger firms.

In general, R and D work has had to be self-financing. Only financially viable firms can afford to carry out intensive R and D on NC machine development, and this confines it to large or very successful businesses. However, one of the many responses to the increasing need for technological collaboration between machine-tool producers and users, has been that automobile producers have entered into cost-sharing and development agreements with machine-tool producers in the field of NC machines for automobile production. Thus, automobile producers have taken the initiative in developing the machine tools they require and financing the cost of development work.[51]

[50] *Focus Japan* (Tokyo), vol. 4, No. 12 (1977), pp. 22-23.

[51] Marx, *loc. cit.*, p. 45.

VI. The machine-tool industry in developing countries

A. Recent developments

Machine tools were among the earliest type of capital goods to be produced in the developing countries. They offered a good opportunity to replace imports and to increase self-reliance in the basic economic activities. Typically, in most developing countries, the machine-tool industry was started for import substitution and then gradually went into exports to other developing countries as the domestic market was saturated by the domestic industry. A few developing countries and areas in Asia such as Singapore, Taiwan Province, China, and, to a much lesser extent, the Republic of Korea were rather exceptional cases where export promotion was part of the original motive for the establishment of the machine-tool industry and other engineering industries.

The types of machine tools which have been adopted in the developing countries are mostly small and simple standard machines with a high price elasticity. Because of the shortage of personnel who can do the programming, either manually or by computer, demand for NC machines is limited. Consequently, the sort of machine-tool industry which produces standard lathes, small drilling and grinding machines and this type of machinery has developed rapidly in several developing countries where there is a relatively large demand from small domestic metalworking workshops and repair shops. The production of these types of machines is also fairly easy.

Opportunities for producing machine tools in the developing countries increased in the 1970s as their engineering industries developed. Not only the cyclical downturn in the major machine-tool user industries, but also the current world industrial restructuring process has had important consequences. In the developed countries, the focus of growth has been shifting gradually from the major machine-tool using industries towards the electronics and information-processing industries, which are not important customers for machine tools. At the same time, various production processes of the main machine-tool using industries have been gradually transferred to the newly industrializing countries and areas (NICs). Consequently, the share of the developing countries in world total consumption of machine tools has increased from an average of 8 per cent in 1970-1971 to an average of 14 per cent in 1979-1980. This, in turn, has created increasing opportunities for machine-tool production in these countries. In fact, the share of the developing countries in world total gross output of machine tools increased from an average 2.5 per cent in 1970-1971 to an average 5.8 per cent in 1979-1980 in line with the

growing emphasis on self-reliance in capital goods in these countries (see figure IX and table 43 in the annex).

The most remarkable case of import substitution occurred in India. In this country, the degree of import dependence decreased remarkably from a level of more than 60 per cent in the 1960s to around 30 per cent by the middle of the 1970s. During this import-substitution period, exports remained at a low level with large annual fluctuations according to the fluctuations in domestic demand. After import substitution was more or less complete for those types of machine tools which India could produce at competitive prices, the country started an export drive. Thereafter, exports started increasing rapidly, and the balance of trade in machine tools was greatly improved (see table 40). Today, only advanced machines are imported.

Table 40. Trade dependence and the trade balance in machine tools in India, 1968-1980

(Percentage)

Year	*Share of imports in consumption*	*Share of exports in gross output*	*Share of net exports in the sum of exports and imports*
1968	67	9	−91
1969	44	11	−73
1970	47	12	−73
1971	45	7	−84
1972	33	6	−75
1973	45	5	−88
1974	29	11	−52
1975	30	11	−56
1976	28	12	−56
1977	35	23	−29
1978	33	25	−20
1979	30	16	−39
1980	35	15	−50

Source: Based on data provided in *American Machinist*, various issues; and data provided by the Statistical Office of the United Nations Secretariat.

One of the problems in this industry is that highly skilled labour is an essential input for successful production of machine tools. The complexity and precision of machine tools and their small-batch type of production limits the scope for employing unskilled labour. Thus, in many developing countries, the shortage of skilled labour and qualified engineers and technicians at all levels of the production process restricts the possibility of producing machine tools, particularly those advanced machine tools which would be competitive in the international market. Reflecting this, production and export capacity in machine tools is extremely concentrated in a few developing countries in which general engineering activities are relatively well advanced. In 1980, around 90 per cent of total output and of total exports of machine tools in the developing countries as a whole were accounted for by five and six countries respectively, all of which had sizeable engineering industries.

During the period 1966-1980, leadership in production changed among the developing countries. In 1966, four countries, Argentina, Brazil, China (excluding Taiwan Province)[1] and India were the only developing countries that produced substantial amounts of machine tools and they accounted for almost all of the developing countries' total output. Among these four countries, India was the largest producer followed by China (excluding Taiwan Province), Brazil and Argentina. From 1966 until the middle of the 1970s, these four countries continued to dominate the developing countries' production of machine tools though leadership changed between them. In 1976, the largest producer was China (excluding Taiwan Province) followed by Brazil, India and Argentina. In that year, the combined share of these four countries in the total output of the developing countries was still as high as 90 per cent. However, in the latter half of the 1970s, production in the Republic of Korea, Singapore, and Taiwan Province, China, started increasing dramatically with a rapid growth of exports and, consequently, the shares of the four previous major producers decreased substantially, although China (excluding Taiwan Province), Brazil and India remained in their leading positions. Because of the concentration of world machine-tool production in a few developed countries, China (excluding Taiwan Province) and Brazil were, respectively, the eleventh and the fifteenth largest producers in the world in 1980, ahead of such countries as Austria, Canada, Hungary, Sweden and Yugoslavia, although their share in world total output was a mere 1-2 per cent (see table 43 in the annex).

Export concentration has been even greater than that of production and it has tended to increase with the emergence of a few extremely export-oriented developing countries like Singapore and Taiwan Province, China, in the world machine-tool market. Owing to the remarkable growth of exports from these countries, the share of the developing countries as a whole in world total exports of machine tools increased from an average of 0.4 per cent in 1966-1967 to an average of 3 per cent in 1979-1980. The distribution of export capacity among the developing countries changed dramatically during these one and a half decades. In 1966-1967, 71 per cent of total exports from the developing countries as a whole was accounted for by Brazil (33%), India (20%) and Argentina (18%). In 1979-1980, approximately the same percentage was accounted for by Taiwan Province, China (47%), Brazil (14%), and Singapore (11%).

In each of these leading developing countries, there are 100-200 establishments engaged in the manufacture of machine tools. However, only a few use modern equipment, possess adequate technology and design capability and produce machines possessing international-standard quality and sophistication. These firms are usually large and sometimes extremely large and dominate the country's production and exports.[2] On the other hand, the majority of firms produce universal-type machines directed at domestic and, to a lesser extent, regional markets. They are generally weak in design and quality. There are also many small workshops which produce models that would be obsolete elsewhere, using antiquated techniques and equipment.

[1]The production and trade data for China which are incorporated in this publication are crude estimates presented in *American Machinist*, various issues.

[2]For example, the largest firm in India currently employs around 24,000 persons. Extremely large firms also exist in Brazil and Taiwan Province, China.

B. Penetration of world markets

Producers in the developed countries find it increasingly difficult to produce simple, standard, universal machine tools at competitive prices and are obliged to concentrate on the production of NC and other advanced machines. Consequently, the extensive demand for universal machine tools is increasingly met by imports. This generates increasing possibilities for the developing countries to penetrate the international machine-tool market. In 1979, the developed market economies imported machine tools valued at $196 million from the developing countries, an enormous 46-fold increase from the corresponding figure of a mere $4.3 million in 1970. Consequently, the share of the developing countries in the total imports of the developed market economies increased from a negligible 0.3 per cent in 1970 to a significant 4.1 per cent in 1979. At the same time, growth of trade within the group of developing countries was also remarkable. In terms of imports, it increased from $13 million in 1970 to $98 million in 1978. In the total value of imports into the developing countries, the share of the developed market economies increased while that of the centrally planned economies decreased, except in Latin America (see table 41). Machine tools that are exported to the developing countries by the centrally planned economies are on average not so labour-saving as those produced in highly industrialized developed market economies. In this sense, they compete against those produced in developing countries, but their price competitiveness has decreased with the emergence of several developing countries in the international market. This has meant that the share of the developing countries in the imports into developing countries has increased at the expense of the share of the centrally planned economies. On the other hand, as development of the engineering industries in developing countries proceeds, relative demand for more advanced machines increases. The major suppliers of such machines are the developed market economies, and this probably explains, at least in part, the increasing share of the developed market economies in the developing countries' imports.

However, on average, the share of the developing countries in the total machine-tool imports of the developing countries is still higher than that of the developed market economies. This can be simply explained by the fact that in the developing countries the demand for low-cost standard machines is relatively much higher than in the developed market economies and that the developing countries have an increasing comparative advantage in these machines in the international market.

It can also be observed that there are regional characteristics in the penetration of imports from the developing countries into the developed market economies as well as into other developing countries. Distance between supplier and market appears to be an important factor in explaining the regional differences in the relative importance of the developing countries. For users in Europe, Africa and, to a lesser extent, Western Asia, standard machines are available at a relatively low cost in neighbouring developed countries such as Spain, Yugoslavia and the European centrally planned economies. On the other hand, South-East Asian markets have several major developing suppliers such as India, the Republic of Korea, Singapore, and Taiwan Province, China. Canada and the United States have close access to

Table 41. Value of imports of machine tools and distribution of import origins, by regional and economic grouping, 1970, 1978 and 1979[a]

Importer	Year[b]	Total value of imports (million dollars)	Origins of imports (percentage share in total value of imports)						
			Developing countries				Developed market economies	Centrally planned economies	Areas unspecified[c]
			Africa	Latin America	Western Asia	Other Asia[c]			
World	1970	1 760.3	0.01	0.38	—	0.38	92.67	6.36	0.19
	1978	4 902.0	0.01	0.66	0.07	1.08	89.78	6.10	2.30
Developing countries									
Total	1970	237.8	0.06	2.18	—	2.00	84.60	10.05	1.11
	1978	1 346.9	0.04	2.11	0.19	2.32	86.59	6.12	2.63
Africa	1970	21.1	0.43	—	0.03	4.55	80.06	14.30	0.64
	1978	219.6	0.03	0.02	0.04	3.12	83.06	12.28	1.45
Latin America	1970	128.1	0.03	4.06	—	0.06	90.51	5.34	—
	1978	551.2	—	5.07	—	0.19	88.15	5.86	0.73
Western Asia	1970	16.2	0.01	—	0.04	0.07	56.53	43.27	0.09
	1978	98.9	0.02	0.29	2.45	1.42	80.63	11.40	3.78
Other Asia	1970	72.5	—	—	0.01	5.11	81.74	9.70	3.44
	1978	477.2	0.09	0.03	—	4.60	87.66	2.50	5.13
Developed market economies									
Total	1970	1 514.0	—	0.10	—	0.13	93.90	5.82	0.05
	1978	3 555.1	0.01	0.11	0.02	0.61	90.99	6.09	2.17
	1979	4 803.0	0.01	0.26	0.03	0.90	90.07	5.85	2.89
North America	1970	287.8	—	0.17	—	0.14	97.97	1.71	0.01
	1978	916.3	—	0.26	—	0.98	89.06	3.56	6.14
	1979	1 355.2	—	0.58	—	1.82	86.42	3.90	7.28
Europe[d]	1970	1 017.8	—	0.10	—	0.09	92.96	6.80	0.05
	1978	2 397.2	0.01	0.06	0.03	0.28	91.77	7.37	0.48
	1979	3 165.5	0.02	0.14	0.04	0.31	92.01	6.71	0.77
Asia and the Pacific	1970	208.4	—	—	—	0.35	92.82	6.71	0.12
	1978	241.6	—	0.01	0.05	2.55	90.58	3.05	3.76
	1979	282.3	—	0.02	—	3.18	85.88	5.49	5.43

Source: Based on data provided by the Statistical Office of the United Nations Secretariat.

[a] Based on current dollars, c.i.f.

[b] The number of countries included differs slightly between 1970 and 1978 according to availability of data.

[c] Taiwan Province, China, is included in areas unspecified.

[d] Including Israel.

Latin American major suppliers such as Argentina, Brazil and Mexico and have traditional links with some of the Asian developing countries mentioned above. In Latin America, intra-regional trade between the region's major producers, Argentina, Brazil and, to a lesser extent, Chile, Colombia and Mexico, plays an important part.

By far the largest single export market for machine tools produced by the developing countries is the United States. In 1980, the United States imported machine tools valued at $14.7 million from the developing countries, which was 8.8 per cent of the country's total imports of machine tools. This was a remarkable increase from 1970 when imports from the developing countries amounted to a mere $0.6 million which was only 0.5 per cent of total imports of machine tools in that year. Following the United States, the Federal Republic of Germany, Japan and the United Kingdom are also significant importers of machine tools produced in the developing countries. In 1980, Japan and the Federal Republic of Germany imported $21.9 million and $15.1 million worth of machine tools, respectively, from the developing countries. In 1979, the total value of United Kingdom imports from the developing countries was $10.9 million. However, while the share of imports from the developing countries in total machine-tool imports was 8.5 per cent in Japan, in the other two countries it was only 1.5 per cent.

Only a few developing countries had a significant share in the machine-tool imports of these major importers. Taiwan Province, China, alone accounted for 70 per cent of United States imports from developing countries. The Republic of Korea, Singapore and Taiwan Province, China, accounted for 98 per cent of total machine-tool imports into Japan from the developing countries, and 69 per cent of those to the Federal Republic of Germany. In the United Kingdom, India and Taiwan Province, China, accounted for 71 per cent of machine-tool imports from developing countries.

United States trade data show that the developing countries have limited or no export capacity in advanced machine tools and that only a very few developing countries have made significant gains with the various types of simple low-cost machine tools in which they have a comparative advantage. In 1974, in terms of both number of units and value, over 90 per cent of the developed market economies' imports from the developing countries was made up of conventional lathes, drilling machines and grinding machines all of which were highly price-elastic.[3] This situation of low-cost machine imports from developing countries has continued in more recent years. As seen above, in 1980, Japan imported $21.9 million worth of machine tools from the developing countries which was 8.5 per cent of the country's total imports of machine tools. However, in terms of quantity, this represented 8,854 machines imported from the developing countries which was half of Japan's total imports of machine tools in that year. This indicates that the machine tools imported from the developing countries were much cheaper than those imported from the developed countries. The average unit price of machine tools imported from the developing countries was $2,480 compared to $28,530

[3]According to 1974 import data for five countries (Germany, Federal Republic of, Japan, Netherlands, United Kingdom and United States). International Trade Centre, UNCTAD/GATT *Marketing of General Purpose Machine Tools from Developing Countries* (Geneva, 1976), pp. 8-9.

for machine tools imported from the developed countries.[4] A similar situation exists for United States' imports. In 1978, the developing countries accounted for 11 per cent in terms of value of total imports of machine tools, but they accounted for three quarters in terms of number.[5]

For the developing countries as a whole, the relative importance of the developed countries as their export market is still small although it has been gradually increasing. In 1978, 66 per cent of the total value of exports from the developing countries was trade between the developing countries, 32 per cent was exports to the developed market economies, and 2 per cent to the centrally planned economies[6] (see table 42). The destinations of developing countries' exports do differ from country to country and also from year to year, to a lesser extent. However, on an aggregate basis, certain regional characteristics can be observed. In the 1970s, the relative importance of the developed countries as export markets declined for developing Latin America but increased for developing Africa, developing Western Asia and developing "other" Asia.

For Latin American exports, the importance of the regional market increased from 80 to 85 per cent between 1970 and 1978, at the expense of the importance of the developed market economies. This was in response to increasing demand in the regional market. The increasing share of the regional market in Latin American exports was accompanied by an increasing share of the regional suppliers in the region's imports. By contrast, for exports from developing "other" Asia, the importance of regional exports declined considerably due to diversification and aggressive penetration into export markets in the developed countries. In developing "other" Asia, there are several countries and areas pursuing export-led growth in their machine-tool industries. In these countries and areas (the Republic of Korea, Singapore and Taiwan Province, China), production lines are highly specialized in the types of product in which the greatest comparative advantage exists with the object of penetrating markets in the developed countries.[7] For example, in 1979, Singapore exported 92 per cent of its output of machine tools, of which 59 per cent went to the developed market economies. The Republic of Korea only exported 9 per cent of its output, but 77 per cent of these machine-tool exports went to the developed market economies.

Exports from developing Africa and developing Western Asia were small and their destination as well as their value tended to vary widely from year to year.

For exports from the developed market economies in North America and Europe, the importance of the developing countries and the centrally planned economies as export markets increased due to a combination of stagnant demand at home with a continuously growing demand from the developing countries and the centrally planned economies.

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[4] *Customs Statistics* (Tokyo, Ministry of Finance).

[5] Ministry of Commerce, United States of America.

[6] This excludes by far the largest exporter, Taiwan Province, China, which in 1978 accounted for more than 40 per cent of total exports from the developing countries and exported 60-70 per cent of its exports to the developed countries.

[7] There is further discussion of this aspect in the next section.

Table 42. Value of exports of machine tools and distribution of export destination, by regional and economic grouping, 1970, 1978 and 1979[a]

Exporter	Year[b]	Total value of exports (million dollars)	Destination of exports (percentage share in total value of exports)						
			Developing countries				Developed market economies	Centrally planned economies	Areas unspecified[c]
			Africa	Latin America	Western Asia	Other Asia[c]			
World	1970	2 002.4	1.38	6.30	1.51	6.30	70.92	12.97	0.61
	1978	6 562.9	3.08	8.74	4.10	9.78	52.34	20.93	1.02
Developing countries									
Total	1970	12.4	5.08	43.63	4.07	19.93	26.32	0.15	0.81
	1978	76.2	6.08	39.48	5.05	15.16	32.31	1.72	0.20
Africa	1970	0.1	78.49	—	—	—	21.51	—	—
	1978	0.3	28.81	—	—	22.71	48.47	—	—
Latin America	1970	6.8	0.13	79.54	—	0.01	20.32	—	—
	1978	34.8	0.50	85.01	1.34	0.30	12.85	—	—
Western Asia	1970	0.5	6.67	—	79.02	12.44	0.88	—	0.92
	1978	0.4	13.10	—	77.64	—	8.58	0.69	—
Other Asia	1970	5.0	10.67	0.18	1.53	48.03	37.28	0.37	1.93
	1978	40.7	10.61	1.23	7.58	27.94	49.05	3.22	0.38
Developed market economies									
Total	1970	1 987.8	1.36	6.08	1.50	6.12	71.27	13.07	0.61
	1978	6 486.7	3.04	8.38	4.09	9.72	52.58	21.16	1.03
	1979	7 724.8	2.29	7.40	2.71	10.24	59.15	16.70	1.50
North America	1970	321.7	0.30	11.32	0.73	3.65	80.89	2.34	0.77
	1978	665.1	0.72	19.17	5.70	7.78	55.49	9.63	1.51
	1979	815.3	0.66	21.26	2.63	8.01	63.83	2.27	1.34
Europe[d]	1970	1 573.2	1.60	5.18	1.73	4.58	71.59	15.21	0.11
	1978	4 798.9	3.89	7.58	4.25	4.94	55.21	23.81	0.32
	1979	5 671.7	2.86	6.36	2.94	6.44	60.46	60.45	0.49
Asia and the Pacific	1970	92.9	1.06	3.01	0.28	40.77	32.60	13.81	8.47
	1978	1 022.6	0.56	5.13	2.29	33.40	38.34	16.23	4.05
	1979	1 237.8	0.76	3.06	1.73	29.14	50.07	9.03	6.21

Source: Based on data provided by the Statistical Office of the United Nations Secretariat.

[a] Based on current dollars, f.o.b.

[b] The number of countries included differs slightly between 1970 and 1978 according to availability of data.

[c] Taiwan Province, China, is included in areas unspecified.

[d] Including Israel.

On the other hand, the importance of the developed market economies as a whole as markets for exports from the developed market economies in "other" Asia and the Pacific increased remarkably at the expense of the importance of the developing countries and the centrally planned economies. The drastic shift in Japanese exports from small conventional machines to NC machines and machining centres and the consequent shift in export destination from the developing countries in "other" Asia to North America and Europe were the main reasons for this.

C. Constraints on development and their consequences

The slow spread of machine-tool production into the developing countries and their general comparative disadvantage in machine tools are due to several structural and institutional constraints on production growth and exports in those countries, besides the relative lack of manpower and other general technological handicaps.

The size and the development level of the domestic market in relation to the minimum efficient scale of production is an important factor, particularly for machine tools, because penetration into international machine-tool markets is very difficult and costly for newcomers and because it is important for product development to co-operate closely with the users who require new technologies and try them out when they are first produced. In the developing countries (even in large ones), demand for many types of machine tools, particularly advanced ones, is limited because of the limited size of the modern sector of the engineering industries where innovativeness and the technical ability to handle advanced machines exist. For example, in a country like Argentina where the engineering industries are fairly well developed compared to most other developing countries; an estimate shows that the annual demand for NC lathes would be 80-100 units even when the domestic economy recovers from the current crisis.[8] This does not allow viable production of standard NC lathes in the country in a free trade context unless they can also be exported. In addition to the limited domestic demand, the lack of innovativeness and technical inability to handle advanced machines, incomplete electricity-supply networks and irregularity of voltage are critical constraints on the rapid diffusion of NC machines in many developing countries.

The engineering industries in the developing countries are generally much more labour-intensive than those in the developed countries. There is also clear evidence that the pace of mechanization and of retooling is much slower. This is often due to inadequate allowance for depreciation such as long-term straight-line depreciation methods, high interest rates, lack of credit facilities to user industries, particularly to small metalworking workshops, and probably most importantly, inadequate motivation in user industries to innovate and rationalize. Limited linkage between domestic user industries and machine-tool producers in the field of technological collaboration, coupled with a general shortage of skilled manpower, results in a limited capability for product design and quality improvement.

[8] ECLA/IDB/IDRC/UNDP, *op. cit.*, p. 22.

The technological difficulties are further worsened by current government protection policies in many developing countries where the machine-tool industry is inward-looking. As in any other infant industry, the newly established machine-tool industry is usually economically unstable and vulnerable, which justifies some form of government protection during the industry's learning period. However, it is important that the industry should become economically viable as soon as possible so that the protectionist measures can be removed in a short time. Prolonged protection may lead to inefficiency in the industry which will be injurious to the successful development of the country's engineering industries as a whole. The success of the engineering industries in a country depends critically upon maximum utilization of technologically suitable, good-quality machine tools. In some developing countries, there are sufficient stocks of machine tools in their engineering industries, but they are often obsolete or not properly used, which results in additional production costs and lower productivity in these industries.

The machine tools produced in the developing countries for local use are often not adequate for high-precision work or are technologically out-of-date compared to those produced in the developed countries. This is because most of the machine-tool producers in the developing countries (except for cottage industries) have started their production with designs and manufacturing techniques obtained from developed countries either through licensing agreements or through partnership arrangements. Many of them have continued production of the initial models without altering their designs. Only a few producers have built up the competence and manufacturing skills to develop their own designs or design modifications. Even then the design skills of these producers are weak compared to international standards, although they are advanced in the local context. Design of a new machine tool in the firm usually takes much longer than in the developed countries and when the new product is completed the design concept is already old in the international market. The design and quality of machine tools are continuously improved in the world market in response to changes in requirements from user industries. A research-intensive phase early in the product cycle characterizes the machine-tool industries in the developed countries that are geared to innovation. The machine tools produced in the developing countries may initially be available at a lower cost than imported machines. But, if foreign firms improve the design of their equipment more rapidly than local ones, a point will be reached at which the price of locally produced machines will exceed that of imported machines. Unless the domestic machine-tool industry is protected, users will move back to purchasing imported machines which will result in stagnant production and excess capacity in the domestic machine-tool industry.[9] This is a problem in comparative advantage which includes research ability among the endowments. However, any type of restriction on imports of machine tools reduces the rate of diffusion of new technology in the whole engineering sector. Thus, the inability to obtain machine tools of a better quality and performance may restrict the growth of the domestic engineering industries other than the machine-tool industry, although many of them may have more comparative advantage in the international market than the machine-tool industry has. This,

[9]See Pack, *loc. cit.*, pp. 241-242.

in turn, will reduce the potential for further growth in the machine-tool industry itself.

From this, it can be seen that the tendency towards slowness of innovation and product development in the machine-tool industry in many developing countries (except for those following export-led growth) is due not only to the lack of R and D capacity and of technological linkages between the machine-tool industry and the engineering industries, but also to the lack of competition with imports resulting from strong tariff protection. A high nominal rate of protection would give a firm a monopolist position in the domestic market, free from import competition. This tends to reduce the firm's incentive to recognize the need for technological innovation and design development for the benefit of user industries. For example, in India, where the industry has been under strict tariff protection, very few machine-tool manufacturers have invested any substantial amount of capital in R and D activities. The country's largest government-owned firm spent only 1.5 per cent of its sales turnover in 1976/1977, compared to corresponding figures of more than 5 per cent in leading developed market economies. And this firm's expenditure was exceptionally high compared to the other five major machine-tool producers in India (one large public firm and four large private firms) which spent an average of only 0.5 per cent of their sales turnover on R and D in the same year.[10]

There are several difficulties for the developing countries in exporting machine tools, particularly to the developed countries. As mentioned earlier, Argentina, Brazil, India, the Republic of Korea, Singapore and Taiwan Province, China, are the only countries or areas that have had a certain success in breaking through into world machine-tool markets including those in the developed countries. The exports of the two Latin American countries, however, have fluctuated widely from year to year because their machine-tool industries were dependent on domestic markets and their exports depended on the availability of exportable surpluses remaining from domestic demand fluctuation rather than on export market conditions. Furthermore, their exports were mainly to the regional market where technological requirements were similar to their own.

There are more than 100 firms manufacturing machine tools in these leading developing countries, of which, however, only a few are able to export their products. These producers initially started production of machine tools for import substitution but in recent years they have begun concentrating on exports for further growth as domestic demand was filled. The exports of countries like Argentina, Brazil, India and the Republic of Korea have shown a clear tendency to increase with less fluctuation since the mid-1970s. As seen earlier, in the case of the Latin American countries, the main export markets continued to be the regional markets while, in the case of the South-East Asian countries, their markets have shifted to the developed countries. There are several difficulties to be overcome in the course of shifting from import substitution to export promotion. The South-East Asian countries have overcome these difficulties through reorganizing the industry for exports to the developed countries, while the Latin American countries have not.

[10] *Commerce* (Bombay), vol. 139, No. 3555 (4 August 1979), p. 11.

Import substitution under strong government tariff protection tends to lead to too much diversification of products in the domestic industry instead of product specialization based on considerations of possible comparative advantage in terms of scale-economy, cost etc. As mentioned earlier, the only types of machine tools which could advantageously be produced in the developing countries are generally those with high price elasticities and low rates of product development in the international market. The lack of specialization in these types of machine tools creates difficulties in export promotion. It is often the case that manufacturers in the developing countries who wish to change their strategies from inward-looking to outward-looking ones tend to look for export markets where there is a potential demand for the models they already produce, but as these models were basically designed for domestic sales, this often proves extremely difficult. Particularly in promoting exports to the developed countries, the design capability of the producers is critically important. In order to be continuously successful in selling their machines in the developed countries, they may have to alter the designs of their machines to suit the requirements of potential buyers in these countries. These are most likely to be quite different from the requirements of domestic users owing to differences in the factor proportions, the technological level and the market structure. At the same time, the price of their machines must be competitive without necessarily being very low compared to that of potential competitors. (In contrast to standardized consumer goods, the low price of a machine tool may generate some doubts about its quality.)

In addition to all this, other structural difficulties which the developing countries tend to face in shifting to export promotion are those of general inefficiency in marketing, technical services and other fields related to sales promotion in the potential export markets, including pricing policies, delivery, payment terms, packing and advertising, all of which are as critically important as the design, quality and performance of the machine tools to be exported.[11] The need to pay attention to these factors, which are of great importance in a competitive economy, has often received little recognition among producers in developing countries where there is government protection of the domestic market.

Advertising in industrial and trade magazines, the organization of trade fairs, the dispatch of sales engineers and the establishment of distribution and service networks are essential for the sales promotion of machine tools in the international market. However, as in the case of product development, there has been limited effort in these areas. It requires, in general, substantial human and financial resources and experience. Such countries and areas as the Republic of Korea, Singapore and Taiwan Province, China, have all-round trading companies which can carry out marketing and sales promotion of domestic products including machine tools in overseas markets.[12] However, in most developing countries, there are neither trading companies nor machine-tool manufacturers' associations which are capable of carrying out these rather complex operations. Only a very few leading producers can afford to do these things by themselves. An example is the largest machine-tool firm in India

[11]For details, see International Trade Centre, UNCTAD/GATT, *op. cit.*, pp. 9-18.

[12]Many producers of machine tools in these countries sell their products abroad through large Japanese firms which have world-wide marketing and sales networks.

which has created a subsidiary company to carry out sales promotion abroad, particularly in the developed countries. This company currently employs some 300 sales and marketing staff and has overseas offices in four developed market economies and three developing countries.

As seen earlier, countries and areas with export-oriented machine-tool industries like the Republic of Korea, Singapore, Taiwan Province, China, and, to a lesser extent, India send more than half of their total machine-tool exports to the developed countries. They have concentrated their marketing and sales-promotion activities on the developed countries, partly because these are large markets where economies of scale in marketing surveys, modifying designs, establishing sales and service networks, and other aspects of sales promotion can be achieved.[13] Also, for various technical and institutional reasons, it is usually much easier to carry out general marketing surveys and sales promotion in developed countries than in developing countries, especially considering that the main customers for machine tools exported by the developing countries are small metalworking workshops.

Even in the developed countries, the financial management of machine-tool businesses is not easy because of large annual fluctuations in machine-tool demand. The machine-tool business in these countries typically follows a cyclical pattern of extensive profit accumulation during the period of economic upturn and exhaustion (or deficit finance) in the period of economic downturn. It is not unusual for this to be accentuated by the increasing need for R and D investment for product development during the period of economic downturn. This was seen in the mid-1970s when, in spite of financial crisis, many machine-tool producers, particularly in Japan, spent a considerable amount of risk capital in developing labour-saving (or highly automated) machines to meet changing requirements from users. The financial management of a machine-tool business in developing countries is generally much more difficult than in developed countries because, in addition to these general characteristics, the industry tends to be less efficient due to all the internal and the external factors mentioned earlier, the heavy dependence on a limited domestic demand, low export capability and general managerial weakness. This is the reason why protectionist policies tend to be prolonged rather than discontinued in many developing countries, although in recent years there has been a tendency towards easing import restrictions in some developing countries.[14]

Possible ways of overcoming technical and financial problems and acquiring important design and financial skills are well presented in the following two examples of a leading firm in Argentina which overcame financial problems by partnership arrangements with firms in a developed country, and a leading firm in India which did so by widespread product diversification.

In Argentina there are some 110 firms which produce machine tools. Of these, only eight have reached a stage of development where the design does

[13] Pack, *loc. cit.*, p. 244.

[14] India, for example, introduced a new import policy in 1978/1979 in which machine tools were, for the first time in two decades, removed from the list of capital goods banned for import and placed on the open-licensing list. By selective exposure to international competition, the new policy aims at improving the efficiency and cost-competitiveness of the domestic capital-goods industries including the machine-tool industry (*Commerce* (Bombay), No. 3492, 15 May 1970, p. 3).

not come from copying machines developed abroad, and among these eight firms, only one firm has recently started producing NC machines (NC lathes). The firm which produces NC lathes has expanded remarkably since 1960 when a Swiss consortium bought it. The development of the firm has been based on two factors, design development and financial capability. During the last two decades, it has gradually created a product-design capability and has increased the complexity of its products from the first parallel lathes to NC lathes. This technological progress was due largely to extensive investment at the end of the 1960s in qualified engineers and technicians which laid the foundation for an elaborate division of labour in product and process research. While the technological development was achieved wholly by Argentina, risk capital has been provided from abroad by the Swiss consortium in times of heavy investment and financial crises. Thus, the foreign consortium has acted as a risk reducer. This financial support has been particularly important in recent years in Argentina which has had stagnant investment in the economy as a whole, extremely high interest rates and lowered tariffs. For example, this firm's main competitor went bankrupt at the end of the 1970s due largely to its heavy loans in pesos, created in the late 1970s for the firm's rapid expansion, for which it had to pay about 30 per cent real interest rate. Whereas, the leading firm had nearly all its loans in dollars due to its link with the Swiss consortium.[15]

This example shows that one of the easiest ways to overcome financial problems is collaboration with a firm based in a developed country. However, collaboration with firms in the developed countries is not always easy and is usually confined to the fields of less sophisticated machines with high price elasticities because the only source of comparative advantage in the developing countries is, in general, lower direct labour costs. However, production of machine tools, particularly of NC and other advanced machine tools, does not benefit from a reduction in direct labour costs so much as many other labour-intensive industries do. As mentioned earlier, the share of direct labour costs in total production costs is relatively small. Even in a country like Sweden they account for only 11 per cent of the total cost of production of NC lathes. This is partly due to the fact that, in developed countries, the introduction of different automatic-feeding mechanisms and material-handling systems allows for a 24-hour operation of the capital stock with the aid of very few direct workers. Moreover, in many developing countries, prices of both domestic and imported materials for machine-tool production tend to be higher than in developed countries because of the weak upstream-linked industries. Thus, for a firm in the developed countries, the advantage of investing in developing countries is, for many types of machine tools, not usually substantial. This is particularly true for NC and other advanced machine tools for which demand in the developing countries is limited. Therefore, to encourage foreign investment in the machine-tool industry in the developing countries, substantial government incentives and regional agreements (e.g., free-trade agreements within the potential regional market) are often necessary.

India's largest firm of machine-tool producers was established in the public sector in 1953 with technical collaboration from a Swiss firm. Since its establishment, the firm has achieved a great diversification of products, ranging from universal machines to special-purpose machines, through licensing

[15] ECLA/IDB/IDRC/UNDP, *op. cit.*, pp. 25-28.

agreements with foreign firms as well as through its own product development and it now produces NC machines. The firm had expanded without serious financial difficulties from its establishment until 1967 when domestic demand for machine tools declined sharply as a result of a steep decline in public investment and the firm found itself, for the first time, in the red. This financial crisis could have been even worse if the firm had not had the watch production unit which had been established in the early 1960s and had achieved a stable performance since then. During the financial crisis, the new line entered into by the firm in setting up the watch factory paid off. Supported by stable and even increasing demand, the watch plant continued to generate substantial profits which played an important role in financing day-to-day expenditure in the firm's machine-tool units. In order further to reduce its vulnerability to changes in the state of the machine-tool market, the firm also established new production facilities for printing machines, agricultural tractors, plastic-moulding machines and the like for which domestic demand was considered to be large, stable and increasing. As a consequence of this product diversification, the share of machine tools in the firm's total sales revenue decreased considerably to some 50 per cent and the firm's dependence on the machine-tool market was considerably reduced.[16] This diversification into products other than machine tools was designed to serve two ends, to shield the firm's finances against economic fluctuations and, simultaneously, to provide a base load of demand for its machine-tool production units.

The various structural, technological, economic and institutional constraints and weaknesses described in this section which affect the development of the engineering industries as a whole, suggest certain policy guidelines. Tariff protection should be removed or at least reduced to relatively low uniform tariffs as soon as the infant stage of development in the domestic machine-tool industry is over. From the point of view of long-term growth, it may be preferable to introduce, instead of tariff protection, an explicit policy of direct subsidies for:

(a) The training of engineers, technicians and other specialists;

(b) The reorganization of firms towards specialization or diversification;

(c) Product and process research;

(d) Marketing;

(e) Assistance in overcoming financial crisis at a time of economic depression.

Alternatively, the establishment of institutes for design improvement, standardization of quality control, marketing and the provision of capital at low interest rates may be effective.[17]

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[16] *Commerce* (Bombay), No. 3385, 10 April 1976, pp. 1-5.

[17] In fact, in those countries where their own capabilities for design and product development have been gradually developed, R and D activities have been carried out to a large extent under government initiative in government technical-research institutes such as the Central Machine Tool Institute in India or technical universities such as the Research Institute of Technology of the University of Sao Paulo in Brazil. Taiwan Province, China, has established an inspection system for quality control of machine tools to be exported.

VII. Prospects for the world machine-tool industry in the 1980s

A. Developed countries

Both the domestic and the overseas markets for engineering products will become more and more competitive. Wage levels will continue to increase, and procurement of skilled labour for direct production will be increasingly difficult. In order to survive in these circumstances, engineering firms will make every effort to reduce costs and to develop new products. This will require continued and substantial retooling of their equipment, a large part of which was purchased during the 1960s and the early 1970s. The demand for automated machine tools will continue to increase, probably even faster, while that for conventional machine tools will be stagnant. The diversification in the engineering industries towards high-technology products will require machine tools with more diversified functions and higher accuracy. In response to these requirements, more efficient machine tools will be developed which, in turn, will stimulate the retooling demand in the user industries.

A foreseeable structural change in the engineering industries in the developed countries will be a gradual shift towards more technology-intensive fields such as aerospace, electronics and electronic computers. Thus, the demand for machine tools for production in these fields will also increase. However, the main users of machine tools will continue to be the automobile and the non-electrical machinery industries. In particular, the increasingly keen competition in international markets among producers of small cars will be the focus of machine-tool demand and its influence on the machine-tool industry will be great.

Along with the development of NC machines and machining centres and of micro-electronics technology, production technology in the engineering industries will develop in revolutionary ways. By far the most important form of modern production technology among them will be computer-aided automatization of the entire production process. The major concern of product development in the machine-tool industry will move gradually from the development of single, independent NC machine tools to the designing of NC machines to be combined with other NC machines, industrial robots and automatic transfer machines in a system of automated manufacturing known as a flexible manufacturing system (FMS). This will make it possible to establish virtually unmanned factories where automatic operations in all fields including forging, cutting, welding, machining, painting, tool replacement, inspection, repair etc. will all be carried out by a hierarchy of micro-processors and a large central computer. The automatization of the 1970s removed the need for skilled

operators for most of the individual machining operations. Machine-tool producers are now trying to dispense with all operators from the entire manufacturing process in the engineering industries.

Japan is the forerunner in the field of machine-tool-based systematization of manufacturing technology and will continue to lead technological development in the world machine-tool industry in the 1980s because of the country's technological lead in NC systems, industrial robots, computer control and other electronics applications.[1] The relatively small social pressures against automatization will also help the development of automated machine tools and production systems in Japan.

An example of Japan's leading position in the field of automatization is the recent growth of Japanese robot production. As in the case of NC machine tools, the production of industrial robots started increasing rapidly in 1976 in response to the growing need in the domestic engineering industries to save labour and increase efficiency. In 1980, some 19,000 units of robots (worth 60 billion yen) were produced by 130 firms, compared to the 1975 production of 4,400 units (worth 11.1 billion yen). At the end of 1979, 56,800 industrial robots were in use in the automobile industry and various other fields of engineering production.[2] In terms of production capacity and diffusion rate, Japan is by far the largest user as well as producer of industrial robots in the world.

Industrial robots have followed a development pattern very similar to that of NC machine tools and electronic computers and they are now in a period of widening applications. In 1979, more than half the demand for industrial robots came from two industries, the automobile industry (38 per cent) and the electrical-machinery industry (18 per cent). So far, the main processes in which robots are employed are cutting, grinding and pressing, moulding of resin, die casting, heat processing and assembly. In the 1980s, as computers come to be used to equip robots with artificial intelligence, robot applications in screw fastening, fabrication, caulking, complex assembly and inspection will increase rapidly. Robots will make automation possible even in those areas of production which involve a large number of components, each in a small volume, and mixed production where it has been difficult to automate conventionally.[3]

As a part of the development of automated manufacturing systems, several leading machine-tool producers in Japan have started producing their own industrial robots for combined use with their machine tools. The largest Japanese producer of NC units has also gone into robot production taking advantage of its NC technology, and has started using its own robots in the production of all its products including the robots themselves.[4]

Programmes are also under way in several developed countries to design prototype unmanned factories. In Japan, two consecutive programmes were started in 1975 and 1978, respectively, under government sponsorship. The first

[1] Almost all the Japanese machine tools displayed in Japan's 10th International Machine Tool Fair in 1980 in Tokyo were NC machines. Very many of them were designed as part of a system for unmanned operation (*Metalworking Production*, January 1981, p. 12 and March 1981, p. 84).

[2] *Asahi Shinbun*, 6 August 1982, p. 9

[3] *Digest of Japanese Industry and Technology* (Tokyo), No. 141, 1979, pp. 27-29.

[4] *Metalworking Production*, March 1981, p. 91; and data from Fujitsu Fanuc Ltd., Japan.

one, "Programme for machines for unmanned manufacturing" was conducted by a government institute but was suspended before completion. The second programme, "Flexible-manufacturing-system complex provided with laser", with a projected cost of about $62 million, has involved not only three government institutes but also twenty manufacturers of materials, machine tools, and controls. These firms are responsible for about 80 per cent of the projected cost. The objective is plainly stated as being to make Japan a world leader in the development of systems that can produce parts automatically in small quantities in a wide variety of configurations. The target is to develop an FMS complex that will have a production time less than half that of current production systems.[5]

The European countries and, to a lesser extent, the United States are behind Japan in the field of automatization technology and its applications and will find it difficult to keep up with the pace of development in Japan, at least for some time to come. This is partly because of the delay in the development of micro-electronics in these countries or in the application of micro-electronics in systems development. However, the most important reason appears to be the strong pressure from labour unions against automatization in general in these countries where unemployment rates are much higher than in Japan. As the expansion of the economy slows down, automatization has become increasingly controversial among social scientists, even in Japan, because of its effect on employment.

A recent survey shows that, in the United States, the trend towards automatization was slowing down in the late 1970s in the engineering sector except for the aerospace industry. From 1978 to 1980, the share of capital invested in automatization decreased from 41 per cent to 28 per cent of total capital invested in the engineering industries. The largest reductions were in the non-electrical machinery industry (from 44 per cent to 27 per cent) and the automobile industry (from 27 per cent to 16 per cent).[6]

In addition to social and technological handicaps in automatization, there exist several other factors which may delay the development of the machine-tool industry in the United States and the European developed market economies. First, Japan is in a dominant position in the world in NC machines, the development of which will be the major concern of the world machine-tool industry in the 1980s. The machine-tool industry in other countries is, therefore, in a defensive position. Second, as mentioned earlier, there are structural difficulties in the industry which militate against changing over to advanced machines including NC machines. Third, the engineering industries in these countries are relatively non-innovative and are losing competitiveness. These factors are particularly pronounced in France, Italy and the United Kingdom. On the other hand, the machine-tool industries in the Federal Republic of Germany, Sweden and Switzerland are relatively well-specialized in advanced machines, and may therefore remain competitive in the world markets for their products in the medium term.

It is probable that delay in the development of machine tools for automated manufacturing systems will result in turn in a delay in the diffusion

[5] *American Machinist*, February 1981, pp. 98-100.

[6] *Ibid.*, p. 100. In this survey, automated machines were defined as advanced mechanical equipment especially in combination with self-regulating or high-speed computers.

of automated production processes and in the development of the latest production technology in the engineering industries in these countries, which will lead to an increasing disadvantage in their competitive position as against Japan in world markets.

Despite increasing social pressure against any kind of labour cut-back, automatization of production processes will probably proceed even faster than in the 1970s in many engineering firms in the developed countries because of their need to reduce costs and improve the quality of their products. They would otherwise risk falling behind in the increasingly competitive domestic and overseas markets. Along with automatization, the engineering industries in the developed countries will become more capital- and technology-intensive and, consequently, the importance of labour costs as a determinant of a country's comparative advantage in engineering production will decrease.

The increasing applications of automated machine tools, industrial robots and their combined use as a system controlled by a central computer are essentially creating new production technologies and processes. This movement, sometimes called the "micro-processor revolution", is eliminating many workers, both unskilled and skilled, from production activities and requires only a few highly qualified technicians. Consequently, the problem of how to absorb the surplus labour force generated in the engineering industries will be a major concern among policy makers in the developed countries in the 1980s.

In the machine-tool industry in the developed countries, the disparity between firms is likely to widen further. As mentioned above, the demand for manufacturing systems such as FMS will grow much faster than that for stand-alone machines, even including NC machines which have not been designed as part of a system. But the producers who are capable of developing system products and of promoting them are only a few.[7] As competition between firms becomes more severe, product specialization will increase in each firm. Overseas markets will become increasingly competitive and, in several developed countries, protectionist measures may be introduced as import penetration by foreign producers increases. Protectionist measures will accelerate the trend for foreign producers to invest directly in production in these countries instead of exporting to them. On the other hand, producers of conventional machines in the developed countries will face growing difficulties due to increasing competition from developing countries together with slow or stagnant growth of demand for their products. Some of them may transfer a part of their production capacity to countries where labour costs are low and demand for their products is large, while others may contract their production capacity or close down their machine-tool production. Only a few will be able to shift their production lines towards advanced machines and manufacturing systems. In this way, polarization in the industry will become greater.

Intra-industry trade in machine tools is still fairly large with a tendency towards export dominance in all the major developed market economies. For this reason, there is no evidence of protectionist movements at the national level in these countries as yet, although there are some signs of protectionism against Japanese NC machines in some of them. So far, government intervention in these countries has been directed at encouraging their own domestic industry.

[7] According to the Machine Tool Builders' Association in Japan, the number of such firms is probably around ten or twenty at most.

For example, in the Federal Republic of Germany, where the machine-tool industry is, for the first time, facing a vigorous challenge from Japanese NC machines, there is likely to be an increase in direct government support to the electronics industry and to the country's machine-tool industry, aimed at increasing its technological capacity for electronics applications. Growing government support for the development of NC machines in other countries such as France, Italy and the United Kingdom has been due, at least to some extent, to the influence of Japanese success in the international market and in penetrating into these countries. In the United States, as mentioned earlier, signs of protectionism have also been emerging.

However, if intra-industry trade declines and import dominance increases because of continued dependence on the production and export of conventional machines and a failure to develop competitive computer-aided machines which will meet the changing requirements of users, protectionism in a much stronger form may emerge in these countries as in the case of automobiles. In this case, protectionism would encourage the foreign firms exporting to these countries to produce their machine tools in these countries through subsidiaries or through licensed production instead of exporting to them. In any case, protectionism in the field of machine tools, unlike that of consumer durables, will be further complicated by the fact that machine-tool development is interlinked with the country's ordnance production.

B. Developing countries

As mentioned earlier, many of the NICs have a well-established machine-tool industry, and are today self-sufficient in their needs for almost all types of universal machines. Therefore, the further growth of their machine-tool industry will depend increasingly on their exports of this type of machine as well as on production of more advanced machines. For the latter, however, the scope is limited without government protection because of the various constraints that were mentioned earlier. On the market side, as the developed countries give up producing many types of universal machines, the position of developing countries as world suppliers of this type of machine will improve. Thus, two-way trade between the developing world and the developed world may increase with the former exporting universal machines and the latter exporting advanced machines. However, assuming that automatization proceeds at a rapid pace in the developed countries' engineering industries, it is most likely that the importance of the developed countries as markets for universal machines produced in the developing countries will decrease. In other words, the few NICs will only find an outlet for their universal machines in the other developing countries.

It is likely that many developing countries other than the NICs will start or expand their domestic production of machine tools, but the limited number of leading NICs will continue to dominate both the production and exports of the developing countries as a whole, because, in the long run, the only source of comparative advantage in machine tools is, as mentioned earlier, a strong design capability and not very low production costs.

Several major machine-tool-producing developing countries, particularly those that depend substantially on exports to the developed countries, will move into production of small low-cost NC machines such as those developed by Japanese producers. There are several reasons for this. First, as NC devices become mature and go into the stage of mass production and standardization in the developed countries, it becomes much easier for developing countries to buy them. Second, the growth of demand for standard machines will be much slower than that for NC machines in the developed countries. Third, Japanese producers, who currently dominate world production and exports of this type of machine, are likely to move into the development of manufacturing systems and competitive pressures from them will be reduced. Fourth, in these developing countries, the engineering industries are relatively well developed and capable of using these machines. Increasing wage levels and increasing requirements for higher accuracy would result in a growing demand in their domestic engineering industries for this type of NC machine in order to maintain their competitiveness in the international market.

However, considering the expected rapid pace of development of machine tools in the developed countries, the technological gap between the developed world and the developing world in machine-tool production is likely to become almost unbridgeable. The most important consequence of this will be a widening gap between the two groups in manufacturing technology and, therefore, in productivity and comparative advantage in the engineering industries.

Annex

ADDITIONAL TABLES

Table 43. World distribution[a] of gross output and exports of machine tools, by country or area, 1966-1967, 1970-1971, 1974-1975 and 1979-1980[b, c]

(Percentage)

	Share in world total gross output				*Share in world total exports*			
Country or area	*1966-1967*	*1970-1971*	*1974-1975*	*1979-1980*	*1966-1967*	*1970-1971*	*1974-1975*	*1979-1980*
Developed market economies								
Australia	0.5	0.3	0.3	0.1	0.2	0.1	0.1	—
Austria	0.3	0.4	0.5	0.5	0.9	0.8	1.2	1.2
Belgium	0.4	0.5	0.7	0.5	1.4	1.4	1.5	1.4
Canada	0.5	0.5	0.5	0.7	0.8	1.0	1.2	1.0
Denmark	0.2	0.2	0.2	0.2	0.7	0.5	0.5	0.4
France	4.4	4.4	4.6	3.7	4.3	4.6	5.2	4.8
Germany, Federal Republic of	15.1	20.7	17.7	17.5	32.2	29.1	31.1	25.9
Italy	3.0	5.7	6.2	6.2	6.2	7.1	7.0	7.2
Japan	6.2	13.0	10.4	13.4	3.4	3.8	5.8	12.6
Netherlands	0.2	0.3	0.4	0.3	0.6	1.1	1.0	0.8
Portugal	—	—	—	0.1	0.1	0.1	0.1	—
South Africa	. . .	0.1	0.1	0.1	—	—	0.1	—
Spain	0.9	1.2	1.6	1.3	0.5	1.2	1.5	1.9
Sweden	0.8	0.9	1.0	0.9	1.6	1.8	1.9	1.8
Switzerland	2.7	3.3	3.8	3.9	7.9	7.6	7.9	8.0
United Kingdom	7.1	6.0	5.0	4.8	7.5	8.4	5.7	5.7
United States	30.5	15.6	17.4	17.8	11.4	10.8	9.4	7.9
Yugoslavia	0.2	0.4	0.6	0.8	0.3	0.3	0.5	0.6
Other countries	—	0.1	0.1	0.1	—	0.1	0.1	0.2

Table 43 *(continued)*

Country or area	Share in world total gross output				Share in world total exports			
	1966-1967	1970-1971	1974-1975	1979-1980	1966-1967	1970-1971	1974-1975	1979-1980
Centrally planned economies								
Bulgaria	0.2	0.3	0.2	0.2	0.5	0.5	0.2	0.2
Czechoslovakia	3.9	3.2	2.3	1.4	5.4	4.5	3.8	2.7
German Democratic Republic	3.5	3.5	4.1	3.4	7.4	7.9	7.0	5.9
Hungary	0.6	0.6	0.4	0.5	1.1	0.9	0.9	0.7
Poland	1.1	1.9	2.9	1.7	1.8	2.0	1.9	1.7
Romania	0.4	0.2	0.5	2.1	0.2	0.3	0.3	1.2
Union of Soviet Socialist Republics	14.4	14.2	14.5	12.0	3.6	3.5	3.4	3.1
Developing countries and areas								
Argentina	0.3	0.4	0.3	0.2	0.1	0.1	0.2	0.2
Brazil	0.7	0.5	0.9	1.4	0.2	0.2	0.2	0.4
China[d]	0.8	0.7	1.6	1.7	—	0.1	0.1	0.2
China (Taiwan Province)	0.1	0.2	0.2	0.9	0.1	0.1	0.3	1.4
India	0.8	0.5	0.7	0.6	0.1	0.1	0.2	0.2
Mexico	—	0.1	—	0.1	—	—	—	—
Republic of Korea	—	. . .	. . .	0.6	—	—	—	0.2
Singapore	—	—	—	0.1	—	—	0.1	0.3
Others	—	0.1	0.1	0.2	—	—	—	—
World total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: American Machinist, various issues; UN, *Bulletin of Statistics on World Trade in Engineering Products*, various issues; data supplied by the Statistical Office of the United Nations Secretariat; and estimates by the UNIDO secretariat.

[a] It was assumed that 38 countries were significant producers of machine tools in 1966-1967, and 42 countries from 1970 onwards.

[b] All calculations were based on data in current dollars.

[c] Annual averages.

[d] Excluding Taiwan Province, China.

Table 44. Measures of market penetration in machine tools, by country or area, 1966-1967, 1970-1971, 1974-1975 and 1979-1980[a, b]

(Percentage)

Country or area	Ratio of exports to the sum of gross output and imports				Ratio of imports to the sum of gross output and imports			
	1966-1967	1970-1971	1974-1975	1979-1980	1966-1967	1970-1971	1974-1975	1979-1980
Developed market economies								
Australia	4.03	5.24	8.13	0.79	61.73	62.36	61.26	87.07
Austria	40.10	33.09	52.49	50.51	52.78	56.52	43.44	53.59
Belgium	41.24	42.31	44.04	51.64	52.33	52.27	50.46	54.76
Canada	7.92	17.85	20.93	24.11	81.51	75.05	76.95	65.59
Denmark	40.42	48.95	45.46	49.44	59.08	46.01	46.06	48.13
Finland	—	. . .	3.23	. . .	100.00	. . .	81.71	. . .
France	18.90	21.92	30.78	40.38	30.04	37.71	31.61	33.24
Germany, Federal Republic of	54.05	42.02	65.22	58.56	7.85	12.27	8.15	13.99
Italy	40.17	31.98	35.39	44.58	29.55	23.98	22.32	16.95
Japan	14.27	8.76	21.57	40.90	10.49	13.25	8.92	5.51
Netherlands	30.67	36.30	42.23	43.29	52.91	66.18	60.40	66.11
New Zealand	—	. . .	0.60	. . .	100.00	. . .	79.03	. . .
Portugal	26.74	12.21	12.52	10.55	52.95	75.57	75.49	69.57
South Africa	. . .	0.96	3.36	2.51	. . .	85.21	82.10	87.13
Spain	8.23	21.40	21.25	50.91	44.06	36.99	41.27	22.53
Sweden	31.38	33.61	36.07	54.31	46.28	49.14	55.82	40.45
Switzerland	66.46	63.68	73.27	79.50	15.68	19.02	13.36	16.33
United Kingdom	22.20	37.18	33.84	36.36	22.79	21.26	27.10	34.18
United States	9.42	21.98	19.64	16.35	8.06	8.33	10.40	20.85
Yugoslavia	12.54	13.13	15.40	17.06	64.42	40.12	50.32	47.54
Centrally planned economies								
Bulgaria	20.57	24.54	14.07	23.17	67.47	55.95	65.89	54.73
Czechoslovakia	29.37	37.78	48.95	56.76	25.15	21.13	27.43	37.60
German Democratic Republic	48.56	63.01	52.93	60.89	14.66	18.00	22.41	22.82
Hungary	32.20	33.44	47.68	31.65	29.53	36.38	44.75	53.28
Poland	24.40	21.93	13.91	23.22	43.44	39.22	47.08	50.29
Romania	6.79	15.05	7.15	16.17	57.31	62.11	70.11	39.92
USSR	6.03	7.12	6.86	9.07	13.37	14.63	28.42	23.83

Table 44 *(continued)*

Country or area	Ratio of exports to the sum of gross output and imports				Ratio of imports to the sum of gross output and imports			
	1966-1967	1970-1971	1974-1975	1979-1980	1966-1967	1970-1971	1974-1975	1979-1980
Developing countries and areas								
Argentina	4.61	4.59	11.68	13.63	35.59	43.96	40.89	61.59
Brazil	4.05	5.80	4.16	9.97	36.33	51.38	53.56	30.59
China[c]	—	2.61	1.26	5.04	46.68	52.74	26.56	24.34
China (Taiwan Province)	13.12	27.23		49.01	. . .	39.17	60.32	32.69
India	1.32	4.34	7.10	11.06	59.41	43.26	27.24	29.10
Mexico	0.14	0.07	—	0.88	93.16	92.89	98.65	92.89
Republic of Korea	—	. . .	. . .	3.95	100.00	. . .	. . .	71.33
Singapore	. . .	. . .	. . .	28.99	. . .	. . .	. . .	74.97

Source: American Machinist, various issues; UN, *Bulletin of Statistics on World Trade in Engineering Products*, various issues; data supplied by the Statistical Office of the United Nations Secretariat; and estimates by the UNIDO secretariat.

[a] All calculations were based on data in current dollars.

[b] Annual averages.

[c] Excluding Taiwan Province, China.

Table 45. RCA index and share in world exports of metalworking machine tools (SITC 7151), by country or area, 1970-1971 and 1978-1979[a]

	Percentage share in world total exports[b]		*RCA index[c]*	
Country or area	*1970-1971*	*1978-1979*	*1970-1971*	*1978-1979*
Argentina	0.13	0.20	0.287	0.429
Australia	0.16	0.08	0.158	0.096
Austria	1.07	1.48	0.824	1.016
Belgium	1.82	1.47	0.368	0.314
Brazil	0.21	0.41	0.367	0.399
Canada	1.14	1.59	0.201	0.398
Chile	—	0.02[d]	0.001	0.064[d]
Colombia	—	0.03	0.013	0.287
Denmark	0.68	0.60	0.488	0.481
Finland	0.02	0.10	0.022	0.094
France	5.84	5.86	0.752	0.672
Germany, Federal Republic of	34.68	31.52	2.186	1.938
Greece	—	0.01	0.006	0.033
Hong Kong	0.06	0.05	0.058	0.043
India	0.14	0.22[d]	0.220	0.472[d]
Ireland	. . .	0.08	. . .	0.133
Israel	0.03	0.03	0.148	0.123
Italy	9.16	8.98	1.496	1.338
Japan	4.89	15.62	0.502	1.435
Kuwait	0.01	—[d]	0.082	0.003[d]
Malaysia	0.01	0.01	0.014	0.012
Mexico	. . .	0.01[d]	. . .	0.042[d]
Netherlands	1.37	0.94	0.274	0.182
New Zealand	—	0.02	0.004	0.057
Norway	0.05	0.05	0.050	0.060
Portugal	0.07	0.06	0.186	0.191
Republic of Korea	0.01	0.11	0.021	0.078
Saudi Arabia	. . .	0.01	. . .	0.022
Singapore	0.05	0.31	0.088	0.293
Spain	1.47	2.48	1.501	1.638
Sweden	2.33	2.18	0.764	0.846
Switzerland	9.59	10.09	4.015	3.983
United Kingdom	10.85	6.28	1.265	0.866
United States	13.94	8.70	0.883	0.656
Venezuela	—	0.01	0.003	0.016
Yugoslavia	0.36	0.69	0.500	1.116
Developing countries and areas not listed above	0.01[e]	0.02[f]	0.023[g]	0.024[h]

Source: Based on data supplied by the Statistical Office of the United Nations Secretariat.

[a] All figures are unweighted annual averages.

[b] Percentage share in total value of exports from the countries listed in the table.

[c] For the definition, chapter III, footnote 7.

[d] 1978 only.

[e] 20 countries.

[f] 38 countries.

[g] Unweighted average among 20 countries.

[h] Unweighted average among 38 countries.

Table 46. Ratio of net exports to total trade[a] in metalworking machine tools (SITC 7151), by country or area and trade partner, 1970-1971 and 1978-1979[b]

(Percentage)

Country or area	Period	Trade partner						
			Developing countries					
		World	Africa	Latin America	Western Asia	Other Asia	Developed market economies	Centrally planned economies
Argentina	1970-1971	−81.0	100.0	62.7	. . .	. . .	−99.6	−100.0
	1978-1979	−62.5	100.0	76.0	. . .	55.2	−96.0	−100.0
Australia	1970-1971	−87.3	100.0	89.7	100.0	38.0	−92.2	−99.5
	1978-1979	−89.0	100.0	59.0	100.0	−14.2	−91.9	−98.3
Austria	1970-1971	−23.4	100.0	100.0	100.0	99.7	−34.0	4.9
	1978-1979	−4.7	100.0	100.0	100.0	87.7	−30.7	70.1
Belgium	1970-1971	−12.5	99.9	100.0	99.1	95.9	−16.0	−20.7
	1978-1979	−6.7	95.7	99.6	99.4	95.4	−19.5	52.0
Brazil	1970-1971	−81.5	100.0	85.9	. . .	100.0	−95.0	−100.0
	1978-1979	−74.9	100.0	82.9	100.0	−70.9	−94.8	−91.6
Canada	1970-1971	−67.0	100.0	88.6	6.5	10.9	−68.6	−75.3
	1978-1979	−29.7	100.0	93.8	87.1	24.9	−30.0	−82.5
Chile	1970-1971	−99.8	−100.0	−97.1	. . .	. . .	−100.0	−100.0
	1978	−79.2	. . .	−40.1	. . .	. . .	−100.0	. . .
Colombia	1970-1971	−99.5	. . .	−86.2	. . .	−100.0	−100.0	−100.0
	1978-1979	−81.0	100.0	−6.7	. . .	−100.0	−99.3	−100.0
Denmark	1970-1971	−14.5	100.0	99.9	100.0	97.9	−30.6	−50.9
	1978-1979	−10.5	100.0	99.9	100.0	97.9	−27.7	−27.7
France	1970-1971	−96.1	. . .	16.9	. . .	−95.8	−95.5	−98.7
	1978-1979	−68.9	100.0	100.0	100.0	5.2	−74.6	−73.8
Germany, Federal Republic of	1970-1971	58.5	99.8	96.7	99.8	97.0	52.2	66.1
	1978-1979	63.0	100.0	98.2	99.4	96.3	46.2	87.5
Greece	1970-1971	−99.5	100.0	—	10.5	−100.0	−99.5	−100.0
	1978-1979	−96.2	100.0	−100.0	99.1	−70.7	−96.5	−99.8
Hong Kong	1970-1971	−62.1	100.0	100.0	100.0	−29.1	−99.2	−100.0
	1978-1979	−83.9	100.0	−6.0	100.0	−76.2	−98.4	−100.0

India	1970-1971	−76.6	100.0
	1978	−49.7	99.9
Ireland	1970-1971	..	...
	1978-1979	−67.7	...
Israel	1970-1971	−94.7	95.1
	1978-1979	−90.6	21.8
Italy	1970-1971	14.4	99.9
	1978-1979	48.3	99.9
Japan	1970-1971	−21.5	100.0
	1978-1979	77.6	100.0
Kuwait	1970-1971	−54.0	18.9
	1978	−79.4	...
Malaysia	1970-1971	−96.3	...
	1978-1979	−96.1	100.0
Mexico	1970-1971	...	...
	1978	−97.9	...
Netherlands	1970-1971	−27.5	99.8
	1978-1979	−31.4	97.7
New Zealand	1970-1971	−99.1	100.0
	1978-1979	−84.2	100.0
Norway	1970-1971	−88.9	100.0
	1978-1979	−84.4	100.0
Portugal	1970-1971	−72.8	98.5
	1978-1979	−78.7	100.0
Republic of Korea	1970-1971	−98.1	...
	1978-1979	−94.7	99.4
Singapore	1970-1971	−86.2	—
	1978-1979	−47.6	43.3
Spain	1970-1971	−15.7	100.0
	1978-1979	31.9	99.7
Sweden	1970-1971	−18.4	100.0
	1978-1979	13.8	100.0
Switzerland	1970-1971	53.5	100.0
	1978-1979	67.7	100.0
United Kingdom	1970-1971	27.3	99.3
	1978-1979	−4.9	98.5

100.0	100.0	100.0	−81.2	−99.4
100.0	99.8	99.8	−70.4	−68.8
. . .	. . .	. . .	. . .	. . .
100.0	100.0	−47.6	−67.4	−100.0
100.0	99.1	—	−97.2	−25.2
24.0	61.5	−4.3	−92.6	−100.0
99.7	98.2	100.0	−5.8	57.2
97.9	99.1	93.9	25.9	71.3
100.0	100.0	99.5	−63.7	−10.2
99.9	99.5	97.6	58.8	88.7
. . .	97.3	57.9	−99.4	−100.0
. . .	100.0	−100.0	−100.0	−100.0
. . .	. . .	−79.4	−100.0	−100.0
−100.0	100.0	−82.5	−98.7	−100.0
. . .	. . .	. . .	. . .	. . .
−84.8	. . .	−100.0	−99.8	−100.0
97.2	96.6	40.0	−29.8	−37.0
98.8	99.6	60.9	−38.6	−1.2
100.0	. . .	−89.5	−99.5	−100.0
100.0	100.0	−59.8	−84.1	−100.0
100.0	100.0	98.4	−90.4	−97.1
100.0	100.0	71.1	−88.9	−83.3
100.0	. . .	100.0	−83.0	−100.0
98.5	100.0	73.7	−82.2	−100.0
. . .	−100.0	−41.6	−98.2	. . .
81.0	99.7	−32.0	−96.1	−100.0
. . .	100.0	7.0	−99.6	−100.0
100.0	99.8	22.7	−59.9	−100.0
99.8	100.0	100.0	−26.6	−98.3
99.9	100.0	99.7	12.3	21.7
98.7	100.0	97.7	−24.5	−7.7
99.9	100.0	88.7	2.2	55.8
100.0	100.0	99.9	43.3	87.7
100.0	100.0	98.0	56.5	91.3
99.7	99.5	98.0	15.5	58.9
95.4	96.2	87.1	−26.2	43.1

Table 46 *(continued)*

Country or area	Period	Trade partner: World	Developing countries: Africa	Developing countries: Latin America	Developing countries: Western Asia	Developing countries: Other Asia	Developed market economies	Centrally planned economies
United States	1970-1971	44.2	100.0	98.1	100.0	97.0	33.0	67.9
	1978-1979	−18.5	99.7	93.9	99.9	59.1	−40.3	1.3
Venezuela	1970-1971	−99.1	. . .	−93.9	. . .	−100.0	−99.1	−100.0
	1978-1979	−99.2	. . .	−98.4	−100.0	−100.0	−99.2	−100.0
Yugoslavia	1970-1971	−59.6	100.0	100.0	100.0	12.5	−69.4	−42.4
	1978-1979	−58.3	100.0	100.0	99.6	49.5	−91.0	−2.6
Developing countries and areas other than those listed above, unweighted averages	1970-1971[c]	−96.0	73.6[e]	55.2[e]	−9.4[e]	−90.3[e]	−99.5[e]	−100.0[e]
	1978-1979[d]	−95.6	60.5[e]	−48.2[e]	2.4[e]	−80.2[e]	−98.4[e]	−100.0[e]

Source: Based on data supplied by the Statistical Office of the United Nations Secretariat.

[a] In symbols, $100(X_i - M_i)/(X_i + M_i)$, where X_i and M_i are respectively the exports and imports of metalworking machine tools of country i.

[b] All figures are unweighted annual averages.

[c] Unweighted averages among 20 countries.

[d] Unweighted averages among 38 countries.

[e] The countries for which neither exports nor imports were reported were excluded from the calculations of unweighted averages.

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