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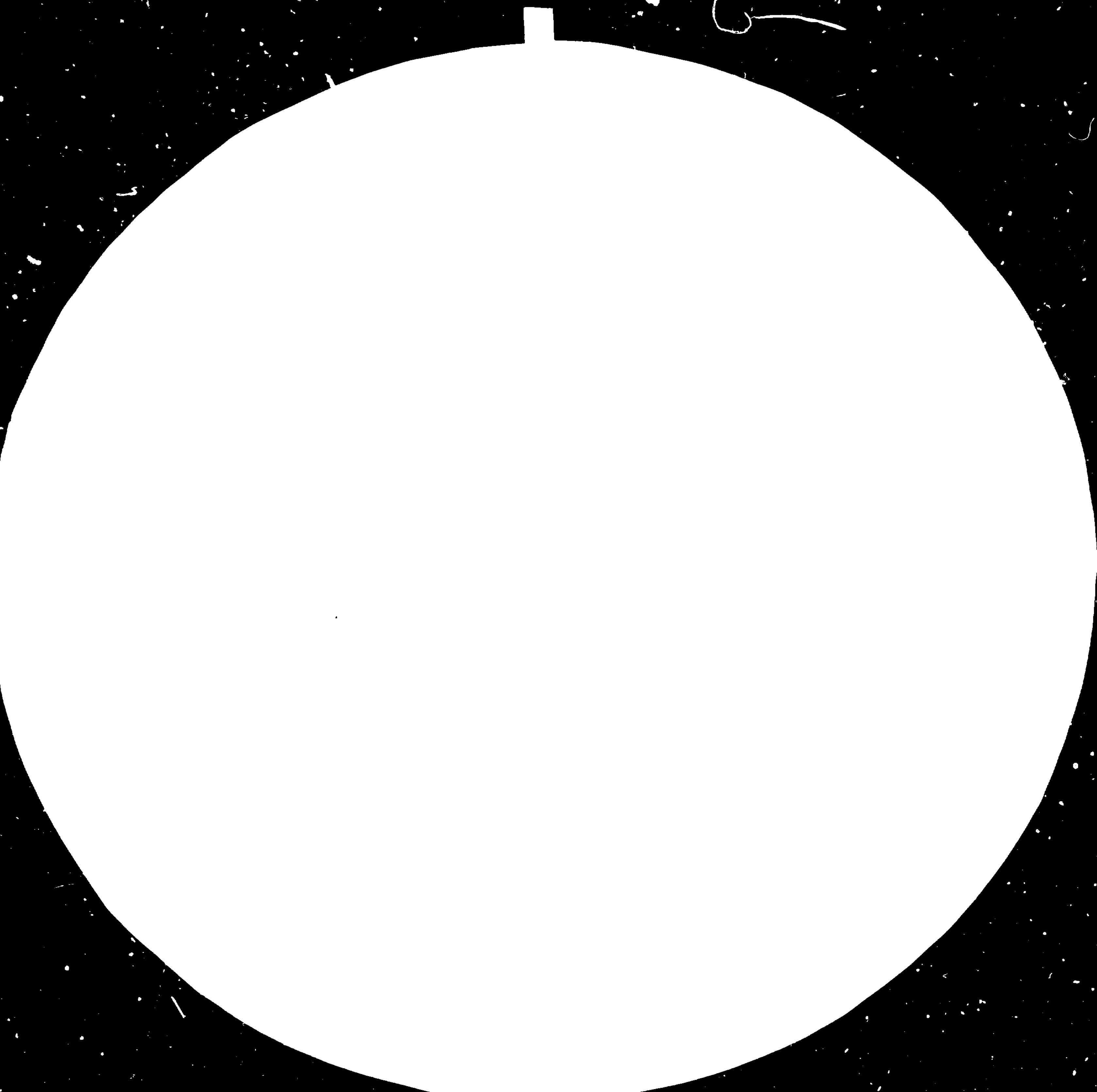
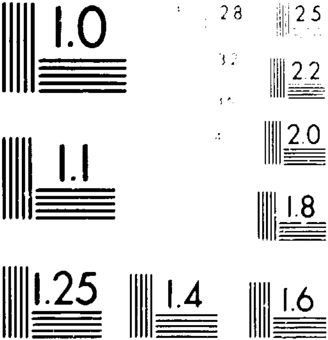
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org





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WORLD DEMAND FOR PETROCHEMICAL PRODUCTS AND THE EMERGENCE OF NEW PRODUCERS FROM THE HYDROCARBON RICH DEVELOPING COUNTRIES

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This document presents major results of work under the element Studies on Petrochemical Industries in UNIDO's programme of Industrial Studies 1982/83.

This paper was prepared by Econometric Research Ltd., Burlington, Ontario, Canada as consultants to UNIDO. The views expressed do not necessarily reflect the views of the UNIDO secretariat.

Preface

This study represents part of a larger study which was especially prepared by the Sectoral Studies Branch, Division for Industrial Studies, for the Arab Industrial Development Organization, entitled "World demand for petrochemical products and the Arab petrochemical industry". In view of the major changes in world economic performance and the development of nominal oil prices since the last forecast for demand and supply of petrochemical products made by UNIDO in 1981, it was felt necessary to produce this forecast independently.

The forecast in this study makes use of the UNITAD Model (UNIDO-UNCTAD world economic model). The regional demands for 24 petrochemical products relate to the UNITAD model, in the sense that endogenous variables of the UNITAD model are the exogenous variables of the petrochemical model contained in this study.

This study was prepared by Economic Research Ltd, Burlington, Ontario, Canada as consultants to UNIDO.

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1. Introduction

1.1 Moving down-stream

Were oil and gas resources everlasting and renewable, the citizens of the oil-producing states would be entitled to a perpetual rent accruing from these resources, and economic diversification would not be a critical consideration. However, oil and gas supplies are finite and non-renewable. At recent rates of utilization, oil will run out in many of the oil-producing developing countries in the lifetime of the present generation, or in a few cases in that of its children or of its grandchildren. Before 1973 exploration, production and utilization of oil were determined by major consumer countries in the industrialized world. The price of oil was low and the pattern of ownership was such that little capital was generated to affect industrial restructuring and further processing of these hydrocarbon resources.

The accumulation of large financial surpluses in the early 1970s, however, preceded any deliberate plan for their domestic absorption or investment abroad. There was no historical experience on which to base predictions of future growth in domestic absorption, and therefore no reason to question the economic rationality of a surplus of the magnitude realized. However, oil producers are no longer oblivious to the risk of accumulating fixed-income-yielding assets in an inflationary and uncertain world. They are, therefore, no longer satisfied with a role as residual suppliers of the world oil requirements. They are actually moving "down-stream" to create an advanced and integrated industrial base and to expand their sphere of control over the transportation, refining liquefaction, processing and marketing of their hydrocarbon resources and derivatives. Although building an industrial establishment based on oil and gas resources does not strictly diversify oil producers' economies, the increase in value added derived from the dwindling supplies of these resources, and the industrial experience gained from capitalizing on comparative advantage will have beneficial implications and will convey definite advantages to all other activities and sectors. It must be realized that despite dramatic increases in the national incomes of the oil producing countries as oil prices increased, the non-oil sectors of most of these economies remained relatively undeveloped. Standards of living in these countries have certainly risen, but essentially and primarily through a form of capital consumption, namely the depletion of oil and gas reserves.

1.2 Why petrochemicals?

Petroleum and gas have traditionally been used primarily for energy and this situation is not likely to change in the near or medium term. Therefore, it is to be expected that hydrocarbon resource prices will reflect primarily energy market developments. Petrochemical manufacture, which absorbs about 5 per cent of the world's oil supplies, is nonetheless a very important source of demand for hydrocarbon resources for many reasons. These include:

(a) Financial considerations

Whereas oil was selling for a little less than 10 cents a pound, petrochemicals and products derived from petrochemicals were selling for 24 to 66 cents or more a pound in 1981.1/ Furthermore, the high sale value of petrochemicals, exceeding $150 billion in 1980, is indicative, albeit indirectly, of a lucrative industry with a significant rate of return on investment2/. In the context of some oil-producing developing countries, it represents a decisively productive use of financial surpluses.

(b) Production sequences

Movements along the production chains to capture economies of scale and to benefit from technical linkages are important industrial considerations for countries concerned with deepening processing activities in their economies. The petrochemical industry is typical of industries with clearly demarcated

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1/ The exchange ratio of ethylene to oil in 1970 was as high as 5.3-6.8; by 1978, this ratio had fallen to 2.8-3.7. For HDPE this exchange ratio was as high as 21.8-27.8 in 1970 and about 5.8-6.9 in 1978. See ID/WG.336/3 and Add.1, Second World-wide Study on the Petrochemical Industry: Process of Restructuring, Vienna, 19 May, 1981, p. 87.

2/ Rates of return on investments in petrochemical production in the Arabian Gulf region are estimated to be about 28 per cent evaluated in 1979 prices. See GOIC, Petrochemical Industries in the Arabian Gulf Countries, Doha: November, 1980, p. 13.

production chains and processes. Although it is difficult to devise a simple system of classification to include all petrochemicals, it is customary to use three broad categories to identify these products, namely, basic, intermediate, and final products.

The main petrochemical basic products are the olefins (ethylene, propylene, butadiene), aromatics (benzene, toulene, xylenes) and methanol. Two primary processes are used in their production: steam cracking of naphtha for the olefins and catalytic reforming for the aromatics. A third process - steam reforming - is also used to synthesize ammonia and methanol. These products form the building blocks from which final petrochemical products are made. The dominant production chains from basic to final include ethylene and propylene as the main inputs in the making of plastics, aromatics in the making of synthetic fibres, butadiene and benzene in the production of rubber, and methanol (converted into formaldehyde) in the manufacture of adhesives.

The increased processing activity in the petrochemical industry raises automatically the value-added component derived from hydrocarbon resources. The larger the use of domestic resources in processing activity, the higher are the returns of these factors and therefore the higher the domestic value added contribution of this activity.

(c) Diversification considerations

Petrochemical manufacture is based on hydrocarbon resources and as such, it is difficult to see that it contributes to a diversified economic base in oil-based economies. The geographic pattern of markets for petrochemical products is, however, substantially different from those of oil and gas. The markets for oil and gas are highly concentrated in OECD countries. Alternatively, this is not likely to be the case for petrochemical products. Thus, an increase in the share of petrochemical products in oil-exporting countries carries with it the possibility of a reduction in the products as well as the market concentration ratios of their exports. Such diversification is important in reducing vulnerability to Western demand fluctuations and to variations in product cycles.

(d) Comparative advantage and learning by doing

The world petrochemical industry is characteristically migratory, technological, capital-intensive, resource-intensive, energy-intensive, scale-sensitive and dominated by Trans-National Corporations (TNCs).

Petrochemical production is scattered over roughly one thousand facilities throughout the world. The United States, Western Europe and Japan produce over 66 per cent of world petrochemical products; some years ago this figure was substantially higher. In the future it is expected to become substantially lower. The shift in regional output shares is a direct result of the nature of the product cycles that characterize petrochemical demands and of the substantial change in the relative prices of the inputs used to produce petrochemicals. On both of these counts--phase of the product cycle and the change of relative price of inputs--oil-based economies are in a privileged position to produce petrochemicals.

The product cycle theory of product demand is based on the premise that as a product matures, consumption increases rapidly after the initial introductory period and then slows down during product maturity; concurrently the number of producers increases rapidly and then also slows; also, the price declines, rapidly at first, but finally tending to level off in the mature stage. These price declines are due partly to the combination of decreased costs as a result of both economies of scale and operating experience, and to increased competition. It is to be noted that whereas consumption proceeds smoothly, capacity can only be augmented in large steps. During the early stages of the product life cycle, one country is the only producer--USA--and hence fills both local and foreign demand. While such exports often are attributed either to a "technological-gap" or "managerial-gap", in many cases they are simply explained by the time lag in commencing production in the importing country due primarily to a limited domestic market and/or to the inability of the importing country to capitalize on its domestic opportunities.

In 1963, US exports of styrene to Germany were negligible, but during 1964 and 1965 averaged $10 million yearly. After this time they dropped back to a negligible quantity as new capacity came onstream in Germany. The whole history of the world petrochemical industry is rife with examples of production migrating from one region to another primarily in response to development of domestic production capabilities or to changes in cost structures. The recent change in the importance of feedstock prices relative to capital costs of petrochemical production suggests that migration of this industry towards the resources is a natural and logical outcome of the workings of economic laws of production and location.

Oil- and gas-based petrochemicals accounted for about 50-70 per cent of total world petrochemical production in industrially developed economies in the 1970s. In 1972, 92 per cent of all organic chemicals in the European OECD countries, 95 per cent in the US and 96 per cent in Japan were produced from oil and gas[3/]. This heavy dependence on oil and gas was bascially in response to significant declines in the real prices of these inputs until 1970.

With the upward adjustment of oil prices in 1973, the decline in the 1960s of chemical prices was arrested and reversed. In 1974, the prices of internationally traded basic petrochemicals were three to four times higher than their 1970-72 levels, and by 1979-80, new peaks were realized. The major result of this dramatic rise in feedstock prices was the rise in the proportion of raw material costs in total production costs of petrochemicals. In the late 1970s, feedstock prices as a percentage of total production costs, accounted for 60-80 per cent in fertilizer production, 45-75 per cent in plastics, and more than 50 per cent in synthetic fibres[4/]. Raw material requirements are highest in the initial stages of manufacturing-- the production of intermediate products and monomers requires 2-4 tons of hydrocarbon raw material for every ton of production; in the final production phase, monomer consumption is no more than 1-1.5 tons per ton of plastic[5/].

Alternatively, the expansion of large-scale production and the higher optimal capacities of individual production facilities have resulted in a substantial lowering of current and capital expenditures per unit of production, in addition to lowering unit operating and management costs. For instance, in the 1960s, the increase in the capacity of ethylene plants from

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3/ L'Industrie Chimique, OECD, 1972, p. 27.
4/ UNIDO, op. cit., p. 88.
5/ Ibid, p. 89.

50,000 to 450,000 tons a year had the effect of reducing average capital costs from $220 to $90 per ton[6/]. Similarly, the increase in the size of an ammonia producing plant from 36,000 to 180,000 tons a year lowered unit capital costs by over 35 per cent[7/]. Examples like this abound.

The combination of a rise in feedstock prices and a decline in unit capital costs raised the efficiency of locating petrochemical plants near hydrocarbon resources. In addition to these factors, the energy-intensive nature of cracking and reforming imply for oil-based countries substantial comparative advantage in producing petrochemicals. Table 1 presents comparative cost conditions in the production of petrochemicals.

A number of pitfalls remain and require careful attention. Recall that, as a general principle, as a product matures, competition grows keener and the quality of the product becomes more standardized so that the ability to sell it becomes very sensitive to price. Under these circumstances, one would expect that any country with intrinsically lower production costs would become a major exporter. This has happened in electronics; South East Asian countries with lower labour costs, have become major exporters to industrialized nations. There is a decisive advantage to countries with lower raw material costs in the export of mature petrochemical products. It is also true that world trade is largest in these commoditities and thus the possibility of building a large, economically efficient state plant is high. This latter consideration is critical to prospective investor countries; it is important to ensure that the higher average fixed costs associated with capital do not wipe out the competitive advantage due to lower average variable costs associated with lower raw material costs.

Equally important to the investment decision is the consideration of products that are least vulnerable to technological obsolescence. Western nations, witnessing the erosion of their competitive edge in petrochemicals as raw material costs have risen and as capital costs have been declining, are

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6/ Ibid, p. 78.
7/ Ibid, p. 78.

TABLE 1.

ARAB GULF: COMPARATIVE ADVANTAGE IN PETROCHEMICAL PRODUCTS

(Production Cost Analysis) 1980

	Methanol (320,000 MTA from Natural Gas)		Ethylene (450,000 MTA from Ethane)		Ammonia (430,000 MTA from Natural Gas)	
	USA	GULF	USA	GULF	USA	GULF
Fuel/MMBTU	$ 4.00	$ 0.25	$ 4.00	$ 0.25	$ 4.00	$ 0.25
Location Factor	1.00	1.25	1.00	1.50	1.00	1.25
Production Cost (¢/kg)						
* Raw Materials	8.52	0.67	22.20	1.59	7.60	0.58
* Utilities	7.16	1.14	9.98	1.91	5.50	1.63
* Other Direct Costs	0.55	0.98	2.97	4.36	0.93	1.27
* Overheads and Taxes	0.62	0.76	2.62	3.29	0.84	1.06
* Depreciation	1.68	2.09	7.04	10.24	2.03	2.53
	18.53	5.64	38.64	20.73	16.90	7.07
% Energy & Feedstock	74%	16%	64%	8%	74%	11%

SOURCE: N. Dabdab and B. Mohyuddin, Oil-Based and Non-Oil Based Industrial Development in the Arab Gulf Region (Doha: GOIC, 1982), p. 11.

expected to capitalize on technical change and technological advances to offset the effects of higher raw material costs[8/]. This suggests that new producers from the developing countries should begin with mature standardized commodities but must also plan and implement massive research programmes. Teaming with multi-nations may not be sufficient, as TNCs are not generally known to sell newly-developed technologies. They do sell established technologies and these need to be purchased and improved upon.

Marketing considerations are also important and need to be examined carefully. Local markets could be developed, particularly as chains and sequences of production are exploited. Regional demands need to be identified and plans made to take advantage of geographical and cultural proximities at the earlier stages of production. Marketing partnerships with TNCs need to be complemented with regional partnerships and with a detailed South-South co-operative effort. There are already several examples of co-operation in this field and instances in which producers from developing countries have invested in complementary down-stream operations in other Third World countries. These activities may have to be expanded and enriched to present a credible marketing strategy[9/].

The emphasis on large size petrochemical plants stems in part from the need to capture economies of scale, thereby reducing the capital component of cost. It is equally important to emphasize the need to present a credible

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8/ For example, Dow Chemical has recently announced the development of a new ethylene production process, referred to as partial combustion cracking (PCC), in which ethylene can be produced directly from crude oil, in one step, or by using other feedstocks such as residual oil, gasoil or naphtha. See Chemical Engineering Progress, Vol. 79, No. 2, February, 1983, pp. 78-81

9/ There are today a number of joint venture projects in which Arab countries are teaming with other Third World governments to produce petrochemicals. Kuwait owns 40 per cent of the Turkish Mediterranean Petrochemical Company. The Kuwaiti Fund is financing a urea and ammonia complex in Sri Lanka. Saudi Arabia has a joint petrochemical venture with Pakistan and another is contemplated in India. The ASEAN group of countries is already committed to an ammonia/urea plant and is contemplating the establishment of petrochemical complexes. The same trend is apparent in Latin America--the Venezuela-Colombia Ammonia Project, etc.

strategy to persuade competitors of the seriousness of the new producers to occupy a substantial world niche in downstream industries, commensurate with their share in world oil production. The larger the committed volume of capital, the more credible is the prospect of their competitiveness, not only on account of the efficiency of these activities, but also because of the belief that they are likely to be willing to absorb substantial operating losses before allowing their huge fixed investment to go down the drain.

Thus credibility grows with size and size depends upon close co-operation. The credibility of new petrochemical producers will be eroded if each oil-producing country mounts a small-scale plant producing the same range of products that its neighbours are producing. There is a definite and serious need for coordination of investment which allocates specialization on a regional basis. Joint ventures are needed to avoid duplication.

Co-operation among petrochemical producers may take a number of forms. Joint ventures is only one such form of co-operation. Equally important are joint marketing strategies, joint bargaining with multi-nationals and the joint development of technology. Sub-geographical groupings may be formed as initial mechanisms of co-ordination, but the eventual articulation of a larger co-operative strategy remains critically needed to maintain the growth of the world market for petrochemical products.

Oil-producing countries embarking on building massive petrochemical complexes are also major importers from industrialized nations. This is an important pressing factor which may induce the industrialized countries to open their market to petrochemicals produced in the developing countries. The interdependent nature of trade relationships is a fact that the petrochemical producers could use to advantage collectively.

2. World demand for petrochemical products 1975-2000

2.1 Introduction

There exists now such a number of forecasts of future demand for and supply of petrochemical products, that for a new forecast to be made, some justification is required.

First, there have been some major changes in world economic performance that were not foreseen in the late 1970s and even in the early 1980s. The pace of world economic activity has slackened and the real price of oil has fallen. These are important variables in the determination of the future profiles of petrochemical demand and supply functions.

Second, few if any of the previous forecasts generated future values of the exogenous variables within the context of a large world model. The need for internationally consistent forecasts calls for such a construction.

Third, most of the previous forecasting exercises either have neglected production function relationships among products (we postulate a derived demand structure for most intermediate and basic products) and/or did not estimate demands for final products that correspond to consumer demand functions; that is, few if any of the previous forecasting exercises included own prices or prices of complementary or substitute products in the demand functions for final products.

Fourth, although many previous forecasts were made on the basis of econometric estimation of demand and supply equations, most of these specifications were suppressed and no explicit display of the estimated equations were published with the forecasting results.

In what follows we specify a set of regional demands for 24 petrochemical products that form an integral part of the UNITAD Model, in the sense that endogenous variables of the UNITAD Model become the exogenous variables of our petrochemical model. The recent world-wide contraction in economic activity and the recent stabilization of the nominal price of oil are built into the system forecasts. Moreover, a special effort is made to introduce prices into the equations estimated, and most equations estimated are reported in detail in the body of the study to display their statistical properties in terms of t-statistics, coefficients of multiple determination and standard errors of estimate. Most of these statistics are used to evaluate the goodness-of-fit of the hypothesized relationship estimated.

In order to obtain forecasts of regional petrochemical demand, by product, to the year 2000, a general model of regional demands for each of 24 petrochemical products was specified and estimated over the period 1974-1981. The estimates were then used to forecast demands for these products, at five year intervals starting with 1985, up to the year 2000. It is the purpose of the following sections to describe this exercise in detail.

2.2 The model

The basic structure of the model follows closely the basic structure of the petrochemical industry[10/]. Outputs of petrochemicals are classified into three product groups - basic, intermediate, and final - according to their positions in the flow of products. The production chains relevant to the 24 products considered in this study are depicted schematically in Figure 1. Each group will be considered in turn.

2.3 Basic products

In the case of basic products, it is assumed, for each region, that the demand for these products is a derived demand; that is, their demands are functions of the demands for the products in which they are utilized as inputs. Since the ultimate focus of this study centres on potential market opportunities for new producers from hydrocarbon rich developing countries, only basic products (and their derivatives) which are of interest to them are considered here; for this reason, few aromatics are included in the model, since most interests, at present, centre on methanol, ammonia, and the olefins.

10/ See, for example, a schematic diagram of the flow of product in UNIDO, Second Consultation on the Petrochemical Industry, Second World-wide Study on the Petrochemical Industry: Process of Restructuring, ID/WG.336/6, p.8

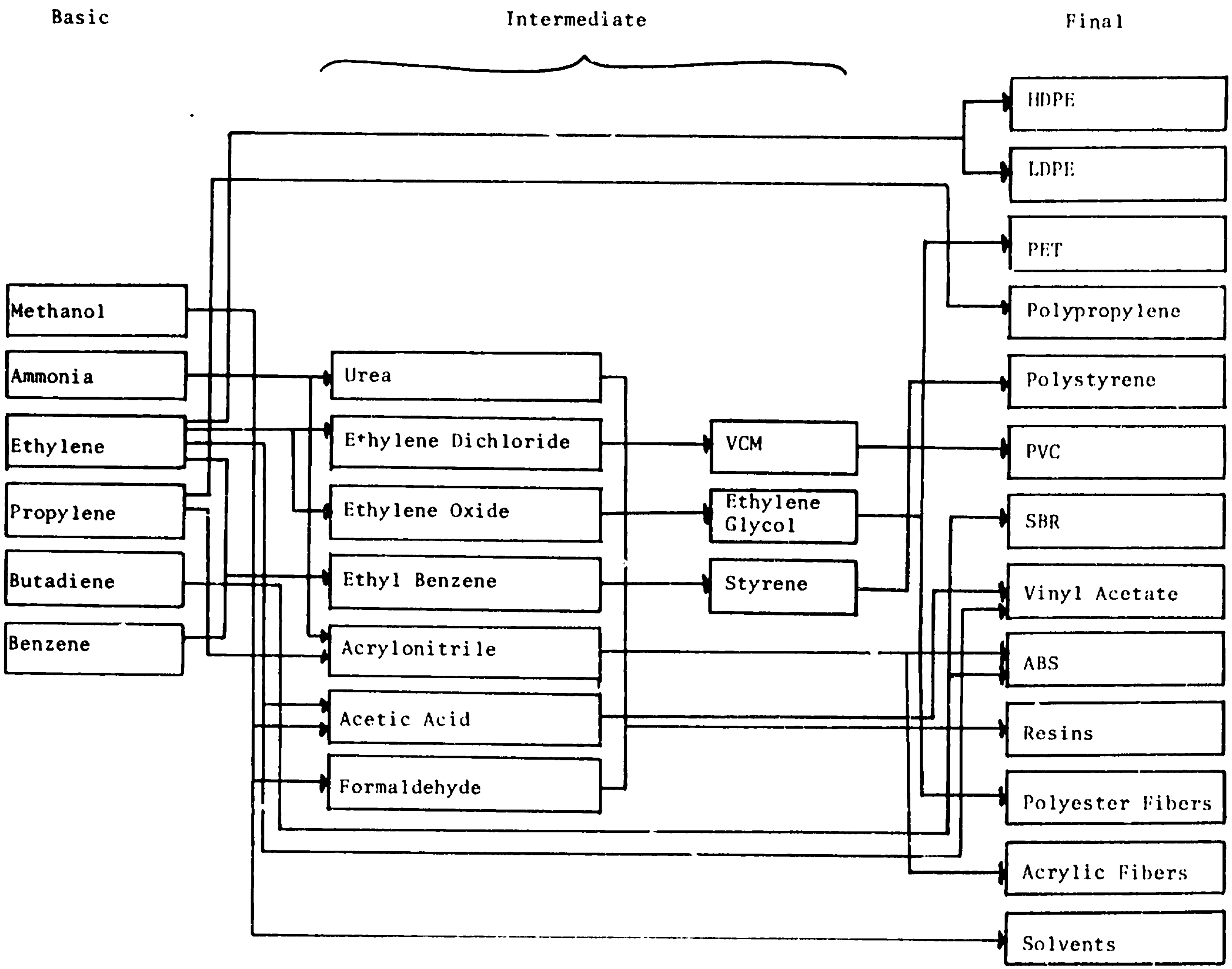
Basic
Intermediate
Final
Methanol
Ammonia
Ethylene
Propylene
Butadiene
Benzene
Urea
Ethylene Dichloride
Ethylene Oxide
Ethyl Benzene
Acrylonitrile
Acetic Acid
Formaldehyde
VCM
Ethylene Glycol
Styrene
HDPE
LDPE
PET
Polypropylene
Polystyrene
PVC
SBR
Vinyl Acetate
ABS
Resins
Polyester Fibers
Acrylic Fibers
Solvents

Figure 1

It is assumed here that the derived demand for each basic product, in each region, is directly proportional to the quantity demanded of one or more intermediate and/or final products in which the basic products is used; that is, the technology of each product is assumed to be of the Leontief type. Since each region may produce a different mix of intermediate and/or final products, and since technologies for the production of various intermediate and/or final products may differ from region to region, there is no reason to expect that the factor or proportionality between a given basic product and a derivative product will be uniform from region to region. Estimation of an equation for each basic product for each region permits these potentially important differences to be reflected in the forecasts.

On the basis of these considerations, the basic products are modelled as follows[11/]:

(1) Methanol $= \alpha_1$ Acetic Acid $+ \alpha_2$ Formaldehyde $+ \alpha_3$ Consumption $+ u_1$

(2) Ammonia $= a_1$(Urea) $+ a_2$(Acrylonitrile) $+ u_2$

(3) Ethylene $= \beta_1$(HDPE) $+ \beta_2$(LDPE) $+ \beta_3$(Ethylene Dichloride)
$+ \beta_4$(Ethylene Oxide) $+ \beta_5$(Vinyl Acetate) $+ u_3$

(4) Propylene $= b_1$(Polypropylene) $+ b_2$ (Acrylonitrile)
$+ b_3$(Value Added - Textiles) $+ u_4$

(5) Butadiene $= \gamma_1$(Acrylonitrile Butadiene Styrene)
$+ \gamma_2$(Polybutadiene Rubber)
$+ \gamma_3$(Styrene Butadiene Rubber) $+ u_5$

11/ The reader will note that not all variables specified in the model sections of this report are used in each and every regional equation for a given product. The model set out in this and two following sections (2.4 and 2.5) is the most general form of the regional model. In estimation, however, some of these variables may be dropped because of lack of significance, on a case by case basis. Thus only a subset of the indicated set of explanatory variables for a given equation may appear in the estimates reported in section 2.8 below.

This completes the description of the specification of the basic group of products in the model.

2.4 Intermediate products

The approach here parallels that for basic products. Two considerations are of particular interest. First, demand for intermediate products is also a derived demand, derived from the demands for final products (or higher-order intermediates) which the intermediates are used to produce. In the second place, a Leontief technology is also assumed to hold in the case of these products, for the same reasons indicated in the case of basic products. The equations for this group are:

(6) Vinyl Chloride Monomer = c_1(Polyvinyl Chloride) + u_6

(7) Ethylene Dichloride = δ_1(Vinyl Chloride Monomer) + u_7

(8) Ethylene Glycol = d_1(Polyethylene Terephthalate)
+ d_2(Value added - Textiles)
+ d_3(Consumption) + u_8

(9) Ethylene Oxide = ε_1(Ethylene Glycol + u_9

(10) Acrylonitrile = e_1(ABS) + e_2(Value Added - Textiles)
+ e_3(Consumption) + e_4(Value Added - Manufacturing)
+ u_{10}

(11) Styrene = ζ_1(Polystyrene) + ζ_2(ABS) + ζ_3(SBR) + u_{11}

(12) Ethylbenzene = f_1(Styrene) + u_{12}

(13) Acetic Acid = η_1(Vinyl Acetate) + u_{13}

2.5 Final Products

Whereas the demand equations for intermediate and basic products were based on a derived demand/fixed proportions technology argument only, the demand equations for final products are assumed to correspond to market demand curves too, aggregates of individual demand curves derived from utility maximization. The theory of the consumer is relevant here because demands for these products are only a step removed from the demands of consumers.

Income and relative prices, according to the theory, are the principal determinants of these demands. For each final product in turn, the appropriate income measure(s) is (are) determined through identification of the sectoral source of the final demand; for example, in the case of styrene butadiene rubber (SBR), a synthetic rubber which is used in tires, adhesives and carpets, the sources of these demands are mainly the construction and transportation sectors, and thus, value added figures for each of these sectors are used as the income measures in the SBR equation. The prices relevant for the final demand equation are those of the product and its principal substitute; in the SBR demand equation, for example, the relative price employed is the ratio of the price of SBR to the price of natural rubber[12/].

The final product equations are indicated below. A variety of functional forms are used in the estimation of these equations, since the final demand equations are less restrictive in form than the intermediate and basic product demands, and it is desired to select the "best", in a sense to be explained below, forecasting equation. Accordingly, these equations are specified in general notation.

(14) Urea = f(VA-agriculture, VA-construction, VA-manufacturing, P_{URE}, u_{14})

(15) HDPE = f(VA-construction, VA-manufacturing, GDP, P_{HDPE}, u_{15})

(16) LDPE = f(VA-manufacturing, VA-manufacturing, GDP, P_{LDPE}, u_{16})

12/ It should be noted that formaldehyde is treated as a final product, despite its formal classification as an intermediate. This is done because it is not possible to specify a final petrochemical product from which the bulk of the demand for formaldehyde is derived. Accordingly, the demand for formaldehyde is treated as a function of sectoral activity (income) levels and prices.

(17) PET - f(VA-light manufacturing, consumption, P_{PET}, u_{17})

(18) Polypropylene = f(VA-construction, VA-manufacturing, GDP, P_{PPR}, u_{18})

(19) Polystyrene = f(VA-manufacturing, VA-construction, consumption P_{PST}, u_{19})

(20) PVC = f(VA-construction, GDP, P_{PVC}, u_{20})

(21) SBR = f(VA-transportation, VA-construction, P_{SBR}, $P_{natural\ rubber}$, u_{21})

(22) Vinyl Acetate = f(VA-construction, GDP, P_{VAC}, u_{22})

(23) ABS = f(VA-contruction, GDP, F_{ABS}, u_{23})

(24) FOR = f(VA-manufacturing, VA-construcction, U_{24})

2.6 The commodity balance relationship

For each of the 24 basic, intermediate and final products it is desired to forecast domestic consumption by region. Available data record apparent consumption, which is equal to domestic production plus the value of the physical change in inventory. In order to measure apparent domestic consumption in this study, it is necessary to employ the following identity:

(25) DOMESTIC PRODUCTION + IMPORTS = APPARENT DOMESTIC CONSUMPTION + EXPORTS

from which apparent domestic consumption is calculated as

(26) APPARENT DOMESTIC CONSUMPTION = DOMESTIC PRODUCTION + IMPORTS - EXPORTS

Equation 26 was therefore used to determine apparent domestic consumption values for all petrochemical products; these were used as the dependent variables in the estimation of equations (1) through (24). It is worth noting here that apparent consumption differs from actual consumption, the difference being the value of inventory change. The smaller inventory changes are, the closer apparent consumption is to actual consumption. Furthermore, apparent consumption includes both final and intermediate demands for the product.

2.7 The independent variable

Below is a list of variables used in the estimation of the model for each region. In all cases, the variables, including the GDP and value added measures, are regional values, in constant 1975 US dollars, and estimation for a given region involves only that region's variables. Estimation is carried out for ten of the eleven UNITAD regions; only region 11, comprising the centrally planned economies of Asia, was excluded for lack of data. In the case of UNITAD region 7, South Saharan Africa, very little production and/or trade in petrochemicals takes place, and thus only two equations, for PET and polypropylene, are estimated. For all other regions, a form of the model appropriate to a given region was estimated; of course, where within a region there was no activity in a given product, no equation was estimated for that product.

List of variables

	Name	Symbol
1.	ABS	ABS
2.	Acetic Acid	ACT
3.	Acrylonitrile	ACN
4.	Ammonia	AMM
5.	Butadiene	BUT
6.	Ethyl Benzene	EBZ
7.	Ethylene	ETH
8.	Ethylene Dichloride	EDC
9.	Ethylene Glycol	EGL
10.	Ethylene Oxide	EOX
11.	Formaldehyde	FOR
12.	HDPE	HDP
13.	LDPE	LDP
14.	Methanol	MET
15.	PET	PET
16.	PVC	PVC
17.	Polypropylene	PPR
18.	Polystyrene	PST
19.	Propylene	PRO
20.	SBR	SBR
21.	Styrene	STY
22.	VCM	VCM
23.	Vinyl Acetate	VAC
24.	Urea	URE
25.	Consumption	CON
26.	GDP	GDP
27.	Value Added-Agriculture	VAG
28.	Value Added-Construction	VCN
29.	Value Added-Light Industry	VLI
30.	Value Added-Manufacturing	VMA
31.	Value Added-Transportation	VTN

2.8 The regression results

The regression results of the static regional demand functions for 23 petrochemical products are presented in Tables 2 - 10 (urea was excluded for lack of data) with each table devoted to one region.

Under each coefficient in the tables is its t-statistic in parentheses. The overall goodness-of-fit of the equation to data is measured by the coefficient of multiple determination (R^2) and the standard error of estimate of the regression.

For each product, a number of forms of the equation were estimated; presented in the tables are the preferred estimates. They are preferred in the sense that the signs of the coefficients are as expected *a priori*, the t-statistics are significant, R^2 is the highest and the SEE lowest in each class.

The emphasis on the standard error of estimate of the regression (SEE) is predicated on the general observation that the SEE is a reasonable basis for comparing a nested set of linear regressions, all of which imply the same dependent variable; so long as units of measurement are the same for all variables, a smaller SEE, which is of course corrected for degrees of freedom, indicates a smaller degree of residual ignorance than a larger SEE.

An alternative criterion for selecting the preferred equation, and one with more statistical rigour, simply runs in terms of tests of significance. Consider the following four equations, each of the last three is nested in the first equation:

(1) $Y_i = a_0 + a_1X_1 + a_2X_2 + u_1$

(2) $Y_i = b_0 + b_1X_1 + u_2$

(3) $Y_i = c_1X_1 + c_2X_2 + u_3$

(4) $Y_i = c_1X_1 + u_4$

Since the first equation can properly be viewed as an 'unrestricted' regression, and each of the remaining equations as a restricted regression relative to the first equation, the following tests are indicated:

Equations 1 and 2: a test of $H_0 : a_2 = 0$, against the alternative $H_a : a_2 = 0$. This is just a t-test.

Equations 1 and 3: a test of $H_0 : a_0 = 0$, against the alternative $H_a : a_0 = 0$. Again, a simple t-test.

Equations 1 and 4: a test of the composite hypothesis $H_0 : a_0 = 0$ and $a_2 = 0$, against the alternative hypothesis $H_a : a_0 = 0$ and/or $a_2 = 0$. This is a straightforward F-test.

We turn to a detailed consideration of the regional results.

2.8.1 Estimates of the North American petrochemical demand functions

Table 2 present estimates of the linear demand functions for 23 petrochemical products for Canada and the United States for the period 1974-1981. The results are generally satisfactory according to all statistical criteria, although, of course, some estimates are better than others. The R^2 are high, in most cases rising above 95 per cent for HDP and PPR. Of course, when the regression is forced through the origin (the constant is set to zero), the R^2 statistic is no longer meaningful.13/

In evaluating the goodness-of-fit of the equations over the historical period of the estimates, the reader may find it useful to compare average error sizes with average values of the dependent variable, and for this purpose, the average percentage error, (A.P.E.), defined as the ratio of the estimated average error of the regression (SEE) to the mean value of the dependent variable, is provided for each equation. Values of 0.1 or less for this measure are taken as satisfactory.

13/ One could in principle define a squared correlation coefficient between the actual and predicted values of the dependent variable for a regression forced through the origin, and call this the R^2. However, the usual computer algorithm for computing the R^2 does not do this calculation correctly.

Table 2: Regression Results of Petrochemical Demand Functions
North America 1974-1981

DEPENDENT VARIABLES \ INDEPENDENT VARIABLES					R^2	SEE	APE
ABS	CONSTANT -676.74 (-1.85)	CON .000387 (1.89)	VCN .00786 (2.63)		.66	54.7	.12
POR	CONSTANT -226.39 (-.22)	GDP .00160 (2.97)			.59	223.9	.08
HDP	CONSTANT -3382.77 (-9.15)	GDP .00265 (13.66)			.96	80.89	.04
LDP	CONSTANT -1721.93 (-2.08)	GDP .00247 (5.70)			.84	180.5	.06
PET	CONSTANT 90.52 (.26)	GDP .00121 (4.22)			.74	76.97	.05
PVC	CONSTANT -1582.56 (-1.78)	GDP .00207 (4.45)			.76	193.90	.08
PPR	CONSTANT -2008.5 (-6.50)	GDP .0071 (10.55)			.95	67.55	.05
PST	CONSTANT -1620.12 (-2.16)	CON .00176 (4.18)	VCN .00132 (2.15)		.81	112.18	.07
SBR	CONSTANT 288.708 (.48)	VCN .0172 (2.45)			.50	128.73	.07
VAC	CONSTANT 268.08 (1.86)	GDP .00017 (2.31)			.47	31.43	.05
EDC	VCM 2.08145 (116.733)					131.98	.02
EGL	PET .02716 (.04)	CON .00143 (1.32)	VMA .00214 (.17)			133.43	.07
EOX	EGL 1.235 (54.28)					120.25	.05
ACN	ABS .596 (3.48)	CON .000158 (1.22)	VMA .000407 (1.35)			32.36	.05
STY	PST 1.610 (18.55)	SBR .0547 (.68)				47.89	.02
EBZ	STY 1.382 (73.54)					144.14	.04
ACT	VAC 2.147 (30.08)					121.44	.09
AMM	ACN 29.478 (15.81)					3170	.16
ETH	EDC .3912 (.99)	EOX 2.155 (9.87)	HDP 1.050 (3.58)	LDP 1.192 (1.81)		11.04	.009
BUT	ABS .6337 (.92)	SBR .8752 (4.84)				99.29	.05
MET	ACT 2.189 (2.94)	CON .000264 (.33)				167.39	.05
PRO	PPR 2.201 (5.85)	ACN 4.311 (3.37)	CON .000376 (.55)			169.60	.03

All of the A.P.E. values for the North American equations are less than 0.10 except for ABS at 0.12. The t-statistics are also invariably high; however, given the high degree of multicollinearity among the explanatory variables, it is difficult in some cases to reach clear decisions as to the statistical significance of each separate variable. This, however, is not vital for forecasting purposes.

It is interesting to note that in linear regressions of the type used here, a negative constant is often indicative of a rising average relation between the dependent and the independent variables. For example, the HDP equation, with a statistically significant negative constant, suggests, that the ratio of HDP to GDP in North America is expected to be higher as GDP increases.

2.8.2 Estimates of the demand for petrochemical production in Western Europe

Table 3 is devoted to the regression results of the demand for petrochemical products in Western Europe. Again, as is the case for North America, the R^2 values are generally high for most of the equations, the t-statistics for most of the variables are statistically significant, and the A.P.E. is satisfactory (except for the FOR equation). These summary statistics indicate an acceptable fit for almost all of the equations.

With the exception of only SBR and PVC, a rise in GDP is generally associated with a higher average relationship between petrochemical demand and GDP. (This is on account of significant and negative constants).

The equations in which the constant is suppressed are technical production functions (of the Leontief type). The coefficients are input-output coefficients. Preference for these equations over those with constants was judged using the t-statistics and SEEs.

2.8.3 Estimates of the demand for petrochemical production in Eastern Europe

The regression results for Eastern Europe are generally satisfactory. The R^2 values of most relevant equations are relatively high, and

Table 3. : Regression Results of Petrochemical Demand Functions
Western Europe: 1974-1981

DEPENDENT VARIABLES \ INDEPENDENT VARIABLES				R^2	SEE	APE
ABS	CONSTANT -488.0 (-4.73)	GDP .000339 (7.52)		.90	19.95	.07
FOR	CONSTANT -21224.6 (-4.61)	GDP .01035 (5.13)		.81	891.4	.38
HDP	CONSTANT -964.038 (-1.92)	GDP .000987 (4.49)		.77	97.07	.07
LDP	CONSTANT -1090.61 (-.95)	GDP .002101 (4.17)		.74	222.45	.06
PET	CONSTANT -40.185 (-.140)	GDP .000325 (2.59)		.53	55.51	.08
PVC	CONSTANT 194.401 (.14)	GDP .001506 (2.51)		.51	265.34	.07
PPR	CONSTANT -2954.10 (-5.18)	GDP .001748 (7.0)		.89	110.28	.11
PST	CONSTANT -73.063 (-.118)	GDP .000727 (2.68)		.54	119.75	.07
SBR	CONSTANT 703.305 (2.03)	GDP .000194 (1.28)		.21	66.92	.06
VAC	CONSTANT -278.84 (-2.14)	GDP .000323 (5.74)		.86	22.2	.05
VCM	PVC 1.1078 (82.38)				138.29	.03
EDC	VCM 1.51 (62.20)				277.71	.04
EGL	PET .8574 (3.58)	WRL .000158 (.63)			53.88	.07
EOX	EGL 1.828 (38.22)				94.31	.07
ACN	ABS 1.464 (2.82)	CON .000353 (3.21)			55.94	.06
STY	ABS 2.491 (2.04)	PST .636 (.94)	SBR .683 (.98)		87.83	.03
EBZ	STY 1.103 (73.19)				107.14	.04
ACT	VAC 1.768 (394.06)				3.20	.003
AMN	ACN 13.76 (31.42)				1128.2	.09
ETH	EDC 1.705 (37.12)	VAC .06628 (.10)			272.69	.03
BUT	ABS 1.664 (3.69)	SBR .533 (4.66)			60.52	.05
MET	FOR .0637 (1.35)	CON .00206 (20.36)			219.67	.07
PRO	PPR .619 (2.86)	ACN 4.753 (8.47)	CON .000413 (1.45)		81.82	.01

Table 4: Regression Results of Petrochemical Demand Function
Eastern Europe: 1974-1981

DEPENDENT VARIABLES \ INDEPENDENT VARIABLES				R^2	SEE	APE
POR	CONSTANT -284.5 (-1.09)	GDP .000788 (2.44)		.54	48.16	.13
HDP	CONSTANT -713.21 (-4.13)	GDP .001036 (4.83)		.82	32.0	.26
LDP	CONSTANT -1317.84 (-3.36)	GDP .00276 (5.67)		.86	72.75	.08
PET	CONSTANT -618.709 (-19.83)	GDP .001188 (30.64)		.99	5.79	.02
PVC	CONSTANT -1157.48 (-6.68)	GDP .00234 (10.86)		.95	32.14	.04
PPR	CONSTANT -396.772 (-10.92)	GDP .000639 (14.17)		.97	6.74	.06
PST	CONSTANT -366.91 (-2.78)	GDP .000881 (5.38)		.85	24.45	.07
SBR	CONSTANT -113.616 (-.48)	GDP .00125 (4.29)		.78	43.53	.05
VCM	PVC 1.417 (42.05)				65.38	.06
EDC	VCM .2564 (24.54)				28.78	.09
EGL	PET .09914 (19.97)				4.48	.13
EOX	EGL 2.192 (20.12)				9.83	.01
ACN	GDP .000082 (11.48)				15.13	.02
STY	PST 1.268 (4.11)	SBR .09256 (.78)			21.38	.04
EBZ	STY 1.036 (411.89)				3.46	.006
AMN	ACN 251.425 (12.75)				350.25	.20
ETN	EDC .858 (2.67)	HDP 1.231 (6.59)	LDP .269 (3.09)		20.90	.03
BUT	SBR .0926 (5.87)				37.36	.04
MET	GDP .00276 (41.42)				141.8	.06
PRO	ACN 3.327 (7.78)				75.96	.04

particularly those for PET, PVC, and PPR; the average percentage error for most equations is adequate, being very small for EOX and EBZ, but relatively high for AMM, EGL and FOR.

The GDP variable is significant in all equations in which it is an explanatory variable. The negative constants in the relevant variables are indicative of rising average relationships of petrochemical consumption of GDP.

Suppression of the constant term, which implies a Leontief production relationship, proved reasonable, as lower SEEs were invariably associated with this equation form.

Since all variables, both dependent and independent, are measured in thousands of tons, an equation such as that of ECX is simply a statement that 2.1 tons of EOX are needed to produce 1 ton of EGC in Eastern Europe.

2.8.4 Estimates of the demand for petrochemical products in Japan

Regression results for Japanese demand for petrochemicals are presented in Table 5. It is clear from the results that most of the estimated equations fit well. The only two exceptions are LDP and VAC (and possibly PPR and ACT).

Given the fact that data on Japan were easily obtainable, the explanatory variables in the equations in Table 5 are more specific and detailed than for most other regions. Value added in manufacturing is a significant variable determining the demand for FOR, value added in construction is significant in the demand equation for HDP, general consumption is highly significant in the demand equation for PET, construction is again, as expected, very significant in the demand equation for PVC (pipes), and in the demands for PPR, PST and VAC.

It is interesting to note that unlike North America, Western Europe and even Eastern Europe, growth in Japanese economic activity is not generally associated with higher average utilization rates of petrochemical products.

Table 5: Regression Results of Petrochemical Demand Function
Japan: 1974-1981

DEPENDENT VARIABLES \ INDEPENDENT VARIABLES						R^2	SEE	APE
	CONSTANT	GDP						
ABS	-208.617	.000745				.82	17.49	.08
	(-2.44)	(4.79)						
	CONSTANT	VMA						
POR	447.72	.003173				.65	76.59	.07
	(2.43)	(3.06)						
	CONSTANT	VCM	VMA					
HDP	-116.669	.00737	.000728			.87	59.01	.13
	(-.76)	(2.90)	(.582)					
	CONSTANT	GDP						
LDP	171.76	.00108				.11	154.66	.20
	(.227)	(.788)						
	CONSTANT	CON						
PET	-782.042	.00388				.91	30.28	.07
	(-4.86)	(7.42)						
	CONSTANT	VCM						
PVC	465.096	.01325				.84	93.28	.07
	(3.19)	(5.21)						
	CONSTANT	VCM						
PPR	75.163	.01055				.68	117.58	.17
	(.41)	(3.29)						
	CONSTANT	VCM	VMA					
PST	31.836	.00384	.0016			.96	23.49	.04
	(.52)	(3.80)	(3.29)					
	CONSTANT	CON	VCM					
SBR	-259.399	.00212	.000594			.91	22.82	.05
	(-1.47)	(2.86)	(.506)					
	CONSTANT	VCM						
VAC	296.439	.00207				.38	43.47	.10
	(4.36)	(1.75)						
	PVC							
VCM	1.154						89.41	.06
	(44.24)							
	VCM							
EDC	1.713						126.73	.05
	(53.58)							
	PET	CON	VMA					
EGL	.0355	.000753	.000801				26.78	.06
	(.137)	(2.04)	(.86)					
	EGL							
EOX	1.3415						64.84	.11
	(23.68)							
	ABS	CON	VMA					
ACN	.7799	.00214	.00161				40.24	.07
	(.85)	(3.92)	(-1.31)					
	ABS	PST	SBR					
STY	2.2899`	.0679	1.31				24.70	.02
	(3.34)	(.23)	(3.82)					
	STY							
BZ	1.127						92.06	.07
	(37.86)							
	VAC							
ACT	1.0636						99.96	.22
	(11.67)							
	EDC	EOX	VAC	HDP	LDP			
ETH	2.237	1.120	1.996	-3.266	-1.723		237.73	.06
	(3.30)	(.82)	(.61)	(-2.51)	(-1.10)			
	ABS	SBR						
BUT	.2164	1.2321					47.85	.08
	(.19)	(2.32)						
	ACT	POR	CON					
MET	.124	1.522	.00201				44.40	.04
	PPR	ACN	CON					
PRO	1.01757	1.2630	.00375				128.48	.05
	(3.08)	(.93)	(1.51)					

2.8.5 Estimates of the demand for petrochemical products in other industrialized countries

Table 6 presents the estimation results of 24 petrochemical product demand functions in other industrialized countries. The equations are generally good according to our criteria; however, some product demand functions are not particularly good fits of the data when judged by their A.P.A. values; otherwise, the equations are all acceptable.

The GDP variable is in most final demand equations and appears to be statistically significant in the majority of these equations. The constant term in these equations (i.e., those that include GDP) is invariably negative, indicating again a rising average propensity to consume these petrochemical products.

The R^2 is quite high for all relevant equations except that of ABS, which seems to be generally an unstable relationship across regions. The production relationship linking EDC to VCM appears to be weak; the average percentage error is 45 per cent and that is quite high. Actually, the same is true for EGL, EOX, ACN, EBZ, AMM and ACT. One common factor in all these equations is that they are presumably production functions. Since this region is not noted for producing much of these products, the production hypothesis that held well in the industrialized OECD countries, is not as valid or adequate in these countries. Tested, however, against the hypothesis of other explanatory variables, these equations held well suggesting that there is a constant implicit relationship between consumption and trade in these products even when they are not produced domestically.

2.8.6 Estimates of the demand for petrochemical products in Latin America

Table 7 presents the regression estimates of demand for petrochemical products in Latin America.

The statistical properties of the Latin American petrochemical demands are exceptionally good. The R^2 values are very high for all the relevant equations, the t-statistics are all significant at the 5 per cent level of

Table 6: Regression Results of Petrochemical Demand Function
Other Developed Countries: 1974-1981

DEPENDENT VARIABLES \ INDEPENDENT VARIABLES				R^2	SEE	APE
	CONSTANT	GDP				
ABS	-11.1361	.000178		.39	1.66	.12
	(-.83)	(1.80)				
	CONSTANT	GDP				
POR	-121.28	.00153		.88	4.19	.04
	(-3.60)	(6.16)				
	CONSTANT	GDP				
MDP	-268.362	.00271		.93	5.46	.05
	(-6.13)	(8.36)				
	CONSTANT	GDP				
LDP	-348.138	.00406		.85	12.71	.06
	(-3.42)	(5.38)				
	CONSTANT	GDP				
PET	-45.716	.00705		.60	4.34	.08
	(-1.31)	(2.74)				
	CONSTANT	GDP				
PVC	-360.433	.00416		.70	20.46	.10
	(-2.19)	(3.42)				
	CONSTANT	GDP				
PPR	-292.064	.00268		.93	5.36	.07
	(-4.79)	(8.42)				
	CONSTANT	GDP				
PST	-104.237	.001149		.81	4.20	.08
	(-3.09)	(4.61)				
	GDP					
SBR	.00302				5.11	.12
	(21.08)					
	GDP					
VAC	.000097				1.28	.09
	PVC					
VCM	.8596				27.87	.15
	(18.73)					
	VCM					
EDC	.7566				70.74	.45
	(5.64)					
	PET					
EGL	.3507				8.67	.51
	(5.32)					
	EGL					
EOX	1.033				8.93	.39
	(6.65)					
	ABS					
ACN	.2466				.84	.26
	(10.08)					
	ABS	PST	SBR			
STY	3.5558	1.385	-.6754		4.53	.05
	(2.01)	(3.96)	(-2.49)			
	STY					
EBZ	.9981				29.10	.33
	(9.04)					
	VAC					
ACT	1.2286				2.5	.15
	(18.64)					
	ACN					
AMN	284.34				296.3	.30
	(8.36)					
	EDC	EOX	LDP			
ETH	.1075	14.47	.2110		10.83	.03
	(.69)	(3.07)	(.49)			
	ABS	SBR				
BUT	3.123	.329			5.24	.09
	(3.35)	(1.08)				
	POR					
MET	.543				1.80	.04
	(68.64)					
	PPR	GDP				
PRO	1.074	.000273			6.17	.06
	(6.57)	(2.61)				

Table 7: Regression Results of Petrochemical Demand Functions
Latin America: 1974-1981

DEPENDENT VARIABLES \ INDEPENDENT VARIABLES					R^2	SEE	APE
ABS	CONSTANT -44.549 (-6.43)	GDP .000176 (9.94)			.95	2.05	.08
FOR	CONSTANT -203.667 (-4.08)	GDP .00124 (9.69)			.95	14.82	.05
HDP	CONSTANT -418.53 (-5.95)	GDP .00162 (8.98)			.94	20.87	.09
LDP	CONSTANT -600.069 (-3.33)	GDP .00309 (6.71)			.90	53.66	.08
PET	CONSTANT -170.34 (-4.96)	GDP .00115 (13.09)			.97	10.19	.03
PVC	CONSTANT -474.668 (-2.90)	GDP .00242 (5.78)			.87	48.45	.10
PPR	CONSTANT -376.519 (-4.86)	GDP .00137 (6.93)			.90	22.98	.14
PST	CONSTANT -284.58 (-3.82)	GDP .00128 (6.72)			.90	22.08	.10
SBR	CONSTANT 11.047 (.16)	GDP .000723 (4.07)			.77	20.50	.07
VAC	CONSTANT -80.4517 (-10.69)	GDP .0042 (19.57)			.98	2.48	.03
VCM	PVC .8317 (22.98)					50.14	.12
EDC	VCM .9726 (21.42)					52.68	.13
EGL	PET .4049 (37.15)					8.11	.07
EOX	EGL .9948 (11.85)					27.94	.25
ACN	ABS 4.021 (36.27)					7.37	.07
STY	ABS 1.8516 (.91)	PST 1.1895 (5.06)				14.66	.04
EBZ	STY .7710 (38.54)					17.92	.07
ACT	VAC 1.416 (30.11)					10.45	.09
AMM	ACN 32.230 (12.59)					685.98	.20
ETH	EDC .4025	EOX 2.197	HDP 1.598	VAC 1.540		25.81	.03
BUT	ABS 1.3390 (2.90)	SBR .6053 (14.86)				6.94	.03
MET	ACT 1.213 (.93)	FOR .4157 (.86)				34.32	.14
PRO	PPR 1.9105 (1.77)	ACN 1.3658 (.75)				40.88	.09

significance, the signs on all the coefficients are consistent with *a priori* economic and technical restrictions, and the A.P.E. values are reasonable (the A.P.E.s associated with AMM and EOX are the only exceptions).

Most of the constants are negative; only that in the SBR equation is positive. This fact suggests that in Latin America, over the sample period, the average propensity to consume petrochemical products was rising.

The GDP variable is highly significant in explaining all the demands in which it is an explanatory variable; it is particularly significant in explaining VAC, PET, HDP, FOR and ABS demands. The production function relationships are not as good statistically as those of final products. This again may be a reflection of the fact that integrated production is not a characteristic of the region. As such, these equations may very well explain import demands.

2.8.7 Estimates of the demand for petrochemical products in North Africa and the Middle East

The regression estimates of petrochemical demand functions for North Africa and the Middle East (Arab region) for the period 1974-1981 are presented in Table 8.

The statistical properties of most equations are relatively good. The R^2 values are relatively high, the signs on the coefficients are consistent with *a priori* restrictions, and the t-statistics are all significant at the 5 per cent level of significance; the A.P.E. values for several equations are, however, rather high.[14/]

The GDP variable enters most of the final demand equations as a proxy for economic activity levels. The fact that we did not have much data on sectoral value added in constant 1975 US dollars for this region precluded their inclusion in the explanatory variable set.

14/ This is to be expected when variables are forecasted with small magnitudes and when the independent variables are too general.

Table 8: Regression Results of Petrochemical Demand Functions
North Africa & Middle East: 1974-1981

DEPENDENT VARIABLE \ INDEPENDENT VARIABLES				R^2	SEE	APE
	GDP					
ABS	.000027				5.45	.97
	(2.58)					
	CONSTANT	GDP				
FOR	-137.356	.000975		.94	5.45	.11
	(-6.48)	(8.84)				
	CONSTANT	GDP				
HDP	-235.588	.00155		.83	15.58	.25
	(-3.89)	(4.93)				
	CONSTANT	GDP				
LDP	-338.JS	.00235		.76	29.25	.25
	(-2.98)	(3.99)				
	CONSTANT	GDP				
PET	-9.876	.000172		.67	2.46	.10
	(-.84)	(2.88)				
	CONSTANT	GDP				
PVC	-343.407	.00216		.76	26.64	.38
	(-3.32)	(4.01)				
	CONSTANT	GDP				
PPR	-63.943	.000423		.98	.82	.04
	(-10.64)	(14.20)				
	CONSTANT	GDP				
PST	-92.98	.000594		.79	6.81	.33
	(-3.52)	(4.32)				
	CONSTANT	GDP				
SBR	-35.292	.000218		.87	1.85	.28
	(-4.92)	(5.84)				
	CONSTANT	GDP				
VAC	-16.2986	.000154		.87	1.32	.10
	(-3.17)	(5.75)				
	PVC					
VCM	.2405				25.45	.79
	(2.44)					
	VCM					
EDC	1.728				8.15	.14
	(17.84)					
	PET					
EGL	.1770				.82	.16
	(12.34)					
	VAC					
ACT	1.1289				11.29	.61
	(4.19)					
	EDC	LDP	VAC			
ETH	.55199	.1207	.98362		8.88	.14
	(4.86)	(1.33)	(1.10)			
	ACT	FOR				
MET	.7269	.4466			11.81	.32
	(.92)	(1.40)				
	GDP					
PRO	.000056				6.78	.59
	(4.19)					

Most of the constants in the relevant demand equations for final products are negative suggesting, here as in other regions, that the average propensity to consume petrochemical products in the Arab region between 1974 and 1981 has been rising and that these products are likely to constitute a rising proportion of GDP over time.

The hypothesized production technology that is presumed to govern the relationship of basic and intermediate petrochemical products to other intermediate and final products is, as expected, not as adequate statistically as in some of the major producing areas of the OECD countries. With the increase in production capacity of basic and other products, these relationships will most likely become more stable over time.

2.8.8 Estimates of the demand for petrochemical products in South Asia

Table 9 presents the regression results of estimating the demands for petrochemical products in South Asia for the period 1974-1981. The results in the table are generally not as good as the results that were obtained for other regions. The R^2 values far from being unsatisfactory, are not as high as those encountered previously. The t-statistics are only marginally statistically significant. The average percentage coefficients of errors for most equations are unsatisfactory.

It is interesting however to note that the major results obtained in other regions still hold true for this region. Economic activity as depicted by the GDP variable is significant in explaining petrochemical product demands, particularly for final products. The constants in the relevant equations are mostly negative, suggesting that in South Asia, the average propensity to consume petrochemical products has been rising during the estimation period and will likely continue to rise in the future.

Technical production relations in this region are weak and most of these relationships should be considered as import demand equations rather than as production functions.

Table 9: Regression Results of Petrochemical Demand Function
South Asia: 1974-1981

DEPENDENT VARIABLE \ INDEPENDENT VARIABLES					R^2	SEE	APE
ABS	CONSTANT -29.4908 (-1.04)	GDP .000311 (1.14)			.30	2.19	.78
POR	CONSTANT -27.1847 (-1.02)	GDP .000681 (2.53)			.56	6.31	.15
HDP	CONSTANT -72.09 (-1.63)	GDP .001155 (2.59)			.57	10.45	.25
LDP	CONSTANT -151.983 (-2.09)	GDP .00214 (2.92)			.63	17.24	.28
FET	CONSTANT -95.068 (-3.80)	GDP .00127 (5.04)			.83	5.93	.19
PVC	CONSTANT -80.25 (-1.59)	GDP .00144 (2.84)			.62	11.9	.19
PPR	CONSTANT -46.3769 (-3.12)	GDP .000541 (3.61)			.72	3.52	.50
PST	CONSTANT -5.5424 (-.76)	GDP .0001938 (2.64)			.58	1.72	.12
SBR	CONSTANT -6.6525 (-.59)	GDP .000306 (2.69)			.59	2.67	.11
VAC	CONSTANT -15.8663 (-3.35)	GDP .000205 (4.31)			.78	1.12	.25
VCM	PVC .7215 (8.73)					15.99	.31
EDC	VCM 1.0353 (22.02)					6.86	.13
EGL	PET .1919 (2.93)	GDP .00006 (2.78)				1.71	.14
EOX	EGL 1.128 (17.58)					2.33	.16
STY	PST 1.520 (29.43)					1.99	.09
EBZ	STY 1.1508 (53.90)					1.26	.05
ACT	VAC 19.029 (1.56)					173.76	1.82
ANH	ACN 729.358 (1.94)					3916.6	.87
ETH	EDC .30207 (1.19)	EOX 5.41457 (2.98)	LDP .494251 (1.67)	VAC -.59379 (-.29)		9.72	.44
BUT	ABS 1.43368 (4.40)	SBR .644036 (14.72)				1.95	.10
MET	ACT .673041 (2.33)	POR 1.80766 (9.22)	GDP -.000409 (-5.31)			2.60	.05
PRO	PPR 1.54360 (2.75)	GDP .000347 (6.80)				7.60	.16

Table 10: Regression Results of Petrochemical Demand Function
Southeast Asia: 1974-1981

DEPENDENT VARIABLE \ INDEPENDENT VARIABLES						R^2	SEE	APE
ABS	CONSTANT -121.343 (-13.25)	GDP .00146 (17.71)				.98	3.40	.08
FOR	CONSTANT -219.525 (-4.19)	GDP .00599 (12.67)				.97	19.44	.04
HDP	CONSTANT -369.815 (-7.84)	GDP .00527 (12.35)				.97	17.54	.08
LDP	CONSTANT -291.227 (-2.10)	GDP .00652 (5.20)				.84	51.55	.12
PET	CONSTANT -676.056 (-8.85)	GDP .01104 (15.97)				.98	28.39	.05
PVC	CONSTANT -838.501 (-18.89)	GDP .01274 (31.74)				.99	16.49	.03
PPR	CONSTANT -569.084 (-8.05)	GDP .00806 (12.61)				.97	26.27	.08
PST	CONSTANT -348.029 (-6.77)	GDP .00524 (11.27)				.96	19.09	.08
SBR	CONSTANT -214.171 (-10.17)	GDP .003027 (15.90)				.98	7.82	.06
VAC	CONSTANT -131.925 (-8.76)	GDP .00157 (11.55)				.96	5.59	.13
VCM	PVC 1.00 (45.87)						38.94	.06
EDC	VCM .9675 (21.75)						79.60	.14
EGL	PET .3982 (27.07)						20.31	.09
EOX	EGL .3241 (5.59)						40.20	.63
ACN	ABS 1.3226 (3.19)	GDP .00108 (6.36)					18.92	.11
STY	ABS 3.06409 (6.99)	PST .171375 (1.85)					15.57	.08
EBZ	STY .52348 (10.81)						28.01	.24
ACT	VAC .65140 (7.01)						13.99	.40
ETH	EDC .2670 (1.28)	BOX 1.5512 (1.39)	HDP .5437 (.43)	LDP .10905 (.25)	VAC 1.8486 (.37)		36.04	.07
BUT	ABS .49815 (2.63)	SBR .36493 (4.77)					6.70	.09
MET	ACT 1.6235 (.99)	FOR .4744 (3.42)					28.32	.10
PRO	PPR .94676 (28.93)						29.26	.10

2.8.9 Estimates of the demand for petrochemical products in South-East Asia

Table 10 presents the regression estimates of petrochemical product demand functions for South-East Asia over the period 1974-1981. Given the entry of this region into petrochemical production in recent years, it is not surprising to see that the estimated equations are as good and even better here than those estimated for industrialized economies. The R^2 values are all very high, the t-statistics are significant at the one per cent level of significance, the signs of the coefficients are all consistent with a priori restrictions, and most of the A.P.E. values are reasonably low. Some demand functions show R^2 values of over 0.98 (PVC, SBR, ABS, and PET). These same equations, not surprisingly, show also low A.P.E. values.

The GDP variable is highly significant in every equation in which it is an explanatory variable; the constants are negative and significant in these equations. As such, the demand for petrochemicals in South-East Asia constitutes a rising proportion of GDP over time.

The hypothesized Leontief technology among basic and intermediate products and between the latter group and final products emerges with some validation. With the exception of the relationships of EBZ and STY, and ACT and VAC, all the other relationships show adequate statistical properties. In the Ethylene equation, we have kept variables which have low t-statistics. Given the high multicollinearity among these variables, we were unwilling to pass judgement on the separate contributions of these variables; jointly they explain fairly well the variations in ethylene demand.

2.8.10 Estimates of the demand for petrochemical products in Africa (South of Sahara), 1974-1981

Since there is not much production or consumption of petrochemical products in this region, only two equations were estimated and these are presented below:

(1) $$PET = -122.54 + 0.00117\ GDP$$
$$(-3.73) \quad (3.95)$$

$R^2 = 0.84$
SEE = 3.134
A.P.E. = 0.43

(2) PPR = 0.00001727 GDP
(4.093) SEE = 1.204
A.P.E. = 0.64

The results are rather crude as a result of the limited activity in the region.

2.9 The role of prices

Rational consumers with fixed incomes and given prices will maximize their utilities by allocating their expenditures in such a way as to derive the same marginal satisfaction per last dollar spent on each commodity. This suggests that prices are important variables in this allocation process. Several prices enter the demand function of any commodity; first, there is the own price, which for normal goods is usually inversely related to quantity demanded. There are also other commodity prices to be taken into account; the prices of substitute commodities are expected to have positive effects on the demand for a specified good, while the prices of complementary commodities are expected to be inversely related to the demand for a given good.

Since the price relationship is generally restricted to "final products" purchased primarily by consumers, we opted to introduce prices into the demand functions of those products only. The introduction of price variables in the demand functions of even the final products was not without problems. Since the number of observations was small to begin with, a new variable consumes another precious degree of freedom. Second, there is the question of identification of the function estimated. Since our observations are price and output combinations over time, if the supply function is stable and the demand function is unstable, we might be estimating supply responses to prices and not demand functions. The opposite is true for estimating demand.

Notwithstanding these reservations, we went ahead and included price variables in most of the demand functions for final products but only in the developed countries, where price behaviour is more evident and where data on prices was available (North America, Eastern Europe, Western Europe and Japan).

Table 11: Regression Results of Petrochemical Demand Functions When Prices are Included: Selected Regions

Dependent Variables \ Independent Variables						R^2
1. North America						
ABS	CONSTANT	GDP	OWN-PRICE			
	-367.34	0.00064	-2.879			0.48
	(-.98)	(2.17)	(-1.62)			
HDP	CONSTANT	GDP	OWN-PRICE			
	-3265.28	0.00248	1.590			0.97
	(-7.44)	(9.33)	(1.10)			
LDP	CONSTANT	GDP	OWN-PRICE			
	-1783.78	0.0034	1.750			0.83
	(-1.64)	(3.62)	(.47)			
PVC	CONSTANT	GDP	OWN-PRICE			
	-1884.47	0.00217	1.258			0.78
	(-1.64)	(2.51)	(.16)			
VAC	CONSTANT	GDP	OWN-PRICE	NATURAL PRICE		
	-1112.86	0.00005	3.64	-2.63		0.84
	(-2.00)	(3.17)	(2.38)	(-2.59)		
PPR	CONSTANT	GDP	OWN-PRICE			
	-1922.12	0.00156	1.718			0.94
	(-5.10)	(6.61)	.62)			
PST	CONSTANT	CON	VCM	VMA	OWN-PRICE	
	-2475.80	0.00072	0.036	0.0007	-1.65	
	(-11.78)	(5.55)	(14.0')	(3.21)	(-2.49)	
SBR	CONSTANT	CON	VCM	OWN-PRICE	NATURAL PRICE	
	-1276.18	0.0006	0.025	7.698	-4.78	0.97
	(-1.90)	(1.06)	(2.31)	(1.32)	(-3.19)	
2. Western Europe						
ABS	CONSTANT	GDP	OWN-PRICE			
	-498.81	0.00035	-0.076			0.90
	(-3.74)	(4.43)	(-.15)			
HDP	CONSTANT	GDP	OWN-PRICE			
	-933.66	0.0002	1.043			0.79
	(-1.47)	(2.77)	(.51)			
LDP	CONSTANT	GDP	OWN-PRICE			
	-1122.95	0.0019	4.68			0.89
	(-1.11)	(3.54)	(1.38)			
PVC	CONSTANT	GDP	OWN-PRICE			
	-2641.81	0.0016	-1.26			0.95
	(-6.06)	(6.83)	(-.30)			
VAC	CONSTANT	GDP	OWN-PRICE	NATURAL PRICE		
	-168.60	0.00027	-.232	.150		0.80
	(-.24)	(.79)	(-.14)	(.12)		
PST	CONSTANT	CON	VCM	VMA		
	182.13	0.0014	-0.031	0.0068		0.74
	(.14)	(2.22)	(-.96)	(.83)		
SBR	CONSTANT	CON	VCM	OWN-PRICE	NATURAL PRICE	
	1488.7	-0.0006	-0.0015	5.77	0.303	0.96
	(4.04)	(-1.90)	(-1.71)	(4.42)	(.52)	
5. Eastern Europe						
HDP	CONSTANT	GDP	OWN-PRICE			
	-756.75	0.00117	-0.542			0.86
	(-4.20)	(4.5)	(-.95)			
LDP	CONSTANT	GDP	OWN-PRICE			
	-1560.65	0.00346	-2.65			0.87
	(-6.72)	(10.00)	(-3.42)			
PVC	CONSTANT	GDP	OWN-PRICE			
	-1227.49	0.0027	-1.09			0.88
	(-9.22)	(11.82)	(-2.22)			
PPR	CONSTANT	GDP	OWN-PRICE			
	-306.98	0.00062	0.182			0.98
	(-10.23)	(9.82)	(.62)			
PST	CONSTANT	GDP	OWN-PRICE			
	-274.86	0.0009	-1.058			0.93
	(-2.45)	(7.02)	(-2.05)			
SBR	CONSTANT	GDP	OWN-PRICE	NATURAL PRICE		
	-858.74	0.00196	4.064	-2.015		0.94
	(-2.10)	(3.23)	(2.40)	(-2.40)		
6. Japan						
ABS	CONSTANT	GDP	OWN-PRICE			
	-180.16	0.00057	0.598			0.88
	(-2.35)	(2.88)	(1.34)			
HDP	CONSTANT	GDP	OWN-PRICE			
	-826.33	0.0017	2.62			0.82
	(-2.36)	(2.48)	(2.34)			
LDP	CONSTANT	GDP	OWN-PRICE			
	204.49	0.000064	3.35			0.63
	(.37)	(.06)	(2.35)			
PVC	CONSTANT	GDP	OWN-PRICE			
	-382.31	0.00048	11.306			0.86
	(-.78)	(.43)	(3.54)			
PPR	CONSTANT	GDP	OWN-PRICE			
	-1191.98	0.00176	8.059			0.66
	(-1.70)	(1.34)	(1.74)			
VAC	CONSTANT	GDP	OWN-PRICE	NATURAL PRICE		
	196.23	0.00011	0.884	0.318		0.44
	(.27)	(.086)	(.37)	(.23)		
PST	CONSTANT	CON	VCM	VMA	OWN-PRICE	
	-710.01	0.0029	0.0016	0.00018	2.25	0.88
	(-1.14)	(1.10)	(.79)	(.13)	(1.47)	
SBR	CONSTANT	CON	VCM	OWN-PRICE	NATURAL PRICE	
	-7.06	0.0011	-0.0002	-0.278	.776	0.90
	(-.096)	(3.35)	(-.50)	(-.58)	(5.05)	

2.9.1 Price behaviour in North America

The results in Table 11 show that only in the case of few products in North America was the own-price effect negative. Moreover, even in those cases, the t-statistics of the price variables were generally quite small to be considered statistically significant.

The own-price effect for ABS is negative but the t-statistic is relatively low (-1.62). The own-price effects for HDP, LDP, PVC, PPR, SBR, and VAC were "unacceptably" positive. The own-price effect of PST was, however, negative and significant.

An interesting note about price behaviour in this region is the negative and statistically significant coefficient on the price of natural rubber in the SBR equation. The negative coefficient of the price of natural rubber in the SBR equation and the negative coefficient of the price of natural fibres in the vinyl acetate equation are most probably the result of spurious correlation. As petroleum and natural gas prices have risen in the 1970s, so has the cost of production and the price of petrochemicals. In the case of SBR, the rising price has led to a substitution of natural rubber for synthetic rubber, and the increased demand for natural rubber has driven up its price. (The short-run supply of natural rubber is extremely inelastic.) Thus in the same period we witness a rising natural rubber price and a falling demand for SBR, giving the mistaken impression that an exogenous increase in the price of natural rubber has caused a drop in the demand for SBR. The same argument can be applied to the apparent negative relationship between the price of natural fibres and the demand for vinyl acetate. Both examples illustrate the inappropriateness of the use of least squares regression on single demand or supply equations as a method of measuring price responsiveness. The appropriate approach is the use of simultaneous equations models and methods.

2.9.2 Price behaviour in Western Europe

Demand price responsiveness in the petrochemical markets in Western Eurpe are not evident during the period 1974-1981. In most of the equations into which prices are admitted as explanatory variables, the signs on price responses are inconsistent with *a priori* economic restrictions. With the exception of the ABS price which has a negative sign but which is statistically insignificant, all other own-price effects are positive. What is perhaps more disturbing is the fact that the introduction of price variables into a number of equations renders the activity proxy variables either insignificant or negative in sign. This is again the familiar simultaneity problem, owing in this case to a rising common trend in most prices and activity variables (see Table 11).

2.9.3 Price behaviour in Eastern Europe

It is generally claimed, without much substantiation, that economic behaviour in planned economies is price insensitive. The evidence in Table 11 for Eastern Europe, though admittedly tentative, suggests that petrochemical product prices are significant variables in influencing consumption of these products. HDP demand is negatively related to its own-price, but the standard error on the price coefficient is large enough to warrant concern about the reliability of this sign. However, LDP demand is negatively related to its own-price, and this coefficient is highly significant. The same is true for PVC and PST. Alternatively, the price coefficient in the PPR equation has the wrong sign, but it is not statistically significant. The own-price effect in the SBR equation has the wrong sign but it is statistically significant, and the price coefficient of the price of natural rubber is negative and significant. (see above)

2.9.4 Price behaviour in Japan

The evidence from Japan indicates that price coefficients are significant but have the opposite signs from what is generally expected on an *a priori* basis. In addition to simultaneity problems, a possible explanation for this phenomenon and one that may be relevant for Japan, with its long distances to the sources of feedstocks and to its export markets, is that price responses are dynamic in nature with lags and expectations playing major roles. If prices are expected to rise tomorrow, more will rationally be purchased today. Given that petrochemical prices are highly correlated with oil prices (see below) and given that 1974-1981 is a special period during which oil prices increased markedly, inventory investment behaviour, which is linked positively to prices, may have nominated flow demand (it must be remembered that apparent consumption includes inventory changes).

Upon examining the particular petrochemical product demand equations for Japan, we find that the ABS price has a positive sign but is not significant. Moreover, the HDP and LDP prices both have the wrong sign and both are statistically significant. The PVC price coefficient is also positive and highly significant, whereas the PPR and PST prices are both barely significant and positive. Interestingly, the SBR own-price effect is negative but is insignificant and the price of natural rubber is positive and is highly significant.

In the next section, the results of using the equations in this section, the forecasts of exogenous variables from the UNITAD model, and our price forecasts, to generate predictions of future petrochemical demands by region until the year 2000 are presented in detail.

3. The forecasting results

3.1 The forecasting methodology

A primitive approach to medium or long-term forecasting involves the use of a mechanical trend extrapolation for some specific variable of interest, or a mechanical trend extrapolation made separately for each of a number of variables. Such a rough procedure may be useful in very simple problems where accuracy and explanation are not essential or where the growth process of the phenomena in question is strongly stable.

To explain most economic phenomena, however, a more defined approach is required; one might attempt to extrapolate simultaneously several endogenous variables, wherein their mutual dependency is reflected in a more or less elaborate dynamic system. The essential rationale for such forecasts is that the future course of any specific variable will impact upon the course of others. All of the variables of the model therefore must be considered simultaneously. One essential ingredient of this system is that, in computing the forecasts, many of the elements that mutually influence each other are not actually observed and must be guessed at. This leads logically to an analysis which does not yield one definite forecast but rather a number of alternative forecasts, each of them derived from a specific set of assumptions regarding the future course of some of the elements that are tied together structurally.

The type of forecast outlined above is often referred to as an "on-looker forecast" á la Ragnar Frisch to distinguish it from forecasting exercises wherein the emphasis in on influencing the course of economic events and wherein models are designed to aid in the process of instrument selection to affect targets. Once the emphasis is shifted from the on-looker viewpoint to that of influencing the course of events, the analytical structure of the exercise changes. Certain variables or constants which now attract particular interest are those which can be selected in a rather direct way to influence the behaviour of the system.

The system employed in this study is basically of the on-looker variety; however, the fact that our structural equations in section 3 are tied to the UNITAD model, which is capable of generating a large set of alternative values for the exogenous variables used in the demand equations for petrochemical products, allows us to consider several alternative paths for these demands. We have opted to use the TREND Forecasts (explained in Appendix A), and to employ two structures to generate the demand forecasts for 1985, 1990, 1995 and 2000, one exclusive of prices and one that includes price variables in the four industrialized regions of the world. The alternative exclusive of prices is referred to as alternative A and the second alternative inclusive of prices is called alternative B. We start with alternative A.

3.2 Alternative A forecasts

There are several ways in which the forecasts of demands for petrochemical products may be organized; we elect to present the analysis in terms of group of products by region. The results of these forecasts, which can be viewed as benchmark forecasts, are arrayed in Tables 12 through 36.

3.2.1 The historical background 1975-1980

North America was, by far, the largest consumer of petrochemical products in 1975, accounting for almost 36 per cent of total world petrochemical demand for some 23 of these products. In the same year, Western Europe accounted for almost 30 per cent, Eastern Europe 14.7 per cent and Japan 11.1 per cent of total world demand for these products. The industrialized countries together consumed over 90 per cent of the world total output of these products. Latin America, South and South-East Asia are the three largest consuming areas in the developing countries (see Tables 12 and 13).

The volume of North America consumption in 1975 varies from product to product. It is highest in ethylene glycol, acetic acid, ethylene oxide, and formaldehyde; all are intermediate petrochemical products. However, in the case of VCM, PVC, methanol, LDPE, EDC and acrylonitrile, North American consumption falls short of that of Western Europe.

Regardless of region, ammonia was the largest petrochemical product consumed in 1975; the percentage shares of its consumption vary, however, from region to region. Japan and South-East Asia are the only exceptions. Ethylene was the second largest consumed petrochemical in most regions, followed by ethylene dichloride.

The pattern of world petrochemical consumption in 1980 is not significantly different from that which prevailed in 1975 (with some minor exceptions). See Tables 14 and 15.

The share of the industrialized countries in total consumption fell slightly, whereas every developing region, with the exception of South-Saharan Africa, showed some minor increases in its corresponding total petrochemical consumption shares. South-East Asia showed the largest increase in shares among developing regions.

Annual rates of growth of total petrochemical consumption between 1975 and 1980 were highest in developing countries. In the Arab region, the growth rate stood at 9.0 per cent, exceeded 22.1 per cent in South-East Asia, 11.7 per cent in Latin America and 13.1 per cent in South Asia. The corresponding rates of growth in the developed regions during the same period were as follows: 6.2 per cent in North America, 5.9 per cent in Japan, 5.6 per cent in Eastern Europe and 8.0 per cent in Western Europe (see Table 16).

Rates of growth of consumption by product were different in each region. In North America, consumption of HDPE grew at the rate of 14 per cent during 1975-1980. Polypropylene, ehtylene dichloride and propylene consumption grew at the rates of 12.7, 9.3 and 9.2 per cent, respectively. However, consumption of SBR actually fell at the rate of 1.7 per cent per year during the same period.

The highest rates of annual consumption growth in Western Europe during the period 1975-1980 were in formaldehyde, polypropylene, ABS and HDPE. On the other hand, SBR and ethylene oxide consumption growth rates were relatively low.

The rates of growth of consumption in Eastern Europe during the same period were relatively high in a number of products, including acrylonitrile, ethylene, ethylene dichloride, ethylene glycol, ethylene oxide, PET, PVC, polypropylene, and VCM. On the other hand, the consumption of butadiene fell drastically from 100 thousand metric tons in 1975 to only 36 thousand metric tons in 1980.

Table 12

WORLD PETRO CHEMICAL CONSUMPTION BY REGION AND PRODUCT,1975
(THOUSAND METRIC TONS/YEAR)

\REGIONS: \ PRODUCTS:\	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH) SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD* TOTAL
ABS	318.0	190.0	0.0	137.0	9.0	17.0	0.0	5.0	0.0	14.0	690.0
ACETIC ACID	1039.0	0.0	125.0	505.0	20.0	76.0	0.0	19.0	23.0	24.0	1831.0
ACRYLONITRILE	481.0	689.0	42.0	453.0	2.0	59.0	0.0	0.0	0.0	119.0	1845.0
AMMONIA	18140.0	10000.0	15500.0	1740.0	850.0	2970.0	260.0	870.0	3370.0	0.0	53700.0
BUTADIENE	1490.0	860.0	100.0	470.0	44.0	159.0	0.0	0.0	15.0	28.0	3166.0
ETHYL BENZENE	2633.0	2138.0	439.0	991.0	41.0	135.0	0.0	0.0	18.0	0.0	6395.0
ETHYLENE	9769.0	7694.0	2000.0	3329.0	308.0	598.0	0.0	51.0	87.0	189.0	24025.0
ETHYLENE DICHLORIDE	3779.0	4743.0	194.0	1931.0	159.0	326.0	0.0	70.0	47.0	151.0	11400.0
EHTYLENE GLYCOL	1740.0	557.0	26.0	334.0	7.0	89.0	0.0	0.0	8.0	122.0	2883.0
ETHYLENE OXIDE	2129.0	1112.0	44.0	494.0	18.0	72.0	0.0	0.0	10.0	7.0	3896.0
FORMALDEHYDE	2171.0	24.0	307.0	835.0	70.0	234.0	0.0	21.0	27.0	333.0	4022.0
HDPE	1031.0	930.0	150.0	310.0	72.0	133.0	0.0	70.0	25.0	125.0	2846.0
LDPE	2197.0	3033.0	747.0	731.0	155.0	432.0	0.0	220.0	36.0	309.0	7860.0
METHANOL	2325.0	2407.0	1905.0	779.0	37.0	152.0	0.0	23.0	27.0	182.0	7837.0
PET	1410.0	572.0	267.0	278.0	50.0	218.0	0.0	19.0	18.0	397.0	3229.0
PVC	1665.0	2934.0	1000.0	1050.0	148.0	340.0	0.0	230.0	47.0	332.0	7742.0
POLYPROPYLENE	798.0	565.0	200.0	440.0	48.0	96.0	3.0	40.0	1.0	188.0	2379.0
POLYSTYRENE	1224.0	1236.0	276.0	442.0	39.0	140.0	0.0	80.0	10.0	118.0	3565.0
PROPYLENE	4311.0	4178.0	1200.0	1980.0	83.0	253.0	0.0	15.0	33.0	124.0	12177.0
SBR	1607.0	1032.0	786.0	355.0	35.0	237.0	0.0	0.0	23.0	55.0	4130.0
STYRENE	2065.0	1931.0	420.0	815.0	56.0	195.0	0.0	0.0	16.0	55.0	5553.0
VCM	1805.0	3200.0	675.0	1213.0	114.0	273.0	0.0	0.0	45.0	275.0	7600.0
VINYL ACETATE	606.0	381.0	0.0	351.0	12.0	55.0	0.0	11.0	4.0	12.0	1432.0
REGIONAL TOTAL	64733.0	50406.0	26403.0	19963.0	2377.0	7259.0	263.0	1744.0	3886.0	3159.0	180193.0

SOURCE: ECONOMETRIC RESEARCH DATA FILES

* DOES NOT INCLUDE CENTRALLY PLANNED ASIAN ECONOMIES

Table 13

WORLD PETRO CHEMICAL CONSUMPTION BY REGION AND PRODUCT, 1975
(ROW PERCENTAGES)

\REGIONS: PRODUCTS:\	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD TOTAL
ABS	46.09	27.54	0.00	19.86	1.30	2.46	0.00	.72	0.00	2.03	100.00
ACETIC ACID	56.74	0.00	6.83	27.58	1.09	4.15	0.00	1.04	1.26	1.31	100.00
ACRYLONITRILE	26.07	37.34	2.28	24.55	.11	3.20	0.00	0.00	0.00	6.45	100.00
AMMONIA	33.78	18.62	28.86	3.24	1.58	5.53	.48	1.62	6.28	0.00	100.00
BUTADIENE	47.06	27.16	3.16	14.85	1.39	5.02	0.00	0.00	.47	.88	100.00
ETHYL BENZENE	41.17	33.43	6.86	15.50	.64	2.11	0.00	0.00	.28	0.00	100.00
ETHYLENE	40.66	32.02	8.32	13.86	1.28	2.49	0.00	.21	.36	.79	100.00
ETHYLENE DICHLORIDE	33.15	41.61	1.70	16.94	1.39	2.86	0.00	.61	.41	1.32	100.00
ETHYLENE GLYCOL	60.35	19.32	.90	11.59	.24	3.09	0.00	0.00	.28	4.23	100.00
ETHYLENE OXIDE	54.79	28.62	1.13	12.71	.46	1.85	0.00	0.00	.26	.18	100.00
FORMALDEHYDE	53.98	.60	7.63	20.76	1.74	5.82	0.00	.52	.67	8.28	100.00
HDPE	36.23	32.68	5.27	10.89	2.53	4.67	0.00	2.46	.88	4.39	100.00
LDPE	27.95	38.59	9.50	9.30	1.97	5.50	0.00	2.80	.46	3.93	100.00
METHANOL	29.67	30.71	24.31	9.94	.47	1.94	0.00	.29	.34	2.32	100.00
PET	43.67	17.71	8.27	8.61	1.55	6.75	0.00	.59	.56	12.29	100.00
PVC	21.51	37.90	12.92	13.56	1.91	4.39	0.00	2.97	.56	4.29	100.00
POLYPROPYLENE	33.54	23.75	8.41	18.50	2.02	4.04	.13	1.68	.04	7.90	100.00
POLYSTYRENE	34.33	34.67	7.74	12.40	1.09	3.93	0.00	2.24	.28	3.31	100.00
PROPYLENE	35.40	34.31	9.85	16.26	.68	2.08	0.00	.12	.27	1.02	100.00
SBR	38.91	24.99	19.03	8.60	.85	5.74	0.00	0.00	.56	1.33	100.00
STYRENE	37.19	34.77	7.56	14.68	1.01	3.51	0.00	0.00	.29	.99	100.00
VCM	23.75	42.11	8.88	15.96	1.50	3.59	0.00	0.00	.59	3.62	100.00
VINYL ACETATE	42.32	26.61	0.00	24.51	.84	3.84	0.00	.77	.28	.84	100.00
REGIONAL TOTAL	35.92	27.97	14.65	11.08	1.32	4.03	.15	.97	2.16	1.75	100.00

SOURCE: ECONOMETRIC RESEARCH DATA FILES

In Japan the rate of growth in the consumption of plastics exceeded other petrochemical product consumption growth rates during this period. Consumption demand for polypropylene grew at the rate of 14.7 per cent per year, for HDPE at the rate of 12.2 per cent and for PET at 12 per cent. Only the demand for acetic acid declined during this period.

Starting from relatively low levels in 1975, Latin American petrochemical demands were markedly higher in 1980. With the exception of only two petrochemical products, ammonia (5.7 per cent) and SBR (8.7 per cent), the annual consumption growth rates for the remaining products were 10 per cent or higher, with the highest rates in propylene, at 22.4 per cent, polypropylene, at 21.6 per cent and ethylene oxide, at 20 per cent.

Demands for petrochemical products in the Arab region also grew very rapidly between 1975 and 1980, and particularly the demand for plastics. In fact, during this period, the demand for ethylene grew at the rate of 32.7 per cent per year and that for formaldehyde at the rate of 28.6 per cent per year. Demands for ABS ethylene dichloride, and propylene declined during this period.

Not surprisingly, in the light of substantial agricultural activity, the demand for ammonia in South Asia grew rapidly at the annual rate of 13.3 per cent between 1975-1980. However, the largest growth occurred in the demand for polypropylene, which grew at an annual rate of 76.2 per cent during this period. Demand for SBR declined as the use of domestic natural rubber was increased.

The demand for all types of petrochemicals in South-East Asia grew very rapidly during this period; the overall annual growth rate exceeded 22 per cent. The rates of growth of demand for most products were quite high, particularly for ethylene oxide, vinyl acetate, ethylene dichloride, ABS and ethylene.

The rapid growth that had characterized the petrochemical industry since the early 1950s was slowed in the mid 1970s; despite the slowdown, it outstripped the growth of most regional GDPs. Two basic characteristics dominate the 1975-1980 world petrochemical consumption patterns. In the first place the rates of growth of demands in developing countries for most of the petrochemicals were significantly higher than those of North America, Western Europe or Japan. Secondly, there existed a structural consumption pattern, with the demand for final petrochemical products being highest in Western Europe, while the demand for intermediates and basics is highest in North America.

With this historical setting in view, we now turn to a brief analysis of the forecasts for 1985, 1990, 1995 and the year 2000.

3.2.2 World demand for petrochemical products by region and commodity, 1985

Discussion of the future demand for petrochemical products will be organized by commodity groups: basic, intermediate and final.

(a) Demand for basic petrochemical products, 1985

The basis block of petrochemical products of special concern to us in this study is that composed of the olefins, ammonia and methanol; each will be discussed separately using the results in Tables 17, 18, 19 and 20.

Total world demand for ethylene in 1985 is estimated to be about 39.8 million MT/y; this represents a growth rate of about 2.6 per cent per year from 1980. Given that the forecast world GDP rate of growth is 2.6 per cent per year, the implied output elasticity for ethylene between 1980 and 1985 is unitary. North America is expected to be the largest consumer with a share of 40.9 per cent of the total world consumption of ethylene; the industrialized countries together account for over 91.8 per cent of expected world consumption in 1985 (See Tables 17, 18 and 19)

World consumption of propylene is forecast to exceed 23.6 million MT/y in 1985; this represents an annual growth rate of 5.4 per cent over the 1980 level and an output elasticity for ethylene demand of over 2.08. Again, North America is the largest consumer, with a 38.4 per cent share of the world total, followed by Western Europe with a 31.2 per cent share; the developing countries together are expected to account for only 7.48 per cent. Demand for propylene is forecast to grow fastest in the Arab region in 1985.

Table 14

WORLD PETRO CHEMICAL CONSUMPTION BY REGION AND FRODUCT, 1980
(THOUSAND METRIC TONS/YEAR)

\REGIONS: \ PRODUCTS:\	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH) SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD* TOTAL
ABS	404.0	335.0	0.0	227.0	14.0	37.0	0.0	3.0	5.0	71.0	1096.0
ACETIC ACID	1387.0	869.0	0.0	352.0	17.0	139.0	0.0	25.0	32.0	56.0	2877.0
ACRYLONITRILE	680.0	927.0	69.0	513.0	3.0	143.0	0.0	0.0	10.0	207.0	2552.0
AMMONIA	22680.0	14000.0	18600.0	2300.0	1180.0	3920.0	350.0	1200.0	6300.0	0.0	70530.0
BUTADIENE	1615.0	1090.0	36.0	630.0	55.0	260.0	0.0	0.0	22.0	99.0	3807.0
ETHYL BENZENE	3921.0	2815.0	606.0	1259.0	144.0	329.0	0.0	0.0	24.0	121.0	9219.0
ETHYLENE	13656.0	11170.0	3100.0	4159.0	414.0	1288.0	0.0	210.0	155.0	866.0	35018.0
ETHYLENE DICHLORIDE	5904.0	6562.0	365.0	2673.0	116.0	584.0	0.0	44.0	51.0	903.0	17202.0
ETHYLENE GLYCOL	2045.0	701.0	42.0	445.0	29.0	146.0	0.0	20.0	13.0	320.0	3761.0
ETHYLENE OXIDE	2499.0	1277.0	105.0	537.0	25.0	179.0	0.0	0.0	16.0	150.0	4788.0
FORMALDEHYDE	2772.0	3736.0	425.0	1120.0	100.0	380.0	0.0	74.0	52.0	547.0	9206.0
HDPE	1987.0	1451.0	400.0	550.0	129.0	328.0	0.0	100.0	51.0	290.0	5286.0
LDPE	3194.0	4203.0	1096.0	868.0	243.0	830.0	0.0	370.0	95.0	466.0	11365.0
METHANOL	3418.0	3303.0	2630.0	1124.0	57.0	344.0	0.0	40.0	70.0	312.0	11298.0
PET	1597.0	712.0	436.0	491.0	54.0	350.0	15.0	28.0	46.0	767.0	4496.0
PVC	2429.0	3931.0	1400.0	1428.0	247.0	678.0	0.0	350.0	80.0	792.0	11335.0
POLYPROPYLENE	1450.0	1239.0	300.0	873.0	102.0	255.0	3.0	60.0	17.0	476.0	4775.0
POLYSTYRENE	1611.0	1676.0	395.0	675.0	63.0	290.0	0.0	95.0	13.0	306.0	5124.0
PROPYLENE	6679.0	5714.0	1800.0	2606.0	150.0	695.0	0.0	3.0	61.0	489.0	18197.0
SBR	1477.0	1171.0	940.0	508.0	40.0	359.0	0.0	12.0	22.0	176.0	4705.0
STYRENE	2715.0	2669.0	589.0	1221.0	114.0	411.0	0.0	2.0	19.0	254.0	7994.0
VCM	2737.0	4181.0	1348.0	1558.0	241.0	609.0	0.0	25.0	41.0	838.0	11578.0
VINYL ACETATE	603.0	490.0	0.0	434.0	13.0	100.0	0.0	19.0	5.0	79.0	1743.0
REGIONAL TOTAL	87460.0	74222.0	34682.0	26559.0	3550.0	12646.0	368.0	2680.0	7200.0	8585.0	257952.0

SOURCE: ECONOMETRIC RESEARCH DATA FILES

* DOES NOT INCLUDE CENTRALLY PLANNED ASIAN ECONOMIES

Table 15

WORLD PETRO CHEMICAL CONSUMPTION BY REGION AND PRODUCT, 1980
(ROW PERCENTAGES)

\REGIONS: \ PRODUCTS: \	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH) SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD TOTAL
ABS	36.86	30.57	0.00	20.71	1.28	3.38	0.00	.27	.46	6.48	100.00
ACETIC ACID	48.21	30.21	0.00	12.23	.59	4.83	0.00	.87	1.11	1.95	100.00
ACRYLONITRILE	26.65	36.32	2.70	20.10	.12	5.60	0.00	0.00	.39	8.11	100.00
AMMONIA	32.16	19.85	26.37	3.26	1.67	5.56	.50	1.70	8.93	0.00	100.00
BUTADIENE	42.42	28.63	.95	16.55	1.44	6.83	0.00	0.00	.58	2.60	100.00
ETHYL BENZENE	42.53	30.53	6.57	13.66	1.56	3.57	0.00	0.00	.26	1.31	100.00
ETHYLENE	39.00	31.90	8.85	11.90	1.10	3.66	0.00	.60	.44	2.47	100.00
ETHYLENE DICHLORIDE	34.32	38.15	2.12	15.54	.67	3.39	0.00	.26	.30	5.25	100.00
ENTYLENE GLYCOL	54.37	18.64	1.12	11.83	.77	3.88	0.00	.53	.35	8.51	100.00
ETHYLENE OXIDE	52.19	26.67	2.19	11.22	.52	3.74	0.00	0.00	.33	3.13	100.00
FORMALDEHYDE	30.11	40.58	4.62	12.17	1.09	4.13	0.00	.80	.56	5.94	100.00
HDPE	37.59	27.45	7.57	10.40	2.44	6.21	0.00	1.89	.96	5.49	100.00
LDPE	28.10	36.98	9.64	7.64	2.14	7.30	0.00	3.26	.84	4.10	100.00
METHANOL	30.25	29.24	23.28	9.95	.50	3.04	0.00	.35	.62	2.76	100.00
PET	35.52	15.84	9.70	10.92	1.20	7.78	.33	.62	1.02	17.06	100.00
PVC	21.43	34.68	12.35	12.60	2.18	5.98	0.00	3.09	.71	6.99	100.00
POLYPROPYLENE	30.37	25.95	6.28	18.28	2.14	5.34	.06	1.26	.36	9.97	100.00
POLYSTYRENE	31.44	32.71	7.71	13.17	1.23	5.66	0.00	1.85	.25	5.97	100.00
PROPYLENE	36.70	31.40	9.89	14.32	.82	3.82	0.00	.02	.34	2.69	100.00
SBR	31.39	24.89	19.98	10.80	.85	7.63	0.00	.26	.47	3.74	100.00
STYRENE	33.96	33.39	7.37	15.27	1.43	5.14	0.00	.03	.24	3.18	100.00
VCM	23.64	36.11	11.64	13.46	2.08	5.26	0.00	.22	.35	7.24	100.00
VINYL ACETATE	34.60	28.11	0.00	24.90	.75	5.74	0.00	1.09	.29	4.53	100.00
REGIONAL TOTAL	33.91	28.77	13.45	10.30	1.38	4.90	.14	1.04	2.79	3.33	100.00

SOURCE: ECONOMETRIC RESEARCH DATA FILES

Table 16

RATE OF GROWTH OF WORLD PETRO CHEMICAL CONSUMPTION: BY REGION AND PRODUCT

1980 - 1975

\REGIONS: \ PRODUCTS:\	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH) SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD* TOTAL
ABS	.049	.120	0.000	.106	.092	.168	0.000	-.097	0.000	.384	.097
ACETIC ACID	.059	0.000	0.000	-.070	-.032	.128	0.000	.056	.068	.185	.095
ACRYLONITRILE	.072	.061	.104	.025	.084	.194	0.000	0.000	0.000	.117	.067
AMMONIA	.046	.070	.037	.057	.068	.057	.061	.066	.133	0.000	.056
BUTADIENE	.016	.049	-.185	.060	.046	.103	0.000	0.000	.080	.287	.038
ETHYL BENZENE	.083	.057	.067	.049	.286	.195	0.000	0.000	.059	0.000	.076
ETHYLENE	.069	.077	.092	.046	.061	.164	0.000	.327	.122	.356	.078
ETHYLENE DICHLORIDE	.093	.067	.135	.067	-.061	.124	0.000	-.089	.016	.430	.086
EHTYLENE GLYCOL	.033	.047	.101	.059	.329	.104	0.000	0.000	.102	.213	.055
ETHYLENE OXIDE	.033	.028	.190	.017	.068	.208	0.000	0.000	.099	.846	.043
FORMALDEHYDE	.050	1.744	.067	.060	.074	.102	0.000	.286	.140	.104	.180
HDPE	.140	.093	.217	.122	.124	.198	0.000	.074	.153	.183	.132
LDPE	.078	.067	.080	.035	.094	.140	0.000	.110	.214	.086	.077
METHANOL	.080	.065	.067	.076	.090	.177	0.000	.117	.210	.114	.076
PET	.025	.045	.103	.128	.016	.099	0.000	.081	.206	.141	.068
PVC	.078	.060	.070	.063	.108	.148	0.000	.088	.132	.190	.079
POLYPROPYLENE	.127	.170	.084	.147	.163	.216	0.000	.084	.762	.204	.150
POLYSTYRENE	.056	.063	.074	.088	.101	.157	0.000	.035	.054	.210	.075
PROPYLENE	.092	.065	.084	.056	.126	.224	0.000	-.275	.131	.316	.084
SBR	-.017	.026	.036	.074	.027	.087	0.000	0.000	-.009	.262	.026
STYRENE	.056	.067	.070	.084	.153	.161	0.000	0.000	.035	.358	.076
VCM	.087	.055	.148	.051	.162	.174	0.000	0.000	-.018	.250	.088
VINYL ACETATE	-.001	.052	0.000	.043	.016	.127	0.000	.116	.046	.458	.040
V. A. AGRICULTURE	.015	-.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.004
V. A. MANUFACTURING	.047	.004	0.000	.093	0.000	0.000	0.000	0.000	0.000	0.000	.030
V. A. CONSTRUCTION	.014	.003	0.000	.070	0.000	0.000	0.000	0.000	0.000	0.000	.017
CONSUMPTION	.037	.034	0.000	.027	0.000	0.000	0.000	0.000	0.000	0.000	.035
GDP	.038	.037	.036	.030	.025	.056	.031	.059	.037	.069	.039
REGIONAL TOTAL	.062	.080	.056	.059	.084	.117	.069	.090	.131	.221	.074

SOURCE: ECONOMETRIC RESEARCH DATA FILES

* DOES NOT INCLUDE CENTRALLY PLANNED ASIAN ECONOMIES

World demand for butadiene is predicted to be about 5.7 million MT/y in 1985; this is about 50 per cent higher than its level in 1980 which translates into an annual growth rate of 8.3 per cent per year. The implied GDP elasticity of world demand for butadiene is 3.2. North America is expected to account for almost half of world consumption. The share of the developing countries is a meager 8.9 per cent. During the period 1980-1985, the demand for butadiene is expected to grow fastest in Eastern Europe.

World demand for methanol is forecast to exceed 12.4 million MT/y in 1985, a figure which represents a slight increase, of 9.9. per cent, over the 1980 level. The implied annual rate of growth is thus 1.9 per cent which translates into an output elasticity of less than one (0.73). Western Europe is the largest consumer followed closely by North America and Eastern Europe. Again the developing countries' consumption share of this product is not expected to exceed 9.3 per cent in 1985. The fastest rate of growth of methanol consumption is in South-East Asia, at 22.7 per cent per year, between 1980 and 1985.

The total demand for ammonia is forecast to excedd 90.4 million MT/y in 1985. This is almost 20 million MT/y above the 1980 level; which translates into an annual growth rate of 5.1 per cent between 1980 and 1985. North America is expected to be the largest market for ammonia, followed by Eastern Europe and South-East Asia. Japan's share of 2.9 per cent in 1985, is exceptionally low, given the intensive use of fertilizers there. The fastest growing demand for ammonia is in Latin America where it is expected to grow at the annual rate of 11.4 per cent between 1980 and 1985.

(b) Demand for intermediate petrochemical products, 1985

Not all of the intermediate products are of special concern to us and thus the discussion here is concentrated on a selected group of products that are tied to the basic block of products through the processing chains depicted in Figure 1.

World demand for ethylene dichloride, which is needed to produce VCM which in turn is needed to produce PVC, is forecast to be 19.4 million MT/y in 1985. This is about 13 per cent above the 1980 demand level and as such represents an average annual rate of growth of 2.4 per cent and less than one (.92) output elasticity over the period 1980-1985. North America and Western Europe each account for over a third of total world consumption of this product. The share of developing countries is slightly above 10 per cent.

Ethylene glycol is another intermediate product of special concern to the Arab region, as it is about to begin production of this product. Only 4.4 million MT/y are expected to be consumed of ethylene glycol in 1985, but this represents an almost 19 per cent increase over the 1980 level of consumption, which translates into an annual rate of growth of 3.1 per cent per year and an output elasticity of demand of 1.19. It is interesting to note that our system of equations predicts a rise in Arab demand for this product at the annual rate of 3.7 per cent. The largest growth in demand is expected to occur in South-East Asia. North America is expected to remain the major consuming region of this product, with a share of 51.9 per cent of total world consumption of ethylene glycol in 1985.

Since, logically, the chains of processing imply that ethylene oxide is demanded primarily for the production of ethylene glycol it is not surprising to see that the consumption patterns of these products parallel one another. The forecast demand for 1985 is 5.6 million MT/y; this is 16 per cent higher than the level of demand for this product in 1980. Much of the consumption of this product takes place in North America (over 50 per cent) and the other developed economies; the pattern in 1985, although marking a slight decline in the share of industrialized countries, is not much different from that which prevailed in the mid-1970s and early 1980s.

The forecast value of demand for acetic acid in 1985 exceeds 3.4 million MT/y; this is almost 20 per cent higher than the 1980 consumption level. An interesting characteristic of this product is the relatively larger share of developing countries in its total consumption, a phase that has grown rapidly since 1975 as the share of developed economies, particularly North America, has declined.

A substantial amount of ethyl-benzene consumption is forecast for 1985. The world consumption rate in that year is expected to be more than 13 million MT/y; this represents an increase of over 41 per cent over 1980. The implicit yearly growth rate between 1980 and 1985 is predicted to exceed

7.1 per cent. Again South-East Asian demand for this product is expected to grow fastest, at 13.3 per cent per year. The industrialized countries account for almost all of the demand, with the developing countries expected to represent no more than 5.5 per cent of total world consumption of this product in 1985.

World demand for acrylonitrile is predicted to be about 3.5 million MT/y in 1985. Again this represents a large increase over 1980 levels --almost 39 per cent more. Western European demand is expected to be the largest, at 33.4 per cent of the total; South-East Asia and Latin America together are expected to account for about 15 per cent of the world total.

The world demand for formaldehyde in 1985 is expected to reach 13.1 million MT/y which represents a significant 43 per cent increase over the level in 1980. Western Europe alone is projected to account for almost 50 per cent of world demand in 1985, while the developing countries combined will account for little over 10 per cent.

Vinyl-chloride-monomer is a second order intermediate petrochemical product which enters into the production of PVC. World demand in 1985 is forecast to exceed 13.7 million MT/y. This represents a modest 18.3 per cent increase over the 1980 demand for this product. Again, Western Europe is expected to the major consuming region with a 34.2 per cent share, North America is expected to account for 25 per cent of the world demand for this product and the developing countries combined will account for almost 15 per cent. The output elasticity of demand for this product over the period 1980-1985 is calculated to be 1.31. The highest rates of annual increase in demand are expected to be those in South Asia with a 13.5 per cent rate, while Japanese demand for this product is expected to decline at the rate of 1.9 per cent per year during the same period.

Styrene is a major intermediate product used mainly to produce polystyrene. World demand for styrene is predicted to reach 11.1 million MT/y in 1985. Demand for styrene is forecast to rise very rapidly between 1980 and 1985, at an average annual rate of increase of about 6.8 per cent. The output elasticity of demand for styrene is relatively high at 2.61. North America is expected to account for 40.1 per cent and Western Europe 27.8 per cent of total world demand for this product; developing countries are not expected to account for more than 9.5 per cent. In terms of rates of annual increases in demand for styrene between 1980-1975, South-East Asia dominates with 10.8 per cent rate; North America is a close second at 10.4 per cent. Even South Asia shows a rate of increase of over 9.3 per cent.

(c) Demand for final petrochemical products, 1985

Demand for plastics dominate other types of demands for final petrochemical products, and LDPE and HDPE together, as derivatives of ethylene, dominate plastics demand.

World demand for HDPE is forecast to reach 6.9 million MT/y in 1985, whereas LDPE is forecast to reach more than double this amount --14.0 million MT/y in the same year. In terms of rates of growth over the 1980 levels, the yearly increase in HDPE consumption during this period is expected to be 5.5 per cent, while that of LDPE is expected to be 4.4 per cent. Both of these products will display an elastic output demand, with HDPE at 2.11 and LDPE at 1.69. The consumption share of Western Europe exceeds that of North America for LDPE but falls below it for HDPE. The share of developing countries for both products is expected to be higher than that for basic and intermediate petrochemical products. For HDPE, it is expected to be over 16.2 per cent, while for LDPE the share will be about 17.8 per cent.

Demand for PET is generally lower than that for LDPE or HDPE. The forecast level of demand for this product in 1985 is expected to reach 5.8 million MT/y. This figure represents almost a 30 per cent increase over the 1980 consumption level. Interestingly, PET is expected to be consumed in major proportions by developing countries; their share in 1985 is forecast at 28.3 per cent, which is above the share of Japan and Western Europe combined. The output elasticity of the demand for PET during the period 1980-1985 is expected to be a high 2.04.

World demand for polypropylene is expected to reach 6.2 million MT/y in 1985; most of this amount will be consumed in North America and Western Europe; the developing countries will account for over 20 per cent of the total. The forecast demand in 1985 is about 30.5 per cent higher than the 1980 demand; this implies a yearly rate of increase of 5.5 per cent and an output elasticity of 2.11.

Polystyrene is yet another plastic and also one with considerable demand. The forecast level of world demand for polystyrene in 1985 is about 6.9 million MT/y or over 34 per cent above the corresponding 1980 level. North America will likely retain its dominant share of world consumption of polystyrene with 38.8 per cent, and the developing countries will likely account for no more than 15.5 per cent by 1985. The average annual increase in demand for polystyrene is expected to be 6.1 per cent, this gives rise to an output elasticity of demand of 2.34.

World demand for PVC in 1985 is expected to exceed 13.3 million MT/y. Although this amount is substantial, it represents only 17.7 per cent increase over the corresponding 1980 level. As is the case for most plastic products, Western European demand is the dominant regional demand, with an anticipated share of 31.9 per cent. Developing countries will consume a combined share of about 19.9 per cent of world demand for PVC in 1985. As a percentage of total regional petrochemical demands, PVC's share is highest in South-East Asia, and its share in other industrialized countries total is second highest. Given the low average annual rate of increase in PVC demand between 1980 and 1985, its output elasticity measured over the same period is 1.23.

The demand for SBR in 1985 is expected to reach 6.4 million MT/y. This represents a 35 per cent increase over the level of demand for SBR that existed in 1980. The implicit rate of growth of world demand for SBR is expected to be 6.2 per cent per year during the period 1980-1985, the corresponding output elasticity measure exceeds 2.38. The highest rate of demand increase for SBR is anticipated to occur in North America (11.3 per cent), while the corresponding West European rate of growth is less than one per cent. The high rate of growth projected for South Asian demand for SBR (8.5 per cent) is suggestive of a high rate of growth in the demand for rubber.

World demand for vinyl acetate is expected to be about 2 million MT/y in 1985. This represents a modest increase over the 1980 demand level of 1.7 million MT/y. The output elasticity of demand for vinyl acetate is roughly unitary. Industrialized countries are likely to account for over 85 per cent of total world demand for vinyl acetate in 1985. Latin America is the major consuming region of this product in the developing countries group.

Table 17

WORLD PETRO CHEMICAL CONSUMPTION BY REGION AND PRODUCT, 1985
(THOUSAND METRIC TONS/YEAR)

\REGIONS: PRODUCTS:\	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH) SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD* TOTAL
ABS	917.8	423.5	0.0	298.6	18.0	52.1	0.0	6.2	10.8	111.0	1838.2
ACETIC ACID	1431.1	1041.3	0.0	441.9	19.6	198.7	0.0	20.3	204.8	76.4	3434.0
ACRYLONITRILE	1016.5	1185.0	86.6	725.0	4.4	289.6	0.0	0.0	0.0	318.7	3545.8
AMMONIA	29963.6	16511.3	21771.2	2600.0	1264.0	6758.2	0.0	1655.0	10070.0	0.0	90393.3
BUTADIENE	2797.3	1357.0	112.5	820.2	72.6	315.8	0.0	0.0	36.7	152.1	5672.3
ETHYL BENZENE	6148.3	3403.1	862.0	1733.7	146.9	487.5	0.0	0.0	34.2	222.5	13008.9
ETHYLENE	16297.9	12158.6	3700.0	3913.5	456.2	1651.1	0.0	350.0	208.6	1370.2	39806.1
ETHYLENE DICHLORIDE	7179.1	7105.6	481.6	2421.3	209.1	688.6	0.0	57.2	73.9	1142.0	19364.3
ETHYLENE GLYCOL	2274.3	854.9	63.6	503.7	24.5	186.8	0.0	24.0	21.1	427.4	4380.2
ETHYLENE OXIDE	2108.8	1563.4	139.5	675.7	25.3	189.8	0.0	0.0	23.0	138.5	5560.9
FORMALDEHYDE	3408.6	6536.8	351.9	1171.5	130.0	476.1	0.0	79.8	61.0	724.3	13144.8
HDPE	2655.1	1684.1	800.0	466.7	175.9	468.4	0.0	110.6	77.4	464.9	6903.0
LDPE	3908.4	4543.4	1900.0	909.2	317.6	1092.8	0.0	550.0	125.4	741.7	14080.4
METHANOL	3520.1	3710.0	2927.0	1040.7	70.6	439.2	15.1	50.4	195.0	470.0	12423.0
PET	1872.4	833.5	541.8	760.4	69.9	491.3	0.0	28.6	69.4	1073.1	5825.7
PVC	3141.0	4232.6	1700.0	1223.9	321.4	851.2	2.0	505.0	107.0	1179.2	13261.3
POLYPROPYLENE	1186.6	1733.6	500.0	679.5	147.5	377.1	0.0	175.0	23.7	707.5	6272.5
POLYSTYRENE	2676.5	1876.7	568.0	616.3	84.1	417.7	0.0	150.0	19.5	481.8	6890.6
PROPYLENE	9086.1	7366.0	2125.0	3096.7	195.0	1006.8	0.0	12.5	81.5	669.8	23639.4
SBR	2531.5	1224.0	1214.6	619.7	49.3	406.3	0.0	13.3	33.0	265.2	6357.0
STYRENE	4448.9	3084.7	832.7	1537.6	147.1	593.4	0.0	0.0	29.7	425.0	11099.1
VCM	3449.1	4689.2	1877.8	1413.1	276.3	708.0	0.0	33.1	77.2	1180.2	13703.9
VINYL ACETATE	666.5	588.7	0.0	415.5	15.9	140.4	0.0	18.0	10.8	117.2	1972.9
REGIONAL TOTAL	114077.5	87506.8	42856.5	28092.5	4241.4	18142.9	17.2	3839.0	11600.4	12163.6	322537.8

SOURCE: ECONOMETRIC RESEARCH DATA FILES

* DOES NOT INCLUDE CENTRALLY PLANNED ASIAN ECONOMIES

Table 18

WORLD PETRO CHEMICAL CONSUMPTION BY REGION AND PRODUCT, 1985
(ROW PERCENTAEES)

PRODUCTS \ REGIONS	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH) SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WOPLD TOTAL
ABS	49.93	23.04	0.00	16.25	.98	2.84	0.00	.34	.59	6.04	100.00
ACETIC ACID	41.67	30.32	0.00	12.87	.57	5.79	0.00	.59	5.96	2.22	100.00
ACRYLONITRILE	28.67	33.42	2.44	20.45	.13	5.91	0.00	0.00	0.00	8.99	100.00
AMMCNIA	33.15	18.04	24.09	2.88	1.40	7.48	0.00	1.83	11.14	0.00	100.00
BUTADIENE	49.32	23.92	1.98	14.60	1.28	5.57	0.00	0.00	.65	2.68	100.00
ETHYL BENZENE	47.26	26.16	6.63	13.33	1.13	3.52	0.00	0.00	.26	1.71	100.00
ETHYLENE	40.94	30.54	9.30	9.83	1.15	4.15	0.00	.88	.52	2.69	100.00
ETHYLENE DICHLORIDE	37.07	36.69	2.49	12.50	1.08	3.56	0.00	.30	.41	5.90	100.00
ENTYLENE GLYCOL	51.92	19.52	1.45	11.50	.56	4.26	0.00	.55	.48	9.76	100.00
ETHYLENE OXIDE	50.51	28.11	2.51	12.15	.46	3.34	0.00	0.00	.43	2.49	100.00
FORMALDEHYDE	25.93	49.73	4.20	8.91	.99	3.62	0.00	.61	.46	5.55	100.00
HDPE	38.46	24.40	11.59	6.76	2.55	6.79	0.00	1.60	1.12	6.73	100.00
LDPE	27.70	32.27	13.49	6.46	2.26	7.76	0.00	3.91	.89	5.27	100.00
METHANOL	28.34	29.86	23.56	8.38	.57	3.54	0.00	.41	1.57	3.78	100.00
PET	32.14	14.31	11.02	13.85	1.20	7.92	.26	.49	1.19	18.42	100.00
PVC	23.69	31.92	12.82	9.23	2.42	6.42	0.00	3.81	.81	8.89	100.00
POLYPROPYLENE	30.27	27.82	8.02	10.90	2.37	6.05	.03	2.81	.38	11.35	100.00
POLYSTYRENE	38.84	27.24	8.24	8.94	1.22	6.06	0.00	2.18	.28	6.99	100.00
PROPYLENE	38.44	31.16	8.99	13.10	.83	4.26	0.00	.05	.34	2.83	100.00
SBR	39.82	19.25	19.11	9.75	.78	6.39	0.00	.21	.52	4.17	100.00
STYRENE	40.08	27.79	7.50	13.85	1.33	5.35	0.00	0.00	.27	3.83	100.00
VCM	25.17	34.22	13.78	10.31	2.02	5.17	0.00	.24	.56	8.61	100.00
VINYL ACETATE	33.78	29.84	0.00	21.06	.81	7.11	0.00	.91	.55	5.94	100.00
REGIONAL TOTAL	35.37	27.13	13.29	8.71	1.32	5.63	.01	1.19	3.60	3.77	100.00

SOURCE: ECONOMETRIC RESEARCH DATA FILES

Table 19

RATE OF GROWTH OF WORLD PETRO CHEMICAL CONSUMPTION: BY REGION AND PRODUCT

1985 - 1980

\REGIONS: PRODUCTS:\	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH) SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD* TOTAL
ABS	.178	.048	0.000	.056	.052	.071	0.000	.155	.166	.094	.109
ACETIC ACID	.006	.037	0.000	.047	.028	.074	0.000	-.041	.450	.064	.036
ACRYLONITRILE	.084	.050	.046	.072	.082	.079	0.000	0.000	0.000	.090	.068
AMMONIA	.057	.031	.032	.025	.014	.115	0.000	.066	.098	0.000	.051
BUTADIENE	.116	.045	.256	.056	.057	.040	0.000	0.000	.108	.090	.083
ETHYL BENZENE	.094	.039	.073	.066	.004	.068	0.000	0.000	.073	.130	.071
ETHYLENE	.036	.017	.036	-.012	.020	.052	0.000	.108	.061	.043	.026
ETHYLENE DICHLORIDE	.040	.016	.057	-.020	.125	.033	0.000	.054	.094	.048	.024
EHTYLENE GLYCOL	.021	.040	.087	.025	-.033	.051	0.000	.037	.102	.060	.031
ETHYLENE OXIDE	.024	.041	.098	.047	.003	.008	0.000	0.000	.083	-.016	.030
FORMALDEHYDE	.042	.118	.054	.009	.054	.046	0.000	.015	.032	.059	.074
HDPE	.060	.030	.149	-.032	.064	.074	0.000	.020	.087	.099	.055
LDPE	.041	.016	.116	.009	.055	.057	0.000	.083	.057	.097	.044
METHANOL	.006	.024	.022	-.015	.044	.050	0.000	.047	.227	.085	.019
PET	.032	.032	.080	.091	.053	.057	.002	.024	.086	.069	.053
PVC	.053	.015	.040	-.030	.054	.047	0.000	.076	.060	.083	.032
POLYPROPYLENE	.054	.069	.108	-.049	.077	.081	-.075	.239	.068	.082	.055
POLYSTYRENE	.107	.023	.075	-.018	.059	.076	0.000	.096	.085	.095	.061
PROPYLENE	.063	.052	.034	.035	.054	.077	0.000	.330	.060	.065	.054
SBR	.114	.009	.053	.041	.043	.025	0.000	.021	.085	.085	.062
STYRENE	.104	.029	.072	.047	.052	.076	0.000	0.000	.093	.108	.068
VCM	.047	.023	.069	-.019	.028	.031	0.000	.058	.135	.071	.034
VINYL ACETATE	.020	.037	0.000	-.009	.041	.070	0.000	-.011	.166	.082	.025
V. A. AGRICULTURE	.037	.027	0.000	.019	0.000	0.000	0.000	0.000	0.000	0.000	.029
V. A. MANUFACTURING	.040	.049	0.000	-.009	0.000	0.000	0.000	0.000	0.000	0.000	.037
V. A. CONSTRUCTION	.091	.026	0.000	-.033	0.000	0.000	0.000	0.000	0.000	0.000	.034
CONSUMPTION	.025	.014	0.000	.040	0.000	0.000	0.000	0.000	0.000	0.000	.021
GDP	.023	.016	.036	.034	.024	.037	0.000	.080	.037	.C41	.026
REGIONAL TOTAL	.055	.033	.043	.011	.036	.075	-.458	.075	.100	.072	.046

SOURCE: ECONOMETRIC RESEARCH DATA FILES

* DOES NOT INCLUDE CENTRALLY PLANNED ASIAN ECONOMIES

ABS is another petrochemical product with a relatively small world demand. The forecast demand for 1985 is slightly more than 1.8 million MT/y. However, this expected level is more than 67 per cent above the corresponding demand in 1980. The implicit annual growth rate between 1980-1975 is very high, at 10.9 per cent (actually this is the highest rate of world demand growth for any petrochemical product). Consequently, the forecast output elasticity is a substantial 4.19. The largest regional demand for ABS in 1985 will be in North America (50 per cent); the developing countries together will acount for less than 10 per cent.

These short term forecasts of world demand for petrochemicals suggest slower rates of growth than those experienced in 1960s and 1970s. Neverthelss, these rates of growth are expected to be higher than the world GDP growth rates. Actually, there is not a single petrochemical product, except methanol and EDC, whose demand growth between 1980 and 1985 is expected to be lower than the growth rate of world real GDP.

The fastest rates of growth in demand for petrochemical products are expected to be concentrated primarily in the developing countries and particularly in South-East Asia (which includes a large concentration of NICs - Newly Industrialized Countries) and the Arab region (which consists primarily of oil producing countries).

3.2.3 World demand for petrochemical products, 1990

The medium-term forecasts of world demand for petrochemical products portray a general improvement in the performance of this industry. World demand growth for petrochemical products between 1985 and 1990 is predicted to exceed 5.2 per cent per year, whereas real world GDP is expected to rise no faster than 3.6 per cent per year during the same period. South-East Asia, the Arab region, and Latin America are projected to show the highest rates of growth in the demand for petrochemicals. All regions except Japan are expected to experience highly elastic demands (with respect to output) for petrochemicals in 1990 (See Tables 20 - 23).

Rates of growth of demand for petrochemical products vary by product and region during this period, which fact explains the rationale behind our discussion of the forecasts by product groups.

Table 20

WORLD PETRO CHEMICAL CONSUMPTION BY REGION AND PRODUCT, 1990
(THOUSAND METRIC TONS/YEAR)

\REGIONS: \ PRODUCTS:\	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH) SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD* TOTAL
APS	1285.7	555.0	0.0	460.8	22.7	82.0	0.0	7.9	18.8	203.9	2636.9
ACETIC ACID	1576.1	1262.7	0.0	475.8	22.7	299.4	0.0	31.1	305.5	141.2	4113.8
ACRYLONITRILE	1330.6	1459.2	103.2	991.4	5.6	329.8	0.0	0.0	0.0	510.0	4729.9
AMMONIA	39223.9	20885.0	25957.2	2900.0	1594.3	10633.6	0.0	2283.0	13740.0	0.0	116417.0
BUTADIENE	3549.8	1616.0	136.2	1207.1	90.0	429.8	0.0	0.0	53.3	268.2	7350.3
ETHYL BENZENE	8178.2	4018.6	1123.5	2579.1	200.2	699.5	0.0	0.0	42.9	402.1	17244.0
ETHYLENE	20272.8	13835.6	4600.0	4162.2	584.5	2505.6	0.0	520.0	288.8	1828.7	48598.3
ETHYLENE DICHLORIDE	9810.2	8083.9	655.1	2814.3	280.7	1020.2	0.0	112.9	107.7	1922.4	24007.4
EHTYLENE GLYCOL	2667.6	986.5	87.6	682.2	31.1	265.5	0.0	20.0	28.9	705.6	5475.3
ETHYLENE OXIDE	3294.6	1804.1	192.1	915.2	32.1	264.5	0.0	0.0	32.6	228.7	6764.0
FORMALDEHYDE	4025.1	10543.1	712.7	1430.5	170.5	686.3	0.0	140.2	78.5	1108.2	18895.1
HDPE	3679.2	2066.2	1200.0	636.5	247.6	742.6	0.0	207.1	107.1	798.3	9684.6
LDPE	4854.0	5356.4	2375.0	1144.9	425.1	1616.3	0.0	750.0	180.5	1154.2	17856.4
METHANOL	3903.4	4440.6	3489.7	1184.0	92.7	648.7	0.0	85.2	283.9	755.0	14883.3
PET	2174.7	959.6	884.2	1253.5	88.6	656.6	37.6	39.3	102.1	1771.7	7967.8
PVC	3942.1	4815.4	2100.0	1422.5	431.6	1261.2	0.0	610.0	144.2	1985.0	16711.9
POLYPROPYLENE	2547.3	2410.1	800.0	837.7	218.5	610.2	2.4	220.0	37.6	1217.3	8901.0
POLYSTYRENE	3568.4	2158.1	747.7	808.0	114.5	634.8	0.0	180.0	24.5	813.3	9049.3
PROPYLENE	11988.0	9183.1	3048.0	4070.3	277.2	1616.2	0.0	250.0	111.9	1152.5	31697.3
SBR	3124.8	1299.1	1469.9	898.7	57.5	528.5	0.0	26.9	40.9	456.6	7992.9
STYRENE	5917.7	3642.6	1084.3	2287.4	200.6	987.0	0.0	0.0	37.3	768.1	14845.0
VCM	4328.8	5334.8	2554.3	1642.4	371.0	1048.9	0.0	65.3	104.0	1986.8	17436.4
VINYL ACETATE	734.1	713.9	0.0	446.6	18.5	211.4	0.0	27.6	16.1	216.7	2384.8
REGIONAL TOTAL	145177.1	106629.8	53320.9	35250.5	5577.3	27699.0	39.9	5576.4	15[illegible].0	20394.4	415552.9

SOURCE: ECONOMETRIC RESEARCH DATA FILES

* DOES NOT INCLUDE CENTRALLY PLANNED ASIAN ECONOMIES

Table 21

WORLD PETRO CHEMICAL CONSUMPTION BY REGION AND PRODUCT, 1990
(ROW PERCENTAGES)

REGIONS: / PRODUCTS:	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD TOTAL
ABS	48.76	21.05	0.00	17.47	.86	3.11	0.00	.30	.71	7.73	100.00
ACETIC ACID	38.31	30.69	0.00	11.55	.55	7.28	0.00	.76	7.43	3.43	100.00
ACRYLONITRILE	28.13	30.85	2.18	20.96	.12	6.97	0.00	0.00	0.00	10.78	100.00
AMMONIA	33.69	17.25	22.30	2.49	1.37	9.13	0.00	1.96	11.80	0.00	100.00
BUTADIENE	48.29	21.99	1.85	16.42	1.22	5.85	0.00	0.00	.73	3.65	100.00
ETHYL BENZENE	47.43	23.30	6.52	14.96	1.16	4.06	0.00	0.00	.25	2.33	100.00
ETHYLENE	41.72	28.47	9.47	8.56	1.20	5.16	0.00	1.07	.59	3.76	100.00
ETHYLENE DICHLORIDE	37.53	33.67	2.73	11.72	1.17	4.25	0.00	.47	.45	8.01	100.00
ENTYLENE GLYCOL	48.72	18.02	1.60	12.46	.57	4.86	0.00	.37	.53	12.89	100.00
ETHYLENE OXIDE	48.71	26.67	2.84	13.53	.47	3.91	0.00	0.00	.48	3.38	100.00
FORMALDEHYDE	21.38	55.80	3.77	7.57	.90	3.63	0.00	.74	.42	5.86	100.00
HDPE	37.99	21.34	12.39	6.57	2.56	7.67	0.00	2.14	1.11	8.24	100.00
LDPE	27.18	30.00	13.30	6.41	2.38	9.05	0.00	4.20	1.01	6.46	100.00
METHANOL	26.23	29.84	23.45	7.96	.62	4.36	0.00	.57	1.91	5.07	100.00
PET	27.29	12.04	11.10	15.73	1.11	8.24	.47	.45	1.28	22.24	100.00
PVC	23.59	28.81	12.57	8.51	2.58	7.55	0.00	3.65	.86	11.88	100.00
POLYPROPYLENE	28.62	27.08	8.99	9.41	2.45	6.85	.03	2.47	.42	13.68	100.00
POLYSTYRENE	39.43	23.85	8.26	8.93	1.27	7.01	0.00	1.99	.27	8.99	100.00
PROPYLENE	37.82	28.97	9.62	12.84	.87	5.18	0.00	.79	.35	3.64	100.00
SBR	39.54	16.44	18.60	11.37	.73	6.69	0.00	.34	.52	5.78	100.00
STYRENE	39.86	24.54	7.39	15.41	1.35	6.11	0.00	0.00	.25	5.17	100.00
VCM	24.83	30.60	14.65	9.42	2.13	6.02	0.00	.37	.60	11.39	100.00
VINYL ACETATE	30.78	29.94	0.00	18.73	.78	8.86	0.00	1.16	.67	9.09	100.00
REGIONAL TOTAL	34.94	25.66	12.83	8.48	1.34	6.67	.01	1.34	3.82	4.91	100.00

SOURCE: ECONOMETRIC RESEARCH DATA FILES

Table 22

RATE OF GROWTH OF WORLD PETRO CHEMICAL CONSUMPTION: BY REGION AND PRODUCT

1990 - 1980

\REGIONS: \ PRODUCTS:\	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH) SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD* TOTAL
ABS	.123	.052	0.000	.073	.050	.083	0.000	.102	.142	.111	.092
ACETIC ACID	.013	.038	0.000	.030	.029	.080	0.000	.022	.253	.097	.036
ACRYLONITRILE	.069	.046	.041	.068	.065	.087	0.000	0.000	0.000	.094	.064
AMMONIA	.056	.037	.034	.023	.031	.105	0.000	.066	.081	0.000	.051
BUTADIENE	.082	.040	.142	.067	.050	.052	0.000	0.000	.093	.105	.068
ETHYL BENZENE	.076	.036	.064	.074	.034	.078	0.000	0.000	.060	.128	.065
ETHYLENE	.040	.022	.040	-.000	.035	.069	0.000	.095	.064	.078	.033
ETHYLENE DICHLORIDE	.043	.021	.060	.005	.092	.057	0.000	.099	.078	.078	.034
EHTYLENE GLYCOL	.027	.035	.076	.044	.007	.062	0.000	0.000	.083	.082	.038
ETHYLENE OXIDE	.028	.035	.062	.055	.025	.040	0.000	0.000	.074	.043	.035
FORMALDEHYDE	.038	.109	.053	.025	.055	.061	0.000	.066	.042	.073	.076
HDPE	.064	.036	.116	.015	.067	.085	0.000	.075	.077	.107	.062
LDPE	.043	.025	.080	.028	.058	.069	0.000	.073	.066	.095	.046
METHANOL	.013	.030	.029	.005	.030	.065	0.000	.079	.150	.092	.028
PET	.031	.030	.073	.098	.061	.065	.096	.034	.083	.087	.059
PVC	.030	.021	.041	-.000	.057	.064	0.000	.057	.061	.096	.040
POLYPROPYLENE	.058	.069	.103	-.004	.079	.091	-.024	.139	.083	.098	.064
POLYSTYRENE	.083	.026	.066	.018	.062	.081	0.000	.066	.066	.103	.059
PROPYLENE	.060	.049	.054	.046	.063	.088	0.000	.556	.063	.090	.052
SBR	.078	.010	.046	.059	.037	.039	0.000	.084	.064	.100	.063
STYRENE	.081	.032	.063	.065	.058	.082	0.000	0.000	.070	.117	.064
VCM	.047	.025	.066	.005	.044	.056	0.000	.101	.098	.090	.042
VINYL ACETATE	.020	.038	0.000	.003	.036	.078	0.000	.038	.124	.106	.035
V. A. AGRICULTURE	.034	.018	0.000	.026	0.000	0.000	0.000	0.000	0.000	0.000	.024
V. A. MANUFACTURING	.041	.040	0.000	.027	0.000	0.000	0.000	0.000	0.000	0.000	.038
V. A. CONSTRUCTION	.069	.022	0.000	.007	0.000	0.000	0.000	0.000	0.000	0.000	.034
CONSUMPTION	.028	.021	0.000	.049	0.000	0.000	0.000	0.000	0.000	0.000	.027
GDP	.027	.022	.036	.045	.027	.046	.015	.065	.037	.055	.031
REGIONAL TOTAL	.052	.037	.044	.029	.046	.082	-.199	.076	.082	.090	.049

SOURCE: ECONOMETRIC RESEARCH DATA FILES

* DOES NOT INCLUDE CENTRALLY PLANNED ASIAN ECONOMIES

Table 23

RATE OF GROWTH OF WORLD PETRO CHEMICAL CONSUMPTION: BY REGION AND PRODUCT

1990 - 1985

\REGIONS: PRODUCTS:\	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH) SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD* TOTAL
ABS	.070	.056	0.000	.091	.048	.095	0.000	.050	.117	.129	.075
ACETIC ACID	.020	.039	0.000	.015	.030	.085	0.000	.089	.083	.131	.037
ACRYLONITRILE	.055	.043	.036	.065	.048	.095	0.000	0.000	0.000	.099	.059
AMMONIA	.055	.043	.036	.022	.048	.095	0.000	.066	.064	0.000	.052
BUTADIENE	.049	.036	.039	.078	.044	.064	0.000	0.000	.077	.120	.053
ETHYL BENZENE	.059	.034	.054	.083	.064	.089	0.000	0.000	.046	.126	.058
ETHYLENE	.045	.026	.045	.012	.051	.087	0.000	.082	.067	.113	.041
ETHYLENE DICHLORIDE	.046	.026	.063	.031	.061	.082	0.000	.146	.062	.110	.044
EHTYLENE GLYCOL	.032	.029	.066	.063	.048	.073	0.000	-.036	.065	.105	.046
ETHYLENE OXIDE	.032	.329	.066	.063	.048	.073	0.000	0.000	.065	.105	.040
FORMALDEHYDE	.034	.100	.052	.041	.056	.076	0.000	.119	.052	.097	.075
HDPE	.067	.042	.084	.064	.071	.097	0.000	.134	.067	.1[illegible]4	.070
LDPE	.045	.033	.046	.047	.060	.081	0.000	.064	.076	.092	.049
METHANOL	.021	.037	.036	.026	.056	.081	0.000	.111	.078	.099	.037
PET	.030	.029	.066	.105	.048	.073	.199	.066	.080	.105	.065
PVC	.046	.026	.043	.031	.061	.082	0.000	.039	.062	.110	.047
POLYPROPYLENE	.062	.068	.099	.043	.082	.101	.031	.047	.097	.115	.074
POLYSTYRENE	.059	.028	.057	.056	.064	.087	0.000	.037	.046	.110	.056
PROPYLENE	.057	.045	.075	.056	.073	.099	0.000	.821	.066	.115	.060
SBR	.043	.012	.039	.077	.030	.054	0.000	.151	.044	.115	.044
STYRENE	.059	.034	.054	.083	.064	.089	0.300	0.000	.046	.126	.060
VCM	.046	.026	.063	.031	.061	.082	0.000	.146	.062	.110	.049
VINYL ACETATE	.020	.039	0.000	.015	.030	.085	0.000	.089	.083	.131	.039
V. A. AGRICULTURE	.030	.009	0.000	.033	0.000	0.000	0.000	0.000	0.000	0.000	.019
V. A. MANUFACTURING	.043	.032	0.000	.065	0.000	0.000	0.000	0.000	0.000	0.000	.040
V. A. CONSTRUCTION	.048	.019	0.000	.048	0.000	0.000	0.000	0.000	0.000	0.000	.033
CONSUMPTION	.032	.027	0.000	.057	0.000	0.000	0.000	0.000	0.000	0.000	.033
GDP	.032	.027	.036	.057	.030	.055	.031	.050	.037	.070	.036
REGIONAL TOTAL	.049	.040	.045	.046	.056	.088	.184	.078	.065	.109	.052

SOURCE: ECONOMETRIC RESEARCH DATA FILES

* DOES NOT INCLUDE CENTRALLY PLANNED ASIAN ECONOMIES

(a) World demand for basic petrochemical products, 1990

World demand for methanol in 1990 is forecast to exceed 14.9 million MT/y. This represents a 40 per cent increase over the corresponding demand in 1980 and about 20 per cent over the 1985 level. Western European demand for methanol will become more dominant with a share of about 30 per cent of the total world demand for methanol. Developing countries together will acount for little less than 12 per cent of the total. Methanol output demand elasticity is almost unitary, implying that it is expected to maintain a constant fraction of GDP.

World demand for ammonia in 1990 is expected to remain very substantial--116.4 million MT/y or over 28 per cent of total world demand for petrochemical products. The level of demand forecast for ammonia in 1990 is almost 29 per cent higher than the demand level that prevailed in 1985; this translates into a rate of growth of about 5.2 per cent per year. The corresponding aggregate world output elasticity of demand for ammonia between 1985 and 1990 is 1.44; that is, increases in world GDP will lead to larger increases in world demand for ammonia. It is not surprising to find that the developing countries will represent a significant 23 per cent share of the market for ammonia in 1990, because of rapid growth of agriculture in these regions.

World demand for ethylene is projected to reach 48.6 million MT/y in 1990. The expected yearly average rate of growth in demand for ethylene between 1985-1990 is set at 4.1 per cent, whereas the 1980-1990 rate is projected to be 3.3 per cent. Thus, the rate of increase in demand between 1985 and 1990 is forecast to escalate above the rate expected to be achieved between 1980 and 1985. The elasticity of demand for ethylene with respect to output is expected to be in the neighbourhood of 1.14.

Ethylene is thus forecast to remain the major building block of petrochemical production, among the olefins; it is followed by propylene the world demand for which is projected to reach 31.7 million MT/y in 1990. The regional pattern of future demand for both products is indicative of the entrenched dominance of industrialized countries in these markets--together, industrialized countries will acount for about 90 per cent of the expected consumption of both products in 1990. It is worth noting here that although ethylene consumption is large and will continue to be larger than that of propylene, the rate at which demand for propylene is growing exceeds that of ethylene demand as is suggested by a propylene demand output elasticity measure of 1.67 compared to 1.14 for ethylene between 1985 and 1990.

World demand for butadiene is projected to amount to 7.3 million MT/y in 1990. This represents an increase of about 30 per cent over the corresponding 1985 expected level. The implicit yearly growth rate is about 5.3 per cent. This suggests that the growth in the demand for butadiene will exceed the rate of growth of world GDP; the implied output elasticity of demand for butadiene is 1.47.

The share of basic petrochemical products in total consumption of petrochemicals in 1990 is expected to exceed 52 per cent. The major consuming areas will be the developed countries. The largest share of developing countries in the world demand for basic products will remain that for ammonia.

(b) World demand for intermediate petrochemical products, 1990

A major share of world demand for intermediate petrochemical products is represented by the demand for ethylene dichloride, which in 1990 will reach 24 million MT/y. The expected annual rate of growth in demand for this product between 1985 and 1990 is put at 4.4 per cent. This suggests that the demand for EDC will be slightly above world real GDP growth; in other words, the implied elasticity with respect to GDP is 1.22. The dominance of the industrialized countries' share in world demand is still evident; however, this dominance is slightly lower than that enjoyed by them in the demand for basic petrochemical products.

World demand for ethylene oxide is expected to be a substantial 6.8 million MT/y. What is perhaps more significant here is the fact that although the demand for ethylene oxide will be growing faster than the rate of growth of world real GDP, the implied elasticity is still relatively low at 1.11. The share of developing countries in total world consumption of this products is expected to be rather low--less than 8 per cent--in 1990.

World demand for ethyl-benzene is forecast to be 17.2 million MT/y in 1990. North America is by far the largest consumer with an expected consumption share of 47.43 per cent in 1990. The developing countries again are expected to represent less than 7 per cent of world consumption, a situation that reflects low production rates of final products. The rate of growth of demand for ethyl-benzene between 1985-1990 is forecast to exceed 5.8 per cent per year.

More than 4.7 million MT/y are expected to be consumed of acrylonitrile by 1990. The industrialized countries will be the main consumers; Western Europe dominates, followed closely by North America and then Japan. The share of developing countries is expected to be relatively high, about 18 per cent. The implicit rate of growth of demand for this product is 5.9 per cent per year which is relatively high and should lead to higher absolute demands for this product in the future.

World demand for acetic acid in 1990 is expected to fall below 1 per cent of total world demand for petrochemical products. This share is not likely to change much as the elasticity measure for this product with respect to GDP growth is almost unitary. North America is expected to remain the largest consuming region in 1990; the developing regions, however, are expected to raise their share of total consumption to about 19 per cent from a share of 7.8 per cent in 1975.

The world demand for formaldehyde is forecast to be about 19 million MT/y in 1990; the rate of growth of demand for formaldehyde is expected to be 7.5 per cent per year throughout the 1980s; this translates into an output elasticity of about 2.08. Thus, it may be expected that formaldehyde's share in total world petrochemical consumption will continue to grow. However, recent environmental concerns about the use of formaldehyde may reverse this process.

Another intermediate product with an expected large demand is VCM. The world demand for VCM is forecast to reach 17.4 million MT/y which represents an average yearly growth of about 4.9 per cent between 1985 and 1990 and about 4.2 per cent between 1980 and 1990. Thus, the rates of growth of demand and share in total world demand for this product will likely rise in the 1990s.

World demand for ethylene glycol is forecast to be 5.5 million MT/y in 1990. This relatively small amount represents not more than 1.3 per cent of the expected total world demand for petrochemicals in 1990. North America is expected to remain the major consuming region with a consumption share of over 48.7 per cent in 1990. South-East Asia is the major consuming developing region with an expected share of 12.9 per cent (which is higher than that forecast for Japan) in 1990.

The last intermediate petrochemical product considered here is styrene, which is forecast to grow rapidly between 1985 and 1990 --at the rate of 6.0 per cent per year-- which is slightly lower than the rate that was forecast for the period 1975-1980, i.e. 6.8 per cent per year. North America will remain the dominant consuming region, and the developing countries are expected to represent only 12 per cent of total world demand for styrene in 1990.

(c) World demand for final petrochemical products, 1990

The largest forecast demand for final petrochemical products in 1990 is that for LDPE; a total of 17.8 million MT/y are expected to be consumed of this product. The yearly average rate of growth of demand for LDPE between 1985 and 1990 is forecast to be 4.9 per cent, this is higher than the 4.6 per cent predicted to prevail during the entire 1980-1990 period. Thus, the demand for LDPE is expected to accelerate in the middle to late 1980s. Western Europe is projected to remain the major consuming region of LDPE in 1990, with a share of 30 per cent. The share of developing countries is predicted to be slightly above 19 per cent.

World demand for HDPE in 1990 is forecast to reach 9.7 million MT/y. This is significantly lower than LDPE demand in the same year; however, the rate of growth of demand for HDPE during the periods 1985-1990 and 1980-1990 is also significantly higher than that of LDPE. In fact, the demand for HDPE is predicted to grow at an annual rate of 7.0 per cent during the period 1985-1990 and at an annual rate of 6.2 per cent during the entire period 1980-1990. Consequently, the demand for HDPE will increase in the latter half of the 1980s. Whereas Western Europe accounts for the largest share of LDPE consumption, North America accounts for the dominant share of total consumption of HDPE, with an expected share of 38 per cent in 1990. Developing countries as a group account for a share of 19.2 per cent in the same year.

The demand for PET in 1990 is projected to be about 8 million MT/y. This level is bound to rise given its annual rate of increase of 6.4 per cent per year between 1985 and 1990 which is significantly larger than the 5.2 per cent average annual increase in total world demand for petrochemicals during the same period. Both South-East Asia and Japan are expected to experience significant increases in their demand for this product, whereas the regional output elasticities for this product in North America and Western Europe are both below one in this period.

World demands for polypropylene and polystyrene are estimated to be 8.9 and 9.0 million MT/y in 1990, respectively. The corresponding demand for PVC is almost equal to the sum of both the demands for polypropylene and polystyrene in the same year. These proportions are bound to change, as the rates of growth in the demand for these products are not equal. During the period 1985-1990, the demand for polypropylene is forecast to grow at the annual rate of 7.4 per cent, whereas the demand for polystyrene and for PVC will grow at the annual rate of 5.6 per cent and 4.7 per cent, respectively.

North America and Western Europe are expected to remain the major consumers of polypropylene in 1990, but the consumption levels of developing countries are expected to account for about 23.5 per cent in the same year. In the case of polystyrene, North America's demand is clearly dominant, with an expected share of about 40 per cent of world demand for this product in 1990; the corresponding share of the developing countries is forecast to be only 18.3 per cent.

The regional consumption patterns of PVC are closer to those of polypropylene than to polystyrene. North America's demand is smaller than Western Europe's, and the developing countries as a group account for about 24 per cent of total world demand for this product in 1990.

World demand for SBR is expected to exceed 7.9 million MT/y in 1990. During the period 1985-1990, demand for SBR will grow at the rate of 4.4 per cent per year, whereas the world demand is expected to grow at 5.2 per cent per year.

World demands for both ABS and vinyl acetate are forecast to be less than 3 million MT/y in 1990; actually, the level of demand for ABS is predicted to reach 2.6 million MT/y, and for vinyl acetate, 2.4 million MT/y. North American demand for ABS will dominate all other regional demands in 1990, whereas it will be equal to Western Europe's demand for vinyl acetate. The share of developing countries in total world demand for ABS is projected to be equal to about 12 per cent, whereas it will reach almost 20 per cent of total world demand for vinyl acetate in 1990.

The medium-term forecasts highlight a number of consistent events and trends. First, the share of developing countries in world demand for petrochemicals is increasing, particularly in the consumption of final products. The developing countries' smaller shares of world demand for basic and intermediate products are symptomatic of a lack of operational production facilities in these regions. Secondly, world demand for petrochemicals is generally output (GDP) elastic, in the sense that increases in GDP in most regions are lower than increases in the demand for petrochemical products. Finally, South-East Asia is predicted to be the fastest growing consumer of petrochemical products.

3.2.4 World demand for petrochemical products in the year 2000

Although forecasts of the world demand for petrochemical products were generated for the intermediate period 1990-1995, only the results of these forecasts will be presented. The discussion in this section is restricted to the forecasts for the year 2000.

These long-term forecasts can be best evaluated by comparing them to the situation existing in 1980. Only then is it possible to portray the emerging trends and structural changes that are expected to take place. For 1995 see Tables 24 to 27, for 2000 see Tables 28 to 31.

(a) World demand for basic petrochemical products in the year 2000

World demand for basic petrochemical products is forecast to more than double between 1980 and the year 2000. In fact, the level of total demand for basic petrochemical products is predicted to exceed 332.0 million MT/y, a figure that is 2.5 times the corresponding level in 1980.

Demand for ammonia at 183.4 million MT/y will still dominate other demands for petrochemicals. The average annual rate of growth in the demand for ammonia between 1980 and 2000 is predicted to be 4.9 per cent, which is exactly equal to the rate of growth of the total world demand for petrochemicals over the same period. Consequently, the share of ammonia in total world demand for petrochemicals, which was 27.9 per cent in 1980, will remain at 28.1 per cent in the year 2000. Developing countries' consumption of ammonia is expected to account for about 25 per cent of the total world demand for this product in the year 2000. This represents a substantial increase over the 1980 share of 17 per cent. The share of industrialized countries will decline, except for that of North America; a major decrease will occur in the share of Eastern Europe's consumption.

World demand for methanol will reach 21.6 million MT/y in the year 2000. This is less than double the level of demand in 1980; thus, the rate of growth of demand for this product will fall short of the overall rate of increase in demand for petrochemicals. The anticipated average annual increase in demand for methanol between 1980 and 2000 is only 3.3 per cent, a figure slightly below the rate of growth of world real GDP. The share of developing countries in total consumption of methanol will rise, as the rates of growth of their respective demands over the period 1980-2000 are relatively high. The annual rate of growth of Latin American demand for methanol will be 6.8 per cent, that of the Arab region 8 per cent during the same period. By the year 2000, developing countries will account for about 17 per cent of the world total consumption of methanol, whereas they represented less than 7 per cent in 1980.

Table 24

WORLD PETRO CHEMICAL CONSUMPTION BY REGION AND PRODUCT, 1995
(THOUSAND METRIC TONS/YEAR)

\REGIONS: \ PRODUCTS: \	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH) SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD* TOTAL
ABS	1741.0	705.6	0.0	674.7	28.2	121.2	0.0	10.1	28.4	333.7	3643.7
ACETIC ACID	1745.8	1516.1	0.0	516.9	26.4	431.1	0.0	44.9	426.2	231.9	4939.3
ACRYLONITRILE	1716.9	1772.9	123.1	1336.7	7.0	487.2	0.0	0.0	0.0	777.8	6221.6
AMMONIA	50612.7	24403.2	30948.1	3100.0	1977.9	15787.3	0.0	3148.0	16700.0	0.0	146597.2
BUTADIENE	4495.5	1912.4	164.4	1706.5	110.1	579.1	0.0	0.0	77.1	430.6	9471.7
ETHYL BENZENE	10652.7	4722.9	1434.3	3694.3	262.3	1016.0	0.0	0.0	53.3	653.4	22489.3
ETHYLENE	24926.9	15754.6	5720.0	4452.2	733.6	3624.4	0.0	816.0	385.0	2890.2	59302.9
ETHYLENE DICHLORIDE	11151.9	9203.4	862.0	3310.1	363.9	1454.4	0.0	184.1	141.0	3014.5	29685.2
EHTYLENE GLYCOL	3129.4	1137.7	116.3	920.8	38.7	369.4	0.0	36.0	38.3	1094.9	6881.5
ETHYLENE OXIDE	3865.0	2080.6	254.9	1235.3	40.0	367.6	0.0	0.0	43.2	355.0	3241.5
FORMALDEHYDE	4746.2	15127.6	904.4	1784.8	217.7	961.8	0.0	217.5	99.5	1638.5	23697.6
HDPE	4876.9	2503.5	1600.0	857.1	331.0	1101.7	0.0	330.3	142.7	1264.8	13008.0
LDPE	5969.3	6286.8	2846.9	1456.0	550.0	2301.6	0.0	1274.0	246.6	1731.5	22662.7
METHANOL	4351.7	5276.7	4160.7	1392.0	118.3	923.0	0.0	129.8	390.5	1153.9	17896.5
PET	2528.1	1103.9	1173.1	1904.1	110.3	912.3	63.7	52.9	141.3	2745.4	10739.1
PVC	4879.1	5482.3	2370.8	1673.1	559.5	1797.9	0.0	1004.0	188.8	3112.7	21148.2
POLYPROPYLENE	3319.9	3184.2	1237.0	1837.4	380.9	915.2	2.7	353.0	54.3	1930.8	12335.5
POLYSTYRENE	4654.8	2480.1	962.1	1064.0	149.8	919.1	0.0	482.0	30.5	1277.1	12019.5
PROPYLENE	15463.7	11262.5	4375.0	5337.8	372.7	2414.1	0.0	350.0	148.3	1828.0	41552.8
SBR	3875.1	1385.1	1774.4	1266.4	66.8	688.5	0.0	44.2	56.3	724.5	9875.3
STYRENE	7708.3	4281.0	1384.3	3276.5	262.8	1317.7	0.0	0.0	46.4	1248.1	19524.9
VCM	5357.7	6073.6	3361.0	1931.8	481.0	1495.3	0.0	106.5	136.2	3115.4	22058.6
VINYL ACETATE	813.1	857.2	0.0	485.9	21.5	304.4	0.0	39.3	22.4	356.0	2900.2
REGIONAL TOTAL	182582.6	128514.0	65772.7	44414.4	7130.2	40210.0	66.4	8703.0	19586.2	31912.6	528892.1

SOURCE: ECONOMETRIC RESEARCH DATA FILES

* DOES NOT INCLUDE CENTRALLY PLANNED ASIAN ECONOMIES

Table 25

WORLD PETRO CHEMICAL CONSUMPTION BY REGION AND PRODUCT, 1995
(ROW PERCENTAGES)

\REGIONS: \ PRODUCTS: \	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH) SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD TOTAL
ABS	47.80	19.36	0.00	18.52	.77	3.33	0.00	.28	.78	9.16	100.00
ACETIC ACID	35.35	30.70	0.00	10.46	.53	8.73	0.00	.91	8.63	4.69	100.00
ACRYLONITRILE	27.60	28.50	1.98	21.48	.11	7.83	0.00	0.00	0.00	12.50	100.00
AMMONIA	34.53	16.65	21.11	2.11	1.35	10.71	0.00	2.15	11.39	0.00	100.00
BUTADIENE	47.46	28.19	1.74	18.02	1.16	6.11	0.00	0.00	.77	4.55	100.00
ETHYL BENZENE	47.37	21.00	6.38	16.43	1.17	4.52	0.00	0.00	.24	2.91	100.00
ETHYLENE	42.03	26.57	9.65	7.51	1.24	6.11	0.00	1.30	.65	4.87	100.00
ETHYLENE DICHLORIDE	37.57	31.00	2.90	11.15	1.23	4.90	0.00	.62	.48	10.15	100.00
EHTYLENE GLYCOL	45.48	16.53	1.69	13.38	.56	5.37	0.00	.52	.56	15.91	100.00
ETHYLENE OXIDE	46.90	25.25	3.09	14.99	.48	4.46	0.00	0.00	.52	4.31	100.00
FORMALDEHYDE	18.47	50.87	3.52	6.95	.85	3.74	0.00	.85	.39	6.38	100.00
HDPE	37.49	19.25	12.30	6.59	2.54	8.47	0.00	2.54	1.10	9.72	100.00
LDPE	26.34	27.74	12.56	6.42	2.43	10.16	0.00	5.62	1.09	7.64	100.00
METHANOL	24.32	29.48	23.25	7.78	.66	5.16	0.00	.73	2.18	6.45	100.00
PET	23.54	10.28	10.92	17.73	1.03	8.50	.59	.49	1.32	25.60	100.00
PVC	23.07	25.92	11.21	7.91	2.65	8.50	0.00	5.13	.89	14.72	100.00
POLYPROPYLENE	26.91	25.81	10.03	8.41	2.44	7.42	.82	2.86	.44	15.65	100.00
POLYSTYRENE	30.73	20.63	8.00	8.85	1.25	7.65	0.00	4.01	.25	10.62	100.00
PROPYLENE	37.22	27.10	10.53	12.85	.90	5.81	0.00	.84	.36	4.40	100.00
SBR	39.24	14.03	17.97	12.82	.68	6.97	0.00	.45	.51	7.34	100.00
STYRENE	39.48	21.93	7.09	16.78	1.35	6.75	0.00	0.00	.24	6.39	100.00
VCM	24.29	27.53	15.24	8.76	2.18	6.78	0.00	.48	.62	14.12	100.00
VINYL ACETATE	28.04	29.56	0.00	16.75	.74	10.50	0.00	1.37	.77	12.27	100.00
REGIONAL TOTAL	34.52	24.30	12.44	8.40	1.35	7.60	.01	1.65	3.70	6.03	100.00

SOURCE: ECONOMETRIC RESEARCH DATA FILES

Table 26

RATE OF GROWTH OF WORLD PETRO CHEMICAL CONSUMPTION: BY REGION AND PRODUCT

1995 - 1980

\REGIONS: PRODUCTS:\	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH) SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD* TOTAL
ABS	.102	.051	0.000	.075	.048	.082	0.000	.084	.123	.109	.083
ACETIC ACID	.015	.038	0.000	.026	.030	.078	0.000	.040	.186	.099	.037
ACRYLONITRILE	.064	.044	.039	.066	.058	.085	0.000	0.000	0.000	.092	.061
AMMONIA	.055	.038	.035	.020	.035	.097	0.000	.066	.067	0.000	.050
BUTADIENE	.071	.038	.107	.069	.047	.055	0.000	0.000	.083	.103	.063
ETHYL BENZENE	.069	.035	.059	.074	.041	.078	0.000	0.000	.055	.119	.061
ETHYLENE	.041	.023	.042	.004	.039	.072	0.000	.095	.063	.084	.036
ETHYLENE DICHLORIDE	.043	.023	.059	.014	.079	.063	0.000	.100	.070	.084	.037
EHTYLENE GLYCOL	.029	.033	.070	.050	.019	.064	0.000	.040	.075	.085	.041
ETHYLENE OXIDE	.029	.033	.061	.057	.032	.049	0.000	0.000	.068	.059	.037
FORMALDEHYDE	.037	.098	.052	.032	.053	.064	0.000	.075	.044	.076	.071
HDPE	.062	.037	.097	.030	.065	.084	0.000	.083	.071	.103	.062
LDPE	.043	.027	.066	.035	.056	.070	0.000	.086	.066	.091	[illegible]
METHANOL	.016	.032	.031	.014	.050	.068	0.000	.082	.121	.091	[illegible]
PET	.031	.030	.068	.095	.049	.066	.101	.043	.078	.089	.060
PVC	.048	.022	.036	.011	.056	.067	0.000	.078	.059	.096	.042
POLYPROPYLENE	.057	.065	.099	.012	.075	.089	-.006	.125	.080	.098	.065
POLYSTYRENE	.073	.026	.061	.031	.059	.080	0.000	.114	.058	.100	.058
PROPYLENE	.058	.046	.061	.049	.063	.087	0.000	.373	.061	.092	.057
SBR	.066	.011	.043	.063	.035	.044	0.000	.091	.057	.099	.051
STYRENE	.072	.032	.059	.068	.057	.081	0.000	0.000	.061	.112	.061
VCM	.046	.025	.063	.014	.047	.062	0.000	.101	.083	.091	.044
VINYL ACETATE	.020	.038	0.000	.008	.034	.077	0.000	.050	.105	.106	.035
V. A. AGRICULTURE	.032	.015	0.000	.028	0.000	0.000	0.000	0.000	0.000	0.000	.022
V. A. MANUFACTURING	.042	.037	0.000	.039	0.000	0.000	0.000	0.000	0.000	0.000	.039
V. A. CONSTRUCTION	.062	.021	0.000	.020	0.000	0.008	0.000	0.000	0.000	0.000	.034
CONSUMPTION	.030	.023	0.000	.051	0.000	0.000	0.000	0.000	0.000	0.000	.029
GDP	.029	.024	.036	.049	.028	.049	.020	.060	.037	.060	.033
REGIONAL TOTAL	.050	.037	.044	.035	.048	.080	-.108	.082	.069	.091	.049

SOURCE: ECONOMETRIC RESEARCH DATA FILES

* DOES NOT INCLUDE CENTRALLY PLANNED ASIAN ECONOMIES

Table 27

RATE OF GROWTH OF WORLD PETRO CHEMICAL CONSUMPTION: BY REGION AND PRODUCT

1995 - 1990

\REGIONS: PRODUCTS:\	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH) SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD* TOTAL
ABS	.063	.049	0.000	.079	.044	.081	0.000	.050	.086	.104	.067
ACETIC ACID	.021	.037	0.000	.017	.030	.076	0.000	.076	.069	.104	.037
ACRYLONITRILE	.052	.040	.036	.062	.044	.081	0.000	0.000	0.000	.088	.056
AMMONIA	.052	.040	.036	.013	.044	.081	0.000	.066	.040	0.000	.047
BUTADIENE	.048	.034	.038	.072	.041	.061	0.000	0.000	.065	.099	.052
ETHYL BENZENE	.054	.033	.050	.075	.055	.078	0.000	0.000	.045	.102	.055
ETHYLENE	.042	.026	.045	.014	.046	.077	0.000	.094	.059	.096	.041
ETHYLENE DICHLORIDE	.044	.026	.056	.033	.053	.073	0.000	.103	.055	.094	.043
EHTYLENE GLYCOL	.032	.029	.058	.062	.045	.068	0.000	.125	.058	.092	.047
ETHYLENE OXIDE	.032	.029	.058	.062	.045	.068	0.000	0.000	.058	.092	.040
FORMALDEHYDE	.034	.075	.049	.045	.050	.070	0.000	.092	.049	.081	.063
HDPE	.058	.039	.059	.061	.060	.082	0.000	.098	.059	.096	.061
LDPE	.042	.033	.037	.049	.053	.073	0.000	.112	.064	.084	.049
METHANOL	.022	.035	.036	.033	.050	.073	0.000	.088	.066	.089	.038
PET	.031	.028	.058	.087	.045	.068	.111	.062	.067	.092	.062
PVC	.044	.026	.025	.033	.053	.073	0.000	.122	.055	.094	.048
POLYPROPYLENE	.054	.057	.091	.044	.066	.084	.031	.099	.076	.097	.067
POLYSTYRENE	.055	.028	.052	.057	.055	.077	0.000	.218	.045	.094	.058
PROPYLENE	.052	.042	.075	.056	.061	.084	0.000	.070	.058	.097	.056
SBR	.044	.013	.038	.071	.030	.054	0.000	.105	.042	.097	.046
STYRENE	.054	.033	.050	.075	.055	.078	0.000	0.000	.045	.102	.056
VCM	.044	.026	.056	.033	.053	.073	0.000	.103	.055	.094	.048
VINYL ACETATE	.021	.037	0.000	.017	.030	.076	0.000	.076	.069	.104	.040
V. A. AGRICULTURE	.030	.009	0.000	.033	0.000	0.000	0.000	0.000	0.000	0.000	.019
V. A. MANUFACTURING	.043	.032	0.000	.065	0.000	0.000	0.000	0.000	0.000	0.000	.041
V. A. CONSTRUCTION	.048	.019	0.000	.048	0.000	0.000	0.000	0.000	0.000	0.000	.034
CONSUMPTION	.032	.027	0.000	.057	0.000	0.000	0.000	0.000	0.000	0.000	.033
GDP	.032	.027	.036	.057	.030	.055	.031	.050	.037	.070	.037
REGIONAL TOTAL	.047	.038	.043	.047	.050	.077	.107	.093	.043	.094	.049

SOURCE: ECONOMETRIC RESEARCH DATA FILES

* DOES NOT INCLUDE CENTRALLY PLANNED ASIAN ECONOMIES

Table 28

WORLD PETRO CHEMICAL CONSUMPTION BY REGION AND PRODUCT, 2000
(THOUSAND METRIC TONS/YEAR)

\REGIONS: \ PRODUCTS:\	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH) SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD* TOTAL
ABS	2307.9	877.8	0.0	957.1	34.6	172.4	0.0	12.9	39.9	515.5	4918.1
ACETIC ACID	1944.3	1806.1	0.0	569.6	33.7	683.6	0.0	62.5	570.9	358.8	5946.4
ACRYLONITRILE	2192.6	2131.9	148.8	1783.5	8.5	693.3	0.0	0.0	0.0	1152.6	8109.1
AMMONIA	64635.1	29344.6	36898.5	3400.0	2423.6	22349.9	0.0	4342.0	20000.0	0.0	183393.6
BUTADIENE	5684.6	2251.5	198.0	2364.7	173.5	774.5	0.0	0.0	96.9	658.0	12161.7
ETHYL BENZENE	13673.8	5528.9	1804.9	5165.3	334.3	1430.6	0.0	0.0	65.9	1005.1	29008.7
ETHYLENE	30376.4	17950.6	7200.0	4785.1	906.8	5069.0	0.0	1193.0	500.3	4375.6	72377.8
ETHYLENE DICHLORIDE	13656.7	10484.5	1108.6	3935.8	460.6	2022.8	0.0	275.1	180.9	4542.7	36667.8
EHTYLENE GLYCOL	3671.9	1311.3	150.4	1240.1	47.5	505.0	0.0	50.0	49.5	1639.8	8665.5
ETHYLENE OXIDE	4535.0	2398.2	329.8	1663.7	49.1	502.4	0.0	0.0	55.9	531.6	10065.6
FORMALDEHYDE	5589.5	20373.8	1133.0	2269.4	272.4	1391.7	0.0	316.3	124.6	2380.5	33781.4
HDPE	6277.7	3003.9	2300.0	1144.1	427.9	1571.7	0.0	487.9	185.4	1917.6	17316.2
LDPE	7273.7	7351.5	3647.7	1866.5	695.1	3198.8	0.0	1741.0	325.8	2539.3	28639.4
METHANOL	4876.0	6233.4	4960.7	1692.2	148.1	1282.1	0.0	186.7	518.2	1712.1	21609.5
PET	2941.6	1269.0	1517.7	2762.6	135.5	1247.1	94.0	70.4	188.2	4117.4	14343.5
PVC	5975.1	6245.4	3049.2	1989.3	708.1	2500.6	0.0	1516.0	242.2	4690.8	26916.6
POLYPROPYLENE	4223.7	4070.1	2400.0	1289.2	396.7	1314.7	3.2	521.0	74.3	2929.2	17222.1
POLYSTYRENE	5980.0	2848.5	1217.6	1486.6	190.9	1291.3	0.0	716.0	37.7	1926.1	15614.7
PROPYLENE	19631.5	13642.0	8044.0	6987.5	483.6	3458.6	0.0	750.0	192.0	2773.3	55962.5
SBR	4823.9	1483.5	2137.4	1751.0	77.6	898.0	0.0	66.3	61.7	1099.4	12398.7
STYRENE	9894.3	5011.5	1741.9	4581.1	334.9	1855.3	0.0	0.0	57.2	1919.9	25396.3
VCM	6561.2	6919.0	4322.7	2296.9	608.7	2079.8	0.0	159.2	174.8	4694.9	27817.1
VINYL ACETATE	905.5	1021.1	0.0	535.5	25.0	426.2	0.0	55.4	30.0	550.8	3549.6
REGIONAL TOTAL	227632.1	153558.2	84308.9	56438.0	8933.4	56589.5	97.2	12521.6	23772.2	48031.0	671182.0

SOURCE: ECONOMETRIC RESEARCH DATA FILES

* DOES NOT INCLUDE CENTRALLY PLANNED ASIAN ECONOMIES

Table 29

WORLD PETRO CHEMICAL CONSUMPTION BY REGION AND PRODUCT, 2000
(ROW PERCENTAGES)

\REGIONS: \ PRODUCTS:\	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH) SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD TOTAL
AES	46.93	17.85	0.00	19.46	.70	3.51	0.00	.26	.81	10.48	100.00
ACETIC ACID	32.70	30.37	0.00	9.58	.52	10.19	0.00	1.05	9.60	6.03	100.00
ACRYLONITRILE	27.04	26.29	1.81	21.99	[illegible]	8.59	0.00	0.00	0.00	14.21	100.00
AMMONIA	35.24	16.00	20.12	1.86	1.32	[illegible]	0.00	2.37	10.91	0.00	100.00
BUTADIENE	46.74	18.51	1.63	19.44	[illegible]	6.37	0.00	0.00	.80	5.41	100.00
ETHYL BENZENE	47.14	19.06	6.22	17.81	[illegible]	4.93	0.00	0.00	.23	3.46	100.00
ETHYLENE	41.97	24.00	9.95	6.61	[illegible]	7.03	0.00	1.65	.69	6.05	100.00
ETHYLENE DICHLORIDE	37.24	28.59	3.02	10.73	1.26	5.52	0.00	.75	.49	12.39	100.00
EHTYLENE GLYCOL	42.37	15.13	1.74	14.31	.55	5.83	0.00	.58	.57	18.92	100.00
ETHYLENE OXIDE	49.05	23.83	3.28	16.53	.49	4.99	0.00	0.00	.55	5.28	100.00
FORMALDEHYDE	16.55	60.31	3.35	6.72	.81	3.91	0.00	.94	.37	7.05	100.00
HDPE	36.25	17.35	13.28	6.61	2.47	9.08	0.00	2.82	1.07	11.07	100.00
LDPE	25.40	25.67	12.74	6.52	2.43	11.17	0.00	6.08	1.14	8.87	100.00
METHANOL	22.56	28.85	22.96	7.83	.69	5.93	0.00	.86	2.40	7.92	100.00
PET	20.51	8.85	10.58	19.26	.94	8.69	.66	.49	1.31	28.71	100.00
PVC	22.20	23.20	11.33	7.39	2.63	9.29	0.00	5.63	.90	17.43	100.00
POLYPROPYLENE	24.52	23.63	13.94	7.49	2.30	7.63	.02	3.03	.43	17.01	100.00
POLYSTYRENE	38.30	18.24	7.80	9.01	1.22	8.27	0.00	4.59	.24	12.34	100.00
PROPYLENE	35.08	24.38	14.37	12.49	.86	6.18	0.00	1.34	.34	4.96	100.00
SBR	38.91	11.96	17.24	14.12	.63	7.24	0.00	.53	.50	8.87	100.00
STYRENE	38.96	19.73	6.86	18.04	1.32	7.31	0.00	0.00	.23	7.56	100.00
VCM	23.59	24.87	15.54	8.26	2.19	7.48	0.00	.57	.63	16.88	100.00
VINYL ACETATE	25.51	28.77	0.00	15.09	.70	12.01	0.00	1.56	.85	15.52	100.00
REGIONAL TOTAL	33.88	22.85	12.55	8.40	1.33	8.42	.01	1.86	3.54	7.15	100.00

SOURCE: ECONOMETRIC RESEARCH DATA FILES

Table 30

RATE OF GROWTH OF WORLD PETRO CHEMICAL CONSUMPTION: BY REGION AND PRODUCT

2000 - 1980

REGIONS: / PRODUCTS:	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD* TOTAL
ABS	.091	.049	0.000	.075	.046	.080	0.000	.076	.109	.104	.078
ACETIC ACID	.017	.037	0.000	.024	.030	.076	0.000	.047	.155	.097	.037
ACRYLONITRILE	.060	.043	.038	.064	.054	.082	0.000	0.000	0.000	.090	.060
AMMONIA	.054	.038	.035	.020	.037	.091	0.000	.066	.059	0.000	.049
BUTADIENE	.065	.037	.089	.068	.045	.056	0.000	0.000	.077	.099	.060
ETHYL BENZENE	.064	.034	.056	.073	.043	.076	0.000	0.000	.052	.112	.059
ETHYLENE	.041	.024	.043	.007	.040	.071	0.000	.091	.060	.084	.037
ETHYLENE DICHLORIDE	.043	.024	.057	.020	.071	.064	0.000	.096	.065	.084	.039
EHTYLENE GLYCOL	.030	.032	.066	.053	.025	.064	0.000	.047	.069	.085	.043
ETHYLENE OXIDE	.030	.032	.059	.058	.034	.053	0.000	0.000	.065	.065	.038
FORMALDEHYDE	.036	.089	.050	.036	.051	.064	0.000	.075	.045	.076	.067
HDPE	.059	.037	.091	.037	.062	.081	0.000	.082	.067	.099	.061
LDPE	.042	.028	.062	.039	.054	.070	0.000	.081	.064	.088	.047
METHANOL	.018	.032	.032	.021	.049	.068	0.000	.080	.105	.089	.033
PET	.031	.029	.064	.090	.047	.066	.096	.047	.073	.088	.060
PVC	.046	.02[illegible]	.040	.017	.054	.067	0.000	.076	.057	.093	.044
POLYPROPYLENE	.055	.061	.110	.020	.070	.085	.003	.114	.076	.095	.066
POLYSTYRENE	.068	.027	.058	.037	.057	.078	0.000	.106	.055	.096	.057
PROPYLENE	.055	.044	.078	.051	.060	.084	0.000	.318	.059	.091	.058
SBR	.061	.012	.042	.064	.034	.047	0.000	.089	.053	.096	.050
STYRENE	.067	.032	.056	.068	.055	.078	0.000	0.000	.057	.106	.059
VCM	.045	.026	.060	.020	.047	.063	0.000	.097	.075	.090	.045
VINYL ACETATE	.021	.037	0.000	.011	.033	.075	0.000	.055	.094	.102	.036
V. A. AGRICULTURE	.032	.013	0.000	.029	0.000	0.000	0.000	0.000	0.000	0.000	.022
V. A. MANUFACTURING	.042	.036	0.000	.046	0.000	0.000	0.000	0.000	0.000	0.000	.040
V. A. CONSTRUCTION	.059	.020	0.000	.027	0.000	0.000	0.000	0.000	0.000	0.000	.034
CONSUMPTION	.030	.024	0.000	.053	0.000	0.000	0.000	0.000	0.000	0.000	.030
GDP	.030	.025	.036	.051	.029	.051	.023	.058	.037	.062	.034
REGIONAL TOTAL	.049	.037	.045	.038	.047	.078	-.064	.080	.062	.090	.049

SOURCE: ECONOMETRIC RESEARCH DATA FILES

* DOES NOT INCLUDE CENTRALLY PLANNED ASIAN ECONOMIES

Table 31

RATE OF GROWTH OF WORLD PETRO CHEMICAL CONSUMPTION: BY REGION AND PRODUCT

2000 - 1995

\REGIONS: \ PRODUCTS:\	NORTH AMERICA	WESTERN EUROPE	CPE EUROPE	JAPAN	OTHER DEVELOPED	LATIN AMERICA	AFRICA (SOUTH SAHARA)	N. AFRICA & MIDDLE EAST	SOUTH ASIA	SOUTH-EAST ASIA	WORLD* TOTAL
ABS	.058	.045	0.000	.072	.041	.073	0.000	.050	.070	.091	.062
ACETIC ACID	.022	.036	0.000	.020	.030	.070	0.000	.068	.060	.091	.038
ACRYLONITRILE	.050	.038	.036	.059	.041	.073	0.000	0.000	0.000	.082	.054
AMMONIA	.050	.038	.036	.019	.041	.073	0.000	.066	.037	0.000	.046
BUTADIENE	.048	.033	.038	.067	.039	.063	0.000	0.000	.058	.088	.051
ETHYL BENZENE	.051	.032	.047	.069	.050	.071	0.000	0.000	.043	.090	.052
ETHYLENE	.040	.026	.047	.015	.043	.070	0.000	.079	.054	.086	.041
ETHYLENE DICHLORIDE	.041	.025	.052	.035	.048	.068	0.000	.084	.051	.085	.043
EHTYLENE GLYCOL	.032	.029	.053	.061	.042	.065	0.000	.068	.053	.084	.047
ETHYLENE OXIDE	.032	.029	.053	.061	.042	.065	0.000	0.000	.053	.084	.041
FORMALDEHYDE	.033	.061	.046	.049	.046	.066	0.000	.078	.046	.078	.056
HDPE	.052	.037	.075	.059	.053	.074	0.000	.081	.054	.087	.059
LDPE	.040	.032	.051	.051	.048	.068	0.000	.064	.057	.080	.048
METHANOL	.023	.034	.036	.040	.046	.068	0.000	.075	.058	.082	.038
PET	.031	.028	.053	.077	.042	.065	.081	.059	.059	.084	.060
PVC	.041	.026	.052	.035	.048	.068	0.000	.069	.051	.085	.049
POLYPROPYLENE	.049	.050	.142	.044	.057	.075	.031	.081	.065	.087	.069
POLYSTYRENE	.051	.028	.048	.057	.050	.070	0.000	.082	.043	.086	.054
PROPYLENE	.049	.039	.130	.055	.053	.075	0.000	.165	.053	.087	.061
SBR	.045	.014	.038	.067	.030	.055	0.000	.085	.041	.087	.047
STYRENE	.051	.032	.047	.069	.050	.071	0.000	0.000	.043	.090	.054
VCM	.041	.026	.052	.035	.048	.068	0.000	.084	.051	.085	.047
VINYL ACETATE	.022	.036	0.000	.020	.030	.070	0.000	.068	.060	.091	.041
V. A. AGRICULTURE	.030	.009	0.000	.033	0.000	0.000	0.000	0.000	0.000	0.000	.020
V. A. MANUFACTURING	.043	.032	0.000	.065	0.000	0.000	0.000	0.000	0.000	0.000	.041
V. A. CONSTRUCTION	.048	.019	0.000	.043	0.000	0.000	0.000	0.000	0.000	0.000	.035
CONSUMPTION	.032	.027	0.000	.057	0.000	0.000	0.000	0.000	0.000	0.000	.034
GDP	.032	.027	.036	.057	.030	.055	.031	.050	.037	.070	.038
REGIONAL TOTAL	.045	.036	.051	.049	.046	.071	.079	.075	.039	.085	.049

SOURCE: ECONOMETRIC RESEARCH DATA FILES

* DOES NOT INCLUDE CENTRALLY PLANNED ASIAN ECONOMIES

World demand for ethylene is projected to be about 72.4 million MT/y in the year 2000, a figure which represents a relatively modest increase over the 1980 level of 35 million MT/y. The implicit annual rate of growth of demand for ethylene over the entire 1980-2000 period is forecast to be 3.7 per cent, which is significantly lower than the expected growth rate of total world demand for petrochemicals. Consequently, the share of consumption of ethylene in total world demand for petrochemicals will likely fall to 10.4 per cent in the year 2000 from 13 per cent in 1980. North America will maintain its share of world consumption of ethylene at about 42 per cent; however, Western Europe will experience a decline in its share of consumption from 32 per cent in 1980 to 24.8 per cent in the year 2000. However, a major decline in the consumption share will take place in Japan, where it is expected to decrease from almost 12 per cent in 1980 to 9 per cent in the year 2000. Developing countries together will account for 15.4 per cent of the total demand for ethylene, which represents a significant increase over their 7.2 per cent share in 1980.

World demand for propylene in the year 2000, while not as high as that of ethylene, will nonetheless be a significant 56 million MT/v This is the result of a rate of growth of 5.8 per cent per year between 1980 and 2000 which is slightly higher than the 4.9 per cent per year growth in total world demand.

North America will account for over 35 per cent of the world demand for propylene, a figure not much different from its share in 1980. Western Europe, however, will experience a decrease in its share, from 31.4 per cent in 1980 to 24.4 per cent in the year 2000, while Japan will almost maintain its share throughout the period. The developing countries, which accounted for almost 8 per cent in 1980, will account for almost 14 per cent in the year 2000.

World demand for butadiene will average about 1.2 million MT/y in the year 2000, or almost 3 times the corresponding level of 1980. The expected annual rate of growth in the demand for butadiene between 1980 and 2000 is 6.0 per cent. Developing countries will account for about 13 per cent of world demand for butadiene in the year 2000, whereas they represented only 5 per cent in 1980.

(b) World demand for intermediate petrochemical products in the year 2000

There have been a number of changes in the structure of demand for intermediate petrochemical products at the commodity and/or regional levels.

The ethylene block (ethylene dichloride, ethylene glycol, ethyl-benzene, ethylene oxide) constitutes the major intermediate building block in the petrochemical production chain. Together these products account for a considerable demand, which is expected to reach 84.4 million MT/y in the year 2000; they will account for 45.5 per cent of the world demand for intermediate petrochemical products at the turn of the century.

The major product within this group is ethylene dichloride. The regional demand pattern for this product is likely to change considerably. Whereas Western Europe had a share of 38.2 per cent of world demand for ethylene dichloride in 1980, this share is forecast to drop to 28.6 per cent by the year 2000. The opposite is expected to happen to the share of North America; it will rise from 34.3 per cent in 1980 to 37.2 per cent in the year 2000. It is also expected that the share of developing countries in world demand for EDC will rise from about 9 per cent in 1980 to over 19 per cent towards the turn of the century. These structural changes are the result of differential growth rates of demands, which are explained primarily by differential output elasticites.

The share of the demand for ethyl-benzene in the total expected world demand for intermediate petrochemicals is projected to increase. This is the result of a relatively high growth rate of 5.9 per cent per year throughout the period 1980-2000. Actually, ethyl-benzene is the only intermediate ethylene-block product whose demand will grow faster than the demand for total petrochemical products during this period.

The general trend of a declining Western European share in world demand for intermediate products is perhaps more evident in this case than anywhere else. Western Europe's share was 30.5 per cent in 1980 and is projected to decline to 19.1 per cent in the year 2000. Again, North America's share will rise, and so will the share of developing countries. Since demand for intermediate products in our model is a derived demand and reflects a demand for a factor of production, the regional patterns of demands may reflect an underlying shift in the production centres of these commodities.

The combined world demands for ethylene-glycol and ethylene-oxide is relatively small. However, both of these products are important products in the manufacture of polyester fibres and PET. Both of these products are scheduled to experience declining shares in total world demand for petrochemicals in the year 2000, and as such both are projected to grow at lower rates than that of the total world demand. During the period 1980-2000, ethylene glycol will grow at the average annual rate of 4.3 per cent, and ethylene-oxide at the rate of 3.8 per cent. In both of these products North America is the major consumer, although its share is expected to drop from 50 per cent and above 1980 to almost 40 per cent in the year 2000. The South-East Asia region is predicted to account for a major proportion of developing countries' demand for these products.

World demand for acrylonitrile is forecast at 8.1 million MT/y in the year 2000. This is almost 3.2 times the corresponding level in 1980. The implicit rate of growth of the demand for acrylonitrile during the period 1980-2000 is 6.0 per cent per year, a figure substantially above the 4.9 per cent per year growth in total world demand for petrochemicals, or the 3.4 per cent per year growth in world real GDP. Western Europe, North America and Japan will each individually account for over 20 per cent of the world demand for this product in the year 2000, whereas Latin America and South-East Asia together will account for almost 23 per cent during the same year.

The demand for acetic acid is forecast to exceed 5.9 million MT/y primarily as an input into the production of vinyl acetate. Developing countries are expected to account for over 25 per cent of world demand for acetic acid by the year 2000. South Asia and Latin America are expected to be the two main areas of consumption of this product.

World demand for formaldehyde is forecast to exceed 33.7 million MT/y at the turn of the century. Much of this demand will be concentrated in Western Europe, which alone will account for 60.3 per cent of world demand for the product. North America, which accounted for 30.1 per cent of the total world demand for this product in 1980, will account for only 16.6 per cent in the year 2000. Developing countries, which together have accounted for little over 10 per cent in 1980, will account for roughly the same percentage in the year 2000.

World demand for VCM, which is a higher-order intermediate petrochemical product, is forecast to reach 11.6 million MT/y. The rate of growth of this demand from 1980 onwards is expected to be 4.5 per cent, which figure is a little less than the overall rate of growth of world demand for total petrochemical products. The share of developing countries in the total demand for VCM was little over 13 per cent in 1980; by the turn of the century, it is expected to be around 25 per cent.

The demand for styrene is expected to grow at 5.9 per cent per year; for this reason, its share in the total demand for petrochemicals will grow in step. In absolute amount, the forecast demand for styrene will reach 25.4 million MT/y. This figure is 3.17 times the corresponding magnitude in 1980. The regional pattern of demand for styrene is expected to undergo some significant changes between 1980 and 2000. The pattern of the demand for styrene in 1980 showed North America and Western Europe with a 1/3 share each, with Japan accounting for 15.3 per cent and the developing countries explaining only about 8 per cent. The regional profile of demand for styrene at the turn of the century shows an increase in the North American share of the total demand for styrene to 39 per cent, a decrease in Western Europe's share to 20 per cent, an increase in Japan's share to 18 per cent, and an increase in the share of the developing countries to 14.1 per cent.

The general trend in the demand for intermediate petrochemical products is abundantly clear; Western European demand is decreasing, that of North America is increasing, but the major increase is in the share of developing countries, and particularly in the South-East Asia region.

(c) World demand for final petrochemical products in the year 2000

Demand for final petrochemical products is expected to account for little over a fifth of the total world demand for petrochemicals. As such, it does not appear to be the case that a major change in the structure of world demand for petrochemicals, with regard to the group of final products, will take place.

The total demand for final petrochemical products in 1980 was 47.5 million MY/y. This demand is likely to exceed 153.3 million MT/y in the year 2000. The final period demand is 2.85 times the initial period demand. By way of comparison, the ratio of final period total petrochemical demand to the initial period magnitude is only 2.59.

Although the group of final petrochemical products will maintain and slightly increase its share in total petrochemical demand throughout the period 1980-2000, the structure of product demand and the regional distribution of demand will change markedly during this period.

World demand for ABS is only a small fraction of the demand for total petrochemical products; however, it is one demand that is likely to grow very fast. In fact, the predicted rate is 7.8 per cent per year, which is the highest rate of growth in the system between 1980 and the year 2000. The regional pattern of demand for this product will change with time. The share of North America in world demand for ABS will increase from 37 per cent in 1980 to 47 per cent in the year 2000. The share of Western Europe will decrease significantly from a 30.6 per cent share in 1980 to a 17.8 per cent at the turn of the century. Japan will maintain almost the same 20 per cent share, whereas the developing countries will increase their share from 10.5 per cent in 1980 to about 15 per cent by the year 2000.

Most of the demands for final products will show a higher rate of demand growth than that of the total demand for all petrochemicals, PET is one such product whose demand growth is predicted to average 6.0 per cent per year. Thus, the total demand for PET, which was 4.5 million MT/y in 1980, is expected to rise to 14.3 million MT/y at the end of the century. Most of the industrialized countries are expected to reduce their share in the total consumption of PET. North America is forecast to reduce its share from 35.5 per cent to 20.5 per cent, Western Europe from 15.8 per cent to 8.8 per cent. On the other hand, the share of developing countries in the consumption of PET is expected to rise markedly from about 27 per cent in 1980 to 40 per cent in the year 2000.

The world combined demand for HDPE and LDPE is forecast to reach 45.9 million MY/y in the year 2000. This is a substantial increase over the level of 16.2 million MT/y. The rates of growth of the individual demands are, however, different, with HDPE growing at an annual rate of 6.1 per cent, whereas LDPE will grow at the rate of 4.7 per cent. The regional pattern of demand for both products is very similar indeed. North America will slightly reduce its share, Western Europe will suffer a major decline in its share, Eastern Europe will experience a rise in its share, and Japan will likely face an increase in its share. On the other hand, the developing countries' demand for these two products will rise quickly and thereby increase each sub-regional demand share in the total demand for HDPE and LDPE by the end of the century.

World demand for polypropylene and polystyrene constitutes a major part of the demand for final petrochemical products. By the year 2000, the total world demand for these two products is forecast to exceed 32.8 million MT/y. The rates of growth of both demands are comparatively high, being 6.6 per cent per year for polypropylene and 5.7 per cent per year for polystyrene. Since both of these rates are significantly higher than the rate of growth of either world real GDP or the total world demand for petrochemicals, the share of these products in world overall demand for petrochemicals will rise accordingly.

The regional distribution of demand is different for each product. The share of demand for polypropylene in North America in total world demand for polypropylene is expected to fall, that of Western Europe to fall slightly, that of Eastern Europe to rise, that of Japan to fall drastically and that of developing countries to rise significantly. This pattern is not evident in the case of polystyrene. The share of North America's demand for polystyrene in world demand for this product is expected to rise in the year 2000 over its 1980 share. However, the share of Western Europe's demand is expected to fall drastically, while that of Eastern Europe to rise slightly, and that of Japan to fall. Moreover, the share of developing countries' demand in the total demand for this product is forecast to rise from almost 13 per cent in 1980 to over 24 per cent in the year 2000.

World demand for PVC is expected to grow at the rate of 4.4 per cent per year, rising from a level of 11.3 million MT/y in 1980 to over 26.9 million MT/y at the turn of the century. Since the rate of growth in the demand for PVC is slightly lower than the growth rate in the overall demand for petrochemical products and higher than the world rate of real GDP growth, the share of the demand for PVC in total petrochemical demand will fall slightly below its 1980 level, but the demand for PVC will continue to rise. The regional distribution of the demand for PVC will change in the generally observed pattern discussed above. North America's demand will maintain its share in the total demand for PVC between 1980 and 2000, Western Europe's share will fall drastically from 34.7 per cent in 1980 to 23.2 per cent in the year 2000, Eastern Europe's share will fall slightly, Japan's will fall by almost half and the share of every developing region will rise, but that of South-East Asia will more than double.

World demand for SBR is projected to reach 12.4 million MT/y in the year 2000. Given that the level of demand for this product was only 4.7 million MT/y in 1980, this represents an annual growth rate of 5.0 per cent. North America is expected to increase its demand share in total SBR demand and again Western Europe will face a declining share, Eastern Europe will experience a slight decline, Japan will increase its share and so will the developing countries (except Latin America, which will face a slight decrease towards the end of the century).

Finally, world demand for vinyl acetate will remain a 3.5 million MT/y by the turn of the century. More important perhaps is the fact that this demand is projected to grow at the rate of 3.6 per cent per year which will lead to a steady decline in its share of total world petrochemical demand, although it will maintain a constant proportion of GDP given that its demand is unitary elastic with respect to GDP.

A number of trends and structures can be seen to emerge in the long-term demand for final products. In the first place, the rates of growth in the demand for final products differ substantially. Among the fast growing demands are those of ABS, HDPE, PET, polypropylene and polystyrene. Secondly, North America is re-emerging as a major consumer of final products, whereas Western Europe, which currently dominates the demand for this group, is losing rapidly this dominance. Finally, developing countries and particularly the South-East Asia region are becoming major demanders of final petrochemical products.

3.3 Alternative B forecasts: world demand for petrochemicals within a price sensitive framework

Price sensitivity may be modelled in a number of ways, but mainly through its introduction into final demand equations. Despite the fact that certain demands are world price inelastic (insensitive to world price changes), there may still be a high degree of sensitivity of demand to regional price differentials. We have concentrated our efforts on modelling the first type of sensitivity, as we were unable to obtain sufficiently long time series on regional prices of petrochemical products to permit modelling of the second type of sensitivity.

Modelling the price impact through the introduction of price variables in the final petrochemical product demands was not an easy task, as was documented in section 3.9. More difficult indeed is the task of predicting price formation in the future. There is no good substitute for a generalized model in which prices are determined endogenously within a framework which reflects the interplay of demand and supply forces. In the absence of such an elaborate system, we had to rely in the linking of petrochemical prices to oil prices, given the close affinity these sets of prices have been shown to possess. The results of the regressions in Table 32 substantiate this claim. The oil price is statistically significant with a high t-statistics, the R^2

Table 32. Regression results of the linkage between petrochemical products prices and the price of oil

Dependent variable	Constant	Oil price	R^2	F	D-W
Price of:					
HDP	64.35 (10.26)	.391 (10.33)	.96	106.6	2.7
LDP	63.42 (6.13)	.372 (5.96)	.90	35.5	2.9
PPR	82.23 (23.23)	.185 (8.66)	.95	75.1	3.5
PST	76.77 (6.27)	.149 (2.02)	.51	4.1	1.5
PVC	85.49 (7.96)	.200 (3.08)	.70	9.5	1.4
SBR	103.29 (6.23)	.159 (1.59)	.39	2.5	1.1
	Price of SBR				
Natural rubber	-176.10 (-2.22)	2.745 (4.46)	.83	19.9	1.5
ABS	93.37 (8.24)	.257 (3.76)	.78	14.1	1.1
VAC	71.98 (7.90)	.198 (3.25)	.76	12.3	2.2
STY	54.60 (2.96)	.444 (3.99)	.80	15.9	2.9
BUT	74.27 (7.30)	.365 (5.94)	.90	35.3	2.6

Table 33. Price forecasts

	OILP	HDPP	LDPP	PPRP	PSTP	PVCP
1974	100.000	140.000	123.000	112.000	112.000	120.
1975	100.000	100.000	100.000	100.000	100.000	100.
1976	106.000	105.000	105.000	100.000	108.000	96.0
1977	117.000	110.000	102.000	109.000	82.0000	107.
1978	117.000	107.000	98.0000	100.000	82.0000	118.
1979	170.000	142.000	144.000	116.000	101.000	134.
1980	295.000	176.000	168.000	136.000	123.000	139.
1981	0.	0.	0.	0.	0.	0.
1985	250.000	162.110	156.367	128.533	114.170	135.
1990	300.000	181.661	174.956	137.793	121.650	145.
1995	331.000	193.733	186.480	143.534	126.288	151.
2000	422.000	229.366	220.312	160.388	139.903	169.
	1	2	3	4	5	

	SBRP	ABSP	VACP	STYP	BUTP
1974	118.000	123.000	110.000	120.000	116.000
1975	100.000	100.000	100.000	100.000	100.000
1976	110.000	123.000	88.0000	105.000	120.000
1977	127.000	132.000	98.0000	100.000	114.000
1978	135.000	132.000	88.0000	87.5000	114.000
1979	150.000	139.000	117.000	160.000	151.000
1980	142.000	167.000	125.000	177.000	177.000
1981	0.	183.000	125.000	177.000	214.000
1985	143.135	157.671	120.353	165.621	165.535
1990	151.103	170.530	130.027	187.825	183.788
1995	156.043	178.503	135.025	201.591	195.105
2000	170.544	201.907	153.632	242.002	228.325
	1	2	3	4	5

values are very high, and the F-statistics are high enough to indicate non-rejection of the null hypothesis that the regression relationship indicates a close linkage between the dependent variable and the independent variables. Only the SBR price is poorly related to the oil price; otherwise, all other prices are highly related to the oil price.

The price forecasts--all index numbers with 1975 = 100--are presented in Table 33. The implied exogenous specification of the oil price is also presented in this table. The assumptions made about the price behaviour of oil are as follows. To begin with, oil prices are required to decline in nominal terms until 1985. Secondly, from 1985 to 1990 the price of oil is allowed to grow at 3.7 per cent per year. Thirdly, between 1990 and 1995, the price of oil is allowed to increase at the annual rate of 2.0 per cent. Fourthly, between 1995 and the year 2000, the price of oil is hypothesized to increase at the annual rate of 5 per cent.

The forecast prices of petrochemical products were introduced into the estimated equations described in Table 11, and a new set of world demands for petrochemical products were generated. The results are presented in Tables 34 to 36.

The new forecasts are for the most part different from those estimated from the equations that do not include prices, and the differences in many respects are systematic.

Firstly, the new forecast demands for petrochemical products in North America are significantly higher than those observed under the assumptions of alternative A, and this holds true for 1985, 1990 and the year 2000. The differences grow as time passes. In 1985, these differences are relatively small, except for methanol, vinyl acetate, styrene, HDPE and ethyl-benzene. In the year 2000, the differences have become large indeed, and particularly for acetic acid, ethyl-benzene, HDPE, methanol, polypropylene, polystyrene, propylene, styrene and vinyl acetate.

Secondly, demands for petrochemicals in Western Europe are forecast to be substantially lower when prices are included than when they are excluded.

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