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産業聯關分析에 依한 石油化學工業의 企劃 : 第 I 報

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Planning of the Korean Petrochemical Industry by Input-output Analysis : part I

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要 約

産業聯關分析에 依하여 韓國의 石油化學工業의 中長期展望을 하였다. 韓國銀行에서 作成한 1970年 産業聯關表(56部門)를 土臺로 하여 非石油化學部門을 再調整하고, 새로이 64個 部門의 主要石油化學品을 添加하여 總90部門의 均衡表를 1970, 1974, 1978, 1982 年에 對하여 各各 作成하고, 電子計算機를 利用하여 4個의 90×90行列을 處理하였다. 여기서 石油化學工業이 他産業部門에 對하여 주고 받는 影響을 나타내기 爲하여 影響力係數, 感應度係數, 誘發係數 等을 數學的으로 定義하였을 뿐만 아니라, 1974, 1978, 1982 年의 各産業分野의 總産出額을 1970 年 不變價格 또는 物量(*MT*)으로 提示하였다.

Abstract

The input-output analysis method was applied for forecasting the total Korean petrochemical outputs for the years of 1974, 1978, and 1982. The methods of measuring the extent of impact of the growth of petrochemical industry on other industrial sectors, and vice versa, were developed mathematically by defining the influence coefficient, sensitivity coefficient, and induced production. A simple method of forecasting the input coefficients and the elements of the final demand vectors, in absence of a sufficient amount of data, was also suggested. The computer analysis was carried out on a 90×90 technology matrix which was derived from a reorganized input-output table in which the original organic chemicals sector in the 1970 56-sectorial interindustry transactions table of the Bank of Korea was subdivided into 64 new major petrochemical products.

Introduction

Since Korea has inaugurated the Ulsan Petrochemical Complex in 1972, the country faces the problem of determining the optimal growth rate of the petrochemical industry under the premise of establishing a stable economic equilibrium with the rest of the industries. Several attempts[1] were made in forecasting the future demand for the petrochemical products by time series analysis, trend projection, etc.[2] The authors, however, do not believe that there existed any real demand patterns or trends in the Korean history for the petrochemical products. So far, any new products introduced into Korea were just immediately absorbed by the market. The thirst of the people for new petrochemical products was never slaked sufficiently, and the real situation here was the

Input Sectors / Output Sectors	Intermediate demand: 1 - 8 Sectors	Intermediate demand: 9 - 72 Petrochemical Sectors	Intermediate demand: 73 - 90 Sectors	Total intermediate demand	Final demand: Private consumption expenditure	Final demand: Gov't consumption expenditure	Final demand: Private fixed capital formation	Final demand: Gov't fixed capital formation	Final demand: Housing investment	Final demand: Increase in Stocks	Final demand: Exports	Total final demand	Subtraction: Imports	Subtraction: Custom duties	Subtraction: Total	Total output
1 - 8 Sectors																
9 - 72 Petrochemical Sectors																
73 - 90 Sectors																
Total intermediate input																
Value added: Compensation of employees																
Value added: Other value added																
Value added: Consumption of fixed capital																
Value added: Indirect taxes less Subsidies																
Value added: Total																
Total input																

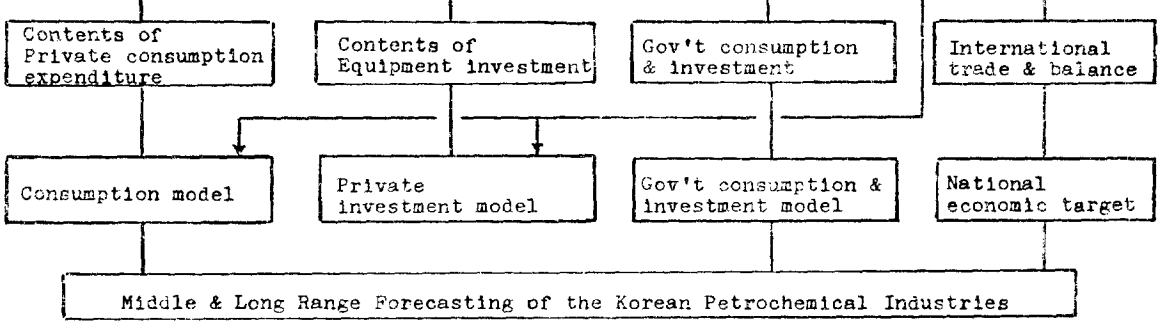

Fig. 1 System of the new Input-output Table.

Table 1. Breakdown of the regrouped sectors.

Nonpetrochemical Sectors in the New I/O Table and Their Abbreviations	Component Sector Nos. in 1970 IIT Table (See the BOK original)
1. Agriculture and Forestry Products (Agr For'y Pdts)	1, 2, 3, 4, 5
2. Fishery Products (Fishery Pdts)	6
3. Ores and Oil	8, 9
4. Agriculture & Fishery Product Processing (Agr Fish'y Pdts Proc)	10, 11, 12, 13, 14
5. Textile Fabrics & Yarn (Tex Fab & Yarn)	16, 17, 18
6. Lumber & Wood Products (Lmbr & Wd Pdts)	20, 21
7. Printing, Publishing, Paper & Paper Products (Prin Pub & Ppr)	22, 23
8. Basic Inorganic Chemicals (Inorg Chem)	24
73. Chemical Fertilizers (Chem Fertlzr)	26
74. Medicines & Cosmetics (Medcns & Cmtcs)	27
75. Other Chemical Products (Oth Chem Pdts)	28, Part of 25
76. Petroleum Products (Petr Pdts)	29
77. Coal & Coal Products (Coal & Coal Pdts)	7, 30
78. Rubber Products (Rubber Pdts)	31
79. Metals & Primary Metal Products (Mets & Pri Met Pdts)	33, 34, 35, 36
80. Nonmetallic Mineral Products (Nonmet Min Pdts)	32
81. Machineries & Instruments (Mach & Instr)	37, 38, 40
82. Transportation Equipments (Trans Equip)	39
83. Miscellaneous Manufacturing (Misc Mfg)	15, 19, 41
84. Construction & Building (Constr & Bldg)	42, 43
85. Electricity & Water (Elec & Water)	44, 45
86. Financing & Insurance (Fin & Insu)	46
87. Communications, Transportation & Warehousing (Comm Trans Warehsg)	48, 49
88. Wholesale & Retail	50
89. Real Estate & Services (RI Est & Service)	47, 51, 52, 53
90. Unclassifiable	54, 55, 56
Other Pertinent Abbreviations	
67. Film, Sheets, Leathers (Flm Sht Lthr)	
68. Building Materials & Household Appliances (Bldg Mat & Hshld Apl)	
69. Tablewares & Containers (Tblwre & Contnr)	
70. Household Goods (Hshld Gds)	
71. Electric & Machinery Parts (Elec & Mach Pts)	
72. Other Plastic Goods (Oth Plstc Gds)	

more the better.

It is for this reason that the input-output analysis method[3,4] was adopted in this work for forecasting the demand for the petrochemical products. It is necessary for this work to replace the 'organic chemicals' sector in the interindustry transactions table of the Bank of Korea[5] with a sufficient number of petrochemical products, deeming each as a sector. The new sectors must include all important petrochemicals, synthetic plastics and their processed goods, synthetic fibres and and rubbers.

Although it may become clearer later, the merits of this method lie, first, in handling simultaneously all factors affecting directly, or indirectly, the forecast of a sector; secondly, in dealing the problem in such a way that any specific forecast matches compatibly with the general economic trend; and thirdly, in calculating quantitatively the extent of impact effected

on each individual sector by a switching of the economic policy.

Although the Bank of Korea has their interindustry transactions table published for the years of 1960, 1963, 1966, 1968, and 1970, only the latest table will be used as the base for constructing a new analysis-suited input-output table. There are two classes in 1970 interindustey transactions table, one comprising 56 endogenous, and the other, 153 endogenous sectors. All the figures shown in these tables were estimated at the producer's price as well as the purchaser's price. The tables are further classified into competitive and noncompetitive imports types. The one adopted by us as the base table is the 56-sectorial competitive imports type, estimated at the producer's price.

The choice of this table is particularly important when one is to avoid any false monetary interaction among sectors introduced in the course of analysis by uneven trade and transportation margins included in the purchaser's price. In our analysis, a pure material interrelation among sectors is hoped to be maintained in order to lead our analysis as logically correct as possible.

Preparation of a New Input-output Table

The first step of this work is to reorganize the base table. The aforementioned 'organic chemicals' sector was substituted with 64 petrochemical products, and the remaining 55 sectors were regrouped into 26 new sectors in order to reduce the size of matrix. The newly constructed input-output table has 90 endogenous sectors as shown in *Table* 3, and the detailed information on the new 26 sectors, in contrast to the old 55 sectors of the base table, is given in *Table* 1. The completed new input-output table will look like *Fig.* 1.

The details of sector names and the actual values of input and output were omitted because of the small space available. The exogenous sectors, at the lower part of the left-most column, are the same as the original interindustry transactions table for 1970. This is the group of 'value added' consisting of four subdivided sectors. Another group, appearing at the right-most end of the top row, is the 'final demands'. This group consists of seven sectors which are again the same as the interindustry transactions table except that here this group includes the 'housing investment' in addition. Actually the housing investment was separated both from the 'private fixed capital formation' and from the 'government fixed capital formation' in order to investigate specifically the interrelation between the housing investment and the petrochemical products.

Once there is a new table constructed, it is only a routine work to produce the so called technology matrix[4]. Each element of matrix is called the input coefficient, and this can easily be prepared by simply dividing the inputs of a sector (read vertically down from a top heading to the last endogenous sector line) with the total output of the same sector. One of these coefficients will be expressed by a_{ij}, and the matrix, in which a_{ij} is the element corresponding to the i-th row and j-th column, will be denoted by $\boldsymbol{A}$.

The arithmetics can be extended down to the 'value added'. However, the coefficient of this type is not importnt in this work.

The matrix $\boldsymbol{A}$, which is extrmely important in this work, is defined purely on the technological information such as the nature of process and the unit consumptions. Therefore, if technology changes, then a_{ij} will also change. Technological innovations or the replacement of raw materials and the energy source, for instance, will drastically change the a_{ij} values. However, it is necessary for a_{ij} to remain fairly stable to warrant the validity of the present method. For fine chemicals, where inventions and innovations are incessant, a_{ij} are prone to changes, while for basic chemicals the changes are relatively slow.

On the other hand, if one goes from left to right after any heading in the table, one will find the portions of product corresponding to the heading sold to the intermediate buyers and the final users. The figure to be written on each of the crossings (i-th row and j-th column) is actually obtained from the marketing information. In 1970, only 29 items of petrochemical products were produced domestically. But as the years are passed, more and more petrochemicals, which normally depended on the imports,

are to be replaced by the domestically produced goods. It is hoped that all 64 items mentioned above, or more, will be produced domestically in the 1980s.

Theory of Input-Output Analysis

1. General Solution

If the portion, value added and the part down below, is disregarded, the implication of the table in *Fig.* 1 can be written as follows in a matrix equation:

$$\begin{pmatrix} a_{11}\cdots a_{1j}\cdots a_{1n} \\ \vdots \quad \vdots \quad \vdots \\ a_{i1}\cdots a_{ij}\cdots a_{in} \\ \vdots \quad \vdots \quad \vdots \\ a_{n1}\cdots a_{nj}\cdots a_{nn} \end{pmatrix} \begin{pmatrix} x_1 \\ \vdots \\ x_i \\ \vdots \\ x_n \end{pmatrix} + \begin{pmatrix} y_1 \\ \vdots \\ y_i \\ \vdots \\ y_n \end{pmatrix} - \begin{pmatrix} m_1 \\ \vdots \\ m_i \\ \vdots \\ m_n \end{pmatrix} = \begin{pmatrix} x_1 \\ \vdots \\ x_i \\ \vdots \\ x_n \end{pmatrix} \quad (1)$$

where $a_{ij}(i=1, n;\ j=1, n)$ is as defined previously, x_1 is the element corresponding to sector i of the output vector X, y_i is the element corresponding to sector i of the final demand vector Y, and m_i is the element corresponding to sector i of the imports+customs vector M.

Simplification of Eq. (1) yields:

$$\boldsymbol{AX}+\boldsymbol{Y}-\boldsymbol{M}=\boldsymbol{X} \quad (2)$$

Solving for $\boldsymbol{X}$, one will obtain:

$$(\boldsymbol{I}-\boldsymbol{A})^{-1}(\boldsymbol{Y}-\boldsymbol{M})=\boldsymbol{X} \quad (3)$$

where, in the above equation, $\boldsymbol{I}$ means the unit matrix, $(\boldsymbol{I}-\boldsymbol{A})$ is called the Leontief matrix, and $(\boldsymbol{I}-\boldsymbol{A})^{-1}$ is the inverse matrix denoted by $\boldsymbol{R}$. The element of inverse matrix r_{ij} is called the inverse matrix coefficient. Accordingly, to solve Eq. (1) means to compute the inverse matrix.

2. Significance of the Inverse Matrix Coefficient

The inverse matrix coefficients have the following significances:

$r_{ij}(i\neq j)$, the amount of commodity i that must be produced (indirectly) to sustain a final demand of 1.0 in sector j.

$r_{ij}(i=j)$, the amount of commodity i that must be produced (directly and indirectly) to sustain a final demand of 1.0 in sector i.

(1) Sensitivity coefficient

Multiplication of inverse matrix $\boldsymbol{R}$ by the sum of the unit vectors of the order of n yields:

$$\begin{pmatrix} r_{11}\cdots r_{1j}\cdots r_{1n} \\ \vdots \quad \vdots \quad \vdots \\ r_{i1}\cdots r_{ij}\cdots r_{in} \\ \vdots \quad \vdots \quad \vdots \\ r_{m1}\cdots r_{nj}\cdots r_{nn} \end{pmatrix} \begin{pmatrix} 1 \\ \vdots \\ 1 \\ \vdots \\ 1 \end{pmatrix} = \left[\sum_{j=1}^{n} r_{1j}, \cdots \sum_{j=1}^{n} r_{ij}, \cdots \sum_{j=1}^{n} r_{nj}\right]^T \quad (4)$$

The element of the resulting vector, say $\sum_{j=1}^{n} r_{ij}$ is the amount of commodity i that must be produced to sustain a final demand of 1.0 in all sectors. The quantity defined by

$$S_i=\sum_{j=1}^{n} r_{ij}-r_{ii},\quad i=1, n \quad (5)$$

is now called the sensitivity coefficient, meaning the amount of commodity i that must be produced to sustain a final demand of 1.0 in all sectors excluding i. S_i is a measure of sensitiveness of commodity i to the increases in production in all industries.

(2) Influence Coefficient

Multiplication of the transpose of $\boldsymbol{R}$ by the sum of unit vectors of the order of n yields:

$$\left[\sum_{i=1}^{n} r_{i1}, \cdots, \sum_{i=1}^{n} r_{ij}, \cdots, \sum_{i=1}^{n} r_{in}\right]^T \quad (6)$$

and the quantity defined by

$$I_j=\sum_{i=1}^{n} r_{ij}-r_{jj},\quad j=1, n \quad (7)$$

is, in this time, called the influence coefficient. I_j means the amount of commodities that must be produced by all the industries excluding sector j to sustain a final demand of 1.0 in sector j. In other words, I_j is the measure of sector j's influence on all industries when j's final demand is increased by a certain amount.

(3) Normalization

The mathematical procedure that converts a series of numerics into another series so that the arithmetic mean of the new series becomes unity is called normalization here. One way of achieving this operation for the sensitivity and influence coefficients is as follows:

$$S_{io}=\frac{nS_i}{\sum_{i=1}^{n} S_i},\quad i=1, n \quad (8)$$

$$I_{jo}=\frac{nI_j}{\sum_{j=1}^{n} I_j},\quad j=1, n \quad (9)$$

where S_{io} and I_{jo} are the normalized sensitivity coefficient and influence coefficient, respectively.

3. Induced Production and Induction Coefficient

The final demand vector, $\boldsymbol{Y}=(y_1, y_2, \cdots y_n)^T$, can be decomposed into seven component vectors, $\boldsymbol{Y}_1, \boldsymbol{Y}_2, \cdots, \boldsymbol{Y}_7$, as follows:

$$Y=\begin{pmatrix}y_1\\y_2\\\vdots\\y_n\end{pmatrix}=Y_1+Y_2+\cdots+Y_7=\begin{pmatrix}y_{11}\\y_{21}\\\vdots\\y_{n1}\end{pmatrix}+\begin{pmatrix}y_{12}\\y_{22}\\\vdots\\y_{n2}\end{pmatrix}+\cdots+\begin{pmatrix}y_{17}\\y_{27}\\\vdots\\y_{n7}\end{pmatrix}, \quad (10)$$

where Y_j $(j=1,7)$ is the j-th sectorial vector of the final demand vector Y, namely, either the 'private consumption expenditure', 'government consumption expenditure', 'private fixed capital formation', 'government fixed capital formation', 'housing investment', 'increase in stocks', or 'exports' vector; $y_{ij}(i=1,n;\ j=1,7)$ is the i-th element of the j-th component vector.

Now, consider that Y_1 is increased by its increment vector, ΔY_1, and the other Y_j's are kept unchanged. Then, the final vector Y' is expressed by:

$$Y'=Y+\Delta Y_1=\begin{pmatrix}y_1\\y_2\\\vdots\\y_n\end{pmatrix}+\begin{pmatrix}\Delta y_{11}\\\Delta y_{21}\\\vdots\\\Delta y_{n1}\end{pmatrix} \quad (11)$$

where Δy_{i1} is the i-th element of the increment vector ΔY_1. One constraint to be imposed on the increment vector is that the sum of all elements is a constant C, namely,

$$\sum_{i=1}^{n}\Delta y_{i1}=C,\quad i=1,n \quad (12)$$

One way of distributing the increment of a fixed sum, C, among the n elements of vector Y_1 is to allocate it in proportion to the initial magnitudes of the elements themselves, or,

$$\Delta y_{i1}=Cy_{i1}/\sum_{i=1}^{n}y_{i1},\quad i=1,n \quad (13)$$

Thus, the new solution of Eq. (3), after Y' is substituted for Y, will be as follows:

$$X=X'=\begin{pmatrix}x_1\\x_2\\\vdots\\x_n\end{pmatrix}+\begin{pmatrix}\Delta x_1\\\Delta x_2\\\vdots\\\Delta x_n\end{pmatrix} \quad (14)$$

A new quantity, called by induction coefficient and denoted by D_{i1}, is now defined as follows:

$$D_{i1}=\Delta x_i/C,\quad i=1,n \quad (15)$$

where Δx_i is the induced production in wons of sector i, and D_{i1} is the induction coefficient of sector i by final demand 1, or the private consumption expenditure.

In general, $D_{ij}(i=1,\ n;\ j=1,n)$ is the induction coefficient of sector i by a certain amount of increment in final demand j. Through this quantity, one can measure to what extent a certain policy change will affect the production level.

Estimation of the Input Data

1. Input Data for the Petrochemical Products

For the 29 domestically produced items in 1970, an intensive study on the manufacturing processes and unit consumptions, including raw materials, auxiliary chemicals and catalysts, byproducts, utilities, labor and overhead, depreciation, indirect taxes, interests and insurances, was made to fill in the blanks in the new input-output table. The information, as to where and how much of the products were sold, was found from the Bank of Korea Report on the 1970 Interindustry Transactions Table.

For estimating the 'value added' only the term, indirect taxes less subsidies, is left to be found because the major constituent information is already available from the unit consumptions.

Throughout the estimation, we used the producer's price with the commodity tax included. For the exports, the prices are given in FOB basis while for the imports, they are based on CIF plus customs. We should note that all prices used in this work are fixed at 1970 prices.

For the nonpetrochemical sectors, the input data were obtained by just summing the data in the original 1970 Interindustry Transactions Table in accordance with the way the sectors were regrouped.

When all the blanks of the new 1970 input-output table were filled in, the total inputs in the bottom were balanced to each corresponding total output in the right end of the table by adjusting the input data for the unbalanced sector and the 'other chemicals' sector.

2. Input Coefficients for 1970, 1974, 1978, and 1982

Once we have the new 1970 input-output table, we can easily prepare the complete table of input coefficients as explained previously. But in determining the input coefficients for future years, the work was performed in case by case.

(1) Petrochemical Products

Table 2. Expenditure on gross domestic product.

Unit: billion wons

	1970		1974		1978		1982	
	Amount	%	Amount	%	Amount	%	Amount	%
Consumption Expenditure								
(Private)	1,993.3	73.1	2,590.0	66.3	3,526.0	58.6	4,800.0	53.9
(Government)	286.7	10.5	375.0	9.6	458.0	7.6	570.0	6.4
Fixed Capital Formation								
(Private)	397.8	14.6	545.7	14.0	1,086.6	18.1	1,347.3	15.1
(Government)	168.9	6.2	215.3	5.5	488.4	8.1	733.7	8.2
(Housing Investment)	121.5	4.4	130.0	3.3	194.0	3.2	240.0	2.7
Increase in Stocks	73.9	2.7	74.6	1.9	−26.4	0.4	39.1	0.4
Exports	376.0	13.8	1,161.0	29.7	2,378.3	39.5	3,801.1	42.7
Imports (−)	689.8	25.3	1,185.9	30.4	2,084.2	34.6	2,619.0	29.4
Expenditure on Gross Domestic Product	2,728.3		3,905.7		6,020.7		8,912.2	

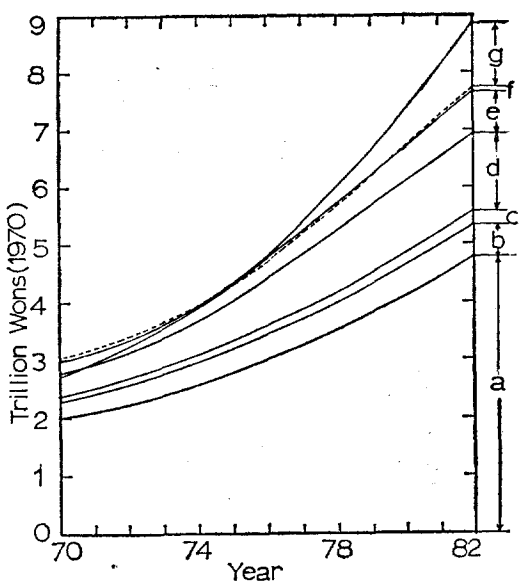

Fig 2. Expenditure on gross domestic product
a: Private consumption expenditure
b: Government consumption expenditure
c: Housing investment
d: Private fixed capital formation
e: Government fixed capital formation
f: Increase in stocks
g: (Export-Import) of goods and services

For the sectors whose input coefficients are not likely to change throughout the forecast years, the 1970 values were used without further revisions. For those sectors which did exist in the home produce list but have changed their production processes or the major raw materials, the new coefficients were estimated by doing everything all over again. For those sectors whose productions appeared anew (acrylonitrile(AN), low density polyethylene(LDPE), etc. in 1974, for example) in the list, the coefficients were estimated by following the regular routine. Since cyclohexane, ethylene oxide(EO), propylene oxide (PO), p-xylene, etc. were neither produced nor imported in 1970, there were no 1970 market prices for them in Korea. For these products, we looked up in the international market price lists[6,7].

(2) Nonpetrochemicals

Let r_{sec} and r_{GDP} be the assumed average annual growth rate of a sector and the gross domestic product (GDP), respectively. Then $(1+r_{sec})^y$ and $(1+r_{GDP})^y$, where y is the number of years away from the base year, are the multipliers that can be applied to the original production of a sector or the GDP to obtain the final production of a sector and GDP after y years from the base.

We will also assume that the value added will grow at the rate r_{GDP} per year, while an industrial

Table 3-a. Total sectorial output.

Unit : MT

	1970				1974				70-74 Growth % Rate, %
	Domestic Demand	Export	Import	Production	Domestic Demand	Export	Import	Production	
Starting Materials									
9 Naphtha	520,343.4		43.4	520,300.0	1,670,703.0	1,463.0		1,672,166.0	33.9
10 Ethylene					84,040.0	6,380.0		90,420.0	
11 Propylene					115,476.0		47,834.0	67,642.0	
12 Butadiene					24,479.0			24,479.0	
13 Benzene	4,670.4	1,932.8	1,459.2	5,144.0	42,233.0	9,873.0		52,106.0	78.4
14 Toluene	10,337.2	1,555.2	4,627.4	7,265.0	24,377.0	15,468.0		39,845.0	53.0
15 o-Xylene	2,711.0		2,711.0		13,013.0		13,013.0		
16 p-Xylene									
17 mixed Xylene	8,704.7		3,275.7	5,429.0	17,199.0	42,581.0		59,780.0	82.2
18 Cyclohexane					26,338.0	1,202.0		27,540.0	
Petrochemicals									
19 Phenol	1,336.0		1,336.0		3,456.0		3,456.0		
20 Dodecyl Benzene	3,221.0		3,221.0		9,949.0	3,611.0		13,560.0	
21 Ethanol	49,192.8		62.8	49,130.0	52,739.0		179.0	52,560.0	1.7
22 Methanol	36,836.3		25,945.3	10,891.1	61,499.0		9,079.0	52,420.0	48.1
23 Formalin	49,243.7		151.7	49,092.0	136,110.0			136,110.0	29.0
24 Acetone	2,915.0		2,915.0		6,571.0		6,571.0		
25 Acetaldehyde	431.0		431.0		858.0		858.0		
26 Acetic Acid	1,902.0		1,787.0	115.0	3,273.0		1,403.0	1,870.0	100.8
27 Ethylene Oxide									
28 Ethylene Glycol	2,566.0		2,566.0		51,168.0		51,168.0		
29 Ethylene Dichloride					106,546.0		106,546.0		
30 Propylene Oxide									
31 Propylene Glycol	1,280.0		1,280.0						
32 PPG	505.0		505.0		1,523.0		1,523.0		
33 Octanol	6,850.0		6,850.0		13,820.0		13,820.0		
34 Pentaerythritol	540.0		125.0	415.0	868.0		343.0	525.0	6.1
35 Maleic Anhydride	553.0		553.0						
36 Phthalic Anhydride	6,224.4		3,524.4	2,700.0	16,487.0		997.0	15,490.0	54.8
37 Ammonia	4,140.2		0.2	4,140.0	54,139.0	26,001.0		80,140.0	109.8
38 Melamine	979.0		979.0		985.0		135.0	850.0	
39 VCM	27,209.1		27,209.1		85,963.0		16,863.0	69,100.0	
40 Styrene	7,761.1		7,761.1		36,792 0		36,792.0		
41 MMA MA	3,798.0		3,798.0		7,752.0		7,752.0		
42 Vinyl Acetate	2,228.0		2,228.0		4,110.0		4,110.0		
43 Caprolactam	21,327.1		21,327.1		55,844.0		30,244.0	25,600.0	
44 Acrylonitrile	22,055.6		22,055.6		71,927.0		45,787.0	26,140.0	
45 DMT	9,790.4		9,790.4		113,879.0		113,879.0		
46 TPA									
Synthetic Resins									
47 LDPE	28,600.0		28,600.0		93,852.0		34,332.0	59,520.0	
48 HDPE	13,821.0		13,821.0		31,272.0		31,272.0		
49 PP	9,265.0		9,265.0		35,275.0		6,235.0	29,040.0	
50 PVC	30,463.5	8,119.7	764.2	37,819.0	70,811.0		1,061.0	69,750.0	16.5
51 PS	7,346.8		1,542.8	5,804.0	26,483.0	377.0		26,860.0	46.7
52 PVA	1,438.0		1,438.0		2,163.0		2,163.0		
53 Phenolic Resin	1,784.0		348.0	1,436.0	2,440.0			2,440.0	14.2
54 Urea Resin	2,238.0		101.0	2,137.0	4,680.0			4,680.0	21.6

Table 3-b.

Unit : MT

1978 Domestic Demand	1978 Export	1978 Import	1978 Production	74-78 Growth% Rate, %	1982 Domestic Demand	1982 Export	1982 Import	1982 Production	78-82 Growth% Rate, %	Current Capacity MT/y
6,724,300.0			6,724,300.0	41.6	13,308,200.0			13,308,200.0	18.6	
854,005.0	19,995.0		874,000.0	76.3	2,149,280.0		57,480.0	2,091,800.0	24.4	100,000
651,592.0	10,008.0		661,600.0	76.9	918,590.0	10,010.0		928,600.0	8.8	62,000
85,030.0			85,030.0	36.5	172,400.0			172,400.0	19.3	20,000
223,047.0	18,953.0		242,000.0	46.8	513,000.0	101,300.0		614,300.0	26.2	74,000
106,909.0	1,191.0		108,100.0	28.3	338,787.0		56,887.0	281,900.0	27.1	57,000
41,724.0		3,964.0	37,760.0		86,770.0	3,430.0		90,200.0	24.3	
168,562.0		35,262.0	133,300.0		329,900.0			329,900.0	25.4	
108,110.0	56,790.0		164,900.0	28.9	455,846.0	75,454.0		531,300.0	34.0	81,000
86,050.0			86,050.0	33.0	125,610.0	9,790.0		135,400.0	12.0	36,000
5,006.0	964.0		5,970.0		4,982.0	658.0		5,640.0	−1.4	
23,025.0	955.0		23,980.0	15.3	38,990.0	1,910.0		40,900.0	14.3	13,000
65,645.0	17,815.0		83,460.0	12.3	72,139.0	3,661.0		75,800.0	−2.4	(fer.) 55,000 (syn.) 30,000
267,773.0	191,027.0		458,800.0	72.0	531,570.0	117,130.0		648,700.0	9.0	74,000
340,600.0			340,600.0	25.8	668,700.0			668,700.0	18.4	160,000
7,750.0		7,750.0			17,196.0		17,196.0			
9,962.0	15,938.0		25,900.0		12,830.0	28,200.0		41,030.0	12.2	24,000
5,699.0	6,301.0		12,000.0	59.2	6,869.0	8,101.0		14,970.0	5.7	9,900
103,700.0			103,700.0		183,000.0			183,000.0	15.3	
104,988.0	34,812.0		139,800.0		200,025.0	46,675.0		246,700.0	15.3	
404,156.0	54,944.0		459,100.0		637,030.0	20,770.0		657,800.0	9.4	
8,086.0	13,884.0		21,970.0		28,413.0	17,747.0		46,160.0	20.4	
7,692.0	1,578.0		9,270.0		31,695.0	5,525.0		37,220.0	41.6	5,000
6,718.0	272.0		6,990.0		20,192.0	848.0		21,040.0	31.7	
32,945.0	5,525.0		38,470.0		80,854.0	2,536.0		83,390.0	21.3	
1,470.0			1,470.0	29.4	1,719.0	631.0		2,350.0	12.4	2,000
4,082.0	4,808.0		8,890.0		35,010.0	1,260.0		36,270.0	42.1	
37,023.0	11,927.0		48,950.0	33.3	97,574.0	2,236.0		99,810.0	19.5	12,400
198,400.0	26,000.0		224,400.0	29.4	307,701.0	18,999.0		326,700.0	9.8	
1,750.0			1,750.0	19.8	3,680.0			3,680.0	20.4	6,000
185,217.0	72,783.0			39.0	436,250.0		29,150.0	407,100.0	12.1	60,000
88,770.0		1,870.0	86,900.0		180,565.0	27,435.0		208,000.0	24.4	
15,780.0		15,780.0			21,724.0		21,724.0			
3,509.0		3,509.0			9,083.0		9,083.0			
83,600.0			83,600.0	34.4	128,049.0		6,049.0	122,000.0	9.9	33,000
127,340.0	4,460.0		131,800.0	49.8	187,355.0	26,745.0		214,100.0	12.9	27,000
116,986.0	15,214.0		132,200.0		222,550.0	4,350.0		226,900.0	14.5	
96,514.0		14,584.0	81,930.0		183,625.0	4,375.0		188,000.0	23.0	
327,832.0		34,332.0	293,500.0	49.0	911,668.0		45,768.0	865,900.0	31.1	50,000
61,400.0	29,800.0		91,200.0		155,474.0		4,874 0	150,600 0	13.4	
90,345.0	8,655.0		99,000.0	35.9	192,040.0	3,460.0		195,500.0	18.5	45,000
184,577.0		30,077.0	154,500.0	22.0	393,811.0		29,811.0	364,000.0	23.9	66,000
67,040.0	2,820.0		69,860.0	27.0	125,600.0	5,280.0		130,880.0	17.0	30,000
3,111.0		3,111.0			3,150.0			3,150.0		
3,550.0			3,550.0	9.8	3,520.0			3,520.0	−0.2	
12,000.0			12,000.0	26.5	19,700.0			19,700.0	13.2	

Table 3-c.

Unit : Sectors 55-66 in MT, the rest in million won

	1970				1974				70-74 Growth % Rate, %
	Domestic Demand	Export	Import	Production	Domestic Demand	Export	Import	Production	
55 Melamine Resin	2,206.0		454.0	1,752.0	2,504.0		624.0	1,880.0	1.8
56 Alkyd Resin	6,202.0		191.0	6,011.0	9,930.0			9,930.0	13.4
57 Plasticizer	5,054.7		870.7	4,184.0	21,177.0		4,167.0	17,010.0	42.0
58 Oth Syn Resins	16,503.0		16,503.0		17,435.0		17,435.0		
Synthetic Fibers									
59 Nylon Fiber	16,436.0	17,071.0	16,080.0	17,427.0	42,850.0	13,170.0		56,020.0	33.9
60 Acrylic Fiber	8,626.0	12,291.0	5,104.0	15,813.0	34,645.0	32,145.0		66,790.0	43.4
61 Polyester Fiber	8,724.0	9,059.0	8,345.0	9,438.0	71,560.0	41,430.0		112,990.0	86.0
62 PVA Fiber	870.4		713.0	157.4	1,370.0			1,370.0	71.9
63 PP Fiber	3,244.8	152.2	86.0	3,311.0	11,452.0	1,628.0		13,080.0	41.0
64 Oth Syn Fibers	12.0	2,541.0	2,553.0		842.0	5,253.0	6,095.0		
Synthetic Rubbers									
65 SBR	9,246.0		9,246.0		29,030.0			29,030.0	
66 Oth Syn Rubbers	2,293.0		2,293.0		17,660.0		17,660.0		
Processed Plastics									
67 Flm Sht Lthr	7,633.5			7,633.5	14,179.8	8,230.0		22,409.8	30.9
68 Bldg Mat & Hshld Apl	3,446.0			3,446.0	6,548.5	2,280.0		8,828.5	26.5
69 Tblwre & Contnr	2,244.6			2,244.6	3,684.8	204.0		3,888.8	14.7
70 Hshld Gds	2,759.3			2,759.3	4,364.0	2,352.0	12.1	6,703.9	24.8
71 Elec & Mach Pts	2,294.5			2,294.5	4,544.7	1,104.0	567.2	5,081.5	22.0
72 Oth Plastc Gds	2,204.6			2,204.6	3,362.4	180.0		3,542.4	12.6
Other Industries									
1 Agr For'y Pdts	1,009,142.4	8,925.1	151,396.5	866,671.0	1,049,604.0	20,150.0	187,941.2	881,812.8	0.4
2 Fishery Pdts	50,434.2	15,837.1	528.5	65,742.8	62,507.7	63,860.0	538.3	125,829.4	17.6
3 Ores & Oil	74,655.0	11,332.0	49,198.2	36,788.8	132,988.3	12,710.0	116,322.3	29,376.0	−5.8
4 Agr Fish'y Pdts Proc	390,702.5	16,754.5	31,642.6	375,814.4	463,339.9	47,916.4	64,550.3	446,706.0	4.4
5 Tex Fab & Yarn	307,920.1	80,558.3	29,713.2	358,765.2	694,404.2	338,065.9	45,818.3	986,651.8	28.8
6 Lmbr & Wd Pdts	49,841.2	28,337.3	1,262.6	76,915.9	72,792.0	74,810.9	1,557.9	146,044.6	17.4
7 Prin Pub & Ppr	93,932.2	1,521.3	16,619.8	78,833.7	104,485.1	4,554.7	26,713.9	82,325.9	1.1
8 Inorg Chem	14,408.2	407.0	5,993.6	8,821.6	28,788.6	7,090.5	10,907.8	24,971.3	29.7
73 Chem Fertlzr	32,124.4	1,730.9	1,419.5	32,435.8	35,929.6	2,235.1	2,550.5	35,614.2	2.4
74 Medcns & Cmtcs	45,806.5	431.8	6,654.8	39,583.5	71,284.0	1,698.1	9,116.9	63,865.2	12.7
75 Oth Chem Pdts	93,433.6	976.8	38,507.7	55,902.7	176,926.8	1,759.0	69,313.9	109,371.9	18.3
76 Petr Pdts	84,229.5	8,631.2	1,971.5	90,889.2	150,207.7	38,840.4	11,652.3	177,395.8	18.2
77 Coal & Coal Pdts	60,344.8	819.2	1,290.0	59,874.0	64,790.4			64,790.4	2.0
78 Rubber Pdts	21,750.5	6,224.1	1,058.0	26,916.6	39,609.3	45,435.9	21,160.1	63,885.1	24.1
79 Mets & Pri Met Pdts	209,912.4	10,144.2	79,565.7	140,490.9	496,028.5	73,038.2	149,302.3	419,764.4	31.5
80 Nonmet Min Pdts	77,763.0	2,921.3	5,034.0	76,650.3	88,426.8	14,137.6	8,053.7	94,510.7	5.7
81 Mach & Instr	224,680.1	16,105.9	143,879.6	96,906.4	339,398.8	90,000.0	267,998.6	161,400.2	13.6
82 Trans Equip	147,859.8	1,722.1	58,712.5	90,869.4	315,809.4	53,200.0	109,735.9	259,273.5	30.0
83 Misc Mfg	112,802.2	36,259.9	3,861.7	145,200.4	126,892.7	78,779.7	11,577.0	194,095.4	7.5
84 Constr & Bldg	467,497.2	7,702.7		475,199.9	625,938.2	26,882.4		652,820.6	8.3
85 Elec & Water	62,262.9	3,314.4	101.7	65,745.6	112,728.4	2,209.6	302.5	114,635.5	15.0
86 Fin & Insu	68,427.4	780.5	128.4	69,079.5	119,693.8	1,466.7	318.4	120,842.1	15.0
87 Comm Trans & Warehsg	263,235.5	41,762.5	3,131.9	301,866.1	411,100.8	61,203.2	7,767.1	464,536.9	11.4
88 Wholesale & Retail	473,584.8	19,452.4	451.3	492,585.9	801,525.8	32,873.9	740.0	833,659.7	14.1
89 Rl Est & Service	670,666.9	9,045.2	1,098.2	678,613.9	934,845.2	11,849.2	2,635.6	944,058.8	8.6
90 Unclassifiable	144,550.4	23,124.2	12,900.9	154,773.7	189,314.5			189,314.5	5.1

Table 3-d

1978 Domestic Demand	1978 Export	1978 Import	1978 Production	74-78% Growth Rate, %	1982 Domestic Demand	1982 Export	1982 Import	1982 Production	78-82% Growth Rate, %	Current Capacity MT/y
3,573.0		423.0	3,150.0	13.8	6,610.0			6,610.0	20.4	
16,800.0			16,800.0	14.0	19,610.0			19,610.0	3.9	
44,000.0			44,000.0	26.8	111,400.0			111,400.0	26.1	22,000
36,695.0		36,695.0			66,828.0		2,638.0	64,190.0		
75,250.0	9,860.0		85,110.0	11.0	126,030.0	4,320.0		130,350.0	11.2	
46,769.0	74,031.0		120,800.0	16.0	61,671.0	105,929.0		167,600.0	8.5	
154,995.0	77,205.0		232,200.0	19.7	326,400.0	115,200.0		441,600.0	17.4	
1,420.0			1,420.0	0.9	1,617.0	243.0		1,860.0	7.0	
22,458.0	2,952.0		25,410.0	18.1	38,922.0	5,258.0		44,180.0	14.8	
30.0	8,123.0	8,153.0			30.0	11,187.0	11,217.0			
91,934.0	8,956.0		100,900.0	36.5	193,900.0			193,900.0	17.7	25,000
26,873.0		26,873.0			46,132.0		46,132.0			
40,005.8	20,092.7		60,099.5	28.0	82,230.1	49,054.1		131,284.2	21.6	
15,984.6	4,727.8		20,712.4	23.8	27,699.4	9,803.5		37,502.9	16.0	
6,746.4	356.8		7,103.2	16.3	9,273.3	624.0		9,897.3	8.6	
7,022.7	4,113.6	8.4	11,127.9	13.5	10,825.8	7,194.8	3.0	18,017.6	12.8	
16,031.1	2,289.3	287.6	18,032.8	37.3	38,152.5	4,747.1	378.3	42,521.3	23.9	
5,927.8	263.5		6,191.3	15.0	22,495.4	385.8		22,881.2	38.7	
1,111,482.4	37,510.0	239,852.9	909,139.5	0.8	1,135,740.0	57,040.0	261,764.7	931,015.3	0.6	
77,959.0	112,220.0	945.9	189,233.1	10.7	94,986.2	170,190.0	1,432.9	263,743.3	8.7	
262,566.9	15,810.0	240,745.3	37,631.6	6.4	481,893.9	17,050.0	450,761.9	48,182.0	6.4	
570,011.9	80,987.7	96,825.5	554,174.1	5.5	688,908.3	136,854.0	125,873.1	699,889.2	6.0	
993,006.0	582,271.1	60,050.3	1,515,227.8	11.3	1,438,292.6	729,727.8	71,311.7	2,096,708.7	8.5	
124,842.6	121,283.0	2,228.0	243,897.6	13.7	173,453.9	152,265.8	2,693.9	323,025.8	7.3	
117,591.8	6,832.1	40,003.1	84,420.8	0.6	132,295.8	9,185.6	51,033.7	90,447.7	1.7	
85,463.7	28,362.0	21,548.5	92,277.2	38.6	178,630.6	70,905.0	51,700.4	197,835.2	21.0	
43,479.0	4,380.0	2,077.5	45,781.5	6.5	52,998.9	4,838.0	1,231.1	56,605.8	5.4	
116,002.2	6,678.2	12,490.2	110,190.2	14.6	187,982.6	26,263.7	17,111.5	197,134.8	15.7	
342,978.2	3,123.2	124,765.1	221,336.1	19.3	543,077.6	5,660.8	224,577.0	324,161.4	10.0	
279,927.6	65,460.2	19,940.4	326,447.4	16.5	465,623.9	111,342.5	33,402.2	543,564.2	13.6	
82,957.3			82,957.3	6.4	119,506.4		3,100.0	116,406.4	8.8	
81,205.9	133,195.7	37,030.8	177,370.8	29.1	150,899.8	247,719.2	52,900.3	345,718.7	18.2	
1,428,950.4	159,263.9	368,779.9	1,219,434.4	30.6	3,608,011.5	283,023.2	236,523.0	3,654,511.7	31.6	
136,352.4	22,667.0	11,075.7	147,943.7	11.9	179,237.0	36,267.0	14,095.2	201,408.8	8.0	
743,846.3	261,232.0	471,499.0	533,579.3	34.8	1,150,030.1	572,320.0	580,712.0	1,141,638.1	20.9	
934,455.9	202,360.0	255,632.2	881,183.7	35.8	2,242,494.4	432,570.0	344,657.4	2,330,407.0	27.5	
145,492.9	177,673.5	18,916.9	304,249.5	11.9	38,552.0	232,063.4	24,698.0	245,917.4	−5.5	
1,207,075.4	63,819.7		1,270,895.1	18.1	1,669,883.9	93,819.7		1,763,703.6	8.5	
231,131.6	2,209.6	507.5	232,833.7	19.4	440,041.8	2,209.6	852.7	441,398.7	17.3	
216,870.5	3,488.8	624.1	219,735.2	16.1	360,486.2	7,040.1	917.5	366,608.8	13.7	
681,670.6	80,263.2	15,189.7	746,744.1	12.6	1,060,037.7	112,432.5	22,328.9	1,150,141.3	11.4	
1,423,312.4	54,570.2	1,123.8	1,481,758.8	15.5	2,365,747.1	70,587.0	1,990.7	2,434,343.4	13.2	
1,300,097.0	19,178.5	6,325.5	1,313,490.0	8.6	1,797,848.3	26,140.6	9,488.2	1,814,500.7	8.4	
277,607.1			277,607.1	10.0	403,272.5			403,272.5	9.8	

sector grows at the rate r_{sec} per year. Then, in calculating the input coefficients for the future years, the endogenous and exogenous coefficients, read vertically down from the 1970 input-output table, were multiplied by $(1+r_{sec})^y$ and $(1+r_{GDP})^y$, respectively, and followingly normalized so that the sum of the resulting coefficients became unity. The coefficients obtained in this manner were used as the input coefficients for the years of 1974, 1978, and 1982.

3. Final Demands for 1974, 1978, and 1982

Let us clarify the following point first. If the total sum of the j-th final demand was denoted by σ_j, then σ_1 would mean the total sum of the private consumption expenditure, σ_2, that of the government consumption expenditure, and so forth. Using the notation of Eq. (10), σ_j can be expressed by

$$\sigma_j = \sum_{i=1}^{n} y_{ij}, \quad j=1,7 \tag{16}$$

where y_{ij} means the j-th final demand allotted to the i-th industrial sector.

For 1970, both σ_j and y_{ij} are known. So, we can immediately calculate the values of y_{ij}/σ_j, or simply f_{ij}, for all values of i and j. The values of $f_{ij}(1+r_i)^y$, or simply g_{ij}, are then calculated for all i and j, and followingly normalized so that the sum of g_{ij}'s are equal to unity for any j. The value of the future y_{ij} is then given by

$$\text{Future } y_{ij} = \sigma_j g_{ij}, \quad i=1,n;\ j=1,7 \tag{17}$$

where the value of σ_j for any specific year i staken from our proposed model for the expenditures on the gross domestic product, constructed in reference to the projcted expenditures on the gross national product (1972—1981) as drafted by the government[8]. The model is shown in *Table* 2 and in *Fig.* 2

The assumed value of r may be overestimated for one final demand and underestimated for the other. so, a certain measure was taken to eliminate the improprieties arising from the indiscriminate application of a single value for r throughout the calculation.

The future imports and exports of nonpetrochemicals were estimated for sector by sector by analyzing the information from the business circles, and of the petrochemicals, by studing the government plan for the petrochemical plants and the raw material requirements for each chemical and its product.

The 'increase in stocks' was far the most difficult

Table 4. Role of the manufacturing industries in the whole industry

(Unit: billion wons)

	1970		1974		1978		1982	
	Output	%	Output	%	Output	%	Output	%
Light Industries	1,035.5	20.6	1,855.8	23.4	2,701.9	19.3	3,455.9	14.6
Agr Fish'y Pdts Proc	375.8	7.5	446.7	5.6	554.2	4.0	699.9	3.0
Tex Fab & Yarn	358.8	7.1	986.7	12.4	1,515.2	10.8	2,096.7	8.9
Lmbr & Wd Pdts	76.9	1.5	146.0	1.8	243.9	1.7	323.0	1.4
Prin Pub & Ppr	78.8	1.6	82.3	1.0	84.4	0.6	90.4	0.4
Misc Mfg	145.2	2.9	194.1	2.4	304.2	2.2	245.9	1.0
Heavy (chemicals) Industries	578.8	11.5	1,371.5	17.3	3,848.6	27.5	9,330.1	39.4
Chem Fertlzr	32.4	0.6	35.6	0.4	45.8	0.3	56.6	0.2
Petrochemicals	63.5	1.3	241.5	3.0	712.3	5.1	1.394.3	5.9
Oil Refinery	94.7	1.9	189.1	2.4	373.3	2.7	636.3	2.7
Coal & Coal Pdts	59.9	1.2	64.8	0.8	83.0	0.6	116.4	0.5
Mets & Pri Met Pdts	140.5	2.8	419.8	5.3	1,219.4	8.7	3,654.5	15.4
Mach & Instr	96.9	1.9	161.4	2.0	533.6	3.8	1,141.6	4.8
Trans Equip	90.9	1.8	259.3	3.3	881.2	6.3	2,330.4	9.8
Total Output in Korea	5,028.0		7,940.8		13,978.7		23,669.4	

item to devise a forecasting routine. These values were taken from those predicted by the government in their Major Economic Target draft[9]. These values taken for the three forecast years constitute another series of σ_j's; the corresponding y_{ij}'s are obtained by multiplying σ_j by f_{ij} of the base year.

It is now possible to tabulate the elements of ($\boldsymbol{Y}$-$\boldsymbol{M}$) vector, which we may call as the policy vector. The tabulated input data were stored in the computer memory device.

The Results of the Computer Analysis

The general solution of Eq. (3) and the inverse matrix were obtained by using the Gauss Jordan Reduction Subroutine (DGJR) of the UNIVAC 1106 Mathematical Package. The main programming contains also the programmings for calculating the sensitivity, influence coefficients, and induced productions by final demands.

1. Total Outputs

The general solution part of the computer results, or the total outputs, are shown in *Table* 3. For the petrochemicals, the computer outputs, initially in money unit, were converted into metric tons, and for the rest, in million wons. The table shows a remarkably fast growth rate of the heavy chemical industries, while on the other hand, showing only a slow growth rate in the case of primary industries. It is clearly indicated that the role played by the petrochemical, mechanical, and steel industries becomes gradually important.

Table 4 compares the manufacturing industry with the whole industry. One will note that the ratios of light and heavy (chemical) industries to the whole industry go through entirely different passes until they reach to the values similar to those of advanced countries. In 1982, the petrochemical industry grows 22 times that of 1970, metals and steel products 26 times, machinery products 12 times, and transportation equipment, 26 times those of 1970, respectively, while the light industries grow only 3 times on the average. By 1973, the productions of some petrochemical products such as propylene, methanol, ethylene dichloride (EDC), octanol, dimethyl terephthalate (DMT), high density polyethylene (HDPE), etc. get large enough in volume that even export may become possible. The machinery products and transportation equipment, most of which are considered to require a highly advanced technology, are no longer imported. Quite on the contrary, approximately 50% of the entire export of Korea will be of these products in 1982. Although an international trade balance will be attained in around 1975 by the 1970 fixed price, it will be attained only in around 1980 by the running price.

Conclusion

Up to this point, we have presented a comprehensive forecast of the total output of each individual sector alongside the domestic demand, export, and import for the three forecast years. Whatever the title of this work was, our result covers, in essence, the entire Korean industry. Any one of the figures is completely intertwined with the rest of the figures, and not a single figure is separate. In this regard, our forecast is completely unprecedented. The concept of the method is beyond the reach of any single or multiple regressional method.

However, one should keep in mind the fact that this forecast is, in effect, a particular response of our input-output model to the government choice of a set of final demands, or the expenditure scheme on the gross domestic product of a specific year.

Further detailed analyses, such as for the impact of the growth of petrochemical industry on other industries, and vice versa, and for the method of correcting the production of any sector for any change in a final demand, will be discussed in a separate report, Part II.

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