Table 4-14 Production and Consumption of Nitrogeneous Fertilizer

(Unit: 1,000 ton)

		69/70	70/71	71/72	72/73	73/74	74/75	75/76	76/77
China	(C)	2663.0	3115.0	3141.0	3459	4015	4000	4360.6	4500.3
	(P)	1235	1426	1853	2245	2791	3090	3172.1	3826.8
India	(C)	1360.3	1487.1	1760	1839	1829.1	1766	2149	2457
	(P)	705	838	946	1054	1049.9	1186.6	1508	1856.8
Iran	(C)	55.0	65.3	107.3	123.8	194.1	188.5	190.0	203.3
	(P)	26.1	30.9	86.2	142.8	130.8	131.0	125.7	155.7
Iraq	(C)	10.2	12.0	13.5	15.0	20.1	27.3	25.0	35.0
	(P)	–	6.0	10.7	26.2	28.1	33.6	24.3	25.3
Pakistan	(C)	272.6	251.5	344.0	386.2	341.9	362.9	443.5	500.4
	(P)	129.5	140.3	215.2	274.4	299.9	310.8	316.4	309.3
Bangladesh	(C)	90.4	97.7	78.1	129.3	127.0	82.8	146.7	165.8
	(P)	43.4	80.2	21.3	92.2	129.7	32.7	131.1	130.4
Total	(C)	4451.5	5028.6	5443.9	5952.3	6527.2	6427.5	7314.8	7861.8
	(P)	2139.0	2521.4	3132.4	3834.6	4429.4	4784.7	5277.6	6304.3
(P)/(C) %		48	50	58	64	68	74	72	80
(C) – (P)		2312.5	2507.2	2311.5	2117.7	2097.8	1642.8	2037.2	1557.5

Note: C ; Consumption P; Production

Source: U.N. "Statistical Yearbook 1978"

4.7 Fabricated Metals

4.7.1 Canal Traffic

The southbound movements of fabricated metals through the Canal in 1978 totaled 7,894 thousand tons, the third largest dry cargo after cement and mineral fertilizer. The volume represented an increase of 103% from 1977, as remarkable as the gain registered by sugar in the year's southbound cargo traffic which on the whole increased appreciably. In 1977, the southbound movements of fabricated metals through the Canal increased by only 4%, but as mentioned above, they increased by more than two times in 1978. Particularly noteworthy in the countrywise breakdown of the 1978 southbound traffic of fabricated metals is that exports from Belgium showed a three-fold increase and imports by China a 3.7-fold rise. By contrast, shipments from the Soviet Union, which was the largest exporter of this item in 1977, fell by half.

Table 4-15 Transited Volume of Fabricated Metals by Major Loading and Unloading Countries

(Unit: 1,000 ton)

	1976	1977	1978
Iron & Steel	1,323	1,370	2,412
Sheets & Plates	773	704	1,195
Pig & Cast Iron	333	478	1,010
Others	1,315	1,341	3,247
TOTAL	3,744	3,893	7,894
LOADING COUNTRIES			
Russia	443	573	290
Italy	381	385	793
Belgium	298	365	1,125
Germany (Fed.)	245	296	784
England	202	255	508
U.S.A.	247	255	289
France	161	186	482
Holland	228	181	618
Poland	177	144	235
Spain	149	105	630
Others	1,214	1,148	2,140
TOTAL	3,744	3,893	7,894
UNLOADING COUNTRIES			
Iran	724	622	1,491
China	650	547	2,005
Japan	245	420	464
Saudi-Arabia	111	303	528
Pakistan	155	236	136
India	163	173	406
Thailand	–	149	202
Vite-Nam	84	117	–
Singapore	–	96	248
Others	1,612	1,230	2,414
TOTAL	3,744	3,893	7,894

4.7.2 Imports

As for the volumes of steel product imports made in the 1974~1978 period by countries situated south of the Suez Canal as given by U.N. Statistics of World Trade in Steel (The statistics cover shipments by 26 principal steel-exporting countries. The Soviet Union and India were not covered because data on steel product exports by these two countries were not made available in time.), China is the largest steel-importing country south of the Suez Canal. She imported 8,843 thousand tons of fabricated metals in 1978, representing a sharp increase of 82% from the 4,849 thousand tons imported in 1977. Iran is the second biggest importer, whose imports in 1978 showed an increase of 40% from 1977.

The total volume of fabricated metal imports made by the countries in this area in 1978 was 30% more than in 1977. This rate of increase is much lower than the 103% upswing in the 1978 Suez traffic of fabricated metals. This is because the shares held by European and Asian steel exporters in trade with this area changed – that is, European exporters considerably expanded their share, doubling the Canal traffic of such goods in 1978. Looking at the trend of fabricated metal imports by countries south of Suez during the six-year span from 1973 through 1978, a marked increase is seen in shipments to major importing countries. China increased her steel imports from 3.7 million tons in 1973 to 8.8 million tons in 1978, Iran from 2 million tons to 4.6 million tons, Saudi Arabia from 0.6 million tons to 1.9 million tons and South Korea from 1.9 million tons to 2.8 million tons.

During the six-year period, the annual movements of such imports had the first peak between 1974 and 1976, became somewhat sluggish in 1977 and sharply increased in 1978. Like Iraq and India, there are those countries whose annual imports increased sharply at first, then dropped considerably and then showed a recovery. Imports by this area, though making such fluctuations, have been generally increasing over the long-term. The year 1978 may have been a special year in which almost every country in this area increased steel product imports appreciably. It is surmised from the U.N. statistics that the 1978 movements of fabricated metals from Europe to the Middle East, Asia and East Africa reached about 10,800 thousand tons. This estimated volume differs by about 2,900 thousand tons from the volume of southbound Canal movement of fabricated metals given for the year in SCA statistics. The reason for this difference between the U.N. and the SCA statistics is not known. It is assumed that part of the steel exports to the areas were made by land. Besides, some fabricated metal cargo may have been listed among other cargoes when masters submitted declarations to the SCA since such cargo is shipped under the name of various products and, in some cases, becomes component parts of other cargo items.
have been listed among other cargoes when masters submitted declarations to the SCA since such cargo is shipped under the name of various products and, in some cases, becomes component parts of other cargo items.

4.7.3 Production

The total crude steel output of 65 steel-producing countries in 1978 amounted to about 714 million tons. The volume represents an increase of only 2% from the output of about 700 million tons recorded in 1973, reflecting the economic setback following the 1973 oil crisis. Countries in the East European bloc, however, showed a high rate of increase in crude steel production during the six-year period. The Soviet Union, the largest steel-making nation in the world, expanded her output from 131 million tons in 1973 to 151 million tons in 1978. Poland increased her production from 14 million tons in 1973 to 19 million tons in 1978, Czechoslovakia from 13 million tons to 15 million tons and Rumania from 8 million tons to 12 million tons. Among other countries, India increased her crude steel production from 7 million tons in 1973 to 9 million tons in 1978, Brazil from 8 million tons to 12 million tons, South Korea from 1 million tons to 5 million tons and China from 25 million tons to 32 million tons. On the other hand, production in major steel-making nations of the Western World declined considerably during the six-year period. The U.S., the second biggest steel-making country in the world, saw a decrease of 10% from 137 million tons in 1973 to 124 million tons in 1978. Japan, the third largest steel-making country, had a drop of 14% from 119 million tons in 1973 to 102 million tons in 1978 and nine EC nations combined had a decline of 11% from 150 million tons to 133 million tons. All this indicates that the world's steel supply-and-demand picture is beginning to undergo a major change.

4.7.4 Exports

As for exports by 31 principal steel-exporting countries (Data on 1978 exports of India and 1977 and 1978 exports of the Soviet Union were not obtained in time.), assuming that exports made by the Soviet Union and India in 1978 amounted to about 6 million tons, the year's total volume of exports by the 31 countries reached some 130 million tons, surpassing the previous peak-year export level (1974) after three years of sluggishness. The 1978 total thus obtained represnets and increase of about 12% from 1977. Countrywise, however, shipments from Japan which is the world's largest steel exporter declined from 36 million tons in 1976 to 34 million tons in 1977 and further down to 31 million tons in 1978. On the other hand, some European countries increased their steel exports during the 1977/1978 period with Belgium expanding her exports from 12 million tons in 1977 to 13 million tons in 1978, West Germany from 15 million tons to 19 million tons, Italy from 7 million tons to 8 million tons and Spain from 3 million tons to 4 million tons. Such East European countries as Poland and Rumania also held firm.

The situation of 1978 steel exports, when looked at from Japan's standpoint is as follows. The world's steel trade in 1978 was characterized by the introduction of new trade-control arrangements. The arrangements include the trigger price system of the U.S.A., the basic price system of the EC and voluntary export restrictions by Japan. They strengthened control on steel trade in terms of both price and quantity. A particularly notable development in Japan's steel exports was a rise in dollar-based export prices which was caused by the sharp appreciation of the yen against the U.S. dollar. (The yen's annual average exchange rate against the U.S. dollar was ¥296.55 in 1976, ¥268.51 in 1977 and ¥210.47 in 1978. There as a rise of 28% between 1977 and 1978.) Due to the upsurge of the yen's value, Japanese steel mills came to place prime emphasis on the pricing aspects rather than on the quantitative aspects of their steel exports and raised their export prices. Because of this, Japanese steel exports in 1978 showed an increase of 12.7% from 1977 in terms of dollar-based value although they were 9.3% less than in 1977 quantitatively. As a result of such a sharp raise in their export prices, Japanese steel mills experienced a rapid decline in their competitiveness especially in West Asia where they had been faced with fierce pricing competition from European steel mills. Under the circumstances, European exports to the area increased sharply. In short, this means that increased demand in the East, Southeast and West Asian regions and the yen appreciation-caused decline in Japanese exports resulted in the sharp rise in the southbound Suez Canal traffic of European fabricated metals. As to the possibility of this trend's continuation, the situation in 1978 should be considered rather exceptional when taking into account the downtrend in the yen's exchange value in 1979 and a trade cycle for steel. Each cara's supply-and-demand situation should be closely watched in predicting the future of the world's steel trade.

4.7.5 Northbound Fabricated Metals

Table 4-16 shows northbound Canal transit of fabricated metals broken down by importing and exporting countries.

Table 4-16 Northbound Transited Volume of Fabricated Metals by Major Loading and Unloading Countries

(Unit: 1,000 ton)

LOADING COUNTRIES	1976	1977	1978
Japan	4,018	3,546	1,792
India	537	575	337
Australia	507	351	300
Singapore	397	—	152
China	59	—	48
Others	154	929	425
TOTAL	6,357	5,401	3,054
UNLOADING COUNTRIES	**1976**	**1977**	**1978**
Russia	1,399	888	701
Turkey	663	771	292
Belgium	622	401	298
Greece	447	311	264
Italy	351	441	146
A.R.E.	235	172	91
Spain	226	—	—
Holland	219	—	—
England	212	140	77
Rumania	207	305	143
Poland	125	—	—
Others	1,651	1,972	1,042
TOTAL	6,357	5,401	3,054

In sharp contrast to the southbound traffic, the northbound traffic of fabricated metals decreased sharply. The northbound traffic of such goods, which was 1.7 times larger than the southbound traffic in 1976, fell to only five-thirteenths of the southbound traffic in 1978. There was no major change in the ranking of both exporting and importing countries in the country-by-country analysis of fabricated metals' northbound movements via the Canal. Both exporting and importing countries invariably showed a quantitative decrease in fabricated metal trade via the Suez Canal. Among exporting countries, Japan accounts for two-thirds of the entire northbound traffic of fabricated metals with the remaining one-third shared by India and Australia.
The Soviet Union and Turkey are leading importers of northbound fabricated matals, followed

by European countries. As for steel imports of West and East European nations, both West and East European countries' imports have been decreasing since 1976 when they reached a peak. In particular, imports of East European countries have halved. Two-thirds of East European imports are accounted for by the Soviet Union.

Japan's steel exports to Europe, which account for the bulk of the northbound Suez traffic of fabricated metals, declined considerbly during the 1976/1978 period as shown below:

(Unit: '000 ton)

	1976	1977	1978
Japan/Western Europe	4,369	2,665	1,187
(Japan/E.C.)	1,619	1,285	631

This sharp decline is mainly a result of Japan's voluntary export restrictions. Because of a particularly serious slump in the West European steel industry, the operating rate of steel mills of nine EC countries fell to 62% in 1977. The EC, as part of its anti-slump measures for its steel-making industry, asked Japan to conduct her steel export business in an "orderly" manner. In response, Japan started the above-mentioned export restrictions in 1976 in both quantitative and pricing aspects. Domestic demand in the EC has remained sluggish. But, the operating rate of EC steel mills improved to 65% in 1978 and to an estimated level of about 70% in 1979. This is because the EC nations stepped up their steel-exporting efforts and, as a result, their exports to such areas as America and West Asia increased.

4.8 Cement

4.8.1 Canal Traffic

Southbound cement was the largest dry cargo in the 1978 Canal traffic. The year's southbound movements of this item through the canal totaled 11,226,000 tons, showing an increase of 86% from 1977. (See Table 4-17)

Among exporting countries, Spain and Greece had a combined share of 64% in the southbound cement traffic of 1978. These countries have been rapidly expanding their cement exports. East European countries like Rumania, Poland, the Soviet Union and East Germany have also been increasing their exports. Destination countries were mostly Arabian nations. Among them, Saudi Arabia alone accounted for 46% of the traffic, in 1978, double its 1977 share, followd by Iran, the United Arab Emirates and Kuwait.

Table 4-17 Southbound Transited Volume of Cement by Major Loading and Unloading Countries

(Unit: 1,000 ton)

LOADING COUNTRIES	1976	1977	1978
Spain	423	1,241	3,900
Greece	1,439	1,973	3,229
Rumania	1,436	1,330	1,479
Poland	297	255	800
Italy	–	–	378
Russia	204	296	370
France	–	–	189
Germany (Fed.)	116	131	187
Germany (Dem.)	118	–	114
Holland	–	85	110
Others	598	724	1,037
TOTAL	4,631	6,035	11,226
UNLOADING COUNTRIES	**1976**	**1977**	**1978**
Saudi Arabia	1,325	2,505	5,117
Iran	227	570	981
United Arab Emirates	573	473	895
Iraq	193	378	–
Kuwait	127	361	865
Jordan	–	199	328
Rep. of Sudan	–	129	236
Pakistan	–	–	–
Others	2,186	1,420	1,443
TOTAL	4,631	6,035	11,226

4.8.2 Production, Exports and Imports

According to statistics of cement-exporting countries in Europe, Spain and Greece have been rapidly boosting their cement exports in recent years. The ratio of via-Suez shipments in their cement exports is high. Table 4-18 shows principal cement-importing countries' production, import volumes, imports via the Suez Canal and imports from Japan. Each country has been rapidly increasing cement consumption and imports since around 1975. Cement production in these countries is small with the exception of Iran and Iraq. Iran's output is relatively large and Iraq's production has been growing at a marked rate. But, production in Saudi Arabia is at 1 ~ 1.5 million tons a year and Jordan produces only 500 thousand to 600 thounsand tons a year. Although production in this region has been expanding at an average rate of about 10%, consumption has been increasing at an exceedingly high rate, resulting in a sharp increase in imports. Needless to say, cement is indispensable for the construction of infrastructure facilities such as roads, railways, ports and bridges. This material is also used for housing and other general projects. Cement is used for similar purposes to steel. Since Arabian Gulf countries have been promoting industrialization on the strength of their abundant oil income, the demand for cement in the region is very strong.

4.8.3 Imports of Arabian Gulf Countries and the World's Cement Situation

A close watch should be paid to the supply picture of exporting countries when examining the trend of cement imports of Arabian Gulf countries. As shown in Table 4.18, Arabian Gulf countries' imports via Suez Canal, that is, imports from Europe, made a very big upswing compared with their imports from Japan. This fact may be very gratifying for the SCA. The world's cement supply become tight in 1977 and 1978. Imports to the Arabian Gulf region, Africa and the U.S. (particularly the West Coast) increased appreciably. South Korea's export capacity shrank because of increased domestic demand for cement in that country. Japanese cement suppliers raised their dollar-based export prices considerably due to the appreciation of the yen and increased domestic demand. As a result, Japan lost some export deals to Europe which offered lower prices in trade with the Gulf area. Also adding to the tight supply situation were contingent and temporary factors in the Pacific basin such as the stoppage of shipments from Taiwan caused by a typhoon in 1977, delays in works as a result of the shortage of water on the U.S. West Coast and the resultant concentration of works on the Coast in 1967/1977, the resumption of Chinese imports in 1978 and demand created by a subway construction project in Hong Kong. At any rate, due note should be taken of the fact that Suez Canal traffic is affected not only by cement consumption and production in the Arabian Gulf area but also by a change in competitive relationship between European exporters and East and Southeast Asian exporters.

Until recent times, seaborne cement transportation was mostly made in bags since this cargo is apt to be easily damaged by dampness and dirt. Currently, however, shipments in the form of semi-processed clinker and in bulk have been increasing because of the need to reduce transportation costs as a result of growing demand for cement. The bulk transportation of cement was made possible as a result of joint efforts by exporters, importers and shipping firms. This system uses general cargo ships or handi-sized bulk carriers, but not cement tankers. To receive such cement at destinations, for instance, Saudi Arabia uses old tankers as floating storage facilities in the ports of Jeddah and Damman. The seaborne freight rate for bulk cement from Japan to the Arabian Gulf is about $17 per ton, as much as 30% lower than the rate of $25 per ton charged for bagged cement on the same route. The loading and unloading costs of bulk cement can be considerably reduced by the mechanization of cargo-handling operations. In exports from Japan, clinker and bulk shipments have been increasing while bagged shipments have been decreasing as shown below. This trend intensified in 1979 and may be the same in Europe/Middle East Trade.

Unit: %

	1977	1978
Bagged	61	39
Clinker	36	45
Bulk	3	16

Table 4-18 Cement Statistics of Arab Countries

(Unit: 1,000 ton)

	1972	'73	'74	'75	'76	'77	'78
Saudi Arabia							
Consumption				3,950	6,400	7,792	9,010
Per capita Kgs.				440	693	770	929
Production	910	964	1,056	1,250	1,300	1,292	1,510
Exports				–	–	–	–
Imports		237	635	2,700	5,100	6,500	7,500
Suez traffic				309	1,325	2,505	5,117
Import from Japan	129	22	141	592	713	1,839	2,032
Iran							
Consumption				6,620	6,900	8,800	10,600
Per capita Kgs.				200	203	257	300
Production				5,370	5,600	7,000	9,000
Exports				–	–	–	–
Imports	58	303	738	1,250	1,300	1,800	1,600
Suez traffic					227	570	981
Import from Japan				53	15	150	84
U.A.E.							
Consumption				877	1,817	1,396	1,401
Per capita Kgs.				4,000	8,000	2,080	1,950
Production				47	305	310	370
Exports				–	129	550	350
Imports				830	1,512	1,636	1,391
Suez traffic					573	473	895
Import from Japan				130	810	711	685
Kuwait							
Consumption				870	2,000	1,694	1,721
Per capita Kgs.				870	1,900	1,500	1,450
Production				285	352	329	621
Exports				–	–	58	170
Imports	716	628	871	850	2,000	1,665	1,900
Suez traffic					127	361	865
Import from Japan	152	12	134	411	1,197	730	556
Iraq							
Consumption				2,625	2,900	5,100	6,800
Per capita Kgs.				236	252	428	552
Production				2,700	2,700	4,600	6,500
Exports				100	50	20	20
Imports		127	60	27	250	500	300
Suez traffic					193	378	
Import from Japan						184	67

Source: CEMBUREAU "World Statistical Review"
U.N. "Statistical Yearbook 1978"
Suez Canal Report

CHAPTER 5 GENERAL CARGO AND LINER FLEET (CONTAINER FLEET RELATING TO THE SUEZ CANAL)

5.1 General

General Cargo (Other Goods)

1) The preceding chapter of this report mainly analyzed main dry cargoes transiting the Canal (mainly major bulk cargoes) item by item.

2) This chapter is mainly intended to analyze all other dry cargoes other than main bulk cargoes mentioned in the preceding chapter. Strictly speaking, therefore, the headword "general cargo" of this chapter means these "other goods."

3) This kind of other goods include a wide range of goods from minor bulk cargo (including such major bulk cargo items as bauxite and alumina not mentioned in the preceding chapter but excluding cement and steel materials) to general cargo which is generally regarded as liner cargo. This classification was made in conformity with the classification method for main cargo items that are hauled through the Suez Canal for statistical purposes.

4) In the field of other goods, trampers and liners compete with each other, and even major bulk cargo items discussed in the preceding chapter are often transported by liners as base cargo.

5) However, the problem is that there are no global statistical data on the "other goods" which mainly consist of minor bulk and general cargoes. Another problem is that it is difficult to know particulars of goods classified as "others" in the Suez Canal Statistics, although their volume is the largest and they are important in terms of analysis.

6) In this chapter, therefore, we attempt to analyze other goods in terms of their total volume on the one hand and to study their relationship with the actual carriage of goods through the Suez Canal on the other hand, as well as to provide data on cargo traffic on major liner trades that are related to the Suez Canal.

Liner (Container) Fleet Relating to the Suez Canal

1) This section is essentially intended to study particulars of operations of container ships (such as the frequency of services and ports of call) by route and operator of the liner fleet relative to the Suez Canal in order to make precise estimates. In this context, it is desirable to survey not only the liner fleet but also the tanker and tramper fleets.

2) In this kind of survey, it is the easiest way to work from the data on vessels registered in the Suez Canal Authority. It will take a lot of time if some other method is employed. The study on the subject has been conducted by taking into consideration a recent survey report of Nippon Yusen Kaisha, entitled "The Container Fleet of the World and Its Operations," and the findings of past surveys of container ships conducted by the Japan Maritime Research Institute. But the detail data is omitted from the report because it is lot of volume.

5.2 General Cargo (Other Goods)

5.2.1 Actual Transit of Dry Cargo through the Suez Canal

1) Actual transit via the Suez Canal of all dry cargoes other than oil and oil products (in the past three years) was 83,832,000 tons in 1976 (41,664,000 tons of southbound goods and 42,168,000 tons of northbound goods), 93,748,000 tons in 1977 (51,996,000 tons of southbound goods and 41,752,000 tons of northbound goods) and 116,600,000 tons in 1978 (75,366,000 tons of southbound goods and 41,234,000 tons of northbound goods).

Thus the traffic of dry cargo grew at an annual rate of 17.94% over the past two years (southbound goods registered a sharp 34.50% increase while northbound goods decreased 1.11%). Southbound goods showed a spectacular growth rate compared with the sluggish volume of northbound goods. On the whole, the growth of southbound goods more than offset the fall in northbound goods. (Note: Goods transported are shown in metric tons in this report.)

It is clear that the decline of northbound goods was caused by the recession and business stagnation in the West and East European countries after the oil shock of 1973. The remarkable increase in southbound goods reflected business activities in the Middle East countries, the newly industrializing countries of Asia, and Japan and Australia among the developed countries, as is evident from the actual cargo movements mentioned in the following 5.2.2 Other Goods.

2) As for dry cargo transported through the Suez Canal, we had an opportunity of surveying the breakdown of items by type of ship for July 1978 in December 1979, with the cooperation of staff members of the Economic Unit of the Suez Canal Authority. The survey showed that liner ships carried 66.5% of all dry cargo, while bulk carriers (including combined carriers) hauled 32.2%, car carriers 1.4% and other vessels 0.1%, as mentioned in the Table 5.1 Actual Carriage Share by Type of Ship and Cargo.

The 66.5% share of liners appears to be a bit too big for dry cargo which includes major bulk cargo items. But it can be regarded as a case peculiar to the Suez Canal. Although the survey shows a general trend for only one month, it provides valuable data that give a clue to the actual carriage of goods by type of ship and shows the trend in seaborne trade.

If the 66.5% share of liners for the particular month is applicable to the rest of the year 1978, liners hauled an estimated 77,539,000 tons (50,118,000 tons of southbound goods and 27,421,000 tons of northbound goods) of the 116,600,000 tons of all dry cargoes transported in that year (75,366,000 tons of southbound goods and 41,234,000 tons of northbound goods).

5.2.2 Other Goods (Actual Transit through the Suez Canal)

1) "Other goods" as used in this section are different from "others" classified in the Suez Canal Report, and they mean the remaining cargoes other than the cargoes taken up in the preceding chapter (Chapter 4) among all dry cargo hauled through the Suez Canal other than oil and oil products, as mentioned in 5.2.1 above.

In other words, they mean cargo items other than metals, cement, fertilizers and cereals so far as southbound goods are concerned and those other than ore and metals so far as northbound goods are concerned. "Other goods" in this limited sense include those carried by bulk carriers and it can be said that they almost correspond to General Cargo mainly carried by liner ships.

2) Table 5.2 Other Goods (a) Southbound, (b) Northbound shows actual carriage of "other goods" (southbound and northbound) by region (for the three years from 1976 to 1978) via the Suez Canal. Southbound goods increased from 22,654,000 tons in 1976 to 31,681,000 in 1977 and to 42,000,000 tons in 1978, registering an average annual growth rate of 36.16% over the past two years which is slightly higher than the 34.50% for all southbound dry cargo.

On the other hand, northbound cargo changed from 27,956,000 tons in 1976 to 34,456,000 tons in 1977 and to 30,977,000 tons in 1978. They registered an abnormal growth rate in 1977 and decreased in 1978 by 10.10%. However, they posted an average annual growth rate of 5.26% for the two-year period. This shows that southbound cargo has been on the increase compared with all northbound dry cargo which decreased (by 1.11%) in 1978. This can be regarded as a proof that general cargo is not so much affected by a recession.

5.2.3 Global Dry and General Cargo Traffic

1) The UNCTAD "Review of Maritime Transport, 1978" estimates, on the basis of U.N. statistics and statistical data of Fearnley & Egers, dry cargo traffic (including general cargo) at 812 million tons (including 327 million tons of major bulk cargo) in 1965, 1,165 million tons (including 488 million tons of major bulk cargo) in 1970, 1,428 million tons (including 634 million tons of major bulk cargo) in 1975 and 1,657 million tons (including 645 million tons of major bulk cargo) in 1977.

According to the UNCTAD estimate, the annual growth rate of dry cargo in the 1965~1977 period with the 1965 figure as the base was 6.12% (5.82% for major bulk cargo) and that in the 1970~1977 period with the 1970 figure as the base was 5.16% (4.07% for major bulk cargo).

Since the world total of dry cargo traffic in 1977 was 1,657,000,000 tons, the 93,748,000 tons of dry cargo hauled through the Suez Canal in that year (see (1) in 5.2.1) represents 5.66% of the total. However, since most iron ore was transported via the Cape, the actual share of the Suez Canal must have been greater if such cargo is excluded.

2) As for general cargo, the OECD "Maritime Transport 1970" reports that the total general cargo traffic of all OECD member countries in 1970 was 190 million M/T (on almost all liner trades). Using it as the base figure, the Japan Maritime Research Institute estimated general cargo traffic in 1975 at 231 million M/T, in 1977 at 250 million M/T, and estimated it as 260 million M/T in 1978 at 4 percent average annual growth rate.

Since 72,977,000 tons of other goods were transported through the Suez Canal in 1978 (42,000,000 tons of southbound goods and 30,977,000 tons of northbound goods, as mentioned in 5.2.2 (2) above), the share of general cargo traffic via the Suez Canal was 28.73%. It compares with the 5.66% share of the Canal in dry cargo traffic and shows that the percentage of liners that transited the Suez Canal was high.

5.2.4 Other Relevant Data

1) H.P. Drewry in the "Middle East Liner Shipping" estimated the total volume of seaborne trade in the Middle East region, which depends highly on the Suez Canal, at 51,000,000 F/T in 1977 (38 million F/T in the Persian Gulf and 13 million F/T in the Red Sea) and, on the basis of the 60% share of liners in cargo traffic, he estimated liner cargo traffic in the same year at 31 million F/T (32 million F/T in 1980 and 39 million F/T in 1985).

As for the regional breakdown of export liner cargo traffic, he estimated that Western Europe accounted for 40%, the Far East including Japan 30% (the share of this market is expected to grow) and North America and other areas (mainly India and the COMECON countries) 15% each.

2) It is not easy to convert cargo volume from F/T into M/T (and vice versa) because the rate of conversion differs for different cargo items and also according to trade practices. However, if the rate of F/T is considered 0.5 to M/T, and also in view of the fact that 64% of the 31 million F/T of Middle East liner cargo in 1977 was shipped in Western Europe (40%), North America (15%) and the COMECON countries (9% if 60% of all goods shipped to other greas were transported through the Suez Canal), it can be estimated that cargo traffic bound for the Middle East through the Suez Canal in 1977 was 19,840,000 F/T, that is, slightly around 10 million M/T.

Another report shows that five Japanese shipping companies operated 143 runs on the liner trade between Japan and the Middle East in 1978, carrying about 10 million F/T (corresponding to 5 million M/T) of cargo. It is considered, therefore that the estimated 30% share of liner cargo traffic involving Japan is proper (although the goods were not transported through the Suez Canal).

3) As for the trade between the Far East and Europe which depends highly on the Suez Canal, liner conference members engaged in the trade involving Japan reportedly haul 4 million F/T of West-bound goods, except steel materials and naked cars, and 2 million F/T of East-bound goods. If steel materials and cars are included, the volume of West-bound traffic increases to 8 millon F/T. Goods shipped from Hong Kong, Taiwan and South Korea by confereance liners also approach the 4 million F/T level.

4) It is said that the Siberian Landbridge service, which competes with conference liners, hauls 1 million F/T of Westbound cargo and 400,000 F/T of East-bound cargo. In terms of TEU, 250,000 TEUs. It can be said that the transport of goods between the Far East and Europe by the American Landbridge service, operated by Sea-Land Service, Inc., of the United States, has little impact at present.

5.3 Liner Fleet, Especially Container Fleet

1) According to the 1978 Lloyd's Register Statistics, there were 11,371 general cargo ships (multi-deck) totaling 60,357,000 G/T, 531 container ships (fully cellular) totaling 8,674,000 G/T and 29 lighter carriers totaling 773,000 G/T. Thus, the total number of these vessles, which can be regarded as liners, was 11,931 and their total tonnage was 69,804,000 G/T. It is difficult and time-consuming to survey actual cargo carriage by route by general cargo ships in view of

diverse forms of operation. However, it is highly desirable to conduct such a survey about not only liner ships but also tankers and trampers for that matter via the Suez Canal from the ship register in the Suez Canal Authority and how often they serve on particular routes.

2) Among liner ships, the current situation about world container fleet is as follows: In this case, container ships mean semi-container ships, full-container ships, Ro/Ro ships, LASH ships and other vessels such as multipurpose ships that can haul containerized cargo (in this sense, container ships include oceangoing bulk containers of 3,000 G/T or more or with a capacity of 150 TEUs each that are placed on liner trades).

5.3.1 Container Ships Completed and New Orders Received in 1978

In 1978, 107 oceangoing container ships, intended to serve on liner trades, totaling 1,920,000 G/T were completed (including remodeled ships) compared with a total tonnage of 1,270,000 G/T built in 1977, exceeding the 1 million G/T mark for the second year in a row. The tonnage of ships completed in 1978 was almost comparable to the all-time high of 2 million G/T registered in 1972. In terms of transport capacity, the ships completed in 1978 exceeded those of 1972 by 20,000 TEUs and established a record of 105,000 TEUs.

As a result, the total tonnage of oceangoing container ships launched on liner trades in the world increased to 9.9 million G/T, approaching the 10 million G/T mark. Their combined transport capacity exceeded the 500,000 TEU mark (an increase of slightly less than 20% over the preceding year).

Orders received in 1978 reportedly totaled 2,850,000 D/W, and order backlogs totaled 318 ships with a total tonnage of 4,710,000 D/T, or the equivalent of 50~60% of the existing tonnage.

5.3.2 Background of the Expanding Container Fleet and Its Features

Liner cargo traffic has been fairly steady except in 1975 reportedly, and container trade has emerged from the traditional pattern that centered round four major markets – the United States, Europe, Japan and Australia – and expanded to the Middle East oil-producing countries and the newly industrializing countries. The global network of container ship services is now expanding to cover South and West Africa, the Caribbean Sea and Central America.

In terms of supply, developed countries have begun to replace old container ships after the first decade of containerization, in addition to the rapid expansion of container fleets of newly industrializing countries, oil-producing countries and East European countries. One trend is the increased construction of large-sized ships to cope with increased competition.

A future problem is how business conditions in the United States, the largest nation in terms of handling containerized cargo, and the second oil crisis will affect the rapid expansion of the world container fleet.

5.3.3 Share of Containerized Seaborne Cargo

The Japan Maritime Research Institute estimates that the rate of containerization of cargo hauled on major routes serving Japan is about 30 percent, in view of the fact that containerized seaborne cargo accounts for 30% of all export and import general cargo traffic, according to Japanese port statistics.

If this rate is applied to containerized cargo traffic between OECD countries which constitute the center of containerization, its estimated volume in 1978 was about 78,000,000 tons because general cargo traffic totaled an estimated 260 million tons in that year (refer to (2) in 5.2.3 above).

5.3.4 Relationship between F/T and TEU

Making a simple conversion between F/T and TEU is prone to error due to specific characters of individual trade items. As for Japan, it is generally said that one TEU is equivalent to about 24 F/T in the case of West-bound goods and about 17 F/T in the case of East-bound goods in trade between the Far East and Europe.

According to a survey of Japan's export and import trades conducted by the Japan Maritime Research Institute, one TEU in export trade is equivalent to 15.4 F/T of goods bound for the West Coast of North America, 15.3 F/T of goods bound for the East Coast of North America, 17.4 F/T of those bound for Europe (the equivalent of 24 F/T for West-bound goods mentioned above is too high) and 21.5 F/T of goods bound for Australia. In import trade, it is equivalent to 13.8 F/T, 14.0 F/T, 15.3 F/T and 18.7 F/T, respectively. In terms of M/T, one TEU is equivalent to 13.8 M/T, 13.3 M/T, 12.7 M/T and 16.5 M/T, respectively.

5.3.5 Container Fleet by Routes (Especially Those Related to the Suez Canal)

There are 32 routes served by container ships in the world, as shown in the attached List of Containerized Trades in Table 5-3 Of them, the eight routes mentioned below seem to be closely related to the Suez Canal.

1. Far East/Europe service,
2. Far East/Mediterranean service,
3. North America/Middle East service,
4. Europe, Mediterranean/Australia, New Zealand service,
5. Europe, Mediterranean/Middle East service,
6. Europe, Mediterranean/South Africa service,
7. Europe, Mediterranean/East Africa service,
8. Europe, Mediterranean/Southeast Asia service.

5.3.6 Container Ships Placed on Routes Related to the Suez Canal

In our survey, container ships serving on the liner trades related to the Suez Canal were 116 full-container ships totaling 4,147,195 G/T (3,884,428 D/T), 214,258 TEUs), 41 semi-container ships totaling 532,253 G/T (716,237 D/T, 20,431 TEUs), eight LASH ships totaling 267,487 G/T (362,036 D/T, 522 barges), 62 Ro/Ro ships totaling 702,104 G/T (1,027,330 D/T, 51,516 TEUs), nine bulk container ships totaling 133,968 G/T (296,978 D/T, 9,835 TEUs), 4 bulk carriers totaling 66,637 G/T (96,411 D/T, 1,775 TEUs), 26 multi-purpose ships totaling 294,857 G/T (435,405 D/T, 11,084 TEUs), four combo ships totaling 40,244 G/T (59,798 D/T, 1,400 TEUs) and 20 conventional vessels totaling 226,364 G/T (295,805 D/T, about 5,514 TEUs). The total 306 ships with a combined tonnage of 6,621,982 G/T (7,510,716 D/T, 324,117 TEUs) include

23 ships in terms of G/T, 9 ships in terms of D/T and 18 ships in terms of TEUs (plus 552 barges) whose particulars are unknown respectively.

It is possible to prepare a list of ships which transited the Suez Canal, including non-container ships, from the original register of vessels registered with the Suez Canal Authority and other sources. For example, it seems possible to learn the number of ships transiting the Canal in a given year, the tonnage of such ships by shipowner or group and their frequencies of service through the Canal and prepare a list of newly completed ships using the Canal.

Table 5-1 Practical Trend of Carriage by Types of Ships and Cargoes in the Suez Canal, July 1978

(Unit: M/T)

Ship Type / Cargo Type		Bulk C.	Conb. C.	Liner Ships				Car C.	Other Ship	Total
				G.C. Ship	Container	Lash Ship	Ro/Ro Ship			
1. Cereals	Total	174,778	–	185,908	–	–	1,187	–	–	361,873
		(48.3%)		(51.4%)			(0.3%)			(100%)
	North	20,450	–	72,011	–	–	–	–	–	92,461
	South	154,328	–	113,897	–	–	1,187	–	–	269,412
2. Phosphate	Total	165,979	36,253	94,804	–	–	–	–	–	297,036
		(55.9%)	(12.2%)	(31.9%)						(100%)
	North	72,500	–	38,850	–	–	–	–	–	111,350
	South	93,479	36,252	55,954	–	–	–	–	–	185,685
3. Fertilizer	Total	231,063	–	159,074	–	–	–	–	–	390,137
		(59.2%)		(40.8%)						(100%)
	North	–	–	–	–	–	–	–	–	–
	South	213,063	–	159,074	–	–	–	–	–	390,137
4. Iron Ore	Total	374,250	36,449	45,569	–	–	–	–	–	456,268
		(82.0%)	(8.0%)	(10.0%)						(100%)
	North	226,637	36,449	38,165	–	–	–	–	–	301,251
	South	147,613	–	7,404	–	–	–	–	–	155,017
5. Fab. Metal (Ept. 4.)	Total	493,022	20	53,128	12,555	–	–	–	532	558,725
		(88.2%)	–	(9.5%)	(2.2%)				(0.1%)	(100%)
	North	176,350	20	25,595	–	–	–	–	213	202,178
	South	317,572	–	27,533	12,555	–	–	–	319	357,979
6. Cement	Total	686,367	–	373,225	–	–	–	–	–	1,059,592
		(64.8%)		(35.2%)						(100%)
	North	–		34,916	–	–	–	–	–	34,916
	South	686,367	–	338,309	–	–	–	–	–	1,024,676
7. Others (Ept. 6.)	Total	1,580,688	56,174	5,444,929	1,167,238	173,562	216,458	161,238	11,415	8,811,702
		(17.9%)	(0.6%)	(61.8%)	(13.3%)	(2.0%)	(2.5%)	(1.8%)	(0.1%)	(100%)
	North	645,494	52,174	2,194,414	467,846	13,514	27,274	95,042	4,127	3,499,885
	South	935,194	4,000	3,250,515	699,392	160,048	189,184	66,196	7,288	5,311,817
Total		3,706,147	128,896	6,356,637	1,179,793	173,562	217,645	161,238	11,947	11,935,865
		(31.1%)	(1.1%)	(53.3%)	(9.9%)	(1.5%)	(1.8%)	(1.4%)	(0.1%)	(100%)
				[7,927,637 (66.5%)]						
	North	1,141,431	88,623	2,403,951	467,846	13,514	27,274	95,042	4,340	4,242,021
	South	2,547,616	40,252	3,952,686	711,947	160,048	190,371	66,196	7,607	7,676,723

Table 5-2 Cargo Movement by Areas of Other Goods in the Suez Canal 1976 – 1978

(a) Southbound goods tonnage by regions
north & south of the Canal

(Unit: 1,000 ton)

REGIONS	Other Goods		
A. North of the Canal:	1976	1977	1978
North & West Europe & U.K. Ports	9,142	13,899	19,467
Baltic Sea ports	785	1,053	1,370
North Mediterranean ports	4,814	7,140	9,481
East & S.E.	794	689	972
West & S.W.	652	1,081	1,648
Black Sea ports	2,941	3,603	4,002
American ports	3,244	3,888	4,643
Others	282	328	417
TOTAL	22,654	31,681	42,000
B. South of the Canal:			
Red Sea ports	4,902	6,720	10,843
East Africa & Aden	1,767	2,153	2,436
India, Pakistan, Sri Lanka & Burma	2,341	3,586	4,262
Arabian Gulf ports	6,182	8,043	10,325
South East Asia & Sunda Islands	2,228	4,777	5,574
Far East	4,312	5,343	7,221
Australia	413	967	1,339
Others	509	92	0
TOTAL	22,654	31,681	42,000

Source: Suez Canal Report

(b) Northbound goods tonnage by regions north & south of the Canal

(Unit: 1,000 ton)

REGIONS	Other Goods		
A. North of the Canal:	1976	1977	1978
North & West Europe & U.K. ports	13,570	15,346	14,817
Baltic Sea ports	1,041	1,253	879
North Mediterranean ports	4,610	6,675	6,581
East & S.E.	1,945	3,212	2,163
West & S.W.	526	930	462
Black Sea ports	3,769	4,446	3,684
American ports	1,504	1,805	1,521
Others	991	789	870
TOTAL	27,956	34,456	30,977
B. South of the Canal:			
Red Sea ports	2,311	2,419	2,637
East Africa & Aden	2,175	2,848	3,574
India, Pakistan, Sri Lanka & Burma	5,720	5,675	4,852
Arabian Gulf ports	478	354	291
South East Asia & Sunda Islands	8,880	10,299	11,311
Far East	5,124	10,056	6,178
Australia	2,675	2,715	2,134
Others	593	90	0
TOTAL	27,956	34,456	30,977

Table 5-3 List of Container Trades in the World

Japan & Far East Trades	US Trades	Europe & Mediterranean Trades	Australia Trades
1. Far East/PSW(U.S.A.)	1. Atlantic Coast of North America/ Europe	1. Europe, Mediterranean/Australia, New Zealand	1. Australia/Middle East, Australia/India and Pakistan, Australia/Pappua New Guinea
2. Far East/PNW(U.S.A.)	2. Gulf (North America) /Europe	2. Europe, Mediterranean/Caribbian, Central & South America	
3. Far East/ Atlantic Coast (North America)	3. Atlantic Coast of North America/ Mediterranean Sea	3. Europe, Mediterranean/Middle East	
4. Far East/Europe	4. Gulf (North America) /Mediterranean Sea	4. Europe, Mediterranean/West Africa	
5. Far East/ Mediterranean Sea	5. Great Lakes & East Coast of Canada/ Europe, Mediterranean	5. Europe, Mediterranean/South Africa	
6. Far East/ Australia, New Zealand	6. Pacific Coast of North America/ Europe, Mediterranean	6. Europe, Mediterranean/East Africa	
7. Far East/Middle East	7. North America/ Australasia	7. Europe, Mediterranean/South & East Asia	
8. Far East/Caribbean Sea, Central & South America	8. North America/ Middle East		
9. Far East/West Africa	9. Atlantic Coast of North America, Gulf/ Caribbian, Central & South America		
10. Japan/Nakhodka	10. Pacific Coast of North America,Gulf/ Caribbian, Central & South America		
11. Japan/China	11. North America/Africa		
12. Asia Area	12. North America Area		

CHAPTER 6 MARITIME TRANSPORTATION COSTS

6.1 General

In the system analysis report for the last fiscal year, the emphasis was placed primarily on tankers, and the cost analysis also centered around tankers. Four size of ships were selected for the respective development projects of the Suez Canal – the 60,000, 150,000 and 250,000 d/wt tankers and the 500,000 ton tanker which is about the largest tanker in existence. Using these four sizes as reference,

1) Calculation was conducted on route selection by voyage estimate, and
2) A cost comparison was made under the per-ton-cost formula on each ship size route and also a study was made on the future trends of the tanker market. This was followed by an analysis made on how the price increase of slow steaming bunker oil and the fluctuation of canal toll would affect route selection.

* For further detailed analysis, see Chapter 1 Analysis of Effects of Freight Market Upon Suez Canal Traffic (VLCC's 1978) in the September 1979 Research Report by the Economic Unit prepared as part of the training program. As a means to supplement the above findings, the three following analysis were made on tankers for the current fiscal year.

1) Analysis of the effects on the tanker market after bunker oil price increased from \$80 to \$160;
2) Analysis of the New World Scale Rates effective January 1, 1980, and
3) Analysis of the economy of canal transit by part-laden tankers.

Analysis for the second fiscal year will be conducted on non-tankers, especially dry bulk carriers and tramps. In general, the traffic volume of non-tankers is relatively unaffected by the fluctuation of the freight market (the same can be said for tankers below 150,000 tons.) Notably, the smaller ships can adequately reap the advantage of passing through the Suez. But in larger ships like bulk carriers over 60,000 tons and combination carriers in the Australia/Europe iron ore and coal trade, canal transit is frequently affected by the freight market. In contrast, the fluctuation of the freight market has relatively little impact on the U.S. Gulf/Arabian Gulf and grain trade because the ships are relatively small. The following shows some actual examples of selecting shipping routes in terms of trade routes and size of ships.

6.2 Effects of Fuel Oil Price on the Canal Traffic

In the Systems Analysis Report (Part III, 5. 7.) of last year, an analysis was conducted on a 10% increase in bunker oil price. The break-even point of C/C and C/S for Ras Tanurs/Rotterdam for 250,000 ton tankers changed only slightly from \$6.69 to \$6.66. Actually, the price rose twofold from \$80 to \$160 after the turmoil in Iran entering 1979. However, the change in break-even point showed a drop of only \$0.29, or 4.3% to \$6.40. (2 points in terms of worldscale) (See Table 6.1) This trend is also seen in other types of ships. Then, has the rise in bunker oil price affected VLCC transit in the Suez Canal? The answer is "Yes". Or, it would be more accurate to say: "The impact comes indirectly after the tanker market has been effected by the price increase."

Table 6-1 Break Even Point of 250,000 ton Tanker in the Trade of Ras Tanura to Rotterdam via C/C and C/S

	Freight rate per ton	World Scale equivalent (C/S)	World Scale equivalent (C/C)
1. Fuel oil price per ton $ 80	$6.69	W 40	W 38
2. Fuel oil price per ton $160	$6.40	W 38	W 36

Table 6-2 Laid-up Tanker Tonnage

	Tanker Lay-up		Tanker Market
	(No.)	(000 dwt)	(World Scale)
30th April 1977	319	26,766	23.8
31st May 1977	319	29,132	22.2
30th June 1977	327	31,112	20.4
31st July 1977	330	33,921	22.0
31st August 1977	332	34,128	23.9
30th September 1977	339	35,085	22.6
31st October 1977	342	37,447	24.6
30th November 1977	324	31,170	28.2
31st December 1977	322	31,503	30.2
31st January 1978	327	33,597	20.4
28th February 1978	335	36,069	20.6
31st March 1978	346	38,399	19.5
30th April 1978	354	40,986	19.0
31st May 1978	357	42,264	20.3
30th June 1978	368	43,521	21.2
31st July 1978	361	43,219	26.3
31st August 1978	356	41,602	31.0
30th September 1978	328	38,013	35.9
31st October 1978	280	29,829	44.9
30th November 1978	249	25,924	49.8
31st December 1978	223	23,164	40.0
31st January 1979	208	21,873	31.4
28th February 1979	196	20,806	22.2
31st March 1979	190	21,639	43.9

Source: General Council of British Shipping
Norwegian Shipping News Tanker freight index

Examine Table 6-2. This is a table contrasting the tanker market (VLCC, by Norwegian Shipping News) with the laid-up tanker tonnage in the two years after April 1977. The volume of lay-up tanker reached its peak of 43,521 thousand d/wt in June 1978. However, in the several months preceding this peaking, the VLCC was about W20 in the tanker market. This table also shows that in 1977, the market was about W23, with lay-up tonnage slightly over 30 million tons. In other words, it indicates that the tanker market during this period was lower than most of the ships' lay-up point. It was notably a severe period for the older uneconomical (inefficient) ships. Here, we would like to say something on lay-up point.

Lay-up point in general means the freight level at which the shipowner determines it is more economical to lay-up a ship than to use it to transport cargo. This is shown in the following equation:

$$\text{Net income per day}\left(\frac{\text{Freight income} - \text{voyage cost}}{\text{Voyage days}}\right) = \text{Ship cost savings per day}\left(\frac{\text{Ship cost savings by lay-up}}{\text{Lay-up days}}\right)$$

Ship cost savings mean the amount of ship cost (crew cost, maintenance cost and insurance etc.) saved by lay-up minus the special expenses required for lay-up. The amount would differ considerably according to the condition of the ship, the method of lay-up and duration of lay-up. The lay-up point is the support base of the tanker market. The lowest limit for the very short-term is the point where the net income per day becomes zero. A rise in the bunker oil price has the effect of raising the tanker market by pushing up either this lowest limit or the lay-up point which is the support base. For example, in the case of a 250,000-ton turbine tanker on the Ras Tanura/Rotterdam C/S route, the cost of consumption of 8,612 of fuel increases from $688,960 at a bunker price of $80 to $1,377,920 at a bunker price of $160. This works out to $2.86 per ton for 240,587 L/T of cargo carried. This is equivalent to 20% of the standard World Scale Rate of $14.28 (July 1, 1978) for the same route, or W20. Assuming that the VLCC lay-up point, or the bottom line of the market is W15 (monthly average in April 1975 was W16.1), the market's lower limit would be W35 as a result of the bunker price rising to $160. As a result, the bottom limit of the VLCC Mediterranean tanker market would surpass the break-even point of C/S and C/C and approach that of N.W. Europe. Consequently, it increases the competitiveness of the Suez Canal. (See Table 6-3) This computation is based on turbine. The figure would be lower (about two thirds) in the case of diesel tanker. However, it would be appropriate to use the figures for turbine because 80% of the 150,000 ~ 300,000-ton ships and all of those above 300,000 tons are turbine. The analysis was conducted on the basis of the conclusion that a rise in bunker oil price would push up the lower limit of the tanker market. However, it would be difficult to answer the question, what would be the WS at ¥160, if for example it is W40 at $80? In general, it can only be said that when the market is in an upswing, the impact of a rise in bunker oil price is smaller if the market is higher.

Table 6-3 Break even point of 250,000 Tanker in the Trade of Ras Tanura to Major ports via C/C and C/S

	Freight rate per ton	World Scale equivalent (C/S)	World Scale equivalent (C/C)
1. Piraeus	$ 3.94	W 27	W23
2. Trieste	$ 4.28	W 28	W 25
3. Genova	$ 4.63	W 30	W 28
4. Fos	$ 4.75	W 33	W 30
5. Rotterdam	$ 6.69	W 40	W 38
6. Halifax	$ 8.83	W 57	W 54
7. Bahamas	$ 12.78	W 81	W 78

6.3 New World Scale Rates (January 1, 1980)

New World Scale Rates (January 1, 1980) were announced by World Scale Association (London) Ltd., and World Scale Association (NYC), Inc. These rates include the rise in fuel oil prices from October 1978 to September 1979 and the changes in port expenses from April 1979 to September 1979 (Port expenses for October 1978 to March 1979 were incorparated in the July 1979 edition of the World Scale Tariff.) The Ras Tanurs/Rotterdam case according to the July 1979 and January 1980 editions are as follows:

Unit: US$

	Suez	Cape/Suez	Cape/Cape
JAN. 1980			
	12.59	16.54	20.56
Additionals for Rotterdam	0.57	0.57	0.57
Suez Differentials	2.34	1.06	–
JULY 1979			
	10.64	13.94	17.32
Additionals for Rotterdam	0.50	0.50	0.50
Suez Differentials	2.24	1.01	–

Note: Additionals for Rotterdam 0.57 are for crude oil and entire discharge.

Table 6-4 Worldscale Rate of Main Routes as of Jan. 1, '80

Loading port / Discharge port	Ras Tanura			M.A. Ahmadi			Kharg Island		
		S	CS		S	CS		S	CS
Milford Haven	20.35	12.33	16.30	20.86	12.84	16.81	21.66	13.64	17.61
Falmouth	20.07	12.06	16.02	20.58	12.57	16.53	21.38	13.37	17.33
Lavera	20.11	9.73	14.85	20.62	10.24	15.36	21.42	11.04	16.16
Venice	21.37	9.04	15.11	21.88	9.55	15.62	22.68	10.35	16.42
Genoa	19.98	9.31	14.57	20.49	9.82	15.08	21.29	10.62	15.88
Rotterdam	21.13	13.16	17.11	21.64	13.67	17.62	22.44	14.47	18.42
Wilhelmshaven	21.35	13.29	17.28	21.86	13.80	17.79	22.66	14.60	18.59
Hamburg	21.58	13.52	17.51	22.09	14.03	18.02	22.89	14.83	18.82
Stockholm	23.38	15.12	19.21	23.89	15.63	19.72	24.69	16.43	20.52
New York	20.54	14.96	17.72	21.05	15.47	18.23	21.85	16.27	19.03
New Orleans	20.73	16.70	18.70	21.24	17.21	19.21	22.04	18.01	20.01
San Francisco	18.61			19.12			19.92		
Los Angeles	19.17			19.68			20.48		
Trinidad	17.75	15.06	16.40	18.26	15.57	16.91	19.06	16.37	17.71
Santos	15.80			16.31			17.11		
Melbourne	13.20			13.71			14.51		
Keelung	10.16			10.67			11.47		
Yokohama	12.42			12.93			13.73		
Piraeus	21.26	7.85	14.44	21.77	8.36	14.95	22.57	9.16	15.75
Trieste	21.22	8.90	14.96	21.73	9.41	15.47	22.53	10.21	16.27
Fos	20.11	19.73	14.85	20.62	20.24	15.36	21.42	21.04	16.16
Halifax	20.06	14.10	17.05	20.57	14.61	17.56	21.37	15.41	18.36
Freeport, Bahamas	20.95	16.45	18.68	21.46	16.96	19.19	22.26	17.76	19.99

Note: S = Via Suez in both direction
CS = Via Cape Town in laden voyage and Via Canal in ballast
$2.34 in S and $1.06 in CS should be added.

This margin of increase is equivalent to about 18%. Let us see how the market indicators change. The indicator for W50 in July 1979 changed to W42.3 for Suez in January 1980, W42.1 for C/S and 42.1 for C/C. Let us next examine the break even points for C/C and C/S routes for a 250,000-ton Ras Tanura/Rotterdam tanker using this new rate and the present fuel price ($160). When we do the calculation by using Part III 5.4 and Table 5.1 (26 & 27) of last year's report (Systems Analysis March 1979), the break-even point comes to $6.40, or W31 for C/S and W30 for C/C when the new scale is used. This is still an attractive figure when compared with the VLCC rate of W50 for A.G./Europe entering 1980.

Moreover during January 1979 the market was about W30 as against the break-even point of W38, and in January 1978 the market was about W20. For reference, a table of new world scale on major trade is attached to this report. (See Table 6-4)

6.4 Profitability of Part-laden Tankers

The number of larger-than-60,000-ton tankers which passed through the canal part-laden in 1978 totalled 235 vessels (224 northbound and 11 southbound). Especially the northbound vessles had transported 47% of the total of 28 million tons of petroleum transported through the canal. It is thought that these ships had passed through the canal part-laden because the present restrictions on draft and ship width prevent them from passing through fully loaded. The same can be said for some of the 40,000 to 60,000-ton class tankers.

According to SUMED officials, some of the tankers would transfer part of their load to SUMED pipeline and reload the oil after passing through the canal on the Mediterranean side. The next Table 6-9 (1) (2) show a study on the profitability of general part-laden tankers that do not use the SUMED. The case study sets the size of tanker at 78,000 dwt. In this case, the types of ships that are allowed to navigate through the canal are those with a width of 127 feet (38.7 m) and draft of up to 36 feet as stipulated in the SCA Rules of Navigation. At a draft of 36 feet, the dead-weight, calculated by the deadweight scale, would be about 63,000 dwt. Let us compare the profitability of shipping between a fully-loaded ship on the C/S route and a part-laden ship on the S/S route. The break-even point

$$\frac{\text{Loaded tonnage X freight rate} - \text{voyage cost}}{\text{No. of days per voyage}}$$

would be $11.52, the same for both. This freight level is not necessarily low. It appears there is very little merit for part-laden Genoa-bound tankers to transit the Canal.

When considering this problem, however, it is necessary to examine the differential in ship size in the tanker market. The tanker market for 1978 as indicated by the Norwegian Shipping News' Freight Index is as follows: (average for January ~ December 1978)

150,000 ~	W.29.1	
60,000 ~ 150,000	W.64.1	
30,000 ~ 60,000	W.107.9	
~ 30,000	W.152.2	(dirty)

For VLCC, this is a level that only covers 60% of the cost. In comparison, the level for small ships is very high and just about covers their entire cost. For the aforementioned part-laden tanker, a higher freight rate for the 63,000-ton level can be obtained, and this is the merit for part-laden operation. The reason for the high freight rate for small ships and low rate for the large ships can, of course, be attributed to the fact that a large number of 60,000-ton class tankers have been chartered to transport U.S. oil imports. As a reflection of this, more and more orders are now being placed for tankers of less than 80,000 tons. Therefore, it is believed that the gap in freight rates will gradually close.

6.5 Profitability of Large Bulk Carrier Transit in the Australia, India/Europe Iron Ore Trades

Northbound iron ore transitting the Canal in 1978 came to about 3,901 thousand tons. The loading countries were India and Australia and the unloading nations were Rumania, the Soviet Union and West European nations. On the other hand, the volume of iron ore shipped to European countries in the same year from Australia and India totalled 16,627 thousand tons (see Table 6-5). Of this total, 23.5% passed through the Canal.

Table 6-5 Iron Ore Movements: Australia, India/Europe Trade, 1978

(Unit: 1,000 ton)

To: / From:	UK. Cont.	Mediterranean	Other Europe	Total
Australia	12,418	1,533	737	14,688
Asia	25	764	1,150	1,939
Total	12,443	2,297	1,857	16,627

Source: Fearnley & Egars Chartering Co., Ltd. "World Bulk Trade 1978"

In other words, the remaining 12 million tons were transported by large vessels via the Cape.

We now turn to a study of the economic possibilities of large ships transitting northbound through the Canal after the latter part of 1980 when the First Stage Development Project is scheduled to be completed. The pattern of distribution by ship sizes in this trade shows that about 80% of the ships are larger than 60,000 tons, according to Fearnley and Egers. Notably, ships over 100,000 tons dominate, accounting for about half of the total.

Thus, a comparative study was made on the profitability of the Suez and Cape routes for 130,000-ton bulk carrier, the typical size that would meet the 53-feet draft limit after the completion of the First Stage. (See Table 6-9 (3), (4)) According to the study, the difference in distance between the two routes is about 2,100 miles (Port Dampier/Rotterdam). The conditions of competition are severer than in the case of the 4,600-mile distance difference in the Arabian Gulf/Europe tanker trade. The break-even point freight rate where the profitability of the two routes becomes equal is $10.26. If the rate is higher, it becomes more advantageous to use the Canal. When we examine the contracts on the trade of ships of this size in the recent dry cargo market, we note that the rate were at a low of $8 in March and April 1979. The rate, however, rose considerably to about $12 in September and October, exceeding the break-even point.

Table 6-6 Ships' size Distribution in the Trade of Australia, India/Europe

	(1,000 DWT)					
	-40	40-60	60-80	80-100	100-	Total
Importing Area						(%)
UK/Continent	8	3	24	12	53	100
Mediterranean	11	13	16	12	48	100
Other Europe	43	22	16	8	11	100
Exporting Area						
Asia	30	15	12	2	41	100
Australia	7	8	8	6	71	100

Source: Fearnley & Egers Chartering Co., Ltd. "World Bulk Trade 1978"

This is atributed to the fact that the dry cargo market was generally bullish, and that there was also a recovery of steel production in Japan and Europe. There are mixed opinions as to whether this trend will continue in the future.

In the India/Europe trade, the ratio of small ships is high. When a similar calculation is made for a 60,000-ton ship, the break-even point comes to $4.16, making it over-whelmingly advantageous to use the Suez Canal. The market will have negligible effect on this trade.

6.6 Profitability of Large Bulk Carrier Transit in the Australia/Europe Coal Trade

The volume of coal transported through the canal in 1978 from Australia to Europe totalled 874 thousand tons. On the other hand, the total Australia/Europe coal trade was 6,733 thousand tons as shown in Table 6.7.

Table 6-7 Coal Movements: Australia/Europe Trade, 1978

(Unit: 1,000 ton)

From: \ To:	UK. Cont.	Mediterranean	Other Europe	Total
Australia	4,636	1,205	892	6,733

Source: Fearnley & Egars Chartering Co., Ltd. "World Bulk Trade 1978"

The distribution of ship sizes is shown in Table 6-8 The ratio of large ships is lower than in the iron ore trade (about 20% of the ships are over 100,000 tons).

Table 6-8 Ships' Size Distribution in the Coal Trade of Australia/Europe, 1978

	(1,000 DWT)					
	-40	40–60	60–80	80–100	100–	Total
Importing Area						(%)
UK/Continent	37	12	26	5	20	100
Mediterranean	32	23	20	11	14	100
Other Europe	66	17	11	1	5	100
Exporting Area						
Australia	14	27	37	1	21	100

Source: Fearnley & Egars Chartering Co., Ltd. "World Bulk Trade 1978"

Table 6-9 (7), (8) is the voyage estimate of the comparative profitability of 130,000-ton bulk carriers using the Cape and Suez routes. The break-even point is $10.85, or about the same as in the case of iron ore. The freight market at present is about $14. Thus, even large bulk carriers will be able to use the Canal in this trade after the completion of the First Stage Development Project. Attached for reference is a comparative study on the profitability of 60,000-ton ships in the Australia/Europe bauxite trade. The break-even point for this is $9.28 and the market price is about $20. The Suez Canal has considerable competitive power in this ship size.

6.7 Profitability of Bulk Carrier Transit in the USA/Indian Ocean Grain Trade

Southbound grains are shipped from the U.S., Canada and France to nations along the Arabian Gulf and the Indian Ocean. Some of the loading areas include the U.S. Gulf, USNH (Northern Hatteras: US East Coast, northern part), St. Lawrence and Great Lakes. The volume is not available because the trade statistics include shipments from the U.S. and West Coast of Canada to Asian countries. As a sample computation for route selection, the case of U.S. Gulf/Karachi by 45,000 ton ship is given. (Table 6-9 (11), (12)) The break-even point is $6.68 which is significantly lower than the present freight market of about $30. The Canal thus is quite competitive.

Table 6-9 (1) VOYAGE ESTIMATE

No.
Date

M/S Tanker (S/S)
(D/W 78,000 L/T) Speed 15.0 K't (laden)
16.0 K't (in ballast)

Cargo: Crude oil — Tons: 60,530 — rate — Freight

Des/Dem $

Port	Distance (mile)	at Sea (day)	in Port (day)	Port charges $
Ras Tanura	4,585	12.7	1.5	9,700
Suez			1.0	92,500
Genoa		1.0	2.0	41,900
Suez		1.0	1.0	75,200
Ras Tanura	4,585	11.9		
				Cargo expense $
				Commission $
(spare)				Sundries $
Total	9,170	26.6	5.5	
	Total	32.1	days	

Fuel consumption
C–F.O. at Sea 65 T/d 1,729 T
in Port 33 T/d 182 T
Total 1,911 T @$160 — $ 305,760

A–F.O. at Sea 2 T/d 64 T
in Port T/d T
Total 64 T @$ 320 — $ 20,480

D/W	63,000	Total expense	$ 545,540
Fuel	1,975	Net proceed	$
Spare	195	Hire cost	$
Water	300	Net profit	$
Others		(C/B)	$
Cargo	60,530	(H/B)	$

Table 6-9 (2) VOYAGE ESTIMATE

No.
Date

M/S Tanker (C/S)
(D/W 78,000 L/T) Speed 15.0 K't (laden)
16.0 K't (in ballast)

Cargo: Crude oil — Tons: 74,446 — rate — Freight

Des/Dem $

Port	Distance (mile)	at Sea (day)	in Port (day)	Port charges $
Ras Tanura	10,945	30.4	1.5	9,700
Cape				
Genoa		1.0	2.0	41,900
Suez			1.0	75,200
Ras Tanura	4,585	11.9		
				Cargo expense $
				Commission $
(spare)				Sundries $
Total	15,530	43.3	4.5	
	Total	47.8	days	

Fuel consumption
C–F.O. at Sea 65 T/d 2,815 T
in Port 33 T/d 149 T
Total 2,964 T @$ 160 — $ 474,240

A–F.O. at Sea 2 T/d 96 T
in Port T/d T
Total 96 T @$ 320 — $ 30,720

D/W	78,000	Total expense	$ 631,760
Fuel	3,059	Net proceed	$
Spare	195	Hire cost	$
Water	300	Net profit	$
Others		(C/B)	$
Cargo	74,446	(H/B)	$

Table 6-9 (3) VOYAGE ESTIMATE

No.
Date

M/S Bulk Carrier (Suez)
(D/W 130,000 L/T) Speed 14.0 K't (laden) / 15.0 K't (in ballast)

Cargo	Tons	rate	Freight	
Iron Ore				
			Des/Dem	$

Port	Distance (mile)	at Sea (day)	in Port (day)	Port charges $
Port Dampier			3.5	65,000
	6,026	17.9		
Suez			1.5	161,000
	3,275	9.7		
Rotterdam			4.5	80,000
(spare)				
Total	9,301	27.6	9.5	
	Total	37.1	days	

Cargo expense
$
Commission
$
Sundries
$

Fuel consumption							
C–F.O.	at Sea	75	T/d	2,070	T		
	in Port	12	T/d	114	T		
	Total			2,184	T @$ 160	$ 349,440	
A–F.O.	at Sea	1	T/d	28	T		
	in Port	2	T/d	19	T		
	Total			47	T @$ 320	$ 15,040	

D/W	130,000	Total expense	$ 670,480
Fuel	2,098	Net proceed	$
Spare	228	Hire cost	$
Water	300	Net profit	$
Others		(C/B)	$
Cargo	127,374	(H/B)	$

Table 6-9 (4) VOYAGE ESTIMATE

No.
Date

M/S Bulk Carrier (Cape)
(D/W 130,000 L/T) Speed 14.0 K't (laden) / 15.0 K't (in ballast)

Cargo	Tons	rate	Freight	
Iron Ore				
			Des/Dem	$

Port	Distance (mile)	at Sea (day)	in Port (day)	Port charges $
Port Dampier			3.5	65,000
	5,221	15.5		
(Cape)			–	–
	6,192	18.4		
Rotterdam			4.5	80,000
(spare)				
Total	11,413	33.9	8.0	
	Total	41.9	days	

Cargo expense
$
Commission
$
Sundries
$

Fuel consumption							
C–F.O.	at Sea	75	T/d	2,543	T		
	in Port	12	T/d	96	T		
	Total			2,639	T @$ 160	$ 422,240	
A–F.O.	at Sea	1	T/d	34	T		
	in Port	2	T/d	16	T		
	Total			50	T @$ 320	$ 16,000	

D/W	130,000	Total expense	$ 583,240
Fuel	2,577	Net proceed	$
Spare	228	Hire cost	$
Water	300	Net profit	$
Others		(C/B)	$
Cargo	126,895	(H/B)	$

Table 6-9 (5) VOYAGE ESTIMATE

No.
Date

M/S Bulk Carrier (Suez)
(D/W 60,000 L/T) Speed 14.0 K't (laden)
15.0 K't (in ballast)

Cargo	Tons	rate	Freight	
Iron ore				
			Des/Dem	$

Port	Distance (mile)	at Sea (day)	in Port (day)	Port charges $
Madras			4.0	30,000
	4,037	12.0		
Suez			1.5	70,800
	3,275	9.7		
Rotterdam			3.0	27,000
				Cargo expense $
				Commission $
(spare)				Sundries $
Total	7,312	21.7	8.5	
	Total	30.2	days	

Fuel consumption
C-F.O. at Sea 46 T/d 998 T
in Port 1 T/d 9 T
Total 1,007 T @$160 — $ 161,120
A-F.O. at Sea 2 T/d 43 T
in Port 2.5 T/d 21 T
Total 64 T @$320 — $ 20,480

D/W	60,000	Total expense	$ 309,400
Fuel	1,041	Net proceed	$
Spare	144	Hire cost	$
Water	300	Net profit	$
Others		(C/B)	$
Cargo	58,514	(H/B)	$

Table 6-9 (6) VOYAGE ESTIMATE

No.
Date

M/S Bulk Carrier (Cape)
(D/W 60,000 L/T) Speed 14.0 K't (laden)
15.0 K't (in ballast)

Cargo	Tons	rate	Freight	
			Des/Dem	$

Port	Distance (mile)	at Sea (day)	in Port (day)	Port charges $
Madras			4.0	30,000
	4,935	14.7		
(Cape)			–	–
	6,192	18.4		
Rotterdam			3.0	27,000
				Cargo expense $
				Commission $
(spare)				Sundries $
Total	11,127	33.1	7.0	
	Total	40.1	days	

Fuel consumption
C-F.O. at Sea 46 T/d 1,523 T
in Port 1 T/d 7 T
Total 1,530 T @$ 160 — $ 244,800
A-F.O. at Sea 2 T/d 66 T
in Port 2.5 T/d 18 T
Total 84 T @$ 320 — $ 26,880

D/W	60,000	Total expense	$ 328,680
Fuel	1,589	Net proceed	$
Spare	144	Hire cost	$
Water	300	Net profit	$
Others		(C/B)	$
Cargo	57,967	(H/B)	$

Table 6-9 (7) VOYAGE ESTIMATE

No.
Date

M/S Bulk Carrier (Suez)
(D/W 130,000 L/T) Speed 14.0 K't (laden)
15.0 K't (in ballast)

Cargo	Tons	rate	Freight	
Coal				
			Des/Dem	$

Port	Distance (mile)	at Sea (day)	in Port (day)	Port charges $
Haypoint			3.5	65,000
	8,251	24.6		
Suez			1.5	161,000
	3,275	9.7		
Rotterdam			6.0	80,000
				Cargo expense $
				Commission $
(spare)				Sundries $
Total	11,526	34.3	11.0	
	Total	45.3	days	

Fuel consumption

C–F.O.	at Sea	75	T/d	2,573	T	
	in Port	12	T/d	132	T	
	Total			2,705	T @$ 160	$ 432,960
A–F.O.	at Sea	1	T/d	34	T	
	in Port	2	T/d	22	T	
	Total			56	T @$ 320	$ 17,920

D/W	130,000	Total expense	$ 755,880
Fuel	2,607	Net proceed	$
Spare	228	Hire cost	$
Water	300	Net profit	$
Others		(C/B)	$
Cargo	126,865	(H/B)	$

Table 6-9 (8) VOYAGE ESTIMATE

No.
Date

M/S Bulk Carrier (Cape)
(D/W 130,000 L/T) Speed 14.0 K't (laden)
15.0 K't (in ballast)

Cargo	Tons	rate	Freight	
Coal	126,212			
			Des/Dem	$

Port	Distance (mile)	at Sea (day)	in Port (day)	Port charges $
Haypoint			3.5	65,000
	7,638	22.7		
(Cape)			–	80,000
	6,192	18.5		
Rotterdam			6.0	
				Cargo expense $
				Commission $
(spare)				Sundries $
Total	13,830	41.2	9.5	
	Total	50.7	days	

Fuel consumption

C–F.O.	at Sea	75	T/d	3,090	T	
	in Port	12	T/d	110	T	
	Total			3,200	T @$ 160	$ 512,000
A–F.O.	at Sea	1	T/d	41	T	
	in Port	2	T/d	19	T	
	Total			60	T @$ 320	$ 19,200

D/W	130,000	Total expense	$ 676,200
Fuel	3,131	Net proceed	$
Spare	228	Hire cost	$
Water	300	Net profit	$
Others		(C/B)	$
Cargo	126,341	(H/B)	$

Table 6-9 (9) VOYAGE ESTIMATE

No.
Date

M/S Bulk Carrier (Suez)
(D/W 60,000 L/T) Speed 14.0 K't (laden)
15.0 K't (in ballast)

Cargo	Tons	rate	Freight	
Bauxite	58,510			
		Des/Dem		$

Port	Distance (mile)	at Sea (day)	in Port (day)	Port charges $
Weipa			5.0	30,000
	7,320	21.8		
Suez			1.5	70,800
	3,400	10.1		
Rotterdam			3.0	27,000
				Cargo expense $
				Commission $
(spare)				Sundries $
Total	10,720	31.9	9.5	
	Total	41.4	days	

Fuel consumption

C–F.O.	at Sea	46	T/d	1,531 T		
	in Port	1	T/d	9 T		
	Total			1,540 T @$ 160	$ 246,400	
A–F.O.	at Sea	2	T/d	64 T		
	in Port	2.5	T/d	23 T		
	Total			87 T @$ 320	$ 27,840	

D/W	60,000	Total expense	$ 402,040
Fuel	1,046	Net proceed	$
Spare	144	Hire cost	$
Water	300	Net profit	$
Others		(C/B)	$
Cargo	58,510	(H/B)	$

Table 6-9 (10) VOYAGE ESTIMATE

No.
Date

M/S Bulk Carrier (Cape)
(D/W 60,000 L/T) Speed 14.0 K't (laden)
15.0 K't (in ballast)

Cargo	Tons	rate	Freight	
Bauxite	58,582			
		Des/Dem		$

Port	Distance (mile)	at Sea (day)	in Port (day)	Port charges $
Weipa			5.0	30,000
	6,830	20.3		
Cape Town			1.0	7,000
	6,163	18.3		
Rotterdam			3.0	27,000
				Cargo expense $
				Commission $
(spare)				Sundries $
Total	12,993	38.6	9.0	
	Total	47.6	days	

Fuel consumption

C–F.O.	at Sea	46	T/d	1,776 T		
	in Port	1	T/d	9 T		
	Total			1,785 T @$ 160	$ 285,600	
A–F.O.	at Sea	2	T/d	77 T		
	in Port	2.5	T/d	23 T		
	Total			100 T @$ 320	$ 32,000	

D/W	60,000	Total expense	$ 381,600
Fuel	974	Net proceed	$
Spare	144	Hire cost	$
Water	300	Net profit	$
Others		(C/B)	$
Cargo	58,582	(H/B)	$

Table 6-9 (11) VOYAGE ESTIMATE

No.
Date

M/S Bulk Carrier (Suez)
(D/W 45,000 L/T) Speed 14.0 K't (laden) / 15.0 K't (in ballast)

Cargo	Tons	rate	Freight	
Grain				
			Des/Dem	$

Port	Distance (mile)	at Sea (day)	in Port (day)	Port charges $
New Orleans			6.0	35,000
	6,463	19.2		
Suez			1.5	53,000
	2,859	8.5		
Karachi			11.5	24,000
(spare)				
Total	9,322	27.7	19.0	
	Total	46.7	days	

Cargo expense $
Commission $
Sundries $

Fuel consumption

C–F.O.	at Sea	38	T/d	1,053 T		
	in Port	1	T/d	19 T		
	Total			1,072 T @$ 160		$ 171,520
A–F.O.	at Sea	2	T/d	55 T		
	in Port	2	T/d	38 T		
	Total			93 T @$ 320		$ 29,760

D/W	45,000	Total expense	$ 313,280
Fuel	1,108	Net proceed	$
Spare	120	Hire cost	$
Water	300	Net profit	$
Others		(C/B)	$
Cargo	43,472	(H/B)	$

Table 6-9 (12) VOYAGE ESTIMATE

No.
Date

M/S Bulk Carrier (Cape)
(D/W 45,000 L/T) Speed 14.0 K't (laden) / 15.0 K't (in ballast)

Cargo	Tons	rate	Freight	
Grain				
			Des/Dem	$

Port	Distance (mile)	at Sea (day)	in Port (day)	Port charges $
New Orleans			6.0	35,000
	7,284	21.7		
Cape town			1.0	6,000
	4,626	13.8		
Karachi			11.5	24,000
(spare)				
Total	11,923	35.5	18.5	
	Total	54.0	days	

Cargo expense $
Commission $
Sundries $

Fuel consumption

C–F.O.	at Sea	38	T/d	1,349 T		
	in Port	1	T/d	19 T		
	Total			1,368 T @$ 160		$ 218,880
A–F.O.	at Sea	2	T/d	71 T		
	in Port	2	T/d	37 T		
	Total			108 T @$ 320		$ 34,560

D/W	45,000	Total expense	$ 318,440
Fuel	868	Net proceed	$
Spare	120	Hire cost	$
Water	300	Net profit	$
Others		(C/B)	$
Cargo	43,712	(H/B)	$

PART IV

SHORT TERM FORECASTING OF CANAL TRAFFIC

CHAPTER 1 INTRODUCTION

1.1 Objectives

This part describes a short term forecasting system whereby the Canal Traffic can be forecast.

A basic system for short term forecasting was proposed and presented last year by JICA. Revised and expanded in 1979, the system now generates more reasonable results with a more detailed analysis.

A short term forecast of tanker traffic through the canal is excluded from this study, because it was explained at the training exercise in Egypt in 1979. Also, short term forecasting of tanker traffic should be made using a model similar to the long term forecasting system described in PART V, after the completion of the first stage expansion project of the Suez Canal.

1.2 Outline of the Study

The method of forecast is explained in Chapter 2, where the step by step forecasting procedures are shown.

Using this model, the following variables can be forecast:

1) Volume of cargo

2) Volume of cargo carried by each ship type

3) Canal transit by SNT, categorized by ship type, ship size, loading condition, etc.

4) Canal transit by number of ships, categorized by ship type, ship size, loading condition, etc.

5) Canal revenue

In Chapter 3, the case study was made to explain the process of traffic forecasting, based on actual data on world economy, world seaborne trade, canal transit records, etc.

CHAPTER 2 METHOD OF FORECAST

2.1 Outline of Method

The short term traffic forecasting method described here is closely related to the long term traffic forecasting method for non-tankers, as shown in PART VI. For this reason, readers are advised to refer PART VI.

The method adopted here consists of two parts. In the first part, the volume of cargoes by cargo type is forecast; and in the second part, the number of ships is forecast, based on the volume of the forecasted cargo.

2.1.1 Forecast of Volume of Cargo

The method of forecasting the volume of cargoes is explained below, and is illustrated schematically in Fig. 2.1.

(1) Forecast the growth rate of GWP (Gross World Products)

(2) Estimat the elastic figure between world seaborne trade and GWP for each type of cargo

(3) Calculate the growth rate of world seaborne trade

(4) Forecast the volume of world seaborne trade

(5) Estimate the share of transit volume through the Canal in world seaborne trade

(6) Forecast the transit volume through the Canal

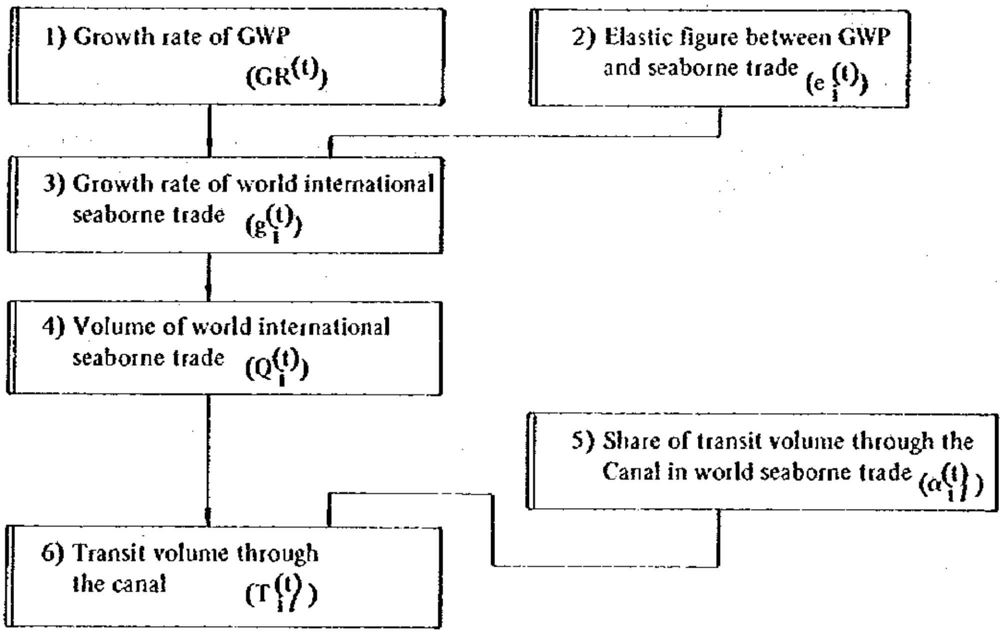

Fig. 2.1 Short Term Traffic Forecasting (Cargo Volume)

The following equations are used to forecast the future transit volume through the Suez Canal for each type of cargo.

$$g_i^{(t)} = E_i^{(t)} \cdot GR^{(t)} \quad \cdots\cdots\cdots \quad (2\text{-}1)$$

$$Q_i^{(t)} = (1 + g_i^{(t)}) \cdot Q_i^{(t-1)} \quad \cdots\cdots\cdots \quad (2\text{-}2)$$

$$T_{il}^{(t)} = \alpha_{il}^{(t)} \cdot Q_i^{(t-1)} \quad \cdots\cdots\cdots \quad (2\text{-}3)$$

where $GR^{(t)}$: growth rate of GWP in the t-th year

$e_i^{(t)}$: elastic figure between GWP and world seaborne trade of cargo (type i) in the t-th year

$g_i^{(t)}$: growth rate of world seaborne trade of cargo (type i) in the t-th year

$Q_i^{(o)}$: present world seaborne trade of cargo (type i)

$\alpha_{il}^{(t)}$: share of transit volume of cargo (type i) through the Suez Canal in the world seaborne trade in the t-th year

i : type of cargo

l : $l = 1$ . . . . Northbound
$l = 2$ . . . . Southbound

$T_{il}^{(t)}$: transit volume of cargo (by type) through the Suez Canal in the t-th year

2.1.2 Forecast of Number of Ships and Revenue

The number of ships, and the canal revenue is forecast by the procedure shown below,

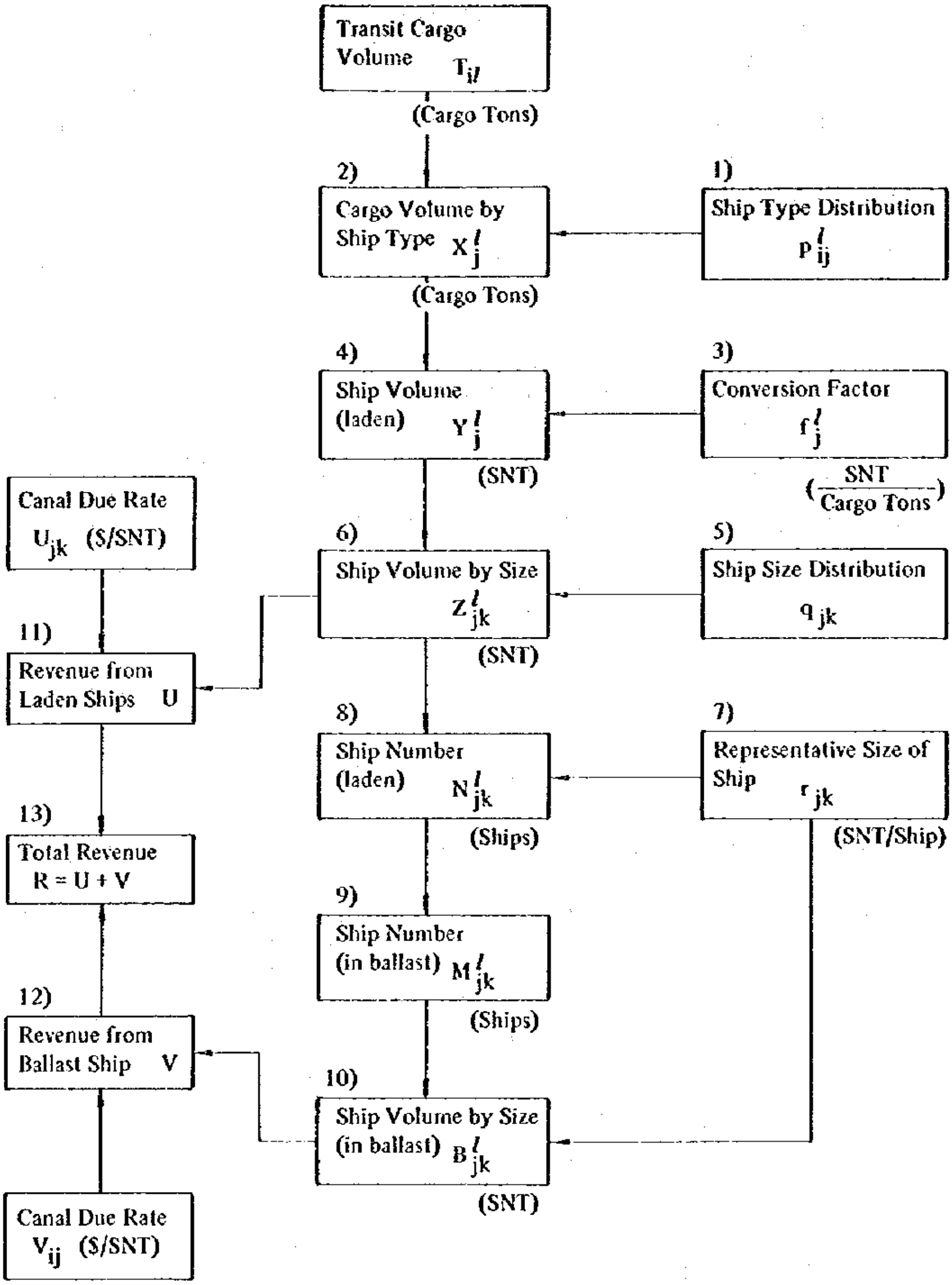

Fig. 2.2 Schematic Diagram of Short Term Traffic Forecasting
(SNT No. of Ships, Revenue)

1) Ship type distribution for each type of cargo (See Table 3.1)

2) Cargo volume by ship type (in metric tons) $X_j^l = \sum_{i=1}^{I} T_{il} \cdot p_{ij}^l$

3) Conversion factor from Cargo Volume to SNT for each ship type (See Table 3.1) f_j^l

4) Ship volume of ship type (in SNT) $Y_j^l = X_j^l \cdot f_j^l$

5) Ship size distribution of each ship type (See Table 3.2) q_{jk}

6) Ship volume by ship type and size, laden case (in SNT) $Z_{jk}^l = Y_j^l \cdot q_{jk}$

7) Representative size of each ship size category (in SNT/ship) (See Table 3.3)

8) Ship number by ship type and size. (laden ships) $N_{jk}^l = Z_{jk}^l / r_{jk}$

9) Ship number by ship type and size (in-ballast ships)

$$M_{jk}^l = \begin{cases} \text{If } N_{jk}^1 \geqq N_{jk}^2 \rightarrow \begin{cases} M_{jk}^1 = 0 \\ M_{jk}^2 = N_{jk}^1 - N_{jk}^2 \end{cases} \\ \text{Otherwise} \rightarrow \begin{cases} M_{jk}^1 = N_{jk}^2 - N_{jk}^1 \\ M_{jk}^2 = 0 \end{cases} \end{cases} \qquad \text{(2-4)}$$

10) Ship volume by ship type and size (in-ballast case)

$$B_{jk}^l = M_{jk}^l \cdot r_{jk} \qquad \text{(2-5)}$$

$$N^l = \sum_{j=1}^{J} \sum_{k=1}^{K} \cdot N_{jk}^l \qquad \text{(2-6)}$$

$$M^l = \sum_{j=1}^{J} \sum_{k=1}^{K} \cdot M_{jk}^l \qquad \text{(2-7)}$$

11) Canal Revenue from Laden Non-Tankers (U)

$$U = \sum_{l=1}^{2} \sum_{j=1}^{J} \sum_{k=1}^{K} \cdot Z_{jk}^{l} \cdot U_{jk} \qquad \text{(2-8)}$$

12) Canal Revenue from Non-Tankers in Ballast (V)

$$V = \sum_{l=1}^{2} \sum_{j=1}^{J} \sum_{k=1}^{K} \cdot B_{jk}^{l} \cdot V_{jk} \qquad \text{(2-9)}$$

13) Total Canal Revenue from Non-Tankers (R)

$$R = U + V \qquad \text{(2-10)}$$

where $l = \begin{cases} 1 \ldots \text{northbound} \\ 2 \ldots \text{southbound} \end{cases}$

- i : $i = 1 \sim I$ (cargo type)
- j : $j = 1 \sim J$ (ship type)
- k : $k = 1 \sim K$ (ship size)
- T_{il} : cargo transit volume through the Suez Canal (in metric tons)
- p_{ij}^{l} : ship type distribution of cargo type i
- X_{j}^{l} : cargo volume carried by ship type j (in metric tons)
- f_{j}^{l} : conversion factor from cargo tons to SNT
- Y_{j}^{l} : ship volume by type j (in SNT)
- q_{jk} : ship size distribution by type j
- Z_{jk}^{l} : laden ship volume by type j and size k (in SNT)
- r_{jk} : representative ship size (SNT) by type j and size k
- N_{jk}^{l} : laden ship number by type j and size k through the Suez Canal
- M_{jk}^{l} : ship number by type j and size k through the Suez Canal in ballast
- B_{jk}^{l} : ship volume by type j and size k through the Suez Canal in ballast (in SNT)
- N^{l} : laden ship number of non-tankers through the Suez Canal
- M^{l} : ship number of non-tankers through the Suez Canal in ballast
- U_{jk} : canal due rate by type j and size k (\$/SNT)
- V_{jk} : canal due rate of type j and size k (\$/SNT)

CHAPTER 3 CASE STUDY

Using the method explained in Chapter 2, a case study has been performed, to forecast the following variables for the year 1980.

i) Transit volume (by cargo)
ii) Transit volume (SNT)
iii) Transit volume (Number of ships)

3.1 Forecasted Commodities

The following commodities have been selected for forecast, based on their importance to the canal, and on the availability of world trade data.

Table 3.1 Commodity Flow

	Commodity	Origin and Destination: North-bound	Origin and Destination: South-bound
1	Iron ore	Australia → Europe India → Europe	USSR → Japan
2	Coal	Australia → Europe	
3	Grain		[USA, Canada] → [A.G., India]
4	Cement		Europe → A.G.
5	Fertilizer		[Europe, U.S.A.] → [China, India, Iran]
6	Steel		Europe → Middle East

Data related to these commodities are shown in Table 3-2 – 3-3.

Table 3.2 World Seaborne Trade (Major Dry Bulk)

Year	IRO-Ore	Grain	Coal	Bauxite	Phosphate	Total	Dry Total
1960	101	46	46	17	18	228	570
1961	98	57	48	17	19	239	600
1962	102	53	53	18	20	246	630
1963	107	59	64	17	22	269	670
1964	134	71	60	19	24	308	790
1965	152	70	59	21	25	327	810
1966	153	92	61	23	27	356	860
1967	164	83	67	25	28	367	890
1968	188	78	73	26	32	397	9666
1969	214	71	83	30	32	430	1034
1970	247	89	101	34	33	504	1165
1971	250	91	94	35	35	505	1173
1972	247	108	96	35	38	524	1247
1973	298	139	104	38	43	622	1403
1974	329	130	119	42	48	668	1476
1975	292	137	127	41	38	635	1438
1976	294	146	126	42	37	646	1555

Table 3.3a Suez Canal Goods Traffic (Northbound)

(by kiloton)

Year	Cereals	Ores and Metals	Other Dry	Total
1960	2,673	8,257	14,281	25,211
1961	3,247	7,994	14,082	25,323
1962	3,035	6,938	16,578	26,551
1963	2,303	6,317	20,543	26,463
1964	2,601	6,745	18,456	27,802
1965	2,665	7,116	18,574	28,355
1966	1,787	6,490	19,173	27,450
* 1975	1,090	2,280	9,801	13,171
1976	2,712	14,209	25,244	42,165
1977	1,592	12,703	27,457	41,752

* Traffic interupted due to military conflict

Table 3.3b Suez Canal Traffic (Southbound)

(by kiloton)

Year	Cement	Fertilizers	Coal & Coke	Fabricated Metals	Cereals & Derivatives	Other Dry	Total
1960	1,131	4,002	458	5,644	4,686	10,307	26,228
1961	1,017	4,279	373	4,423	3,979	12,427	26,495
1962	1,311	3,663	313	3,828	4,758	11,791	25,664
1963	1,383	4,647	447	4,324	5,996	12,243	29,040
1964	1,760	3,897	237	5,096	8,190	13,202	32,382
1965	1,215	5,168	265	4,727	8,042	14,676	34,093
1966	1,407	6,748	605	5,015	9,738	15,259	38,772
* 1975	836	2,821	75	1,743	2,198	9,503	17,178
1976	4,631	5,492	238	3,744	5,143	22,416	41,664
1977	6,035	6,198	331	3,893	4,188	31,350	51,995

* Traffic interupted due to military conflict

3.2 Other Data

The Canal transit forecast was made for each type of ship, using the ship categories adopted by the SCA.

Distribution of cargo type Pij^{l}, is shown in Table 3.4 (from SCA).

Other necessary data, such as the size distribution of the ship (q_{jk}), and the representative ship size (in SNT) for ship type j and size k (r_{jk}), are shown in Table 3.5 – 3.8.

Table 3.4 Breakdown of Ship and Cargo Types (Pij^l)

(by Percent)

Ship type / Cargo type	Bulk Carrier	Combined Carrier	General Cargo Ship	Container Ship	Lash	R0/R0	Other	Total
Iron Ore	90.0		10.0					100.0
Cerals	48.3		51.4			0.3		100.0
Fabricated Metal	88.2		9.5	2.3				100.0
Cement	64.8		35.2					100.0
Fertilizer	62.2		37.8					100.0
Coal	90.0		10.0					100.0
Other	18.5		61.8	13.3 2.0	2.5	1.8	0.1	100.0

Table 3.5 Breakdown of Ship by SNT

(by 1,000,000 SNT)

Ship Type / Route	Bulk Carrier	Combined Carrier	General Cargo Ship	Container Ship	Lash	R0/R0	Car Carrier	Other	Total
Northbound	18.87		39.4	15.3	1.04	5.63	2.19	1.74	88.9
Southbound	24.78		24.1	12.2	0.74	3.55	6.03	1.33	81.4

Table 3.6 Size Distribution of Ship Type j(q_{jk})

(by Percent)

Type \ Size (1,000 SNT)	0–5	5–10	10–15	15–20	20–25	25–30	30–40	40–50	50–60	60–70	70–80	>80
Bulk Carrier	0.8	8.7	24.8	24.5	10.9	6.4	9.2	2.5	5.4	3.9	2.1	0.8
Combined Carrier	0.2	1.2	3.6	3.1	2.9	4.8	27.3	10.1	10.7	19.5	12.5	11.1
General Cargo Ship	12.1	72.2	13.8	1.5	0.2		0.1	0.1				
Container Ship	2.9	6.2	8.5	11.5	15.9	5.7	5.7	38.1	5.5			
Lash			1.9				95.3				2.8	
R0/R0	7.7	44.8	25.8	4.7	4.0	6.1	6.9					
Car Carrier	0.2	1.7	4.0	10.7	2.7	20.2	36.9	19.5	1.1			
Others	36.6	45.5	10.4	0.6	0.8	2.4	1.5	2.2				

Table 3.7 Representative Ship Size for Ship Type j and Size k (r_{jk})

(by 1,000 SNT)

Type \ Size (1,000 SNT)	0–5	5–10	10–15	15–20	20–25	25–30	30–40	40–50	50–60	60–70	70–80	>80
Bulk Carrier	2.7	8.6	12.5	17.5	22.5	27.5	35.0	45.0	55.0	65.0	75.0	100.0
Combined Carrier	3.0	8.0	12.5	17.5	22.5	27.5	35.0	45.0	55.0	65.0	75.0	100.0
General Cargo Ship	2.4	7.7	12.5	17.5	22.5	27.5	35.0	45.0	55.0	65.0	75.0	100.0
Container Ship	3.1	7.4	12.5	17.5	22.5	27.5	35.0	45.0	55.0	65.0	75.0	100.0
Lash	3.3	6.7	12.5	17.5	22.5	27.5	35.0	45.0	55.0	65.0	75.0	100.0
R0/R0	2.8	8.9	12.5	17.5	22.5	27.5	35.0	45.0	55.0	65.0	75.0	100.0
Car Carrier	2.6	7.7	12.5	17.5	22.5	27.5	35.0	45.0	55.0	65.0	75.0	100.0
Others	3.0	8.0	12.5	17.5	22.5	27.5	35.0	45.0	55.0	65.0	75.0	100.0

3.3 Results of Case Study

Employing the method explained in Chapter 2 and based upon the assumptions and data shown in the previous section, the following variables have been forecast and table 2.

1) Transit Volume by Cargo and Direction (Table 3.8)

2) Volume of Cargo by Ship Type and Direction (Table 3.9)

3) Volume by SNT and Categorized by Ship Type (Table 3.10)

4) Transit Volume: No. of Ships by Ship Type (Table 3.11)

5) Canal Traffic: SNT by Ship Type and Size (Table 3.12)

6) Transit Volume: No. of Ships by Ship Type and Size (Table 3.13a, b)

Table 3.8 Transit Volume by Cargo and Direction

(Units: 1,000 tons) Year: 1980

	Northbound	Southbound	Total
Iron Ore	15,500	0	15,500
Coal	0	252	252
Grain	3,500	6,640	10,100
Cement	0	5,370	5,370
Fertilizer	0	5,830	5,830
Steel	0	4,340	4,340
Other	29,300	26,000	55,300
Total	48,300	48,400	96,800

Table 3.9 Volume of Cargo by Ship Type and Direction

(by kilotons) Year: 1980

	Bulk Carrier	Combined Carrier	General Cargo Ship	Container Ship	Lash	Ro/Ro	Car Carrier	Other	Total
Northbound	21,100	–	21,100	4,220	586	743	527	29	48,300
Southbound	19,200	–	23,700	3,850	520	670	468	26	48,400
Total	40,300	–	44,900	8,060	1,110	1,410	995	55	96,800

Table 3.10 Volume by SNT and Categorized by Ship Type

(by 1,000 SNT) Year: 1980

	Bulk Carrier	Combined Carrier	General Cargo Ship	Container Ship	Lash	Ro/Ro	Car Carrier	Other	Total
Northbound	26,800	–	26,700	13,500	816	3,920	6,660	1,470	79,800
Southbound	20,800	–	43,700	16,900	1,150	6,230	2,424	1,920	93,100
Total	47,600	–	70,400	30,400	1,960	10,200	9,080	3,390	173,000

Table 3.11 Transit Volume No. of Ships by Ship Type

Year: 1980

		Bulk Carrier	Combined Carrier	General Cargo Ship	Container Ship	Lash	Ro/Ro	Car Carrier	Other	Total
Northbound	L	1,561	–	4,052	679	23	411	236	270	7,231
	B	0	–	2,580	173	10	241	0	83	3,087
Southbound	L	1,212	–	6,632	851	33	652	86	353	9,820
	B	348	–	0	0	0	0	150	0	498
Total	L	2,773	–	10,684	1,530	56	1,063	322	623	17,051
	B	348	–	2,580	173	10	241	150	83	3,585

Table 3.12 Canal Trafic: N.T. by Ship Type and Size
(by 1,000 SNT)

Year: 1980

Type \ Size (1,000 SNT)		0~5	5~10	10~15	15~20	20~25	25~30	30~40	40~50	50~60	60~70	70~80	> 80
Bulk Carrier	N	202	2,207	6,389	6,565	3,135	1,790	2,423	775	1,403	1,068	592	249
	S	157	1,714	4,963	5,099	2,435	1,390	1,882	602	1,090	830	460	193
	T	359	3,921	11,352	11,664	5,570	3,180	4,305	1,377	2,493	1,898	1,051	442
Combined Carrier	N	–	–	–	–	–	–	–	–	–	–	–	–
	S	–	–	–	–	–	–	–	–	–	–	–	–
	T	–	–	–	–	–	–	–	–	–	–	–	–
General Cargo Ship	N	3,039	18,321	4,580	612	78	4	25	27	2	0	0	0
	S	4,975	29,981	7,497	1,001	127	6	41	44	3	0	0	0
	T	8,013	48,309	12,078	1,613	205	10	66	71	5	0	0	0
Container Ship	N	368	809	1,126	1,525	2,107	848	769	4,876	994	49	1	0
	S	461	1,014	1,412	1,913	2,642	1,063	965	6,115	1,247	61	1	0
	T	829	1,823	2,538	3,438	4,749	1,911	1,734	10,991	2,241	110	2	0
Lash	N	0	0	15	1	0	0	732	45	1	0	22	1
	S	0	0	21	1	0	0	1,029	63	1	0	30	2
	T	0	0	36	2	0	0	1,761	108	2	0	52	3
Ro / Ro	N	284	1,671	1,054	234	160	235	269	16	0	0	0	0
	S	451	2,654	1,673	371	253	372	427	25	1	0	0	0
	T	736	4,325	2,728	605	413	607	695	41	1	0	0	0
Car Carrier	N	13	107	257	686	211	1,277	2,390	1,365	147	6	0	0
	S	5	39	93	249	77	463	868	496	53	2	0	0
	T	18	146	350	935	288	1,741	3,258	1,861	200	8	0	0
Other	N	506	659	183	18	12	34	23	32	2	0	0	0
	S	662	863	239	23	15	44	30	42	3	0	0	0
	T	1,168	1,522	422	41	27	78	53	74	5	0	0	0

N: Northbound, S: Southbound, T: Total

Table 3.13a Transit Volume No. of Ships by Ship Type and Size (Laden Ship)

Year: 1980

Type \ Size (1,000 SNT)		0~5	5~10	10~15	15~20	20~25	25~30	30~40	40~50	50~60	60~70	70~80	80~
Bulk Carrier	N	74.7	256.6	511.1	375.1	139.3	65.1	69.2	17.2	25.5	16.4	7.9	2.5
	S	58.0	199.3	397.1	291.4	108.2	50.6	53.8	13.4	19.8	12.8	6.1	1.9
	T	132.7	455.9	908.2	666.5	247.6	115.7	123.0	30.6	45.3	29.3	14.0	4.4
Combined Carrier	N	–	–	–	–	–	–	–	–	–	–	–	–
	S	–	–	–	–	–	–	–	–	–	–	–	–
	T	–	–	–	–	–	–	–	–	–	–	–	–
General Cargo Ship	N	1,266.4	2,379.4	366.4	35.0	3.5	0.1	0.7	0.6	0.0	0.0	0.0	0.0
	S	2,072.8	3,894.6	599.8	57.2	5.7	0.2	1.2	1.0	0.0	0.0	0.0	0.0
	T	3,339.2	6,273.9	966.2	92.2	9.1	0.3	1.9	1.6	0.1	0.0	0.0	0.0
Container Ship	N	118.6	109.3	90.1	87.1	93.6	30.8	22.0	108.3	18.1	0.7	0.0	0.0
	S	148.7	137.0	113.0	109.3	117.4	38.7	27.6	135.9	22.7	0.9	0.0	0.0
	T	267.3	246.3	203.1	196.4	211.0	69.5	49.6	244.2	40.7	1.7	0.0	0.0
Lash	N	0.0	0.0	1.2	0.1	0.0	0.0	20.9	1.0	0.0	0.0	0.3	0.0
	S	0.0	0.0	1.6	0.1	0.0	0.0	29.4	1.4	0.0	0.0	0.4	0.0
	T	0.0	0.0	2.8	0.2	0.0	0.0	50.3	2.4	0.0	0.0	0.7	0.0
Ro / Ro	N	101.5	187.8	84.3	13.4	7.1	8.5	7.7	0.4	0.0	0.0	0.0	0.0
	S	161.2	298.2	133.9	21.2	11.3	13.5	12.2	0.6	0.0	0.0	0.0	0.0
	T	262.7	486.0	218.2	34.6	18.3	22.1	19.9	1.0	0.0	0.0	0.0	0.0
Car Carrier	N	4.8	13.9	20.6	39.2	9.4	46.4	68.3	30.3	2.7	0.1	0.0	0.0
	S	1.8	5.1	7.5	14.2	3.4	16.9	24.8	11.0	1.0	0.0	0.0	0.0
	T	6.6	19.0	28.1	53.4	12.8	63.3	93.1	41.4	3.6	0.1	0.0	0.0
Other	N	168.5	82.4	14.6	1.0	0.5	1.2	0.7	0.7	0.0	0.0	0.0	0.0
	S	220.5	107.9	19.1	1.3	0.7	1.6	0.9	0.9	0.0	0.0	0.0	0.0
	T	389.0	190.3	33.8	2.8	1.2	2.8	1.6	1.6	0.0	0.0	0.0	0.0

N: Northbound, S: Southbound, T: Total

Table 3.13b Transit Volume No. of Ships by Ship Type and Size
(Unloaded Ship)

Year: 1980

Type \ Size (1,000 SNT)		0~5	5~10	10~15	15~20	20~25	25~30	30~40	40~50	50~60	60~70	70~80	80~
Bulk Carrier	N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S	16.7	57.3	114.1	83.7	31.1	14.5	15.4	3.8	5.7	3.7	1.8	0.6
	T	16.7	57.3	114.1	83.7	31.1	14.5	15.4	3.8	5.7	3.7	1.8	0.6
Combined Carrier	N	–	–	–	–	–	–	–	–	–	–	–	–
	S	–	–	–	–	–	–	–	–	–	–	–	–
	T	–	–	–	–	–	–	–	–	–	–	–	–
General Cargo Ship	N	806.4	1,515.2	233.3	22.3	2.2	0.1	0.5	0.4	0.0	0.0	0.0	0.0
	S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	T	806.4	1,515.2	233.3	22.3	2.2	0.1	0.5	0.4	0.0	0.0	0.0	0.0
Container Ship	N	30.1	27.8	22.9	22.1	23.8	7.8	5.6	27.5	4.6	0.2	0.0	0.0
	S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	T	30.1	27.8	22.9	22.1	23.8	7.8	5.6	27.5	4.6	0.2	0.0	0.0
Lash	N	0.0	0.0	0.5	0.0	0.0	0.0	8.5	0.4	0.0	0.0	0.1	0.0
	S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	T	0.0	0.0	0.5	0.0	0.0	0.0	8.5	0.4	0.0	0.0	0.1	0.0
Ro / Ro	N	59.7	110.4	49.6	7.9	4.2	5.0	4.5	0.2	0.0	0.0	0.0	0.0
	S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	T	59.7	110.4	49.6	7.9	4.2	5.0	4.5	0.2	0.0	0.0	0.0	0.0
Car Carrier	N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S	3.1	8.9	13.1	25.0	6.0	29.6	43.5	19.3	1.7	0.1	0.0	0.0
	T	3.1	8.9	13.1	25.0	6.0	29.6	43.5	19.3	1.7	0.1	0.0	0.0
Other	N	52.0	25.4	4.5	0.3	0.2	0.4	0.2	0.2	0.0	0.0	0.0	0.0
	S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	T	52.0	25.4	4.5	0.3	0.2	0.4	0.2	0.2	0.0	0.0	0.0	0.0

N: Northbound, S: Southbound, T: Total

CHAPTER 4 STATISTICAL ANALYSIS OF SHIPPING ARRIVALS

The number of ships arriving daily at the Suez Canal can be statistically analysed to attempt to fit the arrival pattern to a Poisson's Distribution (bell curve). If there is an adequate fit of the data to the mathmatical curve, then we can determine the optimum size of the canal, based upon two variables: the vessel waiting time; and the size limits of an enlarged canal. In a statistical analysis, we seek a Canal capacity which requires a certain percentage of the arriving ships to wait in a que.

Here is described the accuracy of our comparison of the vessel arrival pattern to a Poisson's Distribution. If the comparison is good, then we can find the theoretical relationship between the Canal capacity and a percentage of the arriving ships which have to wait for a longer time than usual.

4.1 Arrival Number in 1978

The number of ships arriving daily in 1978 are shown in table 4.1. 21,328 ships, an average of about 58 ships per day, passed through the canal. These numbers are summarized in Table 4.2 and in the histogram of Fig. 5.1.

Table 4.1 Ship Arrivals in 1978

Day \ Month	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1	60	52	58	54	55	66	50	67	49	59	61	54
2	56	56	54	30	66	56	47	42	54	61	60	60
3	26	59	55	63	68	60	54	58	55	47	57	63
4	57	65	64	76	61	53	49	54	51	53	53	61
5	55	47	57	48	61	48	50	61	59	63	62	71
6	63	60	63	67	62	55	59	52	62	73	54	54
7	60	49	66	76	60	52	65	60	52	62	53	60
8	57	55	63	64	64	65	54	61	57	47	61	63
9	50	49	54	44	53	47	54	53	54	60	55	60
10	45	47	54	73	51	61	70	62	54	67	52	55
11	62	60	59	70	51	52	66	65	63	57	56	55
12	50	56	59	69	52	67	62	42	71	74	56	58
13	72	69	30	59	54	52	62	56	61	60	69	52
14	67	56	51	56	55	71	69	54	53	68	66	57
15	54	32	72	59	46	62	60	30	52	57	64	11x
16	29	57	67	55	52	47	56	76	55	57	68	51
17	76	64	73	65	64	59	63	60	60	63	60	68
18	75	66	79	68	49	54	57	55	48	68	63	59
19	45	67	47	50	50	64	63	44	54	62	68	45
20	32	63	68	59	69	50	61	53	56	67	58	69
21	81	61	67	64	66	67	64	59	61	53	58	32
22	63	69	65	62	63	64	64	53	47	59	68	24
23	80	68	67	62	57	35	68	63	68	59	65	75
24	72	59	48	70	63	55	65	64	48	69	50	53
25	54	56	62	68	53	66	59	52	53	49	59	69
26	54	54	66	53	69	56	60	53	59	57	61	61
27	58	77	69	64	52	54	60	51	64	70	74	79
28	58	52	66	60	58	52	61	59	64	66	55	62
29	47	–	50	61	64	62	36	49	53	72	66	75
30	53	–	67	56	63	48	75	61	54	54	49	63
31	55	–	81	–	64	–	65	55	–	53	–	60
	1727	1625	1901	1825	1815	1706	1848	1724	1691	1888	1801	1779

Table 4.2 Frequency Distribution of Ships per Day

No of ships / day	11	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
Frequency (f)	1	1	–	1	–	–	1	4	–	3	–	–	2	1	–	–	–	–	–	2	–	2	3	1

No. of ships / day	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
Frequency (f)	10	6	8	8	6	14	18	25	16	14	12	10	19	21	18	15	19	17	9	12	12	13	11

No of ships / day	70	71	72	73	74	75	76	77	78	79	80	81
Frequency (f)	4	3	4	3	2	4	4	1	–	2	1	2

$\Sigma f = 365$

Total number of ships = 21,328 ships/year

Daily average $= \frac{21,328}{365} = 58.4$ ships/day

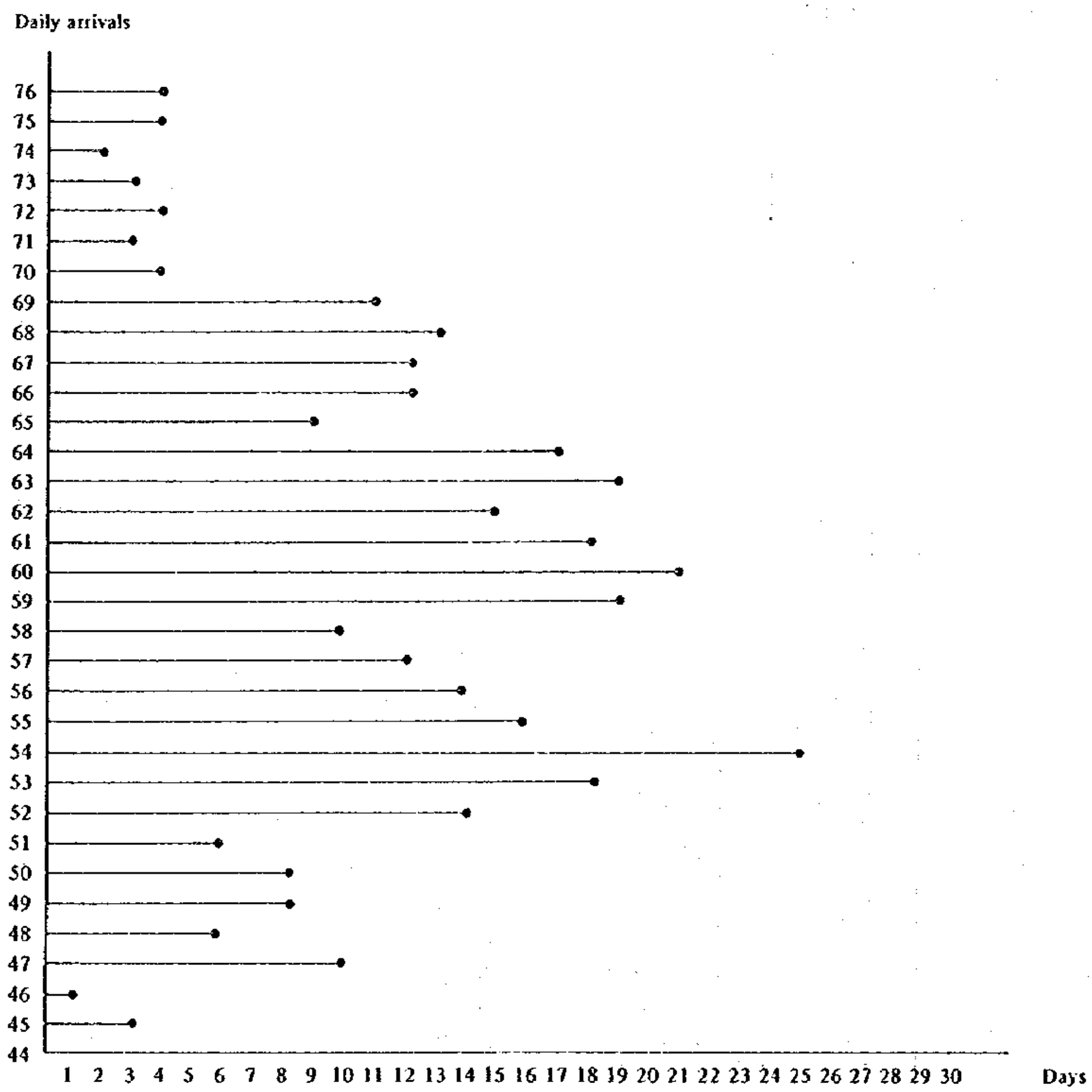

Fig. 4.1 Histogram of Daily Arrivals

4.2 X^2 Test

The X^2 test is used to ascertain if observed data has a predictable distribution form, or has a random pattern. In this case, the test is made assuming that the number of daily arrivals follows a Poisson's Distribution.

The value of X^2 is expressed by the equation (4.1).

$$X^2 = \sum_{i=k}^{N} X_i^2 = \sum_{i=1}^{N} \frac{[X_k - nP_k]^2}{nP_k} \qquad (4.1)$$

where
- N : greatest number of arrivals in one day
- X_k : observed frequency (days) in which the arrival number is k
- P_k : theoretical probability that the arrival number is k
- n : trial number (365 days)

Since we are assuming that the hypothetical distribution follows a Poisson's Distribution, the theoretical probability P_k is expressed by equation (4.2):

$$P_k = \text{Probability } (X{=}k) = \frac{\exp[-m] \cdot m^k}{k!} \qquad (4.2)$$

where m is the average number of arrivals per day.

Table 4.3 shows the calculation process of X^2.

The days with over 77 and under 44 arriving vessels are neglected because their $X^2{}_k$ is relatively small compared with total $X^2 = \sum_K X^2{}_k$.

In this process, the valve obtained for X^2 is 40.57. The value over which X^2 falls at 10% is 40.256, and 43.773 at 10%. Then the hypothetical poisson's distribution is denied with a 10% risk. The reason for the 10% risk is the fact that there is 10% possibility that X^2 falls over 40.256 if observed data follow the hypothetical distribution.
Normally, we consider a distribution model to be accurate if the risk analysis shows a 5% risk. In this case, we must attempt to model the data to another mathmatical distribution, in hope of determining a predictable arrival pattern of the vessels using the Suez Canal. Once a reliable pattern is found, we can, on the basis of the mean permissible que, determine the capacity of the Canal needed for future traffic.

Table 4.3 Calculation of the Value of X^2

k (Ships)	X_k (Days)	P_k	nP_k	X^2_k
45	3	0.01118	4.08	0.286
46	1	0.0142	5.18	3.37
47	10	0.0177	6.46	1.940
48	6	0.0215	7.85	0.436
49	8	0.0255	9.31	0.184
50	8	0.03	10.95	0.795
51	6	0.0342	12.48	3.365
52	14	0.0384	14.02	0.0003
53	18	0.0423	15.44	0.425
54	25	0.0459	16.75	4.063
55	16	0.0465	17.70	0.163
56	14	0.0507	18.5	1.10
57	12	0.0522	19.05	2.61
58	10	0.0525	19.16	4.38
59	19	0.0518	18.91	0.0004
60	21	0.0506	18.47	0.35
61	18	0.0484	17.67	0.0062
62	15	0.0456	16.64	0.162
63	19	0.0423	15.44	0.821
64	17	0.0386	14.09	0.601
65	9	0.0346	12.63	1.043
66	12	0.0307	11.21	0.056
67	12	0.0267	9.75	0.519
68	13	0.0229	8.36	2.575
69	11	0.0183	6.68	2.794
70	4	0.0154	5.62	0.467
71	3	0.0124	4.53	0.517
72	4	0.0102	3.72	0.021
73	3	0.080	2.92	0.002
74	2	0.063	2.30	0.037
75	4	0.050	1.83	2.573
76	4	0.032	1.39	4.701

$X^2 = \Sigma_k X^2_k = 40.565$

PART V

LONG TERM FORECASTING
OF
TANKER TRAFFIC THROUGH THE SUEZ CANAL

CHAPTER 1 INTRODUCTION

Part V describes the basic system of forecasting the canal tanker traffic volume. The principal method of forecast is based on PART V of the Final Report (1978), with two points modified to improve the system. The first point examines the market condition by using freight levels instead of shipping costs, when the route costs are available. The other is an improvement of the route choice model by introducing a multi-modal choice method, to determine the optimum proportions of three round trip voyages. In addition to the improvements in the forecasting method, the forecast values of Chapter 6 are more realistic than those in the Final Report, since the oil trade flows are based on the agreements of the Tokyo Summit, and the parameters in the model are determined through observed traffic data.

CHAPTER 2 FORECAST METHOD

The forecasting process described in this report consists of five phases, all interrelated for the purpose of making long term forecasts regarding tanker traffic though the Suez Canal.

These five phases are:

1) World Energy and Oil Trade
2) Route Costs
3) Route Choice
4) Tanker Traffic through the Canal
5) Canal Revenue from Tankers

The process relationships between these phases are shown in Fig. 2.1.

These five phases will be described briefly in the next section of this Chapter. In the following Chapters a detailed description will be given of the forecasting methods and parameters used in analyzing each phase.

1) World Energy and Oil Trade

Seaborne oil movements relevant to the Suez Canal are forecast, using two possible methods of forecasting. One is a conventional method, not relying on computers; the other is a systematic approach to forecasting oil trade flows, and often requires the use of computer models.

2) Route Costs

Tanker shipping costs may be broken down into two major elements: capital costs and operating costs. The choice of routes, the fleets used on these routes, and the size and of type vessel to be employed is based on tanker shipping costs. In the Final Report (1978), the shipping costs is defined as the route costs which have to be paid when a vessel takes a certain route. In this report, freight level, as reflected in the market condition, is used as the route costs, rather than the shipping cost itself.

3) Route Choice

This process determines how the tonnage of a given seaborne trade is distributed between relevant routes. For this purpose, multinominal modal choice models are used, and the route parameters of the model determines the choice proportions on each relevant route.

4) Tanker Traffic through the Canal

The results of route choice, fleet mix which is given externally under the assumption that it is the same as the world fleet mix, and the trade flow gives the traffic volume allocated to the Canal. The allocated traffic volume is converted to the number of vessels passing through the canal by using the volume of oil which can be carried on a voyage by a tanker.

5) Canal Revenue from Tankers

Canal transit fees for tankers have been set up as unified rates depending on tanker size, the rates further depending on the loading condition of the vessel. Therefore, the number of tankers passing through the Canal, and their size and load category, is used to calculate the Canal revenue.

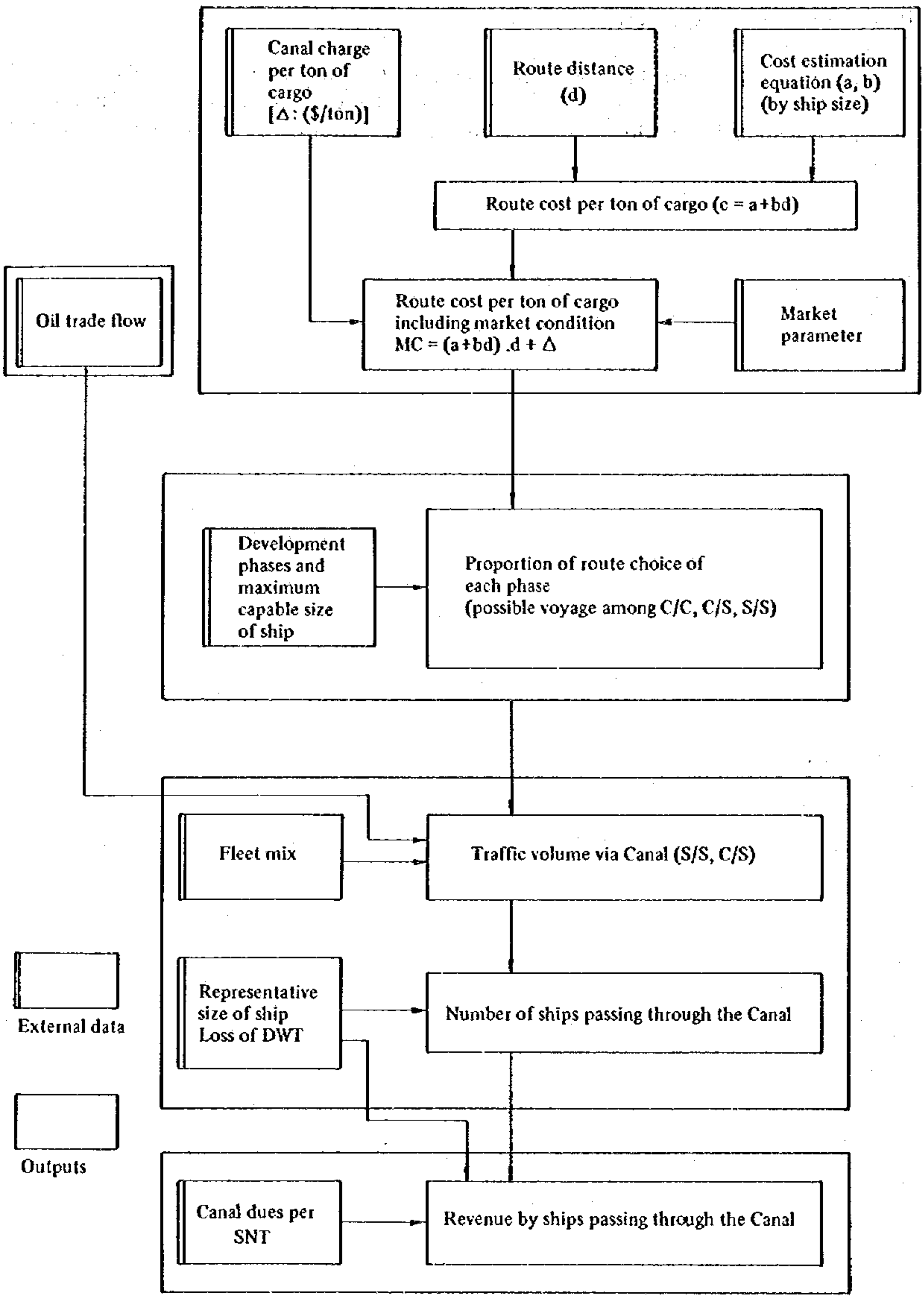

Fig. 2.1 General Forecasting Process

CHAPTER 3 OIL TRADE FLOWS RELEVANT TO THE SUEZ CANAL

3.1 Outline of Forecasts

The trade flow can be represented by five elements: the kind of commodity, the volume of that commodity, the origin and destination areas, and the time during which a volume of that commodity is transported. These are shown in Fig. 3.1.

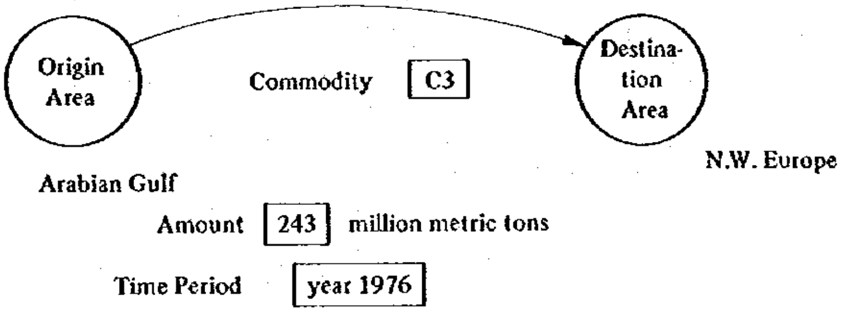

Fig. 3.1 Definition of Trade Flow

Because there are numerous places of origin and destinations, it is very important for an efficient study to adequately classify these origin/destination areas.

Origins/Destinations
Origin/destination zoning requires careful consideration of the availability of International Statistics, the importance of a route to the Suez Canal, and the way in which individual ports can be grouped into an effective single route. It is also important to keep the total number of zones to a minimum for economy in analysis. Table 3.1 shows an example of O/D zoning.

Table 3.1 An Example of O/D Zoning

O/D	Area	Representative Port
Major Oil Exporting Areas	Arabian Gulf (North Africa) (West Africa) (Caribbean) [South East Asia]	Ras Tanura (Tripoli) (Nouadhibou) (Aruba) [Jakarta]
Major Oil Importing Area	North West Europe Mediterranean Europe U.S. East Coast Gulf of Mexico U.S. West Coast [Japan] (Others)	Rotterdam Genoa Philadelphia New Orleans Los Angeles [Yokohama] (–)

The Communist Block is removed from the table according to the assumption that the Bloc continues to be self-sufficient in oil in the future. Although Japan is a major oil importing area, the main routes for oil imports to Japan do not involve the Suez Canal, and thus Japan can be removed from the table. While Southeast Asia (Indonesia) is one of the major oil exporting areas, the main routes for oil exports from this area do not involve the Suez Canal, so Southeast Asia may be removed as well.

The North African, West African and Caribbean areas do not relate directly to the Suez Canal, but they must be taken into consideration when forecasting the oil imports to Europe and to North America from the Arabian Gulf.

Oil trade flows from the Arabian Gulf to Western Europe and North America in 1985 are forecasted here, using the upper limit of the net oil imports to the major oil importing countries, as determined at the Tokyo Summit Meeting.

Table 3.2 Agreement of the Tokyo Summit Meeting

(in 10,000 B/D)

Year / Country	1978	1979	1980	1985
Japan	523	540	540	630-690
U.S.A.	828	850	850	850
U.K.	83	–	–	80
W. Germany	281	–	–	280
France	223	–	–	220
Italy	189	–	–	190
E.C.	–	1,000	950	950

The pattern of oil trade flows in 1985 is assumed to be same as in 1977. The oil trade flows relevant to the Suez Canal in 1977 are shown in Table 3.3.

Table 3.3 Oil Trade Flows in 1977

(in M.M.T.)

From \ To	N/W Europe	Mediterranean	North America
Arabian Gulf	254.9	170.5	154.8
Near East	2.5	17.5	0.1
North Africa	33.8	37.0	68.7
West Africa	28.2	11.9	65.3
Caribbean	3.9	1.7	111.5
South East Asia	0.7	0.3	29.8
Others	42.7	18.4	8.8
Total	366.7	252.3	439.0

(B.P. Statistical Review, Feamley & Egers)

3.2 Forecast Oil Trade Flows from the Arabian Gulf to Western Europe (1985)

The following is a prediction of the oil trade flow in 1985, assuming the same pattern as 1977.

1) Net Imports of Western Europe

(1) E.C. 9 countries: 9.5 MB/D
(2) For other West European countries, the import is set at 2.4 MB/D, based on the past trends.
(3) Western Europe: 11.9 MB/D = 595 M.M.T.

2) Production of North Sea Oil

Production of the North Sea Oil Field in 1985 is assumed to be 200 million metric tons.

3) Gross Imports of Western Europe

Gross Imports of Western Europe in 1985 is forecast using the following equations:

$$A = D + C \qquad (3\text{-}1)$$
$$D = a\,(A + B) \qquad (3\text{-}2)$$

where

D: exports to other areas,
a: exporting ratio, assumed to be the same as 1977 (=0.035)

The solution of A is obtained as follows by solving the above equations.

$$A = \frac{C + a.B}{1 - a} = 623.8 \text{ M.M.T.} \qquad (3\text{-}3)$$

4) Imports to Northwestern Europe and the Mediterranean Area
The imports to Northwestern Europe and to the Mediterranean Area were based on past records:

Import to Northwestern Europe:	369.5 M.M.T.
Import to Mediterranean area:	254.3 M.M.T.

5) Import from Middle Near East
The imports to Northwestern Europe and Mediterranean from the Middle Near East based on the past records:

Imports from Middle Near East to Northwestern Europe:	259.4 M.M.T.
Imports from Middle Near East to Mediterranean Area:	184.4 M.M.T.

6) Seaborne Oil Trade Flows
The seaborne oil trade flows were calculated assuming pipeline flows in 1985 to be 5% for Northwestern Europe and 20% for the Mediterranean Area.

Arabian Gulf to Northwestern Europe:	246.4 M.M.T.
Arabian Gulf to Mediterranean Area:	147.5 M.M.T.

3.3 Oil Trade Flow from the Arabian Gulf to the East Coast of North America in 1985

1) Imports to North America (U.S.A. and Canada)

Import to U.S.A.	8,500,000 B/D
Import to Canada:	600,000 B/D
Total	9,100,000 = 455 M.M.T.

2) Imports to East Coast of North America
The imports to the East Coast of North America was based on past records.

Import to the East Coast of North America:	424.1 M.M.T.

3) Import from the Arabian Gulf
The imports to the East Coast of North America from the Arabian Gulf was based on past records.

Import to East Coast of North America: 160.3 M.M.T.

CHAPTER 4 ROUTE COSTS

4.1 Introduction of Freight Market

The method in the Final Report (1978) uses Shipping Costs as the main factor in choosing shipping movements between relevant voyage routes.

In this report, however, the concept of freight rate is introduced as a consideration of the actual decisions of a shipping service. It is more probable that vessels are allocated by their opportunity cost, rather than their shipping costs. In this case, opportunity costs mean the freight revenues lost through the vessel allocation to a particular route.

While shipping cost is the criterion to judge whether or not a freight rate is high enough to manage the services, opportunity cost (as expressed by freight revenue) is the criterion to judge whether or not the decided route allocation brings more profits than others.

Empirically, freight rates fluctuate around a vessel's shipping costs, according to the conditions of the shipping market. In the next section, the components of shipping costs and their conversion into the costs per cargo ton are reviewed.

4.2 Components of Shipping Costs

Shipping costs include capital costs and operation costs with the latter divided into two categories, management and navigation costs. Capital costs are the costs for the purchase of ships and their depreciation. Management costs are for the maintenance of the organization providing the transportation service and navigation costs are the direct costs for the voyage itself. The composition of costs mentioned above, and their detailed components, are shown in Fig. 4.1.

4.3 Deduction of Shipping Costs per Cargo Ton

In the Final Report (1978), annual costs and annual carrying cargo volume are used to obtain the shipping costs per cargo ton. In this report, shipping cost per cargo ton is defined as the necessary costs in a voyage divided by the cargo volume carried in the voyage, because it brings the same result, and its deduction is simpler than that of the Final Report.

Suppose that the one-way distance of a voyage is d miles and the vessel moves at the speed S1 mile/h on a forward voyage and S2 mile/h on a return voyage.

Then it takes $\left[\left(\frac{d}{S1} + \frac{d}{S2} \right) \frac{1}{24} \right]$ days for the voyage.

It is convenient to obtain the costs per day of a vessel according to the working conditions. When a vessel moves, it costs (using the same concept as in section 4.2):

$$\frac{(1 + E) \cdot Pr \cdot (R_d + R_i + R_r) + (C_r + M_s + A_d + L_b + R_p)}{Da} + P_B \cdot B_2 \qquad (4.1)$$

- Shipping Costs
  - Capital Costs
    - Depreciation Cost — (1 + E) x Pr x Rd
    - Interest — (1 + E) x Pr x Rr
    - Insurance — (1 + E) x Pr x Ri
  - Operation Costs
    - Management Costs
      - Crew Expenses — Cr
      - Miscellaneous — Mr
      - Administration Costs — Ad
      - Lubrication Costs — Lb
      - Maintenance Costs — Rp
    - Navigation Costs
      - Bunker Consumption Charge — B1xPb, B2xPb
      - Port Charges (including canal charge) — Pc
      - Loading and Unloading charge — Tt, To

E: Fitting out Expense rate (%); Pr: Contract Price ($/Ship); Rd: Depreciation Rate;
Rr: Interest Rate; Ri: Insurance Rate; Pb: Bunker Oil Price ($/ton);
B1 and B2: Bunker Oil Consumption During Voyage and at Anchor

Fig. 4.1 Composition of Costs

per day. When a vessel is at anchor only the bunker consumption rate is different: then the cost is:

$$\frac{(1+E)\cdot Pr\cdot(R_d + R_i + R_r) + (C_r + M_s + A_d + L_b + R_p)}{Da} + P_B\cdot B_1 \qquad (4.2)$$

It is probable that B1 is lower than B2, but port charge and loading/unloading costs are added to the daily costs when the vessel is in a port. Noting that moving days are $\left[\left(\frac{1}{S1} + \frac{1}{S2}\right)\frac{d}{24}\right]$ and days at anchor are (Dt + Do), the shipping costs per cargo ton C is expressed by a linear function of voyage distance d (one day).

$$c = a + bd \qquad (4.3)$$

$$a = \left[\frac{(Pr\cdot s+Cr+Ms+Ad+Lb+Rp)\ (Dt+Do)}{Da} + B_2\cdot Pb\cdot(Dt+Do)+Tt+To\right]\frac{1}{DwR} \qquad (4.4)$$

$$b = \left[\frac{(Pr\cdot s+Cr+Ms+Ad+Lb+Rp)}{Da} + B_1\cdot Pb\right]\cdot\left(\frac{1}{S_1}+\frac{1}{S_2}\right)\cdot\frac{1}{24}\cdot\frac{1}{DwR} \qquad (4.5)$$

where d: distance (mile)
a, b: coefficients
s: (1 + E) (Rd + Ri + Rr)

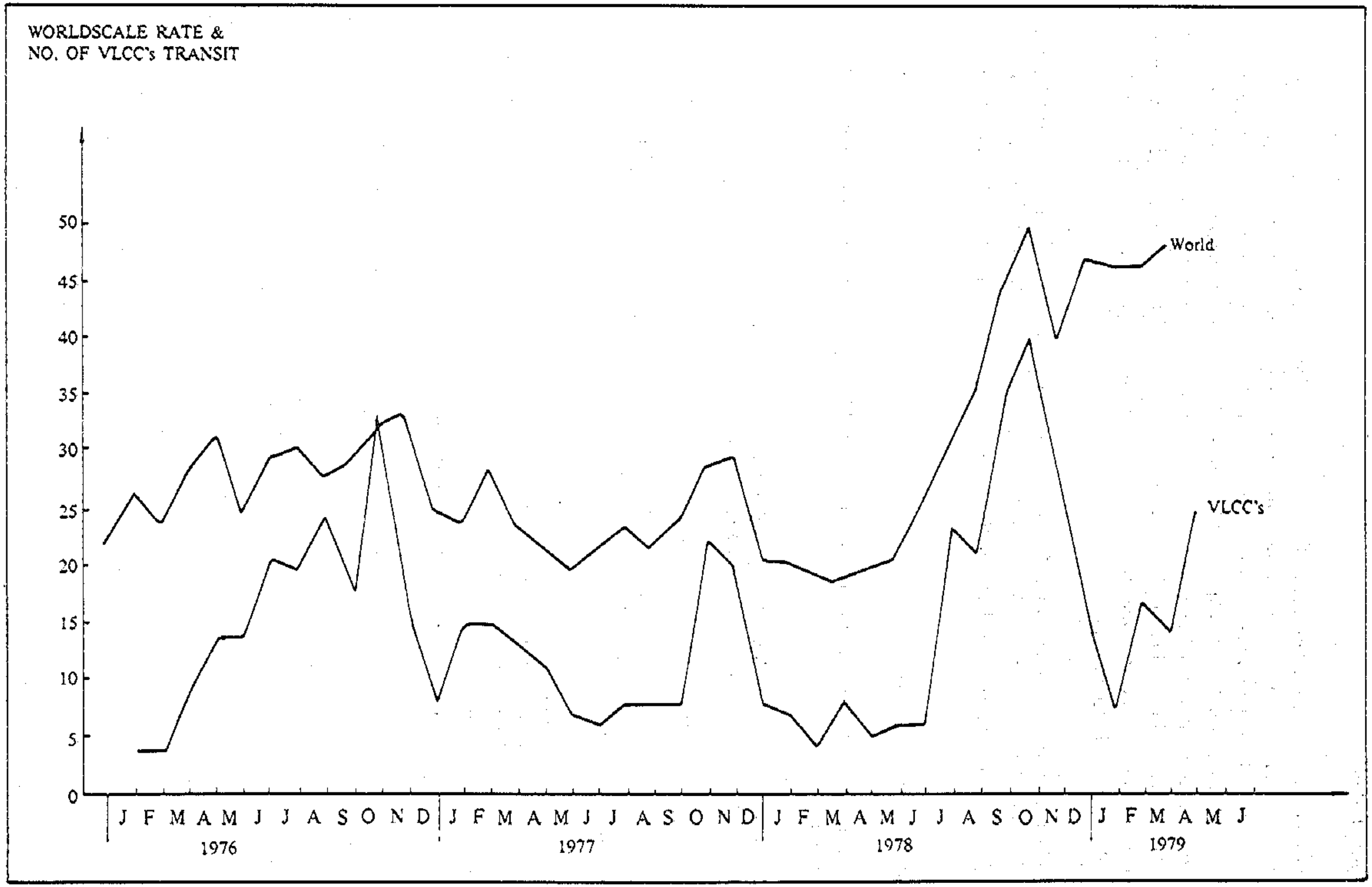

Fig. 4.2 Relationship Between VLCC's Transits and World Scale

4.4 Freight Market

The freight market has a strong effect on the routing allocation of vessels. Fig. 4.2 shows the world historical data, and VLCC routes after reopening of Suez Canal in 1975. The two kinds of index show almost the same tendencies and it can be seen that the freight market has a clear connection with the use of the Suez Canal route. The reason for this relationship is shown in Fig. 4.3. The amount of money saved by using the canal changes according to the freight rate, because it is defined as the product of the saved time and the freight rate. Therefore, an increase in the freight rate brings a greater Suez routes. To express this freight rate, it is convenient to adopt the World Scale Ratio system.

The World Scale Ratio is an index expressing the market condition by a percentage of the freight rate, based on the shipping costs of a 19,500 DWT tanker. Using the World Scale Ratio System, the freight rate can be approximated by the fluctuating level of the shipping cost per cargo ton. Then

$$MC = [a + (b \times d)] \times \alpha \tag{4.6}$$

where, MC is the freight rate, a and b are parameters of shipping cost, and α is a market condition parameter.

In this formula, when $\alpha = 1.0$, $MC = [a + (b \times d)]$, and the freight level just covers the shipping costs. Thus, if the size of a given vessel is 19,500 DWT, α is equal to the W.S. ratio.

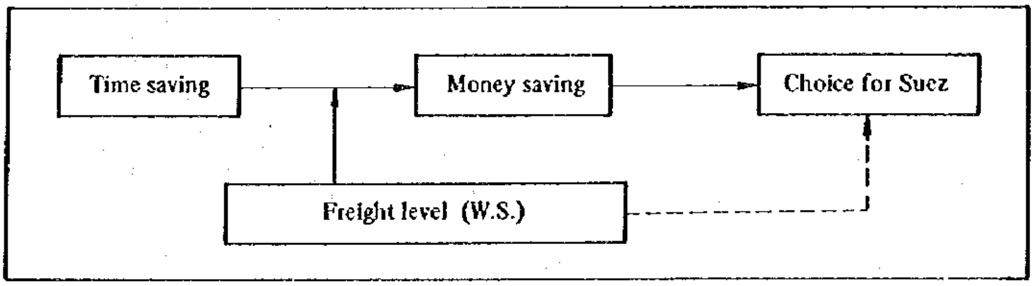

Fig. 4.3 The Effect of Freight Level on the Suez Traffic

CHAPTER 5 ROUTE CHOICE MODEL

5.1 Multinominal Modal Choice Model

The route Choice Model determines the proportion of traffic using the Suez Canal. The Final Report (1978) used a method based on the proportioning of routes for one-way voyages, where the decision between two round-trip routes is made on the basis of the composite routings of the one-way voyages.

In this report, to more realistically determine the route proportioning of round-trip voyages in one step, a multinominal choice model is introduced, with the possibility of more than two paths considered.

5.2 Previous Method

According to the previous method in the Final Report, there are two steps for deciding the proportioning of routes for round-trip voyages. First, we must decide on the proportion of one-way routes without Canal Regulations. Then we choose the proportioning of the routes for round-trip voyages with respect to the Canal regulations, by combining the one-way voyage proportions. The routing composition is shown in Table 5.1.

Table 5.1 Proportioning of Routes for Round-trip Voyages by Combined One-way Voyags

Case	Capability		Alternatives	One-way Choice				Round Choice		
	Laden	Ballast		nPs	nPc	sPs	sPc	C/C	C/S	S/S
I	X	X	C/C	0	1.0	0	1.0	1.0	0	0
II	X	O	C/C, C/S	0	1.0	sPs*	sPc*	sPc	sPs	0.0
III	O	O	C/C, C/S, S/S	nPs*	nPc*	sPs	sPc	sPc	sPs or nPs	nPs

* mPn: denotes the choice proportion for N-th route in the M-th direction (North or South), when two routes (via Suez or via Cape) are given

For one-way proportioning of routes, a probabilistic model based on the distributed difference of shipping costs is used (see Final Report, p. 142-143; freight costs have been used instead of shipping costs). This model is determined in the following way:

1) If a tanker cannot pass through the Suez Canal either in laden or in ballast, it takes the round-trip voyage C/C.

2) If a tanker can pass through the Suez Canal only in ballast, it may choose either voyage C/S or C/C.

In this case, the proportioning of in-ballast traffic between these two routes — — Cape: r_B (C), Suez: r_B (S) — — is made without respect to Suez Canal regulations.

3) If the tanker can pass through the Suez Canal both in-laden and in-ballast, then we assume that the tankers using the Suez Canal for northbound trips (r_L (S)) will also return in-ballast via the Canal (r_B (S)). Thus, in this case S/S equals (r_L (S)) equals (r_B (S)).

The proportion of voyages using the Suez Canal in southbound trips without regulations (r_B (S)) includes voyages C/S and S/S. For this reason, we can obtain the proportion of voyages using C/S by subtracting the proportion using S/S from the proportion using the Suez Canal on southbound trips. The remainder is the proportion of vessels using the C/C voyage.

5.3 Multinominal Route Choice

To eliminate the difficulty in combining the one-way proportion of traffic to determine the round-trip voyage proportions, the multinominal route choice model was developed. It is explained in this report.

The basic concept of the multinominal route choice model is applied in the field of transportation planning as a "modal choice" model for choosing one transport mode from among many. The modal choice model generally is expressed as follows:

$$r_i = f(C_1, C_2 \ldots\ldots C_i, \ldots\ldots C_n) \qquad (5.1)$$

where r_i is the probability that i-th mode is chosen and C_i represents the total costs or disutilities when i-th mode is used. An example of items composing total costs or disutility is shown in Table 5.2.

In this modal choice function r_i, it is useful to note the following about this modal choice function r_i.

$$\frac{\partial fi}{\partial Ci} \quad \circ \qquad \text{(direct effect)} \qquad (5.2)$$

$$\frac{\partial fi}{\partial Cj} \quad \circ \qquad \text{(indirect or cross effect)} \qquad (5.3)$$

where $\frac{\partial fi}{\partial Cj}$ is the marginal increase of fi following the marginal increase of Cj, while other items remain constant.

Due to the direct and indirect effects, the proportion of voyages choosing the i-th mode decreases when the cost with i-th mode, such as the trip time, increases. Furthermore, a decrease in the cost of using another mode will result in the decrease of the proportion of voyages choosing the i-th mode.

The form of the function r_i varies, and is based on the characteristics of the costs or disutilities Ci, the theoretical background of the function, and so on. There are two types of functions

Table 5.2 Items of Transportation Costs (General Case)

Time
total trip time
reliability (variance in trip time)
time spent at transfer points
frequency of service
schedule times

Cost to user
direct transportation changes such as fares, tolls, fuel, and parking
other direct operating costs such as loading and documentation
indirect costs such as the cost of acquiring, maintaining, and insuring an automobile or, for freight, warehousing, interest, and insurance

Safety
probability of fatality or of destruction of cargo
probability of accident of any sort
probability distribution of accident types (shock vibration, water damage, and so on)
perceived security

Comfort and convenience for user
walking distance
number of vehicle changes required
physical comfort (temperature, humidity, cleanliness, ride quality, exposure to weather)
psychological comfort (status, privacy)
other amenities (baggage handling, ticketing, beverage and food service)
enjoyment of trip
aesthetic experiences

Shipper services
division and reconsignment privileges
insurance

which are often used, the Logit and the Resistance Models.

(1) Logit Model
It is assumed that the disutility (or cost) TCm is composed of two parts, a deterministic part

$$C_m = \Sigma W_i \; S_{mi} \qquad (5.4)$$

and a random part E:

$$TC_m = C_m + E = \Sigma \, W_i S_{mi} + E \qquad (5.5)$$

If it is assumed that the mode with the least costs (the k-th mode) is randomly chosen, as if often the case, the probability of chosing this k-th mode is denoted by r_k, and is expressed by the equation:

$$r_k = \text{prob} \, (TC_k < TC_j, \; j \neq k) \qquad (5.6)$$

In addition, if we assume that the probability distribution of E has a Weibull Distribution, then the following results are obtained:

$$rk = \frac{e^{C_k}}{e^{C_1} + e^{C_2} \ldots e^{C_M}} \quad (5.7)$$

To obtain r_k, the Cm's must be calculated using Wi's from Equation 5.5. With these calculated values, a theoretical r_k (equation) will be generated, which fits the observed data. Under the assumption that E is normally distributed, the model is called a Probit model. This was the method used in the Final Report, to establish the proportioning of routes between one-way voyages. Though the Probit model also is used widely, it is a specialized method, utilizing binominal choice.

(2) Resistance Model
Another form of the multinominal model is called the Resistance model, and is expressed by the following equation:

$$rk = \frac{(C_k)^{B_k}}{(C_1)^{P_1} + (C_2)^{P_2} \ldots\ldots (C_m)^{P_m}} \quad (5.8)$$

Empirically, this model has a good fit, although the distribution of E cannot be expressed explicitly. For this reason, the W_is in C_m and B_is (Equations 5.4 and 5.8) has to be estimated by using observed r_k values. In many cases, assumptions can be made about the ratio between W_is or B_is and these parameters, to simplify the model. For example, in the forecast which is discussed in the Chapter 6, $W_i \ldots W_m = 1.0$ and $B_1 = \ldots. = B_m$ are assumed.

CHAPTER 6 FORECAST OF TANKER TRANSIT

In this chapter, actual forecasting process is explained using the developed methodology. The target year is 1985.

6.1 Oil Trade Flow

From the 1985 forecast mentioned in Chapter 3, the oil trade flow for three relevant origin/destinations (O/D) are determined, as shown in Table 6.1.

Table 6.1 Oil Trade Flow in 1985

O/D	Oil Trade Flow (M.M.T.)
Arabian Gulf – North-western Europe	246.4
Arabian Gulf – Mediterranean Sea	147.5
Arabian Gulf – U.S.A.	160.3

6.2 Route Costs

As explained in Chapter 4, the freight level is an important consideration to the route choice and is expressed as follows.

$$\text{Freight level} = \alpha \times (\text{shipping costs}) \qquad (6.1)$$

Since shipping costs are the same as those in the Final Report, Table 6.2 shows freight levels already multiplied with market parameters. (α= 0.3, 0.5, 1.2)

The relevant routes are S/S (via Suez in both directions), C/S (via Cape outbound and via Suez return) and C/C (via Cape in both directions). The route costs for C/S and S/S include the corresponding canal tariffs.

6.3 Proportions of Route

The proportion of traffic on each route is decided using the Resistance Model, as mentioned in Chapter 5.

The actual form of the Resistance Model is expressed by the following equation: .....

$$r\,(S/S) = \frac{(C\,(S/S))^{\beta}}{(C\,(S/S))^{\beta} + (C\,(C/C))^{\beta} + (C\,(C/C))^{\beta}} \qquad (6.2)$$

$$r\,(C/S) = \frac{(C\,(C/S))^{\beta}}{(C\,(S/S))^{\beta} + (C\,(C/C))^{\beta} + (C\,(C/C))^{\beta}} \qquad (6.3)$$

$$r\,(C/C) = \frac{(C\,(C/C))^{\beta}}{(C\,(S/S))^{\beta} + (C\,(C/C))^{\beta} + (C\,(C/C))^{\beta}} \qquad (6.4)$$

where r (S/S), r (C/S), and r (C/C), are the proportions of traffic for S/S, C/S and C/C voyages and C (S/S), C (C/S), C (C/C) are the route costs already obtained in 6.2.

Compared with the general form of Equation 5.8, the value $Cm = \Sigma W_i S_{mi}$ represents only the route cost. When Wi = 1.0, then Smi = C (m), where m is one of the voyages C/C, C/S, S/S.

Furthermore, it is assumed that $\beta_1 = \beta_2 = \beta_3 = \beta$. Value β must be chosen for its fit with the observed traffic proportion data. In this report, $\beta = 20.0$ is used, since it fits well with the total Suez transits in 1972. The results of the calculations for tanker traffic proportioning are shown in Table 6.3.

Table 6.2 Route Costs Based on Freight Market

Size (1,000 DWT)	α*	A.G. – N.E.			A.G. – M			A.G. – U.S.A.		
		S/S	C/S	C/C	S/S	C/S	C/C	S/S	C/S	C/C
0	0.3	7.96	8.52	9.32	6.32	7.52	8.97	9.11	9.24	9.60
|	0.5	11.82	13.56	15.54	9.08	11.89	14.95	13.74	14.76	16.01
60	1.2	25.32	31.19	37.29	18.74	27.19	35.87	29.94	34.06	38.42
60	0.3	5.06	4.73	4.62	4.26	4.24	4.45	5.63	5.08	4.76
|	0.5	6.99	7.23	7.71	5.65	6.42	7.42	7.94	7.82	7.94
150	1.2	13.74	16.00	18.50	10.52	14.04	17.80	16.01	17.41	19.05
150	0.3	4.19	3.59	3.22	3.63	3.25	3.10	4.59	3.83	3.32
|	0.5	5.54	5.34	5.37	4.61	4.77	5.17	6.20	5.75	5.53
250	1.2	10.26	11.46	12.89	8.03	10.10	12.41	11.83	12.43	13.27
250	0.3	3.90	3.21	2.75	3.43	2.92	2.65	4.24	3.42	2.83
|	0.5	5.06	4.70	4.59	4.27	4.22	4.41	5.61	5.05	4.72
300	1.2	9.10	9.93	11.00	7.20	8.78	10.60	10.43	10.76	11.33
300	0.3	3.82	3.10	2.62	3.37	2.83	2.52	4.14	3.30	2.70
|	0.5	4.92	4.53	4.36	4.17	4.07	4.20	5.45	4.85	4.49
350	1.2	8.77	9.51	10.47	6.97	8.41	10.08	10.04	10.29	10.78
350	0.3	3.70	2.94	2.42	3.29	2.69	2.33	3.99	3.12	2.49
|	0.5	4.72	4.26	4.03	4.04	3.84	3.88	5.21	4.56	4.15
400	1.2	8.30	8.87	9.67	6.64	7.86	9.32	9.46	9.59	9.96
400	0.3	3.58	2.78	2.22	3.21	2.55	2.14	3.84	2.95	2.28
	0.5	4.52	3.99	3.70	3.90	3.61	3.56	4.96	4.27	3.81
	1.2	7.82	8.23	8.88	6.31	7.31	8.55	8.87	8.89	9.13

*α is the parameter reflecting the market condition

Table 6.3 (1) Tanker Traffic Proportioning for Relevant Routes

O/D	Size (1,000 DWT)	α *	PH1			PH2			PH3		
			S/S	C/S	C/C	S/S	C/S	C/C	S/S	C/S	C/C
A.G. – N.E.	0 – 60	0.3	0.77	0.20	0.03	0.77	0.20	0.03	0.77	0.20	0.03
		0.5	0.94	0.06	0.00	0.94	0.06	0.00	0.94	0.06	0.00
		1.2	0.98	0.02	0.00	0.98	0.02	0.00	0.98	0.02	0.00
	60 – 150	0.3	0.00	0.39	0.61	0.09	0.36	0.55	0.09	0.36	0.55
		0.5	0.00	0.78	0.22	0.60	0.31	0.09	0.60	0.31	0.09
		1.2	0.00	0.95	0.05	0.95	0.05	0.00	0.95	0.05	0.00
	150 – 250	0.3	0.00	0.10	0.90	0.00	0.10	0.90	0.00	0.10	0.89
		0.5	0.00	0.53	0.47	0.00	0.53	0.47	0.20	0.42	0.38
		1.2	0.00	0.91	0.09	0.00	0.91	0.09	0.89	0.10	0.01
	250 – 300	0.3	0.00	0.00	1.00	0.00	0.04	0.96	0.00	0.04	0.96
		0.5	0.00	0.00	1.00	0.00	0.38	0.62	0.00	0.38	0.62
		1.2	0.00	0.00	1.00	0.00	0.89	0.11	0.00	0.89	0.11
	300 – 350	0.3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.02	0.98
		0.5	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.35	0.67
		1.2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.87	0.13
	350 – 400	0.3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.02	0.98
		0.5	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.25	0.75
		1.2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.85	0.15
	400	0.3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00
		0.5	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00
		1.2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00

* α is a parameter reflecting the market condition.

Table 6.3 (2) Tanker Traffic Proportions for Relevant Routes

O/D	Size (1,000 DWT)	α *	PH1			PH2			PH3		
			S/S	C/S	C/C	S/S	C/S	C/C	S/S	C/S	C/C
	0	0.3	0.97	0.03	0.00	0.97	0.03	0.00	0.97	0.03	0.00
	|	0.5	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	60	1.2	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	60	0.3	0.00	0.73	0.27	0.40	0.44	0.16	0.40	0.44	0.16
	|	0.5	0.00	0.95	0.05	0.92	0.07	0.00	0.92	0.07	0.00
	150	1.2	0.00	0.99	0.01	1.00	0.00	0.00	1.00	0.00	0.00
	150	0.3	0.00	0.28	0.72	0.00	0.28	0.72	0.03	0.27	0.70
	|	0.5	0.00	0.83	0.17	0.00	0.83	0.17	0.62	0.31	0.06
	250	1.2	0.00	0.98	0.02	0.00	0.98	0.02	0.99	0.01	0.00
A.G.	250	0.3	0.00	0.00	1.00	0.00	0.12	0.88	0.00	0.12	0.88
|	|	0.5	0.00	0.00	1.00	0.00	0.71	0.29	0.00	0.71	0.29
M.	300	1.2	0.00	0.00	1.00	0.00	0.98	0.02	0.00	0.98	0.02
	300	0.3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.09	0.91
	|	0.5	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.65	0.35
	350	1.2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.97	0.03
	350	0.3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.05	0.95
	|	0.5	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.55	0.45
	400	1.2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.97	0.03
		0.3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00
	400	0.5	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00
		1.2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00

* α is a parameter reflecting the market condition.

Table 6.3 (3) Tanker Traffic Proportions for Relevant Routes

O/D	Size (1,000 DWT)	α *	PH1			PH2			PH3		
			S/S	C/S	C/C	S/S	C/S	C/C	S/S	C/S	C/C
	0	0.3	0.47	0.36	0.17	0.47	0.36	0.17	0.47	0.36	0.17
	–	0.5	0.78	0.19	0.04	0.78	0.19	0.04	0.78	0.19	0.04
	60	1.2	0.92	0.07	0.01	0.92	0.07	0.01	0.92	0.07	0.01
	60	0.3	0.00	0.22	0.78	0.03	0.21	0.76	0.03	0.21	0.76
	–	0.5	0.00	0.57	0.43	0.30	0.40	0.30	0.30	0.40	0.30
	150	1.2	0.00	0.86	0.14	0.82	0.15	0.03	0.82	0.15	0.03
	150	0.3	0.00	0.05	0.95	0.00	0.05	0.95	0.00	0.05	0.95
	–	0.5	0.00	0.32	0.68	0.00	0.32	0.68	0.07	0.30	0.64
	250	1.2	0.00	0.79	0.21	0.00	0.79	0.21	0.68	0.25	0.07
A.G.	250	0.3	0.00	0.00	1.00	0.00	0.02	0.98	0.00	0.02	0.98
–	–	0.5	0.00	0.00	1.00	0.00	0.21	0.79	0.00	0.21	0.79
USA	300	1.2	0.00	0.00	1.00	0.00	0.74	0.26	0.00	0.74	0.26
	300	0.3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.02	0.98
	–	0.5	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.18	0.82
	350	1.2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.72	0.28
	350	0.3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.01	0.99
	–	0.5	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.13	0.87
	400	1.2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.68	0.32
		0.3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00
	400	0.5	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00
		1.2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00

* α is a parameter reflecting the market condition.

6.4 Traffic Volume on Each Route

The traffic volume is obtained by the following equations:

$$V_k (S/S) = TRADE \times f_k \times r (S/S) \quad (6.5)$$

$$V_k (C/C) = TRADE \times f_k \times r (C/S) \quad (6.6)$$

$$V_k (C/C) = TRADE \times f_k \times r (C/C) \quad (6.7)$$

where V_k (m) is the traffic volume allocated to the k-th size of tanker on m-th route and f_k is the fleet mix (tonnage share) of k-th size of tanker. The results of the traffic volume on each route are shown in Table 6.4.

Table 6.4 (1) Traffic Volume on Each Route (m Tons)

O/D	Size (1,000 DWT)	α *	PH1			PH2			PH3		
			S/S	C/S	C/C	S/S	C/S	C/C	S/S	C/S	C/C
	0	0.3	2.7	0.7	0.1	2.7	0.7	0.1	2.7	0.7	0.1
	|	0.5	3.2	0.2	0.0	3.2	0.2	0.0	3.2	0.2	0.0
	60	1.2	3.4	0.1	0.0	3.4	0.1	0.0	3.4	0.1	0.0
	60	0.3	0.0	4.5	7.0	1.0	4.1	6.4	1.0	4.1	6.4
	|	0.5	0.0	9.0	2.5	7.0	3.6	1.0	7.0	3.6	1.0
	150	1.2	0.0	11.0	0.6	11.0	0.5	0.0	11.5	0.5	0.0
	150	0.3	0.0	8.6	74.5	0.0	8.6	74.5	0.4	8.5	74.1
	|	0.5	0.0	44.0	39.0	0.0	44.0	39.0	16.6	35.2	31.2
	250	1.2	0.0	75.8	7.2	0.0	75.8	7.2	74.1	8.2	0.8
A.G.	250	0.3	0.0	0.0	96.6	0.0	4.2	92.4	0.0	4.2	92.4
|	|	0.5	0.0	0.0	96.6	0.0	36.2	60.4	0.0	36.2	60.4
N.E.	300	1.2	0.0	0.0	96.6	0.0	85.5	11.0	0.0	85.5	11.0
	300	0.3	0.0	0.0	21.2	0.0	0.0	21.2	0.0	0.7	20.5
	|	0.5	0.0	0.0	21.2	0.0	0.0	21.2	0.0	6.9	14.3
	350	1.2	0.0	0.0	21.2	0.0	0.0	21.2	0.0	18.5	2.7
	350	0.3	0.0	0.0	15.8	0.0	0.0	15.8	0.0	0.3	15.5
	|	0.5	0.0	0.0	15.8	0.0	0.0	15.8	0.0	3.9	11.8
	400	1.2	0.0	0.0	15.8	0.0	0.0	15.8	0.0	13.4	2.3
		0.3	0.0	0.0	14.8	0.0	0.0	14.8	0.0	0.0	14.8
	400	0.5	0.0	0.0	14.8	0.0	0.0	14.8	0.0	0.0	14.8
		1.2	0.0	0.0	14.8	0.0	0.0	14.8	0.0	0.0	14.8

* α is a parameter reflecting the market condition

Table 6.4 (2) Traffic Volume on Each Route (m Tons)

O/D	Size (1,000 DWT)	α *	PH1			PH2			PH3		
			S/S	C/S	C/C	S/S	C/S	C/C	S/S	C/S	C/C
	0	0.3	18.5	0.6	0.0	18.5	0.6	0.0	18.5	0.6	0.0
	|	0.5	18.9	0.1	0.0	18.9	0.1	0.0	18.9	0.1	0.0
	60	1.2	19.0	0.0	0.0	19.0	0.0	0.0	19.0	0.0	0.0
	60	0.3	0.0	28.7	10.7	15.6	17.3	6.5	15.6	17.3	6.5
	|	0.5	0.0	37.3	2.1	36.4	2.9	0.2	36.4	2.9	0.2
	150	1.2	0.0	39.0	0.3	39.3	0.1	0.0	39.3	0.1	0.0
	150	0.3	0.0	11.3	29.0	0.0	11.3	29.0	1.2	11.0	28.1
	|	0.5	0.0	33.5	6.8	0.0	33.5	6.8	25.1	12.6	2.6
	250	1.2	0.0	39.6	0.6	0.0	39.6	0.6	39.9	0.4	0.0
A.G.	250	0.3	0.0	0.0	37.2	0.0	4.6	32.6	0.0	4.6	32.6
|	|	0.5	0.0	0.0	37.2	0.0	26.3	10.9	0.0	26.3	10.9
M.	300	1.2	0.0	0.0	37.2	0.0	36.3	0.8	0.0	36.3	0.8
	300	0.3	0.0	0.0	4.9	0.0	0.0	4.9	0.0	0.4	4.4
	|	0.5	0.0	0.0	4.9	0.0	0.0	4.9	0.0	3.2	1.7
	350	1.2	0.0	0.0	4.9	0.0	0.0	4.9	0.0	4.7	0.1
	350	0.3	0.0	0.0	3.5	0.0	0.0	3.5	0.0	0.2	3.4
	|	0.5	0.0	0.0	3.5	0.0	0.0	3.5	0.0	2.0	1.6
	400	1.2	0.0	0.0	3.5	0.0	0.0	3.5	0.0	3.4	0.1
		0.3	0.0	0.0	3.2	0.0	0.0	3.2	0.0	0.0	3.2
	400	0.5	0.0	0.0	3.2	0.0	0.0	3.2	0.0	0.0	3.2
		1.2	0.0	0.0	3.2	0.0	0.0	3.2	0.0	0.0	3.2

* α is a parameter reflecting the market condition.

Table 6.4 (3) Traffic Volume on Each Route (m Tons)

O/D	Size (1,000 DWT)	α *	PH1 S/S	PH1 C/S	PH1 C/C	PH2 S/S	PH2 C/S	PH2 C/C	PH3 S/S	PH3 C/S	PH3 C/C
A.G. – USA	0 – 60	0.3	2.2	1.7	0.8	2.2	1.7	0.8	2.2	1.7	0.8
		0.5	3.6	0.9	0.2	3.6	0.9	0.2	3.6	0.9	0.2
		1.2	4.3	0.3	0.0	4.3	0.3	0.0	4.3	0.3	0.0
	60 – 150	0.3	0.0	5.5	19.7	0.7	5.3	19.2	0.7	5.3	19.2
		0.5	0.0	14.5	10.7	7.5	10.1	7.5	7.5	10.1	7.5
		1.2	0.0	21.6	3.6	20.7	3.9	0.6	20.7	3.9	0.6
	150 – 250	0.3	0.0	2.6	46.8	0.0	2.6	46.8	0.1	2.6	46.7
		0.5	0.0	15.7	33.7	0.0	15.7	33.7	3.2	14.7	31.5
		1.2	0.0	38.8	10.5	0.0	38.8	10.5	33.6	12.4	3.4
	250 – 300	0.3	0.0	0.0	52.1	0.0	1.2	50.9	0.0	1.2	50.9
		0.5	0.0	0.0	52.1	0.0	10.8	41.3	0.0	10.8	41.3
		1.2	0.0	0.0	52.1	0.0	38.3	13.7	0.0	38.3	13.7
	300 – 350	0.3	0.0	0.0	11.9	0.0	0.0	11.9	0.0	0.2	11.7
		0.5	0.0	0.0	11.9	0.0	0.0	11.9	0.0	2.1	9.8
		1.2	0.0	0.0	11.9	0.0	0.0	11.9	0.0	8.5	3.4
	350 – 400	0.3	0.0	0.0	9.1	0.0	0.0	9.1	0.0	0.1	9.0
		0.5	0.0	0.0	9.1	0.0	0.0	9.1	0.0	1.2	7.9
		1.2	0.0	0.0	9.1	0.0	0.0	9.1	0.0	6.2	2.9
	400	0.3	0.0	0.0	8.0	0.0	0.0	8.0	0.0	0.0	8.0
		0.5	0.0	0.0	8.0	0.0	0.0	8.0	0.0	0.0	8.0
		1.2	0.0	0.0	8.0	0.0	0.0	8.0	0.0	0.0	8.0

* α is a parameter reflecting the market condition.

6.5 Number of Voyages on Each Route

The number of voyages necessary to carry the traffic volume calculated in 6.4 is given by the following equations:

$$N_k(m) = V_k(m) / C_k \qquad (6.8)$$

where $C_k = L_k \cdot (DWT)_k \qquad (6.9)$

$N_k(m)$ is the number of voyages per year by k-th size of tanker on m-th route, and C_k is an average volume carried by k-th size of tanker. C_k is the product of the load factor L_k and the representing DWT of the tanker size. In this report, $L_k = 0.9$, and the representing DWT are shown in Table 6.5.

The results of the calculation of the number of voyages are shown in Table 6.5.

Table 6.5 (1) Number of Voyages on Each Route

O/D	Size (1,000 DWT)	α *	PH1			PH2			PH3		
			S/S	C/S	C/C	S/S	C/S	C/C	S/S	C/S	C/C
A.G. – N.E.	0 – 60	0.3	98.5	25.1	4.2	98.5	25.1	4.2	98.5	25.1	4.2
		0.5	119.6	7.6	0.5	119.6	7.6	0.5	119.6	7.6	0.5
		1.2	125.8	1.9	0.1	125.8	1.9	0.1	125.8	1.9	0.1
	60 – 150	0.3	0.0	48.1	74.4	11.0	43.8	67.8	11.0	43.8	67.8
		0.5	0.0	95.7	26.8	74.0	37.8	10.6	74.1	37.8	10.6
		1.2	0.0	116.2	6.4	116.7	5.6	0.3	116.7	5.6	0.3
	150 – 250	0.3	0.0	41.4	359.8	0.0	41.4	359.8	1.8	41.2	358.1
		0.5	0.0	212.5	188.6	0.0	212.5	188.6	80.3	170.0	150.9
		1.2	0.0	366.4	34.8	0.0	366.4	34.8	357.9	39.0	3.7
	250 – 300	0.3	0.0	0.0	390.3	0.0	17.1	373.1	0.0	17.1	373.1
		0.5	0.0	0.0	390.3	0.0	146.4	243.9	0.0	146.4	243.9
		1.2	0.0	0.0	390.3	0.0	345.6	44.6	0.0	345.6	44.6
	300 – 350	0.3	0.0	0.0	72.4	0.0	0.0	72.4	0.0	2.4	70.1
		0.5	0.0	0.0	72.4	0.0	0.0	72.4	0.0	23.6	48.9
		1.2	0.0	0.0	72.4	0.0	0.0	72.4	0.0	63.3	9.1
	350 – 400	0.3	0.0	0.0	48.7	0.0	0.0	48.7	0.0	0.9	47.1
		0.5	0.0	0.0	48.7	0.0	0.0	48.7	0.0	12.1	36.5
		1.2	0.0	0.0	48.7	0.0	0.0	48.7	0.0	41.4	7.2
	400	0.3	0.0	0.0	37.3	0.0	0.0	37.3	0.0	0.0	37.3
		0.5	0.0	0.0	37.3	0.0	0.0	37.3	0.0	0.0	37.3
		1.2	0.0	0.0	37.3	0.0	0.0	37.3	0.0	0.0	37.3

* α is a parameter reflecting the market conditions.

Table 6.5 (2) Number of Voyages on Each Route

O/D	Size (1,000 DWT)	α *	PH1			PH2			PH3		
			S/S	C/S	C/C	S/S	C/S	C/C	S/S	C/S	C/C
A.G. | M.	0 | 60	0.3	683.5	20.6	0.6	683.5	20.6	0.6	683.5	20.6	0.6
		0.5	701.5	3.2	0.0	701.5	3.2	0.0	701.5	3.2	0.0
		1.2	704.3	0.4	0.0	704.3	0.4	0.0	704.3	0.4	0.0
	60 | 150	0.3	0.0	303.4	113.4	165.0	183.2	68.5	165.0	183.2	68.5
		0.5	0.0	395.0	21.7	384.8	30.3	1.7	384.8	30.3	1.7
		1.2	0.0	413.2	3.6	415.4	1.3	0.0	415.4	1.3	0.0
	150 | 250	0.3	0.0	54.6	139.9	0.0	54.6	139.9	5.6	53.1	135.8
		0.5	0.0	161.7	32.8	0.0	161.7	32.8	121.1	161.7	32.8
		1.2	0.0	191.4	3.1	0.0	191.4	3.1	192.5	2.0	0.0
	250 | 300	0.3	0.0	0.0	150.2	0.0	18.6	131.6	0.0	18.6	131.6
		0.5	0.0	0.0	150.2	0.0	106.3	43.9	0.0	106.3	43.9
		1.2	0.0	0.0	150.2	0.0	146.7	3.4	0.0	146.7	3.4
	300 | 350	0.3	0.0	0.0	16.6	0.0	0.0	16.6	0.0	1.5	15.1
		0.5	0.0	0.0	16.6	0.0	0.0	16.6	0.0	10.9	5.7
		1.2	0.0	0.0	16.6	0.0	0.0	16.6	0.0	16.2	0.3
	350 | 400	0.3	0.0	0.0	10.9	0.0	0.0	10.9	0.0	0.6	10.4
		0.5	0.0	0.0	10.9	0.0	0.0	10.9	0.0	6.0	4.9
		1.2	0.0	0.0	10.9	0.0	0.0	10.9	0.0	10.6	0.4
	400	0.3	0.0	0.0	8.2	0.0	0.0	8.2	0.0	0.0	8.2
		0.5	0.0	0.0	8.2	0.0	0.0	8.2	0.0	0.0	8.2
		1.2	0.0	0.0	8.2	0.0	0.0	8.2	0.0	0.0	8.2

* α is a parameter reflecting the market condition.

Table 6.5 (3). Number of Voyages on Each Route

O/D	Size (1,000 DWT)	α *	PH1			PH2			PH3		
			S/S	C/S	C/C	S/S	C/S	C/C	S/S	C/S	C/C
A.G. – USA	0 – 60	0.3	81.6	61.9	28.7	81.6	61.9	28.7	81.6	61.9	28.7
		0.5	133.6	32.2	6.3	133.6	32.2	6.3	133.6	32.2	6.3
		1.2	159.0	12.1	1.1	159.0	12.1	1.1	159.0	12.1	1.1
	60 – 150	0.3	0.0	57.7	208.6	7.1	56.1	203.1	7.1	56.1	203.1
		0.5	0.0	153.0	113.3	79.6	107.3	79.4	79.6	107.3	79.4
		1.2	0.0	228.5	37.8	218.8	40.7	6.7	218.8	40.7	6.7
	150 – 250	0.3	0.0	12.5	226.0	0.0	12.5	226.0	0.3	12.5	225.7
		0.5	0.0	75.8	162.7	0.0	75.8	162.7	15.6	70.8	152.1
		1.2	0.0	187.6	50.9	0.0	187.6	50.9	162.2	60.1	16.3
	250 – 300	0.3	0.0	0.0	210.5	0.0	4.8	205.7	0.0	4.8	205.7
		0.5	0.0	0.0	210.5	0.0	43.5	167.0	0.0	43.5	167.0
		1.2	0.0	0.0	210.5	0.0	154.9	55.5	0.0	154.9	55.0
	300 – 350	0.3	0.0	0.0	40.6	0.0	0.0	40.6	0.0	0.7	39.9
		0.5	0.0	0.0	40.6	0.0	0.0	40.6	0.0	7.1	33.4
		1.2	0.0	0.0	40.6	0.0	0.0	40.6	0.0	29.1	11.5
	350 – 400	0.3	0.0	0.0	28.2	0.0	0.0	28.2	0.0	0.3	27.9
		0.5	0.0	0.0	28.2	0.0	0.0	28.2	0.0	3.7	24.5
		1.2	0.0	0.0	28.2	0.0	0.0	28.2	0.0	19.2	9.0
	400	0.3	0.0	0.0	20.2	0.0	0.0	20.2	0.0	0.0	20.2
		0.5	0.0	0.0	20.2	0.0	0.0	20.2	0.0	0.0	20.2
		1.2	0.0	0.0	20.2	0.0	0.0	20.2	0.0	0.0	20.2

* α is a parameter reflecting the market condition.

6.6 Number of Ships Passing through the Canal

The number of ships passing through the Canal is obtained by the following equation, according to direction of transit.

$$N_k \text{ (NORTH)} = N_k \text{ (S/S)} \qquad (6.10)$$

$$N_k \text{ (SOUTH)} = N_k \text{ (S/S)} + N_k \text{ (C/S)} \qquad (6.11)$$

Where, N_k (North), N_k (South) are the number of tankers that pass through the canal northbound and southbound, respectively.

The values are shown in Table 6.6.

Table 6.6 Number of Ships Passing Through the Canal

Size (1,000 DWT)	α*	PH1			PH2			PH3		
		N	S	T	N	S	T	N	S	T
0 – 60	0.3	864	971	1,835	864	971	1,835	864	971	1,835
	0.5	955	998	1,953	955	998	1,953	955	998	1,953
	1.2	989	1,004	1,993	989	1,004	1,993	989	1,004	1,993
60 – 150	0.3	0	409	409	183	466	649	183	466	649
	0.5	0	644	644	539	714	1,252	539	714	1,252
	1.2	0	758	758	751	799	1,550	751	799	1,550
150 – 250	0.3	0	109	109	0	109	109	8	115	122
	0.5	0	405	405	0	450	450	217	519	736
	1.2	0	745	745	0	745	745	713	814	1,527
250 – 300	0.3	0	0	0	0	41	41	0	41	41
	0.5	0	0	0	0	296	296	0	296	296
	1.2	0	0	0	0	647	647	0	647	647
300 – 350	0.3	0	0	0	0	0	0	0	5	5
	0.5	0	0	0	0	0	0	0	42	42
	1.2	0	0	0	0	0	0	0	109	109
350 – 400	0.3	0	0	0	0	0	0	0	2	2
	0.5	0	0	0	0	0	0	0	22	22
	1.2	0	0	0	0	0	0	0	71	71
400	0.3	0	0	0	0	0	0	0	0	0
	0.5	0	0	0	0	0	0	0	0	0
	1.2	0	0	0	0	0	0	0	0	0

* N, S, and T denote Northbound, Southbound, and Total.

6.7 Revenue

Revenue from the Canal tariffs is obtained by the following equations:

$$R_k \text{ (North)} = (SNT)_k \times \text{Due} \times N_k \text{ (North)} \quad (6.12)$$

$$R_k \text{ (South)} = (SNT)_k \times \text{Due} \times N_k \text{ (South)} \quad (6.13)$$

where, R_k (North) and R_k (South) are the revenues according to the direction, and $(SNT)_k$ is the Suez Canal Registered Net tonnage. $(SNT)_k$ is an emprical function of DWT; in this report the following approximation is used:

$$(SNT)_k = (DWT)^{1.03} \times 0.357 \quad (6.14)$$

The Revenues are shown in Table 6.7.

Table 6.7 Revenue from Tankers
($ Thousand, USD)

Size (1,000 DWT)	α *	PH1			PH2			PH3		
		N	S	T	N	S	T	N	S	T
0	0.3	26,336	23,808	50,144	26,336	23,808	50,144	26,336	23,808	50,144
|	0.5	29,118	24,460	53,577	29,118	24,460	53,577	29,118	24,460	53,577
60	1.2	30,163	24,600	54,763	30,163	24,600	54,763	30,163	24,600	54,763
60	0.3	0	36,452	36,452	20,298	41,543	61,841	20,298	41,543	61,841
|	0.5	0	57,353	57,353	59,681	63,599	123,280	59,681	63,599	123,280
150	1.2	0	67,512	67,512	83,227	71,139	154,366	83,227	71,139	154,366
150	0.3	0	21,681	21,681	0	21,681	21,681	1,947	22,887	24,834
|	0.5	0	89,911	89,911	0	89,911	89,911	53,920	103,655	157,575
250	1.2	0	148,921	148,921	0	148,921	148,921	177,115	162,647	339,762
250	0.3	0	0	0	0	9,729	9,729	0	9,729	9,729
|	0.5	0	0	0	0	71,119	71,119	0	71,119	71,119
300	1.2	0	0	0	0	155,458	155,458	0	155,458	155,458
300	0.3	0	0	0	0	0	0	0	1,301	1,301
|	0.5	0	0	0	0	0	0	0	11,867	11,867
350	1.2	0	0	0	0	0	0	0	30,976	30,976
350	0.3	0	0	0	0	0	0	0	576	576
|	0.5	0	0	0	0	0	0	0	6,937	6,937
400	1.2	0	0	0	0	0	0	0	22,556	22,556
	0.3	0	0	0	0	0	0	0	0	0
400	0.5	0	0	0	0	0	0	0	0	0
	1.2	0	0	0	0	0	0	0	0	0

* N, S, and T denote Northbound, Southbound, and Total.

6.8 Long Term Forecasting

Sections 6.1 - 6.7 describe the process which produce a one year forecast; a similar process is conducted to get forecasts for longer periods of time. Thus, the necessary perameters for the forecast of the tanker traffic in the Suez Canal are:

(1) Trade flows

(2) Market parameters

(3) Shipping costs parameters

(4) Shipping Fleet mix

Since the methodology for determining the Canal traffic has been established in this report, through consideration of these aspects should be made for additional and more detailed analyses.

PART VI

LONG TERM FORECASTING
OF
NON-TANKER TRAFFIC THROUGH THE SUEZ CANAL

CHAPTER 1 INTRODUCTION

1.1 Objectives

This report has been written for the following purposes:

(1) To present to the staff of the Unit of the SCA the basic techniques of systems analysis necessary for understanding long term forecasts of the Canal traffic volume.

(2) To present a basic method of forecasting the Canal traffic volume, and the revenue to be derived from the Canal; and to develop and describe a Canal management method, in relation to the Canal expansion plan.

To achieve the above purposes, this text explains the basic system of forecasting the Canal traffic volume, and the revenue to be derived from the canal, with respect to long term non-tanker traffic.

1.2 Outline

Long term non-tanker traffic through the Suez Canal is considered to be important to the SCA after the completion of the first phase expansion project of the Suez Canal for the following reasons:

Though tanker traffic is expected to increase once the first phase Suez Canal expansion project has been completed, the long term oil trade flows from the Arabian Gulf are not expected to greatly increase because of OPEC's policy. Non-tanker traffic, on the other hand, is considered to increase according to the world economic development, and thus will be in the future the significant past of the Canal traffic. This Part consists of the following four chapters:

Chapter 1, "Introduction" describes the objectives of long-term forecasting for non-tankers and presents the outline of this report.

Chapter 2, "World Economy and Dry Cargo Trade Flows" describes the procedures for forecasting dry cargo trade flows carried by non-tankers. Two methods, A and B, are explained in this chapter. Method A often is used to forecast major bulk cargo carried by bulk carriers. Method B is simpler and more practical than method A, and can be used to forecast not only other bulk cargo and general cargo trade flows but also major bulk cargo.

Chapter 3, "Non-Tanker Traffic through the Suez Canal" describes methods of forecasting non-tanker traffic passing through the Suez Canal. Two methods are explained in the same manner as in Chapter 2.

Chapter 4, "Canal Revenue from Non-Tankers" clarifies the methods of forecasting Canal revenue at a given level of the tariff per ship.

The systems analysis technique in this part provides basic information for determining the scope and timing of Canal development projects, as well as future tariffs.

In the following chapters a detailed explanation will be given about the forecasting methods in analyzing each phase. Fig. 1.1 is a schematic diagram showing the relationships of these three phases and the forecasting process.

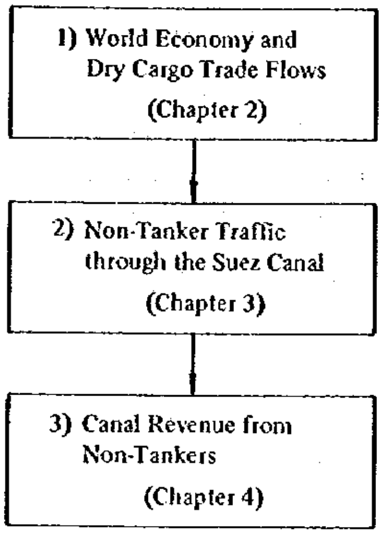

Fig. 1.1 Long Term Forecasting Process of Non-Tanker Traffic through the Canal

CHAPTER 2 WORLD ECONOMY AND DRY CARGO TRADE

2.1 General Remarks

The trade flow can be represented by five elements: the commodity, the volume of that commodity, the origin and destination, and the time during which a volume of that commodity is transported. These are shown in Fig. 2.1.

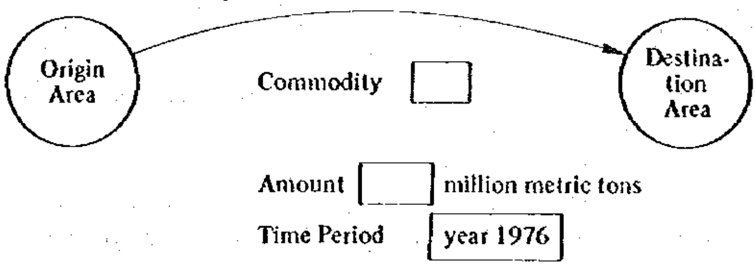

Fig. 2.1 Definition of Trade Flow

Because there are numerous origin and destinations, it is very important for an effective study to adequately classify these origin/destination areas.

2.1.1 Commodities

Commodities related to dry cargo can be classified into the following groups.

- Dry Cargo
  - Dry Bulk Cargo
    - Five Major Bulk Cargos
      - Coal
      - Iron Ore
      - Bauxite and Alumina
      - Phosphate Rock
      - Grain
    - Others
  - General Cargo

2.1.2 Origins/Destinations

Origin/destination zoning requires careful consideration of the availability of International Statistics, the importance of a route to the Suez Canal, and the way in which individual ports can be grouped into an effective single route. It is also important to keep the total number of zones to a minimum for economy in analysis.

2.2 Dry Cargo Trade Flows (Method A)

The general procedure in long term forecasting of seaborne trade flows, for each kind of major bulk cargo, is divided into the following five components:

1) Scenario for world economic development

2) Consumption and production

3) Import and export

4) World trade flows

5) Trade flows relevant to the Suez Canal

Fig. 2.2 is a schematic diagram of the long term forecasting procedure. Note how the components listed above are inter-related.

The whole world can be divided into two groups, One group being the exporting areas (N areas; area i), the other being the group of importing areas (L areas; area j). The relationships among variables i, j and k are as follows:

Exporting area i: 1 – N (k = 1 – N)
Importing area j: 1 – L (N+1 – N+L)

An outline of the methodology underlying such long term forecasts will be described briefly. In the remainder of this section, each component will be explained in detail.

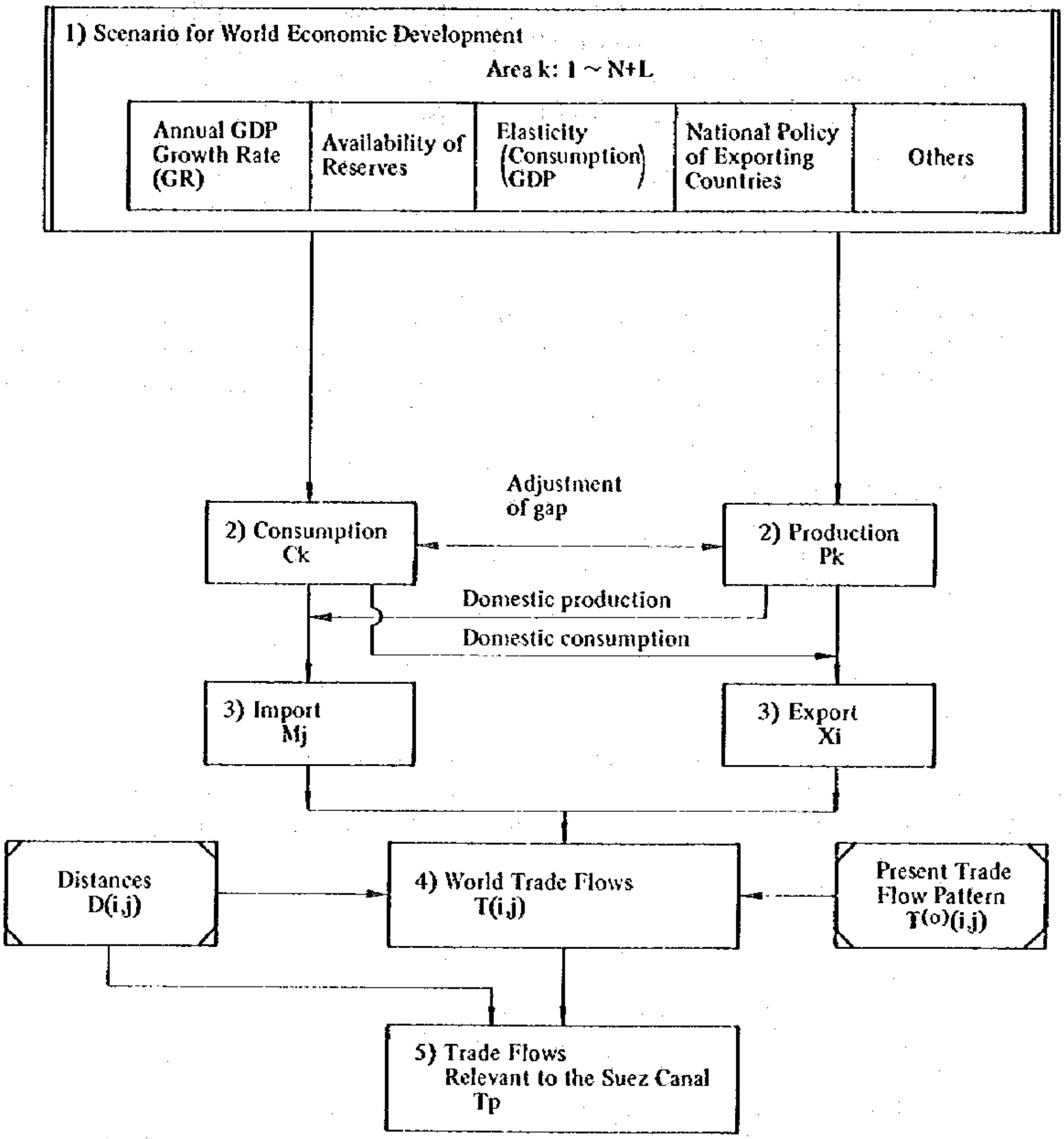

Fig. 2.2 Forecasting Procedure (Method A)

1) Scenario for World Economic Development

In long term forecasts, it is necessary to choose a set of well-defined hypotheses concerning the evolution of the economic environment for each area. If several equiprobable possibilities should be retained, a scenario is made to incorporate each set of hypotheses.

In order to determine a scenario, considerable use will be made of existing forecasts available from various organizations, such as the United Nations and OECD. From a comparison of the various forecasts, several sets of scenarios must be extracted. The extracted scenarios have to include one which will be considered as the most probable, and other which will be derived from a fundamentally different set of hypotheses.

A scenario consists of many factors. The most important factor is the GDP (Gross Domestic Product) annual growth rate for each area. GRk denotes the GDP annual growth rate of area k. In addition to GRk, it is necessary to determine all explanatory variables, the availability of resource reserves, and the national policy of the exporting countries.

In the succeeding parts of this section, the methods of forecasting trade flows will be explained.

2) Consumption and Production

Consumption in area k is denoted by Ck. Ck is often assumed to be dependent on the GRk (GDP growth rate of area k) and the elasticity (consumption growth rate/GDP growth rate, ek) of area k. The following equation is the most popular one representing the relationship between E, GR and e:

$$C_k^n = C_k^o \cdot (1 + ek \cdot GRk)^n \qquad \cdots\cdots (2\text{-}1)$$

where C_k^o: consumption in area k of the base year,

C_k^n: consumption in area k of the n-th year.

GRk and ek have been already determined in the scenario stage.

Production capability in area k (Pk) is forecast by taking into account resource reserves, and the national policy of area i. After forecasting production capabilities, world oil consumption is compared to the world production capability and the following modification is made:

If $\sum_{k=1}^{N+L} Ck \leq \sum_{k=1}^{N+L} Pk$, Pk is modified so that

$\sum_{k=1}^{N+1} Pk$ is equal to $\sum_{k=1}^{N+1} Ck$.

If $\sum_{k=1}^{N+L} Ck > \sum_{k=1}^{N+L} Pk$, Ck is modified so that

$\sum_{k=1}^{N+L} Ck$ is equal to $\sum_{k=1}^{N+L} Pk$.

3) Imports and Exports

Imports to area j (Mj) and exports from area i (Xi) are forecast by the following equations.

$$Mj = \begin{cases} Cj\text{-}Pj, & \text{if } Cj \text{ is greater than } Pj. \\ 0, & \text{otherwise} \end{cases}$$

$$Xi = \begin{cases} 0, & \text{if } Ci \text{ is greater than } Pi. \\ Pi\text{-}Ci, & \text{otherwise.} \end{cases} \qquad \cdots\cdots (2\text{-}2)$$

4) World Trade Flows

Trade flows between areas are forecast based upon data on imports, exports, present trade flow patterns and the distances between areas. The following mathematical methods have been developed and applied in forecasting origin/destination patterns.

a) Constant-Factor Method by Origins
b) Constant-Factor Method by Destinations
c) Furness Method
d) Average Factor Method
e) FRATOR Method
f) Detroit Method
g) Gravity Model.

Of these, the FRATOR method explained below is one of the most sophisticated methods.

FRATOR method

The data which will be used in the FRATOR method is as follows:

$T^{(o)}(i,j)$: present trade flow from area i to area j.
$X^{(o)}(i)$: present total exports from area i.
$M^{(o)}(j)$: present total imports to area j.

$$X^{(o)}(i) = \sum_{j=1}^{L} T^{(o)}(i,j) \qquad \text{(2-3)}$$

$$M^{(o)}(j) = \sum_{i=1}^{N} T^{(o)}(i,j) \qquad \text{(2-4)}$$

X(i) : future total exports from area i.
M(j) : future total imports to area j.

Table 2.1 shows the format for data input. The forecast of future trade flows (T(i, j)) is carried out through the following steps by using the above data.

a) First approximation $T^{(1)}(i, j)$

The following growth factors are calculated as shown below.

$$F^{(o)}(i) = X(i)/X^{(o)}(i) \qquad \text{(2-5)}$$

$$G^{(o)}(j) = M(j)/M^{(o)}(j) \qquad \text{(2-6)}$$

The first approximations $T^{(1)}(i, j)$ are obtained by the equation.

$$T^{(1)}(i,j) = T^{(o)}(i,j) \cdot F^{(o)}(i) \cdot G^{(o)}(j) \cdot \frac{U^{(o)}(i) + V^{(o)}(j)}{2} \qquad \text{(2-7)}$$

where

$$U^{(o)}(i) = X^{(o)}(i) / [\sum_{j=1}^{L} (T^{(o)}(i,j) \cdot G^{(o)}(j))] \quad \text{(2-8)}$$

$$V^{(o)}(j) = M^{(o)}(j) / [\sum_{i=1}^{N} (T^{(o)}(i,j) \cdot F^{(o)}(i))] \quad \text{(2-9)}$$

b) Second approximation $T^{(2)}(i,j)$

$$X^{(1)}(i) = \sum_{j=1}^{L} T^{(1)}(i,j) \quad \text{(2-10)}$$

$$M^{(1)}(j) = \sum_{i=1}^{N} T^{(1)}(i,j) \quad \text{(2-11)}$$

$$F^{(1)}(i) = X(i)/X^{(1)}(i) \quad \text{(2-12)}$$

$$G^{(1)}(j) = M(j)/M^{(1)}(j) \quad \text{(2-13)}$$

$$U^{(1)}(i) = X^{(1)}(i) / [\sum_{j=1}^{L} (T^{(1)}(i,j) \cdot G^{(1)}(j))] \quad \text{(2-14)}$$

$$V^{(1)}(j) = M^{(1)}(j) / [\sum_{i=1}^{N} (T^{(1)}(i,j) \cdot F^{(1)}(i))] \quad \text{(2-15)}$$

$$T^{(2)}(i,j) = T^{(1)}(i,j) \cdot F^{(1)}(i) \cdot G^{(1)}(j) \cdot \frac{U^{(1)}(i) + V^{(1)}(j)}{2} \quad \text{(2-16)}$$

c) m-th approximation $T^{(m)}(i,j)$

$$T^{(m)}(i,j) = T^{(m-1)}(i,j) \cdot F^{(m-1)}(i) \cdot G^{(m-1)}(j) \cdot \frac{U^{(m-1)}(i) + V^{(m-1)}(j)}{2} \quad \text{(2-17)}$$

Iterative calculation is finished when all of $F^{(m)}(i)$, $G^{(m)}(j)$, $U^{(m)}(i)$, and $V^{(m)}(j)$, converges to unity.

Computer programs aid greatly in performing these calculations; Table 2.2 shows a format of the results.

When employing a Gravity Model, distance data between pairs of areas are also used to forecast trade flows.

Future trade flows T(i, j) are forecast using these methods.

5) Trade Flows Relevant to the Suez Canal

The distance data is used to extract origin/destination pairs (p) which have a savings in distance through the Suez Canal. After that extraction, trade flows relevant to the Suez Canal (Tp) are determined.

Table 2.1 Present Trade Flow Table (Input Data)

$T^{(o)}(i, j)$ (in million metric tons)

Exporting Area \ Importing Area	1	2	3	4	j	L-1	L	Total
1								$X^{(o)}(1)$
2								$X^{(o)}(2)$
3								$X^{(o)}(3)$
4								$X^{(o)}(4)$
i					$T^{(o)}(i, j)$			
N-1								$X^{(o)}(N\text{-}1)$
N								$X^{(o)}(N)$
Total	$M^{(o)}(1)$	$M^{(o)}(2)$	$M^{(o)}(3)$	$M^{(o)}(4)$		$M^{(o)}(L\text{-}1)$	$M^{(o)}(L)$	$T^{(o)}$

Table 2.2 Future Trade Flow Table (Output)

T(i, j) (in million metric tons)

Importing Area / Exporting Area	1	2	3	4	j	L-1	L	Total
1								X(1)
2								X(2)
3								X(3)
4								X(4)
i					T(i, j)			
N-1								X(N-1)
N								X(N)
Total	M(1)	M(2)	M(3)	M(4)		M(L-1)	M(L)	T

Table 2.3 Trade Flows Relevant to the Suez Canal

No. of O/D Pair	Trade Flow		Trade Volume (in MMT)	Distance Saving (in miles)
	Origin	Destination		
1				
2				
3				
4				
5				
p			Tp	
Total				

2.3 Dry Cargo Trade Flows (Method B)

This method is often used to forecast commodity trade flows of other bulk and general cargo. If forecasting major bulk trade flows in a way simpler than the method A is desired, this procedure can be applied.

The method of forecast is outlined as follows:

1) Forecast the growth rate of GWP (Gross World Products)

2) Estimate the elastic figure between world seaborne trade and GWP for each kind of cargo

3) Calculate the growth rate of world seaborne trade

4) Forecast the volume of world seaborne trade

5) Estimate the share of transit volume through the Canal in world seaborne trade.

6) Forecaste the transit volume through the Canal

A flow chart of the forecast is shown in Fig. 2.3.

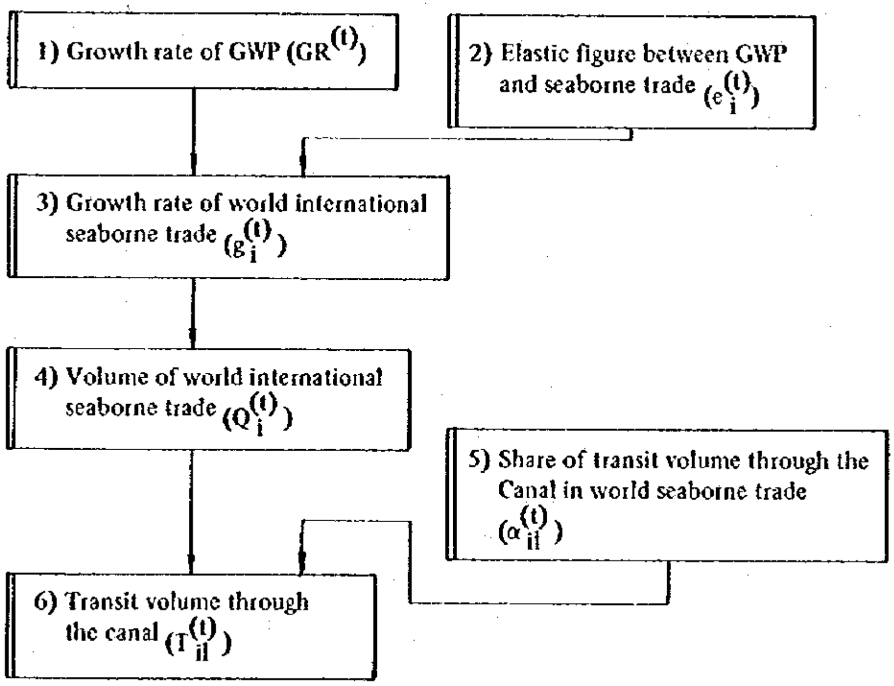

Fig. 2.3 Outline of Method B

The following equations are used to forecast the future transit volume through the Suez Canal for each type of cargo.

$$g_i^{(t)} = e_i^{(t)} \cdot GR^{(t)} \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (2\text{-}18)$$

$$Q_i^{(t)} = (1 + g_i^{(t)}) \cdot Q_i^{(t-1)} \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (2\text{-}19)$$

$$T_{il}^{(t)} = \alpha_{il}^{(t)} \cdot Q_i^{(t)} \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (2\text{-}20)$$

where

$GR^{(t)}$: growth rate of GWP in the t-th year

$e_i^{(t)}$: elastic figure between GWP and world seaborne trade of cargo (type i) in the t-th year

$g_i^{(t)}$: growth rate of world seaborne trade of cargo (type i) in the t-th year

$Q_i^{(o)}$: present world seaborne trade of cargo (type i)

$\alpha_{il}^{(t)}$: share of transit volume of cargo (type i) through the Suez Canal in the world seaborne trade in the t-th year

i : type of cargo

l : $l = 1$ . . . . Northbound
$l = 2$ . . . . Southbound

$T_{il}^{(t)}$: transit volume of cargo (type i) through the Suez Canal in the t-th year

CHAPTER 3 NON-TANKER TRAFFIC THROUGH THE SUEZ CANAL

3.1 Bulk Carrier Traffic through the Suez Canal (Method A)

Trade flows relevant to the Canal, the world fleet structure of bulk carriers, and the shipping costs for each vessel size on each route, are used to forecast the traffic volume through the Canal, in the same way as tankers. This procedure is shown in Fig. 3.1. The procedure is needed if using method A, described in chapter 2.

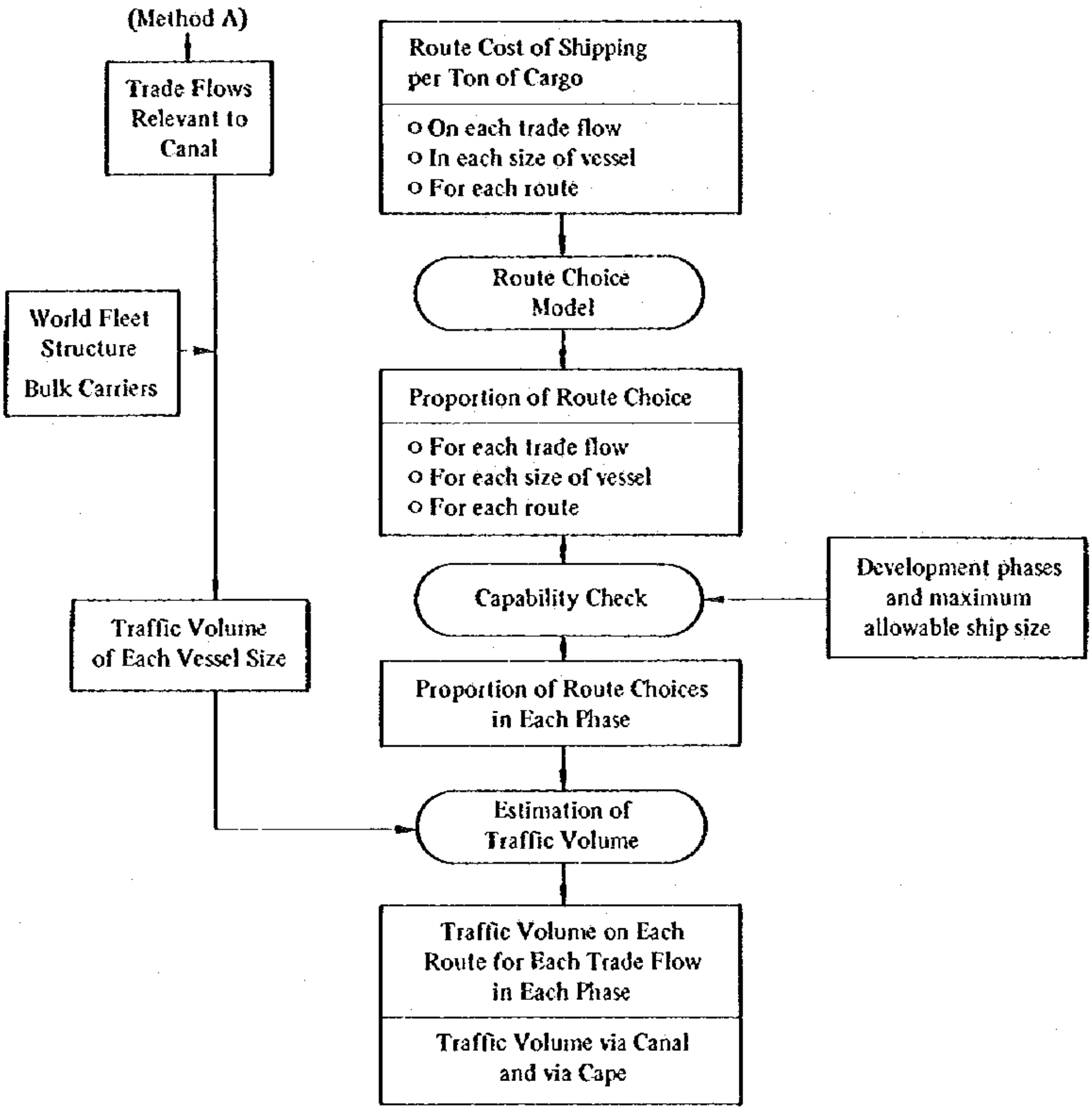

Fig. 3.1 Outline of Forecasting

3.2 Non-Tanker Traffic through the Suez Canal (Method B)

When using Method B, as explained in Chapter 2, it is necessary to forecast non-tanker traffic through the Canal by the following steps:

1) Ship type for each type of cargo (see Table 3.1)

2) Cargo volume by ship type (in metric tons)

3) Conversion factor from Cargo Volume to SNT for each ship type (see Table 3.2)

4) Ship volume by ship type (in SNT)

5) Ship size distribution for each ship type (see Table 3.2)

6) Laden ship volume by ship type and size (in SNT)

7) Representative size of each ship size category (in SNT/ship) (see Table 3.3)

8) Ship number by ship type and size (laden ships)

9) Ship number by ship type and size (in-ballast ships)

10) Ship volume by ship type and size (in-ballast case)

An outline of the procedure is shown in Fig. 3.2.

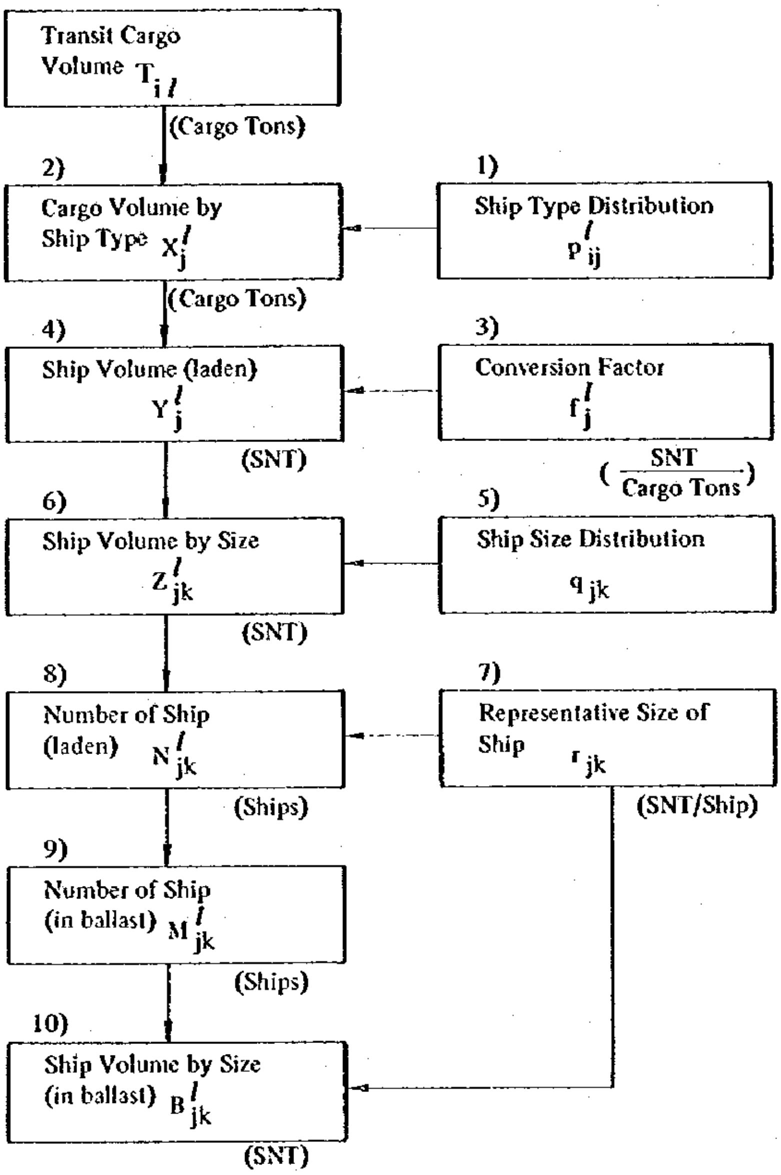

Fig. 3.2 Outline of Forecast Process (Method B)

Non-tanker traffic through the Suez Canal can be forecast by the following equations, after estimating parts 1), 3), 5), and 7), of Figure 3.2, based upon the present fleet structure of non-tankers.

2) $X_j^l = \sum_{i=1}^{l} T_{il} \cdot p_{ij}^l$ .... (3-1)

4) $Y_j^l = X_j^l \cdot f_j^l$ .... (3-2)

6) $Z^{l}_{jk} = Y^{l}_{j} \cdot q_{jk}$ .... (3-3)

8) $N^{l}_{jk} = Z^{l}_{jk} / r_{jk}$ .... (3-4)

9) $$M^{l}_{jk} = \begin{cases} \text{If } N^{1}_{jk} \geqq N^{2}_{jk} \rightarrow \begin{cases} M^{1}_{jk} = 0 \\ M^{2}_{jk} = N^{1}_{jk} - N^{2}_{jk} \end{cases} \\ \text{Otherwise} \rightarrow \begin{cases} M^{1}_{jk} = N^{2}_{jk} - N^{1}_{jk} \\ M^{2}_{jk} = 0 \end{cases} \end{cases}$$ .... (3-5)

10) $B^{l}_{jk} = M^{l}_{jk} \cdot r_{jk}$ .... (3-6)

$$N^{l} = \sum_{j=1}^{J} \sum_{k=1}^{K} N^{l}_{jk}$$ .... (3-7)

$$M^{l} = \sum_{j=1}^{J} \sum_{k=1}^{K} M^{l}_{jk}$$ .... (3-8)

where $l = \begin{cases} 1 \text{ .... Northbound} \\ 2 \text{ .... Southbound} \end{cases}$

- i : $i = 1 - I$ (cargo type)
- j : $j = 1 - J$ (ship type)
- k : $k = 1 - K$ (ship size)
- T_{il} : cargo transit volume through the Suez Canal (in metric tons)
- p^{l}_{ij} : ship type distribution by cargo type i
- X^{l}_{j} : cargo volume carried by ship type j (in metric tons)
- f^{l}_{j} : conversion factor from cargo tons to SNT
- Y^{l}_{j} : ship volume of type j (in SNT)
- q_{jk} : ship size distribution of type j
- Z^{l}_{jk} : laden ship volume of type j and size k (in SNT)
- r_{jk} : representative ship size (SNT) of type j and size k
- N^{l}_{jk} : laden ship number of type j and size k through the Suez Canal
- M^{l}_{jk} : ship number of type j and size k through the Suez Canal in-ballast

B^{l}_{jk} : ship volume of type j and size k through the Suez Canal in ballast (in SNT)

N^{l} : number of laden non-tankers through the Suez Canal

M^{l} : number of in-ballast non-tankers through the Suez Canal

Table 3.1 Ship Type Distribution (P^{l}_{ij})

(%)

Cargo Type i \ Ship Type j		1	2	3	---	J	Total
1	Northbound						100
	Southbound						100
2	Northbound			P^{1}_{23}			100
	Southbound			P^{2}_{23}			100
3	Northbound						100
	Southbound						100
4	Northbound						100
	Southbound						

Table 3.2 Conversion Factor (f^{l}_{j})

(SNT/Metric ton)

Direction l \ Ship Type j	1	2	3	---	J
Northbound $l = 1$	f^{1}_{1}	f^{1}_{2}	f^{1}_{3}	---	f^{1}_{J}
Southbound $l = 2$	f^{2}_{1}	f^{2}_{2}	f^{2}_{3}	---	f^{2}_{J}

Table 3.3 Ship Size Distribution (q_{jk})

(%)

Ship Type j \ Ship Size k	1	2	3	---	K	Total
1				---		100
2	q_{21}	q_{22}	q_{23}	---	q_{2K}	100
3				---		100
---				---		100
J				---		100

Table 3.4 Representative Ship Size (r_{jk})

(SNT/Ship)

Ship Type j \ Ship Size k	1	2	3	---	K
1	r_{11}	r_{12}	r_{13}	---	r_{1K}
2	r_{21}	r_{22}	r_{23}	---	r_{2K}
3				---	
---				---	
J				---	

CHAPTER 4 CANAL REVENUE FROM NON-TANKERS

4.1 Canal Revenue from Bulk Carriers (Method A)

4.1.1 Canal Charges for Bulk Carriers

The Canal charges for a unit S.C.N.R.T. are determined according to the loaded condition, with the vessels S.C.N.R.T. correlated with its D.W.T. using a regression analysis to obtain the quantitative relationship between S.C.N.R.T. and D.W.T. Thus, the canal charges for the transit of a vessel can be calculated according to the vessel's loaded conditions and its D.W.T. One of the most reliable equations using this relationship is the following equation:

$$S.C.N.R.T. = a \times (D.W.T.)^{b} \qquad \text{(4-1)}$$

Coefficients a and b should be estimated from current data.

4.1.2 Number of Bulk Carriers through the Canal

Since canal charges are determined for each passage, the traffic volume through the Canal must be converted to the number of passages, to obtain the Canal revenue. When the traffic volume on each route is determined, the number of ship trips needed to carry that commodity can be obtained by dividing the commodity volume by the transportation capacity of the vessels, as represented by the vessels dead weight tonnage (DWT) multiplied by the load factor R. The following equation gives the number of trips:

$$\text{Trip number} = \text{traffic volume} / (D.W.T. \times R) \qquad \text{(4-2)}$$

4.1.3 Revenue from Bulk Carriers through the Canal

The numbers of ships passing through the Canal, as obtained above, gives the Canal revenue when multiplied by the corresponding Canal charges for bulk carriers.

4.2 Canal Revenue from Non-Tankers (Method B)

In Method B, the Canal revenue from non-tankers can be obtained by applying the following equations:

4.2.1 Canal Revenue from Laden Non-Tankers (U)

$$U = \sum_{l=1}^{2} \sum_{j=1}^{J} \sum_{k=1}^{K} \cdot Z_{jk}^{l} \cdot u_{jk} \qquad \cdots\cdots \quad (4\text{-}3)$$

where Z_{jk}^{l} : laden ship volume of type j and size k (in SNT)

u_{jk} : canal due rate of type j and size k (in $/SNT)

l : l = 1 . . . . Northbound
l = 2 . . . . Southbound

4.2.2 Canal Revenue from Non-Tankers in-Ballast (V)

$$V = \sum_{l=1}^{2} \sum_{j=1}^{J} \sum_{k=1}^{K} \cdot B_{jk}^{l} \cdot v_{jk} \qquad \cdots\cdots \quad (4\text{-}4)$$

where B_{jk}^{l} : ship volume of type j and size k (in SNT)

v_{jk} : canal due rate of type j and size k (in $/SNT)

4.2.3 Total Canal Revenue from Non-Tankers (R)

$$R = U + V \qquad \cdots\cdots \quad (4\text{-}5)$$

PART VII

OTHER STUDIES

OTHER STUDIES

Although the main responsibility of the Economic Unit is within the context of economic and financial feasibility studies of proposed projects, the study team hopes that all the members of the Economic Unit be familiar with not only their own specialized fields, but also with the engineering and operational aspects of all SCA projects. To achieve this aim, Part VII describes the previous engineering and operational feasibility studies for the development of the Suez Canal, which include the following two studies:

1) Development of the Suez Canal Feasibility Study, by Maunsell Consultant LTD., Vols. 2 and 3. (1976)

2) Suez Canal Development Feasibility Study, by Sogreah Consultant Engineers, Vols. 5 and 6. (1976)

The following flowcharts illustrate the elements of concern to the engineering and the operation of the Suez Canal. While not exhaustive in scope, these charts do cover the important aspects of the Suez Canal operations.

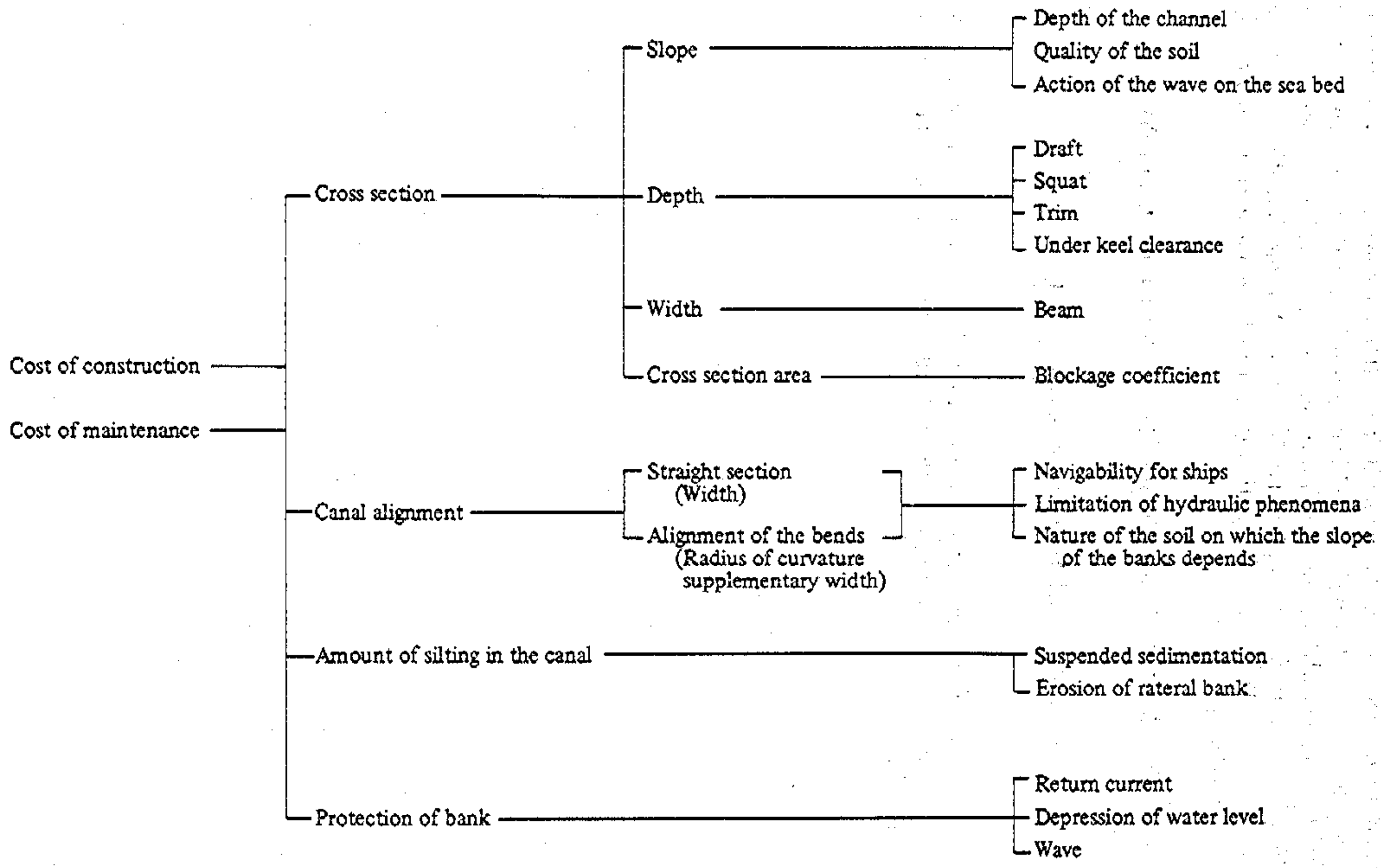

Fig. 1.1 **Flowchart: Cost of Construction and Maintenance**

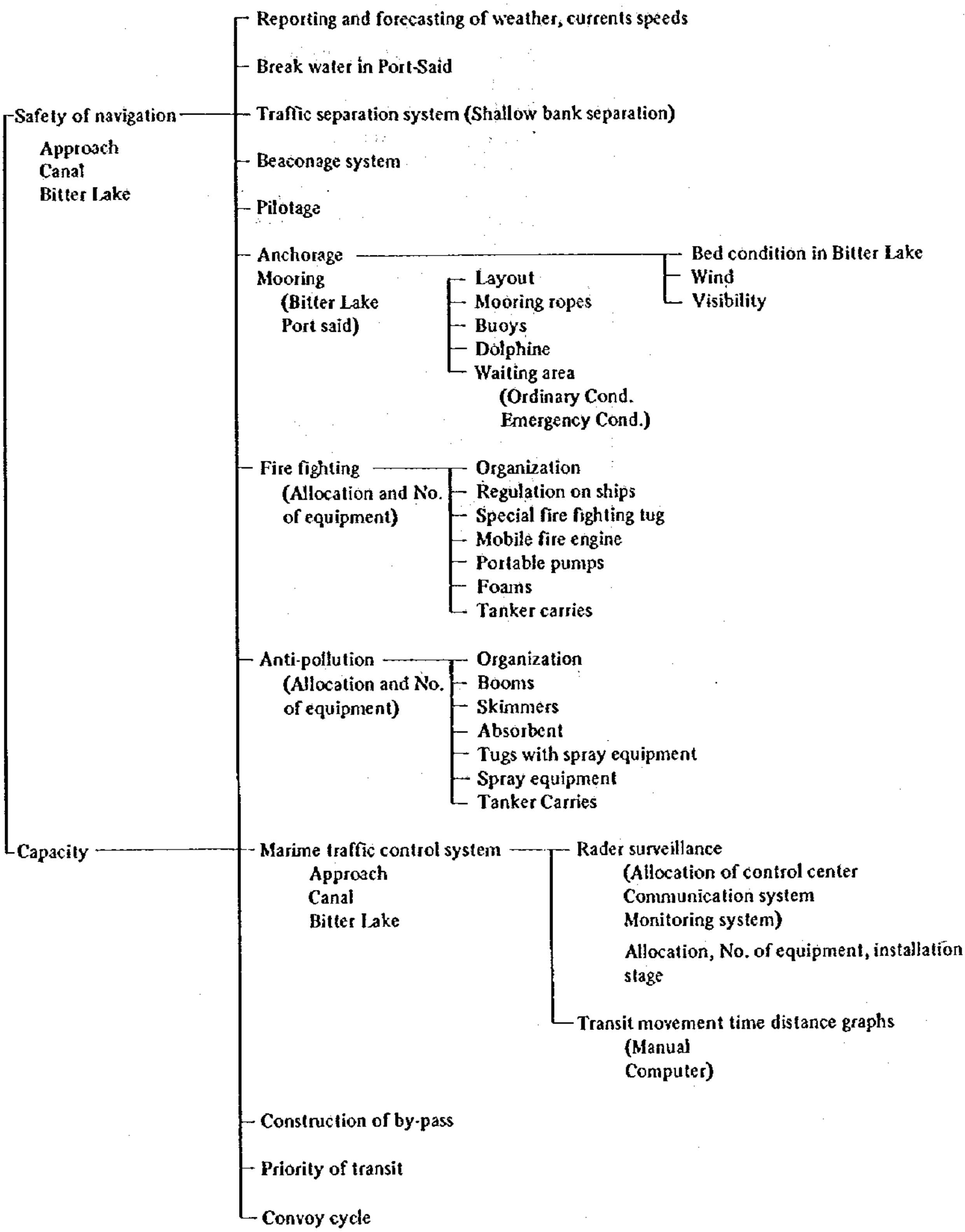

Fig. 1.2 Flowchart: Safety of Navigation and Canal Capacity

- Constant Velocity Experiment
  - Powering (Area ratio/Power/Speed)
  - Squat
  - Handling
  - Handling in cross-wind
  - Handling when model is off center course
  - Handling and powering with heading and following current
  - Effect of draft on powering and handling
- Experiemnt in Curved Canal
  - Helm angle required
  - Helm activity
  - Safe handling
- Investigation on the hydraulic phenomena associated with the transit of ships
  - Draw down
  - Return current
  - Surface wave
  - Erosion of canal cross section
  - Tides and currents in the canal
  - Velocity distribution in the canal
- Estimate of silting in the channel

Fig. 1.3 Experiments Performed

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