FEASIBILITY STUDY REPORT

FOR

ETHYLENE AND VINYL CHLORIDE MONOMER PLANTS

IN

THE KINGDOM OF THAILAND

VOL. II

APRIL 1981

JAPAN INTERNATIONAL COOPERATION AGENCY

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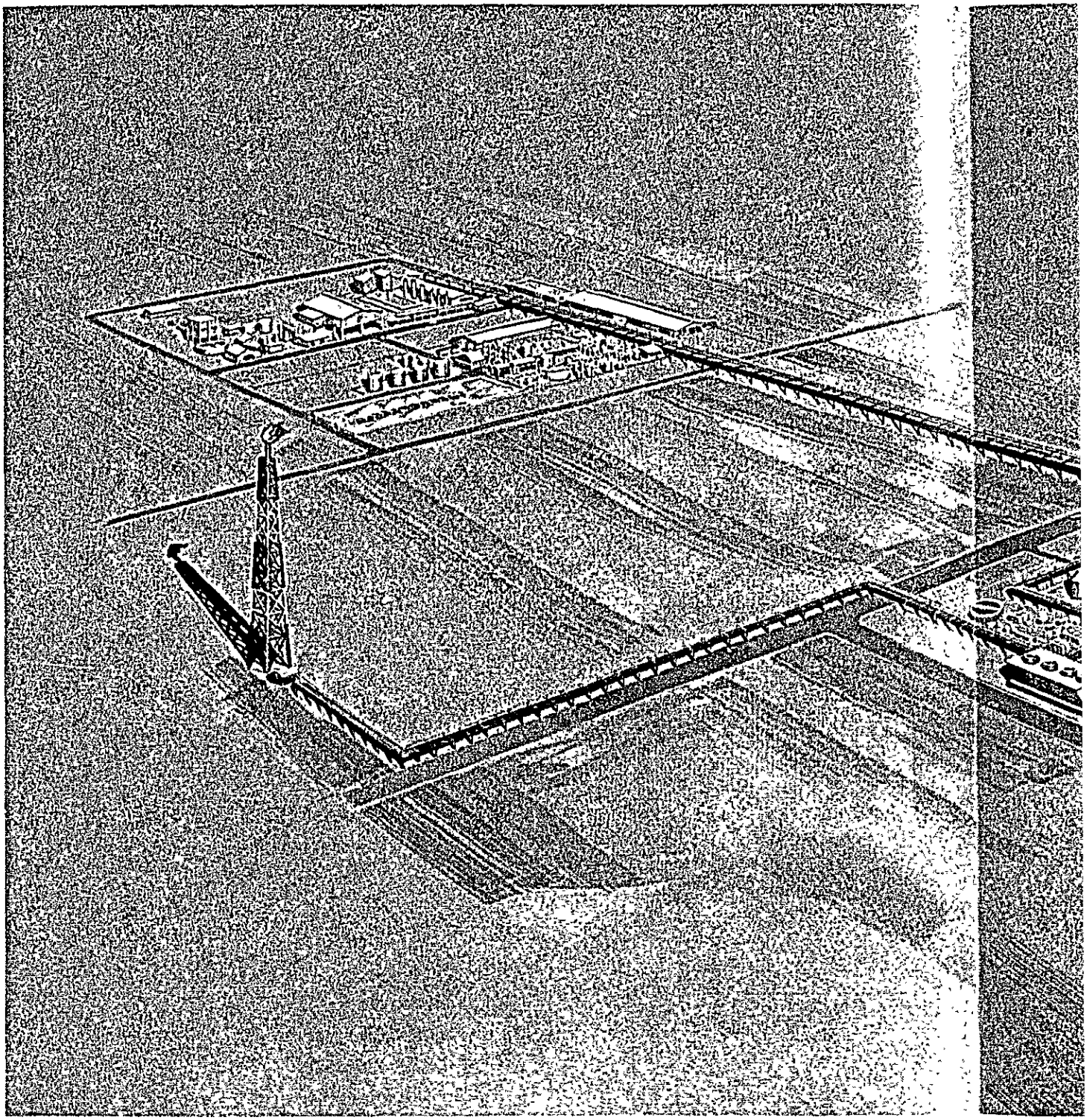
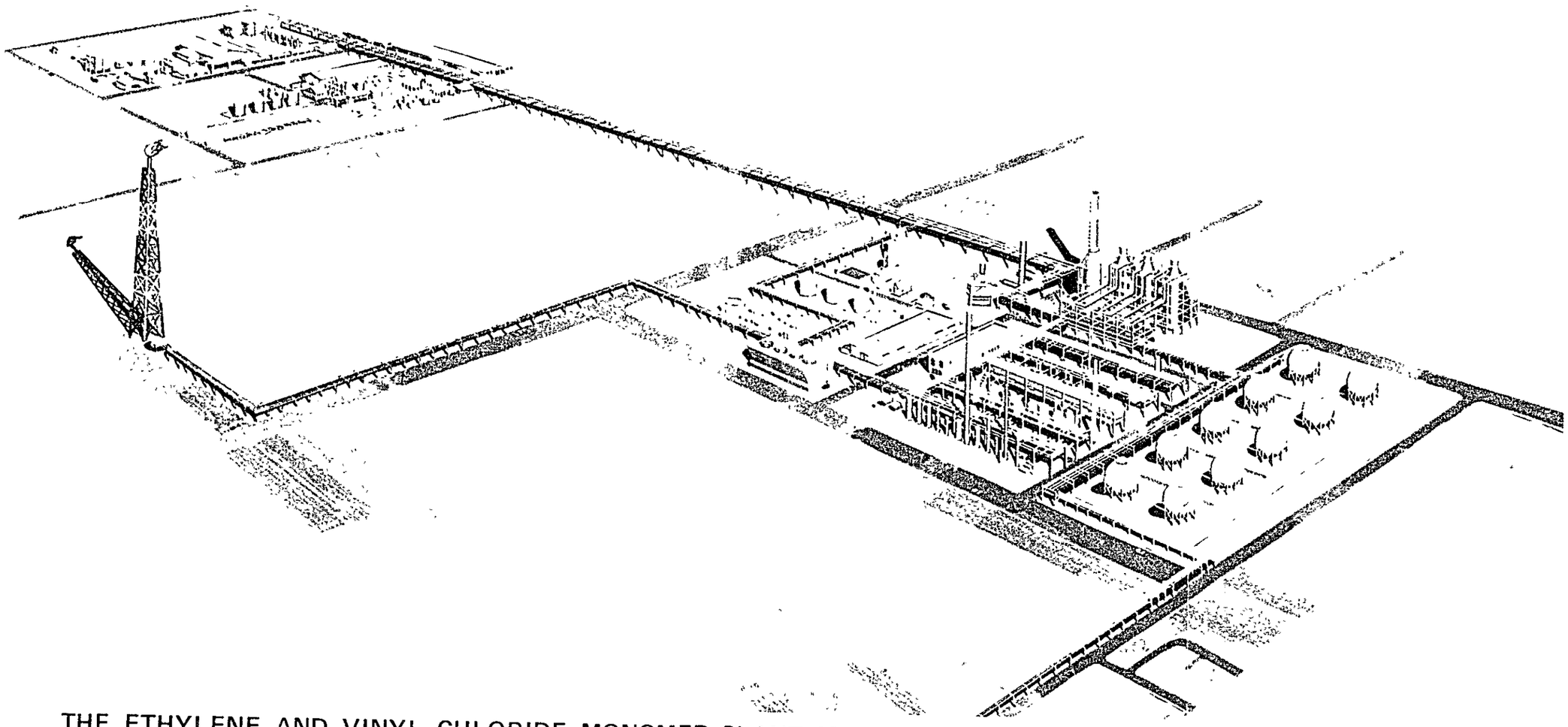


THE ETHYLENE AND VINYL CHLORIDE MONOMER PLANT



THE ETHYLENE AND VINYL CHLORIDE MONOMER PLANT AT RAYONG IN THE KINGDOM OF THAILAND

ABBREVIATIONS AND SYMBOLS

Unit and Conversion

mm	Millimeter
cm	Centimeter
m	Meter
km	Kilometer
in	Inch (1 in = 2.54 cm)
ft	Foot (pl. feet) (1ft = 0.305m)
cm^2	Square centimeter
m^2	Square meter
ha	Hectare (1 ha = 10,000 m^2 = 2.471 acres)
ft^2	Square foot (1 ft^2 = 0.0929 m^2)
Rai	(1 Rai = 1,600 m^2)
m^3	Cubic meter
Nm^3	Normal cubic meter
MMm^3	Million cubic meters
ft^3, cu ft	Cubic foot (1 ft^3 = 0.0283 m^3)
SCF	Standard cubic foot
MMSCF	Million standard cubic feet
l	Liter
gal	Gallon (1 British gallon = 4.546 liters, 1 U.S. gallon = 3.785 liters)
bbl	Barrel (1 barrel = 42 U.S. gallons)
g	Gram
kg	Kilogram
t, T, ton, Ton,	Metric ton
lb (s)	Pound (1 lb = 0.454 kg)
LMT	Liquid metric ton (50% aques solution of caustic soda)
sec	Second
min	Minute
h, hr, Hr	Hour
d, D	Day
m, M	Month
y, Y	Year
°C	Degree centigrade
°F	Degree fahrenheit
cal	Calorie
Kcal, K cal	Kilo calorie
BTU, Btu	British thermal unit (1 BTU = 0.252 K cal)
MMBTU, MMBtu	Million British thermal units

LHV	Low heating value
HHV	High heating value
A	Ampere
V	Volt
W	Watt
kW	Kilowatt
mW	Megawatt
kVA	Kilo-volt ampere
mVA	Mega-volt ampere
kWH, kWh	Kilowatt-hour
mWG, mWh	Megawatt-hour
HP, HP	Horsepower
%	Percent
ppm	Parts per million
g/Nm^3	Gram per normal cubic meter
pH, PH	Hydrogen ion concentration
kg/cm^2	Kilogram per square centimeter
lb/in^2	pounds per square inch
mmAq	mm aqua (= water)
t/d, ton/day, T/D	Tons per day
t/y, ton/year, MTA, MT/Y T/Y	Tons per year
MMSCFD, MMscfd	Million standard cubic feet per day

Technical Terms

ABS	Acrylonitrile-butadiene-styrene copolymer
AS	Acrylonitrile-styrene copolymer
PE	Polyethylene
HDPE	High density polyethylene
LDPE	Low density polyethylene
PO	Polyolefin
PP	Polypropylene
PS	Polystylene
FS	Foamed polystyrene
GPPS (GP)	General purpose polystyrene
HIPS (HI)	High impact polystyrene
PVC	Polyvinyl chloride
EDC	Ethylene dichloride
EG	Ethylene glycol
EO	Ethylene oxide
SM	Styrene monomer
VCM	Vinyl chloride monomer
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
NG	Natural gas
NGL	Natural gas liquid
BOD	Biological oxygen demand
COD	Chemical oxygen demand
ISBL	Inside battery limit
OSBL	Outside battery limit
MSL	Mean sea level

Financial and Economic Terms

DCF	Discounted cash flow
IRR	Internal rate of return
EIRR	Economic internal rate of return
FIRR	Financial internal rate of return
ROI	Return on investment
GDP	Gross domestic product
GNP	Gross national product
C & F	Customs, and freight
CIF	Customs insurance and freight
FOB	Free on board

Exchange Rate

Baht	Thailand Baht (1 U.S. dollar = 20.5 Bahts)
$, U.S.$,	U.S. dollar
yen	Japanese yen (1 U.S. dollar = 215 yen)

Organization and Company

GOT	The Government of Thailand
PTT	Petroleum Authority of Thailand
BOI	Office of the Board of Investment
NESDB	Office of the National Economic and Social Development Board
DTEC	Department of Technical and Economic Cooperation
MOI	Ministry of Industry
ETO	Express Transportation Organization of Thailand
EGAT	Electricity Generating Authority of Thailand
NEA	National Energy Administration
PEA	Provincial Electricity Authority
IEAT	Industrial Estate Authority of Thailand
TAPLACO	Thai Plastic and Chemical Co., Ltd.
THASCO	Thai Asahi Caustic Soda Co., Ltd.
FOIS	Fluor Ocean International Services Inc.
JICA	Japan International Cooperation Agency
JETRO	Japan External Trade Organization

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PART I INTRODUCTION

PART I INTRODUCTION

CHAPTER 1 OBJECTIVE AND SCOPE OF STUDY

1–1 BACKGROUND AND OBJECTIVE OF STUDY

The objective of this project is for the Petroleum Authority of Thailand (PTT) to produce ethylene from ethane contained in natural gas recovered from offshore gas fields in the Bay of Siam; to supply the ethylene to downstream plants now being constructed or planned, which will produce low density polyethylene (LDPE) and high density polyethylene (HDPE) in addition to supplying it to a plant for production of vinyl chloride monomer (VCM) to be supplied to an existing polyvinyl chloride (PVC) plant.

After accepting a request from the Government of Thailand (GOT) for implementation of a feasibility study, the Government of Japan dispatched a preliminary survey team to Thailand in July, 1980, for discussions with the GOT regarding the scope and content of the study. As a result, it was decided that the Japan International Cooperation Agency would carry out the feasibility study as discussed by the two governments.

PTT has already commenced installation of a pipeline partly under water and partly on land as a key aspect of its activities for utilization of the natural gas, and plans to begin commercial recovery of the gas in September, 1981. Design work is now proceeding for a gas processing plant which will produce LPG, as one aspect of those activities. This gas processing plant is to include facilities for separation and refining of ethane, and is planned to start operation in late 1983.

The objective of the present study, against the background described above, is to carry out a comprehensive examination of the feasibility of using ethane from the gas processing plant as feedstock for an ethylene plant, and of a VCM plant, by study of the market for ethylene derivatives, as well as study of technical, financial and economic aspects of both plants.

1–2 SCOPE

The general scope of the study, in accordance with the above objective, was defined as follows.

A. Study of the domestic Thai market for ethylene and its derivatives, and for caustic soda.

B. Study of feedstock ethane and of the chlorine source for VCM production.

C. Determination of the scale of the plants, and their basic design conditions.

D. On the basis of study of location aspects of the plants, and infrastructure, to study technical aspects of construction and operation of the ethylene and VCM plants.

E. Estimation of plant construction cost for both plants.

F. Financial and economic evaluation of the project.

The study was thereupon carried out in accordance with the above.

CHAPTER 2 SUMMARY OF THE PROCESS OF STUDY IMPLEMENTATION

2–1 STUDY METHOD AND SCHEDULE

To carry out this study, a team of 12 experts[1] headed by Takeshi Chino, accompanied by two officials from the Japan International Cooperation Agency, visited Thailand for four weeks from October 6 to November 2, 1980, for in-country research[2] results of which formed the basis for the study which, with its results, is reported in this document.

In conducting research in Thailand, the feasibility study team, held detailed discussions with Mr. Pratin Pathanaporn, Deputy Governer of the Petroleum Authority of Thailand and counterpart staff from PTT[3], collected necessary information and data, analyzed this information and data, carried out a study of the proposed location of the plant site, and carried out a study of related industries.

2–2 OUTLINE OF THE STUDY

The major areas of the study, within the scope given above, are as follows.

A. Study of the domestic Thai market for ethylene derivatives and caustic soda.

B. Raw materials study.

C. Technical study concerning construction and operation of the ethylene and VCM plants.

D. Financial and economic evaluation of the project.

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1) Members of the team who undertook the in-country study are given in Appendix 1.

2) The itinerary of the team in Thailand is as given in Appendix 4.

3) The names of the counterpart experts are given in Appendix 2.

(1) Domestic market study

In the study of the domestic market for ethylene derivatives, emphasis was given to plastics such as LDPE, HDPE and PVC, as well as ethylene glycol which is used for production of polyester fiber. In addition to the potential demand for these ethylene derivatives, an effort was made to estimate the derived demand for ethylene based on the production plants for these derivatives. With regard to caustic soda, consideration was given to the relation between domestic market demand and the caustic soda which would be a co-product of chlorine from the electrolysis plant.

In addition to these studies, as the basis of the financial evaluation of the project, investigation was made of the prices of ethylene, VCM, and caustic soda. The results of these investigations are given in Part II.

(2) Raw materials study

It is assumed that ethane, the feedstock for ethylene production, is to be supplied from the PTT gas processing plant (construction planning now underway). It has been decided that ethane separation is to be performed in this plant; for the present study of raw materials emphasis was given to confirming the suppliable quantity of ethane for use as feedstock, and to supply conditions. Further, study was made of marine salt and rock salt, both of which can be supplied domestically, as the source of chlorine. Results are given in Part III.

(3) Technical study of construction and operation of ethylene and VCM plants

It is necessary here to evaluate the ethylene plant and VCM plant as separate projects undertaken by separate companies. That is, the owner of the ethylene plant is to be PTT, and although the owner of the VCM plant has not yet been decided, there is a strong likelihood that it will not be PTT.

Feedstock for the ethylene plant, and location of the plant, have been decided by PTT, but the most important issue which must be determined is the scale of production by the plant. With regard to the VCM plant, scale of production, location and source of chlorine are the most important factors determining the features which the plan should be given. Results of study of these factors are presented in Part IV.

Together with study of these basic conditions, a study was made of locational aspects of the proposed sites and on the basis of the results the following were examined.

A. Scope of the plant facilities, and their conceptual design.

B. Utilities and ancillary facilities.

C. Environmental aspects.

D. Overall execution of construction, and plant operation and management, with specific reference to construction planning and plant organization.

Technical feasibility of the project was evaluated on the basis of the above. Results of the evaluation are given in Part V.

(4) Financial and economic evaluation

The capital requirements of the project were estimated on the basis of the results of work described in section (3) immediately above and with results as presented in Part VI.

On the basis of the results of study of the capital requirement and other project requirements, the production cost of the ethylene, VCM and caustic soda produced by these plants was calculated and, after formulating a financial plan, financial and economic analysis of both plants was carried out. By this means the viability and financial soundness, as well as the economic effects, of the project were evaluated. With specific regard to the price of feedstock ethane and the sales price of ethylene, in addition to the implications of the ethylene plant, consideration was given to the overall development of the Thai petrochemical industry.

PART II MARKET STUDY

PART II MARKET STUDY

CHAPTER 1 GENERAL

Although this project can enable Thailand's industrial sector to produce polyethylene, vinyl chloride monomer, styrene monomer, ethylene oxide, ethylene glycol and other ethylene derivatives, this study is limited to the following, on the basis of the agreement reached between PTT and JICA, [1] and the domestic demand for these was studied.

(1) Polyethylene (LDPE, HDPE)
(2) Polyvinyl chloride (PVC), vinyl chloride monomer (VCM)
(3) Caustic soda
(4) Ethylene glycol, ethylene oxide

Plastics materials such as polyethylene and PVC are interchangeable in use with other plastics materials, e.g., polypropylene and polystyrene, so that in order to study the two plastics materials noted above it was necessary for the study team to also investigate conditions related to general-purpose plastics in general.[2]

Because almost all ethylene glycol consumed in Thailand is used for production of polyester fiber, demand for ethylene glycol was estimated on the basis of domestic demand for polyester fiber (including that consumed for textile exports).

With regard to production of caustic soda in Thailand, at the present time there is a deficit in the supply of caustic soda because of constraints due to the level of chlorine demand. However, when chlorine is produced for use by the VCM plant, caustic soda obtained as a co-product will be in surplus, and in the future the trend of demand for caustic soda will be more important than that for chlorine. In this study, therefore, the former is assigned the greater importance.

The market for these goods is investigated as reported below from the following three viewpoints:

(1) Past and present trends of demand
(2) Demand analysis
(3) Projections of demand, based on the demand analysis

1) Dated July 25, 1980.
2) Comprising polyethylene, polypropylene, PVC and styrene polymers.

As the demand projection should be made for 20 years hereafter, macroscopic demand analysis and forecast is adopted using GDP and price as two independent variables for plastics materials and per capita GDP for synthetic fibers.

On the other hand, cumulative demand analysis and forecast by application is performed for caustic soda as its consuming industry is rather simple in Thailand.

This part is composed of following chapters:

CHAPTER 2 PLASTICS MATERIALS

2–1 GENERAL DISCUSSION CONCERNING PLASTICS IN THAILAND

2–1–1 Plastics Materials

Plastics materials are broadly classified into two groups, thermosets and thermoplastics. The former includes phenol resins, urea resins, melamine resins, unsaturated polyester, polyamides and others, and the former includes polyethylenes, polypropylenes, PVC, polystyrenes, acrylic resins, and others.[1)]

Of the plastics listed above, demand is highest for polyethylene, polypropylene, PVC, and polystyrene, and these are known as general-purpose plastics.[2)] Recent ratios of production of general-purpose plastics in industrially-advanced countries are as shown in Table II-1; they account for about 70∿80% of total plastics demand.[3)]

Although the uses of plastics materials covers an exceedingly wide range, as is evident from Table II-2, their use for production of building materials and packaging materials is particularly high, after which typical important areas of use are for parts for electrical and electronic devices, and transport equipment, as well as household wares and furniture.

In particular, the general-purpose plastics mentioned above are used in great quantities for production of packaging materials, building materials (including pipes and joints, etc.), and daily-use sundries. The pattern of demand for general-purpose plastics in Japan is as shown in Table II-3 and Fig. II-1.

2–1–2 Present Status of the Plastics Industry in Thailand

The present level of annual demand for plastics materials as reported by the Siam Cement Co. (see Table II-4) is on the order of 240,000 t (1978). The share of general-purpose plastics in that is about 66%, and it is thought that there is potential for this share to increase in the future.

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1) Most of the thermosetting plastics are included in the category of condensation resins in trade statistics but whereas polyamides (nylon, polyacetal) etc. are included in "condensation resins" they are thermoplastics, and while unsaturated polyester and saturated polyester (PET, PBT) are "condensation resins" the first is a thermosetting plastic and the second is a thermoplastic.

2) They are also known as commodity plastics and volume plastics.

3) Whereas in West Germany 32% of demand for all plastics materials is accounted for by artificial resins, this is very high relative to most other countries, and for that reason the share of general-purpose plastics is lowered.

Table II—1 DEMAND PATTERN OF GENERAL-PURPOSE PLASTICS (1979)

(Unit: 1,000t)

	LDPE	HDPE	PP	PVC	PS[1]	Plastics Total
Japan	1,001	665	892	1,491	812	7,255
U.S.A.	3,097	1,909	1,431	2,641	2,375	13,686
U.K.	495	176	243	440	241	2,346
France	595	200	140	695	327	2,968
W. Germany[2]	820	370	220	970	575	5,716[3]
Italy[2]	697		266	673	349	2,490

Notes: 1) Including AS and ABS resins.
2) Domestic demand in 1978.
3) Excluding cellulose.

Sources: Japan; Chemical Industries Statistics of Japan (MITI).
U.S.A.; Modern Plastics International (Jan. 1980).
UK; European Plastics News (Jan. 1980).
France; Plastiques Modernes et Elastomeres (Mar. 1980).
W. Germany; Kunststoffe (Oct. 1979).
Italy; European Plastics News (1980).

Table II—2 APPLICATION PATTERN OF PLASTICS MATERIALS IN MAJOR COUNTRIES (1978)

(Unit: %)

	Building Materials	Packaging Materials	Electric & Electronic Appliances	Trans-portation Machinery	Furniture	Agriculture	Toys & Leisure	Household Wares	Cloth & Shoes	Mechanical Parts	Liquid[1)]	Others
Australia	24	23	10	7	7	3	2	6	1	–	–	17
Austria	21	28	8	4	12	4	1	3	2	7	6	4
Canada	19	36	5	7	9	4	5	3	–	–	–	12
Chile	15	30	10	4	6	4	4	8	2	–	1	16
W. Germany	25	21	14	6	5	4	1	3	–	–	10	12
France	18	29	6	–	5	–	–	4	–	–	–	38
Ireland	32	41	11	–	8	–	–	–	3	–	–	5
Israel	7	10	5	10	5	30	–	5	–	15	–	13
Italy	11	30	9	6	6	4	8	6	1	1	15	5
Japan	14	22	11	7	1	2	1	6	1	1	16	18
Norway	23	20	8	5	3	–	–	10	–	14	–	17
S. Africa	5	18	15	1	2	3	2	2	8	8	8	29
Spain	12	30	10	5	6	5	2	5	–	6	6	13
Sweden	20	24	12	5	4	–	–	4	–	16	–	15
Switzerland	26	24	12	3	4	5	–	5	–	8	–	13
UK	21	30	8	5	7	3	3	5	–	2	8	9
U.S.A.	20	26	8	6	5	–	–	10	–	1	8	16

Note: 1) Including adhesives and paints.

Source: The Japan Plastics Industry Federation.

Nevertheless, the information in Table II-4 has been collected through micro-level inquiries among the plastics processing and distribution industries, and differs somewhat from the macro-level figures (see Table II-10) which have been estimated by the study team. Reference should be made to the study team's findings, as reported in 2–2–1, that whereas the quantity of demand for LDPE and HDPE increased in 1978 because prices fell, demand fell in 1979 when prices rose. Moreover, although demand for PP started to increase in 1977 at that time its price was still higher than that of LDPE, so that it was not until 1978 that there was a firm increase in the quantity of demand for it, and in 1979 in particular there was a strong increase in the quantity demanded, including inventory, and it was in 1979 that it came to possess the strongest demand among the general-purpose plastics.

Further, since Dow Chemical Thailand started to produce polystyrene in 1978 demand began to increase and in 1979 amounted to about 15,000 t/y including AS and ABS resins.

Regarding general-purpose plastics as a whole, even though overall demand increased by a wide margin in 1978, because of the across-the-board price increases caused by the second oil shock in 1979, the growth of demand fell considerably with the exception of demand for certain plastics materials including PP. This situation has carried over into 1980. For example, the Thai Pipe Industry Co., the country's largest maker of PVC pipe, reports that also because of the influence of seasonal factors utilization of capacity in 1980 was at about 70% of that in normal years. Moreover, the Basicharern Cord Factory, a maker of HDPE rope and netting, reduced production volume by 20% in 1980, and expects the pro-

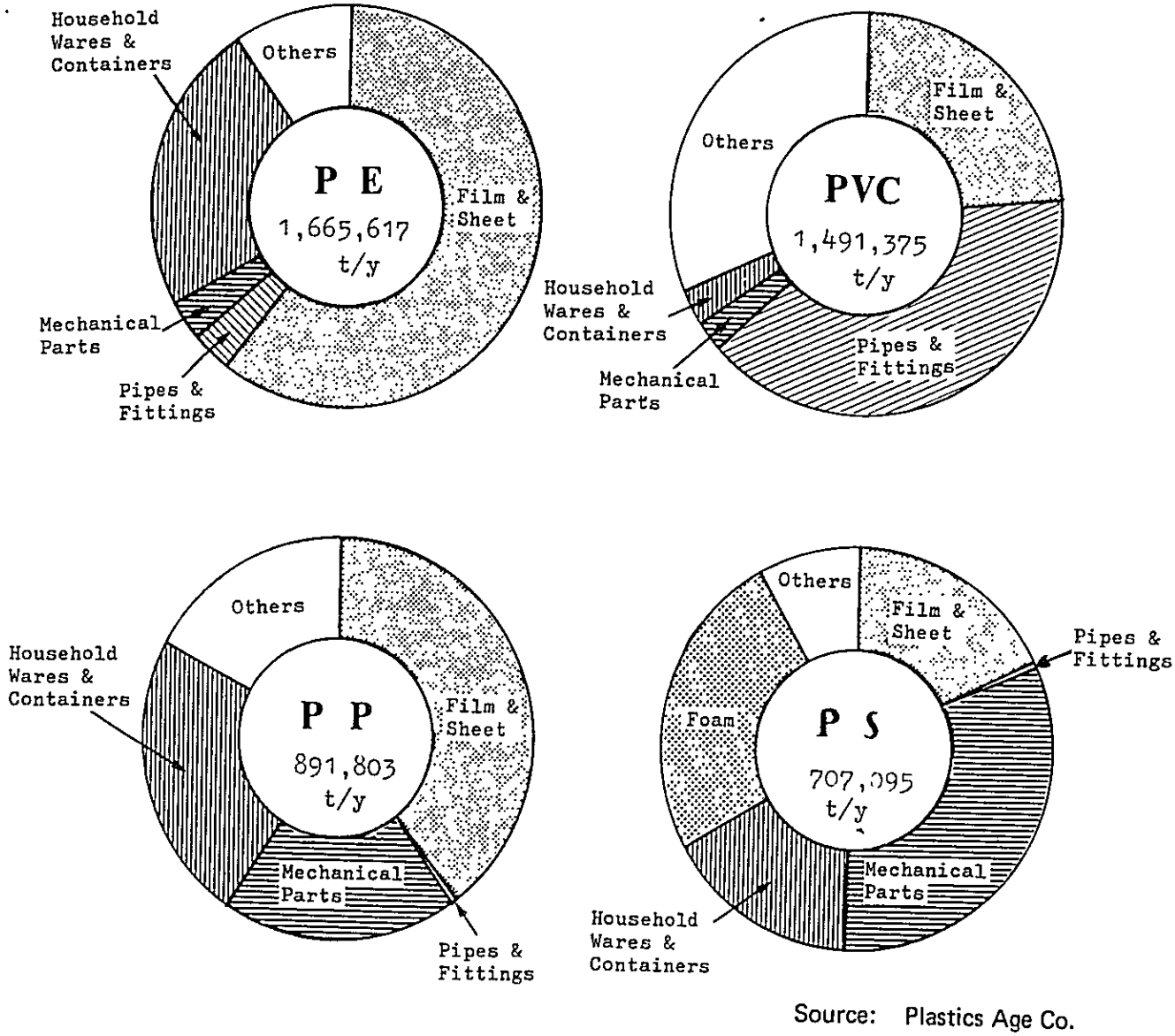
Table II–3 APPLICATION PATTERN OF GENERAL-PURPOSE PLASTICS IN JAPAN (1979)

(Unit: %)

	Film & Sheet[1)]	Pipes & Fittings	Mechanical Parts	Household Wares & Containers	Others	Total
PE	60.0	3.6	3.3	23.3	9.8	100.0
PP	39.3	0.2	19.6	23.6	17.3	100.0
PVC	23.5	39.7	2.2	3.0	31.6[2)]	100.0
PS	17.6	0.2	32.8	15.9	33.5[3)]	100.0

Notes: 1) Packaging materials.
2) Building materials (11.1%), plate (7.0%), imitation leather (5.0%).
3) Including foamed products (25%).

Source: World Plastics Industries Statistics 1980/1981 (Plastics Age Co.).



Source: Plastics Age Co.

Figure II–1 APPLICATION PATTERN OF GENERAL-PURPOSE PLASTICS IN JAPAN (1979)

Table II—4 CONSUMPTION OF PLASTICS MATERIALS IN THAILAND

(Unit: ton)

	1977	1978
LDPE	29,500	33,800
HDPE	29,100	33,200
PP	27,000	30,700
PVC	39,700	45,400
PVAC	8,800	10,000
PS	10,100	11,500
Acrylics	2,920	3,300
Alkyds	2,940	3,300
Others[1)]	55,240	64,100
Total	205,300	235,300

Note: 1) PU, Melamine, Phenolics, Urea, Silicones, Cellulosics, Polyamides, Epoxide, Ion Exchange and Others.

Source: The Siam Cement Co.

duction level to be constant at this lower level for two or three years.

The demand structure of plastics materials in Thailand according to The Siam Cement Co. survey cited above is summarized in Table II-5 and Fig.-II-2. There is a concentration of use of LDPE for film (bags), of HDPE for daily-use sundries, of PP for film (including that for woven bags) and of PVC for pipe and hose; about one-third of PS demand is for daily-use sundries (primarily GP and HI), and about one-third is for expanded products (FS; packing, thermal insulation material), and with regard to AS and ABS resins the most important uses are for production of daily-use items and parts for machines and tools.

If this is compared to the situation in an industrialized country such as Japan (see Table II-3), it is evident that demand in Thailand is relatively concentrated in certain fields, and it is expected that in the future there will be an expansion of the range of application of plastics materials, accompanying the growth of demand.

2–2 DEMAND TRENDS

2–2–1 Method of Estimating Demand

The method used to estimate demand was the following equation.

$$(\text{Demand})^{1)} = (\text{Imports}) - (\text{Exports}) + (\text{Production})$$

The demand thus obtained, which includes inventory, is apparent demand.

Because there is virtually no exportation of plastics materials in Thailand, the above equation becomes:[2)]

$$(\text{Apparent demand}) = (\text{Imports}) + (\text{Production})$$

of the five types of plastic material taken up in this study—LDPE, HDPE, PP, PVC, PS—production in Thailand is carried out only of PVC and PS, so for the others import volumes are taken as equivalent to apparent demand.

1) Including inventories (sales agents and users).

2) Polystyrene is exported recently. For polystyrene domestic shipment is used instead of production.

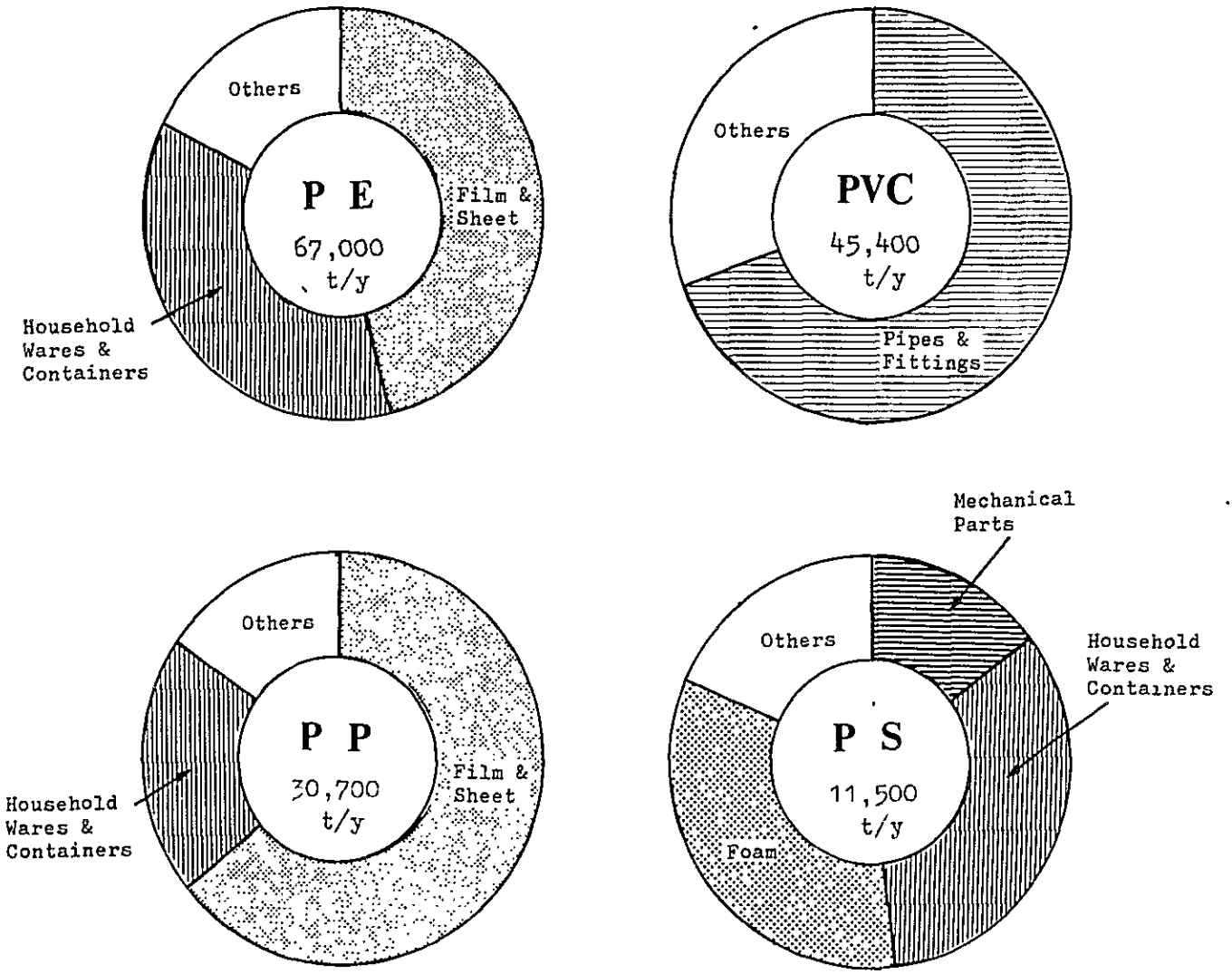
Table II–5 APPLICATION PATTERN OF GENERAL-PURPOSE PLASTICS IN THAILAND (1978)

(Unit: %)

	Film & Sheet[2)]	Pipes & Fittings	Mechanical Parts	Household Wares & Containers	Others	Total
LDPE	72.1	–	–	15.0[4)]	12.9	100.0
HDPE	21.2	–	–	56.1	22.7	100.0
PP	64.1	–	–	20.4	15.5	100.0
PVC	–	69.4[3)]	–	–	30.6[5)]	100.0
PS[1)]	–	–	14.6	33.5	51.9[6)]	100.0
AS Resin	–	–	45.1	54.9	0	100.0
ABS Resin	–	–	66.3	29.9	3.8	100.0

Notes: 1) Including GP, HI and FS.
2) Including woven bags.
3) Including hoses.
4) Including plastic flowers (9.6%).
5) Including imitation leather (14.0%) and sandals (11.9%).
6) Including foamed products (33.4%).

Source: Prepared based on information by the Siam Cement Co.



Source: The Siam Cement Co.

Fig. II–2 APPLICATION PATTERN OF GENERAL-PURPOSE PLASTICS IN THAILAND (1978)

(1) Foreign trade statistics of Thailand

Through 1976, the foreign trade statistics of Thailand merely classified plastics materials as condensation resins, polymerization resins and cellulose, and statistics for LDPE, HDPE, PP, PVC and PS were combined in the polymerization resin category and information on import volumes of each is not available.

The quantities and amount of polymerization resin imports, from Thailand's foreign trade statistics for 1970~1976, as well as the unit price (CIF Baht/kg) calculated therefrom, are given in Table II-6.

Subsequent to 1977, separate statistics are available for PE, PP,PS and PVC; these are given as Table II-7.

(2) Tabulation of Thai-bound export statistics of exporter countries

Statistics for exports to Thailand from Japan, America, England, France, Italy, West Germany and Netherlands plastics materials exporter countries, and Hong Kong and Singapore as entreports, were tabulated in order to determine the quantities and values of Thailand's imports of individual plastics materials,[1] with results as shown in Table II-8. The unit used for value is the average price in US dollars, FOB and per ton.

2–2–2 Estimation of the Volume of Demand

(1) Polyolefins

(i) Imports

It is believe that the totals for polymerization resins in Table II-6 are almost entirely composed of figures for LDPE, HDPE, PP, PS and PVC which are general-use resins. The total for four major resins in Table II-8 (where LDPE and HDPE and combined in a single PE total) is considerably lower than the figures in Table II-6.

The reason for this is that Table II-8 gives 9- or 10-country totals whereas Thailand imports from more than those 10 countries.

Table II-9 provides the share in total imports represented by the sum of import quantities from Japan, America, England, France, Italy, West Germany, Holland, Hong Kong and Singapore, combined from Table II-6. From this it can be observed that from 1970 to 1976

1) Statistics from South Korea were included for 1978 onward.

Table II—6 IMPORT OF POLYMERIZATION PRODUCTS IN THAILAND

	Quantity (t)	C.I.F. (1,000 Baht)	Unit Price (Baht/kg)
1970	52,848	331,354	6.27
1971	77,542	418,848	5.40
1972	87,634	502,113	5.73
1973	104,060	923,508	8.87
1974	49,555	842,276	17.00
1975	86,576	1,138,251	13.15
1976	89,292	1,245,718	13.95

Source: Foreign Trade Statistics of Thailand.

Table II—7 PLASTICS MATERIALS IMPORTS IN THAILAND (1977—1979)

	Description	Quantity (t)	C.I.F. (1,000/Baht)	Unit Price (Baht/kg)
1977	Polyethylene	65,143	730,738	11.22
	Polypropylene	19,235	238,019	12.37
	Polystyrene	6,662	92,728	13.92
	Polyvinyl Chloride	7,058	94,959	13.45
1978	Polyethylene	73,145	808,962	11.06
	Polypropylene	31,732	355,727	11.21
	Polystyrene	5,644	77,409	13.72
	Polyvinyl Chloride	4,369	69,375	15.88
1979	Polyethylene	84,364	1,511,529	17.92
	Polypropylene	54,205	765,352	14.12
	Polystyrene	2,267	42,579	18.78
	Polyvinyl Chloride	8,564	155,036	18.10

Source: Foreign Trade Statistics of Thailand.

Table II–8 PLASTICS MATERIALS IMPORTS FROM SELECTED COUNTRIES[1)]

(Unit: Upper; t/y, Lower; US$/t)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
PE[2)]	37,040	49,478	58,493	57,917	22,767	48,077	45,862	57,284	62,779	58,319
	261.2	257.5	241.6	360.9	718.0	520.0	557.7	552.5	506.6	818.4
PP	5,508	8,068	11,564	13,025	7,075	17,633	13,346	16,676	19,524	38,010
	285.4	268.1	237.6	413.2	739.9	526.4	603.7	603.3	527.1	640.2
PS[3)]	5,430	8,246	8,152	7,201	2,644	6,326	6,670	9,696	10,493	5,157
	252.4	254.4	272.1	467.3	913.7	574.5	663.3	699.2	803.7	1,149.9
PVC	7,325	3,284	1,784	2,102	1,025	24	600	712	750	2,016
Compound	298.2	309.4	313.7	471.7	895.4	843.5	950.3	1,185.0	1,200.0	981.0
PVC	1,832	4,180	5,332	5,579	2,749	2,009	1,940	4,300	4,306	4,737
Resin	309.7	270.3	241.0	407.9	855.1	577.8	616.5	633.0	686.7	832.2

Notes: 1) Japan, U.S.A., W. Germany, France, Italy, U.K., Netherlands, (Hong Kong, Singapore and South Korea).
2) Total of LDPE and HDPE.
3) Total of GPPS, HIPS, FS, AS and ABS resin.

Source: Foreign Trade Statistics of each countries.

Table II–9 SUPPLY RATIO OF POLYMERIZATION PRODUCTS FROM SELECTED COUNTRIES[1] TO THAILAND

	Thai Imports (t/y)	Imports from Selected Countries[1] (t/y)	Ratio (Conversion Factor)
1970	52,848	51,093	0.967
1971	77,542	73,676	0.951
1972	87,643	83,058	0.951
1973	104,060	98,622	0.948
1974	49,555	46,024	0.929
1975	86,576	76,343	0.882
1976	89,292	78,195	0.876

Note: 1) Japan, U.S.A., W. Germany, France, Italy, U.K., Netherlands, Singapore and Hong Kong.

Source: Foreign Trade Statistics of Thailand.

the share of exports from the 10 countries in total Thai imports of polymer resins decreased, from 96.7% to 87.6%. From the standpoint of Thailand, there has been a gradual diversification of import sources, and in addition to importing from industrialized Western nations, the country has increased its imports from East Europe and elsewhere.

The quantities of PE and PP imports from 1970 to 1976 were sought multiplying the decimal ratio of Table II-9 and total export volumes from Table II-8. Thailand's foreign trade statistics (Table II-7) were used as the source of information on imports for 1977 and thereafter.

(ii) Prices

Concerning prices, use has been made of each exporter country's average FOB price, in Table II-8, for 1970∿1979.

The quantities and prices of imports thus obtained, together with information for other plastics materials, are given in Table II-10.

(2) PVC

(i) Imports

Values tabulated in Table II-8 for volumes exported to Thailand in the case of PVC give values for both resin and compound. Compound consists of the resin and a plasticizer and on the average is 58% resin. Therefore, in order to convert Thai's PVC imports to resin, the quantity of compound is to be multiplied by 0.58, and added to the quantity of PVC resin; this is done with the results as shown in Table II-11.

From 1977 on, Thailand's foreign trade statistics, however, combine PVC resin and PVC compound.

From 1977 onward, however, taking into consideration the rapid increase in imports from Taiwan, as shown in Table II-12, the total quantity of Thai imports (Table II-13) was taken as the sum of exports from the industrialized countries and imports from countries others than those included in Table II-12.

Further, because the calculation described above combine resin and compound, conversion to resin quantities has been made as shown in Table II-14.

Table II—10 CONSUMPTION AND PRICE OF PLASTICS MATERIALS

	PE		PP		Polyolefin[3]		PVC (as resin)		PS[4]	
	(t/y)	(Baht/kg)[1]	(t/y)	(Baht/kg)[1]	(t/y)	(Baht/kg)	(t/y)	(Baht/kg)[2]	(t/y)	(Baht/kg)[2]
1970	38,304	5.30	5,696	5.79	44,000	5.36	6,288	9.85	5.430	8.18
1971	52,027	5.23	8,483	5.44	60,510	6.30	8,719	8.04	8.246	8.24
1972	61,701	4.91	12,198	4.82	73,899	4.90	14,098	6.94	8.152	8.75
1973	61,093	7.33	13,739	8.39	74,832	7.52	15,972	14.02	7,201	14.43
1974	24,504	14.58	7,615	15.02	32,119	14.68	12,575	19.36	2,644	27.96
1975	54,509	10.56	19,992	10.69	74,501	10.59	15,202	14.29	6,326	18.12
1976	52,354	11.32	15,235	12.26	67,589	11.53	17,669	16.06	6,670	20.69
1977	65,143	11.22	19,235	12.25	84,378	11.45	25,190	16.31	9,696	21.72
1978	73,145	10.28	31,732	10.70	104,877	10.41	26,142	16.71	14,033	23.14
1979	84,364	16.61	54,205	13.00	138,569	15.20	31,895	22.90	14,847	27.78

Note: 1) Average FOB price.
2) Average ex-factory price.
3) Total of PE and PP.
4) Including AS, ABS resins.

Source: UNICO estimate.

Table II—11 PVC RESIN IMPORTS FROM SELECTED COUNTRIES

(Unit: t/y)

	Resin (a)	Compound (b)	Resin Content in Compound (c) = 0.58 x (b)	Total Resin Imports (a) + (c)
1970	1,832	7,325	4,249	6,081
1971	4,180	3,284	1,905	6,085
1972	5,332	1,784	1,035	6,367
1973	5,579	2,102	1,219	6,798
1974	2,749	1,025	595	3,344
1975	2,009	24	14	2,023
1976	1,940	600	348	2,288
1977	4,300	712	413	4,713
1978	4,306	750	435	4,741
1979	4,737	2,016	1,169	5,906

Source: Table II-3.

Table II–12 PVC IMPORTS[1] (1977 – 1979)
(THAI TRADE STATISTICS)

(unit: t/y)

Country of Origin	1977	1978	1979
Japan	2,257	1,808	3,004
U.S.A.	77	61	88
West Germany	260	162	3
France	–	–	–
Italy	–	–	–
U.K.	48	40	255
Netherlands	–	–	478
Hong Kong	–	–	97
Singapore	590	489	16
Sub-total	3,232	2,560	4,043
Taiwan	2,715	1,477	1,187
Hungary	–	–	1,544
Romania	–	–	1,480
Others	1,111	359	310
Sub-total	3,826	1,836	4,521
Total	7,058	4,369	8,564

Note: 1) Including PVC compound.

Table II—13 ESTIMATED PVC IMPORTS (1977 — 1979)

(Unit : t/y)

	Imports from Developed Countries[1]		Imports from Other Countries[1]		Modified Imports[1]
	UNICO (a)	Thai Statistics (b)	UNICO (c)	Thai Statistics (d)	(e)=(a)+(d)
1977	5,012	3,232	—	3,826	8,838
1978	5,056	2,560	—	1,836	6,865
1979	6,753	4,043	—	4,521	11,274

Note : 1) Total of PVC resin and compound.

Source: Tables II-8 and II-12.

Table II—14 ESTIMATED PVC RESIN IMPORTS (1977 — 1979)

(Unit : t/y)

	1977	1978	1979
Total Imports (t/y)[1]	8,838	6,865	11,274
Ratio of Resin against[2] Total Imports	0.940	0.938	0.875
Estimated PVC Resin Imports[3]	8,308	6,439	9,865

Notes : 1) (e) in Table II-13

2) Calculation formula : $\frac{(a)+(c)}{(a)+(b)}$

where, (a), (b) and (c) are shown in Table II-6

3) Total imports multiplied by ratio of resin

Import price was determined as follows. Taking as the starting point the average FOB price for resin, obtained from exporters' statistics, conversion to Baht was made and as average transport cost 0.6 Baht/kg for up to 1973 and 1.0 Baht/kg for 1974 and thereafter was added to obtain the C&F price, which was multiplied by 1.43 to obtain the landed price (Table II-15).

At the stage of the C&F price, comparison can be made to the CIF price in Thai import statistics (Table II-7), and it is observed that there is not a great difference between them.

(ii) Production

Production of PVC was begun in 1971 by the Thai Plastic and Chemical Co., using imported VCM as raw material. The company's shipments and delivered prices are as shown in Table II-16.

(iii) Apparent demand

The sum of the above-noted import quantity and domestic sales volume was taken as representing domestic apparent demand (Table II-17) and the weighted average of landed price including customs tariff and shipment price of domestic products was taken as the price of PVC in Thailand (Table II-18).

(3) Styrene polymers

(i) Imports

The sources of styrene polymers is limited almost totally to advanced industrial countries. Sources of imports and import volumes as shown by recent Thai foreign trade statistics are given in Table II-19.

Because of the reasons given above, the quantities and unit prices of styrene polymers obtained from tabulations of export statistics from supplier-nations[1] were used to calculate styrene polymers import quantities and unit prices (Table II-8). The landed price of imports was sought in the same manner as for PVC.

1) The figures in Table II-8 are totals of three polystyrenes (GP, HI and FS) and styrene copolymers (AS resin and ABS resin). It is not clear what range of styrene polymers is included in the category "Polystyrene and its copolymers in primary forms" in Thailand's trade statistics but because there is no separate category for AS and ABS resins it can be throught that these copolymers are included therein, and it is also conceivable that they are included in "other synthetic resins in primary forms" for which extremely large quantities are indicated.

Table II–15 IMPORT PRICE FOR PVC RESIN

	FOB[1] (US$/t)	FOB[2] (Baht/kg)	Freight[3] (Baht/kg)	C&F[4] (Baht/kg)	Landed Price[5] (Baht/kg)
1970	309.7	6.29	0.60	6.89	9.85
1971	270.3	5.49	0.60	6.09	8.71
1972	241.0	4.89	0.60	5.49	7.85
1973	407.9	8.28	0.60	8.88	12.70
1974	855.1	17.36	1.00	18.36	26.25
1975	577.8	11.73	1.00	12.73	18.20
1976	616.5	12.51	1.00	13.51	19.32
1977	633.0	12.85	1.00	13.85[4]	19.81
1978	686.7	13.94	1.00	14.94[4]	21.36
1979	822.2	16.89	1.00	17.89[4]	25.58

Notes : 1) See Table II-8.
Average FOB price from the selected countries.

2) Exchange rate, US$1 = 20.3 Baht.

3) Assumption.

4) According to the Thai Trade Statistics.

1977	13.45	Baht/kg	including PVC compound.
1978	15.98	Baht/kg	
1979	18.10	Baht/kg	

5) 1.43 times C&F price.

Table II–16 PVC SALES VOLUME AND PRICE

	Resin		Compound	
	(t/y)	Price (Baht/kg)[1]	(t/y)	Price (Baht/kg)[1]
1971	1,273	6.2	3,805	8.8
1972	4,663	6.1	7,995	9.1
1973	4,265	15.1	7,390	17.6
1974	6,500	16.6	4,635	20.8
1975	9,553	13.6	8,990	19.4
1976	8,977	15.5	10,732	20.5
1977	10,229	14.6	12,920	20.1
1978	12,425	15.2	14,254	20.2
1979	13,777	21.7	15,382	27.7
1980		24.75		

Note : 1) User price.

Source : Thai Plastic and Chemical Co., Ltd.

Table II–17 ESTIMATED CONSUMPTION FOR PVC RESIN

(Unit : t/y)

	Production[1]	Imports[2),3)]	Total
1970	–	6,288	6,288
1971	2,320	6,399	8,719
1972	7,360	6,738	14,098
1973	8,801	7,171	15,972
1974	8,975	3,600	12,575
1975	12,908	2,294	15,202
1976	15,057	2,612	17,669
1977	16,882	8,308	25,190
1978	19,703	6,439	26,142
1979	22,030	9,865	31,895

Notes : 1) Converted to the calendar year production

2) See Tables II-11 and II-14

3) Modified imported volume obtained by applying conversion factors shown in Table II-9 on the figures for 1970 to 1976 in Table II-11.

Table II–18 TREND OF PVC CONSUMPTION AND PRICE IN THAILAND

	Consumption[1] (t/y)	Current Price[2] (Baht/kg)	Real Price[3] (Baht/kg)
1970	6,288	9.85	10.86
1971	8,719	8.04	8.73
1972	14,098	6.94	6.94
1973	15,972	14.02	11.66
1974	12,575	19.36	13.55
1975	15,202	14.29	9.73
1976	17,669	16.06	10.59
1977	25,190	16.31	9.90
1978	26,142	16.72	9.34
1979	31,895	22.90	11.55

Notes : 1) See Table II-17.

2) Weight average of domestic supply price and import price.

3) Current price divided by GDP deflator (at 1972 price).

Table II–19 THAILAND'S POLYSTYRENE IMPORTS (1977 – 1979)

(Unit: t)

	1977	1978	1979
Hong Kong	2,090	1,770	–
Japan	1,608	1,282	210
Singapore	0	–	–
France	11	82	–
W. Germany	871	786	936
Italy	20	26	–
Netherland	4	488	–
U. K.	133	241	123
U. S. A.	1,440	365	390
Sub-total	6,177	5,040	1,659
Others	485	604	608
Total	6,662	5,644	2,267

Source: Foreign Trade Statistics of Thailand.

(ii) Production

The Dow Chemical Thailand Ltd. polystyrene plant began production during 1978, using imported styrene monomer as raw material. Initial production capacity was 10,000 t/y, and this was increased to 22,500 t/y in 1980.

The value of domestic sales volume of this company, since the start of production, is as given in Table II-20. In addition to this there are moderate quantities of exports, so production including inventory at the plant would be somewhat higher than the figures given in Table II-20.

(iii) Apparent demand

The sum of import volume and domestic sales volume is taken as apparent domestic demand, and the weighted average of the landed price including customs tariff and shipment price of domestic products was taken as the price of styrene resin in Thailand (Table II-21).

2–3 MACRO-ANALYSIS OF DEMAND (ELASTICITY ANALYSIS)

2–3–1 Method of Analyzing Demand

The following model was used to perform macro-analysis of demand for plastic materials.

$$\log Q_t = a + e_\theta \log \Theta_t - e_p \log P_t$$

where

Q_t : Demand volume (1,000 t/y)
Θ_t : Real GDP (10^9 Baht)
P_t : Real price (Baht/kg) = current price/GDP deflator
a : Constant
e_θ : GDP elasticity
e_p : Price elasticity

Table II–20 DOMESTIC SALES OF POLYSTYRENE IN THAILAND

	General Purpose		High Impact	
	(t)	(Million Baht)	(t)	(Million Baht)
1978				
3 Qtr.	1,210	22	40	1
4 Qtr.	1,670	30	620	12
1979				
1 Qtr.	2,240	39	670	15
2 Qtr.	1,480	38	680	19
3 Qtr.	1,970	51	760	21
4 Qtr.	1,290	33	600	17
1980				
1 Qtr.	1,790	49	820	24
2 Qtr.	1,550	45	870	27
3 Qtr.	1,600	44	840	25

Source: Dow Chemical Thailand Ltd.

Table II–21 APPARENT CONSUMPTION AND AVERAGE PRICE OF STYRENE POLYMERS IN THAILAND

	Import		Production[1]		Total	
	Quantity (t)	Price[2] (Baht/kg)	Quantity (t)	Price[3] (Baht/kg)	Quantity (t)	Price (Baht/kg)
1970	5,430	8.18	–	–	5,430	8.18
1971	8,246	8.24	–	–	8,246	8.24
1972	8,152	8.75	–	–	8,152	8.75
1973	7,201	14.43	–	–	7,201	14.43
1974	2,644	27.96	–	–	2,644	27.96
1975	6,326	18.12	–	–	6,326	18.12
1976	6,670	20.69	–	–	6,670	20.69
1977	9,696	21.72	–	–	9,696	21.72
1978	10,493	24.75	3,540	18.36	14,033	23.14
1979	5,157	34.81	9,690	24.05	14,847	27.78

Notes: 1) Domestic Sales.

2) Landed Price (including import tarriff).

3) Ex-factory Price.

The real price is the value obtained by dividing the price by the GDP deflator. The method of calculation of elasticity is described in detail in the Attachment.

(1) Volume of demand and real price

Table II-22 indicates the volume of demand and real price (1972 price) for plastics materials for 1970~1979.

(2) Real GDP and the GDP deflator

Table II-23 indicates the real GDP and GDP deflator for Thailand during the Seventies.

2–3–2 Results of Analysis

The results of calculation of elasticity for each plastics material are given in Table II-24. Comparison of real and theoretical values is given in Table II-25 and Figs. II-3 to II-7.

2–3–3 Consideration Related to Results of Demand Analysis

Regarding demand for the five general-purpose plastics materials taken up in this study, it is characteristic of the trend over the past 10 years in Thailand that each of those materials is extremely sensitive to price. That is, immediately following oil shock in 1974, prices swiftly rose, and demand fell drastically; this is verified by the extremely high correlation between the demand and the real price as a variable of a demand model.

(1) Polyethylene

The difference between actual and theoretical values is extremely high for both 1978 and 1979. That is, even though the real price declined in 1978, there was not a great increase in demand. This indicates that even though there was a swift drop in the price beyond a certain level, growth of the market could not catch up to this, and that it is possible that the reduction in the price of the material was absorbed in the course of its distribution, by importers and dealers of the material, processing firms and dealers handling the products. In contrast to this,it is evident that even though demand declined during 1979 in anticipation of an increase in price at the end of 1979 or during the first half of 1980, importation continued and at about mid-1980 dealers were letting the goods go at the low margin of 0.5 Baht per kilogram (the usual margin was four times that). Therefore, it may be thought that the increase in price, as opposed to the decrease in 1978, was absorbed in the distribution process.

Table II–22 CONSUMPTION AND REAL PRICE (AT 1972) OF PLASTICS MATERIALS

	PE		PP		PO[1]		PVC		PS	
	(t/y)	(Baht/kg)	(t/y)	(Baht/kg)	(t/y)	(Baht/kg)	(t/y)	(Baht/kg)	(t/y)	(Baht/kg)
1970	38,304	5.84	5,696	6.38	44,000	5.91	6,288	10.86	5,430	9.02
1971	52,027	5.68	8,483	5.91	60,510	5.71	8,719	8.73	8,246	8.95
1972	61,701	4.91	12,198	4.82	73,899	4.90	14,098	6.94	8,152	8.75
1973	61,093	6.10	13,739	6.98	74,832	6.26	15,972	11.66	7,201	12.00
1974	24,504	10.20	7,615	10.51	32,119	10.27	12,575	13.55	2,644	19.57
1975	54,509	7.19	19,992	7.28	74,501	7.21	15,202	9.73	6,326	12.34
1976	52,354	7.46	15,235	8.08	67,589	7.60	17,669	10.59	6,670	13.64
1977	65,143	6.82	19,235	7.44	84,378	6.96	25,190	9.90	9,696	13.20
1978	73,145	5.75	31,732	5.98	104,877	5.82	26,142	9.34	14,033	12.93
1979	84,364	8.38	54,205	6.56	138,569	7.68	31,895	11.55	14,847	14.02

Note : 1) Polyolefin (Total of PE and PP).

Table II–23 GROSS DOMESTIC PRODUCT BY INDUSTRIAL ORIGIN IN THAILAND

	At Current Prices (Million Baht)	At 1972 Prices (Million Baht)	GDP Deflator	Monthly Bulletin (Bank of Thailand)
1970	136,060	150,092[1]	90.7	
1971	144,607	157,088[2]	92.1	(Bank of Thailand)
1972	164,626	164,626[3]	100.0	
1973	216,543	180,146	120.2	XVIII 1978 Dec.
1974	271,368	189,950	142.9	XIX 1979 Dec.
1975	298,816	203,514	146.8	
1976	337,635	222,509	151.7	
1977	393,030	238,841	164.6	XX 1980 Apr.
1978	477,341	266,840	178.9	
1979	564,431	284,747	198.2	

Note: At 1962 Prices: 1) 120,728 Million Baht.
2) 129,061 Million Baht.
3) 134,475 Million Baht.

Table II–24 RESULT OF ELASTICITY ANALYSIS FOR PLASTICS MATERIALS CONSUMPTION

	Constant	Elasticity		Correlation Coefficient
		GDP	Price	
PE	-0.4008	1.3743	1.2516	0.8906
PP	-4.7184	2.9460	1.0635	0.9578
PVC	-3.3893	2.1784	0.4324	0.9441
PS	-2.9233	2.5424	1.8998	0.9654
PO	-1.1076	1.7349	1.2626	0.9222

Notes: Model $\log Q = a + e_{\theta}\log\Theta - e_{p}\log P$.
Q = Consumption (1,000t).
Θ = Real GDP (Billion Baht).
P = Real Price (Baht/kg, at 1972 Price).
e_{θ} = GDP Elasticity.
e_{p} = Price Elasticity.
a = Constant.

Table II—25 COMPARISON BETWEEN ACTUALL AND THEORETICAL CONSUMPTION FOR PLASTICS MATERIALS

(Unit: t/y)

	PE		PP		PO (PE+PP)		PVC		PS	
	Actual	Theoretical	Actual	Theoretical	Actual	Theoretical	Actual	Theoretical	Actual	Theoretical
1970	38,304	42,753	5,696	6,874	44,000	49,431	6,288	8,013	5,430	6,240
1971	52,027	47,127	8,483	8,528	60,510	55,875	8,719	9,725	8,246	7,111
1972	61,701	60,296	12,198	12,153	73,899	73,494	14,098	11,888	8,152	8,358
1973	61,093	52,005	13,739	10,685	74,832	63,058	15,972	11,556	7,201	5,766
1974	24,504	29,413	7,615	8,095	32,119	37,033	12,575	12,168	2,644	2,608
1975	54,509	50,071	19,992	14,643	74,501	65,207	15,202	16,306	6,326	7,459
1976	52,354	54,054	15,235	17,049	67,589	71,231	17,699	19,094	6,670	7,737
1977	65,143	66,647	19,235	22,922	84,378	89,986	25,190	22,932	9,696	9,856
1978	73,145	77,630	31,732	40,088	104,877	136,711	26,142	29,941	14,033	13,588
1979	84,364	65,576	54,205	43,988	138,569	107,810	31,895	31,465	14,847	13,743

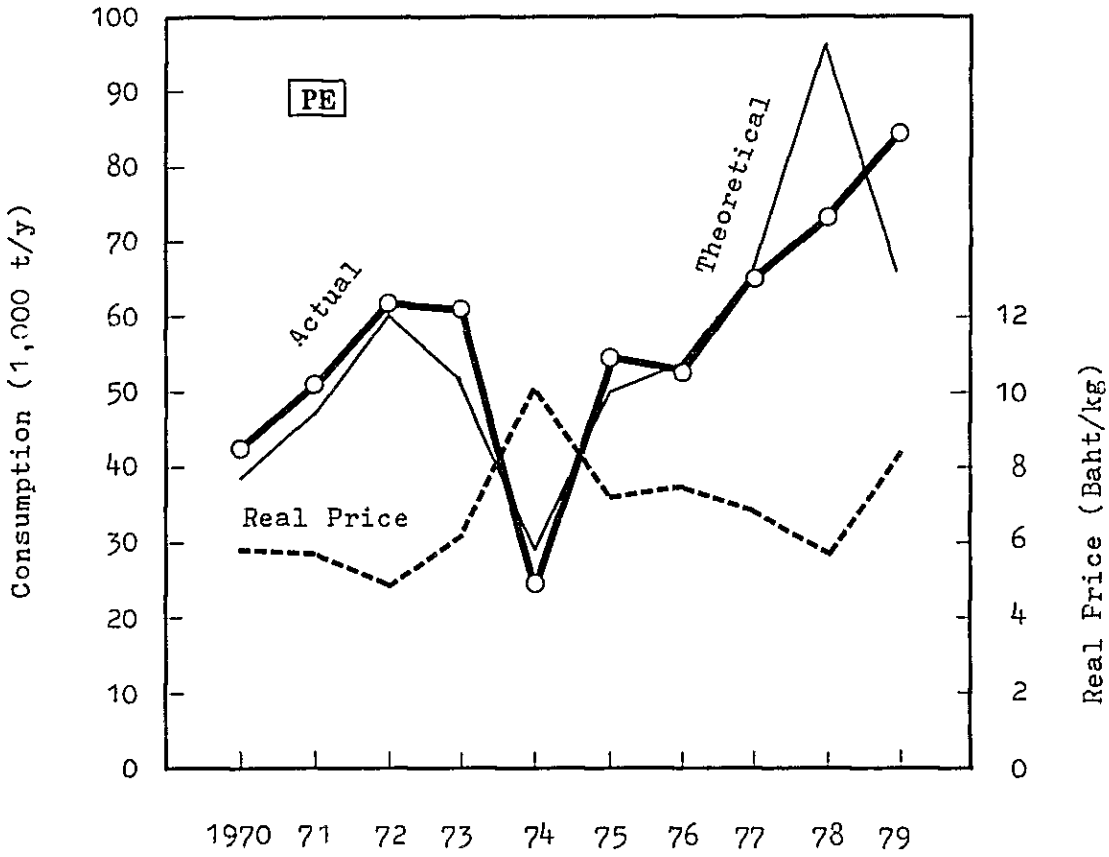


Fig. II–3 CONSUMPTION AND REAL PRICE FOR POLYETHYLENE

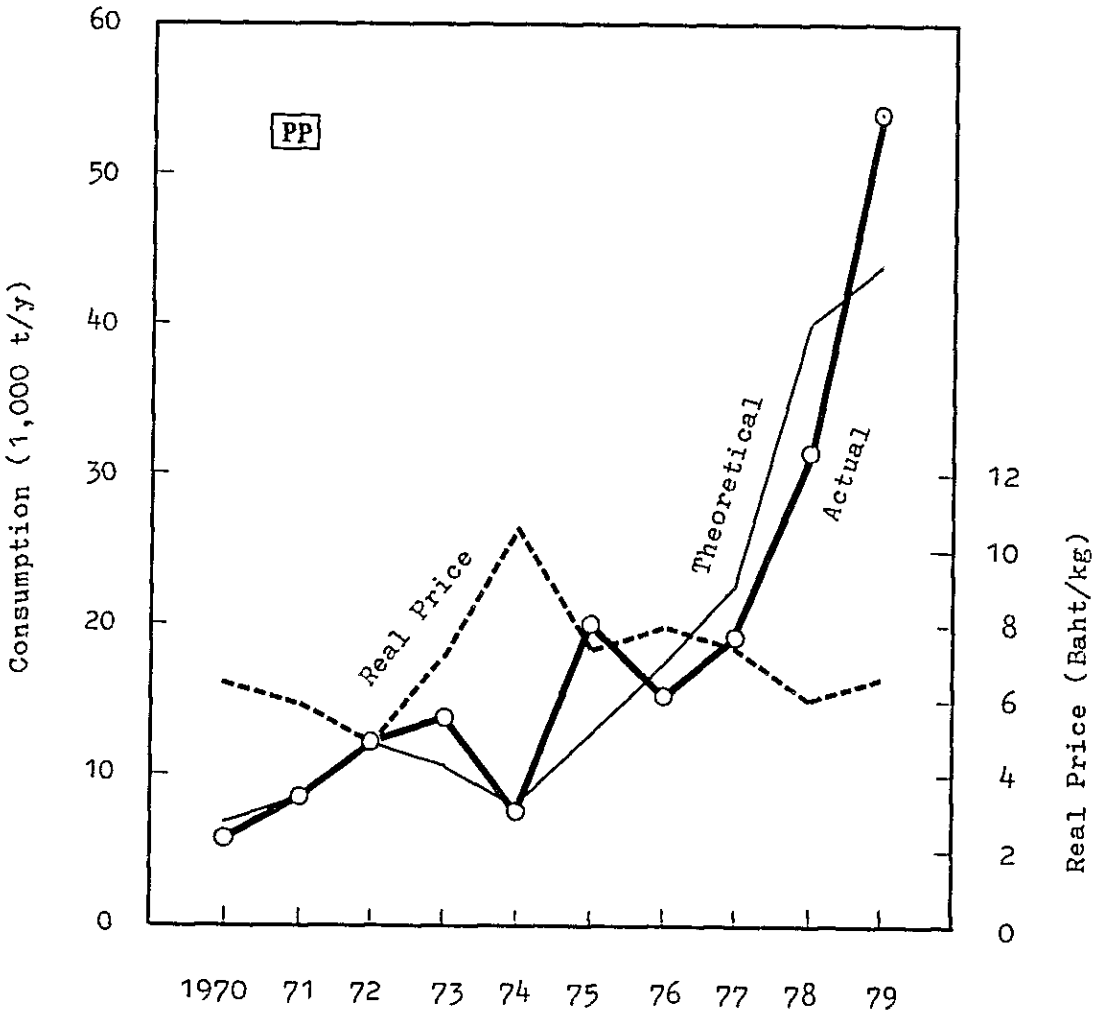


Fig. II–4 CONSUMPTION AND REAL PRICE FOR POLYPROPYLENE

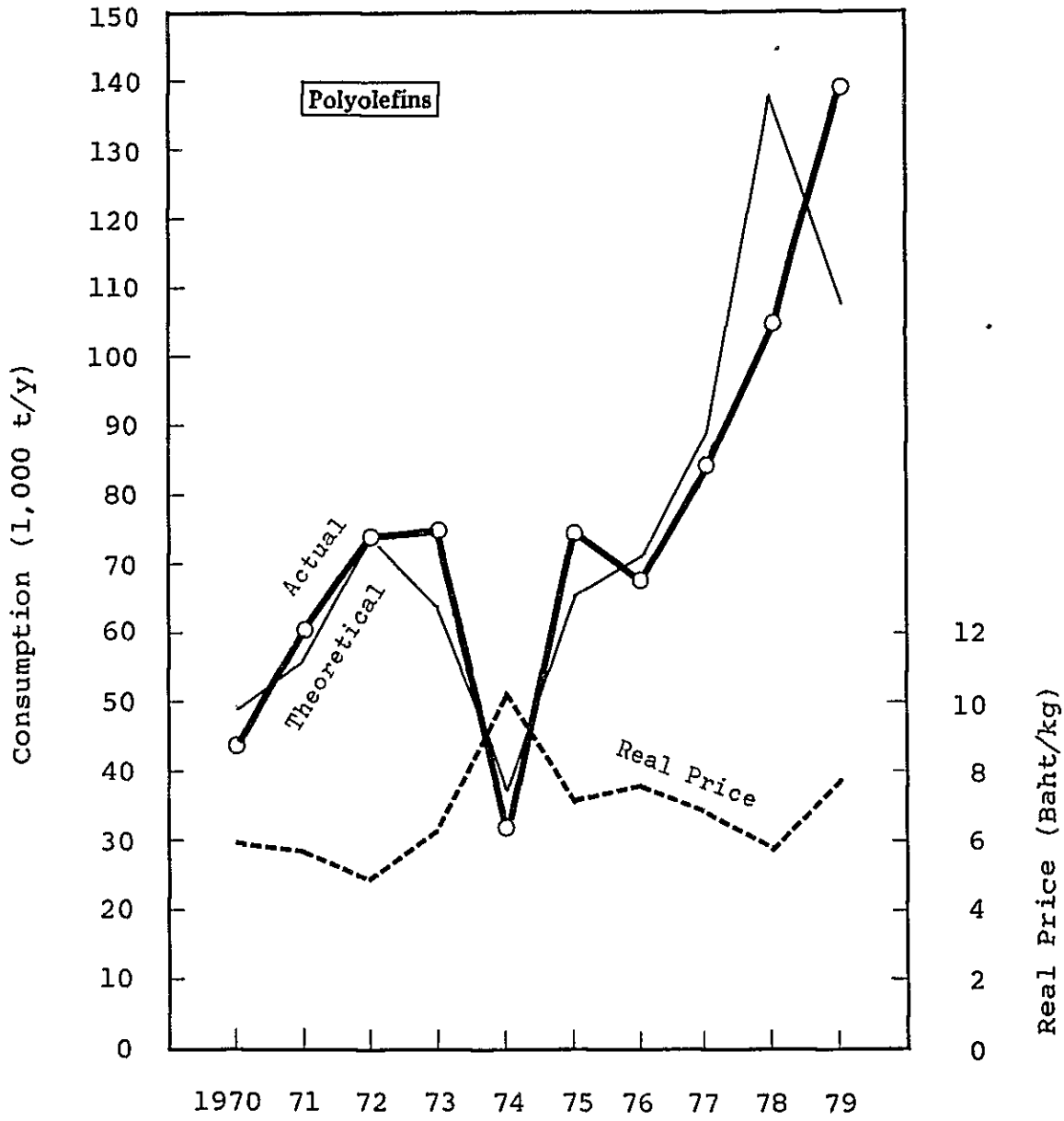


Fig. II–5 CONSUMPTION AND REAL PRICE FOR POLYOLEFIN

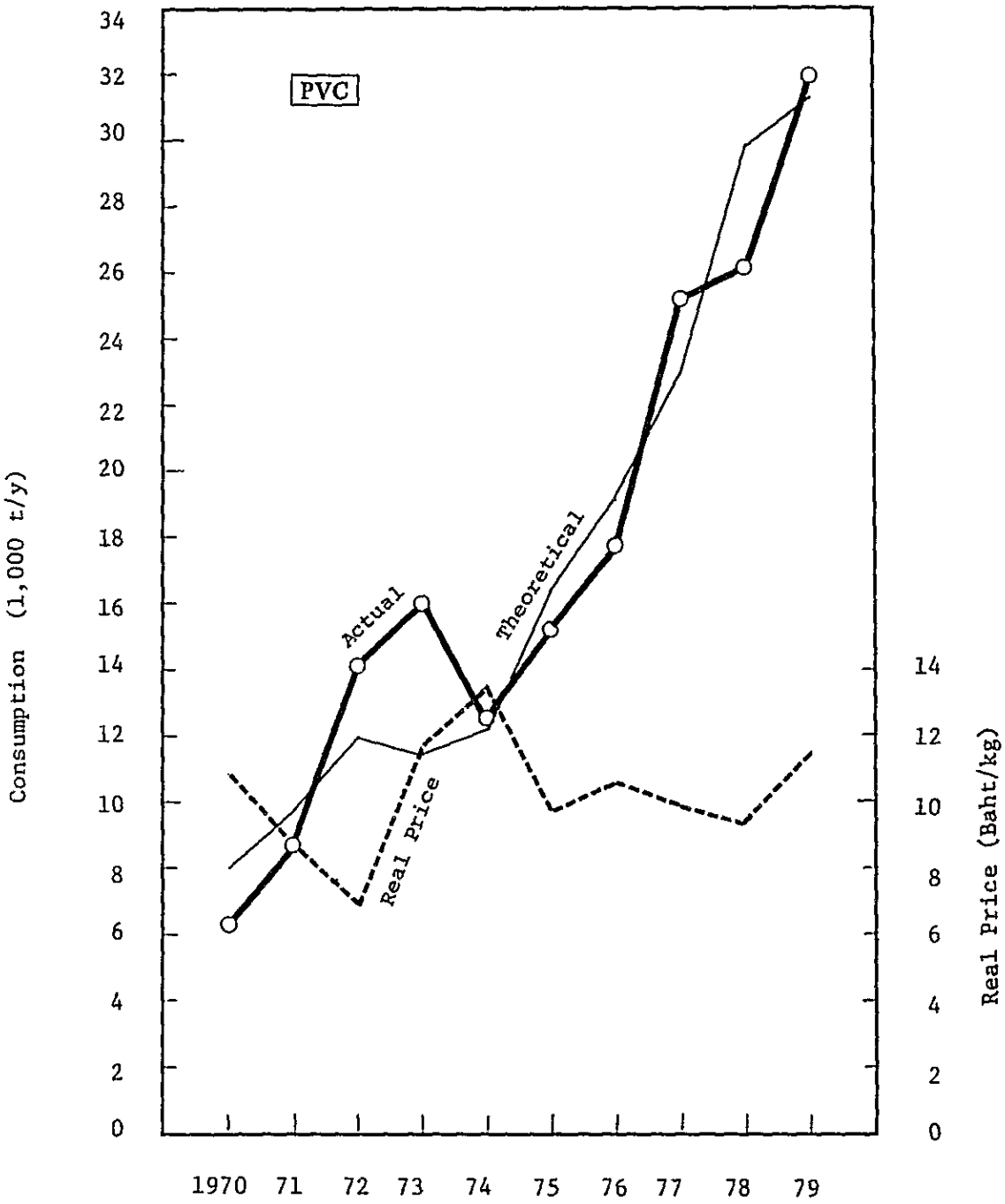


Fig. II–6 CONSUMPTION AND REAL PRICE FOR PVC RESIN

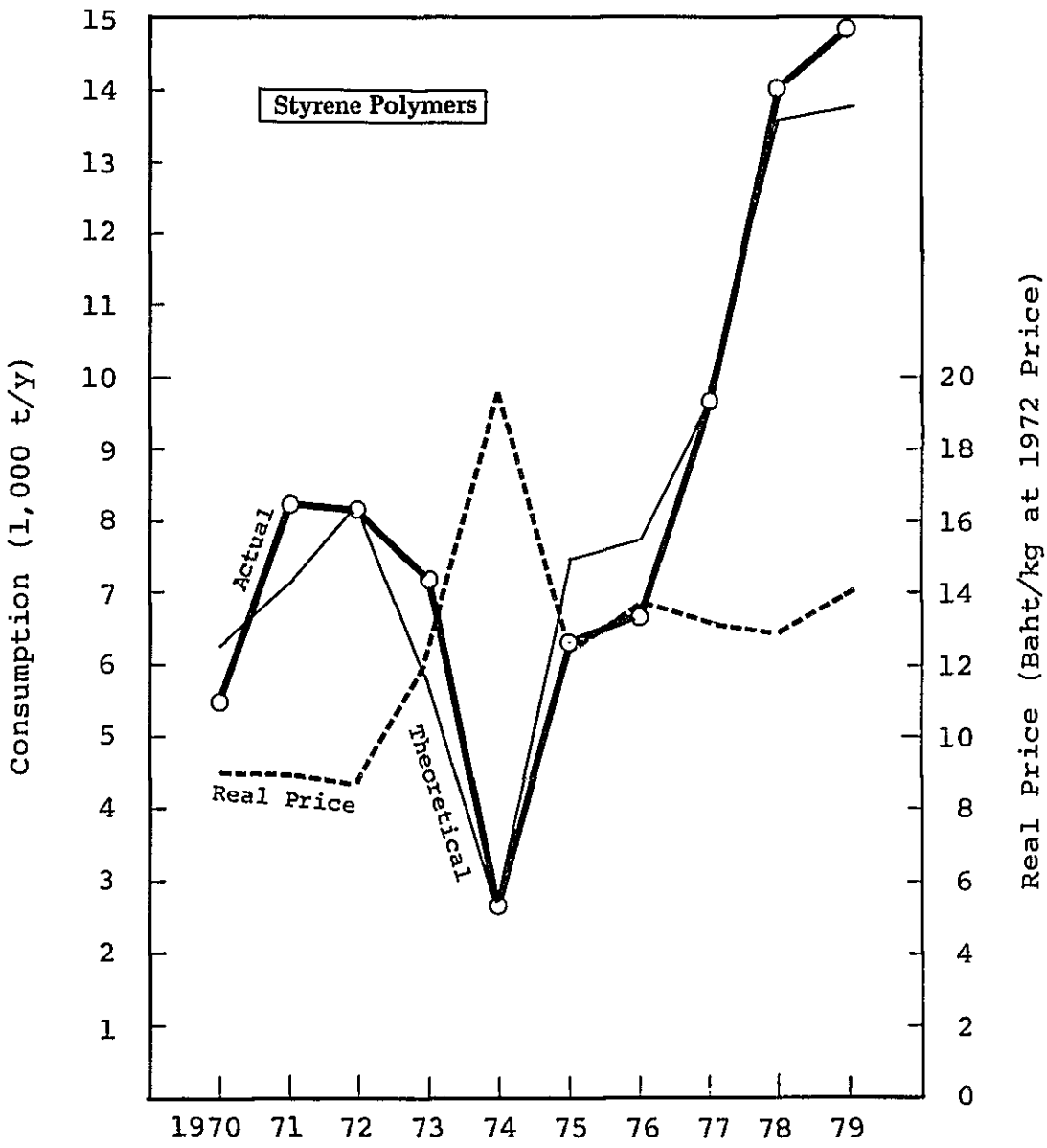


Fig. II–7 CONSUMPTION AND REAL PRICE FOR STYRENE POLYMERS

This is verified by the results of leaving the real price at the same level as in 1977, namely 6.82 Baht/kg, and using the above-mentioned regression formula for demand; the theoretical demand volumes obtained, 77,600 t/y for 1978 and 84,900 t/y for 1979, are quite close to the actual values. However, because the real price in 1979, as is mentioned above, was 8.38 Baht/kg, when the theoretical value is sought by use of the regression equation, 65,600 t/y is obtained as the result.

According to the results[1] of tabulation of import invoices for Thailand, as indicated in Table II-26 the ratio of LDPE to HDPE is 60 : 40, and if that is taken to represent actual demand then:

LDPE : 39,400 t/y
HDPE : 26,200 t/y

According to Thai United Polymer, in 1980 demand for HDPE fell by about 20% relative to the preceding year and presently is at the level of 22,000 to 24,000 t/y.

Considering the process of importation of polyethylene by means of the tabulation of invoices in Table II-27 and Fig. II-8, imports of LDPE began to increase from about the middle of 1978, but fell month by month in 1979 to the level of the average of 1,000 t/m in 1980. In addition to reflecting a decline in quantity demanded due to the increase in price during 1979, this reflects a drawing down in 1980 of stocks built up in 1979.

Regarding HDPE, although a slight difference exists the situation is essentially the same as in the case of LDPE.

(2) Polypropylene

With the real price of 1979 as 6.56 Baht/kg, the theoretical value obtained by use of the regression equation is 44,000 t/y. This value, as is the case with polyethylene, coincides with the figure of 44,621 tons which is the result of tabulation of import invoices. However, the abovementioned regression curve, other than the 1973, 1975 and 1979 values which are lower than actual values, indicates in general high levels. Because these three years, as has already been mentioned, were years when stocks were high because of false demand, the regression curve is believed to be influenced so as to be higher than real demand. Therefore, it would be suitable to reduce the above value by about 10%, to obtain about 40,000 t as the actual demand for 1979.

1) The tabulation of import invoices for polyethylene yields 68,134 t/y which by chance approaches the theoretical value, but it is suggested by a Japanese trading company manager that there are considerable omissions from the invoices used for tabulation.

Table II–26 IMPORTATION OF POLYOLEFINS IN 1978 AND 1979 BY COUNTRY

(Unit: t/y)

Country of Origin	1978			1979		
	LDPE	HDPE	PP	LDPE	HDPE	PP
Japan	6,788	15,514	10,921	8,275	8,987	7,395
U.S.A.	11,289	6,170	2,880	18,185	13,382	19,967
W. Germany	2,064	1,425	1,911	1,403	442	800
France	5,666	–	–	3,478	–	210
Italy	–	–	52	56	104	935
U.K.	38	–	1,335	99	21	531
Netherland	2,650	450	–	528	–	–
Hong Kong	1,187	–	–	–	–	–
Others	10,333	4,578	16,944	8,324	4,850	14,783
Total	40,015	28,137	34,043	40,348	27,786	44,621

Source: A Japanese trading company.

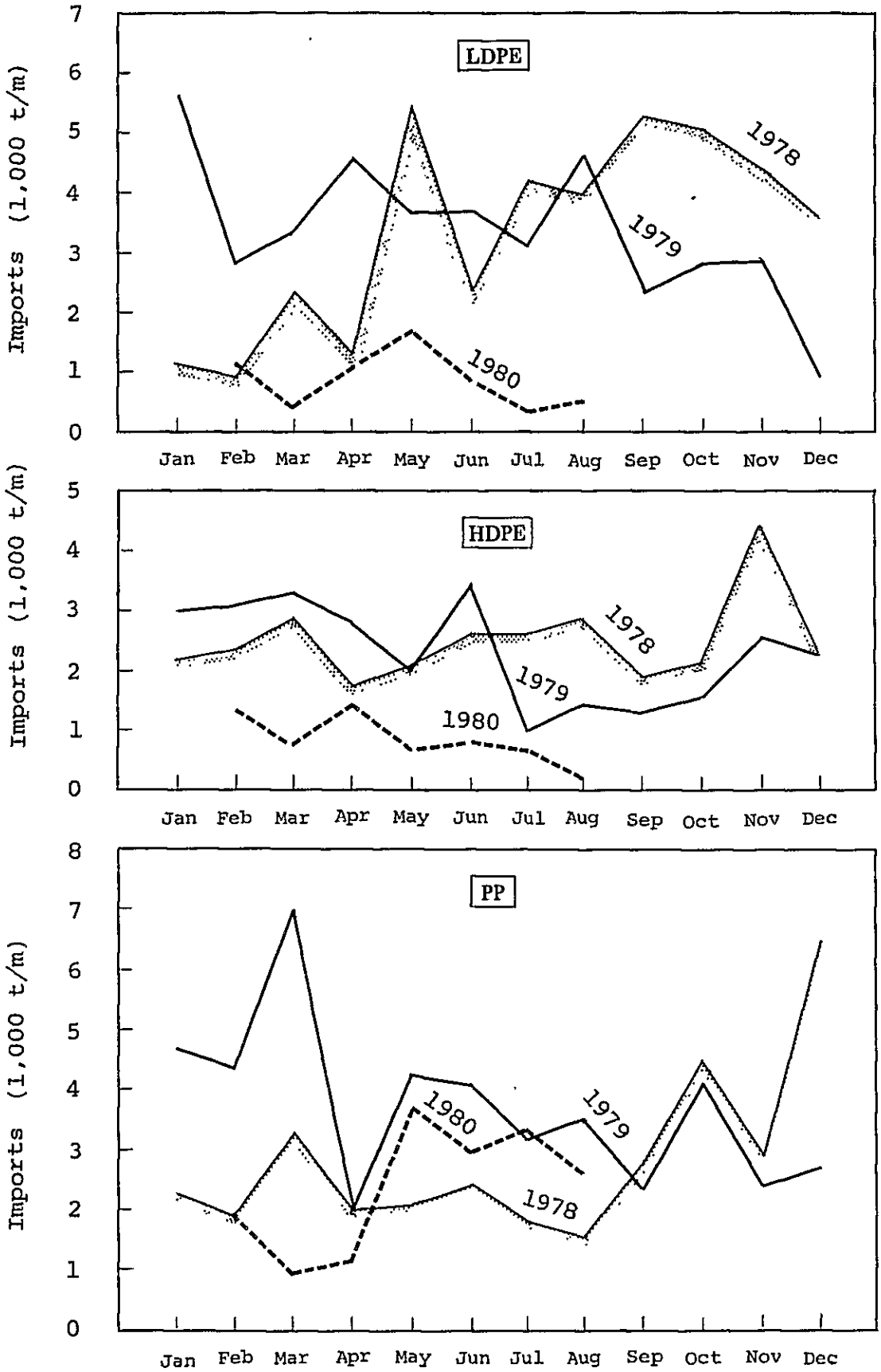
Table II–27 THAILAND'S POLYOLEFINS IMPORTS BY MONTH

(Unit: t/m)

	1978			1979			1980		
	LDPE	HDPE	PP	LDPE	HDPE	PP	LDPE	HDPE	PP
January	1,131	1,185	2,290	5,607	3,020	4,712	–	–	–
February	957	1,325	1,929	2,821	3,083	4,432	1,080	1,362	1,941
March	2,322	2,871	3,263	3,364	4,339	7,024	357	748	899
April	1,269	1,759	1,980	4,514	2,848	2,012	1,080	1,431	1,159
May	5,484	2,126	2,074	3,711	2,012	4,186	1,631	648	3,697
June	2,459	2,672	2,418	3,688	3,483	4,060	848	804	2,899
July	4,166	2,609	1,824	3,098	993	3,171	303	673	3,330
August	3,948	2,884	1,588	4,583	1,420	3,471	496	210	2,610
September	5,249	1,891	2,760	2,385	1,283	2,338	–	–	–
October	5,049	2,141	4,509	2,796	1,488	4,072	–	–	–
November	4,410	4,398	2,927	2,854	2,561	2,429	–	–	–
December	3,573	2,276	6,477	927	1,256	2,714	–	–	–
Total	40,015	28,137	34,043	40,348	27,786	44,621	–	–	–

Note: (–); not available.

Source. Japanese trading company.



Source: A Japanese trading company.

Fig. II–8 POLYOLEFIN IMPORTS BY MONTH

The approximately 14,000 t (4.4 months' volume) which is the difference between this figure and the 54,200 t given by Thailand's foreign trade statistics is surplus, stock in the distribution process. The quantity of PP imports, as shown in Fig. II-8, increased from the second half of 1978, and has remained steady from the second quarter of 1979 to 1980, and 1980 imports were down by more than 10,000 tons or about 40% compared to 1979 (February–August period).

(3) PVC

Actual and theoretical values are extremely closely matched for 1974 onward. Because production of PVC in Japan during 1973 was low because of reasons including a major explosion at a petrochemical complex in Japan, the emergence of pollution problems particularly related to mercury, and limitations to power generation because of a drought, exports of PVC fell sharply. Because of that, Southeast Asian countries which had previously been supplied by Japan turned to America and West Europe for their supply, resulting in a diversification of their supply.

The reason that the actual value is higher than the theoretical value for 1973 is a temporary increase in imports as a diversification effort inspired by anxiety over ability to acquire raw materials in the future, after the worldwide shortage in 1972–1973, and the false demand in anticipation of increases in the price of PVC due to a crude oil price increase in October that year.

(4) Styrene polymers

Of all the plastics materials taken up in this study, it is styrene polymers which have the highest correlation coefficient of the regression equation, and there is a good match of actual and theoretical values. Nevertheless, several problems are encountered if these results are to be used for projections. Among the styrene resin are:

GPPS	:	General Purpose Polystyrene
HIPS	:	High Impact Polystyrene
FS	:	Foamed Polystyrene
AS resin	:	Acrylonitrile Styrene Copolymer Resin
ABS resin	:	Acrylonitrile Butadiene Styrene Copolymer Resin

Each of these five has its special applications, and there is a different market for each of the five. That is, GPPS is used for general-use sundries, and packaging materials; HIPS is used for industrial parts, and especially parts for electric and electronic products. FS is used for packaging materials and as a building material (thermal insulation material). AS resin is used for industrial parts and ABS resin is used for industrial parts and automobile parts in particular. Therefore, it is an ordinary matter for the composition of styrene polymers demand to change in accordance with the development of industry in that country.

Regarding price, the price of copolymers AS and ABS is higher than that of single polymers such as GP and HI, so that the average price of the latter must increase to a greater extent than that of the former when there is a change in the level of demand. Therefore, there are times when it cannot be said that the quantity demanded will increase when the price is lowered.

Because of this, to the extent that use is made of a model which combines all five plastics types, price elasticity is not fixed and ordinarily declines as industrialization proceeds. In order to avoid this inconvenience, it is necessary to use separate models for each of the five. However, adequate information for such analysis is not usually available.

As a whole, actual demand for plastics materials in 1979 is estimated as follows:

	(Unit: t/y)
LDPE	39,400
HDPE	26,200
PP	40,000
PVC	31,500 (as resin)
PS	13,700

2–4 DEMAND FORECAST

2–4–1 Assumption for Demand Forecasts

The following assumption were made for preparation of demand forecasts.

1) The results of analysis of elasticity of demand during the Seventies would be used.

2) Real price is unchanged after 1979.[1] However, because the PP price was very low in 1979, the 1980 PP price was taken as being the same as that of PE from 1980 on.

3) The real growth rate of the GDP from 1980 on is 6.5% p.a.[2]

1) Demand model $\log Q = a + e_\theta \log\Theta$

2) According to The Nation Review, October 10, 1980, the overall economic growth rate should be between 6 to 7% a year in the Fifth Economic and Social Development Plan (1982–86).

(1) Estimation of future GDP elasticity [1)]

The GDP elasticity of demand for each resin during the Eighties and Nineties is shown in Table II-30. Tables II-28 and II-29, respectively given the GDP elasticity and future GDP estimates needed to forecast future GDP elasticity.

(2) Real price

The real prices for 1980 on, estimated for purposes of demand forecasts, are shown in Table II-31. The formula for conversion of 1972 ex-factory price/or landed price into 1979 ex-factory (or landed) price is as follows.

$$\psi = (1.982\phi + 1.0) \times 1.43$$

where,

ψ : 1972 constant price (FOB) (Baht/kg)
ϕ : 1979 constant price (ex-plant shipping price) (Baht/kg)

or, $\psi = 1.982\zeta$

Where, ζ being the ex-plant shipping price in 1972 price.

For PVC and PS which as of 1979 are domestic products, the ex-plant shipping price is shown.

(3) Demand model

With real price constant, the demand model is:

$$\log Q = a + e_\theta \log\Theta$$

For each plastics material, the coefficient for each decade (Eighties and Nineties) is as shown in Table II-32.

1) For method of estimation, see the Attachment.

Table II–28 ESTIMATION OF INITIAL GDP AND ABSOLUTE ELASTICITY

	Initial GDP (Bil. Baht)	Absolute Elasticity
PE	66.0	0.9336
PP	135.6	1.0049
PVC	111.3	1.0002
PS	124.4	1.0053

Table II–29 ASSUMPTION FOR REAL GDP (AT 1972 PRICE)

	Average GDP (Bil. Baht)	Growth Rate (%)
1970–1979	205.8	
(1980)	(303.2)	(6.5)
1981–1990	435.7	6.5
1991–2000	817.9	6.5

Table II–30 FORECAST FOR GDP ELASTICITY

	1970's	1980's	1990's
PE	1.3743	1.1003	1.0155
PP	2.9460	1,4590	1.2046
PVC	2.1784	1.3434	1.1577
PS	2.5424	1.4070	1.1857

Note: 1970's 1970–1979 (1980).
1980's 1981–1990.
1990's 1991–2000.

Table II–31 ASSUMED PRICE FOR DEMAND FORECAST

(Unit: Baht/kg)

	1972 Price	1979 Price[2)]
PE	8.3[1)]	25
PP	8.3[1)]	25
PVC	11.1[2)]	22
PS	14.1[2)]	28

Notes: 1) FOB price
2) Landed or ex-factory price

Table II–32 DEMAND EQUATIONS

	1980's		1990's	
	Constant	GDP Elasticity	Constant	GDP Elasticity
PE	-0.8711	1.1003	-0.6373	1.0155
PP	-2.0055	1.4590	-1.3046	1.2046
PVC	-1.7691	1.3434	-1.2574	1.1577
PS	-2.2889	1.4070	-1.6792	1.1857

Notes: Model $\log Q = a + e_\theta \log \Theta$
Q = Consumption (1,000t)
Θ = Real GDP (Billion Baht)
e_θ = GDP Elasticity
a = Constant.

2–4–2 Demand Forecast

Table II-33 gives demand forecasts according to the above model.

(1) Polyethylene

The ratio of LDPE and HDPE to all polyethylene, in 1979, is 60 : 40, as shown in Table II-26, but in industrially advanced countries the share of HDPE is lower than this, e.g.,

Japan	60 : 40
America	62 : 38
England	74 : 26
W. Germany	69 : 31
France	76 : 24

In Thailand, LDPE is used in relatively great quantity for film, but recently has been replaced by HDPE and PP, so that the share of LDPE has declined. However, in the future if other uses of LDPE are developed the LDPE : HDPE ratio can approach 65 : 35.

Table II-34 gives estimations of quantities demanded of both LDPE and HDPE as they gradually show a change from the 60 : 40 ratio to one of 65 : 35.

(2) Polypropylene

It is estimated that PP demand in Thailand will increase to 86,000 t/y in 1990 and 221,000 t/y in 2000 from 41,000 t/y in 1980. However, it should be noted that PP price in the future is assumed as equal to that of PE for the above demand prediction. Thailand's PP demand has been supported by imports of American PP at cheaper prices and it seems it will continue for the time being. Therefore, until 1985, a larger demand for PP than that shown in Table II-33 will be expected.

The larger demand mentioned above could not be realized when the price of PP which is domestically produced in Thailand will be expensive. Considering this possibility, it is more reasonable to assume the PP price to be the same as that of PE. Pricing of PP should be carefully studied when a feasibility study for the establishment of PP plant in the country is conducted in the future.

(3) PVC

Demand for PVC in resin equivalent is projected as 56,000 t/y in 1985 and 86,000 t/y

Table II–33 PAST TREND AND FORECAST OF PLASTICS MATERIALS DEMAND

(Unit: 1,000t)

	Real GDP (Bil. Baht)	PE	PP	PVC	PS
1970	150.1	38.3	5.7	6.3	5.4
1971	157.1	52.0	8.5	8.7	8.2
1972	164.6	61.7	12.2	14.1	8.2
1973	180.1	61.1	13.7	16.0	7.2
1974	190.0	24.5	7.6	12.6	2.6
1975	203.5	54.5	20.0	15.2	6.3
1976	222 5	52.4	15.2	17.7	6.7
1977	238 8	65.1	19.2	25.2	9.7
1978	266.8	73.1	31.7	26.1	14.0
1979	284.7	84.4	54.2	31.9	14.8
1980	294.4[1]	40.2[1]	39.6[1]	36.7[2]	16.0[2]
1981	322.9	77.6	45.2	40.0	17.4
1982	343.9	83.1	49.6	43.5	19.0
1983	366.3	89.1	54.3	47.3	20.8
1984	390.1	95.5	59.6	51.5	22.7
1985	415.4	102.3	65.3	56.1	24.8
1986	442.4	109.7	71.6	61.0	27.2
1987	471.2	117.6	78.5	66.4	29.7
1988	501.8	126.0	86.0	72.2	32.4
1989	534.4	135.0	94.3	78.6	35.4
1990	569.2	144.7	103.4	85.6	38.7
1991	606.2	154.3	111.5	92.0	41.7
1992	645.6	164.5	120.3	99.0	44.9
1993	687.5	175.4	129.8	106.5	48.4
1994	732.2	187.0	140 0	114.5	52.2
1995	779.8	199.3	151.0	123.2	56.2
1996	830.5	212.5	162.9	132.5	60.6
1997	884.5	226.5	175.8	142.6	65.3
1998	942.0	241.5	189.6	153.4	70.3
1999	1,003.2	257.4	204.6	164.9	75.8
2000	1,068.4	274.4	220.7	177.4	81.7

Note: 1) Tentative information.
2) Forecast.

Table II—34 DEMAND FORECAST FOR LDPE AND HDPE

(Unit: 1,000t)

	LDPE	HDPE	LDPE/HDPE
1980	43.4	29.0	60/40
1981	46.6	31.0	
1982	49.9	33.2	
1983	55.2	33.9	62/38
1984	59.2	36.3	
1985	63.4	38.9	
1986	69.1	40.6	63/37
1987	74.1	43.5	
1988	79.4	46.6	
1989	85.1	49.9	
1990	91.2	53.5	
1991	100.3	54.0	65/35
1992	106.9	57.6	
1993	114.0	61.4	
1994	121.6	65.4	
1995	129.5	69.8	
1996	138.1	74.4	
1997	147.2	79.3	
1998	157.0	84.5	
1999	167.3	90.1	
2000	178.4	96.0	

in 1990. This closely matches the figures in Table II-35, which are projections made by the Thai Plastic and Chemical Co. by aggregating demand data.

However, because the figures for TPC were corrected to a calendar year base from the original accounting year (May – April) tabulation, [1] and compared in Fig. II-9. In the TPO projections, because demand during the first half of the Eighties is somewhat high, and that during the latter half of the decade is somewhat low, projection for after 1990 using elasticity analysis will yield higher values.

(4) Styrene polymers

For styrene polymers, a growth of demand second only to that of polypropylene is projected.

The areas of demand in Thailand today for polystyrene (GP, HI, FS) include items for dinnertable use, pharmaceuticals and cosmetics containers, and, in foamed form, packaging material and thermal insulation material, while in the case of ABS resins use is primarily for parts for home appliances and automobiles. Further, in the case of AS resins, increase of the polystyrene price has narrowed the price differential, and because of its qualities of translucency and mechanical strength it is being used as a substitute for GPPS.

Therefore, considerable increase in demand for styrene resins is anticipated in accordance with progress in industrialization.

1) The following formula was used to correct accounting year demand to a calender year base:
(Previous accounting year's demand) X 1/3 + (Current accounting year's demand) X 2/3

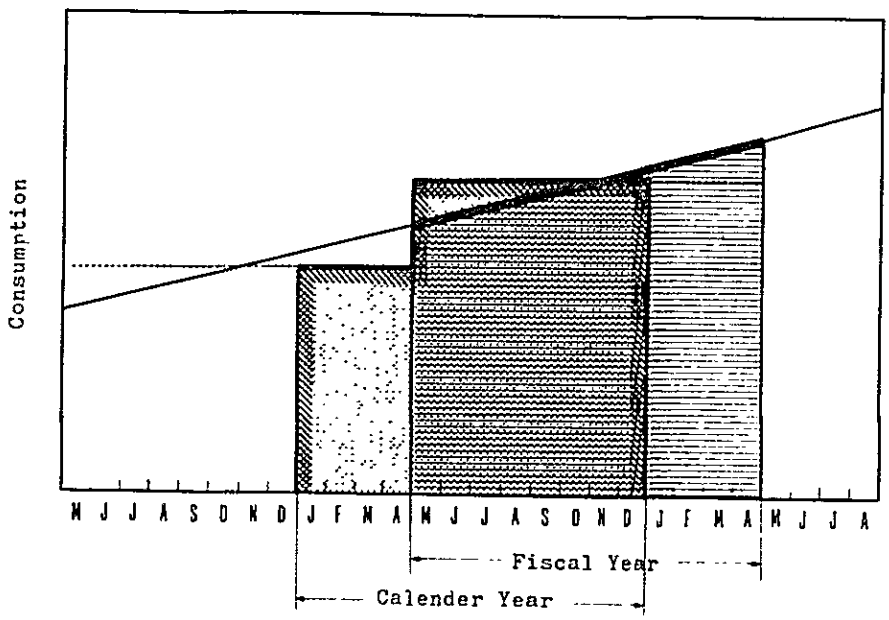


Table II—35 ACCUMULATED DEMAND FORECAST FOR PVC IN THAILAND

(Unit: t/y as resin)

Year[1]	For Compound[2]	Pipe and Fittings	Calendering	Construction	Wire & Cable	Others	Paste Resin	Total
1979[3]	12,908	6,772	7,100[4]	840	(1,788)[6]	1,038[7]	3,000	33,158
1980	13,968	9,926	7,495[5]	1,220	–	1,270[8]	3,000	36,879
1981	15,571	12,904	8,051	1,580	–	1,300	3,165	42,571
1982	17,656	15,485	8,695	1,817	–	1,300	3,340	48,293
1983	19,247	17,808	9,391	2,090	–	1,300	3,520	53,356
1984	21,557	20,479	10,142	2,403	–	1,300	3,720	59,601
1985	22,635	22,117	10,750	2,595	–	1,300	3,920	63,317
1986	23,766	23,886	11,396	2,803	–	1,300	4,140	67,291
1987	24,954	25,796	12,079	3,027	–	1,300	4,365	71,521
1988	26,202	27,860	12,804	3,269	–	1,300	4,600	76,035
1989	27,512	30,089	13,572	3,530	–	1,300	4,860	80,863

Notes: 1) TPC Fiscal year of May to next year April.
2) As resin (content 58%).
3) Actual figure.
4) Including 4,367 t/y imports.
5) Includes 1,500 t/y imports since 1980.
6) Including 625 t/y imports.
7) Including 842 t/y imports.
8) Includes 1,000 t/y imports since 1980.

Source: Thai Plastic and Chemical Co.

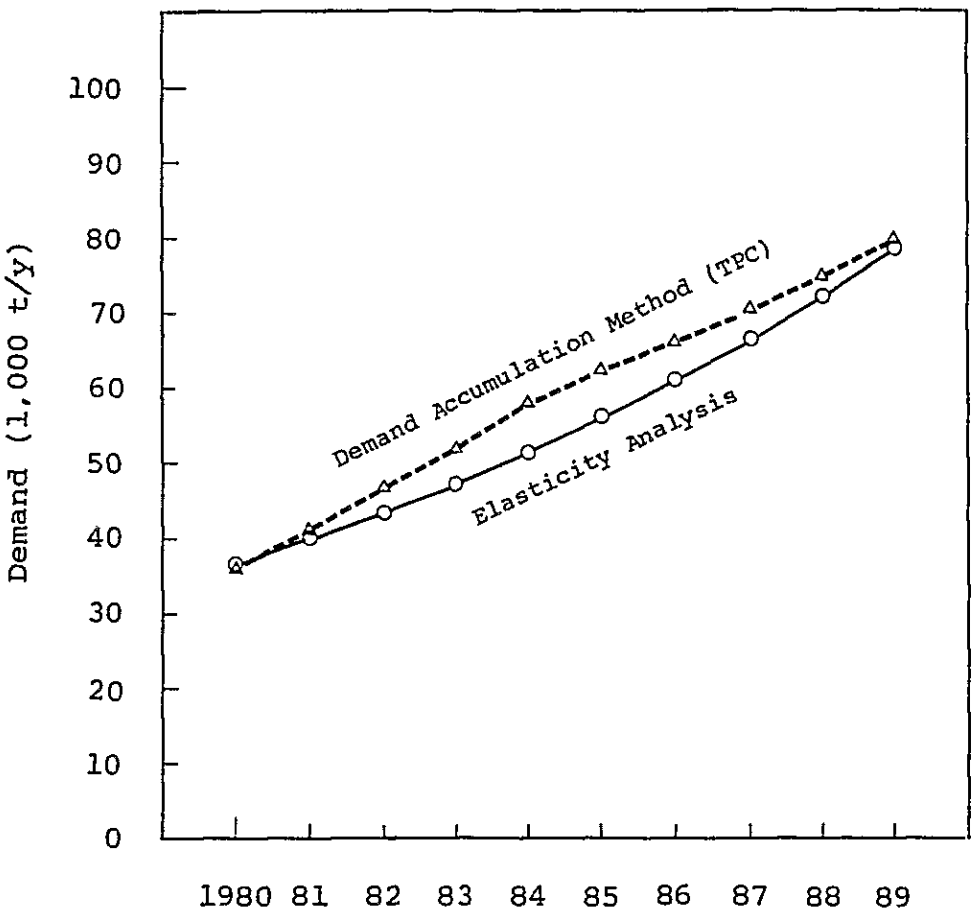


Fig. II–9 COMPARISON OF PVC DEMAND FORECAST BY DIFFERENT METHODS

2–4–3 Results of International Cross-section Analysis

International cross-section analysis is one method which may be deemed useful to project demand for plastics materials. This method involves use of per capita consumption data and per capita GDP which are compared in international terms in order to estimate what the per capita consumption will be in one or more countries when a certain level of per capita GDP is attained.

This method, however, has the following flaws.

(i) As has been mentioned, consumption of plastics materials varies not only according to GDP but is also dependent on price.

(ii) Cross-section analysis is relatively static as a method, but the relationship between per capita GDP and per capita consumption changes from year to year (in general, the regression curve shifts upward from one year to the next).

Therefore, use of this method often results in values lower than those obtained by other methods of projecting future demand quantities. Nevertheless, this method, when used in conjunction with other methods, is useful as a means of obtaining an approximate idea of what to expect.

(1) Per capita consumption quantities and per capita GDP in various countries

Per capita consumption of general-purpose plastics materials in typical countries, and the per capita GDP for those countries, for 1978, are given in Tables II-36 and II-37. Data for plastics materials consumption are estimates made by an industrial journal specializing in plastics and amended by the study team. GDP is in 1975 prices; Predicasts, Inc. data were used.

(2) Results of analysis

As is clear from Fig. II-10~II-14 if logarithms for per capita GDP and per capita consumption quantity are plotted, where per capita GDP is low, growth of per capita consumption is high, and the higher the level of per capita GDP, the lower the rate of growth of consumption. Assuming that the relationship

$$\frac{d(\log q)}{d(\log \theta)} = \alpha - \beta \log \theta$$

is valid, the following demand model may be proposed.

Table II—36 PER CAPITA CONSUMPTION OF MAJOR PLASTICS MATERIALS IN 1978

(Unit: kg)

	LDPE	HDPE	PP	PVC	PS
1. Japan	7.7	4.1	5.1	10.1	6.4
2. S. Korea	4.3	1.6	3.5	5.5	2.0
3. Taiwan	6.0	2.7	3.9	19.4	3.2
5. Thailand	1.0	0.6	0.7	0.6	0.3
6. Malaysia	2.2	2.3	1.0	1.1	0.9
7. Philippines	0.7	0.4	0.7	0.7	0.3
8. Indonesia	0.3	0.2	0.4	0.2	0.1
9. Australia	7 3	3.2	3.1	8.3	0.9
10. New Zealand	5.2	0.8	0.8	5.5	1.7
11. India	0.1	0.1	–	0.1	–
12. Pakistan	0.1	–	–	0.1	–
14. Turkey	1.0	0.7	–	0.4	0.2
15. Egypt	0.3	0.1	0.1	0.1	0.1
16. Nigeria	0.3	0.3	–	0.7	–
17. W. Germany	13.1	6.0	3.5	15.7	9.7
18. France	9.8	3.2	1.3	13.0	6.9
19. Italy	10.4	1.9	4.2	8.7	5.8
20. U.K.	7.8	3.9	4.0	6.6	4.0
21. Ireland	9.4	2.5	4.8	11.8	6.6
23. Netherlands	8.2	3.8	3.5	12.4	4.4
24. Norway	14.0	7.2	2.6	12.0	2.3
25. Denmark	16.5	7.2	4.3	12.6	7.8
26. Sweden	18.0	3.7	1.3	12.0	8.6
27. Finland	21.5	5.4	1.7	10.0	5.6
28. Austria	12.4	–	1.9	8.3	6.3
29. Switzerland	13.3	5.5	2.0	6.4	6.3
30. Spain	7.7	3.4	1.2	5.3	2.6
31. Yugoslavia	2.3	2.1	–	5.6	1.5
32. C.S.S.R.	7.5	4.0	5.2	11.6	3.8
33. Poland	1.3	–	1.2	3.6	1.0
34. Rumania	6.6	1.3	–	8.8	0.8
35. U.S.S.R.	2.0	0.8	0.1	1.6	0.8
36. Hungary	8.8	4.7	2.9	9.3	1.2
37. U.S.A.	13.2	7.6	5.5	11.5	8 6
38. Canada	12.3	6.6	3.4	6.9	4.9
39. Argentina	2.1	–	0.5	1.7	1.3
40. Brazil	2.1	–	0.5	1.8	0.1
41. Mexico	2.0	–	0.7	0.8	0.6

Source: World-Product-Cast.

Table II–37 PUPULATION AND PER CAPITA GDP IN 1978

		Population (million)	Per capita GDP (US$ at 1975)
1.	Japan	114.9	5,154
2.	S. Korea	37.0	775
3.	Taiwan	16.9	1,191
5.	Thailand	45.1	408
6.	Malaysia	13.0	921
7.	Philippines	46.4	411
8.	Indonesia	145.1	258
9.	Australia	14.3	6,580
10.	New Zealand	3.1	4,553
11.	India	638.4	156
12.	Pakistan	76.8	171
14.	Turkey	43.2	959
15.	Egypt	39.6	395
16.	Nigeria	72.2	474
17.	W. Germany	61.3	7,713
18.	France	53.3	7,122
19.	Italy	56.7	3,752
20.	U.K.	56.0	4,470
21.	Ireland	3.2	2,877
23.	Netherlands	13.9	7,654
24.	Norway	4.1	8,027
25.	Denmark	5.1	8,134
26.	Sweden	8.3	8,487
27.	Finland	4.8	5,949
28.	Austria	7.5	5,607
29.	Switzerland	6.3	8,667
30.	Spain	36.8	3,049
31.	Yugoslavia	21.9	1,785
32.	C.S.S.R.	15.1	3,980
33.	Poland	35.0	2,689
34.	Rumania	21.9	2,570
35.	U.S.S.R.	261.3	3,390
36.	Hungary	10.7	2,499
37.	U.S.A.	218.3	8,078
38.	Canada	23.5	7,917
39.	Argentina	26.4	1,355
40.	Brazil	115.4	1.301
41.	Mexico	66.9	1,308

Source: World-Product-Cast

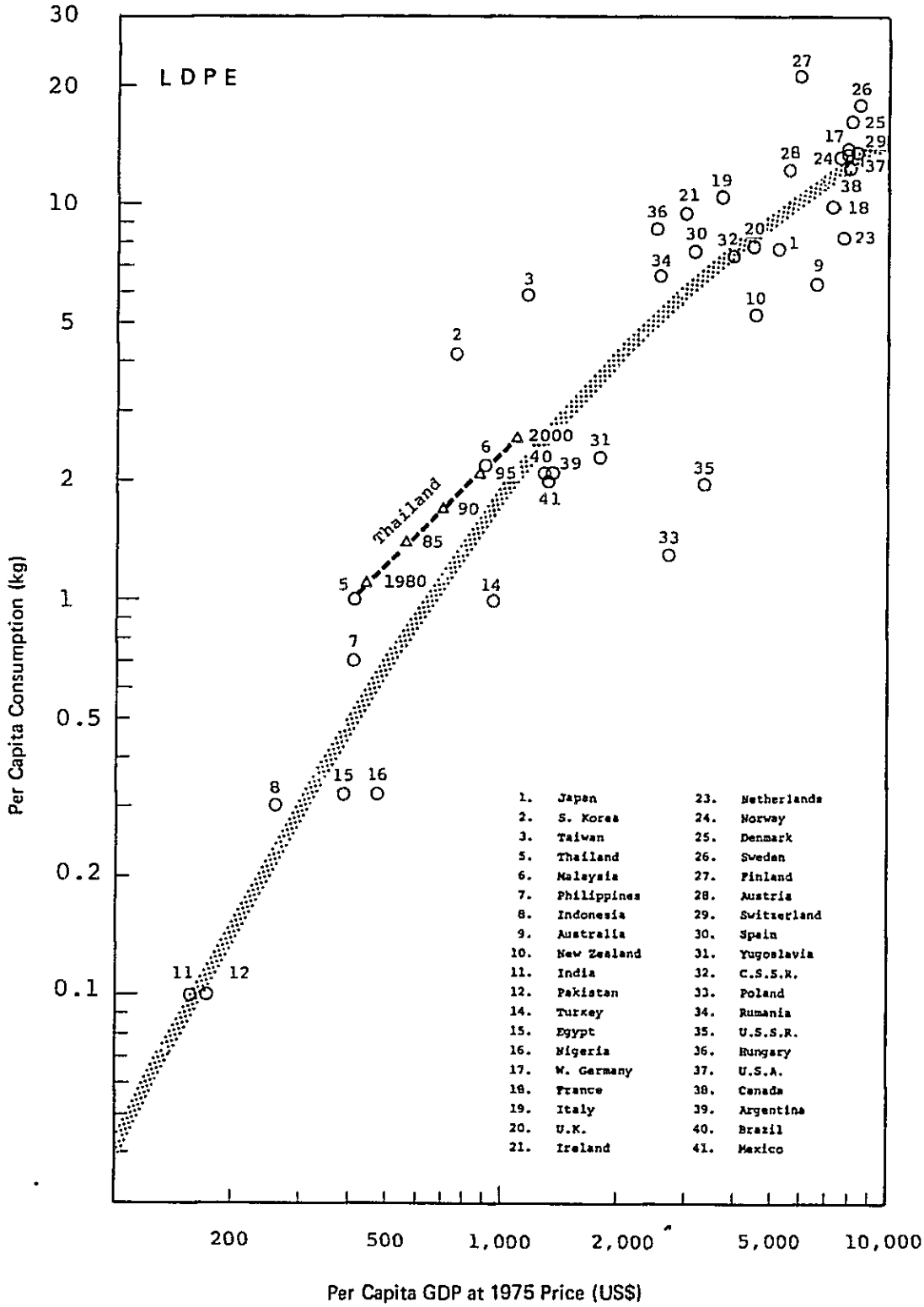


Fig. II—10 INTERNATIONAL CROSS-SECTION ANALYSIS (1)

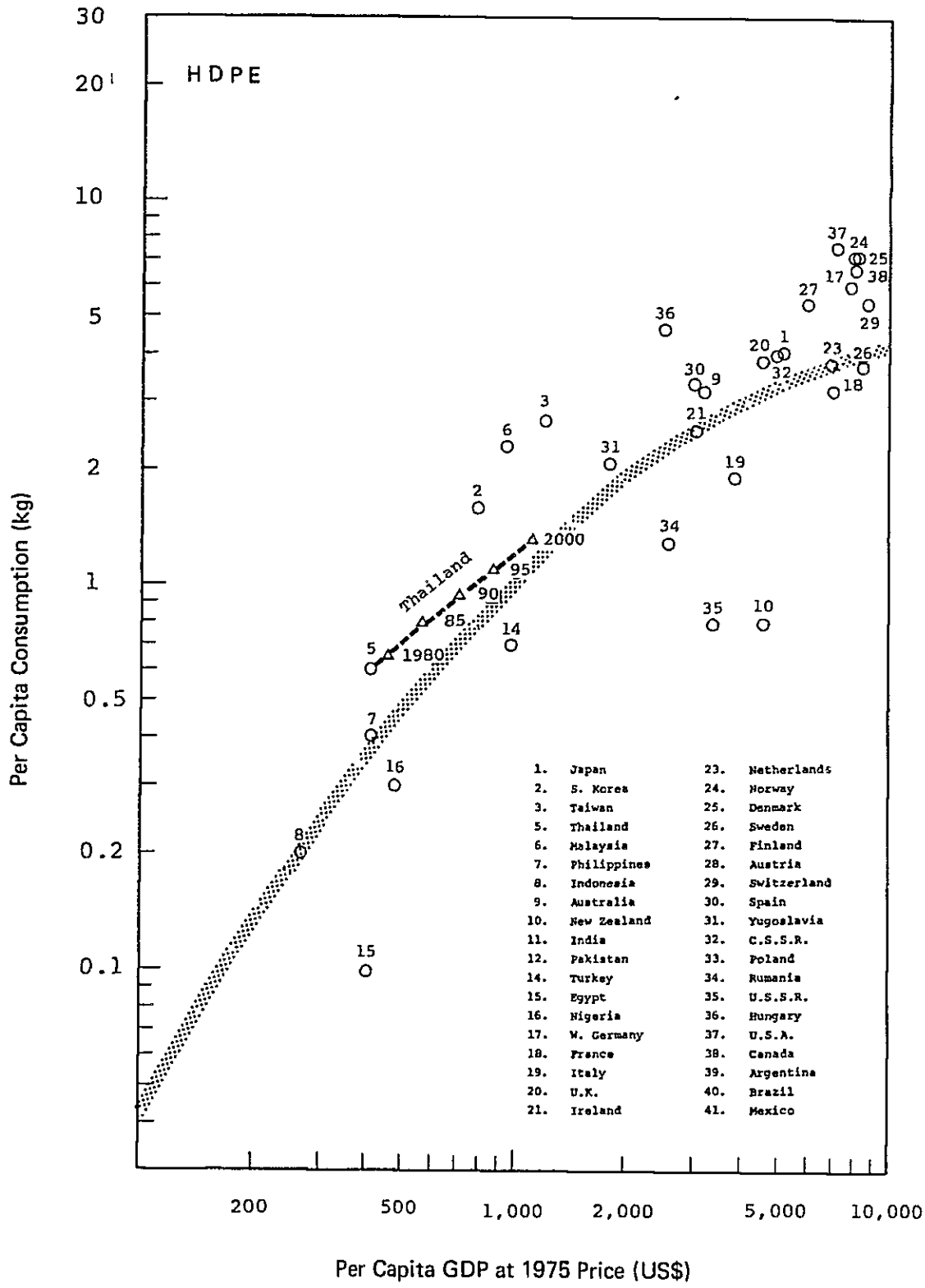


Fig. II—11 INTERNATIONAL CROSS-SECTION ANALYSIS (2)

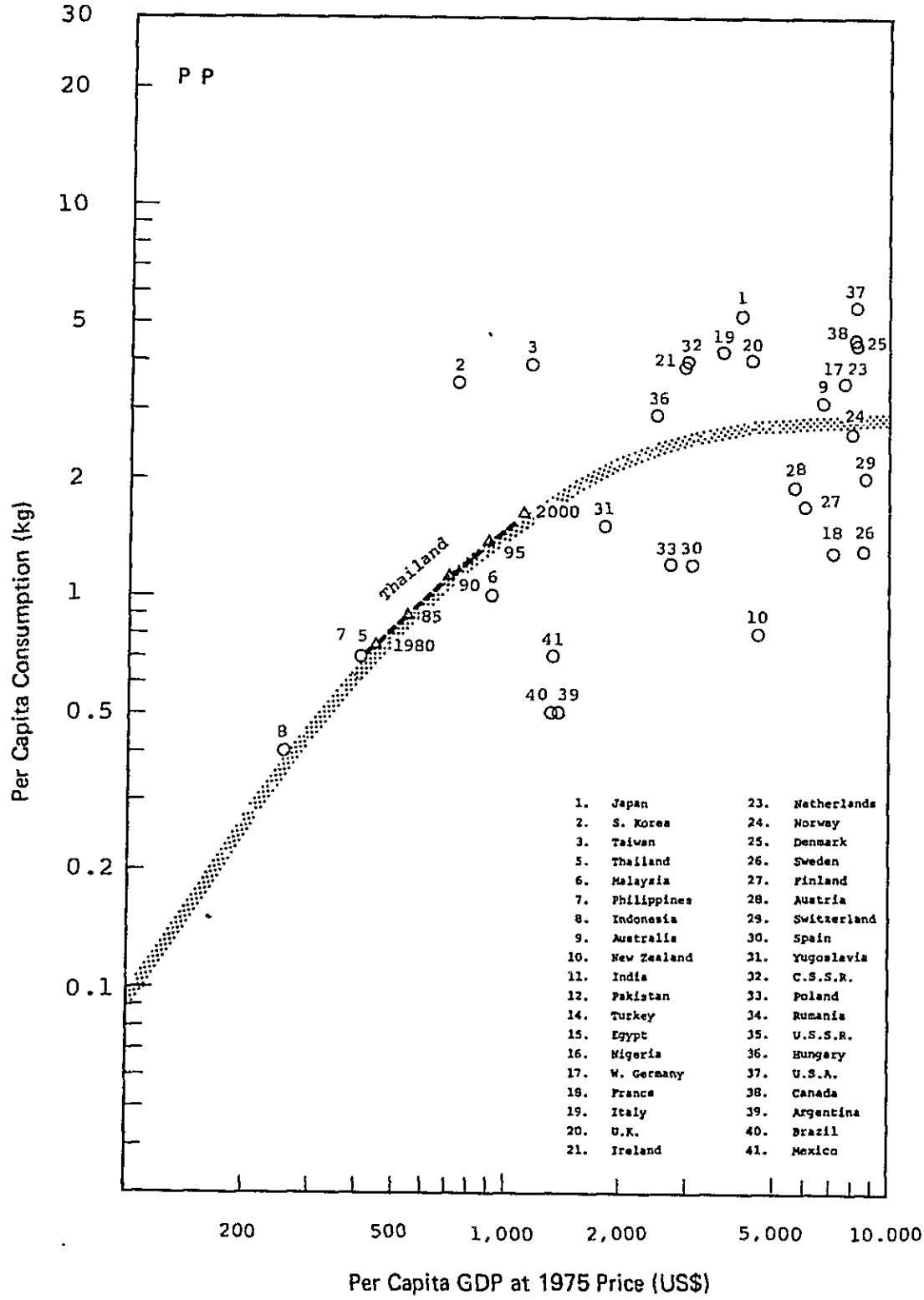


Fig. II–12 INTERNATIONAL CROSS-SECTION ANALYSIS (3)

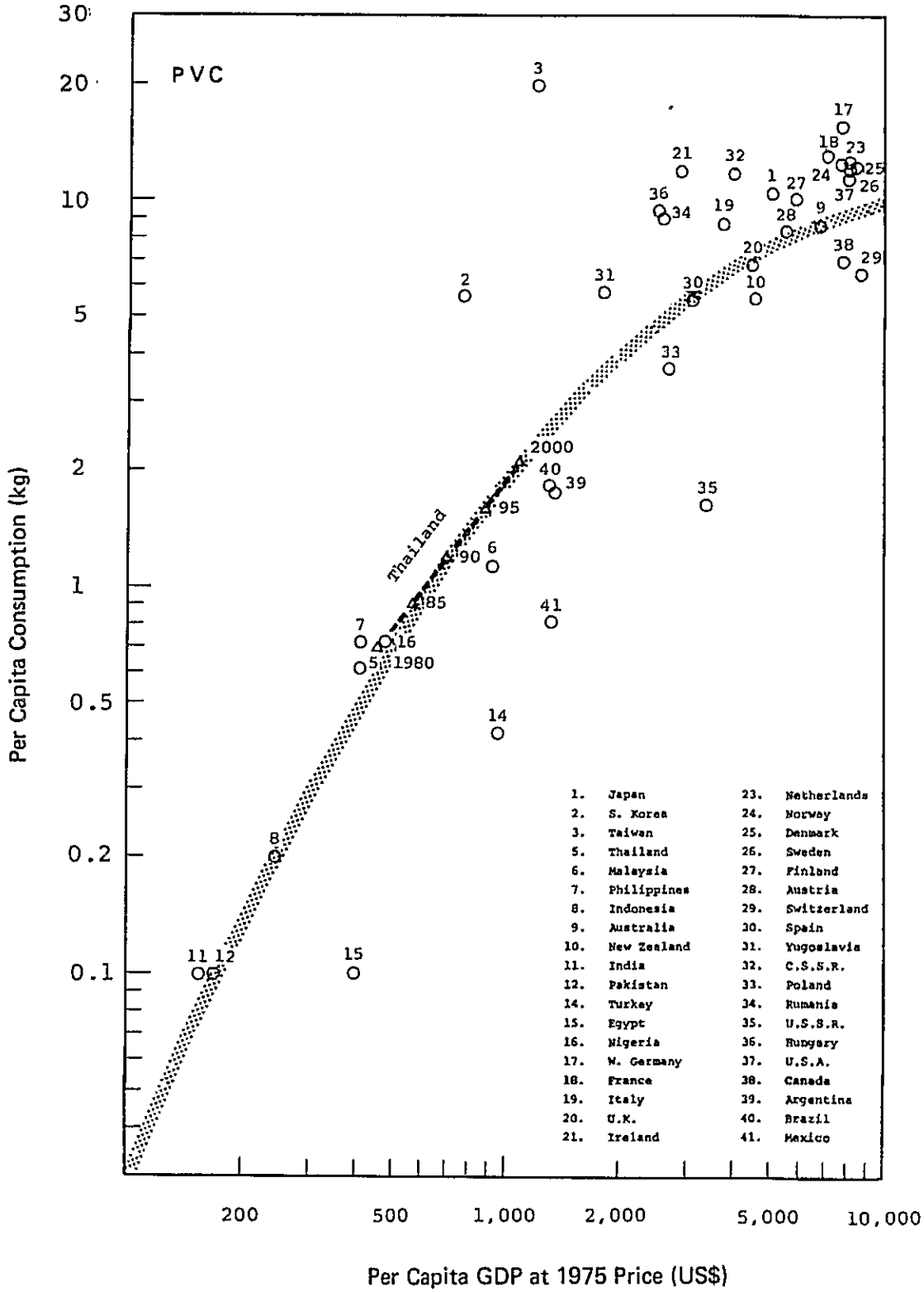


Fig. II—13 INTERNATIONAL CROSS-SECTION ANALYSIS (4)

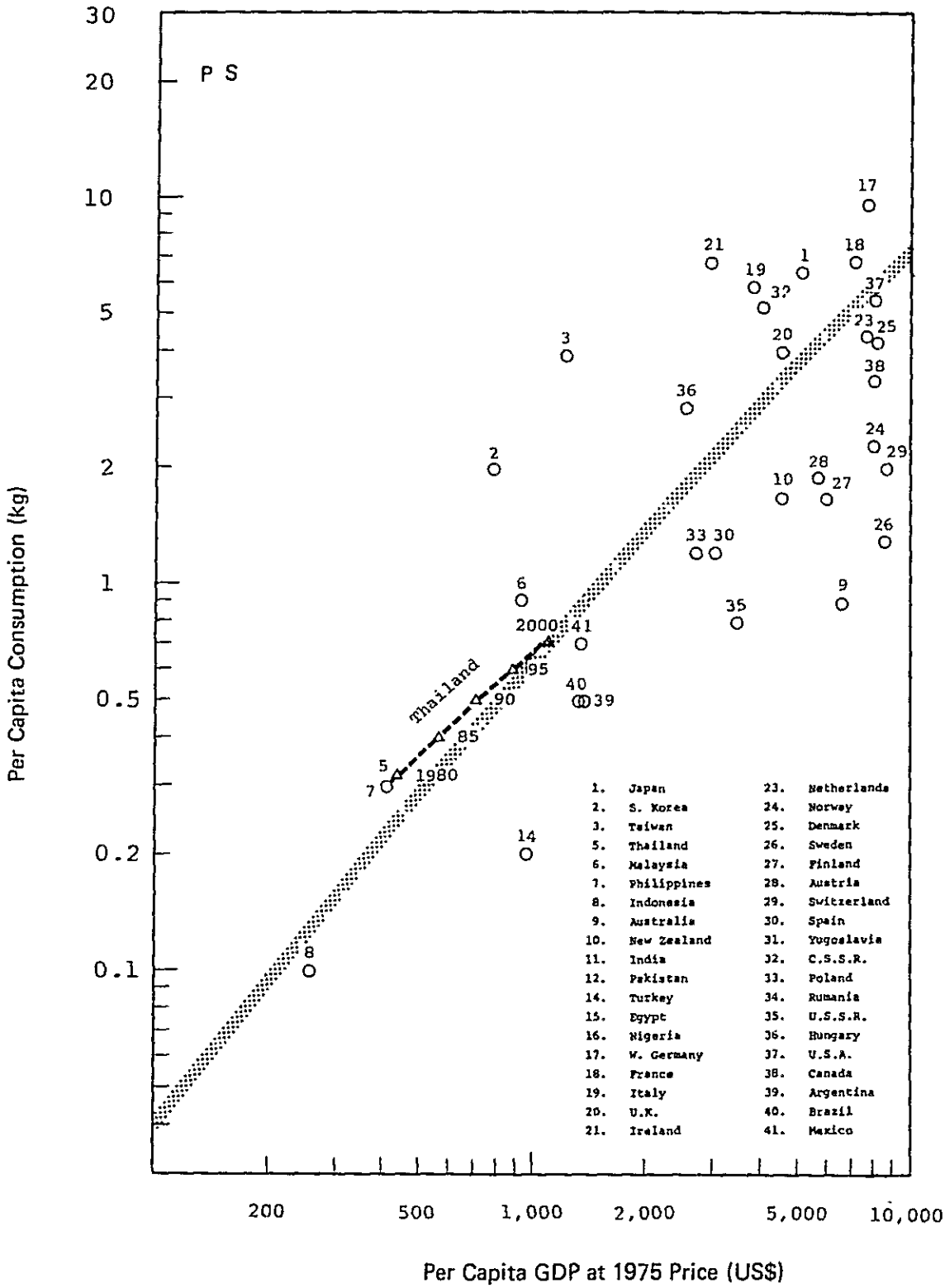


Fig. II—14 INTERNATIONAL CROSS-SECTION ANALYSIS (5)

$$\log q = a + b \log \theta - c(\log \theta)^2$$

where

q : Consumption quantity per capita (kg)
θ : Per capita GDP (1975 prices) (US$)
a, b, c : Constants

Table II-38 gives estimated values for constants a, b and c of the regression curve, and the correlation coefficients for plastics materials. Except for LDPE, the coefficients are generally low and in the case of PP in particular hardly any correlation can be observed to exist. It is thought that this is not because of any defects of the regression model but because of great dispersion in the data.

(3) Projections

(i) Per capita consumption quantity

The projections of demand for plastics materials for every five years between 1980 and 2000, made in accordance with the regression formula, are presented as Table II-40. Projected values are protted in Figs. II-10 to II-14.[1] As is shown by the Thai per capita GDP in 1975 prices, in Table II-39 in 1979 there was a year-to-year increase in 1979 of 4.3% (population increase, 2.3%; GDP growth, 6.7%), and starting in 1980 the average increase is 4.6% a year (average population growth rate, 1.8%; average GDP growth, 6.5%).

(ii) Comparison of projections of aggregate demand and projections obtained through elasticity analysis

Concerning the population figures used for calculating aggregate demand from the per capita demand quantities, the figures used are those given in Table II-41. The population growth rate in this table indicates a gradual reduction each five years from 1.92% p.a. for 1980∿1985 to 1.33% p.a. for 1995∿2000.

Table II-42 presents aggregate demand projections at five-year intervals from 1980 to 2000, and the results of elasticity analysis which are shown in Table II-33.

1) The differential between values for 1978 obtained by calculation using the formula and the actual values was added to the projected value for each year. For example, the calculated value for LDPE for Thailand is 0.6 kg, but the difference between that and actual consumption (1.0 kg) has been added (0.4 kg) to the projected value for each year.

Table II–38 COEFFICIENTS OF REGRESSION EQUATIONS

	Coefficients			Correlation Coefficient
	a	b	c	
LDPE	-6.68	3.37	-0.35	0.94
HDPE	-6.33	3.23	-0.37	0.82
PP	-6.38	3.63	-0.48	0.60
PVC	-8.50	4.57	-0.55	0.80
PS	-4.24	1.57	-0.08	0.81

Note: Demand model

$\log q = a + b \log\theta + c (\log\theta)^2$

q ; Per capita consumption (kg)

θ ; Per capita GDP (at 1975 constant price) (US$)

a, b, c ; Coefficients.

Table II–39 ESTIMATION OF PER CAPITA GDP IN THAILAND

	Per Capita GDP (US$)	Note
1978	408	Actual (Source: Predicasts)
1979	426	Growth rate 4.3%/y
1980	446	Compounded growth rate 4.6%/y
1985	558	
1990	699	
1995	875	
2000	1,095	

Note: At 1975 constant price.

Table II–40 FORECAST FOR PER CAPITA CONSUMPTION OF MAJOR PLASTICS MATERIALS IN THAILAND

(Unit: kg)

	LDPE	HDPE	PP	PVC	PS
1978[1)]	1.0	0.6	0.7	0.6	0.3
1980	1.1	0.6	0.7	0.7	0.3
1985	1.4	0.8	0.9	0.9	0.4
1990	1.7	0.9	1.1	1.2	0.5
1995	2.1	1.2	1.4	1.6	0.6
2000	2.6	1.4	1.7	2.1	0.7

Note: 1) Actual figures.

Table II—41 FORECAST FOR POPULATION IN THAILAND

	Population[1)] (Million)	Growth Rate (%/y)
1979	46.15	
1980	47.15	1.92
1985	52.39	1.73
1990	57.53	1.52
1995	62.44	1.33
2000	67.10	

Note: 1) Mid-year.
Source: UNICO International Corp.

Table II—42 DEMAND FORECAST BY INTERNATIONAL CROSS-SECTION ANALYSIS AND THE COMPARISON WITH ELASTICITY ANALYSIS

(Unit: 1,000 t/y)

	LDPE		HDPE		PP		PVC		PS	
	A	B	A	B	A	B	A	B	A	B
1980	51.9	43.3	28.3	29.0	33.0	41.2	33.0	36.7	14.1	16.0
1985	73.3	63.4	41.9	38.9	47.2	65.3	47.2	56.1	21.0	24.8
1990	97.8	91.2	51.8	53.5	63.3	103.4	65.0	85.6	28.8	38.7
1995	131.1	129.5	68.7	69.8	87.4	151.0	99.9	123.2	37.5	56.2
2000	174.5	178.4	93.9	96.0	114.1	220.7	140.9	177.4	47.0	81.7

Note: A: International cross-section analysis.
B: Elasticity analysis.

(a) Polyolefins

LDPE and HDPE are close to each other in both cases. With regard to PP, in the diagram showing per capita GDP/per capita consumption quantity, for countries where the per capita GDP is high (industrially advanced countries) the quantity consumed is relatively low, and for countries where per capita GDP is low, the quantity consumed is high. That is, the slope of the curve is low. In other words, in industrialized countries, and America and West European countries in particular, the growth of demand for PP has risen at a high rate recently, and reached the level of 17% and 16% respectively in 1979 (comparisons relatively to the preceding year); these rates exceed that for LDPE by as much as 7%. Therefore, the regression curve can be seen to be shifting upward at a rapid rate from year to year. If the per capita consumption quantity regression curve of a country were to shift upward by 3% relative to the per capita GDP[1] then in 2000 in Thailand PP demand would have increased by 1.9 times, and would be nearly the value obtained through elasticity analysis.

(b) PVC

Also with regard to PVC, whereas growth of demand in America and West European countries in the past has been relatively small, the per capita consumption quantity in East European countries, Korea, Taiwan and other newly-industrializing countries present high values in comparison to the per capita GDP of those same countries. Because of this, it is possible that due to the mild slope of the regression curve that values obtained by projections using the curve would be somewhat low. On the other hand, the demand for PVC in Thailand should show a higher growth rate than that obtained by cross-section analysis because there is a concentration of demand in the public works area, for pipe and building materials, and because the GDP elasticity is high. Therefore, it is judged that the projected values will approach the results obtained through elasticity analysis.

(c) Styrene polymers

Per capita consumption quantities given in the cross-section diagram are for polystyrenes (GPPS,[2] HIPS,[3] FS[4]), and copolymer resins such as AS resin and ABS resin are not included.

In countries where per capita GDP is high, demand for polystyrenes and for GPPS in particular has levelled off, whereas ABS resin demand is showing strong growth. For example, refer to the pattern of demand of styrene resins in industrially advanced countries, shown in Table II-43.

1) The growth rate of aggregate PP demand is 10% a year on the average.
2) General purpose polystyrene.
3) High impact polystyrene.
4) Foamed polystyrene.

In Japan, growth of demand for GPPS and HIPS is not particularly great, but because of expansion of the market for AS and ABS resins the share of copolymer resins among the styrene resins is about 33%. In America the market for GPPS and HIPS is large and the share of copolymers is low in comparison to Japan, at about 25%, while for West Europe if non-EC countries are included in the tabulation, and because the demand for AS resin is not clearly known, the share of copolymers is quite low, at about 15%.

In any event, if the share of copolymers reaches the level of about 25% in the future, demand for styrene resins would be about 63,000 t/y in 2000.

2–4–4 Projection of the Supply/Demand Balance

Because projecting demand by using the results of elasticity analysis, as shown in the preceding section, is considered to have adequate reliability, it is on that basis that consideration is given here to the supply/demand balance.

(1) Existing plants

The existing Thai plants producing plastics materials, and their capacities, are as follows.

Table II–43 CONSUMPTION PATTERN OF STYRENE POLYMERS (DOMESTIC) IN THE INDUSTRIALIZED COUNTRIES (1979)

(Unit: 1,000 t/y)

	Japan	U.S.A.	W. Europe
Polyestyrene (Solid)	495	1,353	1,272
Foamed Polystyrene	213	402	351
Sub-total (A)	708	1,755	1,623
AS Resin	62	47	n.a.
ABS Resin	255	571	307
Sub-total (B)	317	618	307
Total (C)	1,025	2,373	1,930
(B)/(C)(%)	30.9	26.0	15.9
(B)/(A)(%)	44.8	35.2	18.9

Source: Modern Plastics International (Jan. 1980); The Association of Petrochemical Industries in Japan.

PVC 54,000 t/y
(Thai Plastic and Chemical Co.)

PS 22,500 t/y
(Dow Chemical Thailand)

(2) Planned plants

Plants, and their production capacities, which have been or are being planned are these.

LDPE 73,000 t/y (approved by BOI, and being constructed)
(Thai Petrochemical Co.)

HDPE 36,000 t/y (approved by BOI)
(Thai United Polymers Co.)

Moreover, the HDPE plant capacity is to be increased to 50,000 t/y at a later date.

In addition to these, plans for PP plants of 60,000 to 65,000 t/y capacity have been submitted to the BOI (by three companies including the Thai and US Investors Co).

(3) Future supply/demand balance

The trend of the supply and demand balance for plastics materials in the Republic of Korea is shown in Table II-44 and Fig. II-15. Regarding polyethylene, because the volume of imports has exceeded the minimum economic scale of production, first- and second-phase plants are being constructed. In the case of Thailand because there is a large-scale supply of ethylene available it is desirable that the plan for construction of the derivatives plant be prepared in such a manner as to minimize the gap which can be expected to develop in the supply and demand balance of derivatives.

It is assumed that a second plant which has the same production capacity as the first plant would be established when it could be operated at the rate of 50% of capacity.

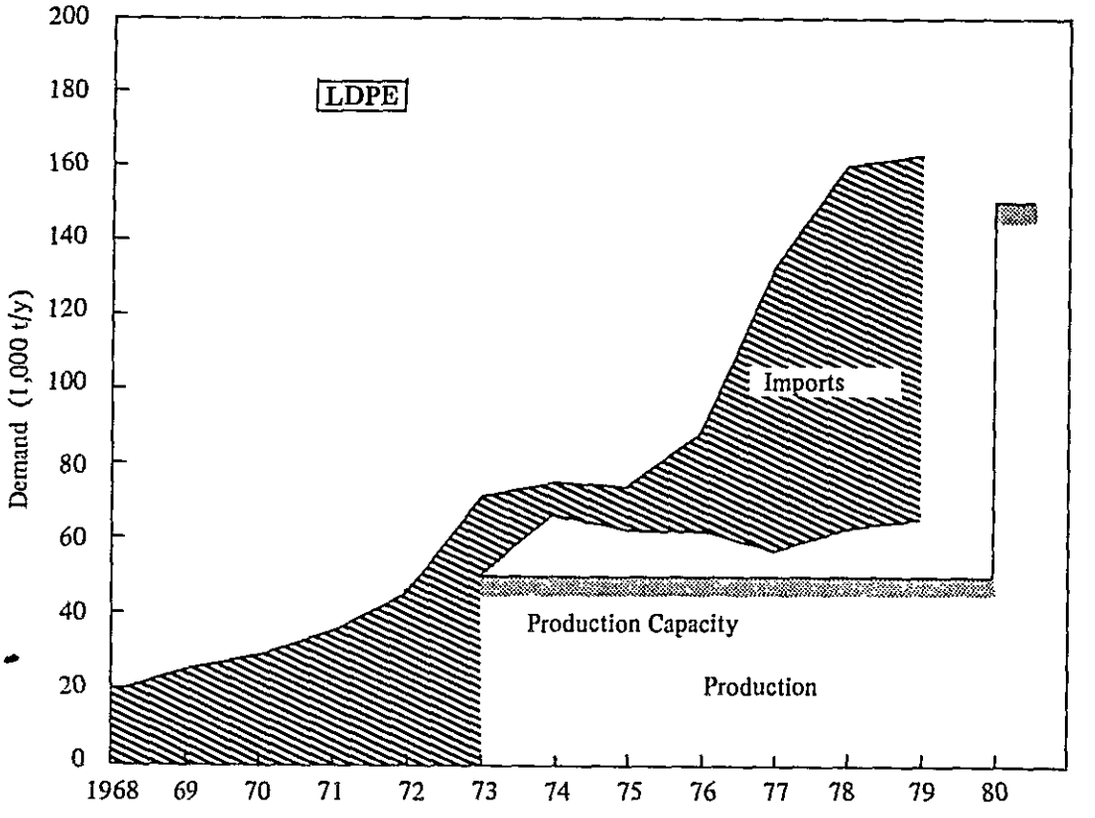
Potential Thai demand for plastics materials, and foreseeable plant production capacities, are shown in Figs. II-16 to II-19.

With regard to LDPE, at present only the 73,000 t/y plant is being constructed, and as it will reach full utilization of capacity in 1986, it is assumed here that capacity will be expanded to 128,000 t/y in 1988, and to 200,000 t/y in 1998.

Table II—44 SUPPLY/DEMAND BALANCE FOR SOUTH KOREAN PLASTICS MATERIALS

(Unit: 1,000 t/y)

	LDPE			HDPE			PP			PVC			PS		
	Prod.	Import	Demand	Prod.	Import	Demand	Prod.	Import	Demand	Prod.	Import	Demand	Prod.	Import	Demand
1968	–	19.3	19.3	–	4.8	4.8	–	1.6	1.6	15.3	0.8	16.1	1.1	1.7	2.8
1969	–	24.6	24.6	–	9.0	9.0	–	3.6	3.6	35.9	0.5	36.4	3.4	1.3	4.7
1970	–	28.8	28.8	–	13.6	13.6	–	9.3	9.3	35.8	0.8	36.6	5.5	1.5	7.0
1971	–	35.5	35.5	–	16.3	16.3	–	16.1	16.1	44.8	1.9	46.7	8.4	1.8	10.2
1972	–	46.0	46.0	–	18.0	18.0	10.3	18.2	28.5	58.6	1.1	59.7	14.7	1.7	16.4
1973	50.8	19.6	70.4	–	18.5	18.5	43.2	7.2	50.4	72.7	2.0	74.7	15.1	2.2	17.3
1974	66.6	8.3	74.9	–	14.6	14.6	53.9	5.2	59.1	67.3	3.3	70.6	8.7	4.5	13.2
1975	62.4	11.1	73.6	1.2	19.0	20.2	60.1	5.2	65.3	68.4	8.8	77.2	13.2	4.2	17.4
1976	62.6	25.7	88.3	14.9	11.9	26.8	79.9	2.5	82.4	96.7	5.1	101.8	23.4	7.8	31.2
1977	57.2	75.3	132.5	6.2	30.0	36.2	107.8	15.0	122.8	114.3	22.0	136.3	36.4	11.1	47.5
1978	62.7	97.0	159.7	33.0	27.4	60.4	75.0	55.3	130.3	198.6	9.0	207.6	56.4	16.8	73.2
1979	65.6	97.6	163.2	45.7	42.9	88.6	100.1	71.0	171.1	224.6	18.3	242.9	38.1	31.2	69.4



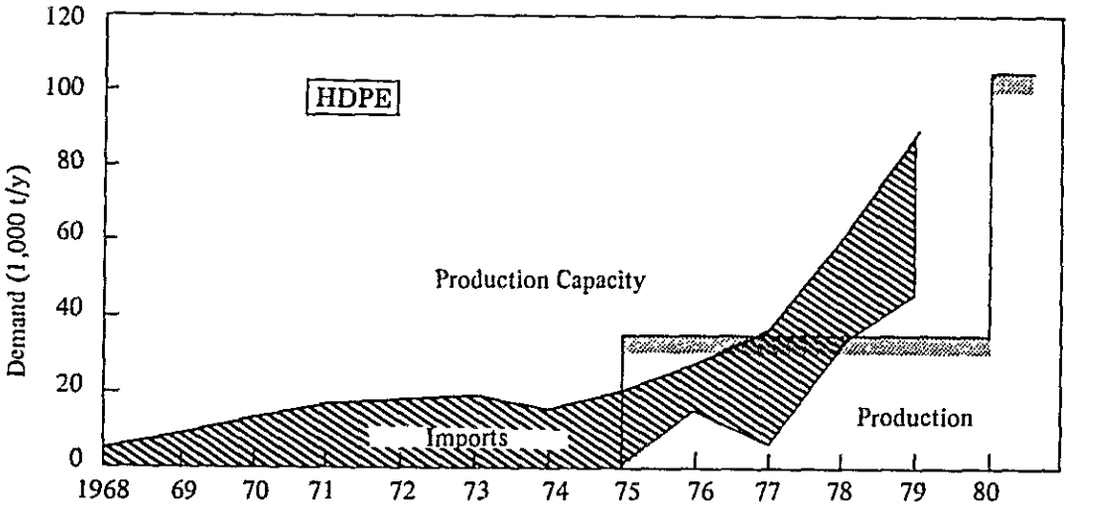
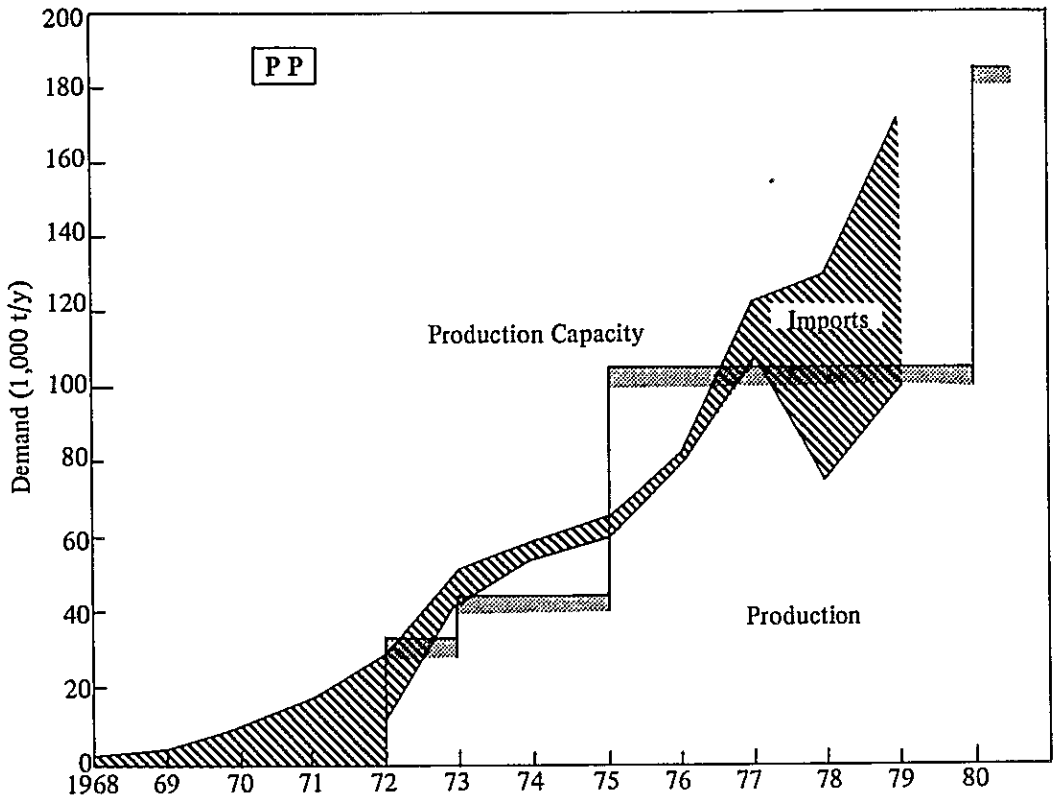


Fig. II–15 SUPPLY/DEMAND BALANCE FOR SOUTH KOREAN PLASTICS MATERIALS



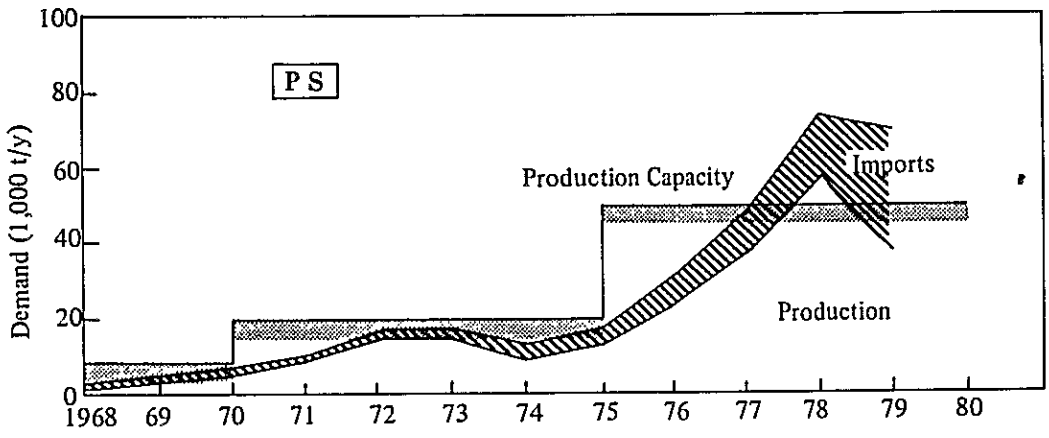


Fig. II–15 (cont'd)

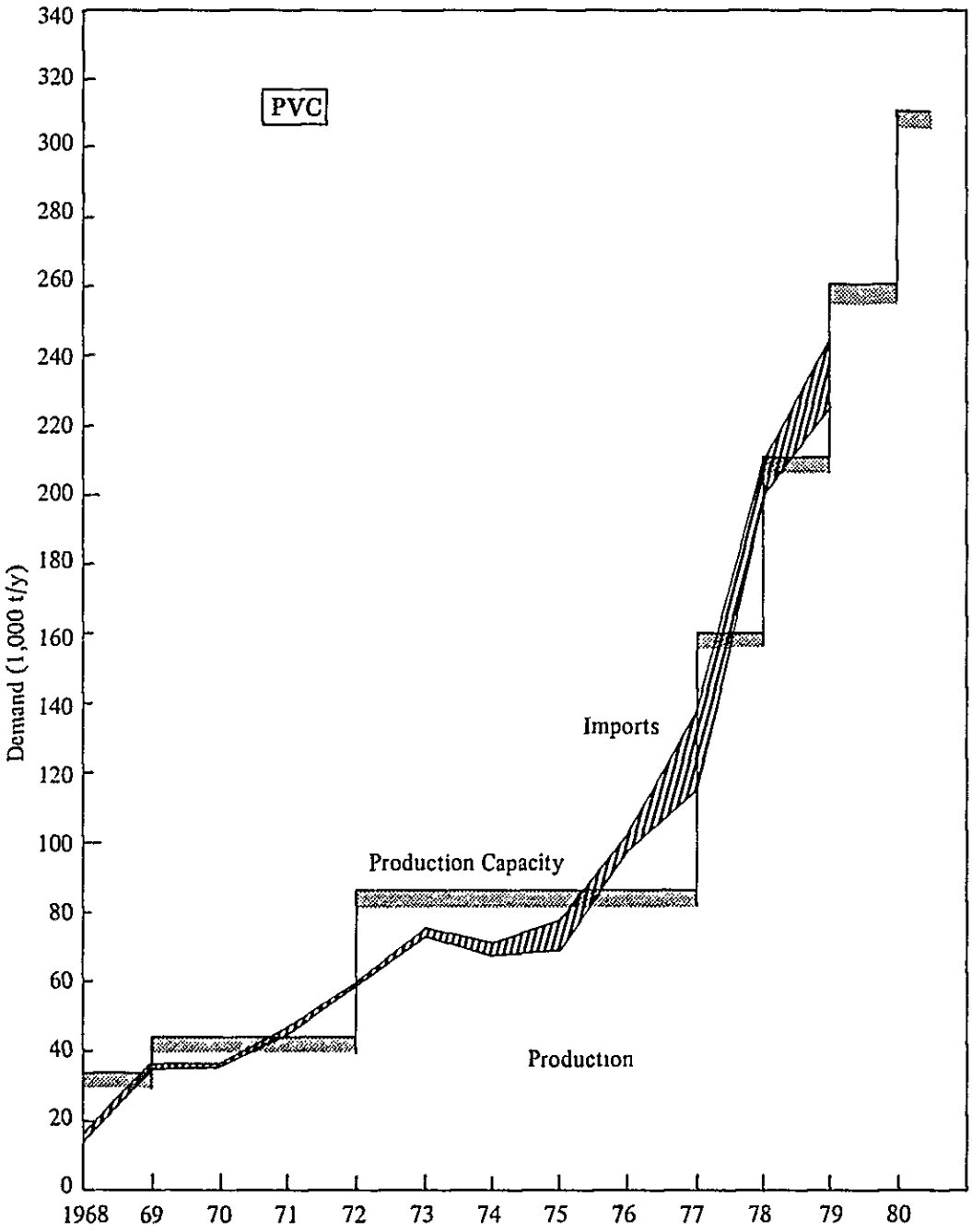


Fig. II–15 (cont'd)

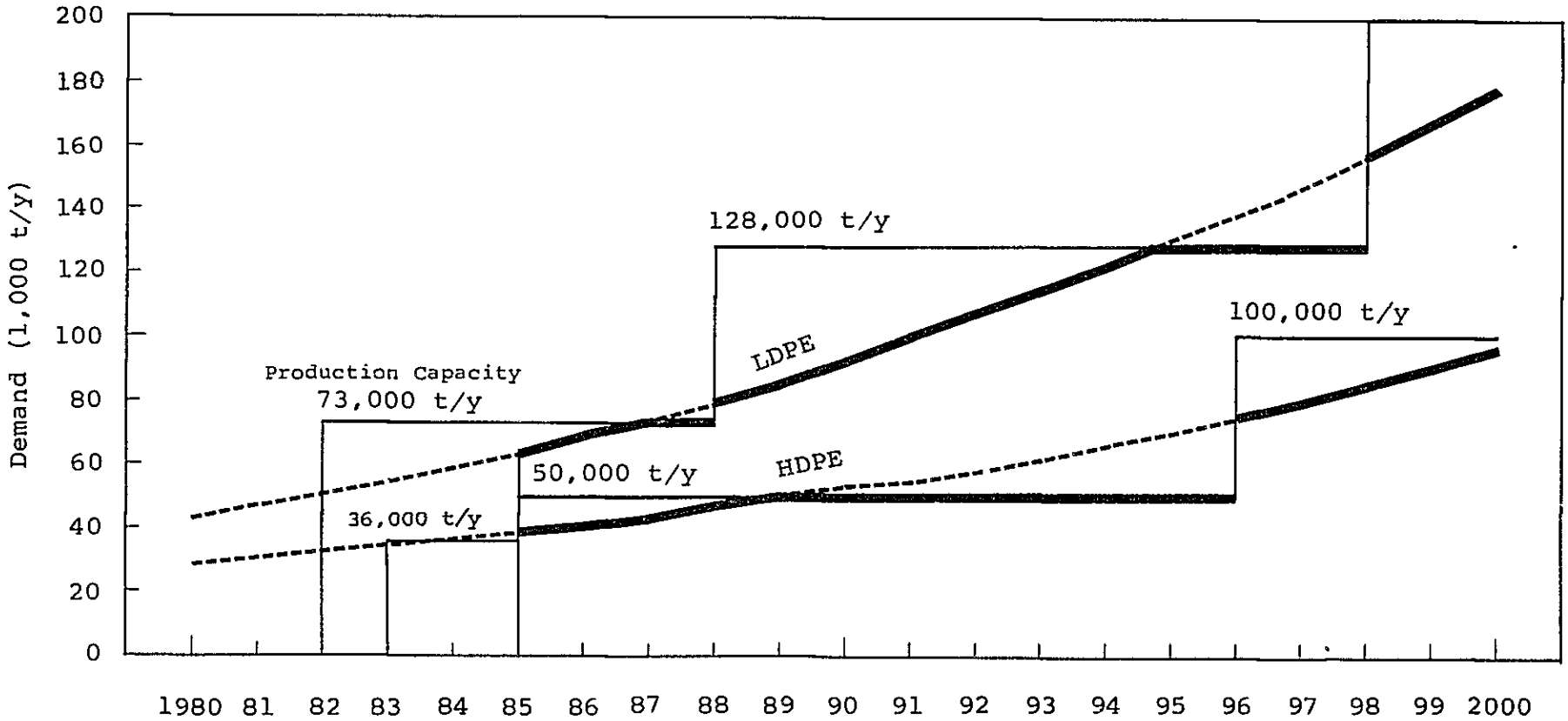


Fig. II—16 DEMAND FORECAST AND PRODUCTION CAPACITY FOR LDPE AND HDPE

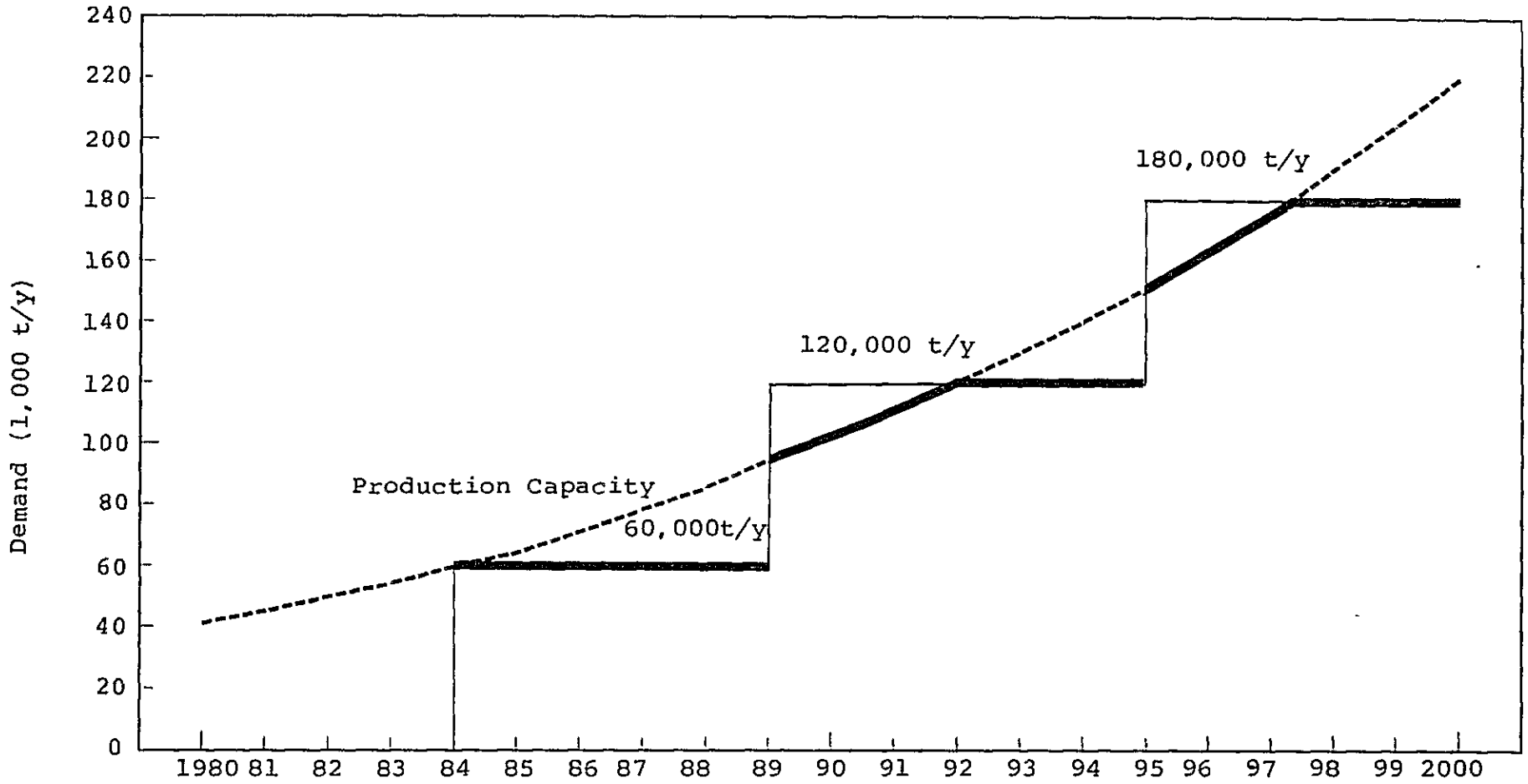


Fig. II—17 DEMAND FORECAST AND PRODUCTION CAPACITY FOR PP

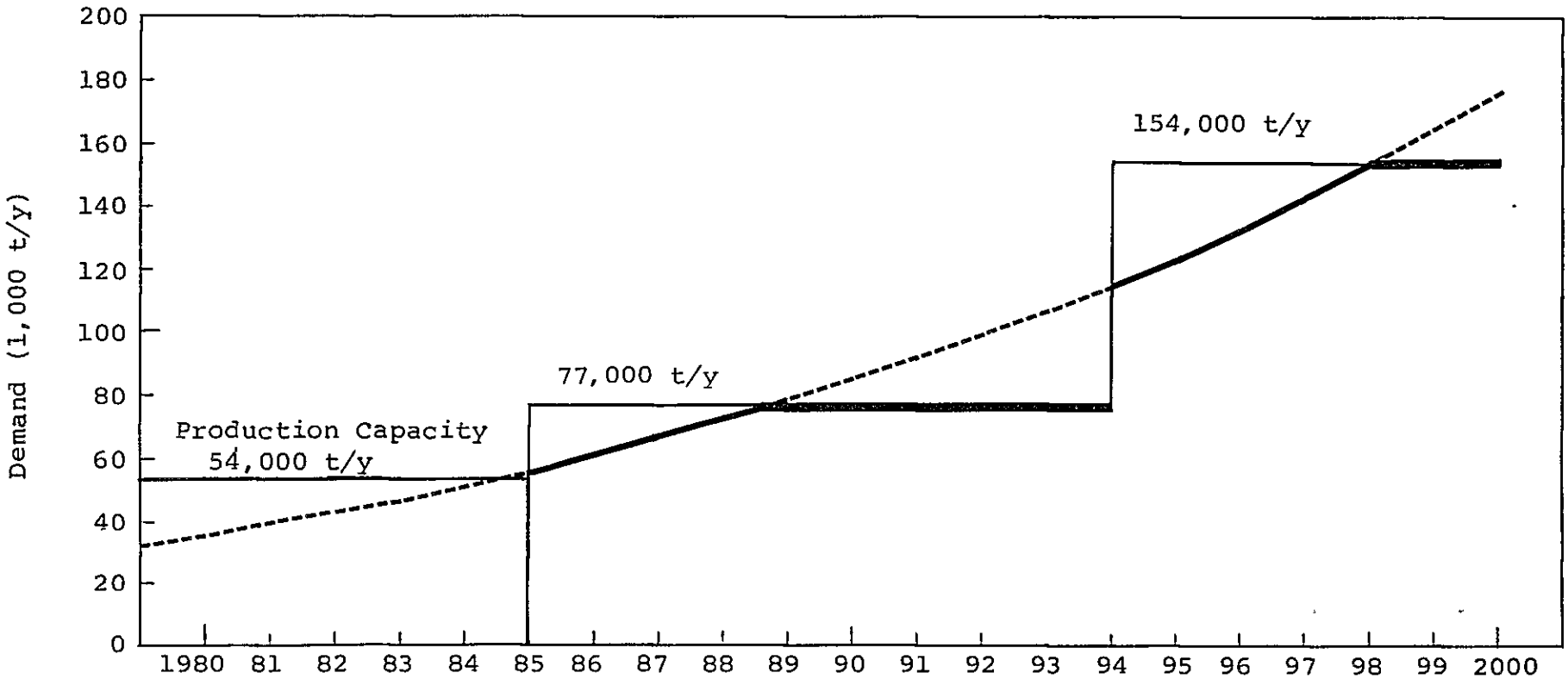


Fig. II—18 DEMAND FORECAST AND PRODUCTION CAPACITY FOR PVC

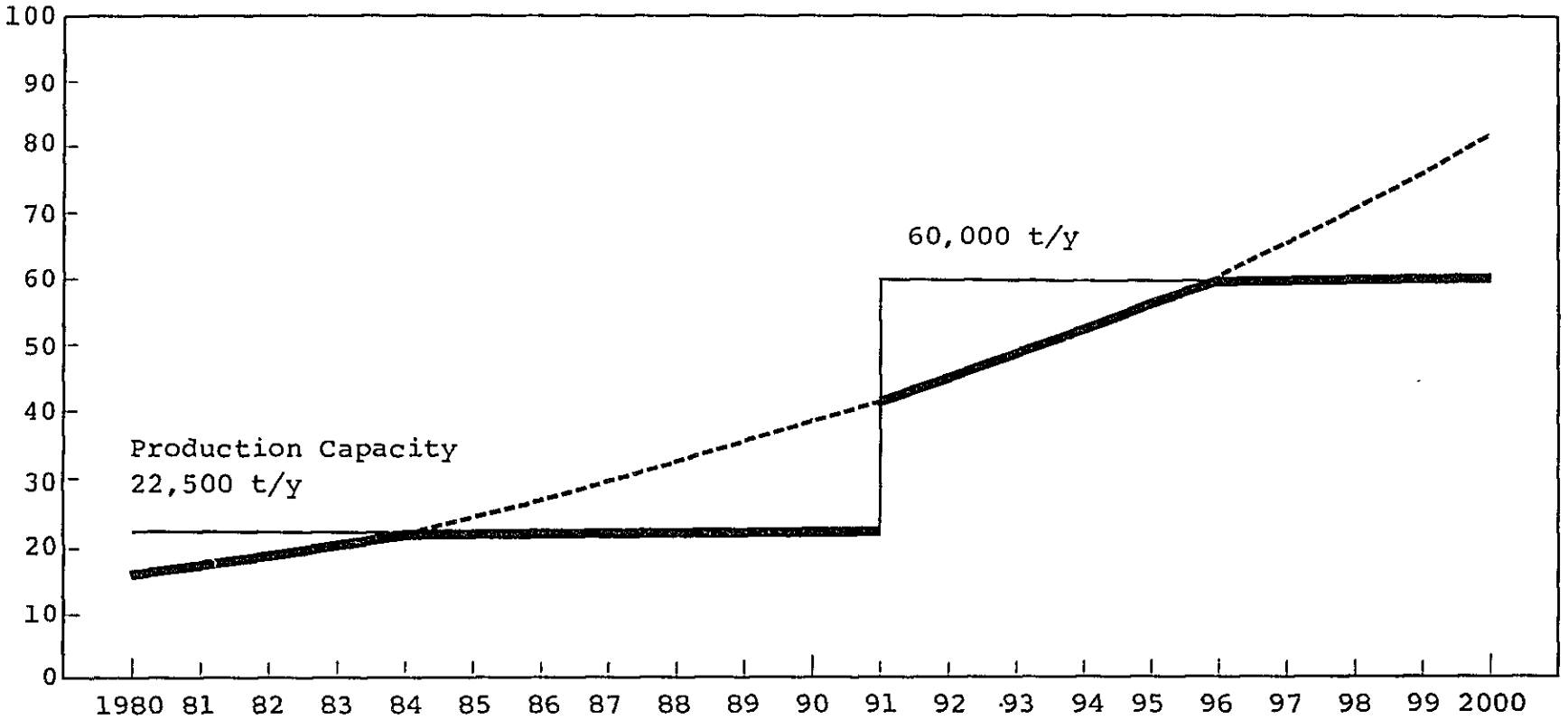


Fig. II—19 DEMAND FORECAST AND PRODUCTION CAPACITY FOR STYRENE POLYMERS

With regard to HDPE, 36,000 t/y is the capacity expected as of this time, and as it is deemed possible that full capacity operation can be attained in 1985, it is assumed here that capacity will be expanded to 50,000 t/y in 1985 and then doubled in 1996.

PVC production capacity is expected to be increased from the present level of 54,000 t/y to 77,000 t/y in 1985, and then doubled to 154,000 t/y in 1994.

It is anticipated that PS production capacity will be increased to 60,000 t/y in 1991.

2–4–5 Projection of Ethylene Demand

Even if the domestic supply systems for plastic materials are improved so as to enable the country to become fully self-sufficient, it will still be necessary to import special grades of products. Furthermore it is to be expected that Hong Kong and other nearly countries will be exporters of some general-purpose grades. It is therefore thought that is general perspective there will be balance in Thailand's imports and exports of plastics materials.

In Table II-45 and Fig. II-20 is given ethylene demand presuming that production is done just to the extent needed to meet domestic demand of polyethylene and PVC. When plant capacity is not sufficient to meet demand, the plants are assumed to be operating at 100% of capacity.

When the LDPE, HDPE and VCM plants operate at 100% capacity the demand for ethylene is as shown in Table II-46.

Table II—45 FORECAST DEMAND FOR ETHYLENE FOR POLYETHYLENE AND PVC

(Unit: 1,000 t/y)

	Demand			Plant Capacity			Ethylene Demand	
	LDPE	HDPE	PVC	LDPE	HDPE	PVC	Potential	Effective
1985	63.4	38.9	56.1	73	50	77	137.3	134.2
1986	69.1	40.6	61.0	73	50	77	147.5	142.7
1987	74.1	43.5	66.4	73	50	77	158.7	149.7
1988	79.4	46.6	72.2	128	50	77	170.6	170.6
1989	85.1	49.9	78.6	128	50	77	183.4	182.6
1990	91.2	53.5	85.6	128	50	77	197.2	189.4
1991	100.3	54.0	92.0	128	50	77	210.8	199.3
1992	106.9	57.6	99.0	128	50	77	225.2	206.6
1993	114.0	61.4	106.5	128	50	77	240.6	214.3
1994	121.6	65.4	114.5	128	50	154	256.9	240.7
1995	129.5	69.8	123.2	128	50	154	274.4	252.2
1996	138.1	74.4	132.5	128	100	154	293.2	287.2
1997	147.2	79.3	142.6	128	100	154	313.1	292.1
1998	157.0	84.5	153.4	200	100	154	334.6	334.6
1999	167.3	90.1	164.9	200	100	154	357.2	352.4
2000	178.4	96.0	177.4	200	100	154	381.6	370.6

Note: (Ethylene Demand) = 1.096 × (LDPE) + 1.040 × (HDPE) + 1.035 × 0.47 × (PVC).

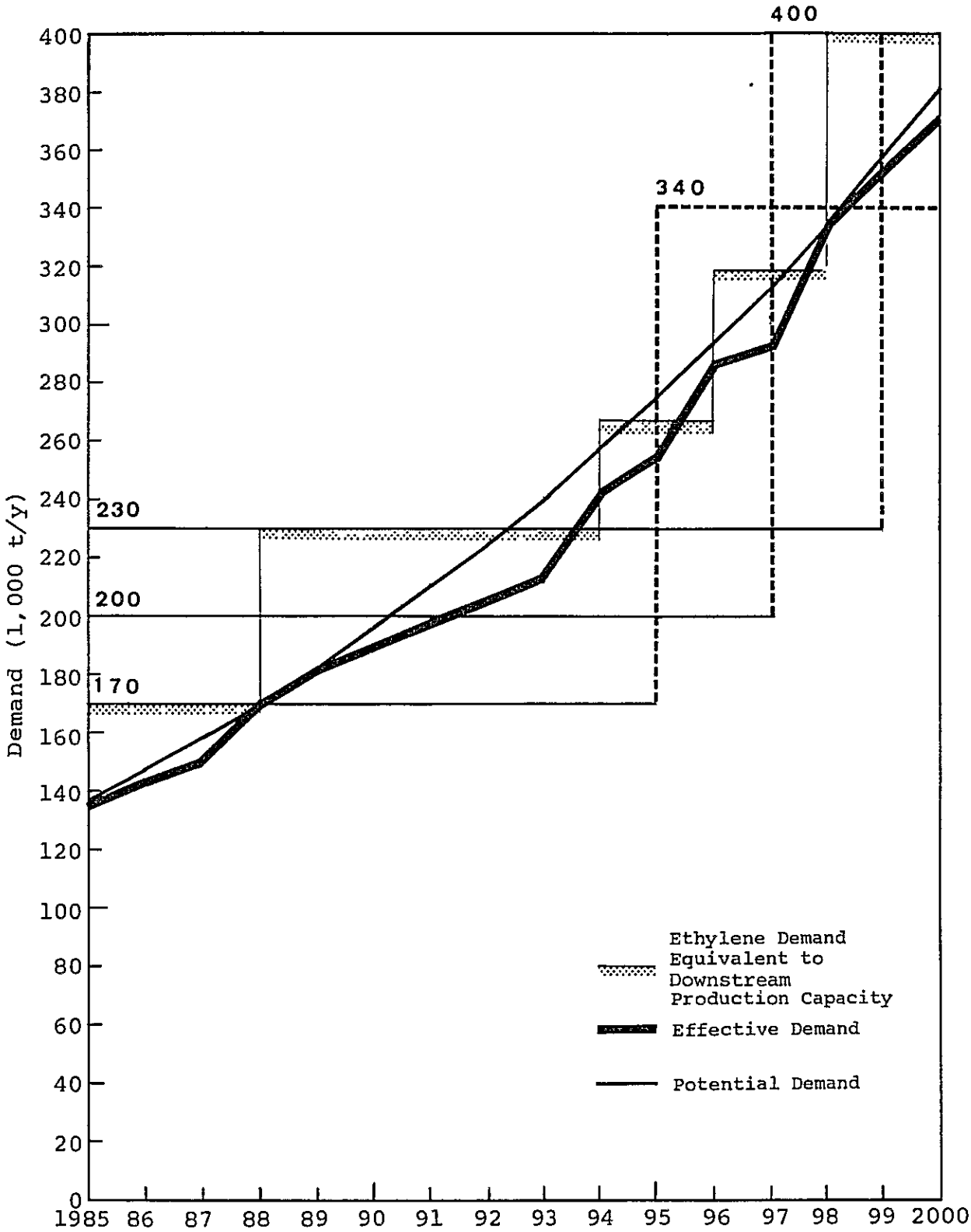


Fig. II—20 ETHYLENE DEMAND FOR POLYETHYLENE AND PVC

Table II—46 ETHYLENE REQUIREMENT FOR DOWNSTREAM UNITS (AT 100% PLANT UTILIZATION)

(Unit: 1,000 t/y)

1985	169.4
1988	229.7
1994	267.1
1996	319.1
1998	398.0

CHAPTER 3 ETHYLENE GLYCOL AND ETHYLENE OXIDE

3–1 INTRODUCTION

Ethylene glycol and ethylene oxide are ethylene derivatives which are not plastics materials. Ethylene oxide, which is obtained through the reaction of ethylene with air or oxygen, for the most part is used for production of ethylene glycol. Ethylene glycol is made through hydration, by bringing ethylene oxide and water together. Its major use is as a raw material for production of polyester fibers, and a portion is consumed for production of antifreeze for automobile radiator water. Because Thailand is a tropical country there is no demand for antifreeze and because it is believed that use of this material is almost entirely for production of polyester fiber, polyester fiber demand and trends can be investigated as the method of obtaining an understanding of the situation with regard to demand and outlook for ethylene glycol.

Polyester fiber is, together with nylon and acrylic, one of the three major synthetic fibers (SF) and filament yarn (FY) are produced, and processing facilities, which perform price of its raw materials (terephthalic acid and ethylene glycol) it is demonstrating growth of its share in the synthetic fiber market. In Thailand at the present time polyester staple fibers (SF) and filament yarn (FY) are produced, and processing facilities, which perform spinning, weaving, knitting, dyeing and finishing, are increasing. For Thailand particular, due to the cotton-centered structure of fiber demand, polyester fiber may be considered to be the most suitable synthetic fiber. In this chapter, the demand for ethylene glycol is projected by projecting future domestic demand as well as exports of polyester fiber.

3–2 TREND OF CONSUMPTION OF ETHYLENE GLYCOL

3–2–1 Consumption and Supply Mechanism of Ethylene Glycol

There is no plant for production of ethylene glycol in Thailand at this time, and ethylene glycol requirements are met entirely by means of imports. Imports of ethylene glycol, obtained by means of tabulation of Thai foreign trade statistics, are shown in Table II-47. In 1978∿1979 about 20∿25,000 tons were imported. About 95% of the imports were acquired from Japan, and this is a reflection of the fact that the major Thai makers of polyester fiber are joint ventures with Japanese companies, and the situation wherein export prices quoted by Japan's ethylene glycol makers are at about the level of the international price. Ethylene glycol makers are relatively limited in number, and there are only four such makers in Japan. Most of the Japanese exports of ethylene glycol to Thailand are handled by Japan's general trading companies.

Table II–47 TREND OF THAILAND's ETHYLENE GLYCOL IMPORTS

	Import	
	Kl	Ton
1974	9.228	10,300
1975	7,036	7,800
1976	14,293	15,900
1977	19,197	21,400
1978	22,005	24,500
1979	20,227	22,500

Source: Foreign Trade Statistics of Thailand.

3–2–2 Requirement of Ethylene Glycol for Polyester Fiber Production

As is noted above, the demand for ethylene glycol in Thailand may be viewed as being the equivalent of the country's requirement of it for polyester fiber production. The quantity of polyester fiber production, and calculated quantity of ethylene glycol needed to attain those volumes, are shown in Table II-48. With consideration given to the fluctuation of inventory level as a consequence of the strength of demand, the requirement shows about the same tendency as does the quantity of imports in Table II-47, demonstrated further that demand for ethylene glycol is dependent on the volume of production of polyester fiber.

3–3 DEMAND ANALYSIS OF POLYESTER FIBER

3–3–1 Method of Analysis and Forecast

Demand for polyester fiber is projected by the following methods.

1. Study is made of the shares which polyester fibers account for within total fiber production and consumption at the present time. The share of polyester fiber is taken as the synthetic fiber ratio (ratio of synthetic fibers consumption to total fibers consumption), and the ratio of polyester fiber consumption within total synthetic fiber consumption.

2. The structure of demand is ascertained by separately studying the domestic demand, exports of processed fiber products (indirect exports) and fiber exports (direct exports).

3. Future domestic demand for fiber is projected by use of per capita GNP and population.

4. By taking into consideration conditions prevailing in Thailand, and supply-related conditions in Thailand and other countries, estimation is made of the synthetic fiber ratio and of the share of polyester fiber within synthetic fiber, and the domestic demand for polyester fiber was thereby projected.

5. Estimation is made of export quantities of polyester fiber and products made using that fiber, and the estimation results together with domestic demand were used for projection of total demand for polyester fiber.

Table II–48 TREND OF POLYESTER FIBER PRODUCTION AND PRODUCTION CAPACITY IN THAILAND

(Unit: 1,000t)

	Production Capacity		Production			EG Requirement for Production[1]
	SF	FY	SF	FY	Total	
1974	15.8	12.5	13.5	8.0	21.5	7.5
1975	22.5	15.3	18.3	11.3	29.6	10.4
1976	36.7	19.5	29.4	13.7	43.1	15.1
1977	49.2	29.2	37.3	19.8	57.1	20.0
1978	49.2	29.2	40.6	18.3	58.9	20.6
1979	49.2	29.2	47.8	17.1	64.9	22.7

Note: 1) EG Consumption/Polyester Fiber Production = 0.35.

Source: Thai Synthetic Fiber Manufacturers' Association.

3–3–2 Trend and Present Status of Material-Wise Textile Consumption

The flow of supply and demand in Thailand for fibers is schematically shown in Fig. II-21. Using statistics from Thailand and elsewhere, consumption of raw fiber in fiber processing mills has been estimated as Table II-49 by material (cotton, regenerated fiber, synthetic fiber).[1)]

As is suggested by the development of the Thai fiber processing industry, the quantity of fiber and yarn consumed in Thai mills is increasing. As is shown in Fig. II-21, these fibers and yarns are processed into woven and knitted fabrics, and clothing, for export and domestic markets. In Thailand, textile products, notably clothing, occupies the most prominent position among exports of light industry products, and have grown to the extent that they have attained status behind rice and rubber as export products.

Production, exports and domestic consumption of fabric, according to the Thai Textile Manufacturers' Association (TTMA) is shown in Table II-50. From this it may be seen that in comparison to cotton fabrics the production of man-made fabrics[2)] is growing at a higher rate.

Table II–49 TREND OF MATERIAL–WISE TEXTILE FIBER MILL CONSUMPTION IN THAILAND

(Unit: 1,000 t)

	Cotton	Regenerated	Synthetic	Total
1974	72	5	45	122
1975	80	4	45	129
1976	108	9	59	176
1977	100	13	72	185
1978	111	16	66	193

Source: UNICO estimate from the data of "International Cotton Advisory Comittee", "Textile Oraganon", "Thai Textile Manufacturers' Association", "Foreign Trade Statistics of Thailand".

1) Wool and silk are properly included among the natural fibers category, but production of these fibers in Thailand, in comparison to the production of cotton, is so low as to be considered negligible in this study.

2) Man-made fabrics include mixed man-made fabrics as well as pure man-made fabrics. Raw fiber consumption per unit width of fabric include loss in processing.

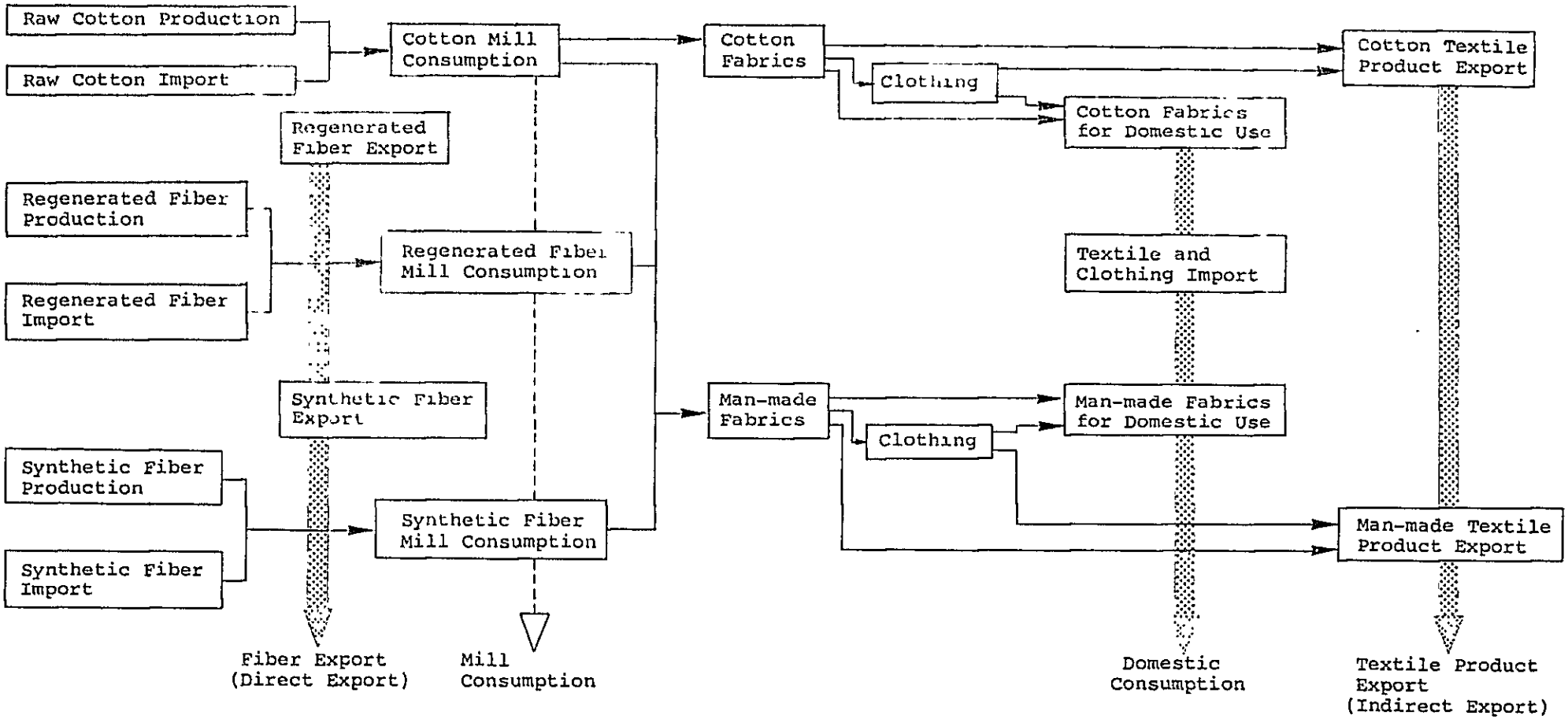


Fig. II—21 SUPPLY/DEMAND STRUCTURE OF TEXTILE PRODUCTS IN THAILAND

Table II—50 TREND OF FABRIC PRODUCTION, EXPORT AND CONSUMPTION

(Unit: Million square yards (%))

	1974	1975	1976	1977	1978	1979
Fabric Production						
Cotton Fabrics	581	633	766	789	835	865
Man-Made Fabrics	429	517	649	705	885	938
Total Fabrics	1,011	1,150	1,415	1,494	1,721	1,803
Export (include apparels)						
Cotton Fabrics	40	57	142	148	164	
Man-Made Fabrics	90	124	198	207	383	
Total Fabrics	130	181	340	355	547	
Domestic Consumption						
Cotton Fabrics	583	608	647	666	700	
Man-Made Fabrics	401	453	494	545	579	
Total Fabrics	984	1,061	1,141	1,210	1,279	
Export/Production (%)						
Cotton Fabrics	6.9	9.0	18.5	18.8	19.6	
Man-Made Fabrics	21.0	24.0	30.5	29.4	43.3	
Total Fabrics	13.2	15.9	24.2	23.8	31.8	
Consumption/Production (%)						
Cotton Fabrics	100.0	96.1	84.5	84.4	83.8	
Man-Made Fabrics	93.5	87.6	76.1	77.3	65.4	
Total Fabrics	97.3	92.3	80.6	81.0	74.3	

Source: Thai Textile Manufacturer's Association.

From statistics for fiber consumption in mills (Table II-49) the level of domestic demand for processed fiber products and of exports (fiber base;[1] refer to footnote) has been estimated with results as summarized in Table II-51.

From these data, it is believed that the present conditions related to fiber consumption in Thailand are as follows.

1. Total annual fiber demand is on the order of 150,000 tons, and is 3.3 kg per capita.

2. The synthetic fiber ratio, on a fiber base, is about 30∿35%.

3. Fiber consumption in Thailand is primarily in the form of staple fabrics, including cotton goods in particular. Domestic demand is growing for both cotton and man-made fiber.

4. About 30% of textile products are exported (excepting from this direct exports of fiber and filament). The ratio of synthetic textile products to total export of textile products is about 50%.

3–3–3 Trend and Present Status of Polyester Fiber Consumption

Study has been undertaken of the structure of supply and demand specifically of polyester fiber. As is indicated in Table II-48, with regard to production capacity for polyester fiber, considerable expansion of capacity for both staple and filament took place in 1976∿1977, through both new entries and internal growth on the part of existing firms. (With regard to staple, there was one new entry besides the one existing maker; there were two new entries besides the two existing makers of filament.) Because of the international recession following the oil shock, and decrease in border business with Thailand's neighboring countries, which combined to depress fiber demand, this expansion of capacity resulted in a surplus of supply capacity in relation to the domestic demand. Production did increase, as shown in Table II-48, but it became necessary for the industry to make an agreement within itself for compulsory export and for curtailment of output, and the rate of utilization of capacity declined.

1) Fiber base consumption means total textile consumption which includes all fiber, yarn and fabrics represented by raw fiber consumption.

Table II—51 TREND OF DOMESTIC TEXTILE CONSUMPTION AND TEXTILE EXPORT (FIBER BASE)

(Unit: 1,000 t)

	Textile Consumption			Textile Export		
	Total	Synthetic	Synthetic / Total (%)	Total	Synthetic	Synthetic / Total (%)
1974	119	42.2	36	16.1	9.5	59
1975	119	39.9	34	20.5	10.9	53
1976	142	45.1	32	42.6	18.1	42
1977	150	55.7	37	44.0	21.2	48
1978	143	43.0	30	61.4	28.4	46

Source: UNICO estimate.

Table II-52 gives production and mill consumption (apparent consumption adjusted for change in fiber imports and exports) for staple and filament. This consumption level, as is noted above, includes domestic consumption and textile exports. With specific regard to polyester fiber, consumption, separately estimated for domestic consumption, direct exports and indirect exports, is as shown in Table II-53. As may be understood through examination of the volume of production in terms of fiber base, and level of supply including imports, in addition to there being progress in import substitution, exports of both fiber and yarn have been increasing. Behind this increase in exports is not only the "pull" of export demand but also, as noted above, the "push" of surplus capacity relative to the domestic market demand. With regard to filament in particular there is a considerable surplus of production capacity relative to domestic market requirements. There is a strong tendency for maintaining operation rates through direct exports of low-margin yarn. Fortunately, the influence of an upward turn in world demand in 1978∿1979, combined with the appreciation of the Japanese yen and attainment of maximum levels of export ability by Korea and Taiwan, enabled exports to improve, but Thailand's fiber exports are those of a marginal supplier, strongly subject to the influence of change in the export environment. It would therefore be a premature conclusion to state that on the basis of the export performance of the Thai textile industry in the past few years that the industry has achieved the status of being an export industry. Direct exports of fiber in particular cannot be said to have become firmly established and it is anticipated that until direct fiber exports decrease there will be no further investment in expansion of capacity. Moreover, the government has adopted restrictions preventing further expansion of fiber production capacity.

Although rapid increase of production capacity of polyester fiber meet with the above-noted circumstances, polyester staple, through blending with cotton or rayon, is puarticularly well suited to the Thai environment and hence has come to account for more than half of synthetic fiber volume. If filament consumption is added, then polyester fiber is found to account for 70∿75% of synthetic textiles in Thailand. Mill equipment in Thailand is for the most part staple processing equipment, primarily for cotton spinning and cotton weaving, but staple processing equipment for synthetic fiber blends is increasing. (At present it is estimated that spinning capacity is at the level of 1,240,000 spindles, of which 500,000 are for polyester-cotton blend yarn and 100,000 are for polyester-rayon blend yarn.) With regard to filament, the worldwide popularity of thin fabric may also be seen in Thailand, where there are some imports and the number of looms producing thin fabric are few, but allowing for an element of fashion behind the present strong demand, it may be said that the present surplus of production facilities will continue to exist for the time being.

Table II–52 TREND OF POLYESTER FIBER MILL CONSUMPTION IN THAILAND

(Unit: 1,000 t)

	1974	1975	1976	1977	1978	1979
Polyester SF						
Production	13.5	18.3	29.4	37.3	40.6	47.8
Import	10.0	3.0	3.2	2.5	0.8	0.9
Export	–	–	–0.3	–1.5	–2.6	–1.2
Mill Consumption	23.5	21.3	32.3	38.3	38.8	47.5
Polyester FY						
Production	8.0	11.3	13.7	19.8	18.3	17.1
Import	1.4	0.2	0.2	0.0	0.2	0.3
Export	–0.8	–1.8	–4.6	–6.1	–8.6	–6.8
Mill Consumption	8.6	9.7	9.3	13.7	9.9	10.6
SF + FY Production	21.5	29.6	43.1	57.1	58.9	64.9
Mill Consumption	31.1	31.0	41.6	52.0	48.7	58.1

Sources: Thai Synthetic Fiber Manufacturer's Association; Foreign Trade Statistics of Thailand; etc.

Table II—53 TREND OF SUPPLY/CONSUMPTION OF POLYESTER FIBER

(Unit: 1,000 t)

	1974	1975	1976	1977	1978	1979
Polyester SF						
Domestic Consumption	21.9	18.6	24.5	29.9	25.4	
Textile Products Export (Indirect Export)	4.9	5.1	10.0	11.1	16.7	
Fiber Export (Direct Export)	—	—	0.3	1.5	2.6	1.2
Total Consumption	26.8	23.7	34.8	42.5	44.7	
Production	13.5	18.3	29.4	37.3	40.6	47.8
Fiber Import	10.0	3.0	3.2	2.5	0.8	0.9
Fiber Supply	23.5	21.3	32.6	39.8	41.4	48.7
Polyester FY						
Domestic Consumption	8.0	8.5	7.0	10.7	6.4	
Textile Products Export (Indirect Export)	1.8	2.3	2.9	4.0	4.3	
Yarn Export (Direct Export)	0.8	1.8	4.6	6.1	8.6	6.8
Total Consumption	10.6	12.6	14.5	20.8	19.3	
Production	8.0	11.3	13.7	19.8	18.3	17.1
Yarn Import	1.4	0.2	0.2	0.0	0.2	0.3
Yarn Supply	9.4	11.5	14.1	19.8	18.5	17.4
Polyester/Synthetic (Domestic Consumption) %						
SF/Synthetic	52.0	47.0	55.0	53.0	59.0	
FY/Synthetic	19.0	21.0	16.0	19.0	15.0	
Polyester/Synthetic	71.0	68.0	70.0	72.0	74.0	

3–4 DEMAND FORECAST OF POLYESTER FIBER

Thailand's total fiber demand, and the country's demand for polyester fiber within that overall demand, are as described above. On the basis that description and information obtained through the market survey in Thailand, a demand forecast of polyester fiber has been made. The forecast was made in three steps, i.e.,

1. Forecasting of total domestic fiber demand.

2. Forecasting of demand for synthetic fiber within total fiber demand, and of polyester fiber within total synthetic fiber demand.

3. Forecasting of direct and indirect exports of polyester fiber.

3–4–1 Total Domestic Textile Demand

In order to undertake a macroeconomic forecast of a country's demand for fiber, the general method employed is to proceed on the basis of the quantity of fiber consumed per capita, and the forecast of the future population. For forecasting fiber consumption per capita, the relation of fiber consumption and per capita national income is used. For national income, gross domestic product (GDP) is used.

(1) Relationship between per capita GDP and per capita textile consumption

The values for population and GDP which are used as the basis of the forecast are shown in Table II-54. By using the information given in Table II-51 for total quantity of fiber demand, in the specific case of Thailand, the relation between per capita GDP and per capita textile consumption is sought through the following model.

$$Y = 0.3785 + 3.8447 \log X$$

where

X : per capita GDP (1972 price; 1,000 Baht/person)
Y : per capita textile consumption (kg/person)

(2) Total domestic textile demand

Forecast textile demand, on the basis of this model, is as shown in Table II-55. Whereas in 1978 per capita annual consumption was 3.3 kg it is expected to be 4.2 kg/person in 1990, and 5.0 kg/person in 2000. Total textile demand is expected to increase to 242,000 tons in 1990 and 336,000 tons in 2000, or more than double the level in 1978.

Table II–54 POPULATION AND GDP IN THAILAND

	Population [1] (Million)	GDP 1972 Price (Billion Baht)
1974	40.8	190
1975	41.9	204
1976	43.0	223
1977	44.0	239
1978	45.1	267
Projected Population and GDP		
1980	47.2	303
1985	52.4	415
1990	57.5	569
1995	62.4	780
2000	67.1	1,068

Note: 1) Midyear Population.

Source: 1974–78: Statistics from the United Nations. Projected value: UNICO estimate.

Table II—55 FORECAST ON DOMESTIC TEXTILE FIBER DEMAND IN THAILAND

	Per capita textile Demand (Consumption) (kg/person)		Total textile Demand (Consumption) (1,000 t)		Per capita GDP (1,000 Baht/person)
	Actual	Calculated	Actual	Calculated	
1974	2.9	2.9	119	120	4.66
1975	2.9	3.0	119	127	4.86
1976	3.3	3.1	142	134	5.17
1977	3.4	3.2	150	141	5.43
1978	3.2	3.3	143	151	5.92
1980		3.5		165	6.43
1985		3.8		201	7.93
1990		4.2		242	9.89
1995		4.6		287	12.49
2000		5.0		336	15.92

Source: UNICO estimate.

3–4–2 Polyester Fiber Demand

(1) Synthetic fiber ratio

The synthetic fiber ratio, within Thailand's present domestic fiber consumption, is about 30∿35% (fiber base), as noted in 3–3–2 above. In order to forecast the future synthetic fiber ratio, it is necessary to give consideration to the demand trends for each fiber, and to factors related to supply.

Thailand produces more cotton than any other ASEAN country. Cotton accounts for the largest share of fiber demand in Thailand, and cotton cultivation in the country is increasing. Domestic cotton production, however, is sufficient for only 20∿30%of domestic demand, and considerable quantities are imported every year, from countries including the United States. Although world cotton production is increasing, the rate of growth is low. Cotton competes with food crops, and although cultivation of cotton will increase if the cotton price rises, cotton is at a disadvantage when competing with synthetic fibers. As a result, the rate of growth of cotton production is not very high. Growth of Thai production of cotton is low relative to growth of the country's demand for fiber and it is considered difficult to greatly increase imports of cotton.

Thai commenced production of rayon staple in 1976, and has made progress in substituting for imports since then. In worldwide perspective, rayon production is declining, and it is presumed that one motivation for starting to produce rayon in Thailand was the domestic demand. Subsequent to the second oil shock there was a tendency for rayon to be somewhat reappraised, but in terms of cost and characteristics it has no particularly great advantages, and in the future production is expected to remain steady or to decrease.

Production of synthetic textiles, which are strong and do not become creased, has expanded rapidly, in keeping with progress in developing processing technology and expansion of supply capability of the petrochemical industry, and in 1978 accounted for 35% of world textile production. After experiencing curbing of rapid growth as a consequence of the increase in oil prices, the synthetic textile industry has entered a period of mild growth. But because of restrictions on increased production of natural fiber and regenerated fiber, as noted above, it is expected that in the future the synthetic fiber ratio will increase. In the case of Thailand demand for cotton is and will remain high because it is a fiber suited to a tropical climate, but because there are restraints on the expansion of supply (domestic production plus imports) demand for synthetics and especially for polyester staple for use in blends will increase, and the synthetic fiber ratio will rise.

The synthetic fiber ratio and synthetic textile demand in Thailand, taking into account the demand for each raw fiber as well as supply factors, is forecast as shown in Table II-56.

Table II—56 FORECAST OF DOMESTIC SYNTHETIC FIBER DEMAND IN THAILAND

	Synthetic Fiber Demand / Total Fiber Demand (%)	Synthetic Fiber Demand (Consumption) (1,000 t)
Consumption		
1974	36	42.2
1975	34	39.9
1976	32	45.1
1977	37	55.7
1978	30	43.0
Projected Demand		
1980	38	62
1985	44	89
1990	52	125
1995	57	164
2000	61	206

Source: Table II—51; UNICO estimate.

The synthetic fiber ratio is expected to pass the level of 50% in 1990, and 60% in 2000. Synthetics demand is expected to pass the levels of 124,000 tons in 1990 and 200,000 tons in 2000. The average growth rate for synthetics for 1978∿2000 is 6.5% per annum.

(2) Domestic demand for polyester fiber

Nylon, polyester and acrylic combined account for 99% of total synthetic fiber production. The relative shares of these three vary from country to country, but in general the growth rate of polyester fibers, which can be widely used for clothing, is high and the share of these fibers is increasing. In particular, in countries having a tropical climate, such as Thailand, demand for acrylic is weak and there are almost no acrylic mills in countries such as these. Nylon filament has been supplanted by polyester in many areas of application for clothing production, and the principal areas of demand are now tire cord, fishnets, rope and carpets. In addition to being widely used in blends with cotton for woven fabrics, polyester staple is used in blends with rayon, for uniforms, slacks and other products, and demand is growing in tropical climates where cotton is a suitable material. It may be safely presumed that such conditions will continue to prevail. Polyester filament demand underwent a swift increase in demand as a result of the boom in jersey and other knitted articles of clothing, and after the knit boom died down, demand has been sustained by thin fabric products such as the georgette. Polyester filament is thus a fiber which is influenced by fashion trends, and in countries where per capita consumption of clothing is high, demand for polyester filament products is high.

The share occupied by polyester staple within synthetic fibers in Thailand, as shown in Table II-53, is such that the share of staple is 55∿60% and the share of filament is 15∿20%; thus, together they are estimated to account for 70∿75%. In view of the above-described situation, demand for polyester fiber, with staple and filament demand given separately, is forecast as is shown in Table II-57. Whereas demand for staple in 1978 was about 30,000 tons, it is expected to be 80,000 tons in 1990 and 150,000 tons in 2000. Demand for filament was about 9,000 tons in 1978, and is expected to increase to 22,000 tons in 1990 and 37,000 tons in 2000. The average annual rates of growth for these two during this period are 7.4% for staple and 6.5% for filament.

(3) Exports of polyester fiber

As noted in 3–3–3 above, polyester fiber is exported through direct means, as staple and filament, and through indirect means, such as in blended fiber apparel. For the Thai fiber industry to develop while balancing domestic demand and exports, in the medium term, the following would be assumed.

1. A portion of blended fabric production must be exported. It is thought that the export ratio will be 30%.

Table II–57 FORECAST OF DOMESTIC POLYESTER FIBER DEMAND IN THAILAND

	Polyester Fiber Demand / Synthetic Fiber Demand (%)		Polyester Fiber Demand (Consumption) (1,000 t)		Growth Rate Per Annum (%)	
	SF	FY	SF	FY	SF	FY
1974	52	19	21.9	8.0		
1975	47	21	18.7	8.5		
1976	55	16	24.6	7.0		
1977	53	19	29.6	10.7		
1978	59	15	25.4	6.4		
1980	61	18	37.8	11.2		
1985	64	18	57.0	16.0	8.6	7.4
1990	67	18	83.8	22.5	7.7	7.1
1995	70	18	114.8	29.5	6.2	5.6
2000	72	18	148.3	37.1	5.3	4.7

Source: Table II–53; UNICO estimate.

2. Direct exports will be made in order to improve the utilization of capacity as long as there is a surplus of capacity, but with improvement of the utilization of capacity, such exports will fall to zero.

If exports are calculated on the basis of these assumptions, the results obtained are as shown in Table II-58. If domestic demand and exports are combined, the total demand for polyester fiber in 1990 will be 150,000 tons, and in 2000 it will be 265,000 tons.

3–5 DEMAND FORECAST FOR ETHYLENE GLYCOL

3–5–1 Ethylene Glycol Forecast

In order to attain the level of polyester fiber demand forecast above in 3–4, not only is it necessary to increase production of polyester fiber but, further, processing facilities must be expanded and newly added. Large sums must be invested in order to do this, but if the outlook justifies such investment, it is expected that private interests will make such investments as are needed, and the industry as a whole, and the national government, will support them in that effort. Demand for ethylene glycol which would be needed in order to support that expanded production of polyester fiber is as shown in Table II-59.

3–5–2 Projected Demand of Ethylene for the Production of Ethylene Glycol

Ethylene glycol may be imported or produced domestically in order to fulfil the demand above. The question therefore is one of determining the level of ethylene glycol demand which would justify building a plant to make it by using ethylene as a raw material. There are ethylene oxide plants in the world today which are of the scale of 300,000 tons/year or greater, but plants of 50,000 to 100,000 tons/year are most common. The demand of ethylene oxide in early 1990's will be 50,000 tons, which justify building an ethylene oxide plant, and this represents demand for about 50,000 tons of ethylene. If it is possible to expand ethylene glycol production capacity in keeping with expansion of polyester demand, the situation would be as shown in Table II-59, and in 2000, the demand for ethylene would be 70,000 tons. Because most of the ethylene glycol would be used for polyester fiber, in view of the trend for demand of polyester as well as the world supply and demand balance for ethylene glycol, it is concluded that construction of a plant should be considered with extreme caution.

Table II—58 FORECAST OF TOTAL POLYESTER FIBER DEMAND IN THAILAND

(Unit: 1,000 t)

	1980	1985	1990	1995	2000
Polyester SF					
Domestic Demand	37.8	57.0	83.8	114.8	148.3
Textile Export	18.1	24.4	35.9	49.2	63.6
Fiber Export	—	—	—	—	—
Sub–Total	55.9	81.4	119.7	164.0	211.9
Polyester FY					
Domestic Demand	11.2	16.0	22.5	29.5	37.1
Textile Export	5.0	6.9	9.6	12.6	15.9
Fiber Export	4.2	3.4	—	—	—
Sub–Total	20.4	26.3	32.1	42.1	53.0
Total Demand (SF + FY)	76.3	107.7	151.8	206.1	264.9

Source: Table II–57; UNICO estimate.

Table II—59 PROJECTED DEMAND FOR ETHYLENE GLYCOL IN THAILAND

(Unit: 1,000 t)

	Ethylene Glycol [1]	Ethylene Oxide [2]	Equivalent to Ethylene
1975	10.4		
1977	20.0		
1979	20.7		
1980	26.7		
1985	36.7		
1990	53.1	42.5	40.4
1995	72.1	57.7	54.8
2000	92.7	74.2	70.5

Notes: 1) EG = 0.35 x Polyester.
2) EO = 0.8 x EG.
3) Ethylene = 0.95 x EO.

Source: UNICO estimate based Table II—58. For 1975 ∿ 1979 : Table II—48.

CHAPTER 4 VCM AND ETHYLENE

4–1 VCM

4–1–1 Quantity of demand

(1) Trend of the quantity of imports, and sources of imports

Since it started operations in 1971 the Thai Plastic and Chemical Co. has imported VCM mostly from Japan, and the quantity imported has steadily grown from 3,000 t/y in 1971 to 20,000 t/y in 1979. But since 1978 expansion of domestic demand in Japan has reduced the exportable quantity and led to higher prices, so that imports have also been made from France and Holland. According to Thai trade statistics, in 1978 imports from France were 2,000 t, and in 1979 imports from France were 4,000 t and from Holland were 3,500 t (see Table II-60). In 1980 in addition to these European countries there were imports of several thousand tons from America.

(2) Demand projections

Demand for PVC is as shown in Table II-33. Projected production volume for PVC is provided in Table II-61, based on the assumption that in the future that with PVC imports and PVC exports balanced, the PVC plant operates at 100% of capacity when demand exceeds the level of production capacity. The quantity of demand for VCM as obtained by multiplying PVC production quantity by the factor 1.035 is as recorded in Table II-61.

4–1–2 Price

(1) Import price trend

According to Thai import statistics, the import price of VCM (CIF) has been as shown in Table II-62. The VCM export price (FOB) in Japan generally had been set at about 20% less than the domestic shipment price prior to 1972, but disorderly prices have been evident since 1974, and at one point the VCM export price rose to double the domestic price, whereafter sluggish domestic demand for VCM in Japan and a tendency for there to be a surplus of VCM led to a lowering of the export price to about US$350/t, or about 7 Baht/kg. After the second oil shock, in 1978, the Thai import price of VCM again rose and returned to the level of the 1974 high, in 1979. The VCM price at one point passed the US$700 (CIF) mark lent thereafter the supply/demand balance based and at the end of the year the price had father to US$540[1].

1) Contract prices were at the low level of US$495 CIF during the first quarter of 1981 indicating a recent softening of the supply/demand balance.

Table II—60 VCM IMPORTS IN THAILAND BY EXPORTING COUNTRY

(Unit : t/y)

	1971	1972	1973	1974	1975	1976	1977	1978	1979
Japan	2,988	6,057	10,782	8,159	9,739	15,701	17,124	9,371	12,937
France	–	–	–	–	1,659	–	–	2,000	4,008
Netherlands	–	–	–	–	–	–	–	2	3,524
U.S.A.	–	–	48	–	–	–	44	21	20
U.K.	10	–	6	20	–	10	–	–	–
W. Germany	–	1	–	3,999	–	–	–	–	–
Total	2,998	6,058	10,836	12,178	11,398	15,711	17,169	11,393	20,491

Source: Foreign Trade Statistics of Thailand.

Table II–61 DEMAND FORECAST FOR VCM

(Unit: 1,000 t/y)

	PVC		VCM
	Demand	Production	Demand
1985	56.1	56.1	58.1
1986	61.0	61.0	63.1
1987	66.4	66.4	68.7
1988	72.2	72.2	74.7
1989	78.6	77.3	80.0
1990	85.6	77.3	80.0
1991	92.0	77.3	80.0
1992	99.0	77.3	80.0
1993	106.5	77.3	80.0
1994	114.5	114.5	118.5
1995	123.2	123.2	127.5
1996	132.5	132.5	137.5
1997	142.6	142.6	147.6
1998	153.4	153.4	158.8
1999	164.9	154.0	159.4
2000	177.4	154.0	159.4

(2) Relation between VCM price and PVC price

(a) Thailand

The VCM import price and PVC resin price since the establishment of the Thai Plastic and Chemical Co. (TPC) has been as shown in Table II-62 and Fig. II-22. The relationship between the VCM price and PVC price, in Thailand, is expressed in the following linear regression equation.

$$Y_T = 5.31 + 1.0071X_T \quad (R = 0.84) \tag{1}$$

where,

X_T = VCM price (landed price; Baht/kg)
which is an increase of 1.1196 times the VCM price given in Table II-62 and Fig. II-22 (including 10% customes revenue)
Y_T = PVC price (resin price; Baht/kg)

Examination of this linear equation indicates that TPC's PVC price is strongly dependent on the VCM price and is equivalent to the VCM price plus about 5.3 Baht/kg (US$260) as a surcharge for processing (polymerization). It appears that inflation of cost factors other than feedstock is almost entirely absorbed in this processing charge. As may be understood from detailed examination, as shown in Fig. II-22 even though the 1974 and 1979 VCM prices were the same, PVC in 1974 was 16.6 Baht/kg, but 21.7 Baht/kg in 1979. This is because even with the same VCM price, although over time there were increase in costs of factors other than VCM, rapid price increases were not readily accepted by users.

To obtain a model which incorporates this time element, we obtain (see also Fig. II-23).

$$Y_T = 4.81 + 0.713t + 0.724X_T \ (R = 0.84) \tag{2}$$

where,

t = Number of years with 1970 as 0
X_T = VCM price (CIF; Baht/kg)
Y_T = PVC price (Baht/kg)

Table II–62 TREND OF VCM AND PVC PRICES IN THAILAND

(Unit: Baht/kg)

	VCM	PVC
1971	3.07	6.2
1972	3.03	6.1
1973	4.47	15.1
1974	12.59	16.6
1975	6.74	13.6
1976	7.39	15.5
1977	8.01	14.6
1978	10.30	15.2
1979	12.50	21.7

Sources: VCM; Foreign Trade Statistics of Thailand
PVC; Thai Plastic and Chemical Co.

Table II–63 TREND OF VCM AND PVC PRICES IN JAPAN

(Unit: ¥/kg)

	VCM	PVC
1970	54.6	86.5
1971	46.3	81.7
1972	44.5	78.1
1973	48.5	88.3
1974	81.1	126.1
1975	89.1	131.6
1976	100.0	154.6
1977	103.1	151.7
1978	96.9	142.7
1979	108.9	154.7

Source: Year Book of Chemical Industries Statistics of Japan.

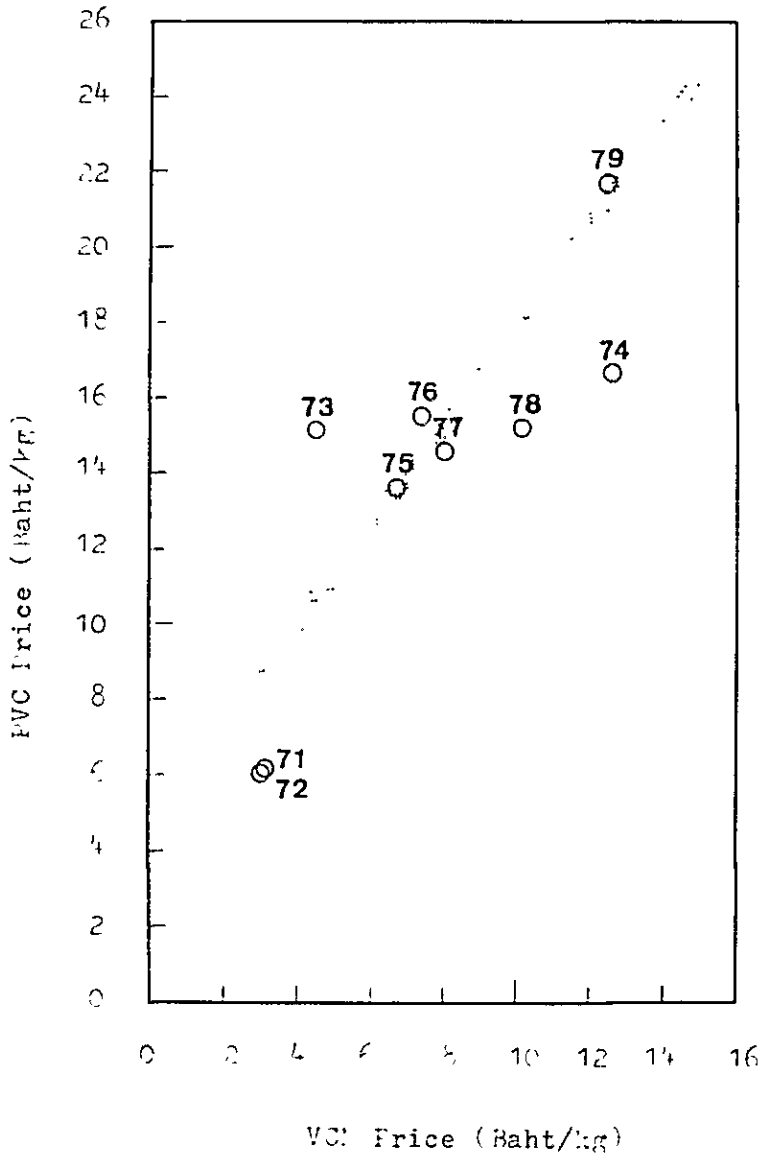


Fig. II–22 EFFECT OF VCM PRICE ON PVC PRICE IN THAILAND

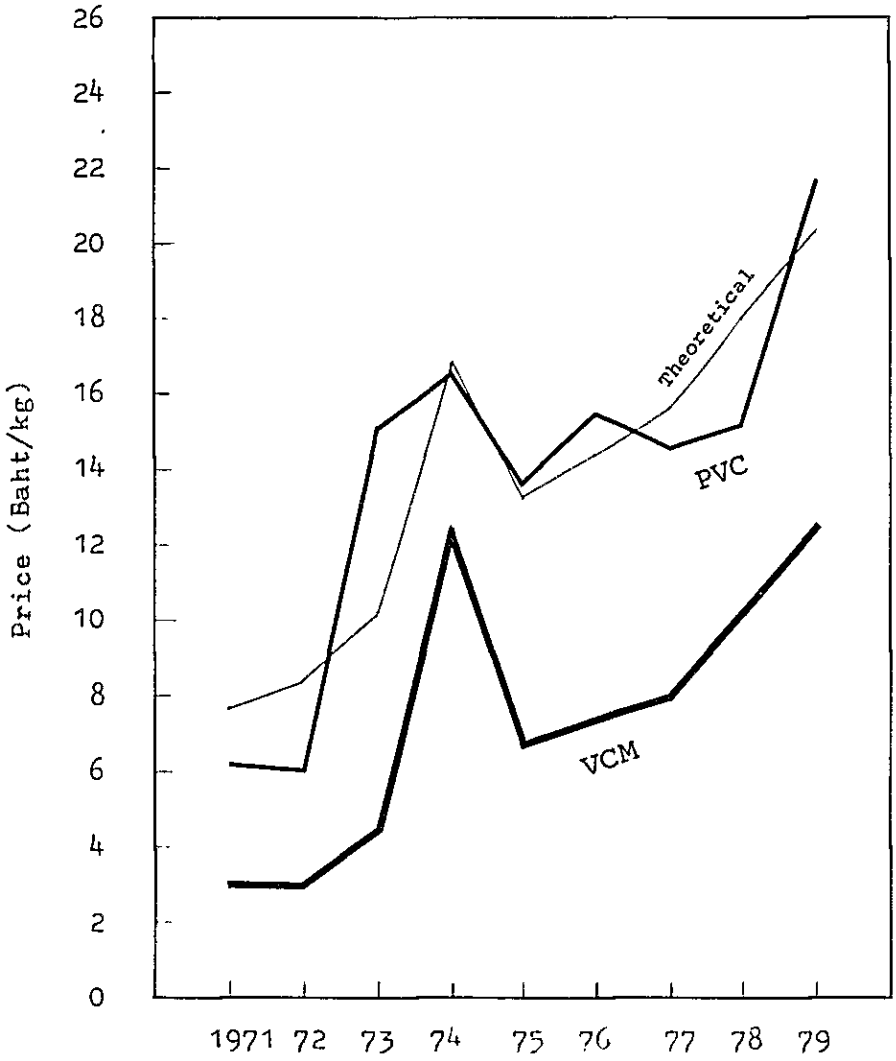


Fig. II–23 TREND OF VCM AND PVC PRICES IN THAILAND

(b) Japan

As shown by Table II-63 and Fig. II-24, in Japan there is a very close relationship between the VCM price and PVC price, and the following regression equation can be derived (see also Fig. II-24).

$$Y_J = 24.03 + 1.2363X_J \quad (R = 0.99) \tag{3}$$

where,

X_J = VCM ex-plant shipping price (Yen/kg)
Y_J = PVC ex-plant shipping price (Yen/kg)

Adding the time factor, similar to the case of Thailand, the following regression equation is obtained (see also Fig. II-25).

$$Y_J = 25.16 + 0.300t + 1.204X_J \quad (R = 0.99) \tag{4}$$

where

t = Number of years with 1970 as 0
X_J = VCM price (Yen/kg)
Y_J = PVC price (Yen/kg)

(c) Comparison of Thailand and Japan

The PVC price in Thailand in 1980 as estimated from the VCM price of US$700 (14.4 Baht/kg) using equation (1) is 19.8 Baht/kg and using equation (2) is 21.3 Baht/kg.

Whereas the domestic VCM price in Japan in 1980 is US$674[1] (145 Yen/kg), when the Thai VCM price (US$700) is used, we obtain 210 Yen/kg (20.0 Baht/kg) using equation (3) and 209 Yen/kg (20.0 Baht/kg) using equation (4), which are the same or slightly cheaper than in Thailand. Fig. II-26 shows the PVC price when the VCM price is changed within the range of US$600 to US$900, where Thailand and Japan have the same PVC price for the same VCM price.

1) Using the exchange rate of 215 Yen per U.S. Dollar as the January–September average.

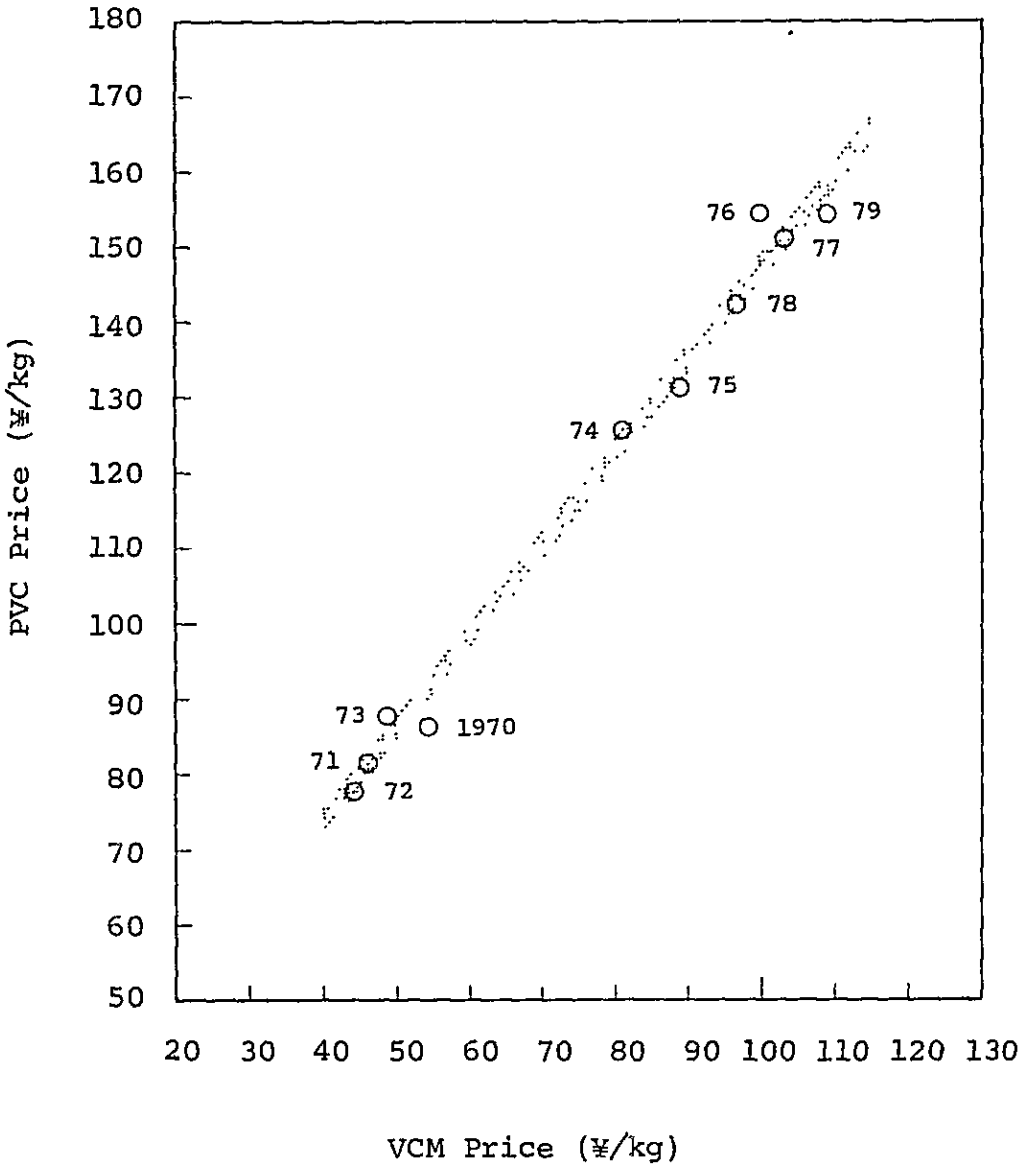


Fig. II–24 RELATIONSHIP BETWEEN VCM PRICE AND PVC PRICE IN JAPAN

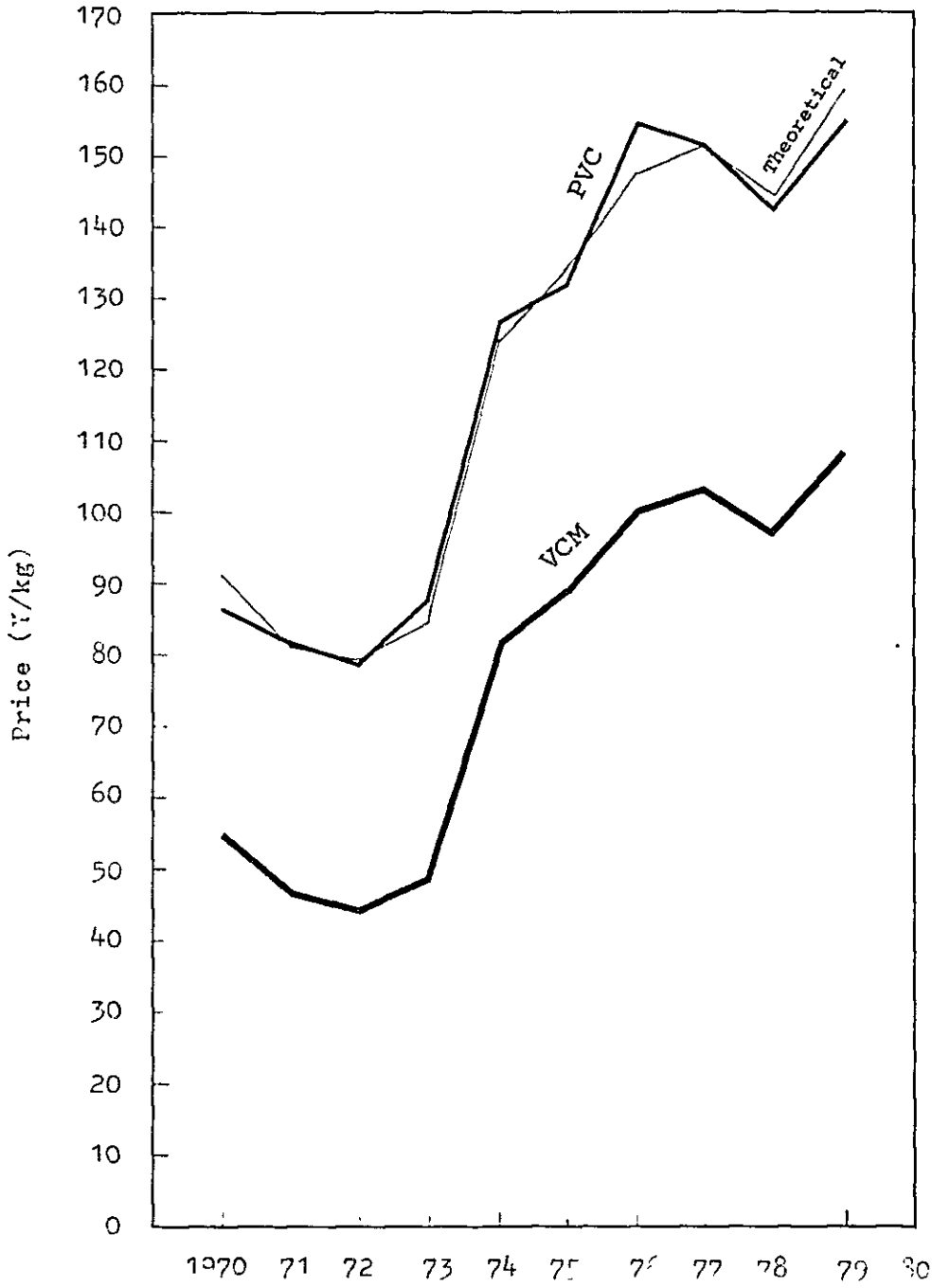


Fig. II–25 TREND OF VCM AND PVC PRICES IN JAPAN

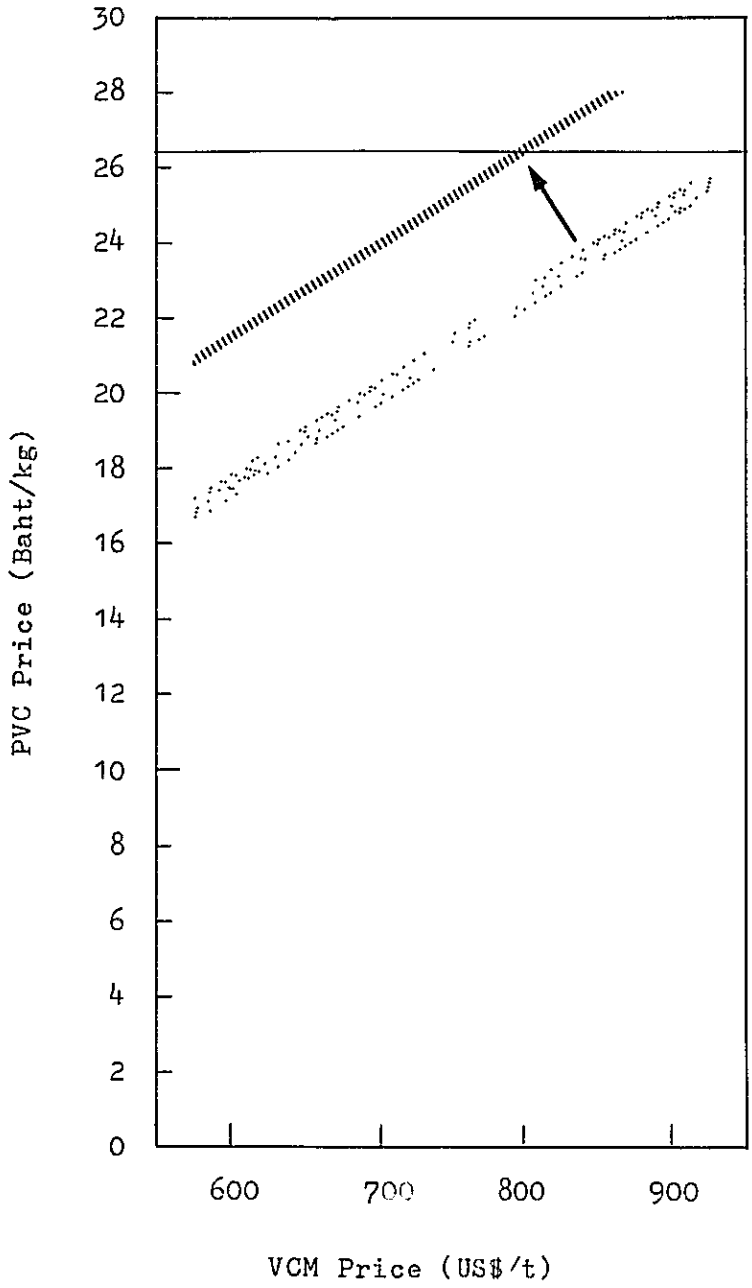


Fig. II–26 ESTIMATED PVC PRICE IN THAILAND AND JAPAN

What must be given special attention here is that about half of the VCM production in Japan is by companies which themselves use VCM as feedstock. It may be thought that the price for VCM in much a case is 5∿10% lower than the price of VCM sold to others for them to use. As is shown in Fig. II-27 the increase of prices in Thailand since 1978 has been quite higher than that of preceding years so that besides the increase in VCM cost it is necessary to expect an increase in the production cost of PVC due to these others price increases.

The Thai Plastic & Chemical Co. has completed its expansion as recently as 1980, and when it is also considered that it will be necessary to have further expansion in a few years, even if the same VCM price is used, it would be suitable to expect the PVC production cost to be higher in Thailand than in Japan.

(3) Future VCM price

As is stated in Chapter 2, section 2–4–1, the quantity of PVC demand used in this study is based on the assumption that the 1979 PVC price (estimated to be 22 Baht/kg) remains in use in the future, as the real price (excluding the factor of inflation).

To convert the 1979 real price to the 1980 price, it should be multiplied by rate of increase of the GDP deflator over its level in the preceding year. The Thai GDP deflator, as shown in Table II-64 and Fig. II-27, is catching up with the consumer price index. If we assume the rate of increase of the consumer price index in 1980 is 20%[1] the 1980 PVC price would be 26.4 Baht/kg.

As indicated by the figure given in the preceding section, even if the VCM price in Thailand is US$800, there would be no difficulty in producing 26.4 Baht/kg PVC.

1) Bangkok Post, October 21, 1980.

Table II–64 TREND OF PRICE INDEX IN THAILAND

(1972 = 100)

	Price Index (All Items) [1]		GDP
	Whole Sales	Consumer	Deflator[2]
1970	92.4	94.3	90.7
1971	–	–	92.1
1972	100.0	100.0	100.0
1973	122.8	111.7	120.2
1974	158.3	137.7	142.9
1975	164.1	143.4	146.8
1976	170.7	150.4	151.7
1977	179.8	163.1	164.6
1978	188.3	177.4	178.9
1979	212.6	195.6	198.2

Sources: 1) Calculated from U.N. Statistical Yearbook.
2) Table II–18.

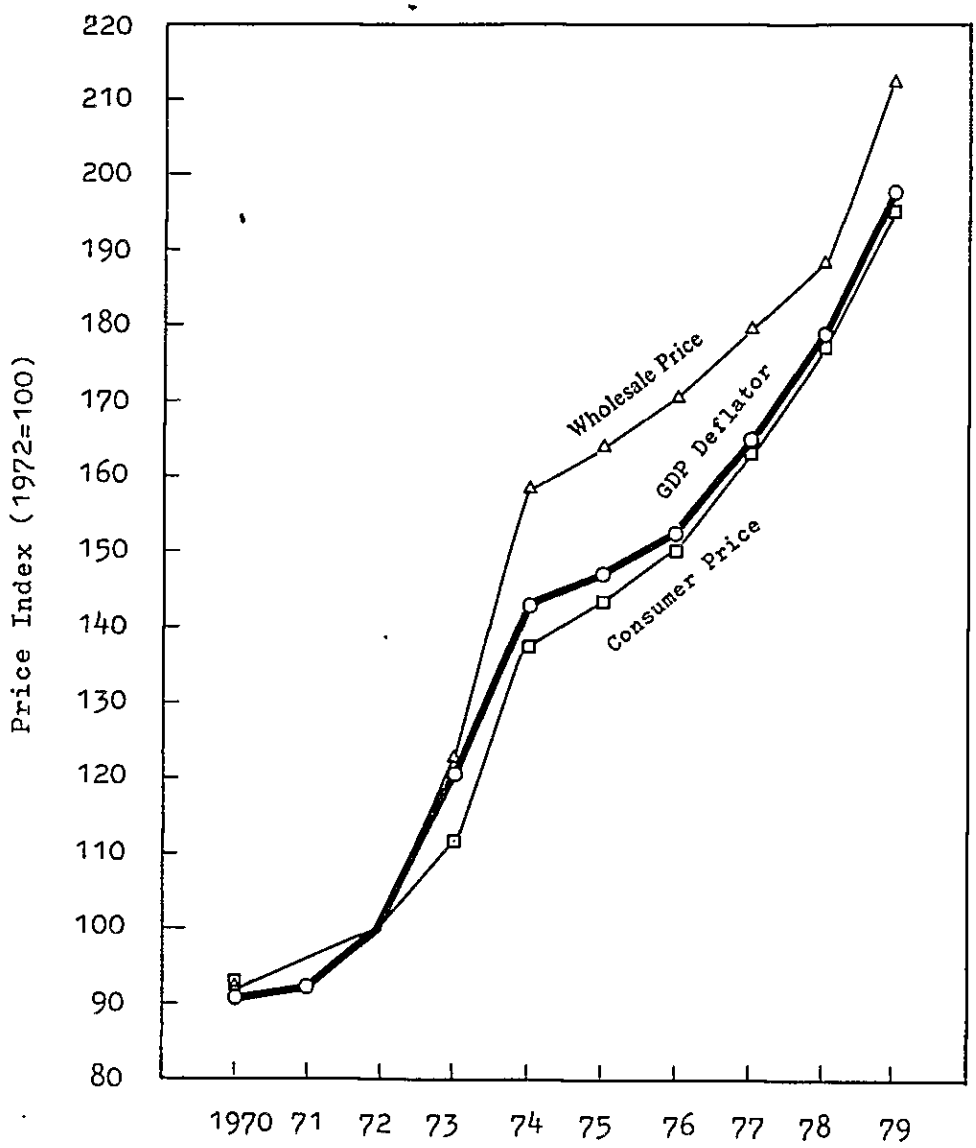


Fig. II–27 TREND OF PRICE INDEX IN THAILAND

4–2 ETHYLENE

4–2–1 Demand

Whereas ethylene demand for plastics materials (LDPE, HDPE, VCM) is taken up in section 2–4–5, here consideration is given to total demand including that for ethylene glycol.

As noted in section 3–5–2, Thailand's demand for ethylene glycol will gradually increase, at the annual average of 6.2%, from the 1980 level of about 28,000 t/y, and in terms of ethylene this means 21,000 t/y in 1980, and 70,000 t/y in 2000. Therefore the total potential demand for ethylene is estimated as follows.

	(1,000 t/y)
1985	165
1990	238
1995	329
2000	452

However, actual demand for ethylene will be some what lower than these levels because they necessarily reflect the construction and opertation of downstream industrial plants, and therefore demand is expected to be as follows.

	(1,000 t/y)
1985	134
1990	189
1995	307
2000	428

The potential and effective demand for ethylene, by year, is shown in Table II-65 and Fig. II-28.

Table II–65 TOTAL ETHYLENE DEMAND

(Unit: 1,000 t/y)

	Potential Demand for			Effective Demand[1] for		
	Plastics	EO	Total	Plastics	EO[2]	Total
1985	137.3	27.9	165.2	134.2	–	134.2
1986	147.5	30.0	177.5	142.7	–	142.7
1987	158.7	32.4	191.1	149.7	–	149.7
1988	170.6	34.8	205.4	170.6	–	170.6
1989	183.4	37.5	220.9	182.6	–	182.6
1990	197.2	40.4	237.6	189.4	–	189.4
1991	210.8	42.9	253.7	199.3	–	199.3
1992	225.2	45.6	270.8	206.6	–	206.6
1993	240.6	48.5	289.1	214.3	–	214.3
1994	256.9	51.6	308.5	240.7	51.6	292.3
1995	274.4	54.8	329.2	252.2	54.8	307.0
1996	293.2	57.6	350.8	287.2	57.0	344.2
1997	313.1	60.6	373.7	292.1	57.0	349.1
1998	334.6	63.7	398.3	334.6	57.0	391.6
1999	357.2	67.0	424.2	352.4	57.0	409.4
2000	381.6	70.5	452.1	370.6	57.0	427.6

Notes: 1) Supply to downstream plants.

2) EO plant of 60,000 t/y capacity is assumed to be started operation in 1994.

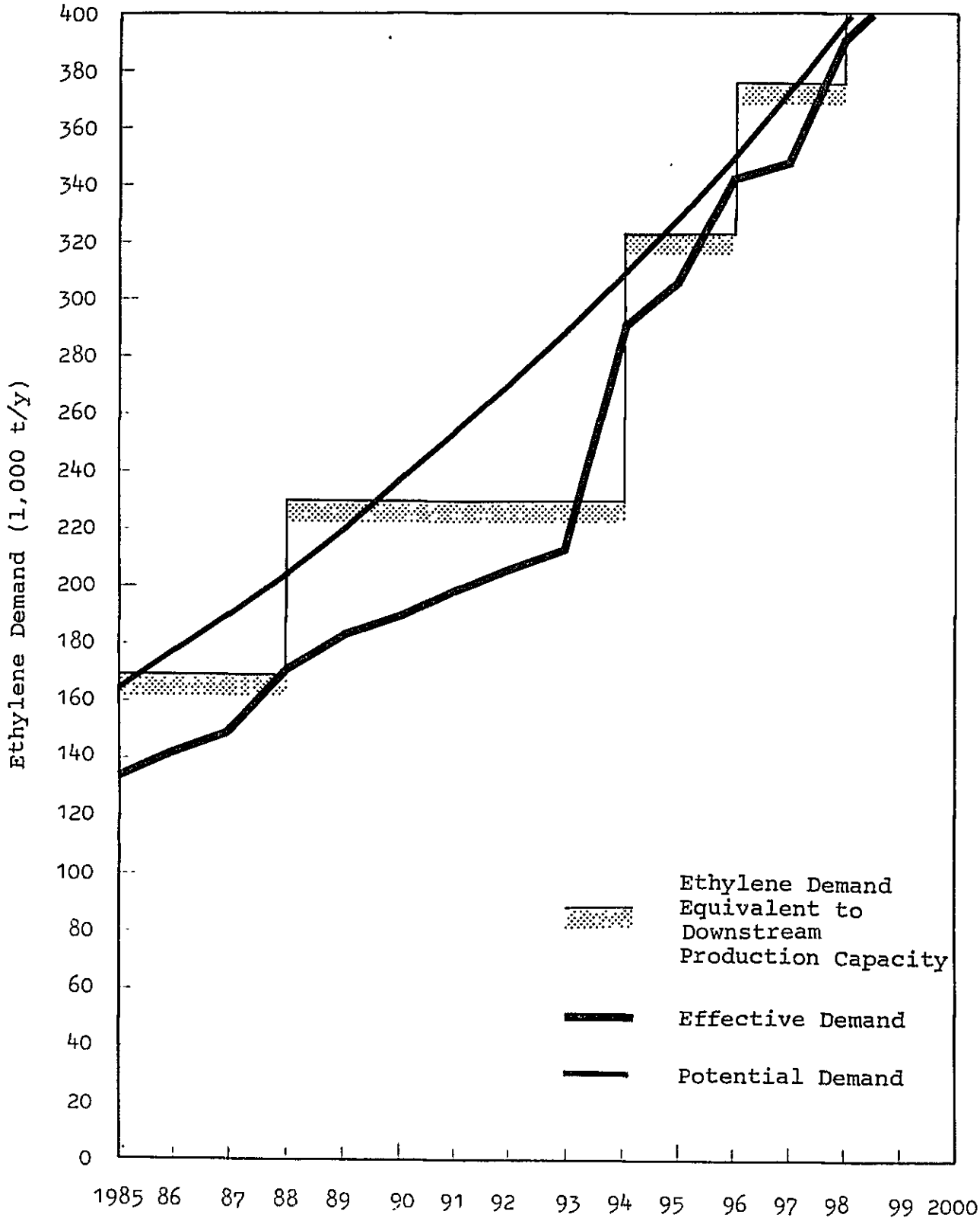


Fig. II–28 FORECAST FOR TOTAL ETHYLENE DEMAND IN THAILAND

4–2–2 Price

(1) Relation between ethylene price and polyethylene price

The polyethylene price in Japan, America, and industrialized nations of the EC has risen rapidly, together with the ethylene price, and in each country has tripled from 1972 to 1980, during which time the ethylene price increased by 5.5 to 6 times. Price trends are shown by Table II-66 and Figs. II-29 and II-30. Ethylene prices here are market prices. In Japan, almost all ethylene production is by companies which use the ethylene themselves, and the price of their ethylene will differ from company to company.

The relationship between the ethylene price and polyethylene price is as follows; for all countries approximately the same polyethylene price (US$1,200 – 1,300/t) prevails when the ethylene price in Japan and Europe is US$800/t (1980) (see Fig. II-31).

LDPE:

Japan	y = 178.3 + 1.3187x
America	y = 294.7 + 1.0948x
EC	y = 218.3 + 1.3002x

HDPE:

Japan	y = 255.2 + 1.1711x
America	y = 304.5 + 1.0917x
EC	y = 229.4 + 1.1993x

Here, x indicates the ethylene price (US$/t) and y indicates the polyethylene price (US$/t). When x = US$800/t,

			(US$/t)
	Japan	America	EC
LDPE	1,230	1,170	1,260
HDPE	1,190	1,180	1,120

Note: The same as in the case of VCM, when the time factor is introduced with regard to the ethylene price, the linear regression equation for polyethylene price, for Japna, is as follows:

LDPE	y = 56.4 + 2.34t + 1.18x	
HDPE	y = 94.4 + 1.78t + 0.85x	(Fig. II-29)

where, x is the ethylene price (Yen/kg) and y is the polyethylene price (Yen/kg). According to this equation, with the 1980 ethylene price US$800/t (172Yen/kg), the price of LDPE is 282Yen/kg (US$1,310/t) and this price of HDPE is 258Yen/kg (US$1,200/t), which are almost the same results as in the main text.

Table II—66 TREND OF PRICES OF ETHYLENE AND POLYETHYLENE IN INDUSTRIALIZED COUNTRIES

	Japan (¥/kg)			U.S.A. (US$/t)			E C (US$/t)		
	Ethylene	LDPE	HDPE	Ethylene	LDPE	HDPE	Ethylene	LDPE	HDPE
1971	30	100	128	—	—	—	—	—	—
1972	30	92	119	88	286	297	—	—	—
1973	33	101	126	77	347	369	—	—	—
1974	73	146	157	—	—	—	—	—	—
1975	87	166	170	232	518	551	287	515	581
1976	98	192	198	261	650	623	322	630	656
1977	97	194	202	276	672	670	332	665	620
1978	82	173	180	285	694	700	362	766	658
1979	120	213	203	354	700	700	582	982	895
1980	190[1)]	268[1)]	260[1)]	489	811	831	800[1)]	1,178[1)]	1,231[1)]

Note: 1) February.

Sources: Yearbook of Chemical Industries Statistics of Japan; ECN.

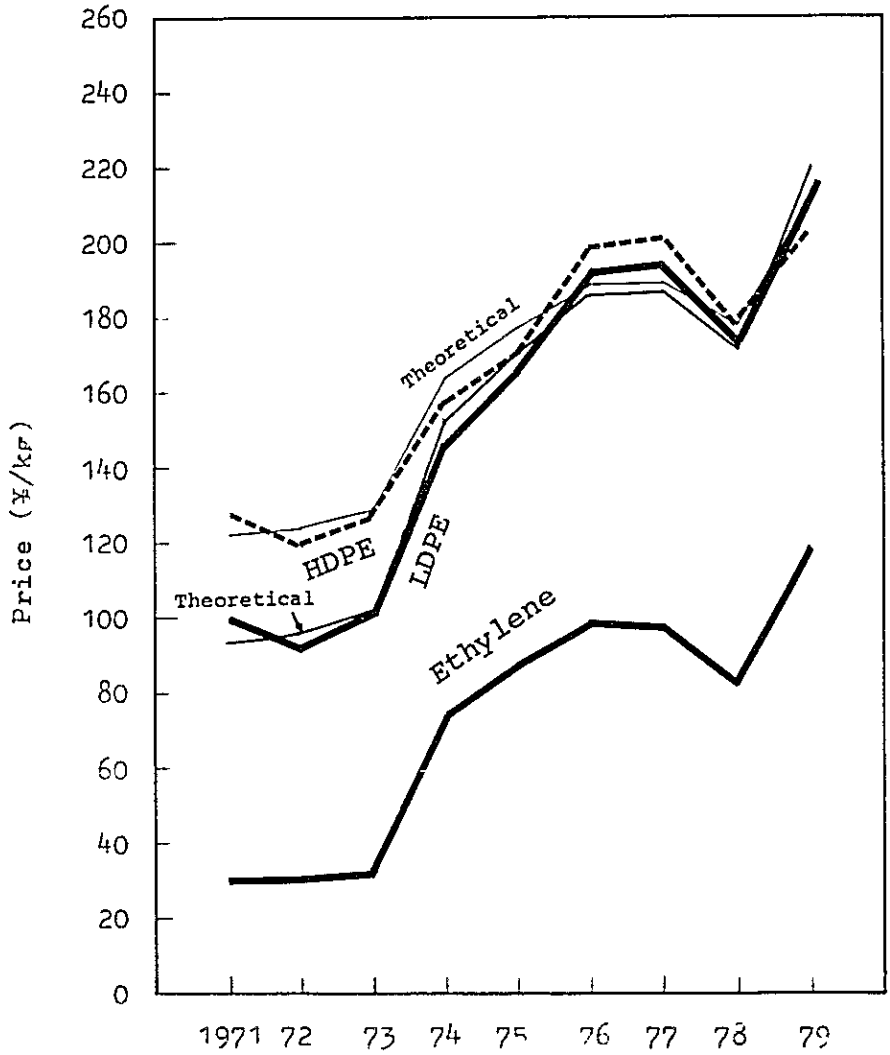


Fig. II–29 TREND OF PRICES OF ETHYLENE AND POLYETHYLENE IN JAPAN

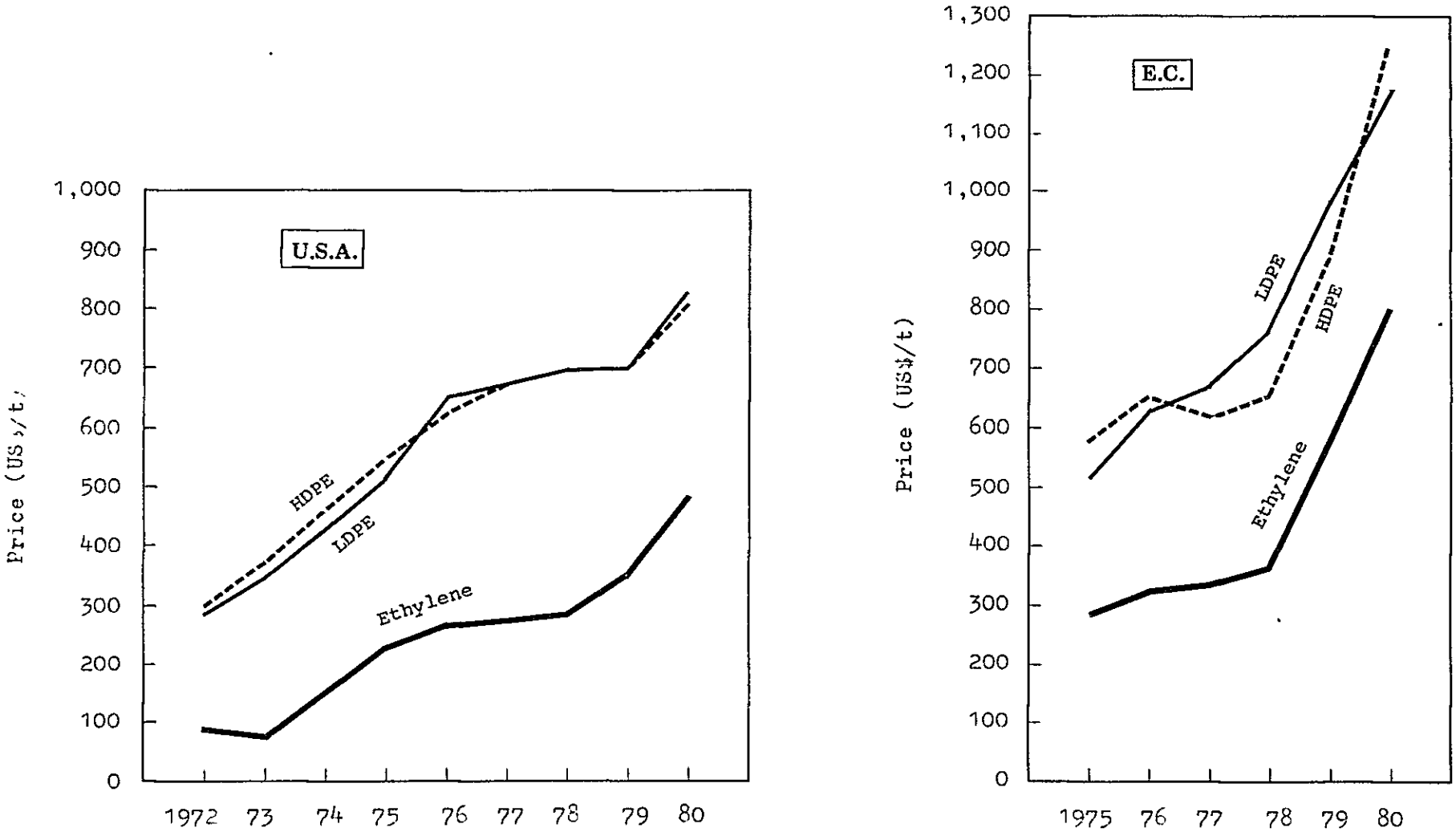


Fig. II—30 TREND OF PRICES OF ETHYLENE AND POLYETHYLENE IN THE U.S.A. AND EC COUNTRIES

Summing up the above, it is suitable to view the polyethylene price in industrialized nation as US$1,200 ∿ 1,300/t when the ethylene price is US$800/t; this corresponds to 25 ∿ 27 Baht/kg.

Because production of HDPE and LDPE in Thailand is to be done in grassroots plants, it is expected that the high cost of plant construction and high utilities costs will cause the production cost to be higher than that prevailing in industrialized countries. Even taking this into consideration, in 1980 prices the HDPE and LDPE prices in Thailand being 30 Baht/kg, even if the ethylene price is set at US$800 it is judged that it will not present a problem regarding polyehtylene production in Thailand.

(2) Relationship between ethylene price and VCM price

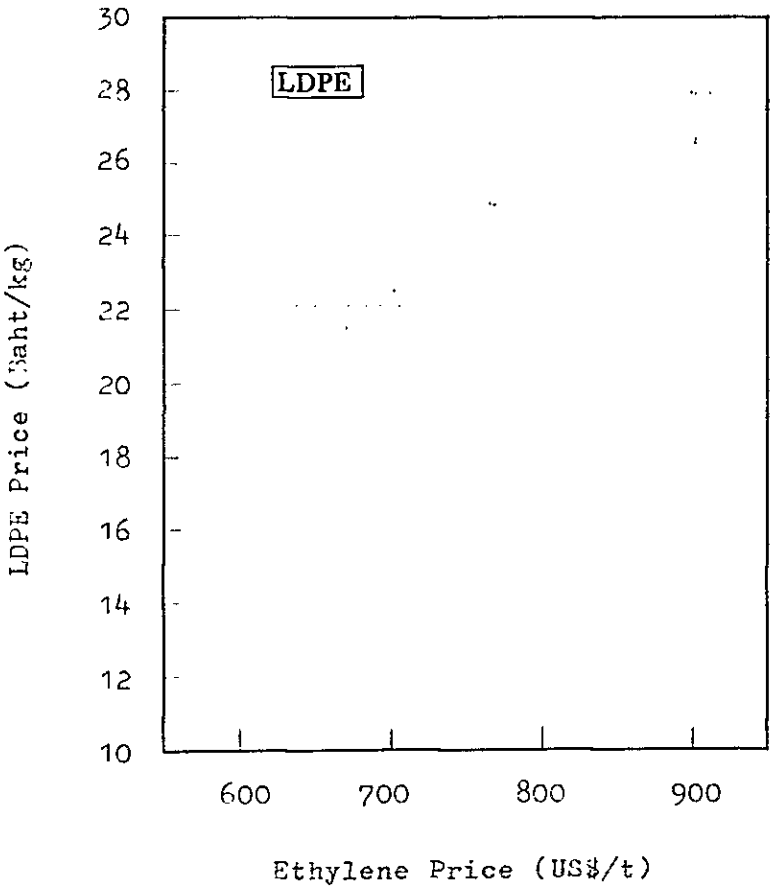
Regarding the relation between the ethylene price and VCM price, attention is invited to the part where economic analysis of the VCM plant is given. This sub-section on price relationship accordingly is limited to a semi-subjective investigation.

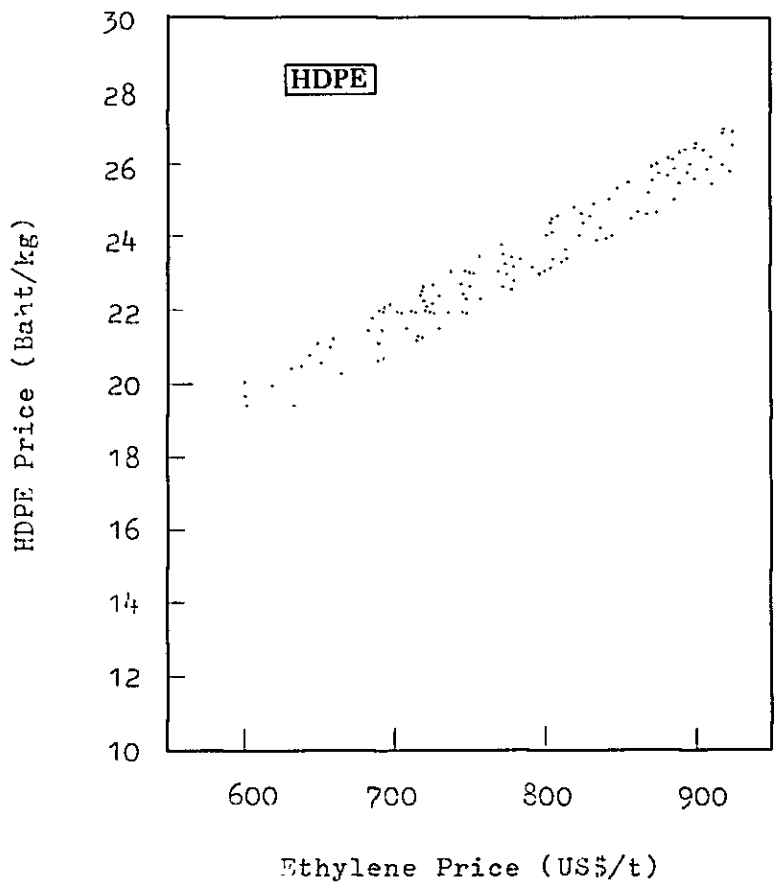
Recently in Japan imports of EDC have increased greatly. Importation of EDC by Japan has been done as a means of correcting the unbalance in supply and demand for caustic soda and chlorine. However due to the recent increases in chlorine price caused by higher energy costs, and a supply shortage of chlorine becuase of the smaller demand for caustic soda as compared to chlorine demand combined with an increase of the ethylene price, has made the importation of EDC a structural necessity. In 1979 Japan's EDC imports reached the level of 370,000t equal to about one-third of production.

In Taiwan as well, Formosa Plastics has undertaken production of EDC and VCM in America because of insufficient supply of VCM in Taiwan and is importing part of that production. Thus there has emerged a recent trent for EDC and VCM production to shift to countries which produce natural gas, because of the desire to use less expensive ethylene and chlorine. Not only does America provide those conditions but also, the general investment environment there is good, so it is expected that in the future there will be an increase in investment there in EDC and VCM production.

That the American ethylene price is considerably lower than that in countries which use naphtha as feedstock, such as Japan and European countries, has already been mentioned (see Table II-66 and Fig. II-30). This is because naphtha (feedstock for ethylene) and natural gas are evaluated lower than in other industrial countries.

However, it is expected that the lifting of price controls on domestic crude oil in America will result in the price of that crude oil approaching the OPEC price in October 1981 or about that time. Controls on the domestic natural gas price have already been lifted and the





. Fig. II—31 ESTIMATION OF POLYETHYLENE PRICE

price is increasing by 3 ∿ 5% a year higher than the inflation rate, and controls will be completely removed in 1985 for gas produced from below 5,000 feet and in 1987 for gas from above 5,000 feet, so that prices will be determined in more of a free-market type of situation.

Feedstock for ethylene in America, as of 1980, is 70% natural gas and 30% naphtha and gas oil, and is expected to change to 55% of natural gas and 45% naphtha and gas oil in 1985. Therefore regarding the American ethylene price, the medium-term outlook for ethylene derivatives is as shown in Figs. II-32 and II-33 expectively, and the long-term outlook for ethylene price is shown in Fig. II-34. It is expected that starting in 1981 the price will gradually rise. As Fig. II-33 illustrates, the American ethylene price is expected to rise from US$500/t in 1980 to US$1,100/t in 1985. If the average rate of increase of prices in America for these five years is 10%, that US$1,100 figure is US$700 in terms of the 1980 price. That is, becuase even in 1985 America will be able to use relatively inexpensive natural gas as feedstock, it will be able to produce ethylene at somewhat lower cost than Japan and Europe. After 1985, however, it is thought that the price differential between America and Japan and Europe will be narrowed owing to a greater use of naphtha.

As is stated in the preceding section, the reason for the relatively high US$800/t price for ethylene used for polyethylene production is that there is a 40% customs duty assessed on polyethylene.

In comparison with this, in the case of VCM the import tariff is 10%, because it is necessary to set the ethylene price lower than for polyethylene in order to for it to be competitive with imports.

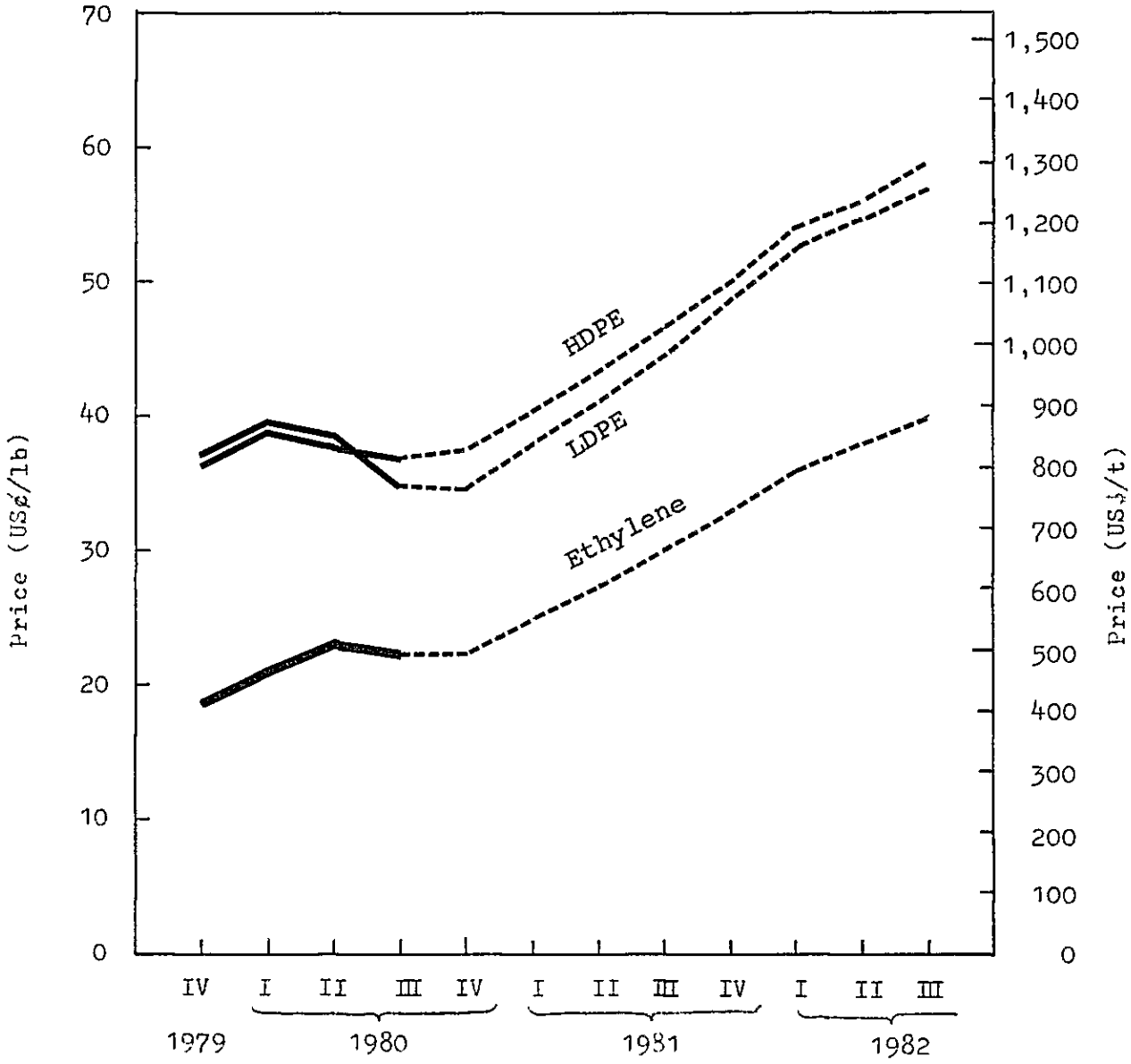


Fig. II–32 AMERICAN TREND AND FORECAST OF ETHYLENE AND POLYETHYLENE PRICES

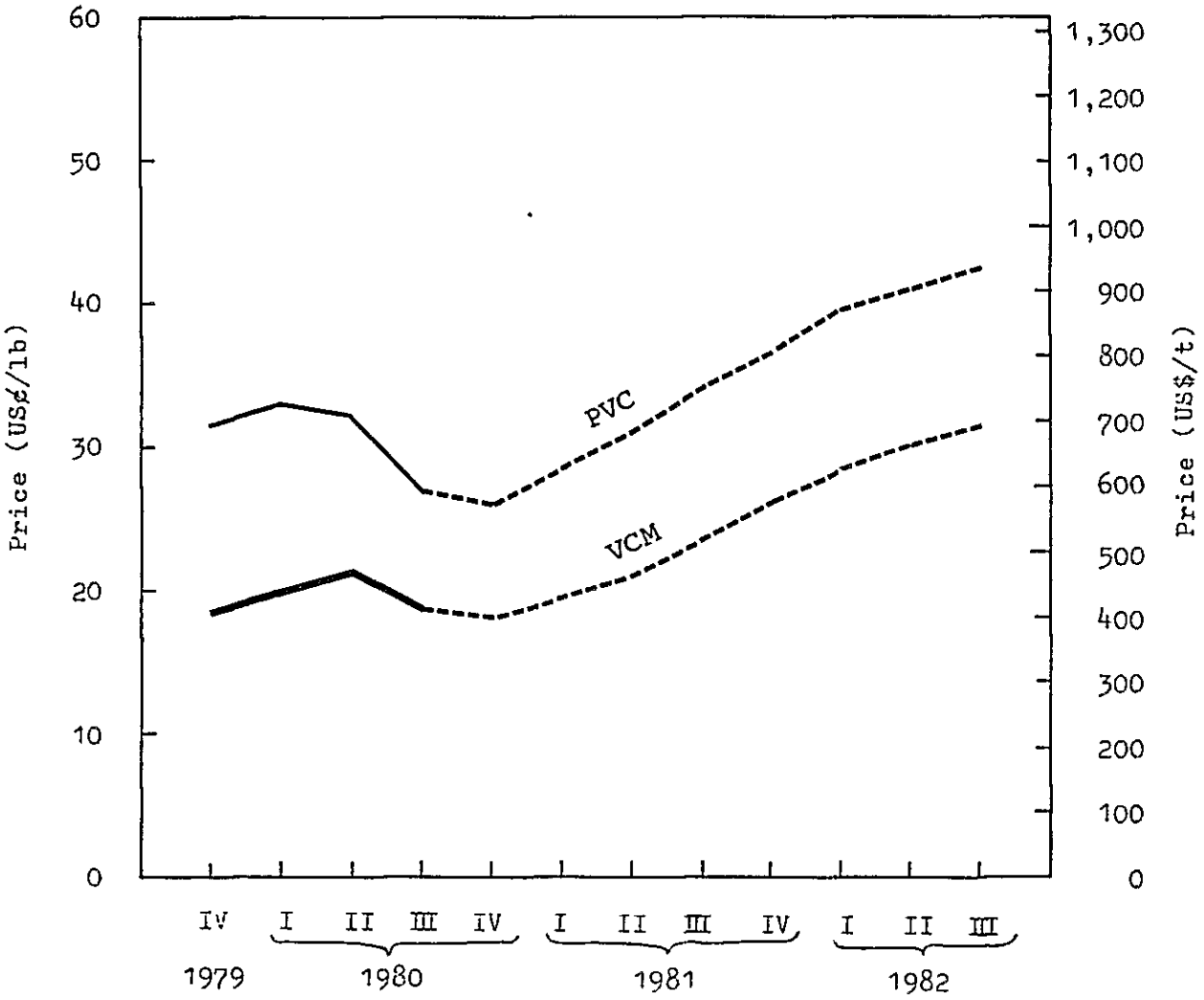


Fig. II–33 AMERICAN TREND AND FORECAST OF VCM AND PVC PRICES

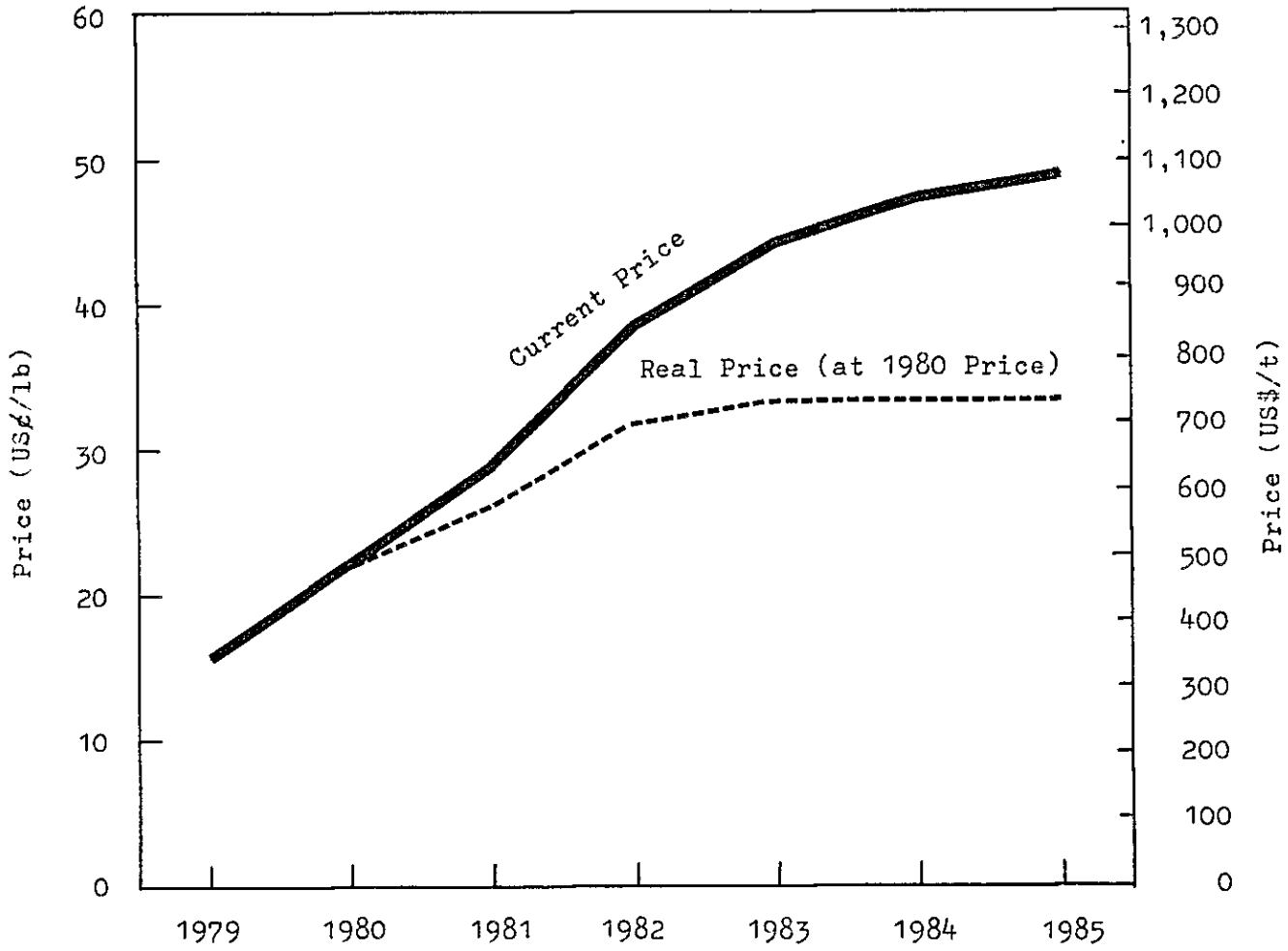


Fig. II—34 ESTIMATION OF FUTURE ETHYLENE PRICE IN THE U.S.A.

CHAPTER 5 CAUSTIC SODA

5–1 PRESENT STATUS OF THE CAUSTIC SODA INDUSTRY IN THAILAND

5–1–1 Supply

At present six companies (operating seven plants) are producing caustic soda in Thailand (see Table II-67). Of them, five companies produce to meet their own consumption requirements (of which three firms market their surplus production), and only one company, Thai Asahi Caustic Soda (THASCO) sells its entire output. The total production capacity of the six companies is 74,400 LMT/y and because THASCO has been authorized to increase capacity 40,000 LMT/y it is now in the process of expanding capacity to 60,000 LMT/y, to be accomplished by the end of 1981. Moreover, Ajinomoto is planning to expand the capacity of its electrolysis plant which produces for the company's own use.

The production trend has been as shown in Table II-68; since 1970 annual production has increased at the average rate of 9% a year. Government statistics for 1979 production are not available, but accordng to THASCO it is about 70,000 LMT.

Because industries which are large users of chlorine, such as EDC, VCM and pulp industries, are not highly developed in Thailand, chlorine demand is low relative to caustic soda demand. Production of caustic soda has been at levels lower than demand, becuase of constraints imposed by the level of chlorine demand.

Table II-69 shows the import trend of caustic soda after 1970. Major sources are Japan, Taiwan, West Germany, Poland, Romania and England.

5–1–2 Demand

The composition of demand for caustic soda, by type of use, is shown in Table II-70. The textile and sodium glutamate industries are the most important and together account for 55% of total demand. In Japan, these two areas of demand account for only 8% and 3% respectively of total demand (see Table II-71). Demand for caustic soda in Thailand has not developed because of its high price and insufficient supply. It is thought that if production is increased and the price is lowered in the future, that there will be a diversification of the areas of demand. In particular, it is expected that chemical industry demand, which accounts for 54% of demand in Japan, will expand greatly.

Table II–67 PRODUCTION CAPACITY OF CAUSTIC SODA IN THAILAND

Name of Company	Production Capacity (LMT/y)	Note
Thai Asahi Caustic Soda	40,800	Sale
Ajinomoto	15,600	Own use
Thai Fermentation	8,400	Own use and sale
Thai Chemical	4,800	Own use and sale
Dhyon Chemical	3,600	Own use and sale
Bang Pa Paper	1,200	Own use
Total	74,400	

Source: THASCO.

Table II–68 PRODUCTION TREND OF CAUSTIC SODA IN THAILAND

(Unit: LMT/y)

1970	32,745
1971	38,634
1972	38,936
1973	46,969
1974	53,427
1975	56,246
1976	59,712
1977	65,282
1978	62,097
Compounded Growth Rate (%/y)	9.0

Source: Industrial Statistics 1978, Ministry of Industry, Thailand.

Table II–69 CAUSTIC SODA IMPORTS IN THAILAND

(Unit: 1,000 t/y)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Japan	1,063	1,417	1,402	1,281	406	848	1,102	2 (2)	341 (2,063)	9,461 (5,859)
Taiwan	1	221	5	30	600	130	1,845	4,147 (3,591)	719 2,810)	100 (8,223)
W. Germany	236	914	217	317	1,995	175	177	503 (0)	214 (1)	1,442 (86)
Italy	251	–	5	250	1,050	340	1,414	2,707 (287)	302 (0)	100 (284)
Netherlands	585	209	–	–	1,315	200	200	0 (0)	160 (240)	0 (0)
Poland	–	–	–	–	200	299	299	398 (0)	960 (100)	3,470 (250)
Romania	–	–	–	–	–	–	950	5,048 (1,397)	2,959 (399)	1,634 (400)
UK	549	556	26	60	69	23	1,399	1,703 (796)	1,952 521)	2,052 (872)
U.S.A.	–	80	70	1,062	1,739	109	1	0 (0)	0 (0)	192 (1)
Others	1,824[1)]	181	2	27	172	166	901[2)]	71 (1)	8 (1)	779[3)] (0)
Total	4,509	3,578	1,727	3,027	7,546	2,290	8,288	14,579 (6,074)	7,615 (6,135)	19,230 (15,975)

Notes: 1) Malaysia 1,331 t/y, France 360 t/y.
2) Spain 600 t/y, France 302 t/y.
3) Norway 700 t/y.
4) Upper column-solid, lower column-aqueous solution.

Source: Foreign Trade Statistics of Thailand.

Table II—70 DEMAND PATTERN OF CAUSTIC SODA BY APPLICATION IN THAILAND (1979)

Application	Demand		Major Consumer
	(1000LMT/Y)	(%)	
Textile	29.4	27.7	Thai Rayon and others
Mono-Sodium Glutamate	28.8	27.2	Ajinomoto
Detergent	16.8	15.8	Lever Brothers, Colgate, Lion, Kao
Pulp and Paper	6.0	5.7	Bang Pa In
Food Industry	4.8	4.5	
Petroleum	3.6	3.4	
Alumina	3.0	2.8	
Others	13.6	12.8	
Total	106.0	100.0	

Source: THASCO.

Table II–71 APPLICATION FIELD OF CAUSTIC SODA IN JAPAN (1979)

		Demand (1,000 LMT/y)	Ratio (%)
Chemical Fiber		245	7.9
Pulp and Paper		360	11.7
Cellophane		45	1.5
Alumina		194	6.3
Dyeing		63	2.0
Chemical Industry	Detergent	65	2.1
	Dye and Intermediate	86	2.8
	Tar	6	0.2
	Inorganic Chemicals	434	14.1
	Electrolysis	79	2.6
	Organic Chemicals	43	1.4
	Sodium Hypochlorite	151	4.9
	Petrochemicals	87	2.8
	Others	702	22.8
	Sub-total	1,653	53.7
Mono-sodium Glutamate		87	2.8
Oil Refining		35	1.1
Other Usage		397	12.9
Domestic Demand Total		3,078	100.0
Exports		134	–
Grand Total		3,213	–

Source: UNICO International Corp.