CHAPTER V   DEMAND FORECAST

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The forecast of future demand is a crucial step in framing master plans for port development. Usually, in such studies, the economic frames are presented in national and regional development plans, and port development takes place in coordination with the national policy.

In the case of Valparaiso and San Antonio, however, there are no long-term national or regional economic or infrasdtructural plans available. On the other hand, the "Multimodal Corridor Study" is currently being conducted by the Chilean government, and we have carried out our forecast making frequent reference to this ongoing study.

As for the forecast procedure, the macro forecast of the total port cargo volume was done independently by the JICA study team taking into consideration the results of the Multimodal Corridor Study. The forecast volume of each individual commodity was basically taken directly from the study.

V-1 Socioeconomic Frame

(1) Socioeconomic Frame of the Country

To forecast the future cargo throughput of Chilean ports, many trial analyses were carried out in an effort to determine the correlation between various socioeconomic indices and total throughput. Unfortunately, the analyses show weak correlation coefficients. In other words, historically these indices have not been closely correlated with total cargo throughput and thus the projected future socioeconomic indices cannot be used to accurately forecast future cargo throughput.

Nonetheless, population and gross domestic product (GDP) are the most basic economic indices, and it is reasonable to assume that they will generally indicate the future trend of cargo throughput. Thus, we have analyzed the historical data and forecast the future population and GDP for the years 1990, 1995, 2000, 2005 and 2010.

1) Population

The records of Chilean population are shown in Table V-1-1 for the 25

years from 1960 to 1984.

Table V-1-1   Population of Chile

(In thousands)

Year	Population
1960	7,585.2
61	7,765.9
62	7,952.3
63	8,140.8
64	8,327.8
1965	8,509.7
66	8,686.0
67	8,859.1
68	9,029.8
69	9,199.0
1970	9,367.6
71	9,534.0
72	9,697.4
73	9,860.6
74	10,026.1
1975	10,196.4
76	10,371.9
77	10,550.9
78	10,732.9
79	10,917.5
1980	11,104.3
81	11,294.1
82	11,275.4
83	11,682.3
84	11,878.4

The population is, generally speaking, exponentially correlated with the year. In Chile, the correlation equation between the two is as follows:

P: Population (in Thousands)

Y: Calender Year

$$P = (2.50548 \times 10^{-12}) \times e^{(1.81968 \times 10^{-2}) \times Y} \quad ----- (1)$$

*(1)R = 0.998827   *(2)R_2 = 0.997655

*(1)R : Correlation coefficient

*(2)R : Decision factor

[Note] Regressive Analysis of the Linear function by Least Square Method

$$Y = A \times e^{B \times X}$$

$$\log Y = \log A + B \times X$$

$$y = a + bx$$

$$\left(\begin{array}{l} y = \log Y \\ x = X \end{array} \right)$$

$$\therefore a = \bar{y} - b\bar{x}$$

$$b = \frac{Sxy}{Sxx}$$

$$R = \frac{Sxy}{\sqrt{Sxx \quad Syy}}$$

$$R_2 = \frac{Sxx \times Sxx}{Sxx \times Syy}$$

$$\left(\begin{array}{l} Sxx = \Sigma x^2 - \frac{(\Sigma x)^2}{n} \\ Syy = \Sigma y^2 - \frac{(\Sigma y)^2}{n} \\ Sxy = \Sigma (x \times y) - \frac{\Sigma x \times \Sigma y}{n} \end{array} \right)$$

It is clear from the values of R_1 and R_2 that this numeric equation well represents the tendency of Chilean population growth, and the average annual growth rate is about 1.82 percent.

Another statistical method can also be applied. Based upon the records, the average annual growth rate from 1960 to 1984 can be calculated as shown below.

Pn: Population of n Year

$$P_{1984} = (1 + \alpha)^{24} \times P_{1960} \qquad\qquad ----- (2)$$
$$\therefore \alpha = 1.8864 \%$$

That is to say, the historical growth is about 1.89 percent a year, which is nearly equal to the growth rate obtained by equation (1).

Using the numeric model, we estimate the future population of Chile as shown in Table V-1-2. The population in 2000 and 2010 will be about 16 million and 19 million, respectively, which is roughly 1.3 times and 1.6 times the population in 1984.

Table V-1-2   Future Population of Chile

(in Thousands)

Year	Population	Index
1984	11,878	1.00
1990	13,348	1.12
1995	14,620	1.23
2000	16,012	1.35
2005	17,537	1.48
2010	19,208	1.62

The historical data and the forecast results are shown in Fig. V-1-1. The graph shows that the Chilean population will increase very moderately if it follows the historical trend.

In Fig. V-1-1, the future population assuming linear growth is also marked for reference. In this case, the average annual growth rate is about 1.21% from 1984 to 2010, somewhat lower than the other estimates.

By the provisional figures of the National Bureau of Statistics, the population of Chile is estimated to reach 13,061 thousand in 1990, 14,017 thousand in 1995 and 14,994 in 2000, and the average annual growth rate can be calculated as 1.59% from 1984 to 1990, 1.42% from 1990 to 1995 and 1.36% from 1995 to 2000. This means that the growth rate will decrease in the future to a rate lower than the historical record. The National Bureau of Statistics estimates are also illustrated in Fig. V-1-1. These estimates fall in between the exponential and linear growth estimates. The deviation is 1,018 thousand (6.4%) from the former and 380 thousand (2.6%) from the latter.

2) Gross Domestic Product (GDP)

The records of the gross domestic product of Chile are shown in Table V-1-3 for the 25 years from 1960 to 1984; the prices are real values in 1977.

The gross domestic product (GDP) is also correlated with the year exponentially, and in Chile, the equation between the two is as follows.

GDP :   Gross Domestic Product (in Billion Pesos at 1977 Prices)
Y   :   Calender Year

$$GDP = (5.52920 \times 10^{-19}) \times e^{(2.41654 \times 10^{-2}) \times Y} \quad \text{------ (3)}$$
$$R = 0.912280 \qquad R_2 = 0.832254$$

It is clear from the values of R and R_2 that the equation well represents the tendency of the national GDP growth, and the average annual growth rate is about 2.42 percent.

From 1960 to 1971, the records show stable economic growth of 4.65 percent a year. However, since 1971 growth has been irregular. The forecast using the exponential equation (3) will vary depending on which historical years are considered. In this study, the forecasting range is 25

Fig. V-1-1 Forecast of Population

Legend:
- ○------○ Linear Growth
- □------□ Exponential Growth
- △------△ Average Annual Growth Rate ('60~'84): 1.8864%
- ×------× Estimation by National Bureau of Statistics

Data points:
- 19.3
- 19.2
- 17.6
- 17.5
- 16.4
- 16.0
- 16.0
- 15.5
- 15.0
- 14.6
- 14.6
- 14.6
- 14.0
- 13.7
- 13.3
- 13.3
- 13.1
- 12.9

Population (Million) — vertical axis: 20, 15, 10

Year — horizontal axis: '60, '70, '80, '90, 2000, 2010
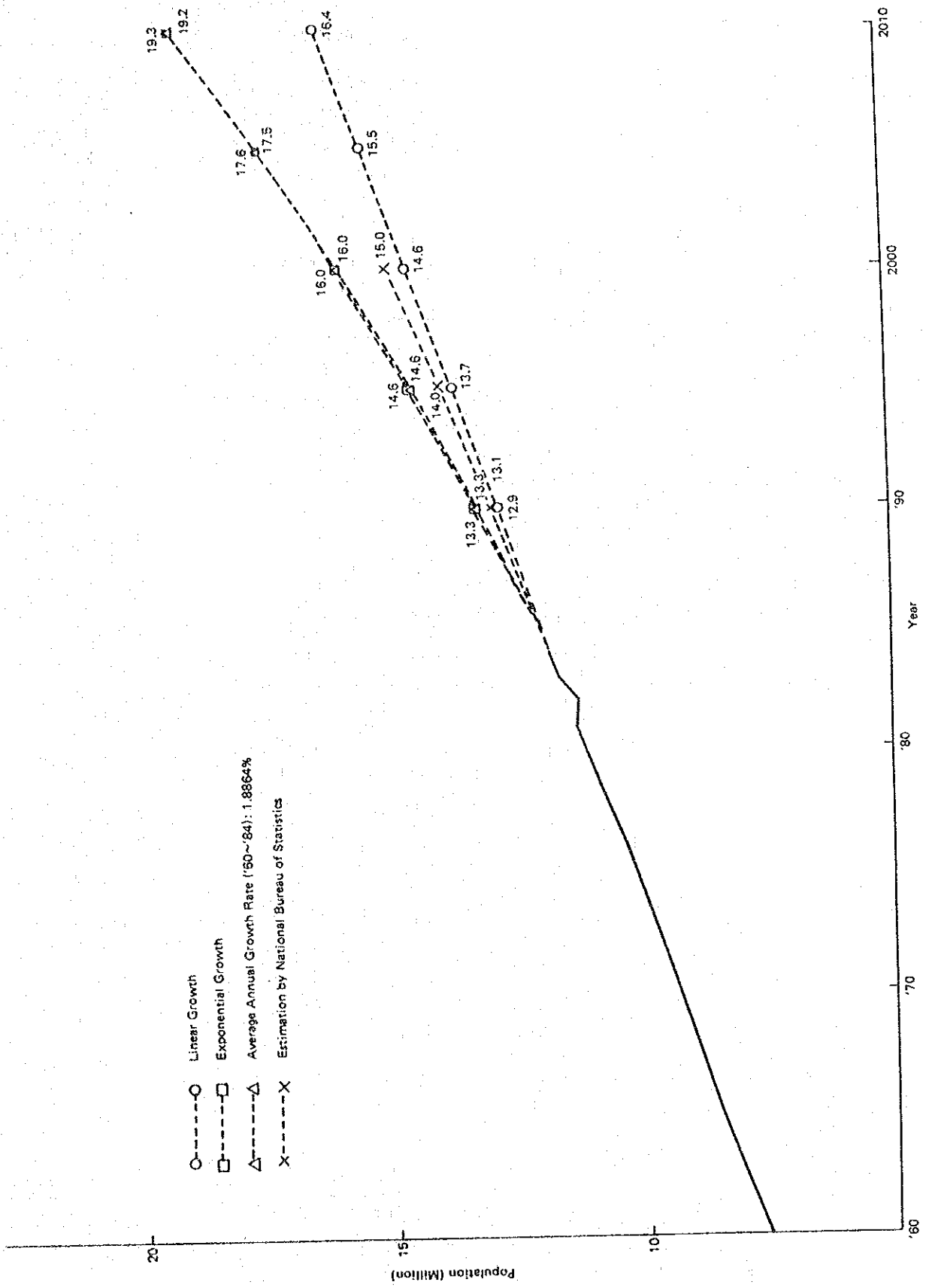
years so it is preferable to utilize long historical records.

Another statistical method, as in the case of population, is also applicable to GDP. Based upon the records, the average annual growth rate from 1960 to 1984 can be calculated as follows.

GDPn : GDP of n Year

$$GDP_{1984} = (1 + \beta)^{24} \times GDP_{1960} \qquad \text{------ (4)}$$

$$\therefore \beta = 2.6185\%$$

The value is about 2.62 percent a year, slightly higher than the estimate by the numeric model.

Table V-1-3 Gross Domestic Product of Chile

(Pesos at 1977 Prices)

Year	GDP
1960	187.10×10^9
1961	196.05
1962	205.34
1963	218.33
1964	223.19
1965	224.99
1966	250.08
1967	258.20
1968	267.44
1969	277.39
1970	283.10
1971	308.45
1972	304.71
1973	287.75
1974	290.55
1975	253.04
1976	261.95
1977	287.77
1978	311.42
1979	337.21
1980	363.45
1981	383.55
1982	329.52
1983	327.18
1984	347.93

Anyway, we assume that the economic structure of Chile and the overall world economy will not change drastically during the forecasting period. Using equation (3), we estimate the future GDP of Chile in 1990, 1995, 2000, 2005 and 2010 as shown in Table V-1-4.

Table V-1-4   Future GDP of Chile

(in Million Pesos at 1977 Prices)

Year	GDP	Index
1984	348	1.00
1990	424	1.22
1995	479	1.38
2000	540	1.55
2005	609	1.75
2010	688	1.98

The GDP of Chile is estimated as about 540 Million Pesos in 2000 and 688 Million Pesos in 2010, roughly 1.6 times and 2.0 times the GDP in 1984.

In Fig. V-1-2, the historical records and the forecast results are shown graphically. This shows that the estimated average annual growth rate in the future is lower than the rates from 1960 to 1971 and from 1975 to 1981 due to the influence of the 1971 ～ 1975 recession on the forecasting equation. It will be necessary to pursue a positive economic policy in order to realize the forecast growth.

Fig. V-1-2 also shows, for reference, that by regression analysis of the linear function the growth rate is 1.43%.
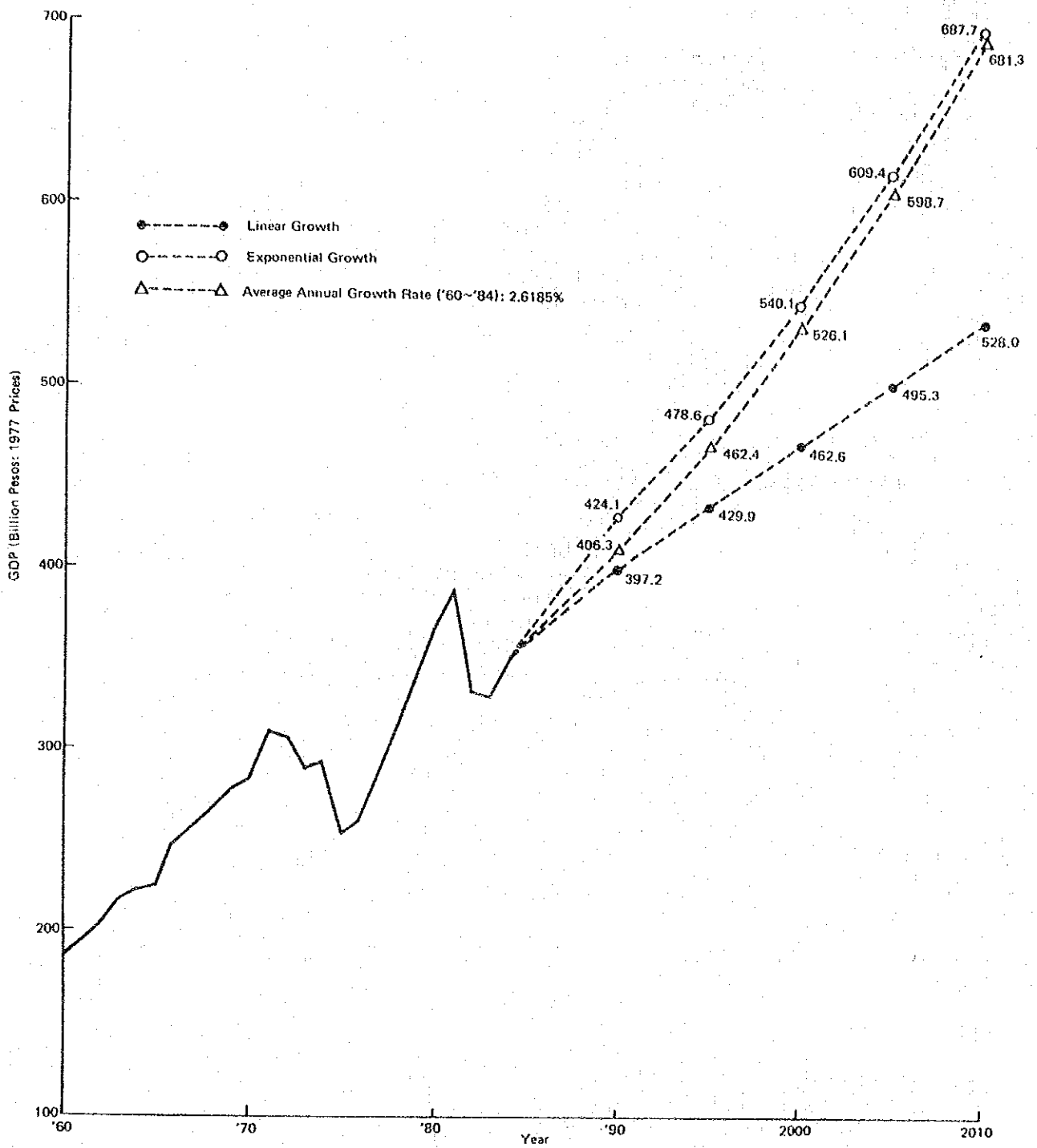
Fig. V-1-2 Forecast GDP of Chile

(2) Socioeconomic Frame of the Hinterland

1) Hinterland of the Ports

A study on the origin and destination of the cargoes handled at the ports of Valparaiso and San Antonio was conducted as part of the Multimodal Corridor Study, and Tables V-1-5 and 6 are made from the study data. The tables show the share of cargoes by region and commodity for export and import in 1984.

If we accept the criterion of a 10 percent share in any column of Table V-1-5 or 6 to choose the regions which are closely connected to the two ports, the regions from V to VIII come up to the standard. However, we must also consider Region IV, taking into consideration the allottted functions of the port of Valparaiso and the port of Coquimbo. Considering the development of the port of Valparaiso and of related inland transportation, Region IV should also be considered as part of the port's hinterland for forecasting future demand. Moreover, as the basic planning concept states that the Ports of Valparaiso and San Antonio are to be regarded as one wide-range port, Region IV should be included in the hinterland of the Port of San Antonio as well.

Thus, in this study we assume that the hinterlands of the planned ports are the Santiago Metropolitan Region and Regions IV through VIII. (Refer to Fig. V-1-3)

Later on, we will discuss the preparation of special port facilities required for handling emergency cargoes in case of a catastrophe such as a major earthquake. The extent of the hypothetical disaster shall be assumed, and appropriate facilities provided. Considering historical disasters, the emergency facilities shall be sufficient to support the Santiago metropolitan area and regions V and VI.

Table V-1-5　Share of Traffic by Origin/Destination through the port of Valparaiso (1984)

	Region Product	IV	V	RM	VI	VII	VIII	Others	Unknown	Total
		%	%	%	%	%	%	%	%	%
Export	G.C. (Container)	3.1	16.3	34.4	8.6	1.5	3.8	8.7	23.6	100.0
	G.C. (Non-Container)	1.7	19.5	15.1	6.1	2.1	14.0	–	25.8	100.0
	Fruit	4.9	23.7	20.2	29.6	17.7	0.8	3.1	–	100.0
	Copper	–	91.1	5.9	3.0	–	–	–	–	100.0
Import	G.C. (Container	–	6.1	66.4	2.3	–	1.0	24.2	–	100.0
	G.C. (Non-Container)	0.8	4.4	79.7	1.1	0.8	4.1	9.6	–	100.0

Tavle V-1-6　Share of Traffic by Origin/Destination through the port of San Antonio (1984)

	Region Product	IV	V	RM	VI	VII	VIII	Others	Unknown	Total
		%	%	%	%	%	%	%	%	%
Export	G.C. (Container)	–	6.8	40.6	10.2	12.4	7.7	4.3	18.0	100.0
	G.C. (Non-Container)	–	3.9	64.4	–	9.5	12.7	3.8	5.7	100.0
	Fruit	–	10.1	9.9	50.1	29.9	–	–	–	100.0
	Copper	–	12.5	15.3	72.2	–	–	–	–	100.0
Import	G.C. (Container)	0.0	6.5	80.4	1.8	1.4	5.1	4.8	–	100.0
	G.C. (Non-Container)	0.0	8.6	58.2	9.4	–	20.6	3.2	–	100.0
	Wheat	0.1	10.3	69.8	10.1	5.0	0.4	2.3	2.1	100.0

Port of Coquimbo

IV REGION

V REGION

Port of Ventanas

Port of Valparaiso

Port of San Antonio

santiago

METROPOLITAN REGION

VI REGION

San Fernando

VII REGION

Tarica

LEGEND

+++++ RAILWAY

———— ROAD

o----o PIPELINE
(Petroleum)

Port of Lirquén

Port of Penco

Port of Talcahuano/San Vicente

Port of Huachipato

Port of Coronel

Port of Lota
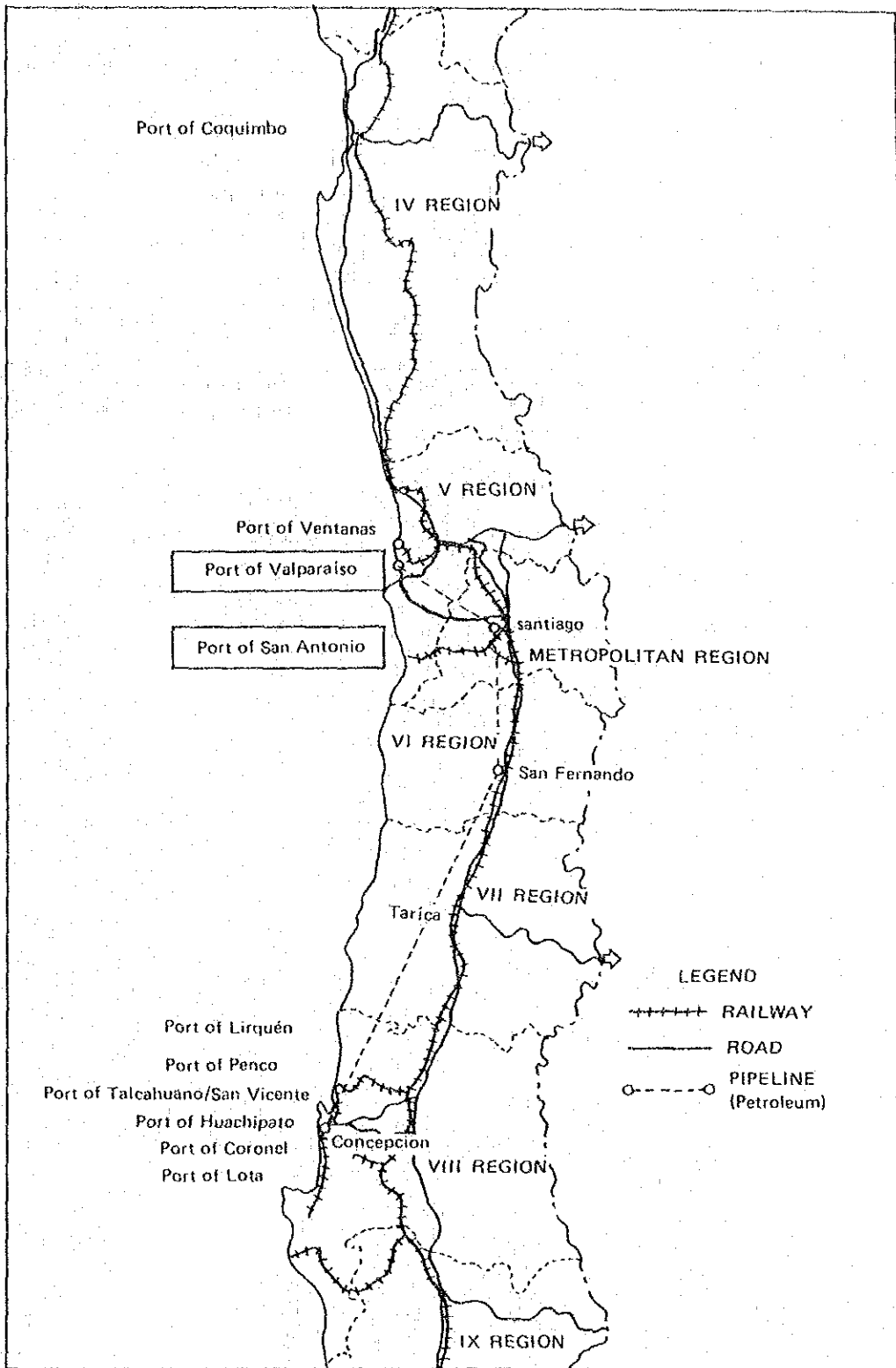
Concepcion

VIII REGION

IX REGION

Fig. V-1-3 Hinterlands of the Subject Ports

2) Population

The population of the hinterland and of each region in thge hinterland is shown in Table V-1-7 from 1974 to 1983 along with the regional percentages of the national population.

The records show that the populations of each of the regions in the hinterland except for Santiago Metropolitan have increase in absolute numbers but have not significantly changed in terms of percentage of the national population, and that the percentage of the national population in the entire hinterland expanded slightly over the 10 years. This is mainly because population has been slowly concentrating in the Santiago Metropolitan region.

Taking into account the historical trend, we estimate that the share of the national population in the hinterland will increase slightly to 79.5% in 2010. The total population of Santiago Metropolitan and Regions IV to VIII is estimated as about 12.7 million in 2000 and 15.3 million in 2010. Table V-1-8 shows the population estimates.

As for the population of Santiago Metropolitan and Regions V and VI, the projections are shown in Table V-1-9. These will be used for estimating the demand for emergency port cargoes.

Table V-1-7　Population of the Hinterland

(in Thousands)

Year	Chile Total	%	Hinterland Total	%	Santiago Metropolitan	%	Region IV	%	Region V	%	Region VI	%	Region VII	%	Region VIII	%
1974	10,026	100.0	7,755	77.3	3,689	36.8	380	3.8	1,105	11.0	533	5.3	671	6.7	1,377	13.7
1975	10,196	100.0	7,899	77.5	3,786	37.1	388	3.8	1,125	11.0	540	5.3	674	6.6	1,385	13.6
1976	10,372	100.0	8,047	77.6	3,880	37.4	394	3.8	1,146	11.0	545	5.3	680	6.6	1,402	13.5
1977	10,551	100.0	8,197	77.7	3,974	37.7	400	3.8	1,167	11.1	551	5.2	687	6.5	1,419	13.4
1978	10,733	100.0	8,350	77.8	4,070	37.9	405	3.8	1,188	11.1	556	5.2	693	6.5	1,437	13.4
1979	10,918	100.0	8,504	77.9	4,167	38.2	411	3.8	1,210	11.1	562	5.1	700	6.4	1,455	13.3
1980	11,104	100.0	8,661	78.0	4,274	38.5	415	3.7	1,231	11.1	560	5.0	705	6.3	1,476	13.3
1981	11,294	100.0	8,820	78.1	4,373	38.7	421	3.7	1,252	11.1	566	5.0	712	6.3	1,496	13.2
1982	11,275	100.0	8,744	77.6	4,295	38.1	419	3.7	1,205	10.7	585	5.2	723	6.4	1,517	13.5
1983	11,682	100.0	9,143	78.3	4,572	39.1	432	3.7	1,295	11.1	579	5.0	728	6.2	1,538	13.2
1984	11,878	100.0	9,306	78.3	4,673	39.3	437	3.7	1,316	11.1	586	4.9	735	6.2	1,559	13.1

Table V-1-8 Future Population of the Hinterland

(in Thousands)

Year	Chile	Hinterland	Share(%)	Index
1984	11,878	9,306	78.3	1.00
1990	13,348	10,518	78.8	1.13
1995	14,620	11,564	79.1	1.24
2000	16,012	12,698	79.3	1.36
2005	17,537	13,925	79.4	1.50
2010	19,208	15,270	79.5	1.64

Table V-1-9 Future Population of Santiago
Metropolitan and Regions V and VI

(in Thousands)

Year	S. M.	R. V	R. VI	Total
1984	4,673	1,316	586	6,575
1990	5,417	1,473	631	7,521
1995	6,048	1,619	671	8,338
2000	6,730	1,778	686	9,193
2005	7,450	1,949	724	10,123
2010	8,246	2,138	764	11,147

3) GRP

The gross regional product of each region in the hinterland from 1979 to 1982 is shown in Table V-1-10 with the percentage of the GNP. The records, though only over a short period, indicate that the total GRP of the hinterland increased each year except for 1982 in absolute terms, but changed little in terms of GDP share over the four years. As for the GRP of each region, all the regions in the hinterland except for Santiago Metropolitan maintained essentially the same share of the GDP during the observation period.

Generally speaking, the GDP of the hinterland is the main factor in

determining the cargo of any given port. However, in this case as few records are available and the correlation between the GRP and port throughput is also unreliable, we cannot forecast future cargo throughput based only on projected GRP. Here, the future GRP is estimated to serve as a rough profile of the future economic state of the hinterland.

If we assume that the regional percentage of GDP in the future will remain almost the same as in the past, that is about 78.0% of the GDP, through the forecasting period, the GRP of the hinterland will reach 421.2 billion pesos in 2000 and 536.4 billion pesos in 2010 in 1977 prices. The forecast is shown in Table V-1-11. It indicates that the GRP in 2010 will reach twice the GRP in 1982, and that the average annual growth rate will be about 2.7%, somewhat larger than the growth rate of the GDP (2.4% - 2.6%).

Table V-1-10 GRP in the Hinterland

(in Billion Pesos at 1977 Prices)

Year	Chile Total		Hinterland Total		Santiago Metropolitan		Region IV		Region V		Region VI		Region VII		Region VIII	
		%		%		%		%		%		%		%		%
1979	337.21	100.0	264.85	78.5	152.16	45.1	6.42	1.9	39.06	11.6	20.85	6.2	14.05	4.2	32.31	9.6
1980	363.45	100.0	283.01	77.9	164.58	45.3	6.39	1.8	41.20	11.3	22.28	6.1	14.24	3.9	34.32	9.4
1981	383.55	100.0	301.84	78.7	176.26	46.0	6.60	1.7	41.88	10.9	24.48	6.4	16.00	4.2	36.62	9.5
1982	329.52	100.0	255.07	77.4	144.10	43.7	5.81	1.8	35.58	10.8	23.51	7.1	14.38	4.4	31.69	9.6

Table V-1-11 Future GRP of the Hinterland

(in Billion Pesos at 1977 Prices)

Year	Chile	Hinterland	Share (%)	Index
1982	329.5	255.1	78.0	1.00
1990	424.1	330.8	78.0	1.30
1995	478.6	373.3	78.0	1.46
2000	540.1	421.2	78.0	1.65
2005	609.4	475.3	78.0	1.86
2010	687.7	536.4	78.0	2.10

V-2　Port Cargo

(1)　National Port Cargo

1)　Total Cargo

The cargoes handled at Chilean ports from 1960 to 1983 are shown in Table V-2-1, classified by foreign (import and export), domestic and transit cargo.

Based on the available data, there is no clear trend in cargo throughput. This is the main reason why there is no clear correlation between the national cargo throughput and the national socioeconomic indices as described before.

As for cargo by category, no clear trends can be observed in the historical data, though imports and domestic cargoes show a slight growth trend and exports may be decreasing.

Before proceeding, two important statistical factors must be considered. These are the double counting of domestic cargo and the treatment of transit cargo.

In the case of domestic cargo transport, cargoes are counted once when loaded at the port of origin and again when unloaded at the port of destination, and are thus counted twice in national port statistics. The domestic cargo volumes presented in Table V-2-1 are the total volume of cargoes on coastal ships, usually referred to as traffic at a cross section. For certain purposes, this is a useful measurement, but for planning port capacity, the double counting of domestic cargoes may be more appropriate. Thus, the double volume of the domestic cargoes is also shown in Table V-2-1 for later analyses.

As for the treatment of transit cargoes which are only transited through domestic ports while being transported from one foreign country to another, such cargoes have essentially no relation to the Chilean economy in terms of such activities as production, consumption, living level and employment. Certainly, strictly speaking, the transportation of transit cargoes requires labour, facilities, services and so on which promote the national economic growth to a very slight extent. In the study, however, transhipment is regarded, as usual, as an activity outside Chile, that is to say, which is determined by factors other than the Chilean economy.

Table V-2-1　National Port Cargo

(in Thousand Tons)

Year	Total (A)=(B)+(C)×2	Foreign Trade	(B) Import	(B) Export	Domestic Trade(C)	Transit (D)	Domestic Trade(C)×2
1960					2,689		5,377
61					3,440		6,880
62					3,951	260	7,902
63					4,471	307	8,941
64					4,444	282	8,889
1965					4,533	295	9,067
66					4,587	292	9,174
67					5,011	398	10,022
68					4,631	381	9,262
69					4,782	408	9,564
1970	25,469	16,203			4,633	297	9,265
71	27,120	17,998			4,561	302	9,122
72	–	–			4,795	296	9,591
73	27,486	17,097			5,194	203	10,389
74	30,843	18,376			6,234	324	12,467
1975	27,397	17,595	4,854	12,741	4,901	405	9,802
76	28,800	18,691	5,508	13,183	5,054	334	10,108
77	27,149	17,423	5,479	11,944	4,863	405	9,726
78	26,493	16,655	6,180	10,475	4,919	549	9,837
79	25,620	15,717	4,902	10,814	4,952	–	9,903
1980	29,728	19,091	6,666	12,425	5,318	612	10,636
81	30,752	19,121	7,386	11,735	5,816	493	11,631
82	28,353	17,126	5,186	11,940	5,614	407	11,227
83	27,985	15,976	5,276	10,700	6,005	519	12,009

[Note]　1. The total and the foreign and domestic trade figures show only non-transit cargoes.

2. The transit cargoes of Chile are regarded as those handled by EMPORCHI.

Now, we consider three average annual growth rates of national port cargo throughput for estimating future demand.

The first rate is calculated based on the average annual growth rate of national port cargo throughput in the past.

PC_n : Port Cargo Volume in n Year (in Thousand Tons)

$$PC_{1983} = (1 + \gamma)^{13} \quad PC_{1970} \qquad\qquad ----- (5)$$

$PC_{1983} = 27,985.0$ and $PC_{1970} = 25,468.6$

$\therefore \gamma_1 = 0.7274\%$

The growth rate is less than 1.0% per year and it is too small to apply for forecasting future demand.

The next rate is calculated based on the elasticity between port throughput and GDP. The elasticity is defined as the ratio of the two growth rates. The rate is obtained as follows, using data from 1970 to 1983.

$$GDP_{1983} = (1 + \beta') \times GDP_{1970} \qquad\qquad ----- (6)$$

$\therefore \beta' = 1.1194\%$

$\therefore e = \gamma_1/\beta' = 0.6498$

Though normally this elasticity (e) would be applied to estimate the average annual growth ratio of GDP from 1983 to 2010, after trial calculations, we decided to multiply (e) by the average annual growth ratio of GDP from 1960 to 1984 (ß), which is about 2.6% per year.

$$\gamma_2 = \beta \times e = 1.7016\%$$

This method is based upon the idea that the average annual growth rate of the national port cargo throughput will increase in relation to the long historical growth rate of GDP based on the growth rate over 14 recent years with economic conditions similar to those expected during the forecast period.

The third rate is the same as the growth rate of the national GDP, noted as (ß).

$$\therefore \gamma_3 = \beta = 2.6185\%$$

The estimation of total throughput by this rate (γ_3) is considered as too aggressive taking into account the historical record of cargoes handled

at Chilean ports and the present situation of the Chilean economy.

The 3 forecast results are summarized in Table V-2-2 with comments, and in Fig. V-2-1 along with historical data. The volumes are total throughput excluding transit cargo.

Table V-2-2 Comparison of Future Volume Estimates

(In Million Tons)

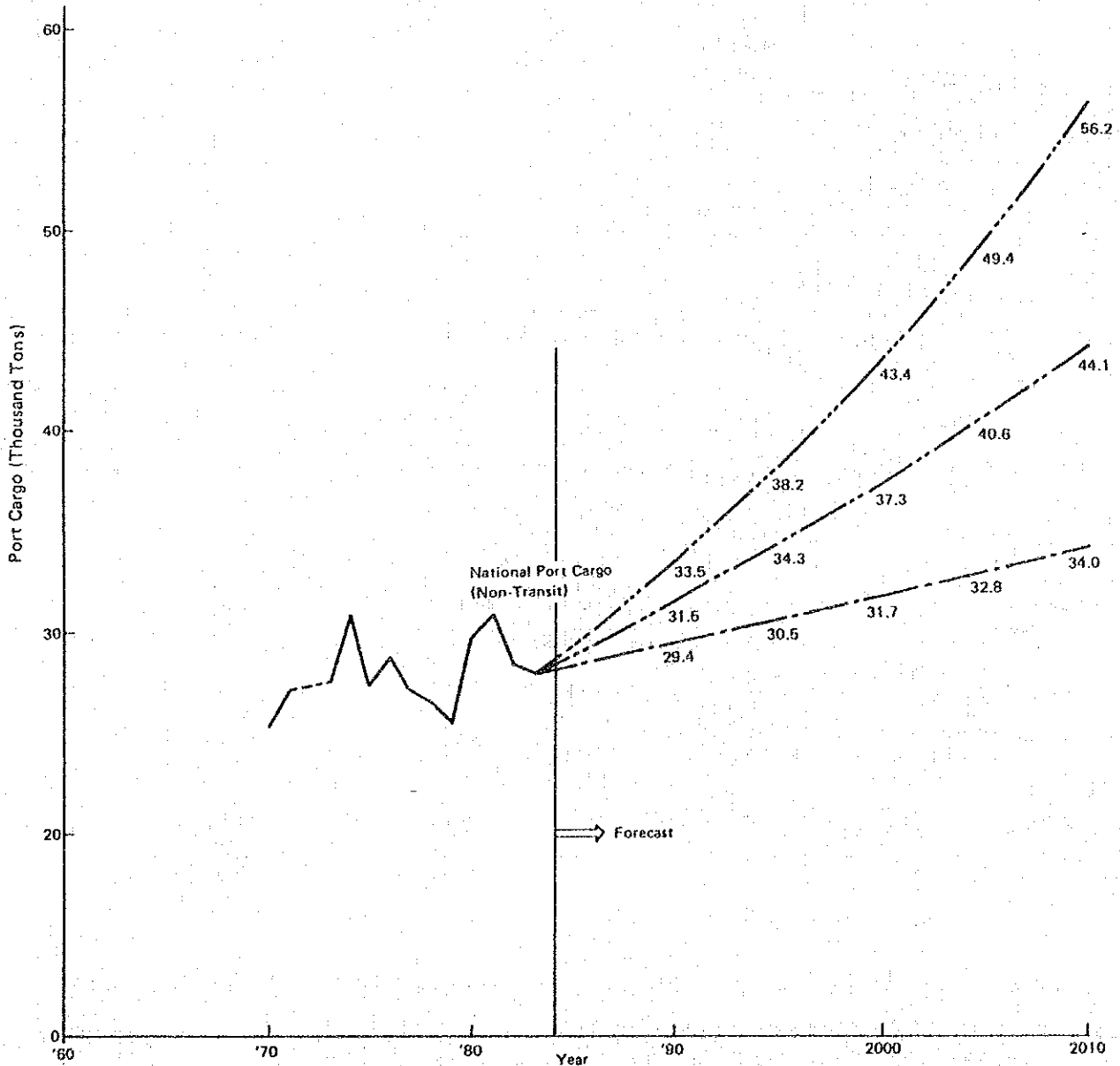| Rate \ Year	1990	1995	2000	2005	2010	Comments
0.7274%	29.4	30.5	31.7	32.8	34.0	too small compared with GDP growth
1.7016%	31.5	34.3	37.3	40.6	44.1	based upon elasticity to GDP
2.6185%	33.5	38.2	43.4	49.4	56.2	too large compared with actual records

Fig. V-2-1 Comparison of Future Cargo Volume Estimates
(Excluding Transit Cargo)

—254—

For this study, we adopt the second estimate, based on the elasticity to GDP, from the viewpoint of coordination with the Chilean economy and the actual records. The future throughput estimates are summarized in Table V-2-3.

Table V-2-3   Future Port Cargo in Chile

(in Thousand Tons)

Year	Cargo Volume	Index
1983	27,985	1.00
1990	31,494	1.13
1995	34,266	1.22
2000	37,282	1.33
2005	40,564	1.45
2010	44,135	1.58

2) Foreign (Import and Export) and Domestic Cargo

The historical growth rates of both foreign and domestic trade indicate no relation to socioeconomic indices, nor do import and export volumes. In this case, it may be most reliable to use trends of the changes of their share to predict future volumes. Table V-2-4 shows the historical record of the percentage of total cargo volume for each category. The domestic cargo figures are calculated using the double counting system, as mentioned before.

Table V-2-4 indicates that the share of foreign cargoes has been decreasing slightly and that the share of domestic cargoes has been slightly increasing. Specifically, the decreasing trend of foreign cargoes is due to decreased exports.

Increased exports give Chile more foreign exchange. Thus, it is politically advantageous to promote exports. The data obtained in the last survey show that the Chilean government has set high growth targets: 4.0 - 5.0% for overall economic growth and export growth rates for copper and non-copper over 8%. On the other hand, the policy to expand the areas under wheat cultivation is aimed at reducing imports. These policies are all

aimed at realizing a suitable balance of trade.

Considering the above, we project the tendencies of each category as shown in Table V-2-5 and Fig. V-2-2. The share of foreign cargoes is estimated to decrease slightly, and the share of imports is projected to remain at its historic level. Thus, the share of exports is projected to decrease slightly.

Table V-2-4   Percentages of Foreign and Domestic Cargoes

(in %)

Year	Total	Foreign	Import	Export	Domestic
1970	100.0	63.6	–	–	36.4
1971	100.0	66.4	–	–	33.6
1972	–	–	–	–	–
1973	100.0	62.2	–	–	37.8
1974	100.0	59.6	–	–	40.4
1975	100.0	64.2	17.7	46.5	35.8
1976	100.0	64.9	19.1	45.8	35.1
1977	100.0	64.2	20.2	44.0	35.8
1978	100.0	62.9	23.3	39.5	37.1
1979	100.0	61.4	19.1	42.2	38.6
1980	100.0	64.2	22.4	41.8	35.8
1981	100.0	62.2	24.0	38.2	37.8
1982	100.0	60.4	18.3	42.1	39.6
1983	100.0	57.1	18.9	38.2	42.9

[Note] Hyphens mean that the data is not available.

Table V-2-5   Future Share of Foreign
and Domestic Cargo

(in %)

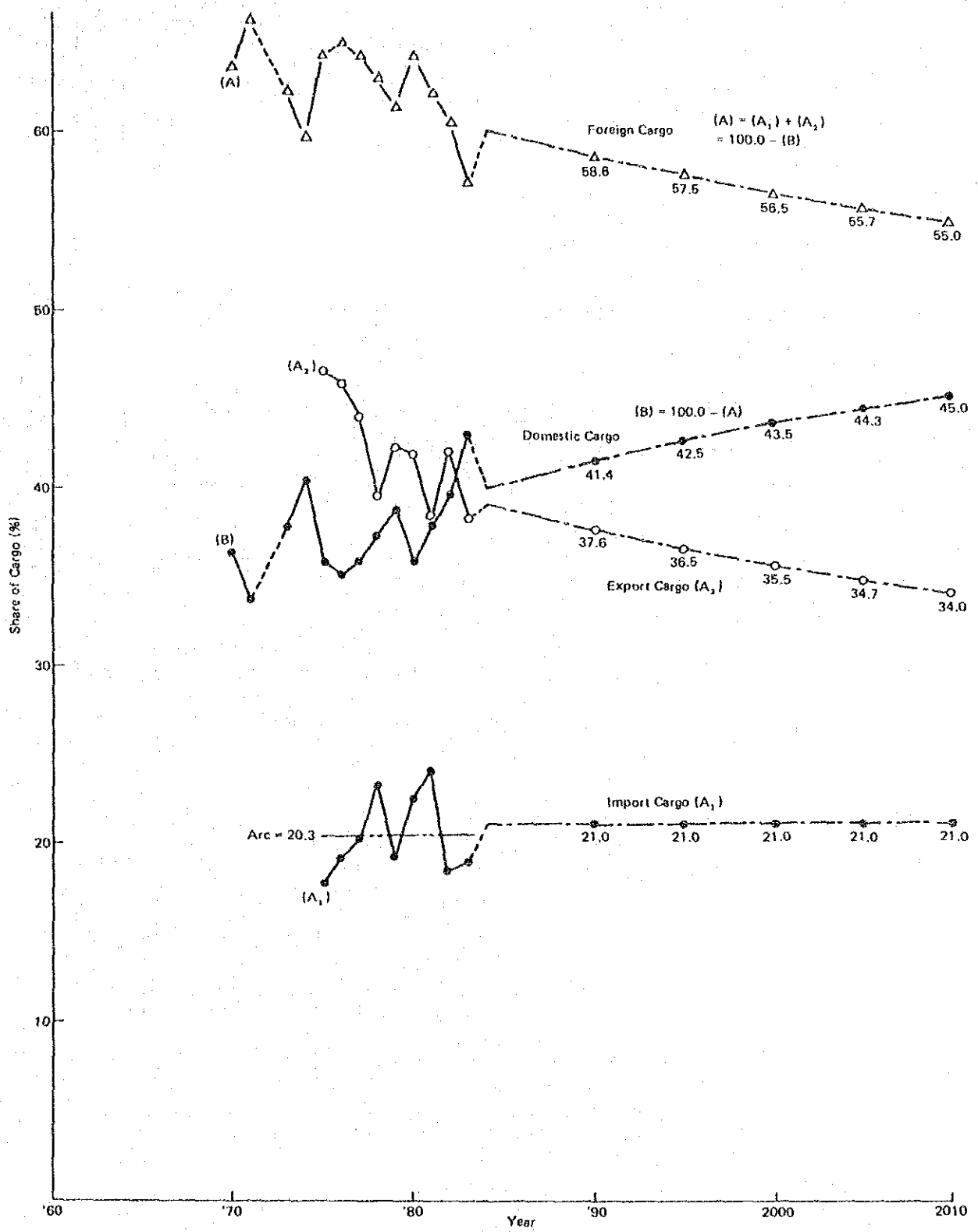| Year	Foreign	Import	Export	Domestic
1990	58.6	21.0	37.6	41.4
1995	57.5	21.0	36.5	42.5
2000	56.5	21.0	35.5	43.5
2005	55.7	21.0	34.7	44.3
2010	55.0	21.0	34.0	45.0

Fig. V-2-2 Share of Foreign (Import & Export) and Domestic Cargo
in Total Cargo Throughput (Excluding Transit Cargo)

Multiplying the shares in Table V-2-5 by the estimated total cargo throughput, the future cargo volume by category can be calculated. The results are shown in Table V-2-6 and Fig. V-2-3.

However, it is likely that the actual cargo volumes in the future will be slightly higher than these estimates.

Table V-2-6   Future Cargo Volume (Chile)

(in Thousand Tons)

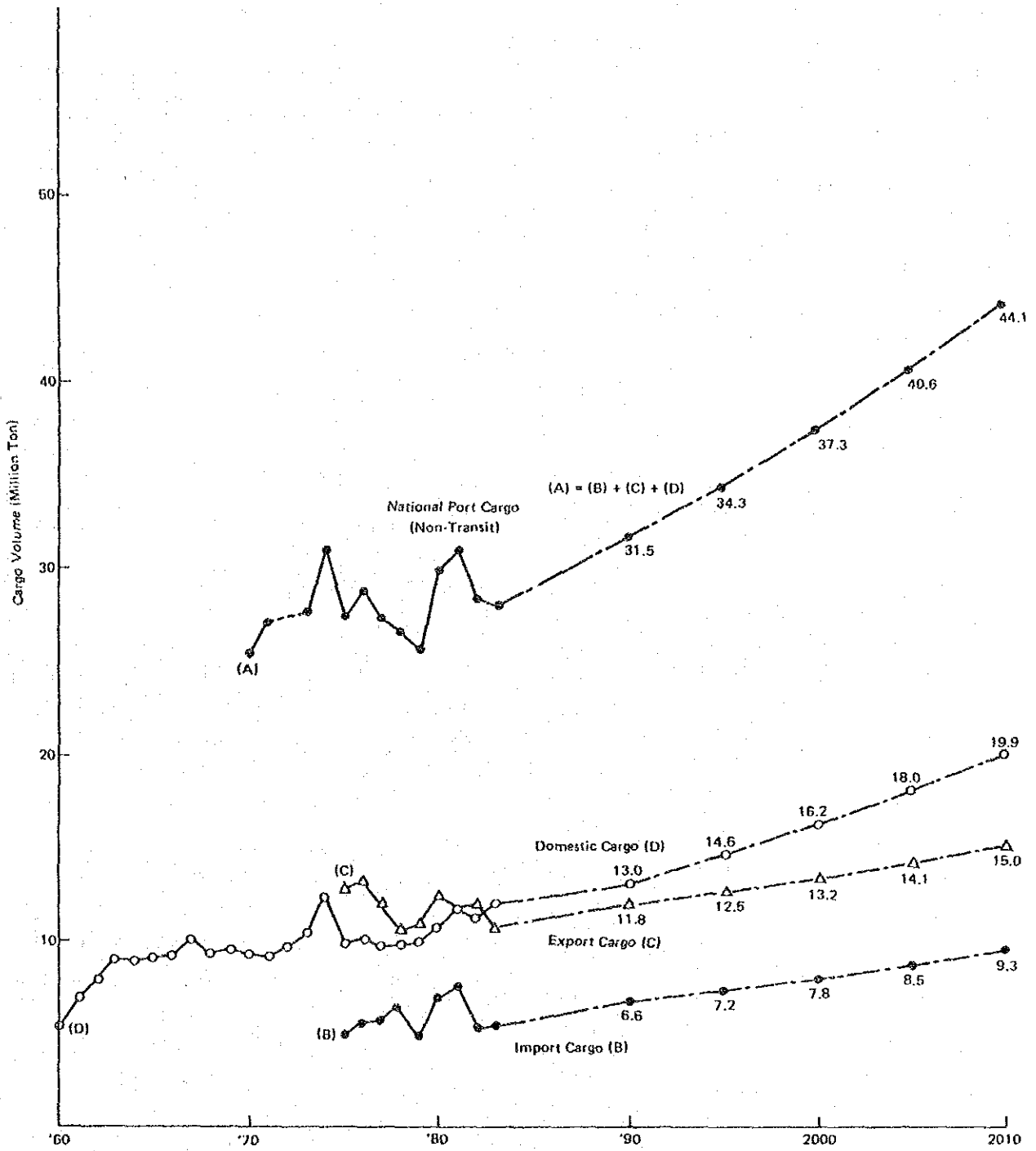| Year	Total	Foreign	Import	Export	Domestic
1983	27,985	15,976	5,276	10,700	12,009
1990	31,494	18,455	6,614	11,841	13,038
1995	34,266	19,703	7,196	12,507	14,563
2000	37,282	21,064	7,829	13,235	16,218
2005	40,564	22,594	8,518	14,076	17,970
2010	44,135	24,274	9,268	15,006	19,861

Fig. V-2-3 Forecast of Port Cargo (Whole Chile)

(2) Port Cargo at Valparaiso and San Antonio

The cargo volume to be handled at the ports of Valparaiso and San Antonio is first forecast as the total volume of the two ports as a macro estimate. The cargo volumes of individual goods are left out of this analysis. Individual volumes are then estimated separately based upon the results of the Multimodal Corridor Study, and the sum of these volumes is coordinated with the macro estimate.

The reasons why we are taking this approach are as follows:

① The cargoes of the two ports are determined in connection with national cargo statistics estimated on the basis of the state of the Chilean economy.

② The concept that the two ports will play their roles as part of one wide-range port is applied to formulate the master plans.

③ The methodology of the Multimodal Corridor Study in the future estimation of port cargoes by goods is reasonable enough for us to adopt the results as the micro estimate for our study.

The sum of the cargoes handled at the ports of Valparaiso and San Antonio from 1962 to 1983 is shown in Table V-2-7 by import, export, domestic and transit cargoes. The domestic volume is the total volume of loaded and unloaded cargoes. The shares of each type of cargo in the total cargo volume are also shown in the table.

1) Total Cargo

(i) Estimation by Numeric Model

Although only limited historical data are available, it is worth conducting an analysis on the correlation between the cargo volumes handled at the two ports and the GRP of their hinterland, which is the normal approach for forecasting future demand. Based upon the data in Table V-2-8, the following equation can be

formulated.

PCR : Port Cargo of Valparaiso and San Antonio
(in Thousand Tons)

GDPR : Gross Domestic Product of the Hinterland
(in Million Pesos at 1977 Prices)

PCR : 44.427 + 14.234 × GDPR   ----- (7)

$$R = 0.8299 \qquad R_2 = 0.6888$$

The values of the correlation coefficient (R) and the decision factor (R_2) indicate the reliability of the equation, and putting the forecast GDP (Refer to Table V-1-11) into the numeric model, the future cargoes can be calculated as shown in Table V-2-9.

Table V-2-7   Cargo Volume at Valparaiso & San Antonio Ports

(in Thousand Tons)

Year	Total	Import	%	Export	%	Domestic	%	Transit	%
1960									
1961									
1962	2,032	708	34.9	346	17.0	978	48.1	15	0.7
1963	2,086	621	29.8	375	18.0	1,090	52.2	26	1.3
1964	2,152	637	29.6	415	19.3	1,100	51.1	6	0.3
1965	2,286	837	36.6	414	18.1	1,035	45.3	5	0.2
1966	2,333	980	42.0	391	16.8	962	41.2	6	0.3
1967	2,277	956	42.0	407	17.9	914	40.1	17	0.7
1968	2,342	1,076	45.9	438	18.7	828	35.4	16	0.7
1969	2,425	1,297	53.5	450	18.6	678	28.0	13	0.6
1970	2,257	1,163	51.5	497	22.0	597	26.4	0	0.0
1971	2,322	1,260	54.3	437	18.8	625	26.9	0	0.0
1972	2,372	1,549	65.3	381	16.1	442	18.6	–	0
1973	2,552	1,839	72.1	271	10.6	442	17.3	–	0
1974	2,399	1,509	62.9	464	19.3	426	17.8	–	0
1975	2,081	1,153	55.4	635	30.5	293	14.1	–	0
1976	2,517	1,335	53.1	836	33.2	346	13.8	–	0
1977	2,753	1,321	48.0	1,056	38.4	376	13.6	–	0
1978	3,267	1,918	58.7	998	30.5	351	10.8	–	0
1979	3,539	2,097	59.3	1,089	30.8	353	10.0	–	0
1980	4,140	2,590	62.6	1,111	26.8	439	10.6	–	0
1981	4,358	2,887	66.2	1,165	26.7	306	7.0	–	0
1982	3,866	2,244	58.0	1,354	35.0	268	6.9	–	0
1983	3,660	1,985	54.2	1,418	38.8	257	7.0	–	0

Table V-2-8   Correlation between Port Cargo
and Regional GDP

Year	Port Cargo (in Thousand Tons)	GDP (in Billion Pesos)
1979	3,538.8	264.9
1980	4,140.4	283.0
1981	4,358.0	301.8
1982	3,865.7	255.1

Table V-2-9   Future Cargo Volume
by Numeric Model

(in Thousand Tons)

Year	Port Cargo	Index
1983	3,660	1.00
1990	4,753	1.30
1995	5,358	1.46
2000	6,040	1.65
2005	6,810	1.86
2010	7,679	2.10

(ii) Estimation by Percentage of Total Chilean Throughput

Table V-2-10 shows the percentage of the cargo handled at the two
ports in the total port throughput of Chile from 1970 to 1983. It
is clear that this percentage increases over the recorded period.
Based on the historical trend, the future percentages are
estimated in Table V-2-11, taking into consideration the future
population and GRP of the hinterland. The two tables and Fig.
V-2-4 also show the correlation between the cargo percent and the
population percent and between the cargo percent and the GDP
percent.

Table V-2-10   Hinterland Ratios

Year	Cargo %	Population %	Correlation	GDP %	Correlation
1970	8.9				
1971	8.6				
1972	not available				
1973	9.3				
1974	7.8	77.4	10.1		
1975	7.6	77.5	9.8		
1976	8.7	77.6	11.3		
1977	10.1	77.7	13.1		
1978	12.3	77.8	15.9		
1979	13.8	77.9	17.7	78.5	17.6
1980	13.9	78.0	17.9	77.9	17.9
1981	14.2	78.1	18.2	78.7	18.0
1982	13.6	77.6	17.6	77.4	17.6
1983	13.1	78.3	16.7		

Note: 1) Cargo % is the percent of total national throughput handled at the two subject ports.

2) Population % and GDP % are the percentages of the national population and the GDP in the hinterland.

Table V-2-11   Future Hinterland Ratios

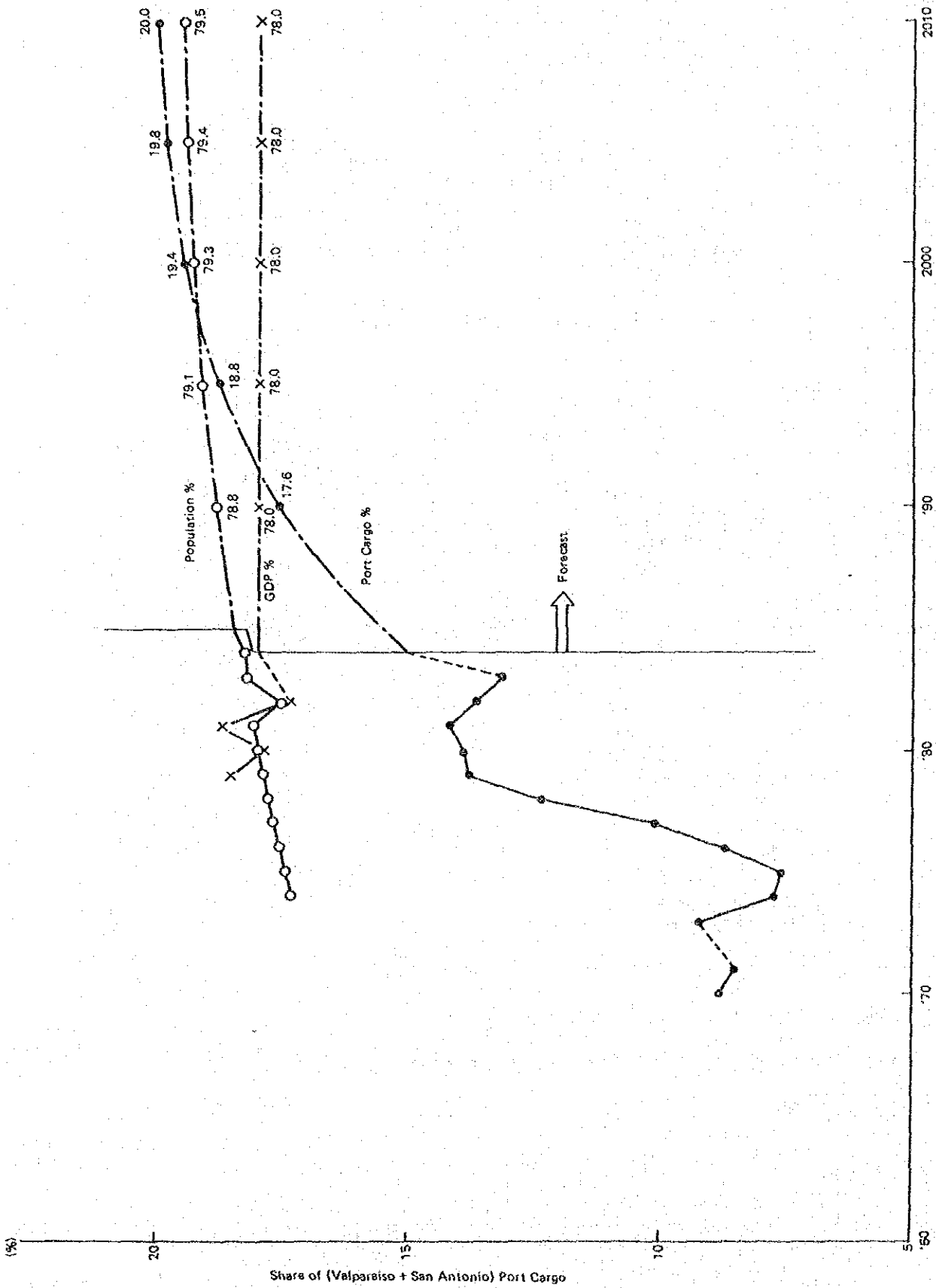| Year	Cargo %	Population %	Correlation	GDP %	Correlation
1990	17.6	78.8	22.3	78.0	22.6
1995	18.8	79.1	23.8	78.0	24.1
2000	19.4	79.3	24.5	78.0	24.9
2005	19.8	79.4	24.9	78.0	25.4
2010	20.0	79.5	25.2	78.0	25.6

Fig. V-2.4　Future Share of (Valparaiso + San Antonio) Cargo and Hinterland Ratios

The future cargoes of the two ports can also be estimated by multiplying the forecast cargo percent by the forecast national throughput, and the results are shown in Table V-2-12.

Table V-2-12   Future Cargo by Percent
of National Throughput

(in Thousand Tons)

Year	Port Cargo	Index
1983	3,660	1.00
1990	5,543	1.51
1995	6,442	1.76
2000	7,233	1.98
2005	8,032	2.19
2010	8,827	2.41

(iii)   Estimation by Percentage in EMPORCHI

Table V-2-13 shows the portion of national cargoes handled at ports administrated by EMPORCHI and the percentage of the EMPORCHI cargo handled at the two ports.
The multiplied results of the above two parameters are theoretically equal to the percentage of national cargoes handled at the two ports, as follows.

PC$_K$: Cargo Handled in Port K

PC$_{Valparaiso+San\ Antonio}$/PC$_{Chile}$ =

PC$_{Valparaiso+San\ Antonio}$/PC$_{EMPORCHI}$ × PC$_{EMPORCHI}$/PC$_{Chile}$

However, we judged after trial examinations that it is more meaningful to estimate the future values of the two parameters separately, because each showed a moderate and smooth change in historical records for more than ten years if abnormal data is

disregarded (Refer to Fig. V-2-5). Additionally, it is important to analyze how EMPORCHI promotes the activities of its ports. The graph indicates that EMPORCHI is taking a positive policy to gather port cargoes, and this fact should be considered in forecasting future demand. Based upon Fig. V-2-5, we can obtain the future values of the two shares - the ports of Valparaiso and San Antonio to EMPORCHI and EMPORCHI to Chile - as shown in Table V-2-14.

Table V-2-13   Portion of EMPORCHI in Chile and
Planned Ports in EMPORCHI

(in %)

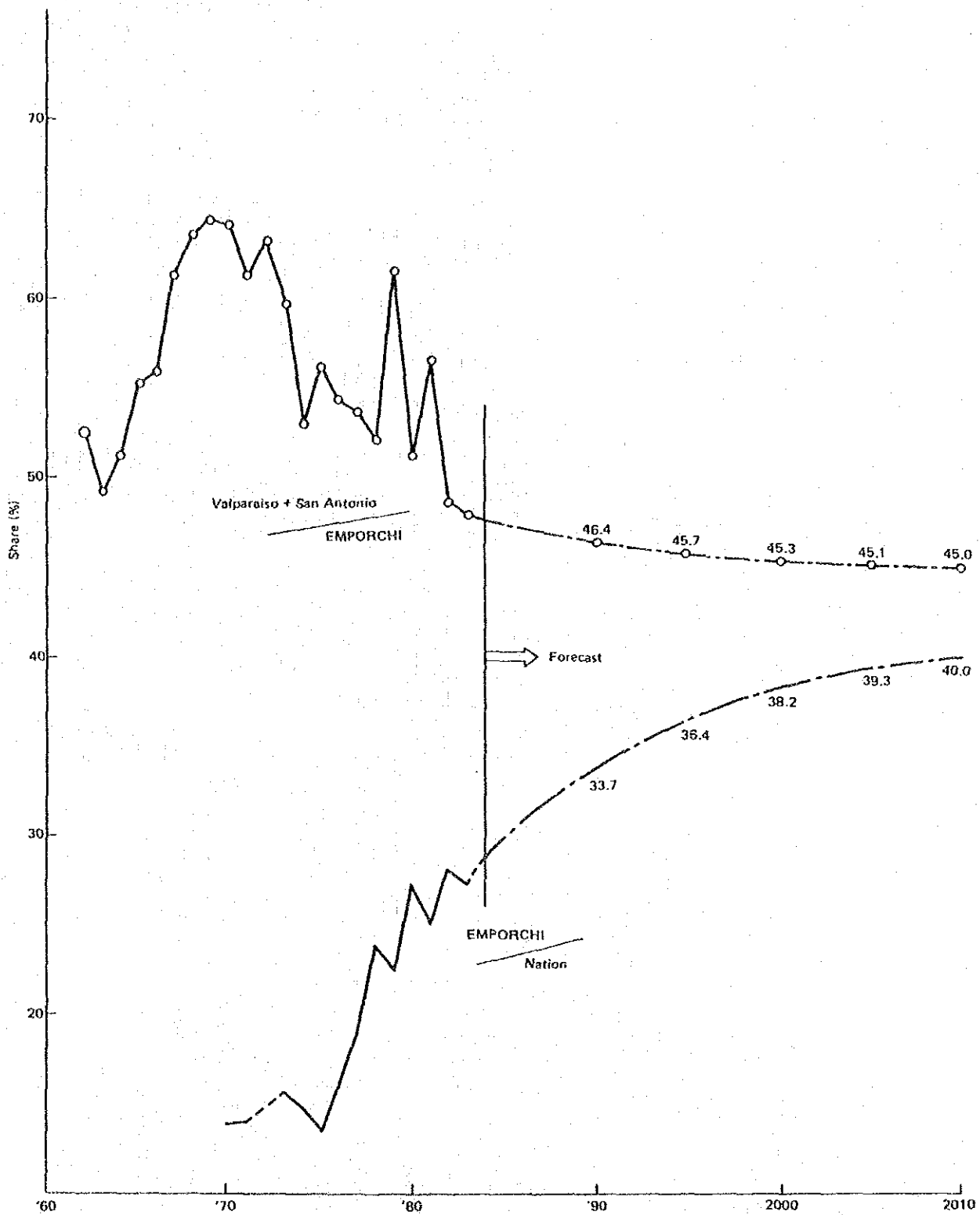| Year	EMPORCHI/Chile	The two/EMPORCHI
1962		52.5
1963		49.0
1964		51.2
1965		55.3
1966		55.9
1967		61.4
1968		63.5
1969		64.3
1970	13.8	64.1
1971	14.0	61.2
1972	not available	63.4
1973	15.5	59.7
1974	14.7	52.9
1975	13.5	56.2
1976	16.08	54.4
1977	18.90	53.7
1978	23.73	52.0
1979	22.40	61.7
1980	27.22	51.2
1981	25.06	56.6
1982	27.99	48.7
1983	27.25	48.0

Fig. V-2-5   Cargo Share
            (EMPORCHI to National Cargo)
            (Valparaiso and San Antonio to EMPORCHI Cargo)

Table V-2-14   Future Percentage of EMPORCHI to Chile
and Planned Ports to EMPORCHI

(in %)

Year	EMPORCHI/Chile	The two/EMPORCHI
1990	33.7	46.4
1995	36.4	45.7
2000	38.2	45.3
2005	39.3	45.1
2010	40.0	45.0

The future volume of cargoes to be handled at the two ports can be calculated using these percentages, and the results are summarized in Table V-2-15.

Table V-2-15   Future Cargo by Portion
to EMPORCHI

(in Thousand Tons)

Year	Port Cargo	Index
1983	3,660	1.00
1990	4,925	1.35
1995	5,700	1.56
2000	6,452	1.76
2005	7,190	1.96
2010	7,944	2.17

(iv) Estimation of Total Cargo

The analyses conducted above give three kinds of forecasts for the target years. As the volumes were forecast independently and show a deviation from the average of roughly -8.0% ~ +10.0%, the future estimate of the cargo throughput at the two ports is taken as the average volume of the three forecasts. (Refer to Table V-2-16).

Thus, the total cargo volume is determined as shown in Table V-2-17 and Fig. V-2-6.

Table V-2-16   Deviation of Each Forecast

(in Thousand Tons, %)

Year	Average	By Model	Deviation	By Portion to Chile	Deviation	By Portion to EMPORCHI	Deviation
1990	5,074	4,753	Δ 6.3	5,543	+ 9.3	4,925	Δ 2.9
1995	5,833	5,358	Δ 8.1	6,442	+10.4	5,700	Δ 2.3
2000	6,575	6,040	Δ 8.1	7,233	+10.0	6,452	Δ 1.9
2005	7,344	6,810	Δ 7.3	8,032	+ 9.4	7,190	Δ 2.1
2010	8,150	7,679	Δ 5.8	8,827	+ 8.3	7,944	Δ 2.5

Table V-2-17   Total Port Cargo of Valparaiso and San Antonio

(in Thousand Tons)

Year	Cargo Volume	Index
1983	3,660	1.00
1990	5,074	1.39
1995	5,833	1.59
2000	6,575	1.80
2005	7,344	2.01
2010	8,150	2.23

The future throughput at the ports is estimated as 6,575 thousand tons in 2000 and 8,150 thousand tons in 2010, that is 1.80 times and 2.23 times the 1983 throughput.
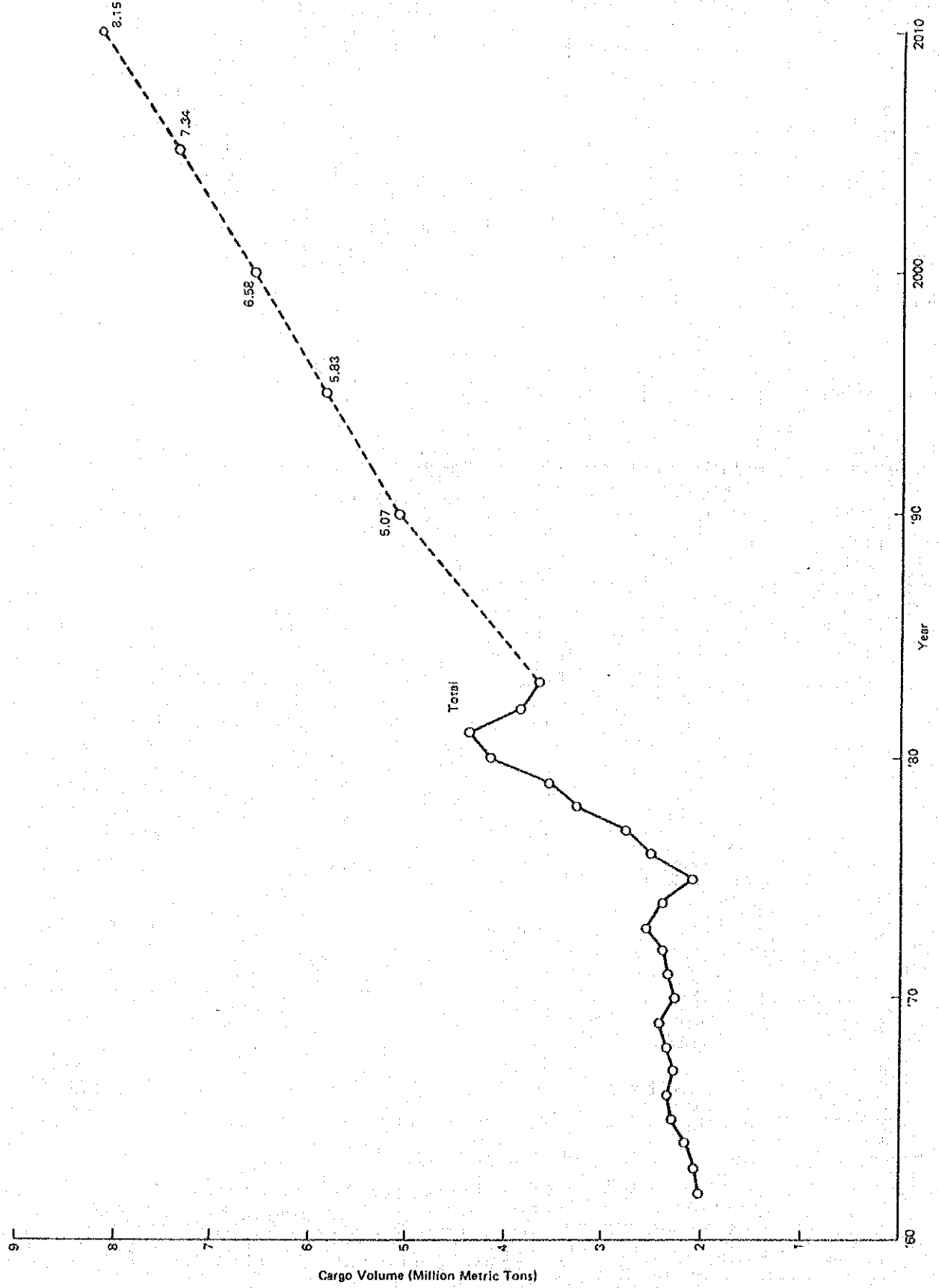
Fig. V-2-6 Cargo Throughput of Valparaiso & San Antonio Ports

2) Foreign and Domestic Cargo

The trend of share changes of foreign and domestic cargoes in the total cargoes of the two ports is discussed based upon Table V-2-7. These share trends are also applicable for the forecast of each cargo volume.

The actual records show that the percentage of domestic cargo is continuously decreasing, and that the shares of import and export show no regular trend (Refer to Fig. V-2-7). The fact is that foreign cargoes might not depend on the economic state of Chile but on the circumstances of world trade and on the domestic political situation.

Here, we assume as follows.

As for the domestic cargo of the two ports, its portion to the total will decrease slightly in accordance with the historical trend. The share of foreign cargo, as a whole, will increase in response to the reduction of the domestic share. Import cargo will hold the same level as in 1983, 55% of the total, taking into account the Chilean foreign exchange situation, and the export cargo will increase slightly in accordance with the national policy.

These assumptions give the future percentages of each item as shown in Table V-2-18 and Fig. V-2-7.

Table V-2-18 Future Percentage of Import,
Export and Domestic Cargoes

(in %)

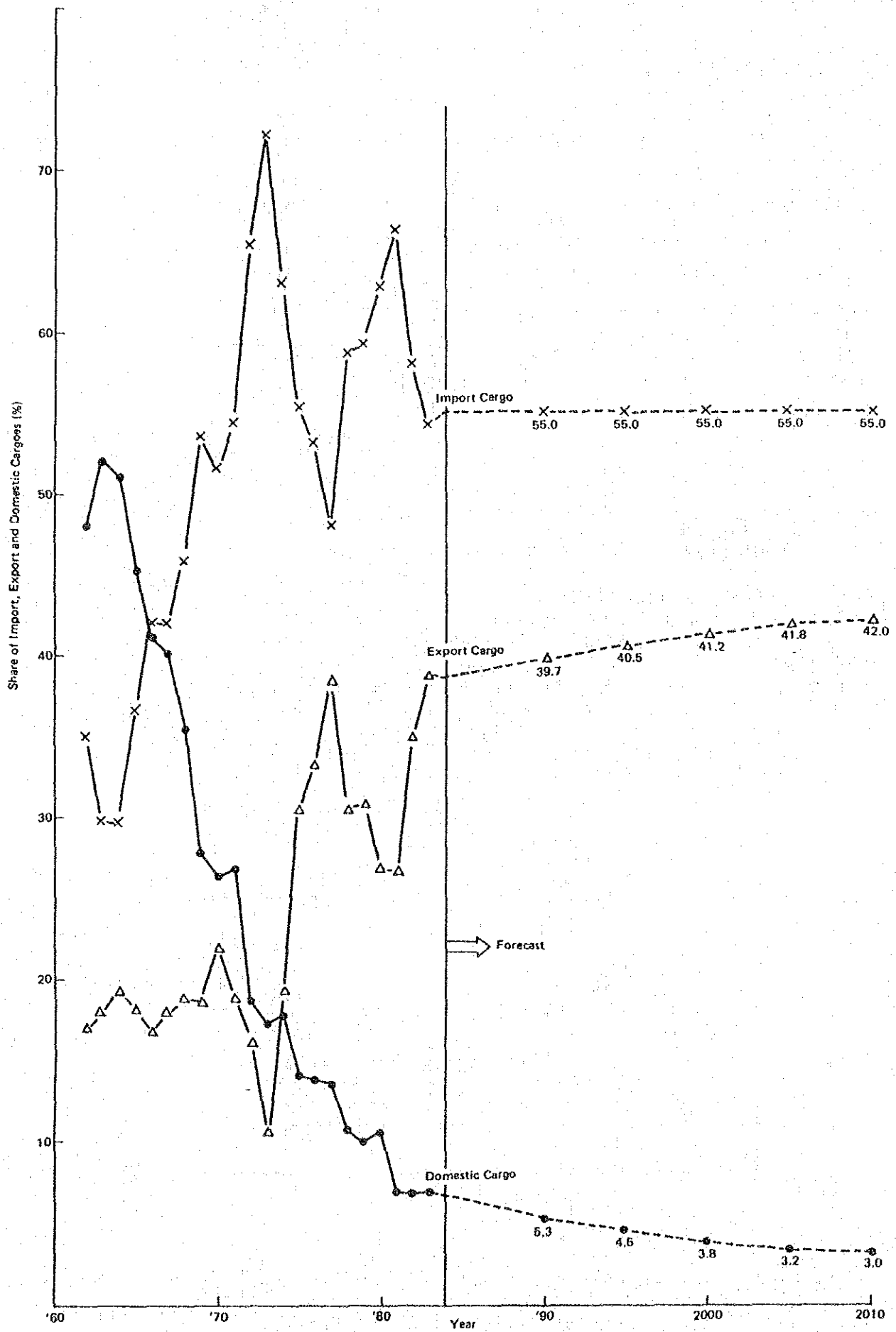| Year	Import	Export	Domestic
1990	55.0	39.7	5.3
1995	55.0	40.5	4.5
2000	55.0	41.2	3.8
2005	55.0	41.8	3.2
2010	55.0	42.0	3.0

Fig. V-2-7 Percentages of Import, Export and Domestic Cargoes

The future cargo throughput at the ports of Valparaiso and San Antonio are obtained by multiplying the percentages by the estimated total cargo of the two ports for each category, and Table V-2-19 shows the results.

Table V-2-19   Import, Export and Domestic Cargoes of
the Subject Ports in the Future

(in Thousand Tons)

Year	Import	Index	Export	Index	Domestic	Index
1983	1,985	1.00	1,418	1.00	257	1.00
1990	2,791	1.41	2,014	1.42	269	1.05
1995	3,208	1.62	2,362	1.67	263	1.02
2000	3,616	1.82	2,709	1.91	250	0.97
2005	4,039	2.03	3,070	2.17	235	0.91
2010	4,483	2.26	3,423	2.41	244	0.95

The import cargo is estimated to reach about 3,616 thousand tons in 2000 and 4,483 thousand tons in 2010, which is 1.82 times and 2.26 times the 1983 cargo. The export cargo is forecast as 2,709 thousand tons (1.91 times) in 2000 and 3,423 thousand tons (2.41 times) in 2010, which indicates higher growth than imports. As for domestic cargo, Table V-2-19 shows a 5% reduction from 1983 to 2010 on a mathematical basis, but it can be estimated that the handling volume will stay almost the same as at present throughout the forecasting period.

3) Transit Cargo

We, now, have estimated the volumes of non-transit port cargo at Valparaiso and San Antonio. However, taking into consideration the potential of the ports, the topographical advantages of Chile and good relations with neighboring countries, there seems a possibility of an increase in the transit cargoes to and from other countries, especially Bolivia, Peru and Argentina. This has to be discussed and studied in more detail, but at this moment it is very difficult to estimate the type and quantity of transit cargoes as well as their origins and destinations

because of the lack of appropriate information and data.

In this study, we assume that the volume of such transit cargoes will not exceed the port capacity, and that the cargoes will be general cargoes including container cargoes. Thus, it is judged acceptable that the estimation of the volume of such transit cargoes can be left for a future study.

A "Land Bridge", which would connect the inland areas of Argentina to the Pacific Ocean may be realized in the future.

4) Future Cargo

The cargoes to be handled at the ports of Valparaiso and San Antonio in the target years for formulation of the master plans are summarized as shown in Table V-2-20 and Fig. V-2-8.

Table V-2-20 Future Port Cargoes of Valparaiso and San Antonio

(in Thousand Tons)

Year	Total	Foreign Trade	Import	Export	Domestic Trade
1990	5,074	4,805	2,791	2,014	269
1995	5,833	5,570	3,208	2,362	263
2000	6,575	6,325	3,616	2,709	250
2005	7,344	7,109	4,039	3,070	235
2010	8,150	7,906	4,483	3,423	244
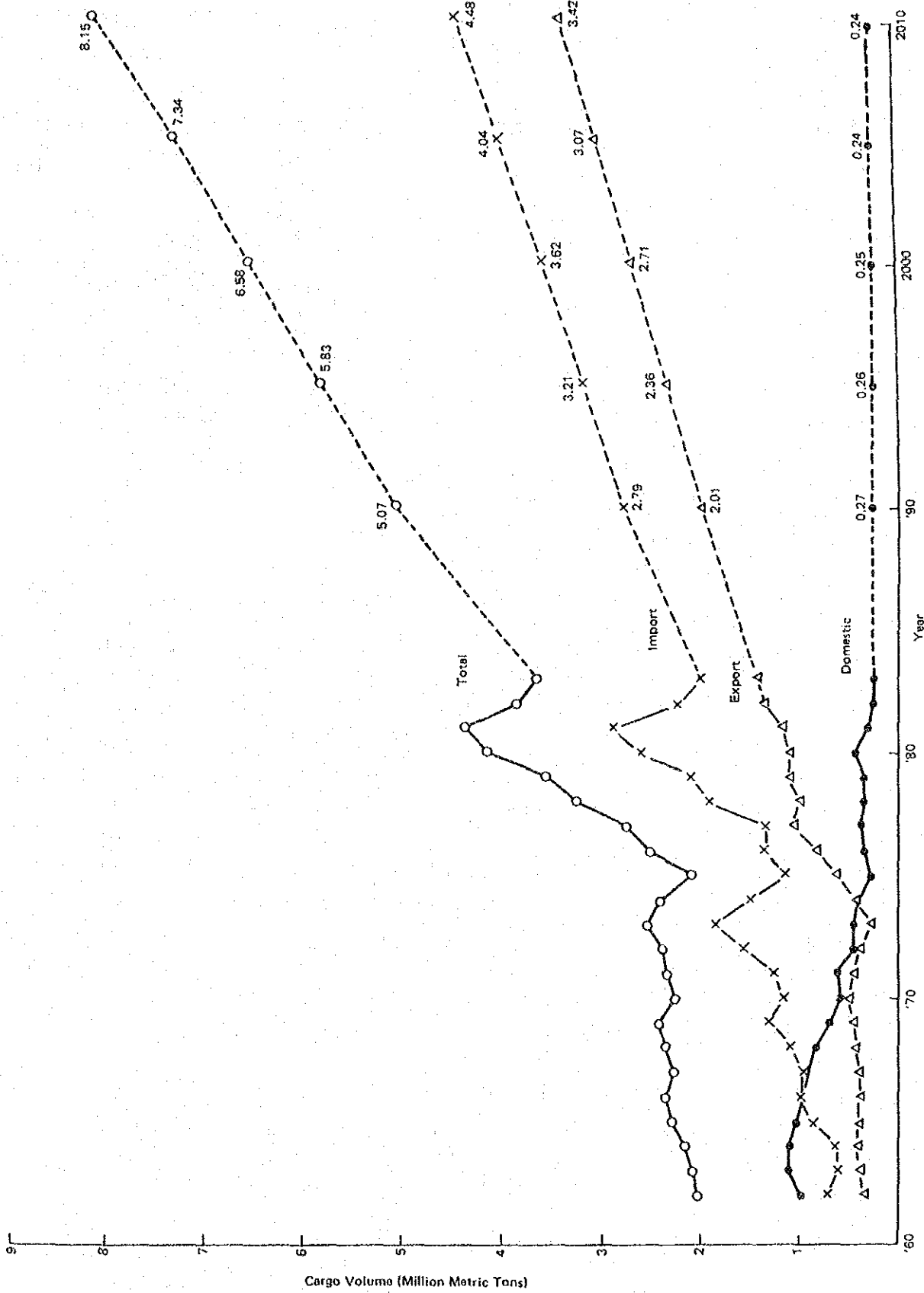
Fig. V-2-8 Cargo Volume of Valparaiso & San Antonio Ports

Cargo Volume (Million Metric Tons)

The forecast volume of future cargoes from the Multi-modal Corridor Study are presented in Table V-2-21.

For both total cargo and foreign cargo, our macro estimates presented above are larger before 2000 and smaller after 2000 than the figures in the multi-modal study. As for domestic cargo, the Multi-modal Corridor Study forecasts an increasing tendency contrary to the forecast in this JICA study, but from the viewpoint of the volumes involved, the difference is considered negligible.

However, there are some differences in terms of import and export cargo volumes. The multi-modal study seems to lay greater store on the national policy than on historical records, and it leads to a stronger forecast of export cargo than our estimation. This difference is remarkable until 2000, as indicated by the fact that the volume of the export cargo is larger than that of imports.

For reference, the differences in estimates are illustrated in Fig. V-2-9.

Table V-2-21   Forecast by Multi-modal Corridor Study

Year	Total	Foreign Trade	Import	Export	Domestic
1990	4,708	4,390	1,840	2,550	307
1995	5,630	5,287	2,305	2,982	330
2000	6,451	6,079	2,912	3,167	358
2005	7,889	7,482	3,745	3,737	389
2010	9,789	9,342	4,866	4,476	427

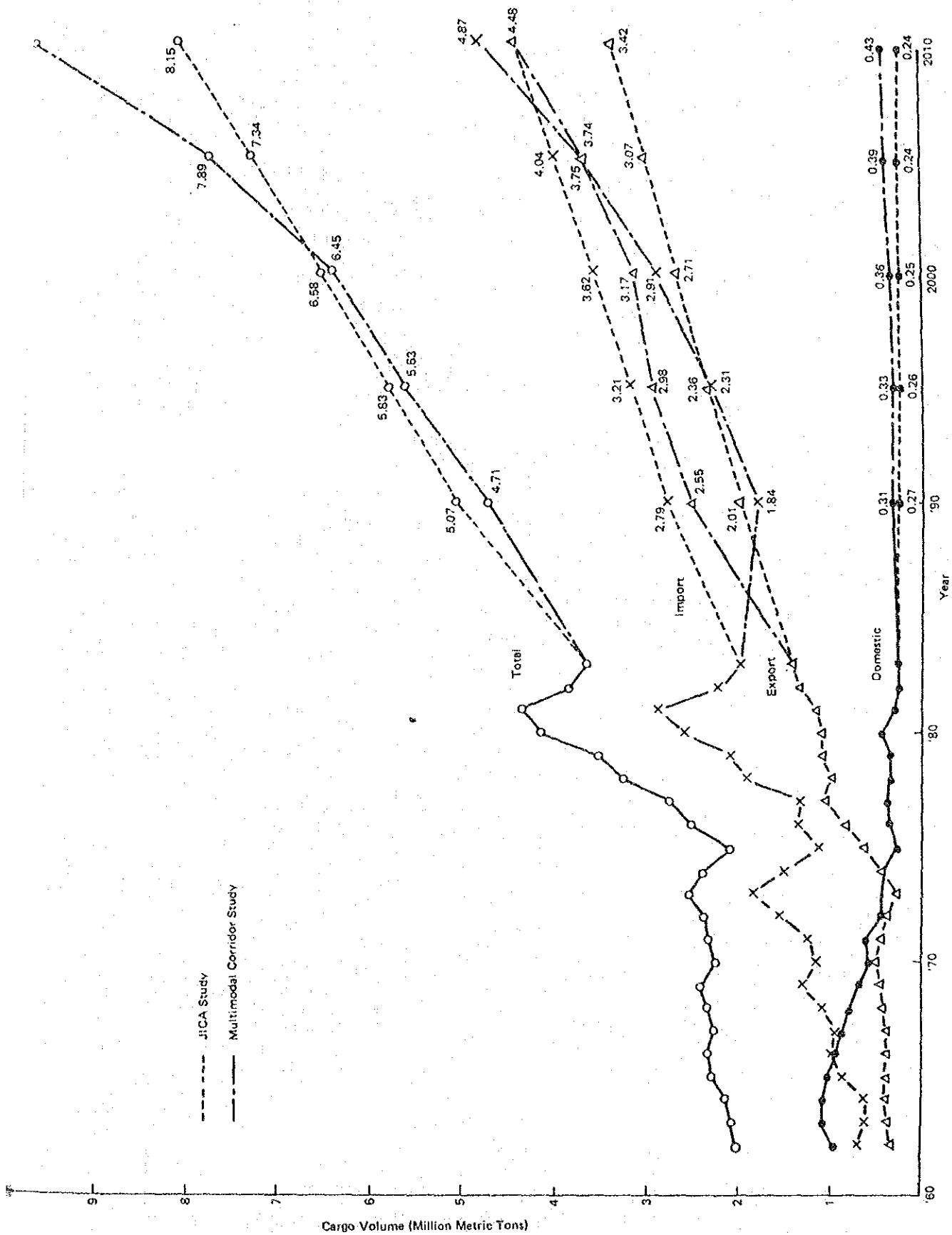[Note]   The sum of the foreign and domestic cargoes does not equal the total.

Fig. V-2-9 Difference between Estimation of Multimodal Corridor Study and JICA Study

(3)　Forecast by Major Commodity Groups

1)　General

For this forecast, cargo handled at the ports of Valparaiso and San Antonio is classified into fruits and vegetables, copper, wheat and other general cargo. These cargoes comprise the main cargoes at both ports.

Concerning the cargo volume of fruits and vegetables, copper, and wheat, forecasts were executed in the Multi-modal Corridor Study, and these cargo forecasts are adopted based on our review. But as for other general cargo, an independent forecast is executed in this JICA study.

2)　Fruits and Vegetables

(i)　General

The historical data of fruits and vegetables exports through the ports of Valparaiso and San Antonio is shown in Table V-2-22.

Table V-2-22　Fruit Cargo Handled at Both Ports

('000 tons)

| Year | Port | | Total | Annual Growth (%) |
	Valparaiso	San Antonio		
1976	130.0	0.8	130.8	
1977	144.5	0.2	144.7	11
1978	182.6	37.1	219.7	52
1979	210.8	28.9	239.7	9
1980	238.9	47.6	286.5	20
1981	250.2	82.5	332.7	16
1982	280.0	89.8	369.8	11
1983	346.8	62.4	409.2	11
1984	419.7	96.5	516.2	26
Average Annual Growth	16%	82%		19

Source : EMPORCHI, INECON

Total exports in 1984 were 516 thousand tons, of which 420 thousand tons were handled at the port of Valparaiso and 96 thousand tons at the port of San Antonio. As may be seen in Table V-2-22, the average annual growth of the total exports was 19% during the period 1976 ~ 1984. Exports at the port of Valparaiso grew 83% and exports at the port of San Antonio grew 17% during the same period. Table V-2-23 shows the composition of the fruits and vegetables exported through each port.

Table V-2-23

a) Port of Valparaiso

Products	Period 1982~83		Period 1983~84	
	Volume (tons)	Percentage	Volume (tons)	Percentage
Grapes	154,311	46.7	192,526	48.2
Apples	126,644	38.3	129,217	32.4
Pears	19,918	6.0	18,382	4.6
Nectarines	13,326	3.0	17,807	4.5
Onions	1,237	0.4	15,863	4.0
Melons	7,388	2.2	10,668	2.7
Plums	5,318	1.6	9,252	2.3
Peaches	1,717	0.5	4,005	1.0
Others	894	0.3	1,642	0.4
Total	330,753	100.0	399,362	100.0

b) Port of San Antonio

Products	Period 1982~83		Period 1983~84	
	Volume (tons)	Percentage	Volume (tons)	Percentage
Apples	45,360	72.7	76,010	78.8
Grapes	14,117	22.6	7,760	8.0
Others	2,938	4.7	12,688	13.2
Total	62,415	100.0	96,458	100.0

Source: Analisis del Periodo de Embarque de Productos
        Hortofruticolas

(ii) Fruit Exports in the Future

The forecast of the export of agricultural products was executed in the Multi-modal Corridor Study.
In the Multi-modal Corridor Study, the methodology used to forecast the export of agricultural products took into account the following points:

① Area planned at the present time, by region and by type of fruit
② Regional production by type of fruit
③ Percentage of production exported.
④ Area available by region that is suitable for fruit
⑤ Forecasts of the cultivated area and production published in the Triennial Plan 1984 ~ 1987

In addition to above points, it has been assumed that some of the production of the 3rd and 4th Regions will be shipped through the port of Coquimbo.

Finally, the overall results of the forecasts show that the exports through both ports will grow at an average rate of 3% per year, reaching a total of 1,052 thousand tons by 2010, as may be seen in Table V-2-24.

Table V-2-24 Fruits and Vegetables Cargo Forecast

	1984	1990	1995	2000	2005	2010
III	12.4	22.3	19.1	22.3	25.5	28.7
IV	19.9	19.9	17.3	20.3	23.4	26.5
V	114.2	116.4	134.3	152.5	171.3	190.7
RM	81.4	112.5	130.0	146.2	163.4	182.1
VI	165.8	299.0	319.8	332.4	345.9	360.4
VII	102.8	216.4	232.2	242.4	252.8	263.4
Total	496.5	786.5	852.8	916.2	982.3	1051.9

Source: The Report of the Multi-modal Corridor Study

2) Copper

(1) General

The historical volume of copper production and exports is shown in
Table V-2-25. As may be seen, the production volume was 1,308
thousand tons in 1984, and almost all of this (1,260 thousand
tons) was exported. In the 5th Region, there are three copper
export ports (the ports of Quitero, Valparaiso and San Antonio)
shown in Fig. V-2-10, and about 800 thousand tons was handled at
these ports in 1984. The remaining volume (from the Chuquicamata
mines) was handled at the port of Antofagasta.
The port of San Antonio has exported, on the average, about 65% of
the total copper exported by the subject ports (1979 ~ 1984), with
the remaining 35% being handled at the port of Valparaiso as shown
in Table V-2-26. The report of the Multi-modal Corridor Study
states that this high share of the port of San Antonio is due to
the fact that this port has specialized in copper exports.
Towards this, the El Teniente Division of CODELCO and the mine
Disputada de los Condes have their own facilities including
storage areas and handling equipment within the port.

Table V-2-25   Copper Production and Exports in Chile

Year	Production ('000 tons)	Export ('000 tons)
1979	1,068	1,010
1980	1,063	1,045
1981	1,106	1,038
1982	1,255	1,211
1983	1,255	1,251
1984	1,308	1,260

Source: Anuario dela Mineria de Chile 1984

Road
Railway
Factory
Port
Mine
Copper Deposit

IV REGION

V REGION

VENTANAS
QUINTERO

VALPARAISO

PUDAHUEL

ANDINA

DISPUTADA

SANTIAGO

REGION METROPOLITANA

SAN ANTONIO
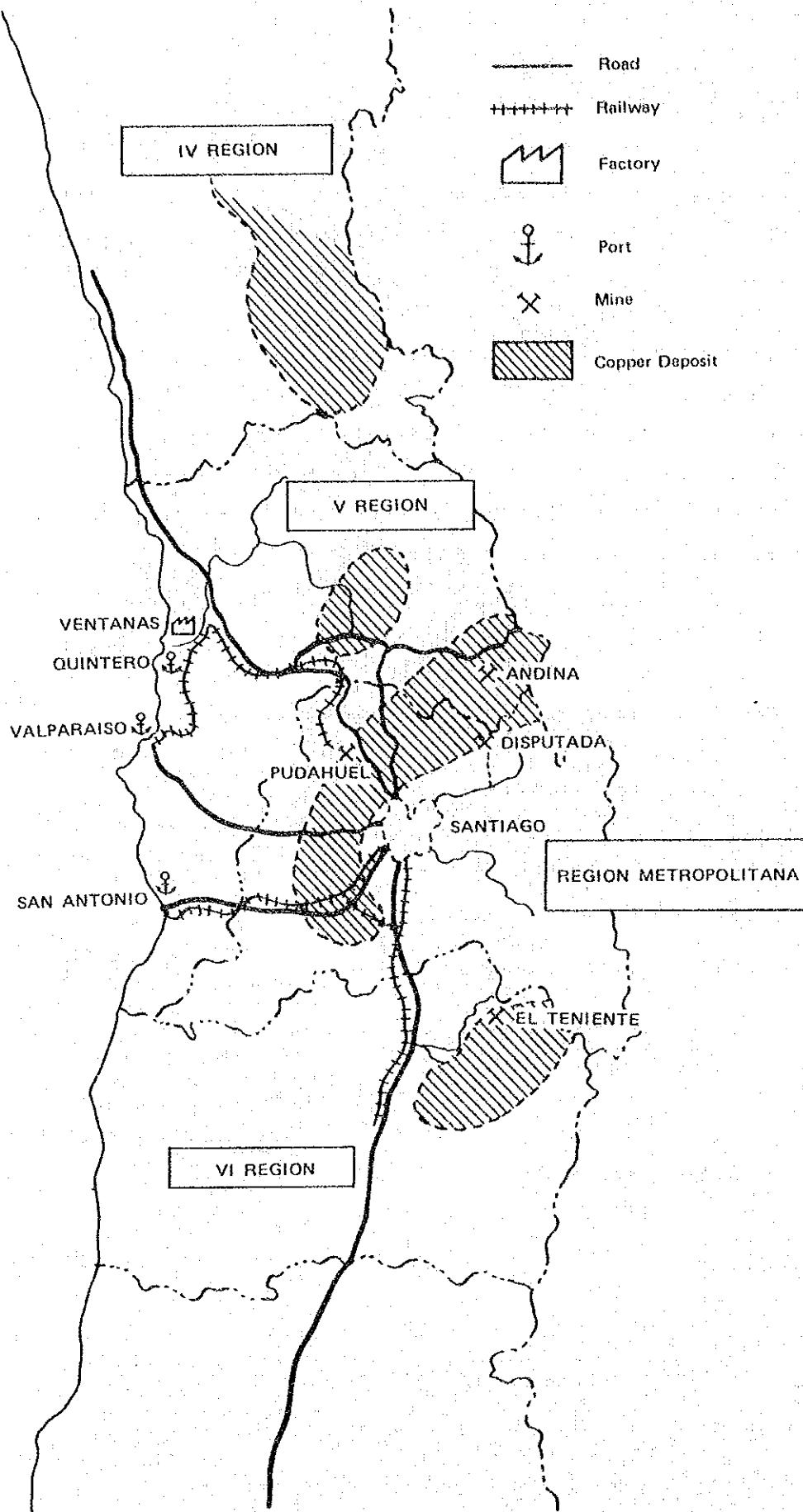
EL TENIENTE

VI REGION

Fig. V-2-10 Distribution of Mines and Ports

Table V-2-26   Copper Exports at the Two Subject Ports

('000 tons)

Year	Valparaiso	San Antonio	Total
1979	154.1	248.7	402.8
1980	151.9	276.4	428.3
1981	182.9	283.8	466.7
1982	167.2	379.7	546.9
1983	212.2	404.5	616.7
1984	193.4	401.7	595.1

Source : EMPORCHI

(ii) Exports

Table V-2-27 shows the forecast copper exports at 5th Region ports. These figures were supplied through the ministry by the Comision Chilena de Cobre which carried out the Multi-modal Corridor Study. We have also adopted these figures for the forecast of copper exports. In the report of Multi-modal Study, the comment by the Commission runs as follows.

With respect to the volumes exported, it will be seen that in the case of blister and refined copper, an increase of approximately 100 thousand tons is forecast for the year 1990 compared with 1984, maintaining thereafter a level of the order of 600 thousand tons, relatively steady up to the year 2010. For copper concentrates, an increase of the order of 200 thousand tons per year is expected for the period 1990 ~ 1995 compared with 1984, then a strong decrease for the period 1995 ~ 2010 ending at a level of approximately 90 thousand tons, almost 200 thousand tons less than that exported in 1984. This decrease is due in part to a reduction in the export of concentrates from Andina, which will be transformed into refined copper, and in part to a significant reduction in the export of concentrates by Disputada on account of the working out of El Soldado.

Table V-2-28 shows the total cargo volume of copper exports at both ports, given from the Commission.

Table V-2-27   Forecast Copper Exports for 5th Region Ports

('000 tons)

	1984	1990	1995	2000	2005	2010
a) Blister, Refinados REGION/YACIMIENTO						
VI EL TENIENTE	319	362	362	342	342	342
V (Chagres) LA DISPUTADA	37	44	44	44	44	44
V (Ventanas) ENAMI	172	210	210	210	210	210
RM (Pudahuel) MINERA PUDAHUEL	13	15	15	0	0	0
SUB-TOTAL	541	631	631	596	596	596
b) Concentrado de cobre						
V (Los Andes) LA ANDINA	199	268	181	0	0	0
V (El Soldado) LA DISPUTADA	19	119	159	47	47	47
RM (Los Bronces) LA DISPUTADA	68	119	159	47	47	47
SUB-TOTAL	286	506	499	94	94	94
TOTAL	827	1137	1130	690	690	690

Source: The Report of the Multi-modal Corridor Study
        (The Comision Chilena de Cobre)

Table V-2-28   Forecast of Copper Exports

('000 tons)

Year	1984	1990	1995	2000	2005	2010
Forecast Volume	595.1	869	948	690	690	690

Source: The Report of the Multi-modal Corridor Study (Comision
        Chilena de Cobre)

3) Wheat

(i) General

Most of the agricultural bulk cargo currently handled at Chilean ports is wheat. Up to 1984, maize and sugar were imported, but as a result of the new agricultural policy, the volume of imported maize through the port of San Antonio abruptly decreased from 355 thousand tons in 1982 to 34 thousand tons in 1984. Besides, the Triennial Plan includes a policy to increase the rate of self-supply in these products. For example, the rate for sugar will reach 93% in 1987. As mentioned above, assuming that Chile will become sufficient in maize and sugar in the near future, it is sufficient to execute only the forecast for wheat.

Table V-2-29 shows historical wheat imports through the port of San Antonio and the total wheat imports in Chile. The port of San Antonio is the main port for wheat imports and its share was 89% in 1984.

Table V-2-29   Wheat Imports

('000 tons)

Year	(A) National Total	(B) Imported through the Port of San Antonio	(B)/(A) (%)
1979	729	593	81.3
1980	870	792	91.0
1981	1,029	862	83.7
1982	992	896	90.3
1983	1,160	981	84.6
1984	958	848	88.6

Source: EMPORCHI, Central Bank

To forecast the future total annual imports of wheat, it is necessary to first determine the national consumption and the national production, since the difference between these is the amount of wheat that has to be imported.

Table V-2-30 shows the historical data related to the production and consumption of wheat in Chile. The forecast results are shown in Table V-2-31.

Table V-2-30 Wheat Production and Consumption in Chile

Year	Sown Area (hectares)	Yield (100kg/ha)	Production (tons)	Population	Total Consumption (tons)	Per Capita Consumption (kg)
1965	727,078	15.3	1,112,429	8,509,717	1,022,018	120.1
1966	779,970	17.3	1,349,348	8,674,772	1,076,993	124.1
1967	718,500	16.7	1,199,895	8,843,028	1,053,744	119.2
1968	700,160	17.4	1,218,278	9,014,548	1,091,181	121.0
1969	743,050	16.3	1,211,172	9,189,394	1,123,605	122.3
1970	740,300	17.7	1,310,331	9,367,632	1,176,317	125.6
1971	727,420	18.8	1,367,550	9,527,817	1,227,235	128.8
1972	711,820	16.8	1,195,858	9,690,742	1,227,734	126.7
1973	533,790	14.0	747,306	9,856,453	1,332,295	135.2
1974	591,010	12.4	732,852	10,024,997	1,332,033	132.8
1975	686,190	14.6	1,001,837	10,196,423	1,254,242	123.0
1976	697,570	12.4	864,987	10,371,856	1,375,242	132.6
1977	628,010	19.4	1,218,339	10,550,306	1,285,695	121.9
1978	579,590	15.4	892,569	10,731,828	1,329,708	123.9
1979	560,470	17.8	997,637	10,916,472	1,334,994	122.3
1980	545,740	17.7	965,960	11,104,293	1,258,652	113.3
1981	432,160	15.9	685,970	11,291,884	1,295,520	114.7
1982	373,800	17.4	650,452	11,482,643	1,278,787	111.4
1983	359,180	16.3	585,953	11,676,626	1,304,607	111.7
1984	413,225	21.0	867,773	11,873,885	1,330,000	112.01

Source: The Report of the Multi-modal Corridor Study
(Ministerio de Agricultura Oficina de Planificacion Agricola)

Table V-2-31 Forecast of Wheat Imports

('000 tons)

		1984	1990	1995	2000	2005	2010
Consumption	Population (thousand persons)	11,878.4	13,348.0	14,619.5	16,012.0	17,537.1	19,207.6
	Per Capita Consumption (kg/year/person)	112	109	105	101	100	100
	Total Consumption (thousand tons)	1,330	1,455	1,535	1,617	1,754	1,921
	Other Usages (thousand tons)	495	538	568	598	649	711
	① National Consumption (thousand tons)	1,825	1,993	2,103	2,215	2,403	2,632
Production	Cultivation ('000 ha)	413	600	600	600	600	600
	Yield (100kg/ha)	21	24	26	27	28	30
	② National Production (thousand tons)	867	1,440	1,560	1,620	1,680	1,800
①－②	National Imports (thousand tons)	958	553	543	595	723	832

4) General Cargo

(i) General

The general cargo described here is comprised of the following
items:
Fruits (only imports)
Flour
Celulose and Wood pulp
Timber
Copper (only imports)
Vehicles
Foodstuffs
Agricultural products
Mineral products
Industrial products
Chemical products
Others

The cargo volumes of each of these commodities handled at both
ports from 1976 to 1984 are shown in Tables V-2-32 and V-2-33 and
Figures V-2-11 and V-2-12.
As may be seen, the handling volume of each of the commodities at
both ports varied greatly year by year showing no obvious trends.
But as indicated in Fig. V-2-4, the total volume of these cargoes
in relation to GDP_R (Gross Domestic Product of the Hinterland) was
relatively stable. So the total cargo volumes in the target
years are forecast by the method using Regression Analysis.

Table V-2-32 Imported General Cargo

('000 tons)

	VALPARAISO									SAN ANTONIO								
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1976	1977	1978	1979	1980	1981	1982	1983	1984
Fruits	31.5	48.2	54.4	81.7	99.9	126.6	97.6	47.4	48.8		0.05	0.2	0.2	2.9	1.5		0.5	2.0
Flour	11.0	20.6	9.2	9.5		3.5	8.2	6.6	1.9	5.9	3.4	2.4	3.0	2.4	0.6	2.2	0.2	3.9
Cellulose, Wood Pulp	1.0	1.5	2.0	1.0		1.6	1.1	1.3	0.8	1.5	0.5	0.2	0.2	0.4	0.2			
Timber	0.2	0.5	0.4	0.1		2.9	1.5	0.4	0.3	0.2	0.007	0.06	0.2	0.04	0.1			
Copper	0.4	1.3		4.7			0.4	14.6	0.02	0.005		0.08		0.5				
Vehicles	8.4	38.4	28.7	44.6	73.3	136.1	21.9	7.7	12.4	1.8	0.1	2.1	3.7	7.5	20.9	4.1	1.1	1.1
Foodstuffs	35.6	53.2	64.1	79.2	31.7	26.0	26.9	50.2	76.4	23.8	1.5	8.3	15.2	22.9	7.9		16.3	1.9
Agricultural Products	12.6	20.4	5.7	4.4		6.2	3.0	3.1	4.4	19.5	6.7	15.8	59.7	29.5	0.02		0.4	15.1
Mineral Products	36.8	45.1	55.2	59.2		129.0	27.4	29.5	53.8	7.0	5.8	16.8	9.0	54.0	28.5	12.8	20.0	9.6
Industrial Products	50.3	82.2	98.7	98.6		76.4	153.4	225.6	223.5	1.8	3.4	33.1	9.7	14.8	17.4		14.1	36.0
Chemical Products	50.0	113.4	120.1	135.2		76.2	88.5	106.5	93.0	6.0	9.3	18.4	43.5	73.6	107.3	71.1	83.3	279.2
Others	104.4	127.9	208.4	341.8	809.4	686.2	186.4	66.1	115.5	11.1	30.5	65.9	139.1	71.7	193.8	199.7	176.1	186.2
TOTAL	342.2	552.7	646.9	859.9	1,014.3	1,270.7	616.3	559.0	630.8	78.6	61.4	163.3	283.5	280.2	378.2	289.9	312.0	454.6
TOTAL (Valparaiso and San Antonio)	420.8	614.1	810.2	1,143.4	1,294.5	1,648.9	906.2	871.0	1,065.4									

Source : EMPORCHI

Table V-2-33　Exported General Cargo

('000 tons)

VALPARAISO

	1976	1977	1978	1979	1980	1981	1982	1983	1984
Flour	4.0	0.1				0.3	0.8	0.2	-
Celulose, Wood Pulp	0.005	0.003	0.2			0.2	2.4	2.4	0.1
Timber	8.2	6.9	1.5	0.07		0.3	6.1	10.0	9.1
Vehicles	0.2	0.3	0.2	0.2	0.5	0.1	0.3	2.0	0.1
Foodstuffs	15.1	37.2	36.5	27.4	1.5	51.2	55.8	46.3	57.3
Agricultural Products	83.6	138.8	82.1	93.1		23.8	16.8	10.1	11.4
Mineral Products	9.1	6.1	2.7	2.9		7.1	14.9	9.0	9.4
Industrial Products	12.1	27.8	4.7	1.4		3.1	11.0	13.0	11.8
Chemical Products	9.6	12.1	19.8	19.0		11.7	17.0	14.3	19.0
Others	50.5	48.3	74.5	101.1	219.9	72.1	33.5	20.0	25.6
TOTAL	192.4	277.6		245.2	221.9	169.9	156.2	127.3	143.8

SAN ANTONIO

	1976	1977	1978	1979	1980	1981	1982	1983	1984
Flour	10.6	3.6	4.0	-	-	0.2	0.3	3.5	-
Celulose, Wood Pulp			0.09	45.8	0.4	13.4	10.6	7.1	10.9
Timber	1.6	8.6	15.4	7.2	5.7	0.7	2.3	2.5	3.4
Vehicles	0.005	0.01	0.07	0.2	0.05	0.02	0.3	1.2	1.5
Foodstuffs	0.2	16.8	18.0	20.5	5.8	0.5	6.9	22.0	3.7
Agricultural Products	6.2	29.3	30.8	43.3	36.5	20.9	20.0	7.7	27.1
Mineral Products	8.1	2.5	5.0	4.7	5.5	3.2	8.3	2.1	47.5
Industrial Products	1.3	12.7	5.7	1.5	1.8	3.0	7.3	0.4	5.0
Chemical Products	0.03	0.4	0.3	1.05	1.3	1.6	1.4	3.3	4.5
Others	53.7	81.7	104.0	78.2	143.3	153.3	232.3	215.5	171.1
TOTAL	81.7	155.6	183.4	202.5	200.4	196.8	289.7	265.3	274.7

TOTAL (Valparaiso and San Antonio)

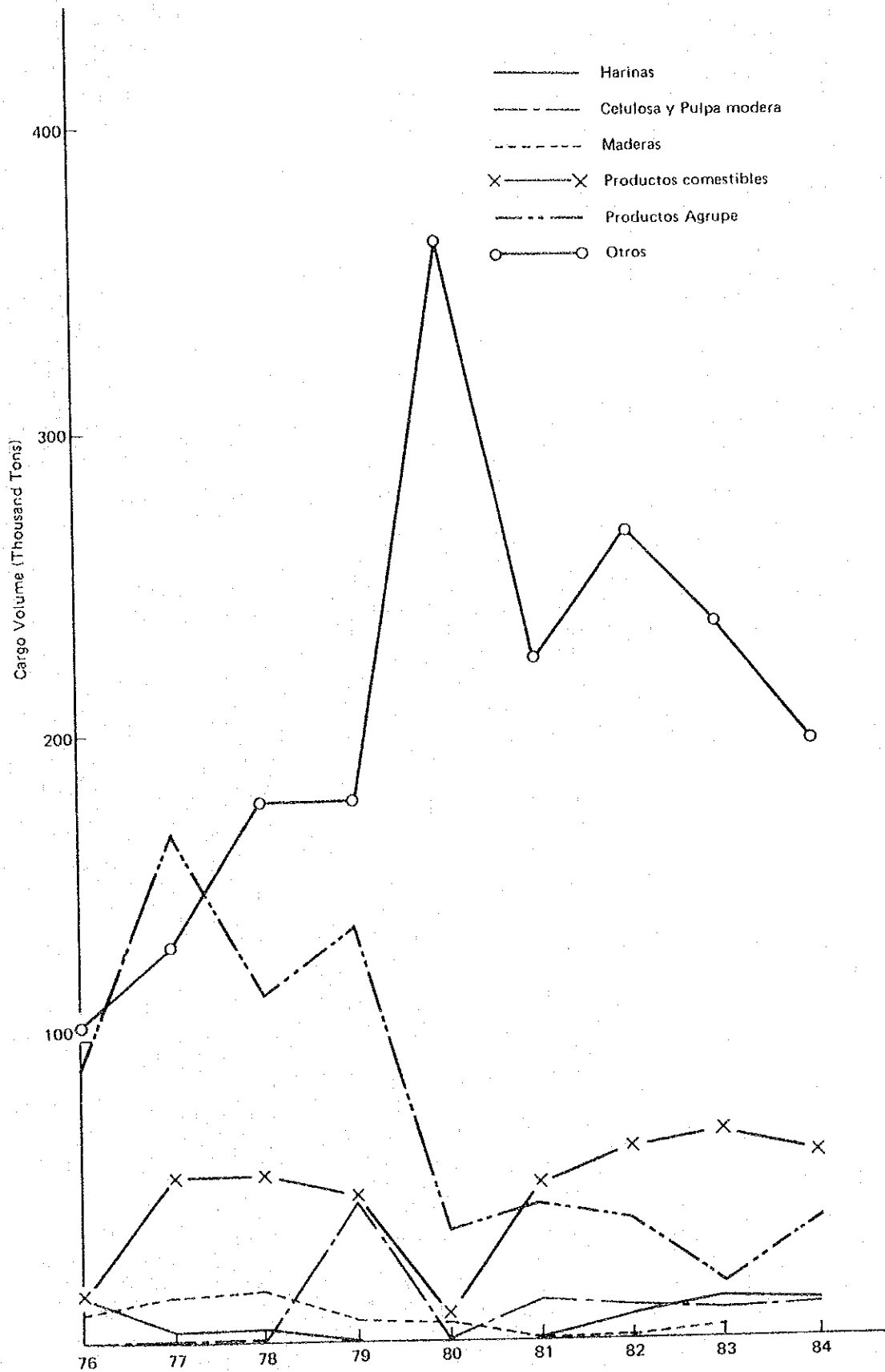|	1976	1977	1978	1979	1980	1981	1982	1983	1984
TOTAL (Valparaiso and San Antonio)	274.1	433.2	405.6	447.7	422.3	366.7	445.9	392.6	418.5

Source : EMPORCHI

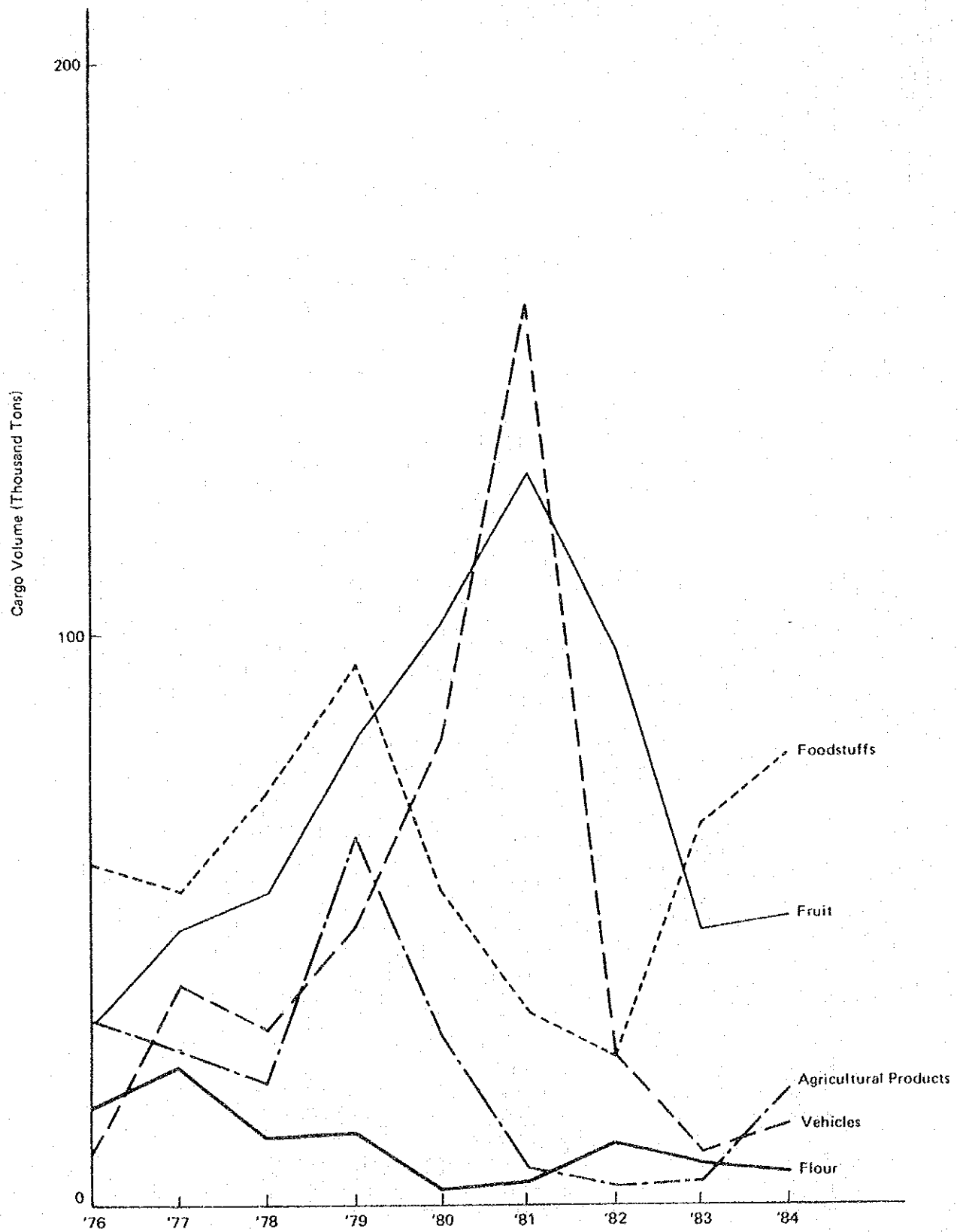Fig. V-2-11 Trend of Export Cargo
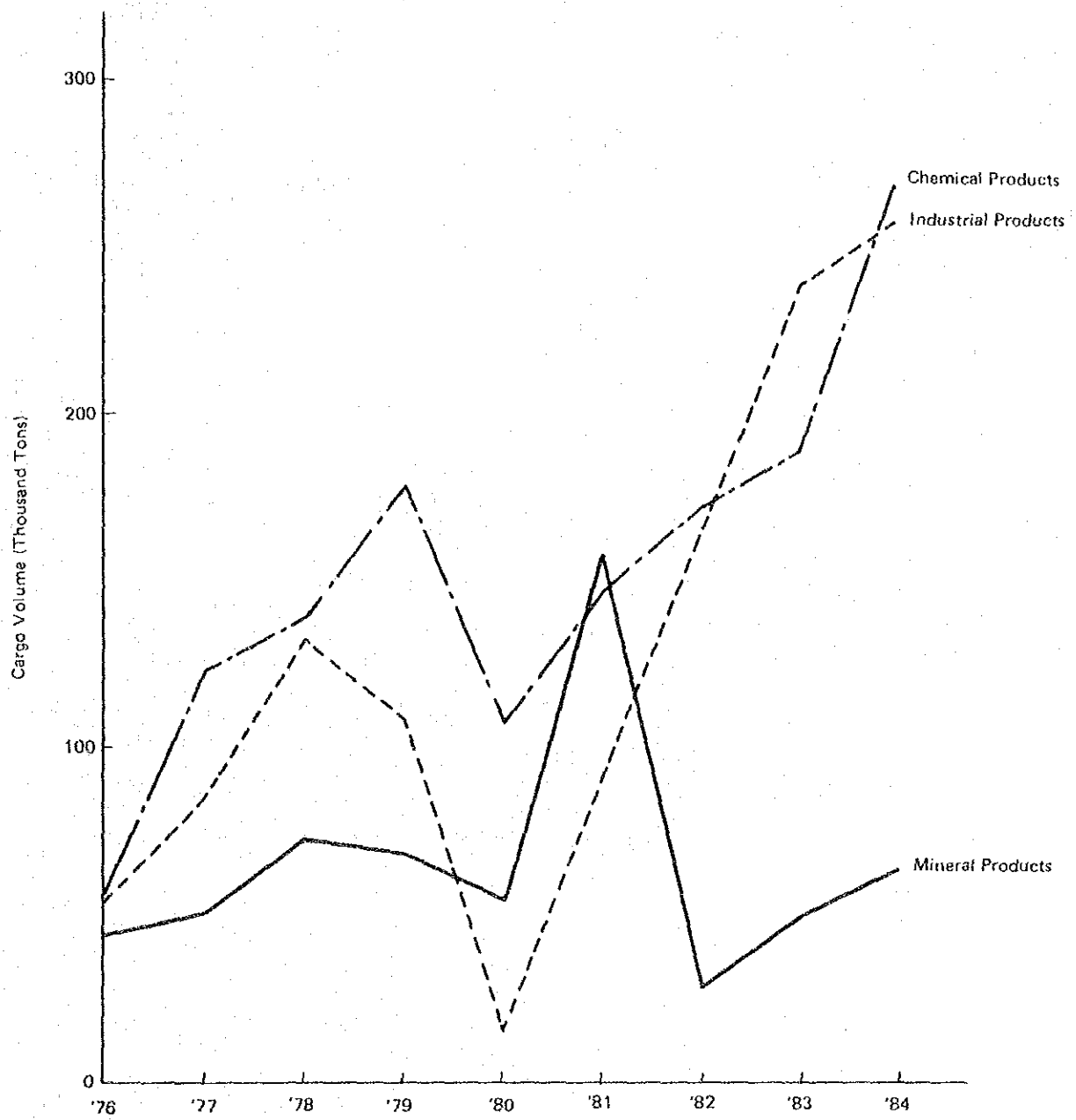
Fig. V-2-12   Trend of Import Cargo (a)
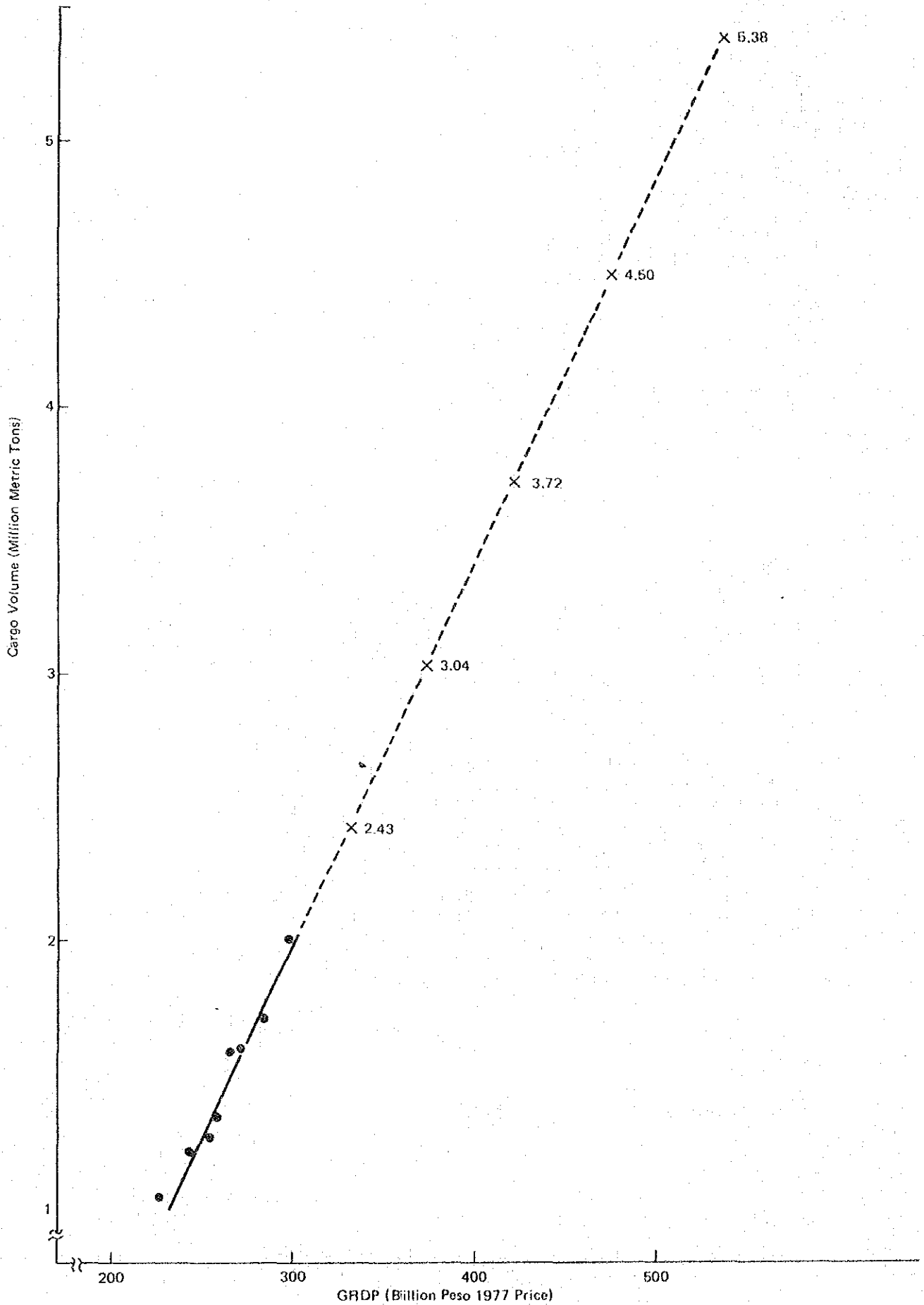
Fig. V-2-12   Trend of Import Cargo (b)

Fig. V-2-13   Correlation between Cargo Volume and GRDP

(ii)　Result of the forecast by Regression Analysis

The correlation formula between these cargoes and GRP_R is shown below, and the future cargo volumes are estimated as shown in Table V-2-34.

$Y = 14.36 X - 2324$　　　(R = 0.97)

　X: GRP_R

　　　(Unit: Million pesos in 1977 constant prices)

　Y: Cargo volume (Unit: thousand tons)

　R: Correlation coefficient

Table V-2-34　Forecast of General Cargo Throughput by
Correlation between Cargo Flow and GRP

('000 tons)

Year	1984	1990	1995	2000	2005	2010
GDP_R (Million Pesos)	269.3	330.8	373.3	421.2	475.3	536.4
Cargo Volume (thousand tons)	1,604	2,426	3,037	3,724	4,501	5,378

(iii)　Cargoes which cannot be Containerized (Bulky cargoes)

In the commodities mentioned above, there are some cargoes which are not suitable for containerization such as timber and liquid cargo. It is necessary to separate the volume of these cargoes from the total general cargo volume before forecasting the future container cargo volume.

i)　Timber

The export volume of timber and wood products in Chile was 1,953 thousand tons in 1984, exported mainly through the port of San Vicente. Chilean timber is highly competitive on the international market. Because of this, the Government has designated timber and wood products as a key export cargo, and

is promoting this industry. In the Triennial Plan, it is estimated that exports of timber and wood products will increase dramatically. In line with this national policy, CORFO has planned a forest development project in the 6th Region, calling for the development of 500 thousand hectares. In addition, a plan covering 90 thousand hectares of forest has already been implemented. Considering these plans, we estimate that wood and timber exports will grow at an average annual growth rate of 9.6% as projected in the Triennial Plan. The forecast result is shown in Table V-2-36.

ii) Liquid Cargo

The volume of liquid cargo including chemical products and foodstuffs in 1984 is shown in Table V-2-35. These cargoes are mainly import cargoes.

Table V-2-35 Imported Liquid Cargo handled at Both Ports

('000 tons)

	1983	1984
Port of Valparaiso	5	5
Port of San Antonio	179	159
Total	184	164

It is assumed that these cargoes will increase at the growth rate of 3% presented in the macro forecast. The forecast result is shown in Table V-2-36.

Thus, the total volume of cargoes unsuitable for containerization is estimated as 625 thousand tons in 2010.

Table V-2-36 Forecast of General Cargoes Unsuitable
for Containerization

('000 tons)

	1984	1990	1995	2000	2005	2010
Liquid Cargo (Import)	164	196	214	263	288	354
Timber (Export)	25	43	57	108	143	271
Total	189	239	271	371	431	625

(iv) Result

A summary of the total foreign cargo forecasts is shown in Table V-2-37.

Table V-2-37 Total Foreign Cargo Forecast

('000 tons)

	1990	1995	2000	2005	2010
Fruits and Vegetables	787	853	916	982	1,052
Copper	869	948	690	690	690
Wheat *	481	472	518	629	724
General Cargo	2,426	3,037	3,724	4,501	5,378
Total	4,563	5,382	5,848	6,802	7,844

(Note) * Refer to Table V-2-48

On the other hand, Table V-2-38 is a comparison of the total foreign cargo volumes obtained by the macro and micro forecast methods. The forecast cargo volumes seem to be within an allowable difference.

Herein, the total foreign cargo volumes handled at both ports in the target years are forecast as those figures obtained by the macro forecast method.

Table V-2-38   Comparison of Cargo Volumes Between
Macro and Micro Forecasts

('000 tons)

Year	1990	1995	2000	2005	2010
(A) Macro Forecast	4,805	5,570	6,325	7,109	7,906
(B) Micro Forecast	4,563	5,382	5,848	6,802	7,844
Difference (A)-(B)/(A) (%)	5.0	3.4	7.5	4.3	0.8

Finally, the volume of general cargo is obtained by subtracting the cargo volumes of fruits and vegetables, copper, and wheat from the total cargo volume. The result is shown in Table V-2-39.

Table V-2-39   General Cargo Forecast

('000 tons)

	Year	1984	1990	1995	2000	2005	2010
Total	Total	1,604	2,668	3,297	4,201	4,808	5,440
	Import	1,142	2,310	2,736	3,098	3,410	3,759
	Export	408	358	561	1,103	1,398	1,681
General Cargo	Total	1,415	2,429	3,026	3,830	4,377	4,815
	Import	978	2,114	2,522	2,835	3,122	3,405
	Export	383	315	504	995	1,255	1,410
Bulky Cargo	Total	189	239	271	371	431	625
	Import	164	196	214	263	288	354
	Export	25	43	57	108	143	271

5) Container Cargo

Generally, container cargo volume is defined as "container cargo volume which is carried by full container ships". Thus, containerized cargo which is carried by conventional cargo ships is usually excluded.

Whether or not cargo will be containerized depends on the following factors:

① whether container service will operate on the cargo route.

② whether the cargo can be carried in containers.

③ Whether the containerization conditions in the nation are suitable (for example, inland transportation, various laws, etc.)

Additionally, the number of containers to be imported and exported must be balanced. Empty containers must be carried if this number is out of balance.

If the balance between container imports and exports is very bad, the route cannot be economically containerized.

In this section, the container cargo volume portion of general cargo is estimated.

(1) Method

The progress of containerization in Japan is shown in Table V-2-40. This table shows that the progress closely resembles a "Logistic Curve". The curve is similar to the one used to project population growth. The basic equation is as follows:

$$\frac{dP}{dt} = r \times P \left(1 - \frac{P}{PM}\right)$$

Where, P : population

PM : upper limit

r : constant

t : time (year)

Table V-2-40   Percentage of Containerization in Maritime Transportation from 1974 to 1983 in Japan

(Unit: %)

Year	Total	Routes between Japan and advanced countries	Routes between Japan and developing countries
1974	41.2	70.0	17.0
1975	47.3	81.4	23.5
1976	53.5	85.0	30.1
1977	56.0	88.2	30.9
1978	60.0	89.2	36.0
1979	59.9	89.4	36.4
1980	61.1	89.5	37.1
1981	64.2	90.9	41.0
1982	65.8	90.5	43.8
1983	69.0	89.5	49.8

Note: Percentage of containerization
$= \dfrac{\text{Volume of container cargoes}}{\text{Volume of cargoes transported by liners}}$

The formula can be developed as follows:

$$P = \frac{PM}{1 + C^{(t - t_0)}}$$

where, P : percentage of containerization in year t

PM : limit of containerization

t : year

C : constant

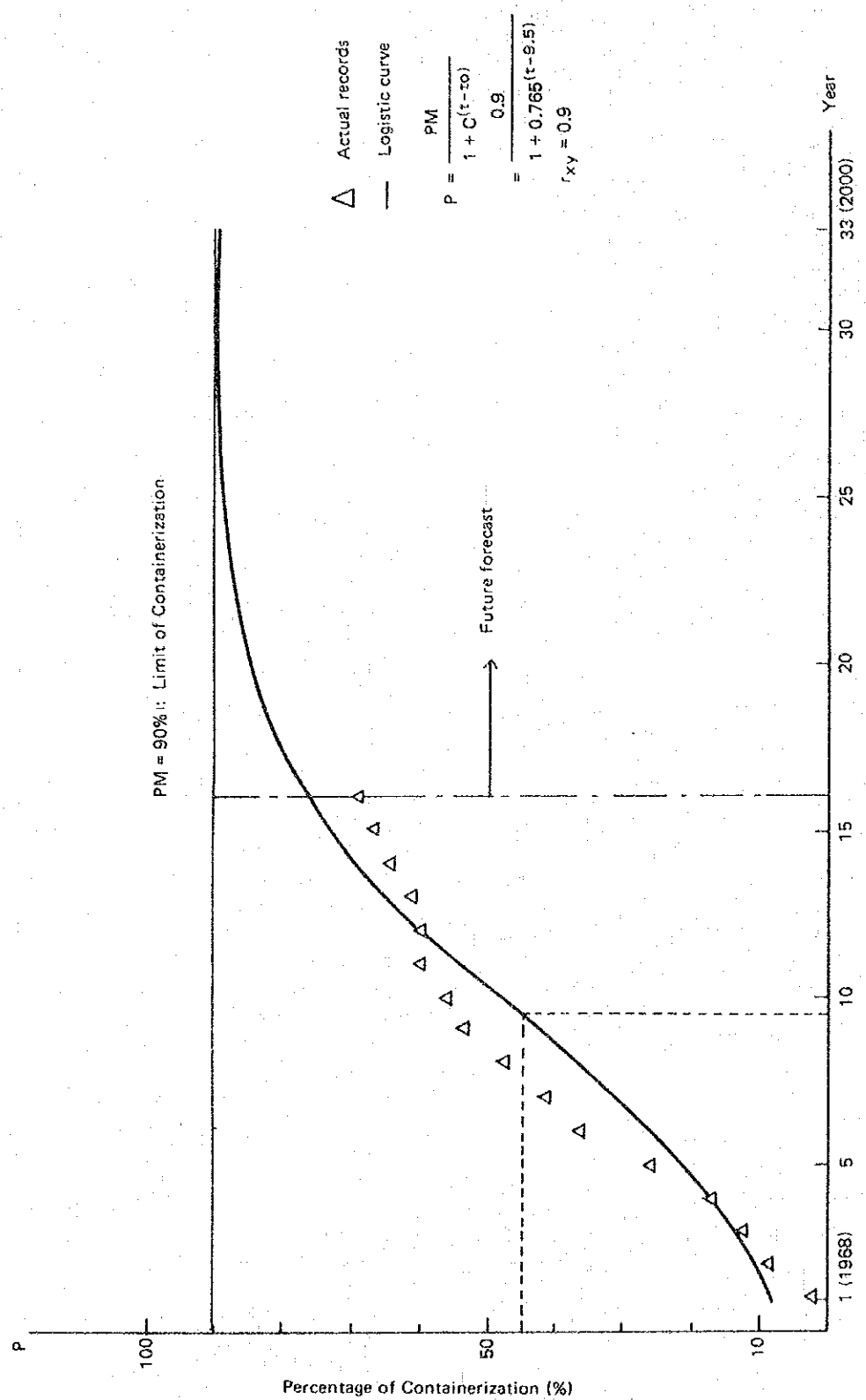to : the year in which the containerization rate will reach half the limit

Fig. V-2-14 Percentage of Containerization on the Routes between Japan and other Countries

The method to determine the variable is as follows:

① Limit of Containerization: determine by historical trends or by the limit of individual commodities.

② Constant (a figure which determines the slope of the curve): determine by correlation with historical trends of by reference to other countries.

③ to : determine by correlation with historical trends or by consideration of circumstances such as national policy, shipping company trends, intentions of shipper and consignors, volume and commodities of cargo, and so on.

(ii) Forecast of Containerization

The method using the historical trend is adopted to estimate the future containerization because the historical trend of containerization is not so low at the ports.
The multi-modal study showed that the ultimate containerizability (the limit) is about 70 percent on each liner route as shown in Table V-2-41.

Table V-2-41 Containerization in Valparaiso and San Antonio Ports

(%)

Item / Route	Imports		Exports	
	Actual (1984)	2010	Actual (1984)	2010
North America	38.9	75	57.7	80
North Europe	53.3	85	57.9	85
Middle Europe	55.0	85	70.3	85
Far East (and Australia)	30.0	70	53.2	75
South Africa	5.0	40	35.7	60
West Coast of South America	25.4	50	30.2	50
East Coast of South America	18.3	50	20.1	40
Total	36.9	69.7	48.6	70.2

Source: Diagnostico, Analisis y Recomendaciones para el Desarrolo de un corredor de Transporte Multimodal entre Santiago y Puertos de la Va Region, PORT OPERATION CONSULTANTS CON INECON LTDA

Figures V-2-15 and V-2-16 show the estimated curves for the progress rate of containerization for export and import cargo at the ports. In these curves, the progress rate of containerization for the target years is forecast as follows:

Item year	1990	1995	2000	2005	2010
Export Container	68%	69%	70%	70%	70%
Import Container	56%	65%	68%	69%	69%

By using the general cargo volume forecast in the previous section (viz. Table V-2-39) and the rate of containerization, the future container cargo is estimated as shown in Table V-2-42.

Table V-2-42   Container Cargo Forecast

('000 tons)

Year	1984	1990	1995	2000	2005	2010
Import	349	1,184	1,639	1,928	2,123	2,349
Export	300	214	348	697	879	987
Total	639	1,398	1,987	2,625	3,002	3,336

On the other hand, the container cargo volume of fruit was estimated in the report of the Multi-modal Corridor Study, and is shown in Table V-2-43.

Table V-2-43   Forecast Container Cargo Volume of Fruit

('000 tons)

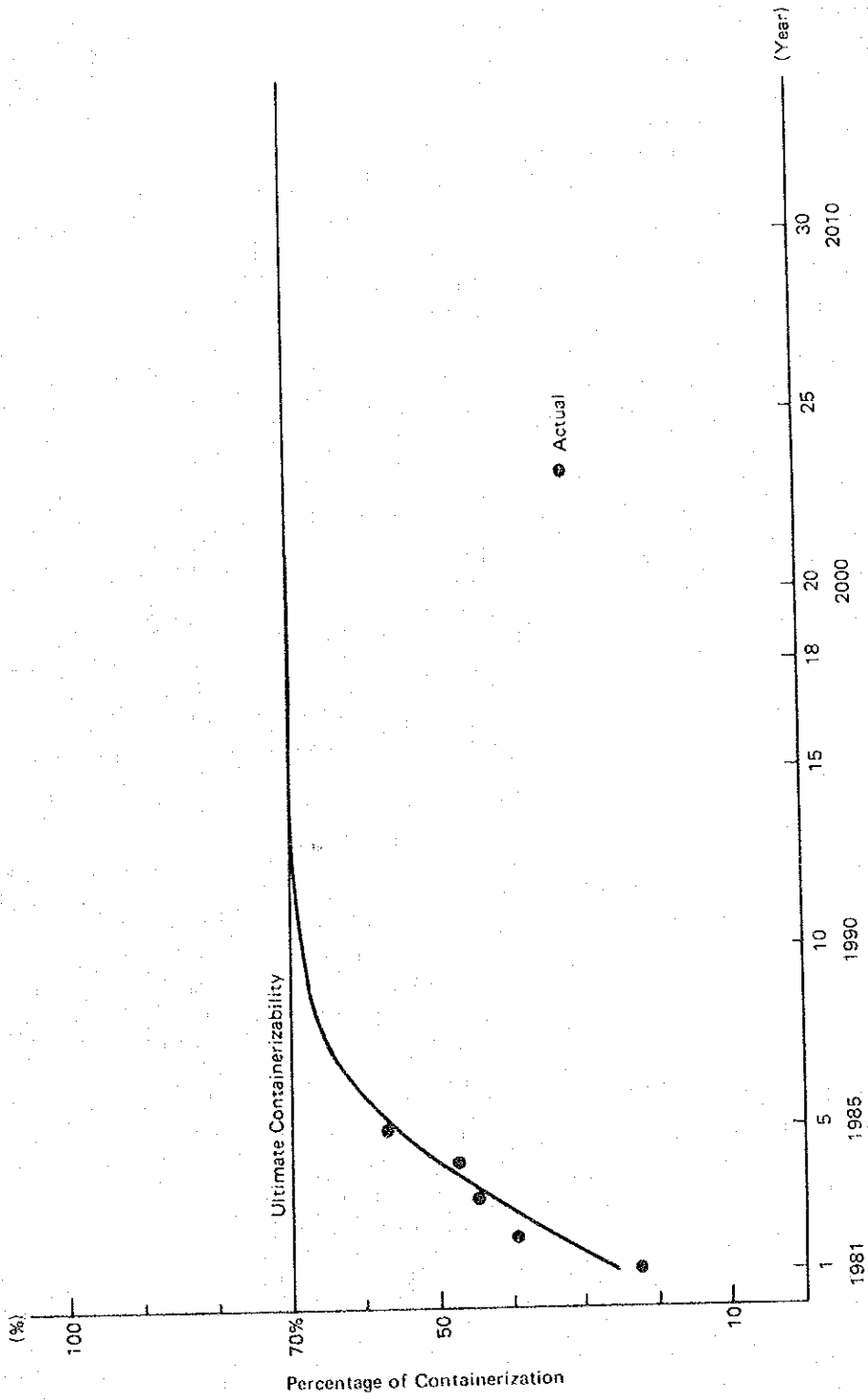| Year	1990	1995	2000	2005	2010
Export	129	191	242	272	299

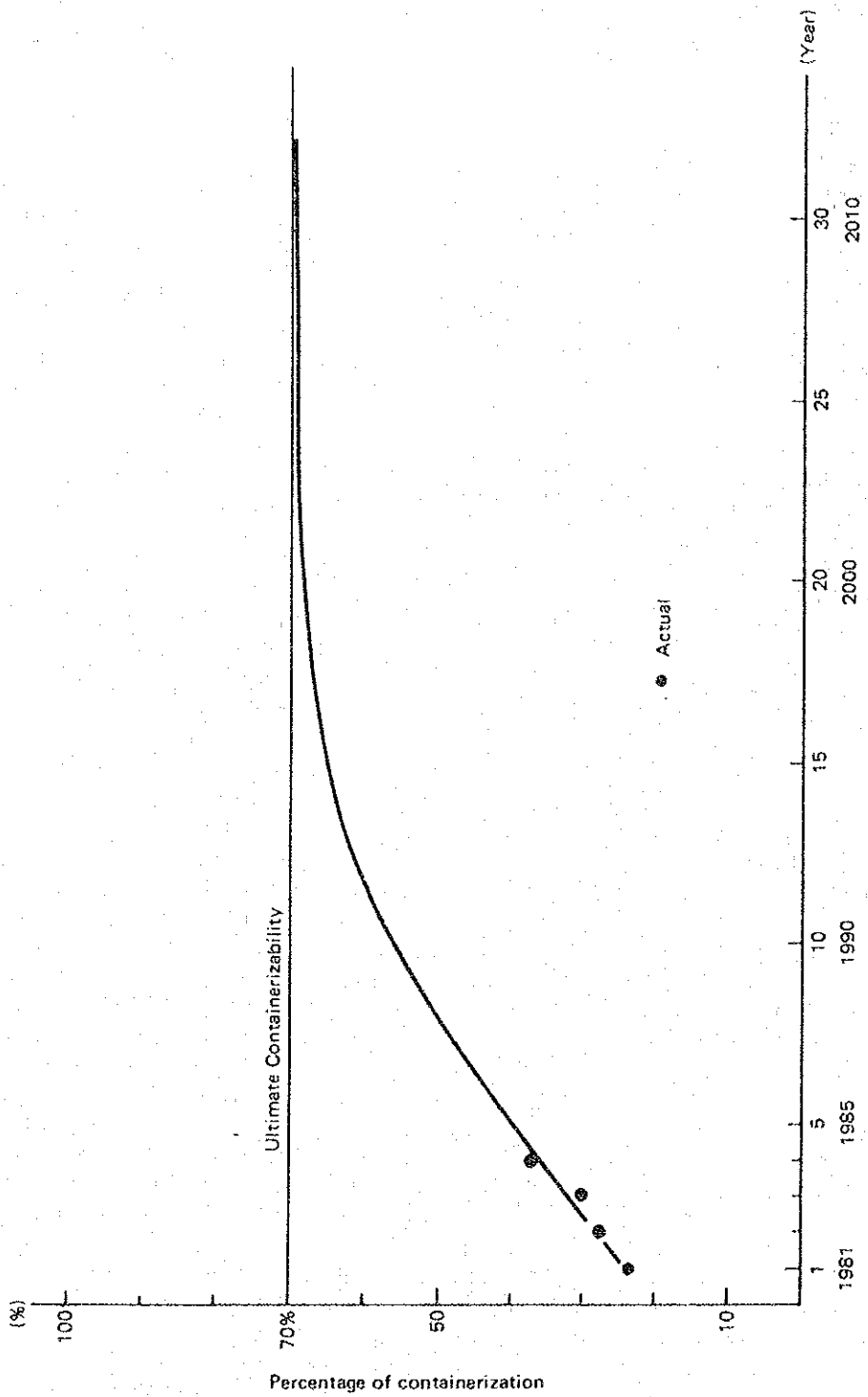Fig. V-2-15 Progress Rate of Containerization (Export)

Fig. V-2-16 Progress Rate of Containerization (Import)

Then, the total container cargo volume is estimated as shown in Table V-2-44.

Table V-2-44   Forecast Total Container Cargo Volume

('000 tons)

Year	1984	1990	1995	2000	2005	2010
Import	349	1,184	1,639	1,928	2,123	2,349
Export	300	343	539	939	1,151	1,286
Total	639	1,527	2,178	2,867	3,274	3,635

(3)   Cargo Volume at Each Port

Based on the functions of each port mentioned in chapter V, the cargo volumes of the four groups forecast above are divided between the two ports.

1)   Fruits and vegetables

As may be seen in Table V-2-45, fruits and vegetables are seasonal cargo. In fact, March is the peak month of exports for grapes, apples and pears. The export season is from November to June, and the rate of concentration reaches 83% in the period from February to April, March has a concentration of 43%. If these cargoes are only handled at one port, the harbor will become congested during the peak season. So, the forecast cargo will be divided between both ports as shown in Table V-2-46.

Table V-2-45 Volume of Exported Fruits (1983-1984)

(thousand boxes)

	November	December	January	February	March	April	May	June	TOTAL
Grapes	-	135.9	1,930.7	5,674.8	10,022.6	4,972.6	869.6	31.7	23,637.9
Nectarines	11.3	465.5	764.5	854.6	42.6	0.1			2,138.4
Plums	2.5	139.7	673.3	326.3	9.2	6.3			1,157.3
Peaches	4.0	117.5	129.0	229.3	102.6	7.4			589.7
Pears	5.2	0.1	92.9	295.1	890.3	165.5	50.2	18.3	1,517.4
Apples	10.2	2.6	1.1	466.4	4,726.2	3,043.7	1,458.9	457.1	10,166.3
Kiwis						45.1	9.6	0.2	54.9
Cherries	12.8	153.6	1.4						167.8
Apricots	2.4	21.1	1.1						24.6
Persimmons						2.9	3.1		6.0
Melons		13.8	123.1	257.7	113.1	0.8			508.5
Onions		13.4	10.7	333.9	431.4	179.9	4.7		974.0
Total	48.4	1,063.2	3,727.8	8,438	16,338	8,424	2,396.1	507.3	40,942.8

Source: INECON. (Panorama Economico de la Fruticultura 1984)

Table V-2-46   Fruits and Vegetables Exports at Each Port

('000 tons)

Year	1984	1990	1995	2000	2005	2010
Total	516.2	787	853	916	982	1052
Port of Valparaiso	419.7	630	682	733	787	845
Port of San Antonio	96.5	157	171	183	195	207

The share of the ports : Valparaiso 80%, San Antonio 20%.

2) Copper

The Commision Chilena de Cobre estimated the copper export cargo by each port, and these figures are adopted for the forecast. Table V-2-47 shows the result.

Table V-2-47   Copper Exports at Each Port

('000 tons)

Year	1984	1990	1995	2000	2005	2010
Port of Valparaiso	193.4	225	225	210	210	210
Port of San Antonio	401.7	644	723	480	480	480
Total	595.1	869	948	690	690	690

3) Wheat

Wheat is a bulky cargo, and should continue to be handled at the port of San Antonio.

In order to forecast the volume to be handled through San Antonio, the average historical proportion of 87% has been taken. This figure has been fairly stable over the past 6 years as shown in Table V-2-22. In this way the forecast annual import through San Antonio is obtained as shown in Table V-2-48.

Table V-2-48   Wheat Imports at the Port of San Antonio

('000 tons)

Year	1984	1990	1995	2000	2005	2010
Total National Imports	958	553	543	595	723	832
Port of San Antonio	848	481	472	518	629	724

4) General Cargo

Of the general cargo forecast above, the bulky cargo should be handled at the port of San Antonio and the rest of the cargo should be divided equally between the two ports.   The result is shown in Table V-2-49.

Table V-2-49   General Cargo Forecast

('000 tons)

Year		1990	1995	2000	2005	2010
Total	Total	1,031	1,039	1,205	1,375	1,479
	Import	930	883	907	999	1,056
	Export	101	156	298	376	423
Port of Valparaiso	Total	539	546	630	716	768
	Import	465	442	454	500	528
	Export	74	104	176	216	240
Port of San Antonio	Total	492	493	575	659	711
	Import	465	441	453	499	528
	Export	27	52	122	160	183

5) Container Cargo

As stated in Chapter V, the port of Valparaiso should be the base port for container cargo, and container cargo should mainly be handled at Valparaiso.   But the facilities at the port of San Antonio should function as a supplementary container berth for the port of Valparaiso.

Therefore, container cargo will be divided between the ports with a share of 85% for the port of Valparaiso, as shown in Table V-2-50.

Table V-2-50   Container Cargo Forecast
(excluding fruit containers)

('000 tons)

Year		1984	1990	1995	2000	2005	2010
Total	Total	639	1,398	1,987	2,625	3,002	3,336
	Import	349	1,184	1,639	1,928	2,123	2,349
	Export	300	214	348	697	879	987
Port of Valparaiso	Total		1,188	1,689	2,231	2,552	2,836
	Import		1,006	1,393	1,639	1,805	1,997
	Export		182	296	592	747	839
Port of San Antonio	Total		210	298	394	450	500
	Import		178	246	289	318	352
	Export		32	52	105	132	148

In addition to the above, the fruit container cargo will be divided between the ports based on the present share. Table V-2-51 shows the future fruit container cargo at each port.

Table V-2-51   Estimated Volume of Fruit Container Cargo

('000 tons)

Year	1990	1995	2000	2005	2010
Total	129	191	242	272	299
Port of Valparaiso	107	159	201	226	248
Port of San Antonio	22	32	41	46	51

Total container cargo at each port is shown in Table V-2-52.

In 2010 the port of Valparaiso will handle 3,084 thousand tons of container cargo, and 551 thousand tons of container cargo will be handled at the port of San Antonio.

Table V-2-52 Total Container Cargo Forecast

('000 tons)

Year		1984	1990	1995	2000	2005	2010
Total	Total	639	1,527	2,178	2,867	3,274	3,635
	Import	349	1,184	1,639	1,928	2,123	2,349
	Export	300	343	539	939	1,151	1,286
Port of Valparaiso	Total	416	1,295	1,848	2,432	2,778	3,084
	Import	213	1,006	1,393	1,639	1,805	1,997
	Export	203	289	455	793	973	1,087
Port of San Antonio	Total	222	232	330	435	496	551
	Import	136	178	246	289	318	352
	Export	86	54	84	146	178	199

6) Result

As a conclusion, Table V-2-53 shows a summary of the cargo forecasts for each port. The port of Valparaiso will handle a total of 3,987 thousand tons in 2000 and 4,837 thousand tons in 2010, and the port of San Antonio will handle 2,588 thousand tons in 2000 and 3,313 thousand tons in 2010. As for domestic cargo, the volume is adopted from the figures forecast before (the macro forecast).

Table V-2-53 Cargo Forecast Summary

(a) Port of Valparaiso

('000 tons)

Year			1990	1995	2000	2005	2010
Foreign Trade	Imports	General Cargo	465	442	454	500	528
		Container Cargo	1,006	1,393	1,639	1,805	1,997
		Sub-Total	1,471	1,835	2,093	2,305	2,525
	Exports	Fruits & Veg.	523	523	532	561	597
		Copper	225	225	210	210	210
		General Cargo	74	104	176	216	240
		Container Cargo	289	455	793	973	1,087
		Sub-Total	1,111	1,307	1,711	1,960	2,134
	Total		2,582	3,142	3,804	4,265	4,659
Domestic			196	192	183	172	178
Grand Total			2,778	3,334	3,987	4,437	4,837

(b) Port of San Antonio

('000 tons)

Year			1990	1995	2000	2005	2010
Foreign Trade	Imports	Wheat	481	472	518	629	724
		General Cargo	661	655	716	787	882
		Container Cargo	178	246	289	318	352
		Sub-Total	1,320	1,373	1,523	1,734	1,958
	Exports	Fruits & Veg.	135	139	142	149	156
		Copper	644	723	480	480	480
		General Cargo	70	109	230	303	454
		Container Cargo	54	84	146	178	199
		Sub-Total	885	1,055	998	1,110	1,289
	Total		2,223	2,428	2,521	2,844	3,247
Domestic			73	77	67	63	66
Grand Total			2,296	2,505	2,588	2,907	3,313

One of the important functions of the ports of Valparaiso and San Antonio is to handle cargoes during emergencies.

Generally speaking, if a major earthquake occurs, transportations by roads and railways is strictly limited due to damages on land including collapsing of bridges, closure of roads, discontinuation of electric power, destruction of tunnels and general road damage. However, even on such occasions, maritime transportation is generally feasible as long as port facilities are not completely destroyed. It has become increasingly important to prepare facilities which are strong enough to withstand earthquakes and other disasters as urban areas grow in the vicinity of ports, and population concentrates in the immediate hinterlands of major ports.

The same phenomena can be seen around the two subject ports. Moreover, the hinterlands of the ports, especially the immediate hinterlands, are quite steep and thus the provision of aseismic berths is all the more important.

As mentioned before, Chile is located in the circum-Pacific earthquake belt and has experienced many major earthquakes. Therefore, it is preferable to study how the network of aseismic ports shall be established not only for handling emergency cargoes but also to support worldwide maritime trade following major earthquakes. In this study, according to the methodology described in the Inception Report, the cargo volume to be unloaded just after a large earthquake is estimated based upon the prevailing concept in Japan, which is also famous for its earthquakes.

(1) Assumption of Affected Area

In order to estimate the cargo volume, we assumed the conditions as below.

① The scale of the earthquake is more than Magnitude 7 or 8.

② The epicenter of the earthquake is located west of Region V, not so far from the Pacific coast.

③ The areas affected by the earthquake are those within 150 Gal of horizontal accelation on the earth's surface.

The report written by two Japanese groups* which were dispatched by the Ministry of Education and by the Japan Society of Civil Engineers (JSCE) last April gives valuable information as to the situation of general damages from earthquakes. The magnitude of the last major quake was 7.8, and the location of its epicenter was about 40 KM east from the port of San Antonio and 15 KM below the sea bottom.

The maximum accelation recorded was more than 700 Gal horizontally, and 800 Gal vertically, and the seismic intensity reached more than 7 near the port of San Antonio. (Refer to Fig. V-3-1, 2).

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* The members of the mission dispatched by Ministry of Education were Dr. Motohiko Hakuno, Prof., The Earthquake Institute of Tokyo University, Dr. Akinori Shibata, Assist. Prof., Engineering Department of Tohoku University, and Dr. Hirohisa Suzuki, Assist. Prof., The Newspaper Institute of Tokyo University.

The members of the mission dispatched by JSCE were Dr. Hiroyuki Watanabe, Assist. Prof., Engineering Department of Saitama University and Mr. Mikio Takeuchi, Director, Nuclear Power Office of Okumura-gumi.
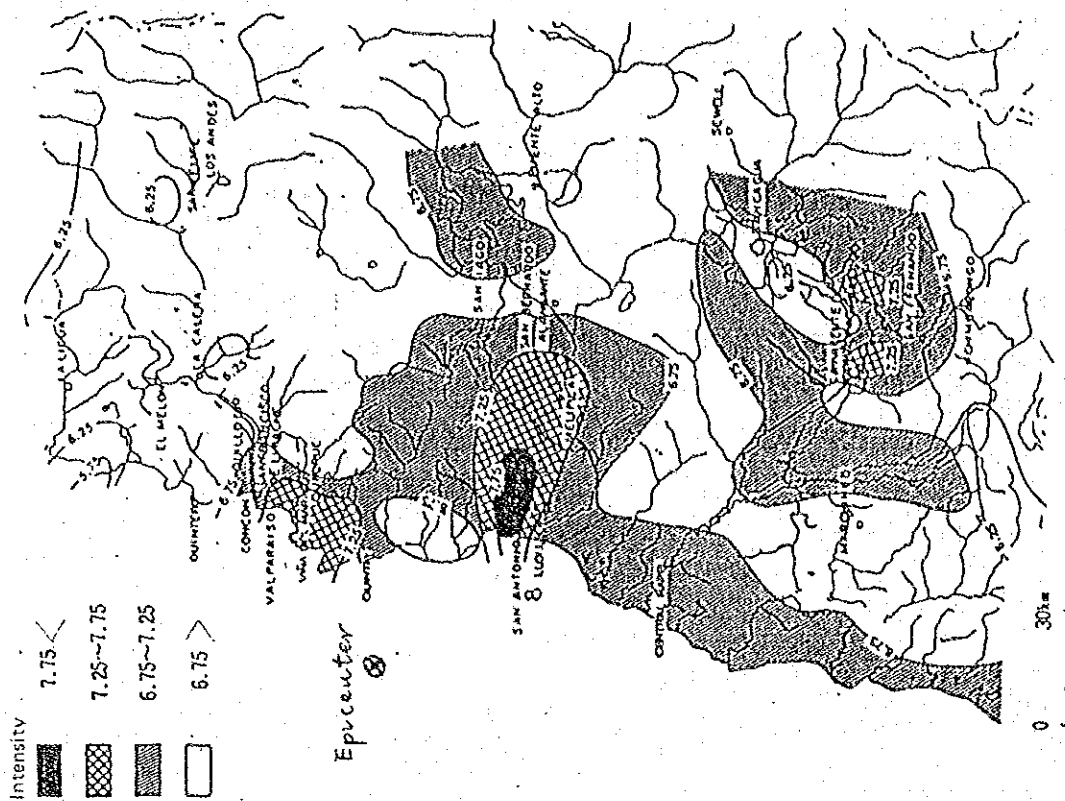
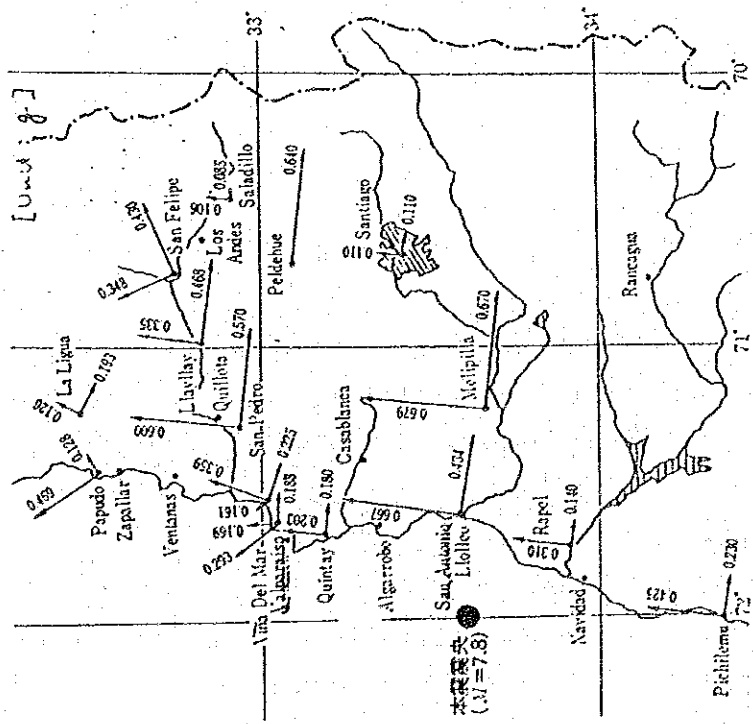Fig. V-3-2 Distribution Map of Seismic Intensity

Fig. V-3-1 Distribution Map of Horizontal Accelation

The damaged area extended from the coastal zone to more than 100 KM inland if judged by the destruction of adobe houses. (Refer to Fig. V-3-3).
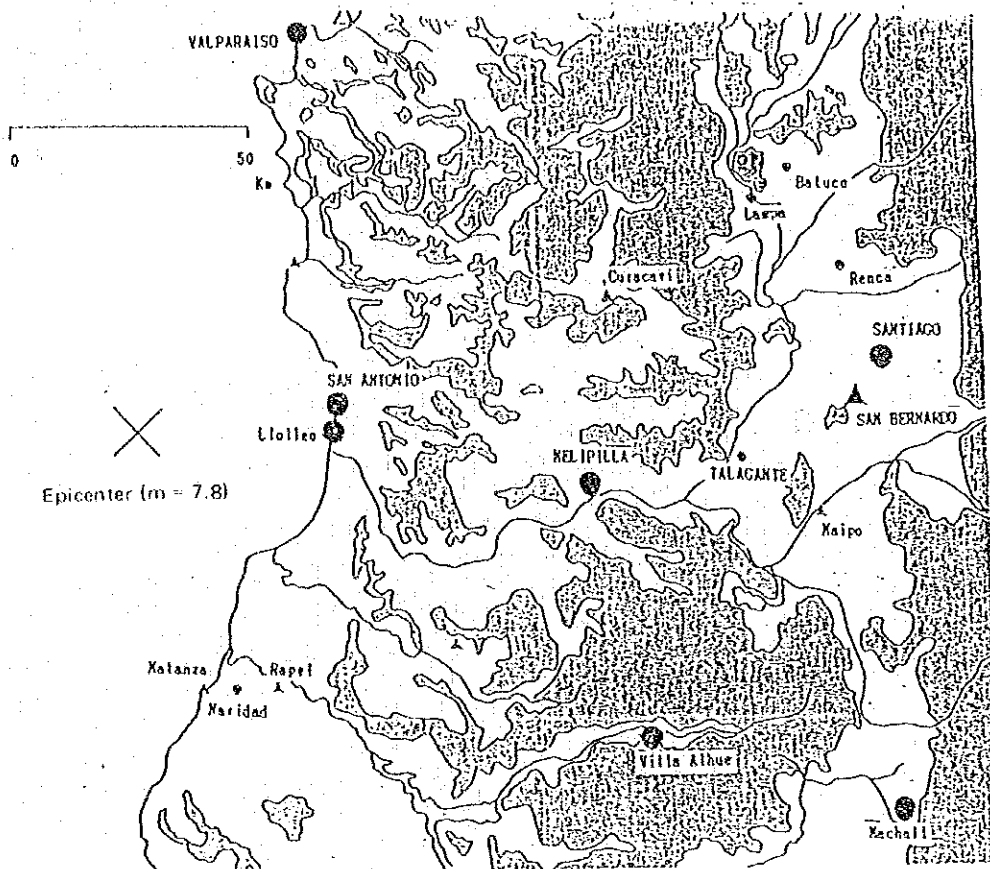

Fig. V-3-3   Distribution Map of Damaged Adobe Houses

The report also recounts the human damage as shown in Table V-3-1.

The number of fatalities was 179 in Regions V through VIII including Santiago Metropolitan and 2,575 persons were injured in essentially the same regions.   The damage to the inhabitants and buildings was widespread especially in Regions V and VI and the Santiago Metropolitan area.

From this analysis, we assumed the affected areas of a hypothetical earthquake would be Regions V and VI and the Santiago Metropolitan area for estimation of emergency cargoes.   (Refer to Fig. V-3-4)

Table V-3-1 Damage to Inhabitants and Structures

Region	Dead	Injured	Sufferers									Houses		Public Buildings	
			Indoors				Outdoors				Total	Absolute Destruction	Partial Destruction	Absolute Destruction	Partial Destruction
			Families	Adults	Children	Sub-total	Families	Adults	Children	Sub-total					
I															
II															
III															
IV			3	6	5	11	32	66	96	162	173	24	10		
V	68	923	1,975	3,231	2,943	6,174	55,749	131,010	119,500	250,510	256,603	20,087	37,083		56
Metro-politan	80	1,338	2,256	5,730	4,411	10,131	108,653	276,486	212,266	488,752	498,883	31,306	79,804	101	621
VI	26	254	132	310	286	596	40,136	34,319	85,892	180,211	180,007	17,876	22,303		53
VII	2	60	27	82	42	124	12,430	38,160	17,652	55,812	55,936	3,696	8,762		104
VIII	1														
IX															
X															
XI															
XII															
Total	179	2,575	3,793	9,359	7,677	17,036	217,200	540,041	435,415	975,456	992,492	72,989	148,052	101	834

Port of Coquimbo

IV REGION

V REGION

Port of Ventanas

Port of Valparaiso

Santiago

METROPOLITAN REGION

Port of San Antonio

VI REGION

San Fernando

VII REGION

Tarica

Port of Lirquén

Port of Penco

Port of Talcahuano/San Vicente

Port of Huachipato

Port of Coronel

Port of Lota

Concepcion

VIII REGION

LEGEND

+++++ RAILWAY

———— ROAD

o– – –o PIPELINE (Petroleum)

IX REGION
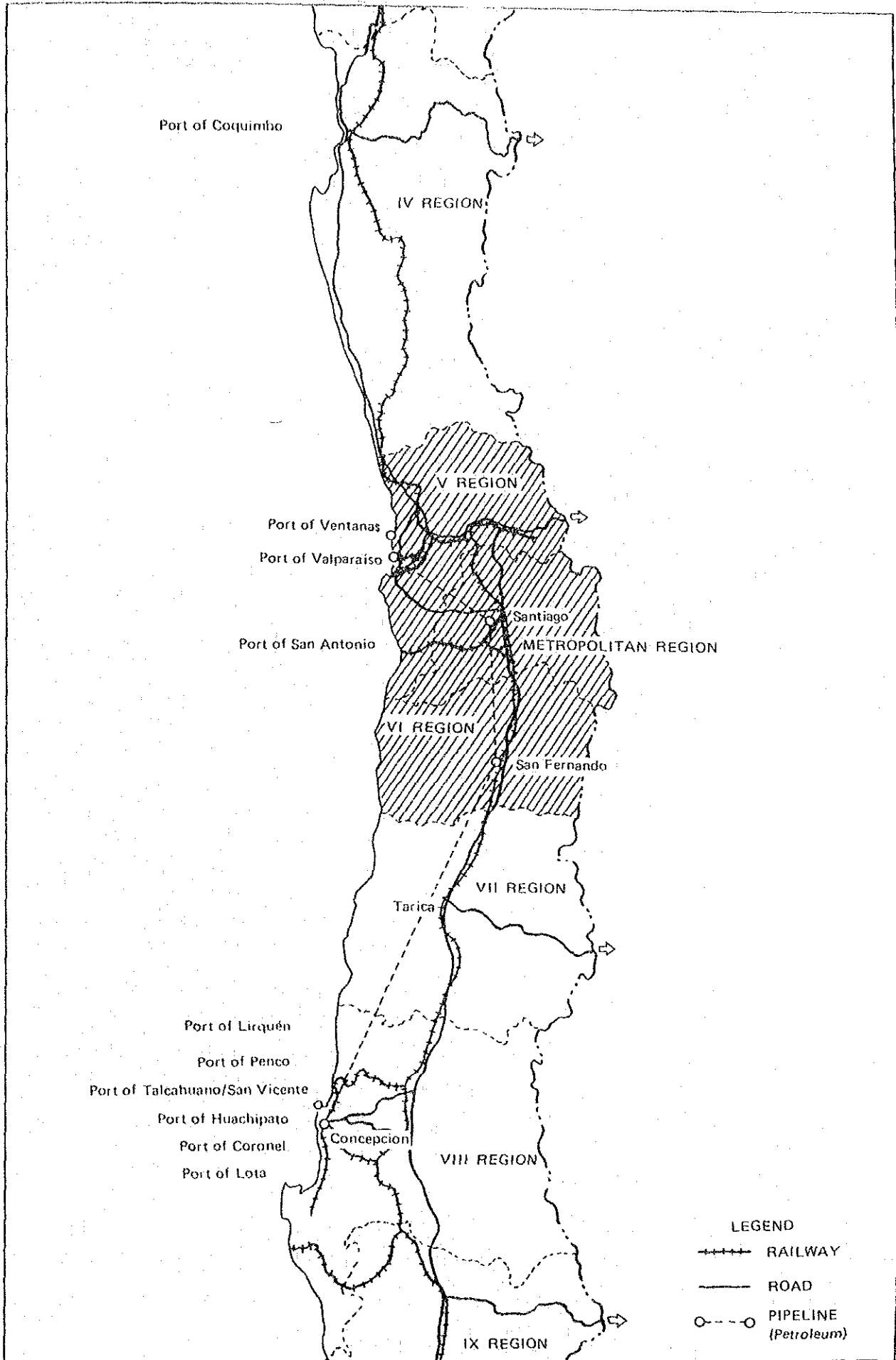
Fig. V-3-4　Affected Areas by Hypothetical Earthquake

(2) Estimation of Damage Percentage

Table V-3-2 shows the calculation results of the damage percentage estimations for inhabitants and dwellings.

As appropriate data are not available, there is some time difference between the population and dwelling figures and the damages given in Table V-3-1. However, this statistical difference is negligible in terms of percent and has little influence on the calculation results.

Table V-3-2 Damage Percentage

(in Thousands)

	Region	V	%	Santiago Metro-politan	%	VI	%	Total	%
	Population *1	1,316	100.0	4,673	100.0	586	100.0	6,575	100.0
	Dwellings *2	328.1	100.0	930.1	100.0	122.1	100.0	1,380.2	100.0
*3 Damage	Population	257	19.5	499	10.7	180	30.7	936	14.2
	Dwellings	57.2	17.4	111.1	12.0	40.3	33.0	208.6	15.1
	Absolute	20.1	6.1	31.3	3.4	17.9	14.7	69.3	5.0
	Partial	37.1	11.3	79.8	8.6	22.4	18.3	139.3	10.1

(Note) *1 in 1984

*2 in 1982

*3 in 1985

Most of the emergency cargoes will be materials for temporary houses for the sufferers. Therefore, we assume the damage percentage for estimation of the cargoes as follows.

Damage Percentage for Cargo Estimation
= (Damage Percentage of Population) x [Damage Percentage of Dwellings
(Absolute Destruction) x 1/2]
= (14.2%) x (5.0% x 1/2) = 0.355%

The coefficient of (1/2) is determined taking into consideration that

the damage percentage of adobe dwellings was high compared with wooden houses, and that in the future the percentage will decrease due to the structural change of houses. This value is applied in Japan as a coefficient between new (less than 30 years) and old (more than 30 years) houses.

(3) Estimation of Cargo Volume

These cargoes are for temporary relief in response to an emergency assuming that land transportation will be temporarily interrupted. In the study, the period is regarded as one week, and the full-scale, permanent relief measures are assumed to starts even days after the emergency using both maritime and land transportation.

The commodities of the emergency cargoes are clothing, food and water, daily necessities and housing materials, and the volume per capita of each item is shown in Table V-3-3 based upon studies in Japan.

Table V-3-3   Emergency Cargo Volume Per Capita by Commodity

Commodity / Unit	Clothing	Food and Water	Daily Necessities	Housing Materials
Volume	5.4	7.0	2.0	425.0
Unit	kg/person	kg/person. day	kg/person	kg/person

The total emergency cargo volume of each commodity is calculated using the future population, the damage percentage and the emergency cargo volume per capita. The results are shown in Table V-3-4. The total cargo volume indicates all the cargo required for all the sufferers, not only the volume to be carried by maritime transportation.

Table V-3-4   Total Emergency Cargo Volume

Item / Unit / Year	Population Thousands	Sufferers Thousands	Clothing Tons	Food and Water Tons/Week	Daily Neces- sities Tons	Housing Materials Tons	Total Tons
1990	7,521	26.7	144.2	1,308.2	53.4	11,346.6	12,852.4
1995	8,338	29.6	159.8	1,450.3	59.2	12,579.5	14,248.8
2000	9,193	32.6	176.2	1,599.1	65.3	13,870.1	15,710.7
2005	10,123	35.9	194.1	1,760.9	71.9	15,273.2	17,300.1
2010	11,147	39.6	213.7	1,939.0	79.1	16,818.2	19,050.0

The total emergency cargo is to be provided through railways, roads and the two ports. There is no exact percentage for each transport mode, but taking into account the Pan-Pacific Highway and the survival of some National Railways, we assume a modal split of 5% for railways, 50% for roads, and 45% for the two ports.

Thus, we can estimate the emergency cargoes to be unloaded at the ports of Valparaiso and San Antonio in the first week after the occurrence of a hypothetical major earthquake as follows.

Emergency Cargo Volume per Day
= Emergency Cargo Volume per Week
   x Modal Split of Ports
   x Peak Ratio

The peak ratio, here, is taken as 2/7, meaning that twice the average cargo per day is expected to be handled at the peak time.

The final results are shown in Table V-3-5.

Table V-3-5 Maritime Emergency Cargo per Day

(in Thousand Tons)

Year	Usual Time	Peak Time
1990	0.83	1.65
1995	0.92	1.83
2000	1.01	2.02
2005	1.11	2.22
2010	1.22	2.45

The emergency cargo calculated above is general cargo rather than bulk cargo.

This cargo volume, however, is not added to the port cargoes estimated in Section V-2. The emergency cargo is calculated to determine the number, location, scale and structural conditions of the normal berths which, in the event of a major disaster, will be used to carry emergency cargoes.