CHAPTER 6 FREIGHT MARKET

6.1 General

The purpose of conducting an analysis of the freight market in this chapter are twofold:

(1) To learn the trends of trade and of fleet from the freight market which shows the supply-demand relation between the two in maritime transportation. Long-term voyage charters and time charters themselves reflect forecasts and thus constitute data for making long-range forecasts.

(2) To obtain a clue for forecasting Suez Canal traffic in the near future and to analyze actual traffic by analyzing the freight market which has a direct effect on Suez traffic, particularly tanker traffic. (See Chapter 5). For this, the important data are the spot market and the contracts for comparatively short-term time charters and voyage charters.

Even if one studies the freight market and learns much about it, it is a most difficult task to make a market forecast. The stagnant market from 1974 up to the present is itself a severe commentary on the erroneousness of forecasts made prior to 1973. A more recent case in point is that the rise in the tanker and dry cargo markets in the latter half of 1978 was contrary to most forecasts.

In view of this situation, this chapter does not study freight market forecast methodology but aims to deepen understanding about the characteristics of the market, i.e., to obtain an understanding of the overall trend.

For an understanding of the characteristics, freight market trends in the past 30 years or so (during which the world's maritime transportation made big advances) will be analyzed in 6.2 below.

In 6.3, recent trends in 1977 ~ 78 will be examined. As one example of forecasting the future, OECD's Maritime Transport 1976 will be taken up in 6.4. In 6.5, long-term contracts, newbuilding orders, transactions in second-hand ships and AFRA rate will be studied.

6.2 Freight Market During Past 30 Years

Briefly, looking back on the past 30 years of the freight market, the volume of cargo moved increased steadily from 360 million tons in 1946 to 3,352 million tons in 1976 (UN: Monthly Bulletin of Statistics). In contrast, for about half of this period the market stagnated. Although there were five stretches of what might be called good business, each period of prosperity lasted for less than one year for a combined total of less than five years. The remaining years were just so-so years.

What is more, the five periods of prosperity were occasioned by what might be called non-economic stimuli. They were the Korean war (1950), the first closure of the Suez Canal (1956), the second closure of the Suez Canal (1967), curtailment of Libyan oil production and closing of Tapline (1970), and the Oil Crisis (1973). At the peak, freight rates zoomed to a maximum of 20 times but soon plummetted and there followed a period of sluggish business. This pattern vividly shows the speculative nature of shipping, the briefness of prosperity and the protraction of slump.

Data Sources:

1) Norwegian Shipping News; Voyage Index Dry Cargo & Tankers.
   Dry Cargo Time Charter Index
2) General Council of British Shipping; Time Charter Index
3) Bundesministerium für Verkehr; Liner Freight Index
4) H.P. Drewry (Shipping Consultants) Ltd.; Five-year Tanker Time Charter Rates
5) John I. Jacobs & Co., Ltd.; Tanker Voyage Rates
6) Mullion Tankers (shipbroking); Weekly Tanker Voyage Index

Of the above, the most convenient data are provided by Norwegian Shipping News 1) because tankers and dry cargo carriers are separated and tankers are divided into five sizes since 1974. The data, moreover, are continuous since 1947. The data should be tabulated in the form shown for our purpose in Table 6.1.

Table 6.1 Norwegian Shipping News Freight Indices

	Tanker					Dry Cargo	
	VLCC ULCC	Medium Sized	Small Sized	Handy Dirty	Handy Clear	Voyage Charter	Time Charter
1947							
~							
1973							
1974							
1975							
1976							
Jan.							
Feb.							
Mar.							
~							
1977							
Jan.							
Feb.							
Mar.							
~							
1978							
Jan.							
Feb.							
Mar.							
~							

6.3 Review of 1977 ~ 78

As of January 1979, the reports which are available from general sources are:

Fearnley & Egers Chartering Co., Ltd.; Review 1978
Fairplay International Shipping Weekly; 18th January 1979 "Annual Review"

Available from official organs are:

UNCTAD; Review of Maritime Transport, 1977
OECD; Maritime Transport 1977

These reports point out that in 1977 (UNCTAD, OECD) the business level was stagnant and in 1978 (F&E, Fairplay) the freight market (especially of tankers) rose unexpectedly in the latter half. For details refer to the above reports.

6.4 Prospects of Tanker Supply and Demand

Numerous reports have been published on the supply-demand prospects of tankers, some of which are introduced in Chapter 7. It is to be noted that, of these, OECD's "Maritime Transport 1976" divides the use of the Suez Canal into three cases, depending on the degree of use. The first case is that of the most probable form in which the Canal will be used, i.e., laden via Cape and ballast via Suez. The second case is that of complete non-use of the Canal. The third is that of complete use together with the Middle East pipelines. For each case, the report analyzes the effect on tanker supply and demand.

With respect to supply and demand of maritime transportation, OECD's "World Energy Outlook" is used as a base and several combinations of energy policy and economic growth rates are assumed. These assumptions are correlated to the above cases of the degree of use of the Canal in order to reach a forecast on the time of recovery of the ship supply-demand balance. This, it is believed, will serve as reference in forecasting the future market. For details and the conclusions, please refer to the original report.

With regards to prospects of tanker supply and demand, the forecast reports of Exxon Corporation, Tilney & Co., and Terminal Operators Ltd. are introduced in Chapter 7, so please refer to them.

6.5 Other Markets

The analysis above centered on the spot market (spot contracts for single voyage and short-term) which reflects the market situation most straightforwardly. In relation to maritime transportation, there are some other markets which are closely related to the freight market (such as medium and long-term contracts, newbuilding orders, transactions in second-hand ships). These markets serve as reference in analyzing the current freight market and in making future projections.

6.5.1 Medium and Long-term Contracts

Medium and long-term contracts are those which extend for more than one year and includes voyage charter, time charter, contract of affreightment, etc.. These contracts signify that the charterer and the shipowner are more or less agreed on the view that the market during the contract period will be roughly at the contract price. Thus, they serve as a guide in forecasting the future market. However, in the present situation where the market is stagnant, long-term contracts are very rare. These contracts are reported in Lloyd's List and in Fairplay International Weekly. The main contracts should be noted and used as reference. The overall trend indicated by these contracts can be judged from H.P. Drewry's Five-year Time Charter Rate.

6.5.2 Newbuilding Orders

Newbuilding orders are like long-term contracts in that they have the character of indicating the future. Both the volume of orders and ship prices are linked to the freight market. When the market was climbing in 1973, a large number of orders were placed and ship prices increased by 50% over that of the preceding year. At present, orders are extremely sluggish, and, in the case of VLCC particularly, there are hardly any new orders. Statistical data available include:

Fearnley & Egers; Review 1978. This carries newbuilding ship prices by type and size for the past eight years.

Fairply International Shipping Weekly, 18th January 1979. This shows ship prices of 11,000/13,000 tonner open/closed shelter decker.

Platou Report. Includes report on newshipbuilding prices.

6.5.3 Transactions in Second-hand Ships

In nature, transactions in second-hand ships are the same as newbuilding orders. Information on second-hand ship transactions, however, is more plentiful than on newbuildings and ship prices are accurately reported. Therefore, they can be said to reflect the current market and prospects more accurately. By calculating backwards from the ship age, it is possible to estimate the price of newbuildings. Data are available in Fairplay, Lloyd's List (every Tuesday), and Fearnley & Egers' Review 1978 (Table 18 and 19).

6.5.4 AFRA

AFRA, Average Freight Rate Assessment (Tankers), is published every month by the London Tankers Brokers Panel. It shows the weighted average freight rate for all charters operated during the period covered by the report. It includes long-term contracts and ships owned by petroleum companies (because cost is not known, values of similar long-term contracts are used). Because it is in the nature of an average freight rate, it displays a more moderate movement than the spot market. Under the present market situation, this AFRA rate is higher than spot. Ships in the AFRA are divided into the following five types and expressed in World Scale.

General purpose:	16,500 ~ 24,999 dwt
Medium range:	25,000 ~ 44,999
Large range 1:	45,000 ~ 79,999
Large range 2:	80,000 ~ 159,999
Large range 3:	160,000 ~ 319,999

PART IV

A BASIC SYSTEM FOR SHORT TERM FORECASTING

CHAPTER 1 INTRODUCTION

1.1 Objectives

This report describes a basic system for short term forecasting of Canal traffic; this system is to be used as part of systems analysis. The report aims to:

(1) Describe the systems analysis techniques required by the staff of the Economic Unit of the Suez Canal Authority to perform short term forecasting of Canal traffic and other related items; and

(2) Explain in a simple manner the procedure for this short term forecasting performed by the Unit.

This report will set out a basic system for short term (yearly and monthly) forecasting of the number of vessels passing through the Canal, Suez Canal net registered tonnage (SCNRT), goods tonnage and revenue from the Canal. This report will include concrete procedures as often as possible so that the report may also be used as basic manual for short term forecasting.

1.2 Outline

The standard procedure for forecasting is as follows:

1) Determination of purposes and scope of forecasting
2) Investigation of related items, data collection and analysis
3) Model building
4) Forecasting
5) Studies of the results

In this report, Item (1) is described in Chapter 1, while part of Item (2) is dealt with in Chapter 2. Items (3) and (4) are explained in Chapter 3 using concrete models and forecasting procedures. For Item (5), precautions are described for studying the results.

Chapter 4 of this report describes the method of studying whether Canal capacity can meet the expected traffic demand.

The following points should be noted when using this report:

(1) This report explains basic methods; several other methods are available for practical forecasting. This report also introduces several other methods. The method used will differ from case to case, and the selection of a method requires a considerable degree of analysis and forecasting experience. Therefore, knowledge concerning method selection will be acquired after accumulating practical analysis and forecasting experience.

(2) Forecasting always involves uncertainty, and forecast values naturally change with changes in preconditions. This fact should be kept in mind when utilizing the basic forecasting system described in this report. A forecasting and evaluation system taking uncertainty into consideration is one of the most sophisticated techniques, and should be learned only after sufficient experience in analysis and forecasting.

CHAPTER 2 PREPARATION OF DATA

This Chapter describes the data necessary to perform the forecasting handled in this report.

2.1 Data to be Collected

The data required for forecasting includes figures on Suez Canal traffic collected by the Suez Canal Authority as well as those on world seaborne movements, etc. prepared by other authorities such as the United Nations. Table 2.1 lists such items and the periods during which the data are to be obtained. Data on Canal traffic should be arranged in terms of southbound, northbound, tanker and non-tanker vessels for ease in future forecasting.

Table 2.1 Data to be Collected

Item	Category	Periods	Source
Number of Vessels	Monthly, Northbound/Southbound, Tanker/ Non-tanker, laden/ballast	1975 ~	SCA
SCNRT	Monthly, Northbound/Southbound, Tanker/ Non-tanker, laden/ballast	1975 ~	SCA
Goods Tonnage	Monthly, Northbound/Southbound, Oil/Non-oil Products	1975 ~	SCA
Revenue	Monthly, Northbound/Southbound, Tanker/ Non-tanker	1975 ~	SCA
GDP	Yearly, World/OECD/etc.	1955 ~	United Nations OECD
Seaborne Movement	Yearly, Oil/Non-oil Products	1955 ~	United Nations/BP

2.2 Data Arrangement

The data such as the number of vessels passing through the Canal, and SCNRT obtained by the Suez Canal Authority should be arranged in terms of months by using one sheet for the data of each year. Tables 2.2 through 2.5 show the formats.

It is advisable to determine the format for the annual data on GDP and world seaborne movements so that data for 10 - 70 years may be arranged on one sheet. Examples of the format are set forth in Tables 2.6 and 2.7.

2.3 Graph Preparation

One of the most important steps is the graphing of the data series obtained monthly or yearly and to study these graphs. First, all data collected in the previous Section should be plotted on graph paper, and changes in the past should be examined. Fig. 2.1 shows changes in the oil seaborne movements in the world, for example.

Table 2.2 Number of Vessels

	1975			
	Jan.	Feb.	Dec.	Total
Northbound Total				
Tanker				
laden				
ballast				
Non-Tanker				
laden				
ballast				
Southbound Total				
Tanker				
laden				
ballast				
Non-Tanker				
laden				
ballast				
North & Southbounds				
Tanker				
laden				
ballast				
Non-Tanker				
laden				
ballast				

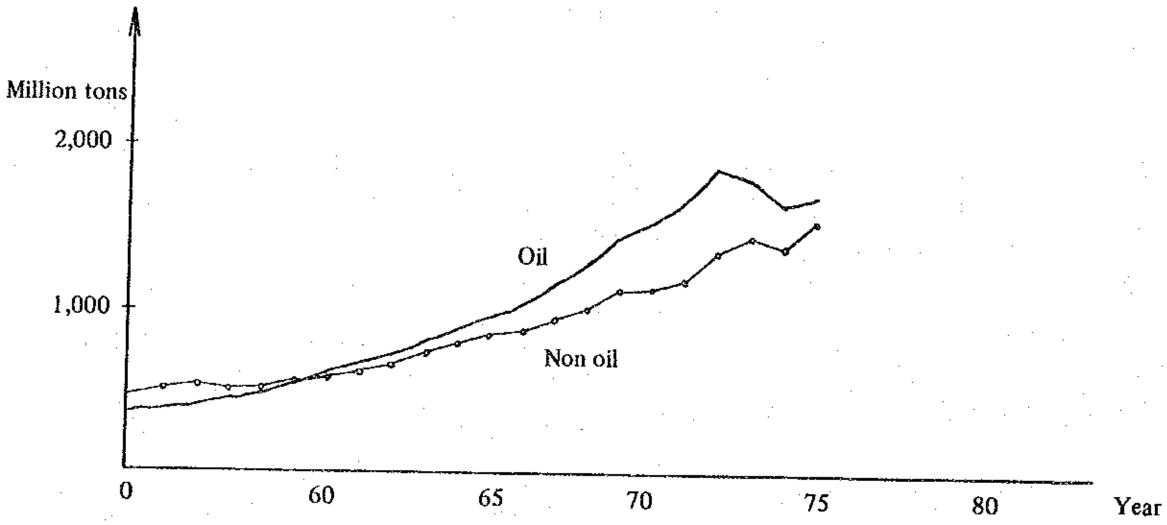


Fig. 2.1 World Seaborne Movement

Table 2.3 SCNR Tonnages

	1975			
	Jan.	Feb.	Dec.	Total
Northbound Total Tanker laden ballast Non-Tanker laden ballast				
Southbound Total Tanker laden ballast Non-Tanker laden ballast				
North & Southbounds Tanker laden ballast Non-Tanker laden ballast				

Table 2.4 Goods Traffic

	1975			
	Jan.	Feb.	Dec.	Total
Northbound Total Oil Non-oil Products				
Southbound Total Oil Non-oil Products				
North & Southbounds Oil Non-oil Products				

Table 2.5 Revenue from the Canal

	1975			
	Jan.	Feb.	Dec.	Total
Northbound Total Tanker Non-tanker				
Southbound Total Tanker Non-tanker				
North & Southbounds Tanker Non-tanker				

Table 2.6 GDP Development of the World

	1955	1956	1957
GDP World OECD			

Table 2.7 World Seaborne Movement Development

	1955	1956	1957
Oil Non-Oil Total			

CHAPTER 3 FORECASTING METHODS

3.1 Short Term Forecasting (Annual)

This Section explains forecasting of Canal traffic and revenue from the Canal for the following year. The methods of forecasting Canal traffic can be divided into the following two. In the first, the traffic in the future is forecast directly from the data on the traffic. In the second method, the Canal traffic is forecast indirectly on the basis of trends in world seaborne trade. Both of these methods will be explained below.

3.1.1 Short Term Forecasting Based on Traffic Results

(1) Outline

In this type of short term forecasting, monthly data on the passage of vessels through the Suez Canal is observed to estimate traffic trends in the future using a simple mathematical model. As mentioned previously, data obtained over time is generally called time series data. Time series data involves long term trends, cyclic variations, seasonal variations and random variations. If we consider that these variation factors are combined by mathematical addition, then the time series observed can be represented by the equation:

$$X(t) = P(t) + C(t) + S(t) + I(t) \qquad (3-1)$$

where $X(t)$ is the original time series, $P(t)$ is trend, $C(t)$ is cyclic variation, $S(t)$ is seasonal variation and $I(t)$ is random variation.

To investigate trends in Canal traffic, it is particularly important to understand $P(t)$ and cyclic variation $C(t)$. Generally, the trend and cyclic variation cannot easily be separated from each other and are therefore analyzed in combination in many cases. The method of forecasting Canal traffic in the future on the basis of the trend will be described below with seasonal and/or random variations removed from the original time series.

(2) Forecasting Procedure

Forecasting should be performed following the procedure shown in Fig. 3.1. The forecasting method will be explained below according to the flow chart.

1) Preparation of required data

The following are required for forecasting:

Data on the number of vessels (monthly, 1975 ~)
Data on revenue from the Canal (monthly, 1975 ~)
Data on goods tonnage (monthly, 1975 ~)

These data have already been prepared in Chapter 2.

2) Adjustments for seasonal variation

When observing monthly data on the number of vessels obtained since the reopening of the Suez Canal, seasonal variations can be seen in addition to the trend and random variations. Adjustment should be made for seasonal variations by means of the fixed seasonal value method or 12 month moving average method.

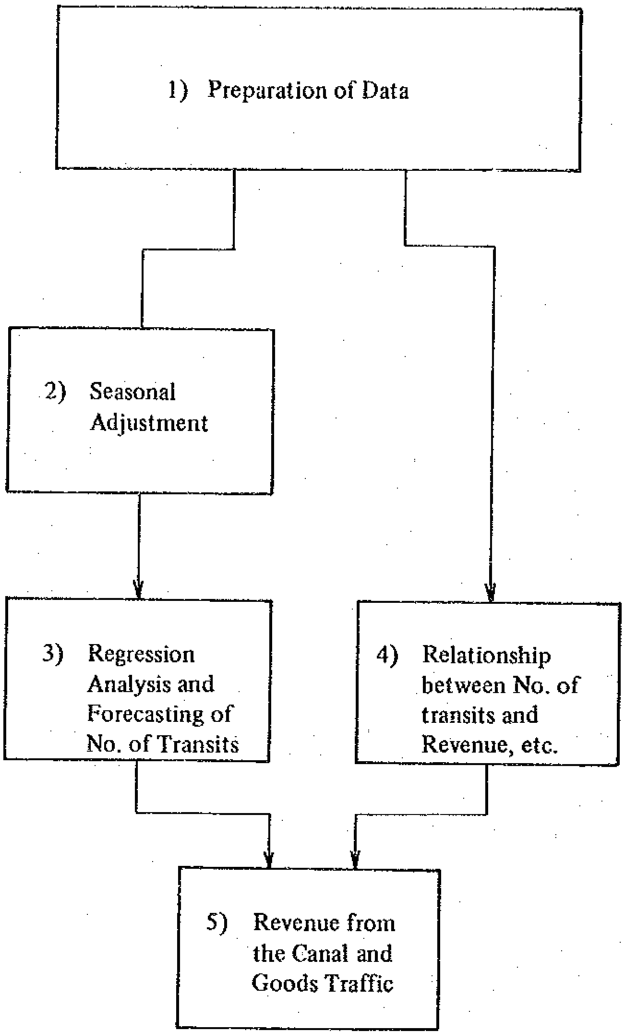


Fig. 3.1 Forecasting Procedure

(a) Fixed seasonal value method

Adjustment for seasonal variations by the.fixed seasonal value method can be performed according to Table 3.1.

i) Enter Xij (i = 1, ... , n: year; j = 1, ... , m: month)

ii) Calculate the following:

$$Vi = X\cdot i/n = \sum_{j}^{n} Xji/n$$

$$Ui = Xi\cdot /m = \sum_{j}^{m} Xij/m$$

$$\overline{U} = \sum_{i}^{n} Ui/n$$

iii) Calculate Ci.

$$Ci = Vi - \overline{U}$$

iv) Calculate the following:

$$Yij = Xij - Cj \quad j = 1, \ldots, m$$

Yij is free from seasonal variation.

(b) 12 month moving average method

In performing seasonal adjustment by the 12 month moving average method, the monthly data X(1), X(2), ... , X(i), . . . are averaged by the equation:

$$Y(t + 5.5) = (\frac{1}{12}) \times \{ X(t) + X(t+1) + \ldots + X(t+11) \}$$

$$Z(t+6) = Y(t+5.5) + Y(t+6.5)$$

Z(t) represents the seasonally adjusted series. In this method, the seasonal and random variations are removed at the same time.

It is generally more convenient to calculate according to Table 3.2 rather than using the above equation for actual calculations.

In Table 3.2, Xi is original time series, $Si = \sum_{j=1}^{i} Xj$, $di = S_{i+12} - Si$, $\overset{1}{di} = d_i + d_{i+1}$

and $Y_{i+6} = d'i$ (adjusted series).

This method is frequently used as a convenient method of seasonal adjustment, although the first six and the last six in the time series are lost.

Table 3.1 A Format for the Seasonal Adjustment

	Month / Year	Jan.	Feb.	March	April	May	June	July	Aug	Sept.	Oct.	Nov.	Dec.	Total	Mean
1)	1976	X_{11}	X_{12}	∘									$X_{1,12}$	$X_{1\cdot}$	U_1
	1977	X_{21}	∘										∘	$X_{2\cdot}$	U_2
	1978	•											•	$X_{3\cdot}$	U_3
	1979	X_{41}											$X_{4,12}$	$X_{4\cdot}$	U_4
	Total	$X_{\cdot 1}$	$X_{\cdot 2}$										$X_{\cdot,12}$	$X_{\cdot\cdot}$	
	Mean	V_1	V_2										V_{12}		$\overline{U}$
2)		C_1	C_2										C_{12}		
3)	1976	Y_{11}	Y_{12}										Y_{12}		
	1977	Y_{21}	∘										∘		
	1978	Y_{31}											∘		
	1979	Y_{41}											$Y_{4,12}$		

Table 3.2 12 Month Moving Average Format

	a) Xi Original Time Series	b) Si Sum	c) Shift 12	d) di b) – c)	e) di' Sum of di + di+1	f) e)/24	Seasonally Adjusted Time Series
1977 Jan.	X_1	S_1					
Feb.	X_2	S_1					
Mar.	X_3	S_3					
Apr.	X_4	S_4					
May	X_5						
.	X_6						
.	X_7						Y_7
.	X_8						Y_8
.	X_9						Y_9
.	X_{10}						Y_{10}
Nov.	X_{11}	.					Y_{11}
Dec.	X_{12}	S_{12}	0	d_1			Y_{12}
1978 Jan.	X_{13}	S_{13}	S_1	d_2	$d_1 + d_2$	Y_7	Y_{13}
Feb.	X_{14}	S_{14}	S_2	d_3	$d_2 + d_3$	Y_8	Y_{14}
.	.	S_{15}	S_3	d_4	$d_3 + d_4$	Y_9	Y_{15}
.	.	S_{16}	S_4	d_5	$d_4 + d_5$	Y_{10}	Y_{16}
.	X_i	S_{17}	S_5	d_6	$d_5 + d_6$	Y_{11}	Y_{17}
	.	S_{18}	S_6	d_7	$d_6 + d_7$	Y_{12}	Y_{18}
	.	S_{19}	S_7	d_8	$d_7 + d_8$	Y_{13}	.
		.	S_8	d_9	$d_8 + d_9$	Y_{14}	.
		.	S_9	d_{10}	$d_9 + d_{10}$	Y_{15}	
						Y_{16}	
.						Y_{17}	
Dec.							
1979 Jan.							
Feb.							

(3) Forecasting and the application of regression equations
A regression equation should be applied to the seasonally adjusted time series Y_i to determine the annual number of transit vessels for the target year in the future. The regression equation to be used should be determined by investigating the changes in the data. The equation $Y = a + bX$ is used in the case described here, taking the relatively linear increase in the number of vessels into consideration. (If the number of vessels changes in the form of a quadratic equation, equation $Y = a + bX + cX^2$ should be used. An appropriate evaluation should be made during forecasting.)

The regression equation can be applied according to the format in Table 3.3. In Table 3.3, X_i is point of time (numbered in the order of month as 1, 2, 3, . . .), and Y_i is number of vessels (seasonally adjusted).

For example, the following equation can be used satisfactorily in cases where the number of vessels 12 months from now is to be forecast on the basis of data for 36 months:

$$Y_{48} = \hat{a} + \hat{b}\, X_{36}$$

Table 3.3 Least Squares Calculations

	(1) X_i	(2) No. of Transits Y_i	(3) $x_i = X_i - \overline{X}$	(4) $Y_i x_i$	(5) x_i^2	(6) $\hat{Y}_i = a + b x_i$	(7) $Y_i - \hat{Y}_i$	(8) $(Y_i - \hat{Y}_i)^2$
1967 Jan.	1							
Feb.	2							
Mar.	3							
·	4							
·	5							
·	6							
	7							
	8							
	·							
	·							
	n							
	$\Sigma X_i =$ $\overline{X} = \frac{\Sigma X_i}{n}$	ΣY_i $\overline{Y} = \frac{\Sigma Y_i}{n}$	$\Sigma X_i = 0$	$\Sigma Y_i x_i$	Σx_i^2			$\Sigma(Y_i - Y_i)^2$ $S^2 = \frac{1}{n-2}\Sigma(Y_i - \hat{Y}_i)^2$

$\hat{a} = \overline{Y}$ $\hat{b} = \frac{ZY_i x_i}{Zx_i^2}$ $S = \sqrt{S^2}$

(4) Relation between the number of vessels and goods tonnage or revenue from the Canal Coefficients for calculating, based on the number of vessels, the goods tonnage and revenue from the Canal can be obtained by investigating the relation between the number of vessels and the goods tonnage or revenue from the Canal.

(a) Relation between the number of vessels and goods tonnage
A conversion coefficient can be obtained on a graph by plotting the monthly number of vessels on the abscissa and the goods tonnage on the ordinate (Fig. 3.2).

i) Plot the number of vessels and goods tonnage on the co-ordinate.
ii) Draw a regression line passing through the origin so that the plotted points are distributed on both sides of the line.
iii) Determine the slope α_1 of the line.

(b) Relation between the number of vessels and revenue from the Canal
In like manner to the above, the monthly number of vessels and revenue from the Canal are to be plotted on the abscissa and ordinate respectively to determine the slope α_2 on the graph (Fig. 3.3).

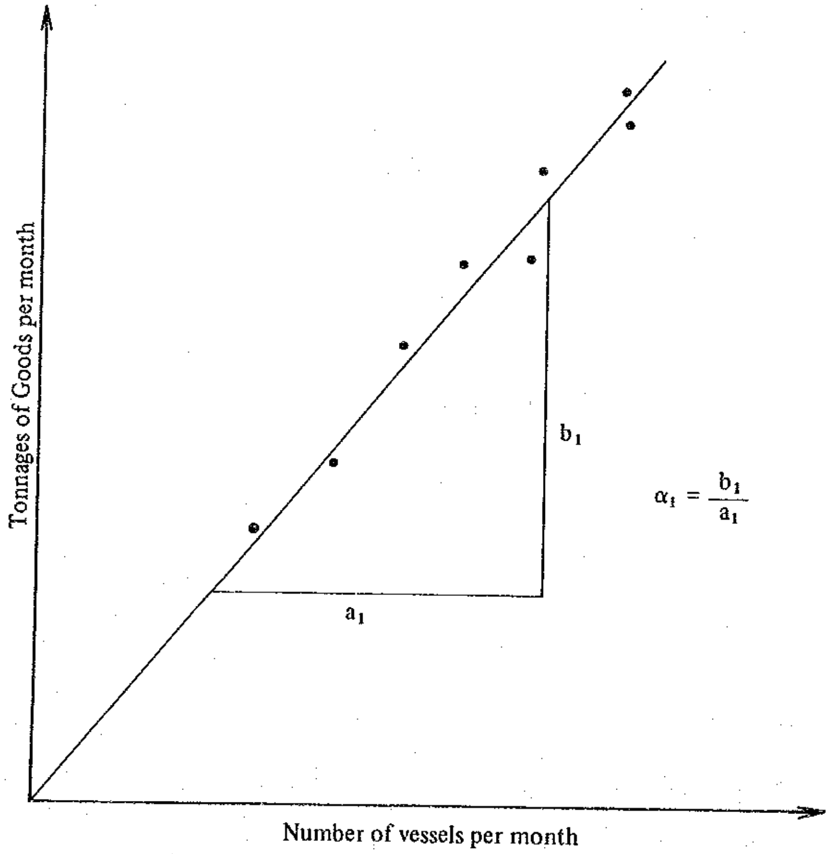


Fig. 3.2 Calculation of α_1

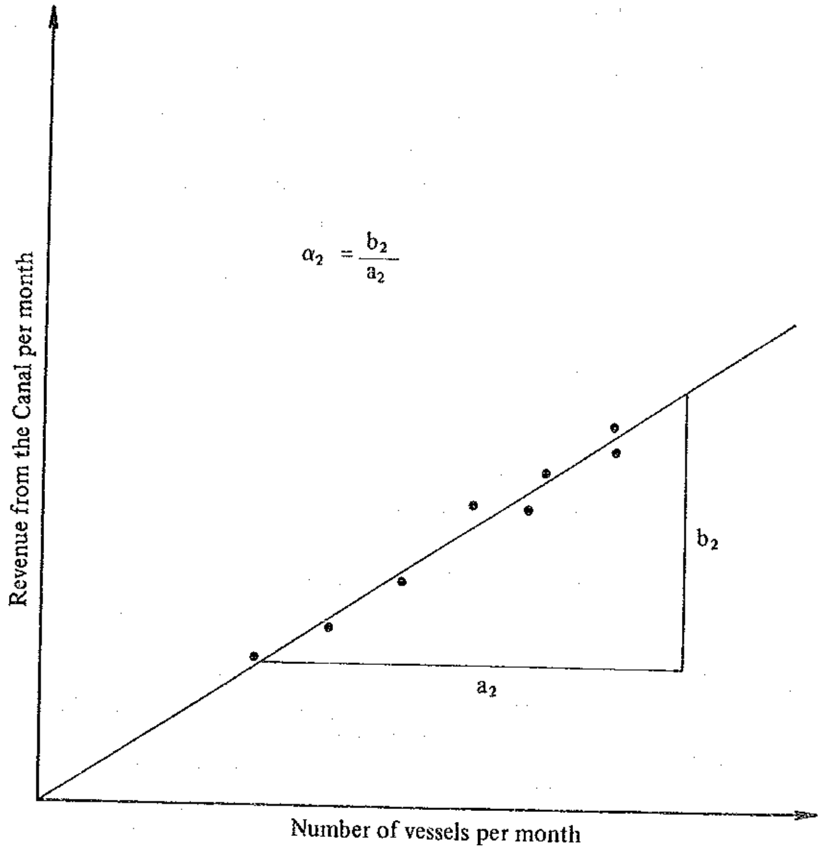


Fig. 3.3 Calculation of α_2

(5) Forecasting of goods tonnage and revenue from the Canal

Goods tonnage T(t) and revenue R(t) in the future can be calculated by the following equation using estimated value for the number of vessels Y(t) obtained in (3) above as well as coefficients α_1 and α_2 obtained in (4) above:

$$T(t) = Y(t) \times \alpha_1$$

$$R(t) = Y(t) \times \alpha_2$$

where t is the time of forecasting (month), and Y(t) is number of vessels at point (t) (obtained in (3) above). Notation Y(t) is used instead of Yt.

3.1.2 Short Term Forecasting Based on World Seaborne Movements

(1) Outline

Part of the world seaborne trade passes through the Suez Canal. Therefore, it could be possible to forecast the Canal traffic by predicting changes in the world trade. This is important also for evaluating the position of the Canal in world trade. The goods tonnage transported through the Canal at present accounts for 5% or less of the total world seaborne trade. Use of this method under these circumstances will involve problems in guaranteeing the forecasting accuracy. On the other hand, use of this method has the following advantages:

1) It is important for management of the Canal that changes in the world trade volume be forecast and monitored continuously.

2) The goods tonnage, particularly the crude oil tonnage transported through the Canal will probably increase considerably when the Canal is expanded. In this case, the role of the Canal in world trade will increase, and it will become possible to forecast the goods tonnage through the Canal as part of the world seaborne trade.

(2) Forecasting procedure

Fig. 3.4 shows the forecasting procedure.

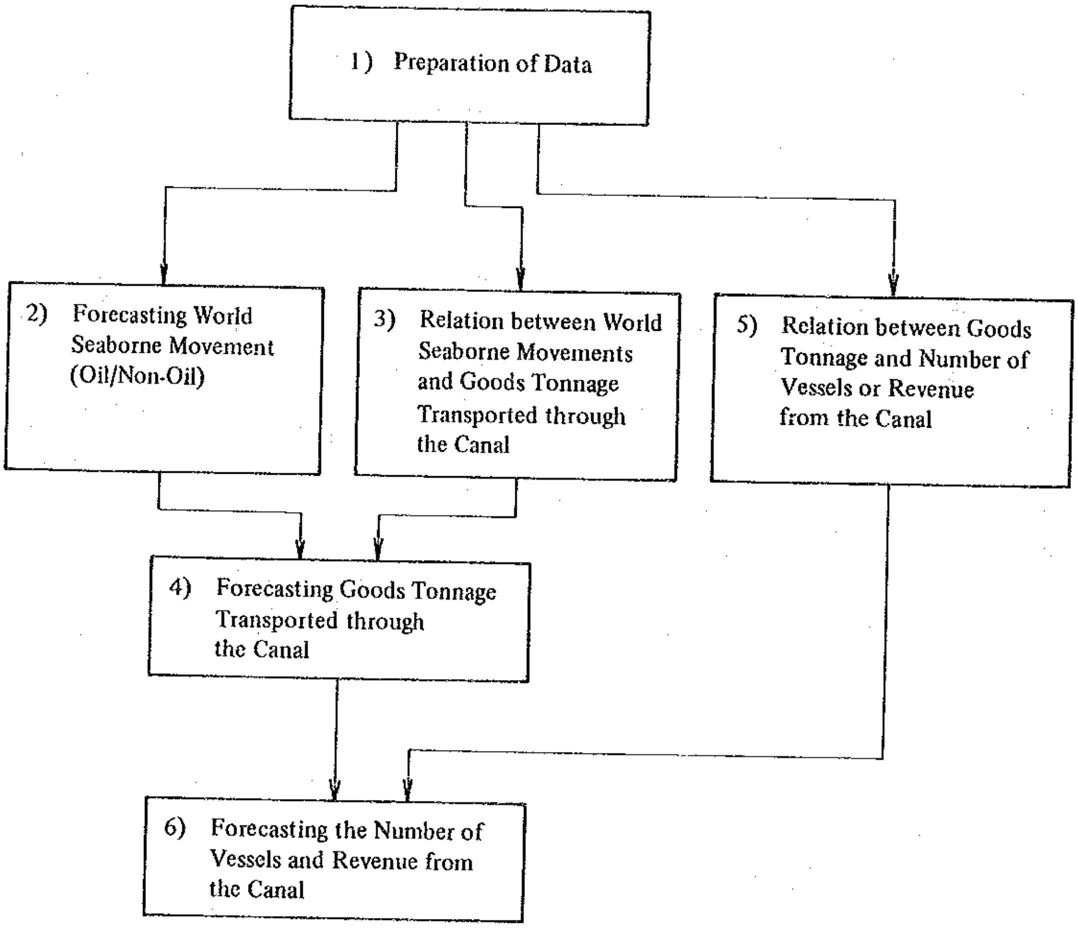


Fig. 3.4 Forecasting Procedure

1) Data required

The following data are required:

World seaborne movements (oil/non-oil: 1975 ~)
GDP (whole world, OECD countries: 1975 ~)
Canal traffic (number of vessels, goods tonnage: 1975 ~)
Revenue from the Canal (1975 ~)

2) Forecasting world seaborne movements

Data on seaborne movements of oil, five major commodities, and all freight are available; forecasting may be performed for each items. For simplicity and out of consideration for conditions in the future, the forecasting method is explained here in terms of oil and non-oil products. Forecasting can be done easily by determining the elasticity of seaborne movements of respective items in relation to the GDP on the basis of data from the past several years, and then, forecasting the movements in the future with the use of this elasticity. Table 3.4 shows the procedure for the case where data from 1975 through 1978 is obtained.

Table 3.4 Forecasting Procedure

		Seaborne Movements Oil & Oil Products	Seaborne Movements Non-Oil Products	GDP World, Major Countries
a)	Data for 1975	O (75)	N (75)	G (75)
b)	Data for 1978	O (78)	N (78)	G (78)
c)	b) – a)	O (78) – O (75)	N (78) – N (75)	G (78) – G (75)
d)	c) / a)	$RO = \frac{O(78) - O(75)}{O(75)}$	$RN = \frac{N(78) - N(75)}{N(75)}$	$RG = \frac{G(78) - G(75)}{G(75)}$
e)		$E_o = \frac{RO}{RG}$	$E_n = \frac{RN}{RG}$	
f)	$O(t) = O(78)\left\{1 + E_o RG^{\frac{1}{3}(t-78)}\right\}$ $N(t) = N(78)\left\{1 + E_n RG^{\frac{1}{3}(t-78)}\right\}$ where O(t) is seaborne movement (oil) in year (t), and N(t) is seaborne movement (non-oil) in year (t).			

In Table 3.4, the movements O(t) and N(t) of oil and non-oil products in the future can be calculated by the equations:

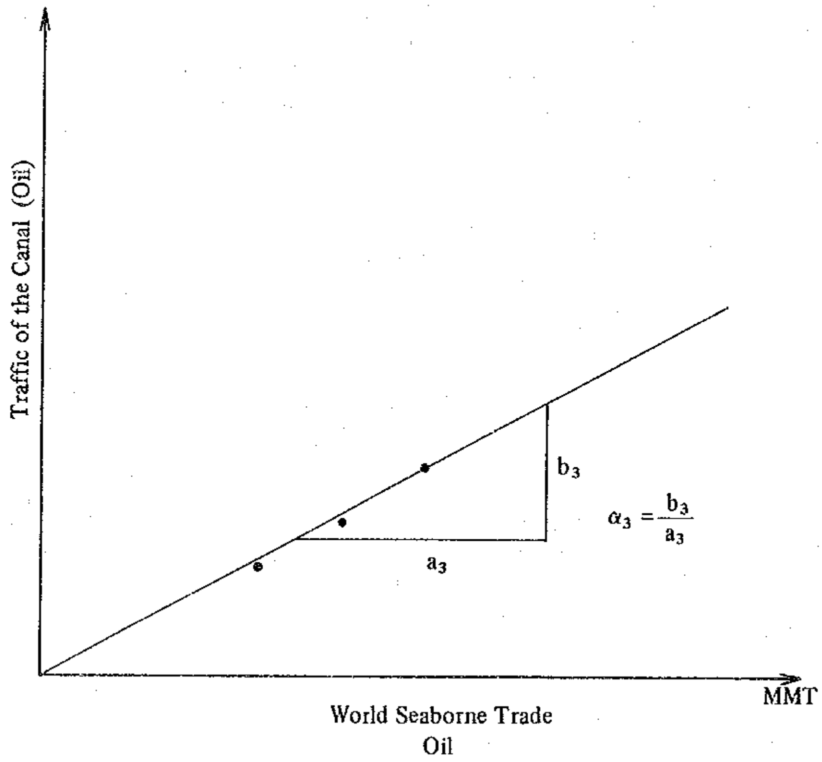
$$O(t) = O(78)\left\{1 + E_o RG^{\frac{1}{3}(t-78)}\right\}$$

$$N(t) = N(78)\left\{1 + E_n RG^{\frac{1}{3}(t-78)}\right\}$$

Where O(78) is seaborne movement of oil in 1978,
N(78) is seaborne movement of non-oil products in 1978,
E_o is elasticity of oil movement,
E_n is elasticity of non-oil movement,
RG is GDP growth rate (three years, in the case shown), and
t is the year for which forecasting is made.

3) Relation between world seaborne movements and goods tonnages

The ratio of goods tonnages to world seaborne movements is to be determined on the graph for each of oil and non-oil products. The ratio is given by slopes α_3 and α_4 of the lines in Fig. 3.5.



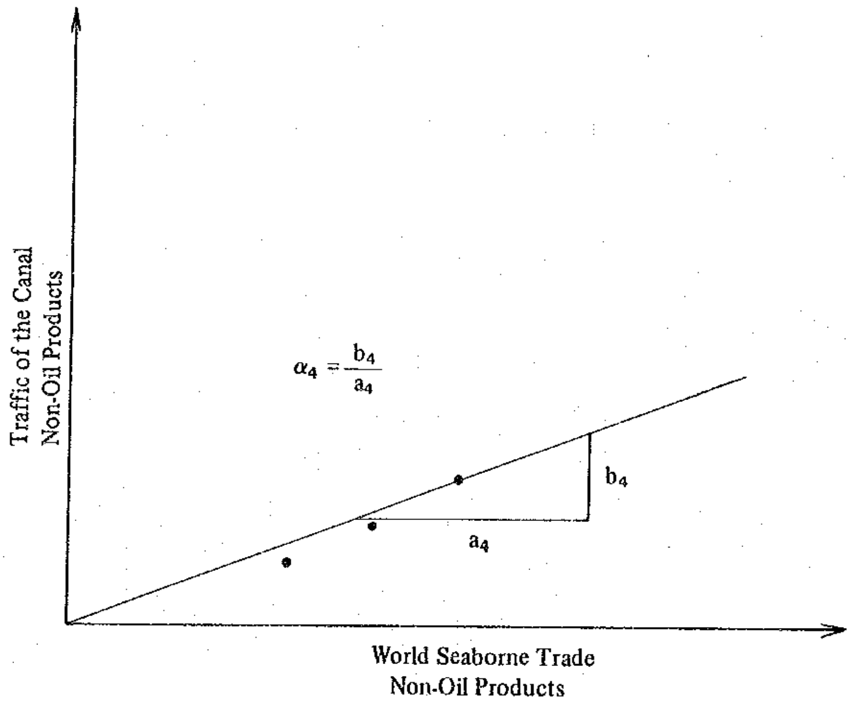


Fig. 3.5 Calculation of α_3, α_4

4) Forecasting of goods tonnages

The goods tonnage which will be transported through the Canal in the future is forecast on the basis of the world seaborne movements using the following equations. The world movements have been forecast in 2) above and coefficients α_3 and α_4 were determined in 3):

$$Os(t) = O(t) \times \alpha_3$$

$$Ns(t) = N(t) \times \alpha_4$$

where Os (t) is the volume of oil transported through the Canal, and
Ns (t) is the volume of non-oil products transported through the Canal.

5) Relation between goods tonnage and number of vessels or revenue from the Canal

Coefficient α_5 for converting the goods tonnage to the number of vessels can be calculated from coefficient α_1, obtained previously, by the euqation:

$$\alpha_5 = \frac{1}{\alpha_1}$$

Coefficient α_6 for converting goods tonnage to revenue from the Canal can be calculated from coefficients α_1 and α_2 (obtained previously) by the equation:

$$\alpha_6 = \frac{\alpha_2}{\alpha_1}$$

6) Forecasting of number of vessels and revenue from the Canal

The number of vessels T(t) and revenue from the Canal R(t) in the future can be calculated from the goods tonnage Os(t) and Ns(t) (obtained in 4) above) as well as coefficients α_5 and α_6, (obtained in 5) above) by the equations:

$$T(t) = (Os(t) + Ns(t)) \times \alpha_5$$

$$R(t) = (Os(t) + Ns(t)) \times \alpha_6$$

3.1.3 Forecasting of World Seaborne Movements by Regression Analysis

The forecasting of world seaborne movements by regression analysis can be considered as a more general method than that described in 3.1.2 (2), 2). Forecasting based on regression analysis is one of the most typical forecasting methods. The method of forecasting oil seaborne movements by the elasticity in relation to the GDP is equivalent to an application of the following equation in regression analysis:

$$\log O = a + b \log GDP$$

Coefficients a and b can be calculated according to the format shown in Table 3.5. The estimated value $\hat{b}$ for b corresponds to Eo in Table 3.5.

The procedure described below can also be employed as an another method. Namely, forecasting can be made on the assumption that seaborne movements are explained in terms of seaborne movements of the previous year and the GDP. The equation is as follows:

$$O(t) = a + b\,O(t-1) + c\,GDP(t)$$

Estimated values a, b and c for the coefficients can be calculated according to the procedure of multiple regression analysis, which is set forth in Table 3.6.

Similar results will be obtained whichever method is used. Particular methods will be selected according to the observations of the analyst and other factors. The GDP in the future should be determined by referring to the forecast results given by authorities such as the OECD.

3.2 Short Term Forecasting (Monthly)

This Section deals with methods of forecasting Canal traffic over a very short term e.g. for the following month or for the month after that. It is very difficult to accurately forecast Canal traffic in the following month since monthly traffic will change at random. However, if the traffic can be estimated on an average, it will constitute a piece of significant information for the Suez Canal Auhtority. Models of probability processes have been developed to describe statistical phenomena, and forecasting using an exponential smoothing model, one of the most simple among such probability models, is expalined below.

3.2.1 Forecasting with an Exponential Smoothing Model of the First Order

In the method, the forecast value for the point of time (t + 1) is determined from the weighted mean of the forecast value in the previous point of time and the currently observed values in cases where the time series data X(1), X(2), ... , X(t), ... are available. Thus,

$$\hat{X}(t+1) = \lambda X(t) + (1-\lambda)\hat{X}(t)$$

where $X(t)$ is currently observed value,
$\hat{X}(t)$ is forecast value for time (t) obtained in the forecasting made at time (t – 1),
$\hat{X}(t+1)$ is forecast value for time (t + 1) obtained in the forecasting made at t, and λ is parameter $(0 \leq \lambda \leq 1)$.

The above forecasting method is used for the time series data without any clear long term trend. If $\lambda = 0$, forecasting is made without using any information obtained currently, while $\lambda = 1$ means that the currently observed value is taken as the value in the future without using any information obtained in the past. The value λ should be selected so that the best fit may be achieved.

The procedure is set forth in Table 3.7.

Table 3.5 Least Square Calculations

(1) O_i	(2) $Y_i = \log O_i$	(3) G_i	(4) $X_i = \log G_i$	(5) $x_i = X_i - \bar{X}$	(6) x_i^2	(7) $Y_i x_i$	(8) $\hat{Y}_i = \bar{Y} + \hat{b}x_i$	(9) $(Y_i - \hat{Y}_i) = e_i$	(10) $(Y_i - \hat{Y}_i)^2 = e_i^2$
O_1	$\log O_1$	.							
O_2	$\log O_2$	.							
O_3	.								
.	.								
.									
	ΣY_i		ΣX_i	$\Sigma x_i = 0$	Σx_i^2	$\Sigma Y_i x_i$			$\Sigma(Y_i - Y_i)^2$
	$\bar{Y} = \Sigma Y_i/n$		$\bar{X} = \Sigma X_i/n$						$S^2 = \frac{\Sigma(Y_i - Y_i)^2}{n-2}$
	$\hat{a} = \bar{Y}$				$\hat{b} = \frac{\Sigma Y_i x_i}{\Sigma x_i^2}$				$S = \sqrt{S^2}$

Therefore, the estimated linear regression equation is:

$$Y_i = \hat{a} + \hat{b}\,x_i$$

$$= \hat{a} + \hat{b}\,(X_i - \bar{X})$$

or $\quad \log O_i = \hat{a} + \hat{b} \log G_i - \hat{b}\bar{X}$

Table 3.6 Least Squares Estimates for Multiple Regression of Y on X and Z

	$Yi = Oi$	$Xi = O_{i-1}$	$Zi = Gi$	$x_i = X - \overline{X}$	$z_i = Z_i - \overline{Z}$	$Yi\,Xi$	Yiz_i	x_i^2	z_i^2	x_iz_i	$Yi = \hat{a} + \hat{b}x_i + \hat{c}z_i$
1975 1	O_1	O_0	G_1								
2	O_2	O_1	G_2								
3	O_3	O_2	G_3								
4	O_4	O_3	G_4								
4	O										
12											
1976 1											
2											
3											
	ΣYi $\overline{Y} = \Sigma Yi/n$	ΣXi $\overline{X} = \Sigma Xi/n$	ΣZi $\overline{Z} = \Sigma Zi/n$	$\Sigma x_i = O$	$\Sigma Zi = O$	ΣYix_i	$\Sigma Yi Zi$	Σx_i^2	ΣZi^2	Σx_iz_i	

$\boxed{\hat{a} = \overline{Y}}$

$$\begin{bmatrix} \Sigma x_i^2 & \Sigma xizi \\ \Sigma x_iZi & \Sigma z_i^2 \end{bmatrix} \begin{bmatrix} \hat{b} \\ \hat{c} \end{bmatrix} = \begin{bmatrix} \Sigma Yixi \\ \Sigma Yiz_i \end{bmatrix}$$

$$\hat{Y}i = \hat{a} + \hat{b}(Xi - \overline{X}) + \hat{c}(Zi - \overline{Z})$$

Table 3.7 Procedure of Exponential Smoothing (1st Order)

	① Original Time Series X_i	②=①× λ λX_i	③ = $(1-\lambda)\hat{X}_{i-1}$	④=②+③ Predicted Value $\hat{X}_i$	⑤ Error $E_i = \|X_{i+1} - X_i\|^2$	⑥ Sum of Errors ΣE_i
				$\hat{X}(0)$		
1976 1	X_1					
2	X_2					
3	X_3					
4	•					
5	•					
6	•					
7	X_i					
8	•					
9						
10	X_{10}					

The value of λ is selected from values such as 0.1, 0.2, . . . , 0.9 so that the forecasting error ΣE_i will be minimized. If the selected value is expressed as λ^0, then the forecasting model can be represented by the equation:

$$X(t+1) = \lambda^0 X(t) + (1 - \lambda^0)\,\hat{X}(t)$$

where t = 1, 2, . . . , and
$\hat{X}(0)$ is the mean value of $X(-1)$, $X(-2)$, $X(-3)$, etc.

If the number of vessels is forecast with the above model, then the goods tonnage and revenue from the Canal can be forecast, as required, by the methods described previously.

3.3 Studies of the Results

Procedure for several typical forecasting methods have been described above. Mere calculation of forecast values according to the procedures does not suffice in forecasting however. It is important to interpret the forecast results and attention should be paid to the following points:

(1) Preconditions of forecasting
(2) Validity of the method used
(3) Validity of the regression equation used
(4) To what degree the forecasting accuracy can be studied
(5) Validity observed by comparisons with other forecasting results
(6) Validity observed by intuition of the analyst
(7) Suitability and accuracy of the data used

CHAPTER 4 EVALUATION OF CANAL CAPACITY

4.1 Objectives

Canal capacity is determined by the layout of the Canal, the method of operation and other factors. The number of ships which transit the Canal in a given period cannot exceed the capacity.

If the number of ships attempting to transit the Canal exceeds the capacity, delays and/or extensions of transit time occur. These are unacceptable to the ship operators. Furthermore, a fall in demand may result. This will have detrimental effects on the revenue of the SCA.

On the other hand, if the capacity of the Canal were much larger than the demand, utilization of the Canal would be low and this too would have an undesirable effect on the management of the SCA.

As a result, it is very important to properly evaluate Canal capacity. The objectives of this section are to show a method of evaluating Canal capacity and to check the balance between supply and demand.

4.2 A Method of Evaluating Canal Capacity

The capacity of the Canal is defined as the number of ships that are able to transit the Canal in a given period. The capacity of the Canal depends upon the following factors:

(1) the physical layout of the Canal
(2) the manner in which the Canal is operated
(3) the transit rules (vessel speeds, arrangement of vessels in convoys, etc.)

Several methods are available to evaluate Canal capacity.
These include:

(1) diagram analysis
(2) computer simulation

In this section, we will introduce the diagram analysis method. The procedure involved in drawing a diagram is described in the following:

1) Draw a frame with two axes on section paper. The X-axis indicates the distance from Port Said Lighthouse, and the Y-axis time equal to cycle time.

2) Draw vertical lines at both ends of each by-passes.

3) Decide the manner in which the Canal is operated.
   It is assumed that a three convoy system is used (one is northbound without stopping at by-passes; the others are southbound) in the following explanation.

4) Draw an oblique line AB with a positive gradient of 14 km/h (the speed of a standard ship) from A.

5) Draw an oblique line EF with a negative gradient of 14 km/h from E.
F is located at the southern end of by-pass II.

6) Draw a line CD a little below F which is parallel to AB.

7) Draw a line GH parallel to EF.

8) Draw a line IJ parallel to EF.

9) Draw a line KL parallel to IJ so that the length of JL equals that of EG.

10) Draw a line DM parallel to EF. Mark M' at the side opposite M.

11) Draw a line M'N parallel to EF.

12) Draw lines OP and RS parallel to EF.
Mark P' at the side opposite P.

13) Draw a line P'Q parallel to EF.

14) Mark T so that the length of TS equals that of QD.
Draw a line TU parallel to EF.

To calculate Canal capacity use the following procedure:

(1) Calculate the number of ships n which pass a given point (excluding by-passes per hour) as the inverse of the interval between successive ships. If each ship is separated by an interval of 10 minutes, then n equals 6 ships/hour.

(2) Calculate number of ships in each convoy N_1, N_2, and N_3.

N_1 (northbound convoy) = AC x n

N_2 (first southbound convoy) = EG x n

N_3 (second southbound convoy) = TS x n

(3) Sum up (N) the numbers in each convoy.

$$N = N_1 + N_2 + N_3$$

N is the number of ships which is able to transit the Canal in a given cycle time.

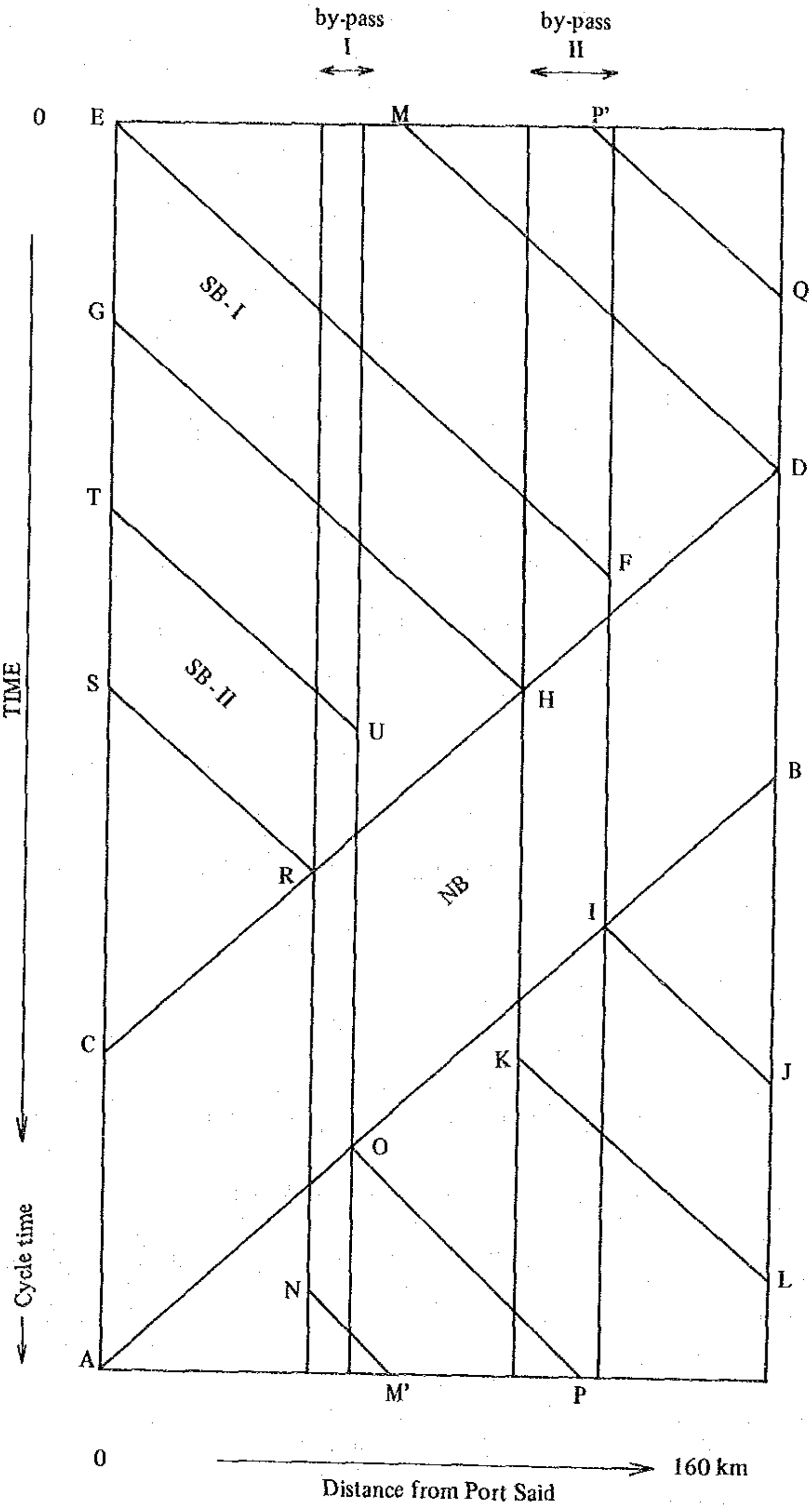


Fig. 4.1 Diagram of Convoy System

The actual capacity is reduced by the following factors:

(1) Tolerance time at the by-passes; the time interval that must be allowed between the time when the last ship of a northbound convoy passes the entrance of the by-pass and the time when the first ship of a southbound convoy leaves the by-pass.

(2) The randomness of ships' transiting speeds and other unexpected factors

The actual capacity C is assessed as N multiplied by 0.9 because of these reducing factors.

$$C = N \times 0.9$$

4.3 Evaluating the Canal Capacity

In short term forecasting, it is important to check whether Canal capacity will meet the projected demand, and give a warning to the Transit Department etc. in the case of excessive demand.

A procedure to assess how many days each month (or year) the number of ships wishing to transit the Canal will exceed Canal capacity is described in the following:

(1) Calculate the average number of ships wishing to transit the Canal per day Naa using number forecasted per month (or year).

(2) Calculate the standard deviation σ of Naa.

$$\sigma = \sqrt{Naa}$$

(3) The probability β that the number of ships wishing to transit the Canal will exceed Canal capacity C is given by the following expression.

$$\beta = \frac{1}{\sqrt{2\pi}\,\sigma} \int_{C}^{\infty} \exp\left(-\frac{x^2}{2\sigma^2}\right) dx$$

Calculate α to obtain β without integration

$$\alpha = \frac{C - Naa}{\sigma}$$

Use Table 4.1 to find α and β corresponding to α.

(4) Calculate how many days M per month (or year) the number of ships wishing to transit the Canal will exceed Canal capacity.

$$M = 30\beta$$

Table 4.1 Relationship between α and β

α	β
0.0	0.5000
0.5	0.3085
1.0	0.1587
1.5	0.0668
2.0	0.0227
2.5	0.0062

PART V

A BASIC SYSTEM FOR LONG TERM FORECASTING OF TANKER TRAFFIC THROUGH THE SUEZ CANAL

CHAPTER 1 INTRODUCTION

1.1 Objectives

This report has been made for the purposes listed below based on the results of the training given in Japan for the trainees from the Suez Canal Agency (SCA) in 1978.

(1) To describe the information required for the staff members of the "Economic Financial and Traffic Planning Unit" (hereinafter referred to as Unit) of the SCA to acquire basic techniques of systems analysis necessary for understanding the long term forecast of the canal traffic volume.

(2) To explain elementarily and plainly the method required by the Unit's personnel to forecast the canal traffic volume and the revenue from the canal, as well as to effect the canal management analysis in relation to the canal expansion plan.

To achieve the above purposes, this report elucidates the basic system of forecasting the canal traffic volume in terms of tankers and the revenue to be derived from the canal over a long term, centering on the petroleum trade and tankers. The explanations are made by using concrete procedures as much as possible so that this report can also be used as a manual for basic forecasting.

Among various types of ships, this report deals with petroleum tankers because it is estimated that petroleum tankers will account, for most part, for the increase in traffic volume occurring after the Suez Canal expansion plan is completed. Another reason, is that the traffic volume of ships other than tankers can be forecast in a simple manner similar to the forecasting method for tankers.

The analyses and forecasts for the items listed below and included in the basic system for the long term forecast of the canal traffic volume of tankers.

1) World energy and oil trade
2) World tanker fleet
3) Tanker shipping costs
4) Tanker traffic through the Canal
5) Canal revenue from tankers

The following points should be noted when utilizing this report.

(1) This report deals with elementary methods, while several other methods have been developed and used in practical forecasts. This report also introduced several methods. The particular method to be used should be selected case by case, and the selection requires experience in high-degree analysis and forecasting. Therefore, the way to select the proper method should be learned after the acquisition of sufficient experience in analyses and forecasting.

(2) Forecasts always involve some uncertainty, and estimated values should naturally be changed with a change in the preconditions. This point should be kept in mind when using the basic forecast system described in this report. The forecasting and evaluation system, taking

uncertainty into consideration, requires a highly advanced technique and, therefore, its method should be learned after the acquisition of sufficient experience in analyses and forecasting.

1.2 Outline of the Report

The forecasting process described in this report consists of five phases which are all intimately involved in any attempt to make long term forecasts regarding tanker traffic through the Suez Canal. These five phases are:

World Energy and Oil Trade
World Tanker Fleet
Tanker Shipping Costs
Tanker Traffic through the Canal
Canal Revenue from Tankers.

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

Here seaborne oil movements relevant to the Suez Canal are forecast. Two different methods of forecasting are possible: one is a conventional method which does not rely on computers; the other is a systematic approach to the forecasting of oil trade flows and often requires the use of computer models. These are explained in Chapter Two.

2) World Tanker Fleet

The size of tankers which may pass through the Canal is important to the revenue of the Suez Canal Authority. The fleet mixes for the various kinds of trade flowing through the Canal depends upon the world fleet mix, the Canal transit regulations, and the limitations of ports. Methods of forecasting the world tanker fleet will be described in Chapter Three.

3) Tanker Shipping Costs

Tanker shipping costs may be broken down into two major elements: capital costs and operating costs. The choice of routes and fleet which route is to be used and what sorts of vessels (size) are to be employed – is based on tanker shipping costs. Forecasting of tanker shipping costs will be discussed in Chapter Four.

4) Tanker Traffic through the Canal

A distribution model is used to determine how the tonnage of a given OD (Origin/Destination) seaborne trade will be distributed between different routes and tankers of different sizes. These distributions are based on a comparison of shipping costs as well as tanker market conditions which may have effects on shipping costs.

Canal transit tonnages for both oil and tankers are determined through the two steps. First, canal transit tonnages for oil and tankers are calculated without the Canal regulations (potential traffic). In the second step the potential tonnage is adjusted according to the regulations (actual traffic). The method is explained in Chapter Five.

5) Canal Revenue from Tankers

Canal transit fees for tankers have been set up as unified rates for tanker size. These rates in turn depend on the loading condition. Therefore, the number of tankers passing through the Canal, their size categories and their loading conditions are used to calculate the Canal revenue. The forecasts of revenues are based on the methods described in Chapter Six.

Fig. 1.1 is a schematic diagram which shows the relationships of these five phases and the forecasting process.

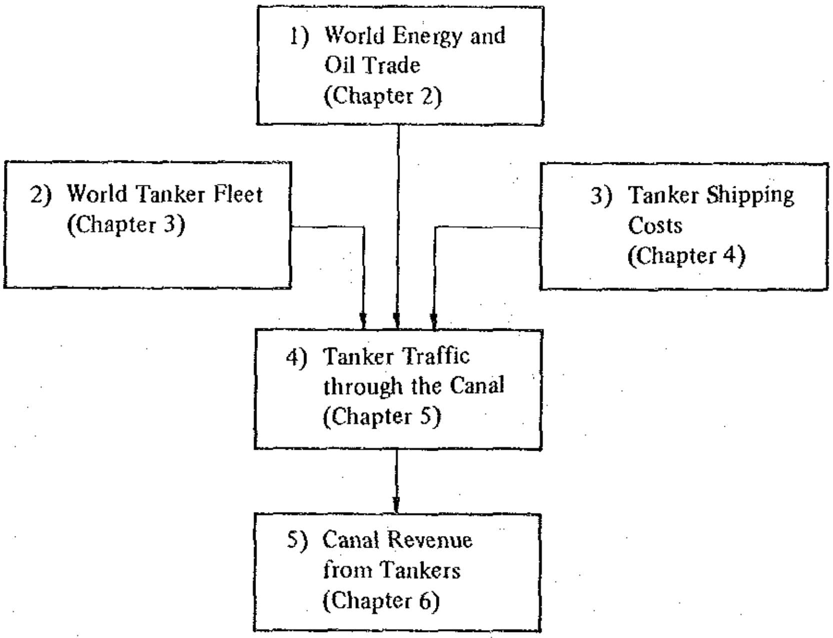


Fig. 1.1 Long Term Forecasting Process of Tanker Traffic through the Canal

CHAPTER 2 WORLD ENERGY AND OIL TRADE

2.1 Conventional Forecasting of Oil Trade Flows

(1) General Remarks

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. 2.1.

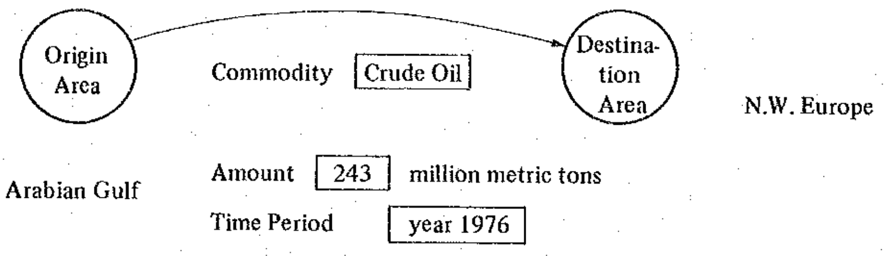


Fig. 2.1 Definition of Trade Flow

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

Commodities

Commodities related to oil can be broken down into the two major divisions of crude oil and oil products.

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 2.1 shows an example of O/D zoning.

Table 2.1 An Example of O/D Zoning

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

The Communist Bloc can be removed from the table because it is assumed to be self-sufficient in oil also in 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 too can be removed from the table. And 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 either, 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 the U.S.A. from the Arabian Gulf.

Amount of Trade
The amount of trade is expressed in millions of metric tons per annum in long-term forecasts.

2) Western European Imports of Crude Oil from the Arabian Gulf
The basic procedure for forecasting crude oil imports to Western Europe from the Arabian Gulf is explained in Fig. 2.2.

3) U.S.A. Imports of Crude Oil from the Arabian Gulf
The basic procedure for forecasting crude oil imports to the United States from the Arabian Gulf is explained in Fig. 2.3.

Crude oil imports to other areas from the Arabian Gulf are also forecast in these ways.

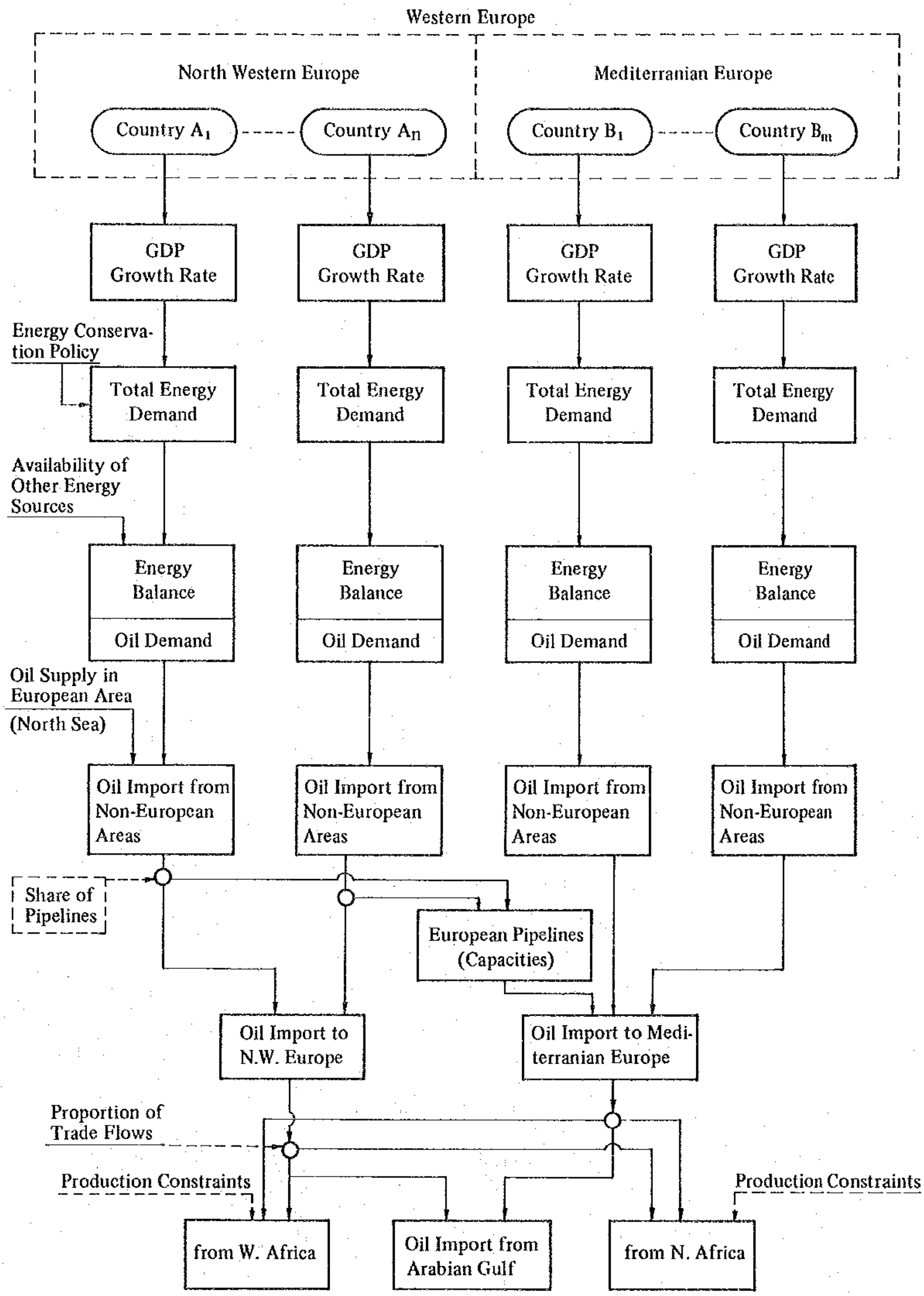


Fig. 2.2 Forecasts of Crude Oil Imports to Western Europe

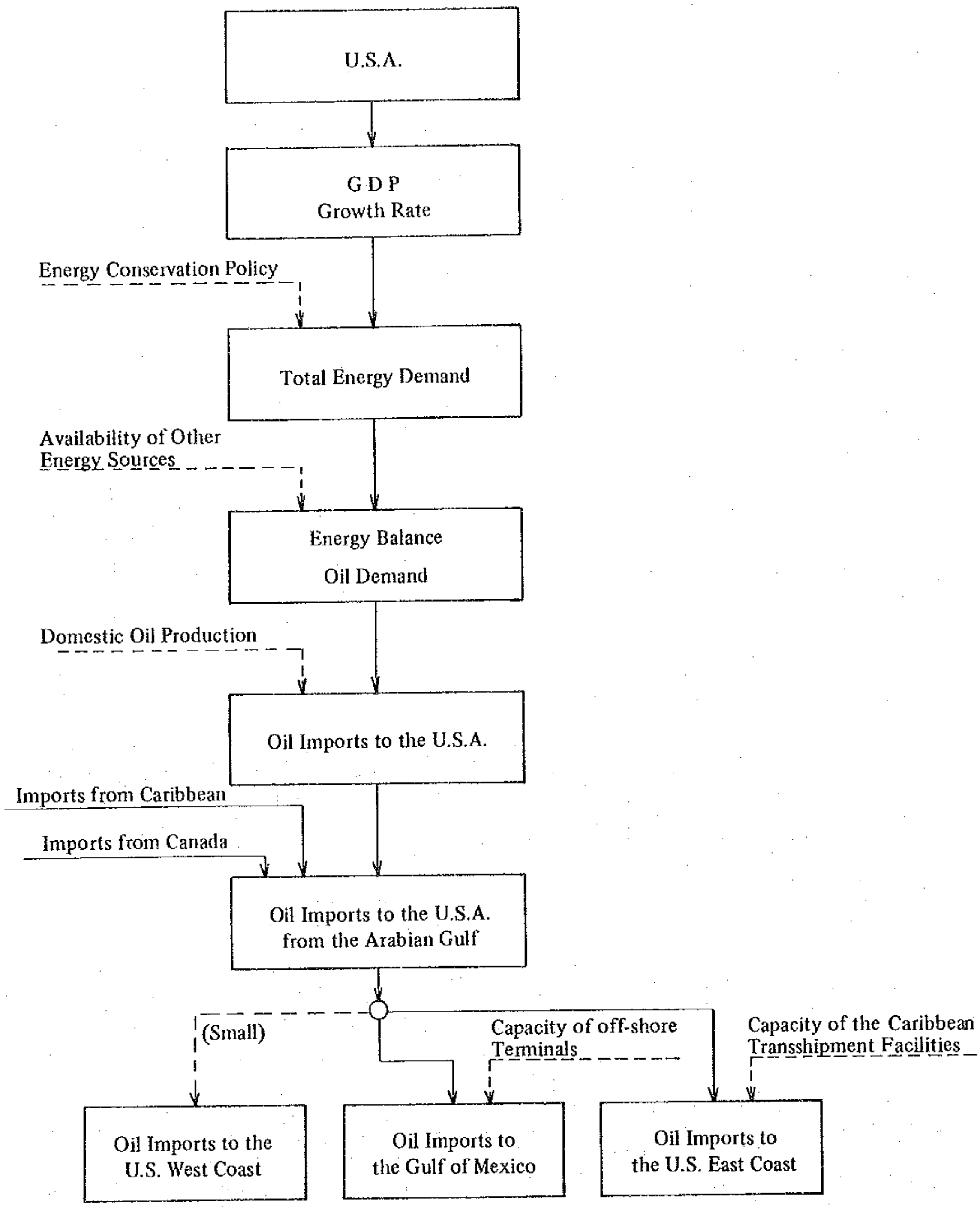


Fig. 2.3 Forecasts of Crude Oil Imports to the U.S.A.

4) Seaborne Oil Movements Relevant to the Suez Canal

There are three routes for oil movements which affect the Suez Canal. These routes are as follows:

1) via the Suez Canal (Seaborne Trade);
2) via the Cape (Seaborne Trade);
3) through Middle Eastern pipelines to the eastern Mediterranean or North Africa (TAPLINE, IPC, KIRKUK, and SUMED).

For each of these oil movements, the trade flow which would use pipelines is forecast on the basis of planned pipeline capacities and transportation cost differences between seaborne trade and pipeline trade. By subtracting the volume which would use pipelines from total volume, seaborne oil movements relevant to the Suez Canal can be forecast.

2.2 A System Approach to Forecasting Oil Trade

The general procedure in long term forecasting of seaborne oil trade flows may be divided into the following six components.

1) scenario for world economic development.
2) oil consumption and production.
3) oil imports and export.
4) World trade flows of oil.
5) oil trade flows relevant to the Suez Canal.
6) seaborne oil movements relevant to the Suez Canal.

Fig. 2.4 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 is the oil exporting areas (N areas; area i), the other is the group of oil importing areas (L areas; area j). The relationships among variables i, j and k are as follows:

Exporting area i: $i = 1 \sim N$ $(k = 1 \sim N)$
Importing area j: $j = 1 \sim L$ $(k = N+1 \sim N+L)$.

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

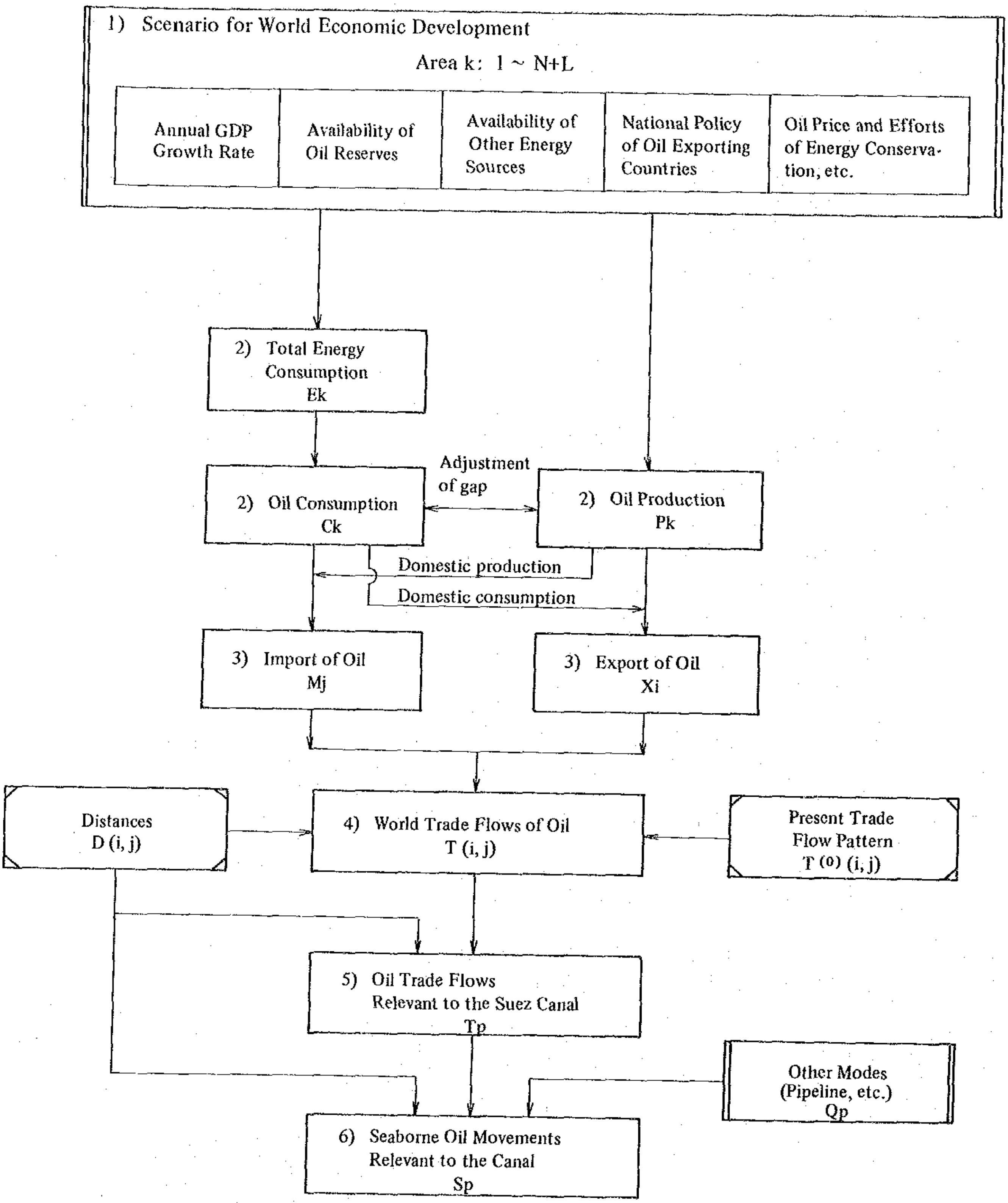


Fig. 2.4 Outline of Forecasts

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 others which will be derived from fundamentally different 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, availability of oil reserves, national policy of the oil exporting countries, important discoveries of oil fields and the availability of other energy sources.

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

2) Oil Consumption and Production

Energy consumption in area k is denoted by Ek. Ek is often assumed to be dependent on the GRk (GDP growth rate of area k) and the elasticity (energy 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:

$$E_k^n = E_k^o \cdot (1 + ek \cdot GRk)^n \quad \ldots\ldots\ldots\ldots\ldots\ldots (2\text{-}1)$$

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

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

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

Future oil consumption in area k (Ck) is forecast by taking into account the availability of alternative energy sources in that area as follows:

a) Major sources of energy are grouped into oil, natural gas, solid fuels, hydraulic power and nuclear power. The future energy consumption by sources is forecast by means of regression analysis using the past data.

b) Their sum is not always equal to future energy consumption (Ek). Some adjustment is needed. One convenient means of adjustment is to allocate Ek in proportion to future consumption in area i (Ck) can be forecast. Another way of forecasting oil consumption (Ck) is to subtract the sum of planned figures for other energy sources in area i from Ek.

c) Oil production capability in area k (Pk) is forecast by taking into account oil 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

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

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) Oil Imports and Exports

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

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

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

4) World Trade Flows of Oil

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.

$$X^{(o)}(i) = \sum_{j=1}^{L} T^{(o)}(i, j)$$

$$M^{(o)}(j) = \sum_{i=1}^{N} T^{(o)}(i, j)$$

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

Table 2.2 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.

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

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

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

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

where,

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

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

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

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

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

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

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

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

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

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

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

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

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

Computer programs aid greatly in performing these calculations, Table 2.3 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) Oil Trade Flows Relevant to the Suez Canal
The distance data is used to extract origin/destination pairs (p) which after distance savings through the Suez Canal. After that extraction, trade flows relevant to the Suez Canal (T_p) are determined.

6) Seaborne Oil Movements Relevant to the Suez Canal
For each OD pair (p) relevant to the Suez Canal, the share of the seaborne trade is estimated by taking into account the following information.

a) Capacities of other transportation modes available for the trade (pipeline, land-bridge, etc.).
b) Transportation cost difference between seaborne trade and the trade by other transportation modes.

Future oil movements through other transportation modes relevant to the extracted OD pairs are used to forecast the seaborne trade flows (Sp).

$$S_p = T_p - Q_p \quad \cdots\cdots (2\text{-}18)$$

where Q_p is the future oil movements through other transportation modes between OD pair p.

Table 2.4 shows a format of the results.

Table 2.2 **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								$X^{(o)}(N-1)$
N								$X^{(o)}(N)$
Total	$M^{(o)}(1)$	$M^{(o)}(2)$	$M^{(o)}(3)$	$M^{(o)}(4)$		$M^{(o)}(L-1)$	$M^{(o)}(L)$	$T^{(o)}$

Table 2.3 **Future Trade Flow Table (Output)**

$T(i, j)$

Exporting Area \ Importing 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 2.4 Trade Flows Relevant to the Suez Canal

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

CHAPTER 3 WORLD TANKER FLEET

3.1 Methodology

Forecasts concerning the size of the world tanker fleet may be begun from either the supply or the demand point of view.

When approached from the supply side, the present world fleet of tankers as well as future new construction are calculated based on available statistical data. Following this calculation, the future world fleet may be calculated by subtracting the volume of scrapping and projected losses from the total fleet supply. This particular approach is particularly useful in forecasting the world fleet size in the near future.

If the demand side is used as the basis for such forecasts, the necessary tanker transits on each trade route are forecast based on projected world oil trade flows. From that the total tanker tonnage requirements are calculated. Since the tonnage displacement will decrease in the future, this approach is suitable for use in long range forecasts.

A procedure combining these two approaches is shown in Fig. 3.1.

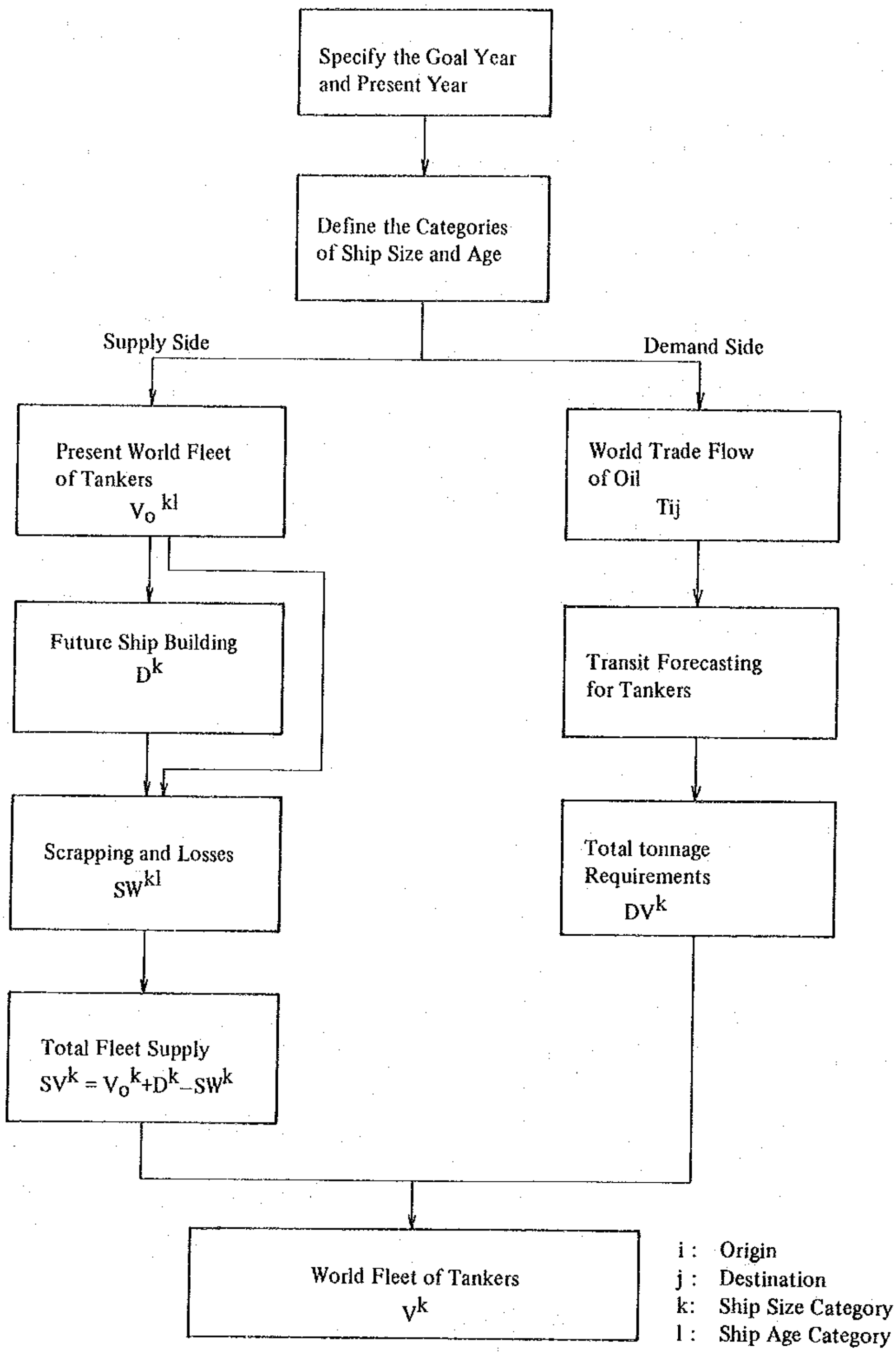
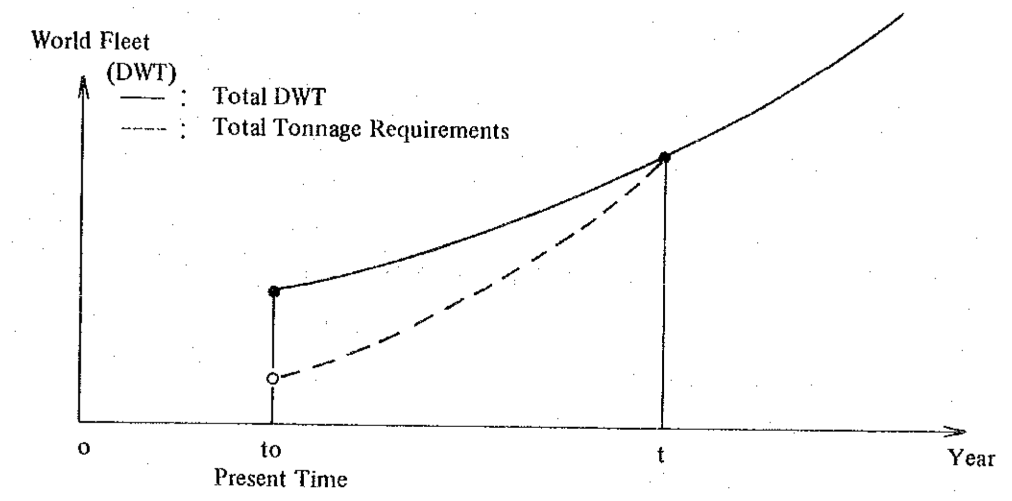


Fig. 3.1 Forecasting the World Fleet

The approach from the demand side must forecast transit volume and trade flows in the future. The methods to forecast transit volume and trade flows are discribed in Chapters 2, 5, and 6. The outputs of this chapter, world fleet of tankers (V^k), are calculated with the following equation.

$$V^k = \begin{cases} SV^k & \text{iff. } SV^k > DV^k \\ DV^k & \text{iff. } SV^k \leq DV^k \end{cases}$$

When the supply of tankers exceeds the demand for tankers, world tanker tonnage for each size will be adjusted to the supply of tankers. In the other case, it will be adjusted to the tanker tonnage requirements.



Note: The gap between demand and supply is zero at time t.

Fig. 3.2 Changes in the World Fleet of Tankers

3.2 Present Status

The present tanker supply for oil transport may be summarized as follows. This data can be obtained from available statistics drawn up by Fearnly & Eagers, Lloyd, etc..

Table 3.1 Summary of Present Supply of Tankers

Ship Age / Ship Size (000 DWT)	0 ~ 4	5 ~ 9	------------	Total
0 ~ 60				
60 ~ 150				
⋮				
Total				

3.3 Future Deliveries

The picture of new deliveries is clear for data analyses involving deliveries at the present time. Although we can forecast future deliveries in five to ten years, it is difficult to estimate the deliveries much beyond this using present data of Jacobs & Drewly, Fair play, and etc. Thus future deliveries are useful for calculation of the gap between supply and demand in the near future. Future deliveries may be summarized as follows.

Table 3.2 Summary of Future Deliveries (Example)

(000 DWT)

Year / Size (000 DWT)	Future			
	1980	1981	- - - - - - - - - - -	1990
0 ~ 60				
60 ~ 150				
⋮				
Total				

Future deliveries may be derived from the orders already placed at the present time minus several factors:

1) Possible future cancellations.
2) Conversions to other carriers.
3) Postponement of deliveries.
4) Production levels of ship yards.

3.4 Future Scrapping and Losses

Future scrapping and losses should be a small percentage of the total fleet, but they will affect the overall tonnage. We can specify future scrapping and losses by taking into account the trends of the past few years, and future scrapping policy. The main factors which influence future scrapping and losses are the age of tankers and the gap between supply and demand.

In this section, the fundamental procedure is shown below.

First, it is necessary to summarize the past scrapping and losses as shown in Table 3.3

Table 3.3 Recent Trends in Scrapping and Losses (Example)

Age of Tanker / Year	5 ~ 9	10 ~ 14	- - - - - - - - - - - - -	25 ~
1960				
1961				
⋮				

Second, it is necessary to adopt the following equation which is useful in estimating the average percentage of scrapping and losses.

$$Sl = \frac{1}{a + b \cdot C^n} \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (3\text{-}1)$$

where, a, b, c : Constant Parameters
n : Ship Age
Sl : Theoretical percentage of Scrapping and Losses.

These parameters (a, b, c) can be estimated by regression analysis.

The gap between the theoretical percentage (Sl) and the actual percentage depends upon the level of ships laid up.

$$Rl = \alpha + \beta \cdot \log L \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (3\text{-}2)$$

where, Rl : Actual Percentage/Theoretical Percentage
L : Laid up Ratio
(the DWT of Laid up Ships/Total DWT)
α, β: Constant Parameters.

The gaps between the theoretical percentages and actual ones are shown in Fig. 3.3.

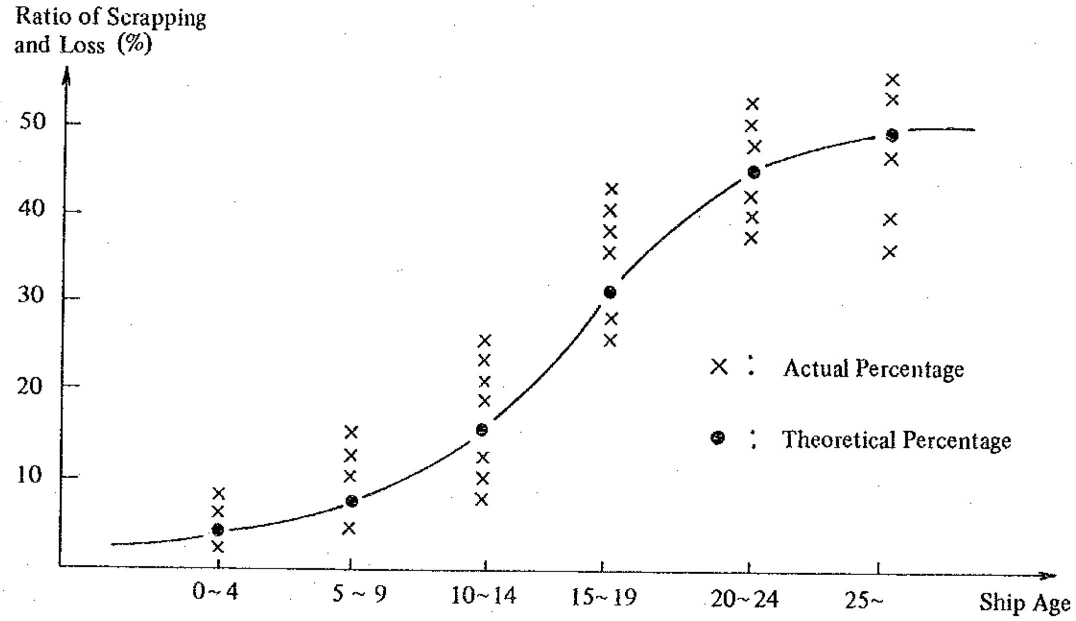


Fig. 3.3 Results of an Analysis of Scrapping and Losses

The forecast percentage can be calculated using equations (3-1), (3-2).

$$\hat{Sl} = Rl \cdot Sl$$

$$= \frac{\alpha + \beta \cdot \log L}{a + b \cdot C^n} \quad \cdots\cdots \quad (3\text{-}3)$$

where $\hat{Sl}$: The Forecast Percentage of Scrapping and Losses for each Age of Ship.

Annual scrapping and losses until the goal year can be forecast using equation (3-3) based on the present tanker supplies and future deliveries.

3.5 Future World Fleet Supply

The world supply of tankers in the future is summarized in Table 3.4.

Table 3.4 Summary of Future World Supply of Tankers

(000 DWT)

Year	Item	Symbol	Size Category		
			0 ~ 60	60 ~ 150	--------------
Present	Present Fleet of Tankers	V_o^k			
Future	Future Deliveries until Goal Year	D^k			
	Scrapping and Losses until Goal Year	SW^k			
	Supply of World Fleet	SV^k			
	Requirements for the World Fleet	DV^k			
	Displacement Tonnage	$SV^k - DV^k$			
	World Fleet Supply in the Future	V^k			

Notes: $V^k = \begin{cases} SV^k & \text{iff. } SV^k > DV^k \\ DV^k & \text{iff. } SV^k \leq DV^k \end{cases}$

$SV^k = V_o^k + D^k - SW^k$

CHAPTER 4 TANKER SHIPPING COSTS

4.1 Methodology

Shipping cost analysis is essential when examining the economics of Canal development projects, because shipping costs affect the transit volume of the Canal as well as the world fleet structure.

Shipping costs are defined as the cost per cargo ton. Voyage distances and ship size are important factors when forecasting shipping costs.

Voyage distances influence the productivity of ships, or their Annual Carrying Capacity.

$$\text{Annual Carrying Capacity} = \frac{\text{Annual Shipping Volume (tons)}}{\text{Ship Size} \quad \text{(DWT)}} \quad \cdots\cdots\cdots\cdots \quad (4\text{-}1)$$

Shipping cost per cargo ton is obtained by the following equation.

$$\text{Shipping Cost/ton} = \frac{\text{Annual Shipping Cost} \quad (\$)}{\text{Annual Shipping Volume} \quad \text{(ton)}}$$

$$= \frac{\text{Annual Shipping Cost } (\$)}{\text{Annual Carrying Capacity (ton/DWT) x Ship Size (DWT)}} \quad \cdots\cdots\cdots\cdots \quad (4\text{-}2)$$

Annual carrying capacity and annual shipping costs are composed of many elements, and these are calculated by estimation equations. These will be shown in the following sections. The general procedure for cost estimation is shown in Fig. 4.1.

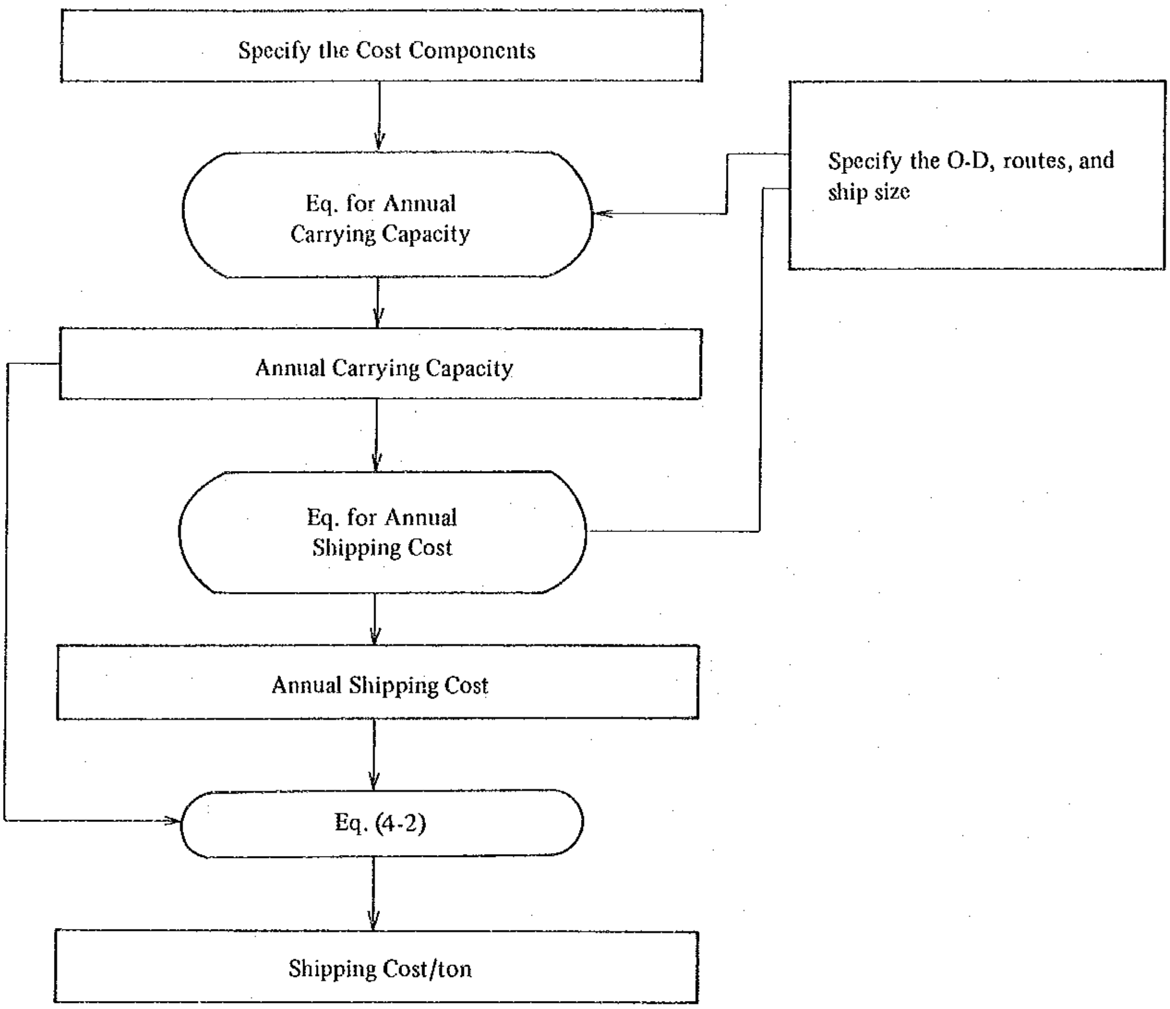


Fig. 4.1 Shipping Cost Estimation

4.2 Annual Carrying Capacity

Annual Carrying Capacity is an index which shows the annual tonnage which may be carried by one deadweight ton on a route. It is defined by eq. (4-1) and can be expressed as follows:

$$ACC = \frac{Da}{\frac{d}{24S_1} + \frac{d}{24S_2} + Dt + Do} \times R \qquad \text{(4-3)}$$

where, ACC: annual carrying capacity (ton/DWT)
Da : days in operation (days/year)
Dt : loading time (days/voyage)
Do : unloading time (days/voyage)
d : distance (miles)

S_1 : speed in laden (miles/hour)
S_2 : speed in ballast (miles/hour)
R : load factor.

The load factor R shows the efficient utilization ratio and is calculated by dividing the cargo tons by the dead weight tonnage of the ship.

To derive the annual carrying capacity, it is necessary to derive the components (Da ~ R) by considering the shipping market, and shipbuilding technology. If this data is not available, the following simplified equation may be used:

$$ACC = \frac{365 - Ds}{\left(\frac{d}{24S}\right) \times 2 + D} \times R \quad \ldots\ldots\ldots\ldots \quad (4\text{-}3')$$

where S : Ship speed (mile/hour)
D : loading and unloading time (days/voyage)
Ds: days in rest (days/year).

Annual carrying capacity is summarized in Table 4.1.

Table 4.1 Summary of Annual Carrying Capacity

year	size (000 DWT)	route	days in rest (days)	distance (miles)	speed (miles/hour)	loading & unloading time (days)	loss of dead weights	Annual Carrying Capacity (tons/DWT)
1970	10	A → B	35	3820	13	7	0.95	9.96

4.3 Annual Shipping Costs

Annual shipping costs (C_T) are composed of capital costs and operating costs.

$$C_T = Ck + Co \quad \ldots\ldots\ldots\ldots \quad (4\text{-}4)$$

where Ck : capital costs
Co : operating costs.

Capital costs are composed of the five items. The following equation show the relationship between them.

$$Ck = Pr \cdot (1 + E) \cdot (Rd + Pr + Ri) = Pr \cdot C \quad \ldots\ldots\ldots\ldots \quad (4\text{-}5)$$

where Pr : contract price ($/ship)
E : fitting out expense rate (%)
Rd : depreciation rate (%)
Rr : interest (%)
Ri : insurance rate (%)
C : cost conversion rate (%).

Operating costs are expressed by the following components.

$$Co = Bk + Pt + Cr + Ms + Ad + Lb + Rp \quad \cdots\cdots \quad (4\text{-}6)$$

where Bk : bunker consumption charge ($/year)
Pt : port charge ($/year)
Cr : crew expenses ($/year)
Ms : miscellaneous ($/year)
Ad : administrative costs ($/year)
Lb : lubrication costs ($/year)
Rp : maintenance costs ($/year).

The bunker consumption charge, which is a component of the operating costs, is expressed as follows:

$$Bk = B_1 \cdot Pb \cdot Da + B_2 \cdot Pb \cdot (Dt + Do)\,(ACC/R) \quad \cdots\cdots \quad (4.7)$$

where B_1 : bunker oil consumption in a voyage (tons/day)
B_2 : bunker oil consumption at anchor (tons/day)
Pb : bunker oil price ($/ton)
Da : days in voyage (days/voyage)
Dt : loading time (days/voyage)
Do : unloading time (days/voyage).

The port charge component may be expressed as follows:

$$Pt = (Tt + To)\,(AEC/R) \quad \cdots\cdots \quad (4\text{-}8)$$

where Tt : loading cost ($/voyage)
To : unloading cost ($/voyage).

4.4 Shipping Costs per Cargo Ton

Shipping costs per cargo ton (C) are defined as the annual shipping cost divided by the annual shipping volume (see eq. (4-2)). A shipping cost estimation equation can be obtained by using eq.'s (2) ~ (8). It is arranged as follows:

$$C = a + b \cdot d \quad \cdots\cdots \quad (4\text{-}9)$$

where d : distance (mile),
a, b : coefficients.

$$a = \left[\frac{(Pr\cdot C+Cr+Ms+Ad+Lb+Rp)(Dt+Do)}{Da} + B_2 \cdot Pb \cdot (Dt+Do)+Tt+To\right] DwR \quad \cdots\cdots \quad (4\text{-}10)$$

$$b = \left[\frac{(PrC+Cr+Ms+Ad+Lb+Rp)\,(Dt+Do)}{Da} + B_1 \cdot Pb\right] \cdot \left(\frac{1}{S_1} + \frac{1}{S_2}\right) \cdot \frac{1}{24} \cdot \frac{1}{DwR} \quad \cdots\cdots \quad (4\text{-}11)$$

$$C = (1 + E)\,(Ra + Rr + Ri) \quad \cdots\cdots \quad (4\text{-}12)$$

The cost per cargo ton is thus expressed as a linear function of voyage length.

4.5 Data and Results

When data is specified for the components, it becomes possible to estimate shipping costs per cargo ton using eq.'s (4-9) ~ (4-12).

The necessary data is summarized in Table 4.2. Much of this data has not been published and therefore must be based on experimental knowledge or on the results of surveys sent to shipping components. The results of a cost analysis can be summarized as follows.

Table 4.2 Necessary Data to Obtain the Ship Cost

Name	Unit	Symbol
ship size	DWT	Dw
load factor	ton/DWT	R
distance	miles	d
days in voyage	days/year	Da
loading time	days/voyage	Dt
unloading time	days/voyage	Do
speed in laden	miles/hour	S_1
speed in ballast	miles/hour	S_2
contract price	$	Pr
fitting out expense rate	%	E
depreciation rate	%	Rd
interest	%	Rr
insurance rate	%	Ri
crew expenses	$/year	Cr
miscellaneous	$/year	Ms
administrative costs	$/year	Ad
lubrication costs	$/year	Lb
maintenance costs	$/year	Rp
bunker oil price	$/ton	Pb
bunker oil consumption in voyage	tons/day	B_1
bunker oil consumption at anchor	tons/day	B_2
loading costs	$/voyage	Tt
unloading costs	$/voyage	To

1) Cost Estimation Equations

Table 4.3 Summary of Cost Estimation Equations

Size category (000 DWT)	Representing size (000 DWT)	Equation
10 ~ 60	40	C = 1.27 + 0.6d
60 ~ 150	105	C = 0.70 + 0.4d

2) Summary of Cost Analysis

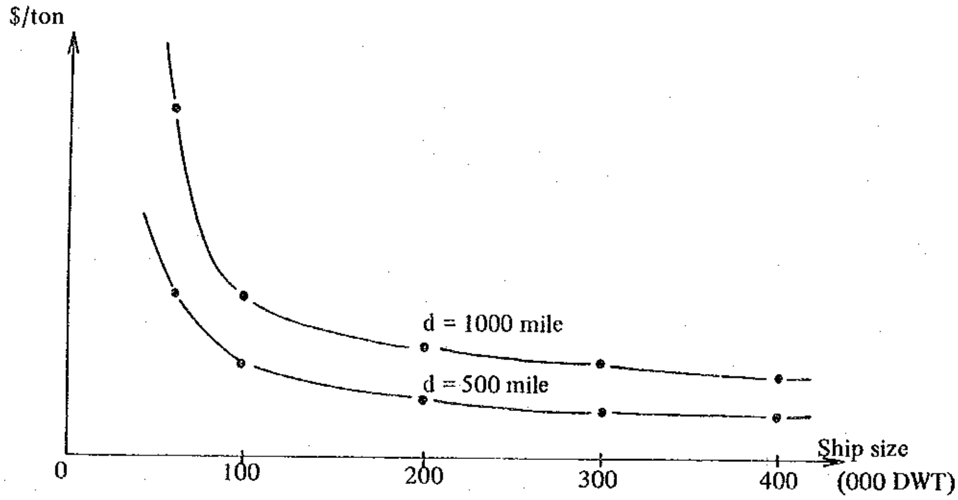


Fig. 4.2 Summary of Cost Analysis

(3) Annual Carrying Capacity and Cost per Cargo Ton on Each Route

Table 4.4 Summary of Annual Carrying Capacity and Cost/ton (Example)

Route	Ship Size (000 DWT)	Distance (mile)	Annual Carrying Capacity	Cost/ton ($/ton)
Kuwait – Rotterdam	40	6500	9.96	10.00

CHAPTER 5 TANKER TRAFFIC THROUGH THE CANAL

5.1 Methodology

To forecast the Canal traffic of tankers for each development phase of the Suez Canal (for example, see Table 5.1), trade flows relevant to the Canal, world fleet structure and shipping costs for each size vessel on each route are used. The procedure is shown in Fig. 5.1.

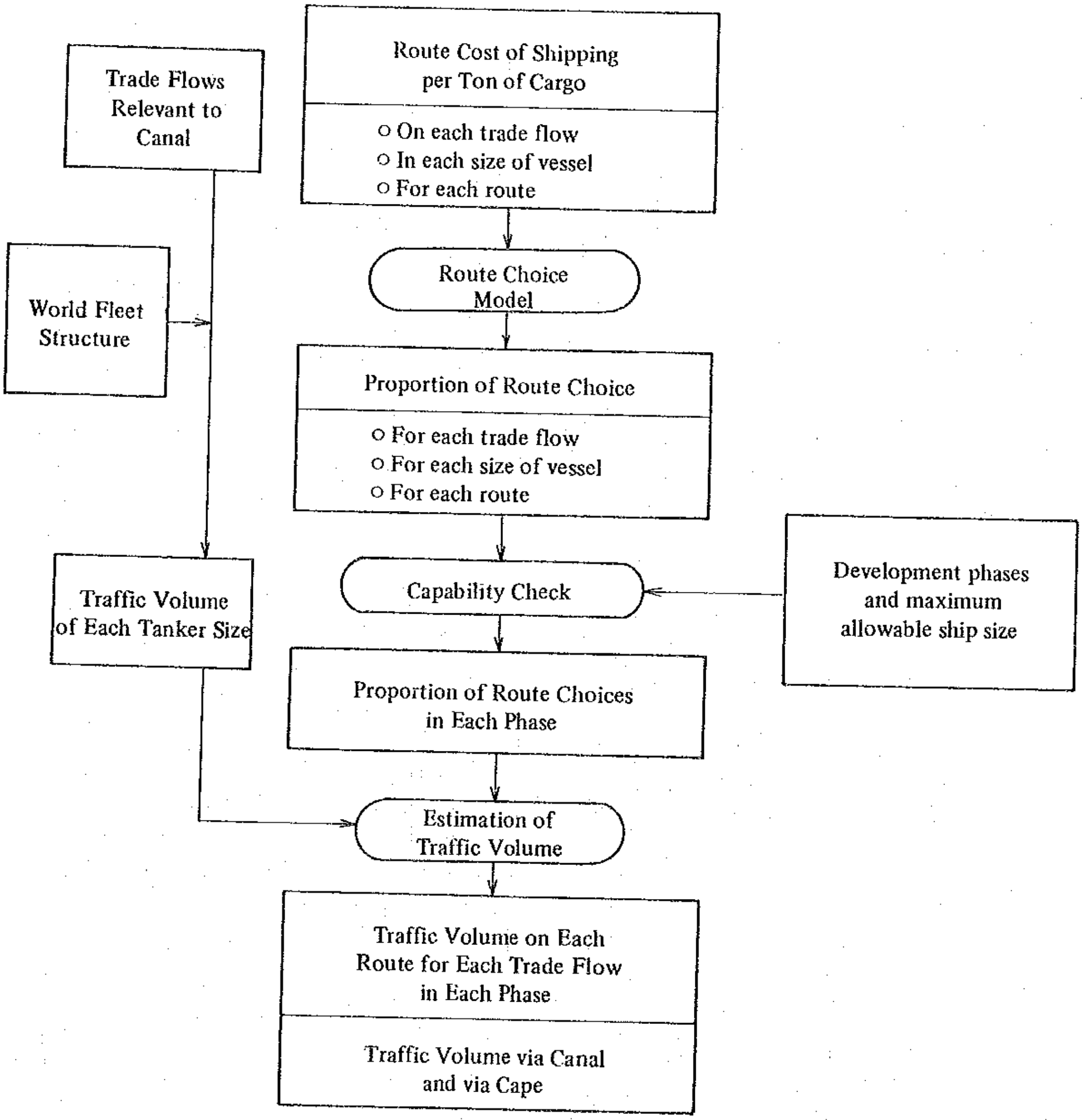


Fig. 5.1 Forecasting Procedure

Table 5.1 Examples of Development Phases for the Suez Canal

Development Phase	Draught (feet)	Net Cross-section (m^2)	Maximum Size (1,000 DWT)	
			Laden	Ballast
I	38	1,800	60	200
II	53	3,600	150	330
III	67	5,000	260	700

In the first place, the proportion of oil tonnages between routes, (via the Suez and via the Cape) are determined without considering the Canal regulation. These proportions are determined using the route choice model based on differences in shipping costs. Secondly, Canal regulations are introduced, and the volume which cannot pass through the canal is diverted to the route via the Cape. These actual proportions, which differ according to tanker size and traffic volume allocated to each size, give the traffic volume passing through the Canal.

5.2 Route Choice without Canal Regulations

(1) Route Choice Model
The vessel is assumed to choose the route lower in shipping costs when alternative routes are possible. Let C_A and C_B be the shipping costs on routes A and B respectively. The route chosen depends upon the value of ($C_A - C_B$). If $C_A \geqq C_B$, route B will be chosen; otherwise route A is chosen.

However, since C_A and C_B both have a distribution mentioned above, ($C_A - C_B$) also has this distribution. Therefore, integration of the probability that C_B is cheaper than C_A gives the proportion of occasions when route B is preferable to route A.

(2) Proportion of Traffic via the Canal without Regulations
Let Cc and Cs be the shipping costs via the Cape and via the Canal respectively, and suppose that they have normal distributions with averages $\overline{C}c$, $\overline{C}s$ respectively and standard deviation σ. The distribution of cost difference (Cc – Cs) is normal and its average (μ) is $\overline{C}c - \overline{C}s$. Its standard deviation (s) is $\sqrt{2\sigma}$

Since we can obtain the proportion of occasions when the Suez Canal is preferred by integrating the positive region of the distribution (shaded portion of Fig. 5.2), the following equation gives the proportion r.

$$r = \int_0^\infty f(x)\,dx \qquad \text{(5-1)}$$

$$\text{where } f(x) = \frac{1}{\sqrt{2\pi}\,s} \exp\left[-\frac{(x-\mu)^2}{2s^2}\right].$$

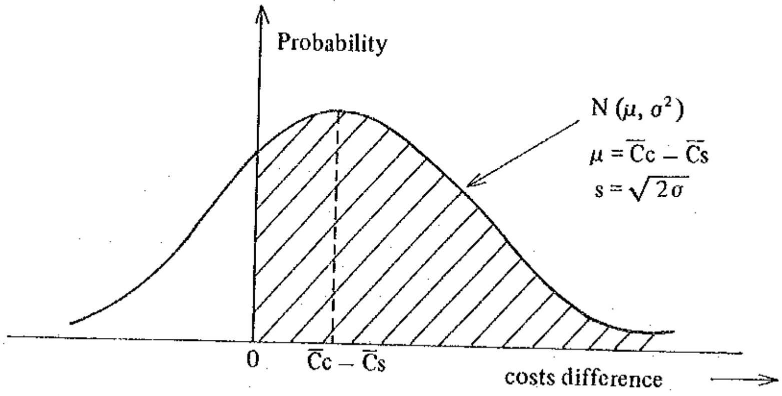


Fig. 5.2 The Proportion of Tonnage on the Suez Canal

5.3 Route Choice with Canal Regulations

Canal regulations governing the maximum vessel size capable of passage are introduced to determine the actual proportions on each route. Further, routes are defined as round trip voyage rather than one way routes.

The relevant routes are the following:

1) via the Suez Canal both in laden and in ballast (S/S).
2) via the Cape in laden and via the Suez Canal in ballast (C/S).
3) via the Cape both in laden and in ballast (C/C).

The proportions are determined in the following way, taking into account the results of route choices without regulations (let $r_L(C)$, $r_L(S)$ the propotions for via the Cape and for via the Suez Canal in laden, and $r_B(C)$, $r_B(S)$ in ballast)

a) if tankers cannot pass through the Suez Canal either in laden or in ballast, they take the round voyage C/C.

b) if a tanker can pass through the Suez Canal only in ballast, it may choose either voyage C/S or C/C. These shares follow the proportions without the regulations between routes via the Cape ($r_B(C)$) and via the Suez Canal ($r_B(S)$) in ballast that are the result of route choices without regulations.

c) if the tanker can pass through the Suez Canal both in laden and in ballast, the proportion of voyages S/S is equal to that of choice for the Suez Canal in northbound trips without regulations ($r_L(S)$) on the assumption that those tankers which use the Suez Canal on northbound trips (in laden) necessarily pass through the Suez Canal on a southbound trip (in ballast). The proportion for the Suez Canal in southbound trips without regulations ($r_B(S)$) includes voyages C/S and S/S. We can then obtain the proportion for C/S by subtracting the proportion for S/S from the proportion for the Suez Canal on southbound trips. The remainder is the proportion for voyages C/C.

5.4 Traffic Volume

(1) Assumption
The fleet mix of OD's relevant to the Canal is assumed to follow the world fleet mix. In a strict sense, the fleet mix relevant to the canal is related to the results of route choices, because displacements differ according to tanker sizes. A kind of iteration method is used to take account of this relationship. For simplicity, however, the fleet mix is assumed to be given.

(2) Traffic Volume on Each Route
Actual traffic volume are obtained by allocating trade flow volume with the corresponding proportions. Firstly, total volume is distributed between tanker sizes according to the proportions to follow those on tanker sizes in the world.

The volume of each size is further distributed between the voyage routes according to the proportions obtained by the route choice model. The results of forecasting tanker traffic volume are summarized as shown in Table 5.2.

Table 5.2 Summary of Traffic Volume on Each Route

O/D	Ship size / Voyage phase	Traffic volume								
		S/S			C/S			C/C		
		I	II	III	I	II	III	I	II	III
i → j*	0 – 60									
	60 – 150									

* i → j represents trade flow from region i to region j.

CHAPTER 6 CANAL REVENUE FROM TANKER

6.1 Canal Charges per Tanker Transit

The canal charges for a unit S.C.N.R.T. are decided according to the loading conditions. S.C.N.R.T. is correlated with D.W.T. and a regression analysis is used to obtain the quantitative relationship between S.C.N.R.T. and D.W.T. The canal charges for a unit transit of a tanker can be calculated according to a tanker's loading conditions and its D.W.T. size. One of the most reliable relationships is represented as following equation.

$$\text{S.C.N.R.T.} = a \times (\text{D.W.T.})^b \qquad \text{(6-1)}$$

Coefficients a, b and the type of equation should be estimated from up-to-date data.

6.2 Number of Tankers through the Canal

Since canal charges are decided for unit transits, traffic volume through the Canal must be converted to the number of transits to obtain the Canal revenue.

When the traffic volume on each route is given, the number of ship trips needed to carry it can be obtained by dividing the volume by the transportation capacity of the vessels that are represented as the size of tankers (DWT) multiplied by the load factor R. The following equation then gives the number of ship trips.

$$\text{Trip number} = \text{traffic volume}/\text{D.W.T.} \times R \qquad \text{(6-2)}$$

From the number of trips for voyages, the number of ships through the Suez Canal according to the loading condition can be calculated with the following equations.

$$\text{The number of ships (Northbound: laden)} = N\,(S/S) \qquad \text{(6-3)}$$

$$\text{The number of ships (Southbound: ballast)} = N\,(S/S) + N\,(C/S) \qquad \text{(6-4)}$$

where N (S/S), N (C/S) means the number of ships on S/S trips and C/S trips respectively.

6.3 Revenue from Tankers through the Canal

The numbers of ships passing through the Canal obtained above gives the revenue when multiplied by the corresponding Canal charges per tanker transit. The results of these calculations are summarized in Table 6.1.

Table 6.1 Summary of Tanker Transit Revenues

Phase	Ship size	Northbound		Southbound		Total	
		Number of transits	Revenue	Number of transits	Revenue	Number of transits	Revenue
I	0 – 60						
	⋮						
	Total						
II	0 – 60						
	⋮						

6.4 Sensitivity Analysis

Sensitivity analysis is used to test the stability of the solution under uncertainty or to find the optional tariff structure.

Tariff structure affects tanker transits and thus revenues. Therefore it is possible to choose the tariff level that realizes optimization according to given criteria. Fig. 6.1 shows the tanker transit demand function and Fig. 6.2 shows changes in revenue with respect to tariff levels. The result shows the tariff that will maximize the revenue. This change is obtained by following the procedure above for various tariff levels. However, if the relationship between tariff level and the corresponding number of tanker transits is stable, and can be represented as a certain function, it is convenient to use the demand function directly. This is because the elasticity of the demand function with respect to tariff level will show whether the revenue will increase or not given a small change in tariff levels.

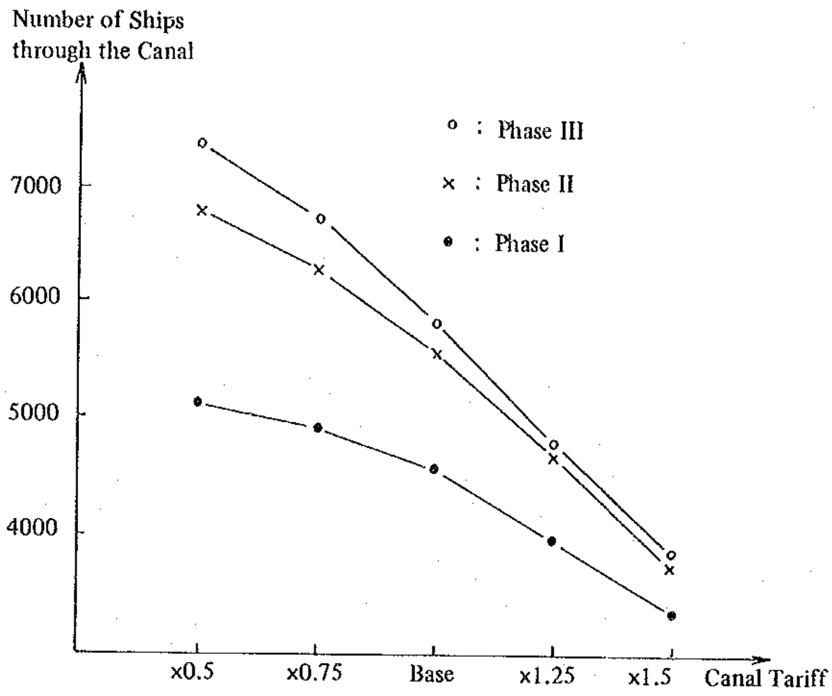


Fig. 6.1 Tanker Transit Demand Function

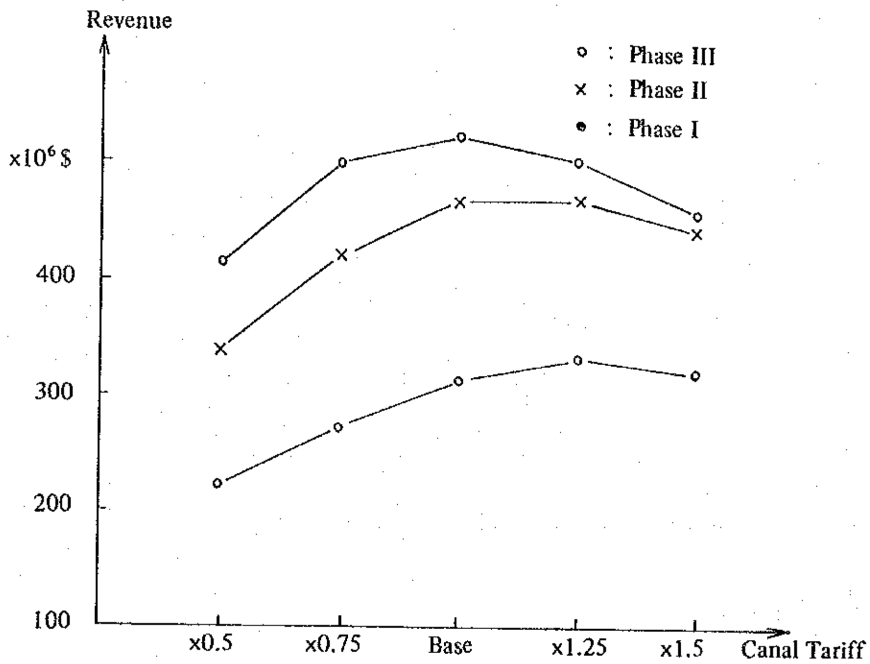


Fig. 6.2 Revenue Function with Respect to Tariff

PART VI

SUMMARY OF PREVIOUS FEASIBILITY STUDIES

CHAPTER 1 INTRODUCTION

It is hoped that by the end of the present technical cooperation program the members of the Economic Unit will at least reach a level where they are capable of assessing and judging the technical contents and merits of a feasibility study on a project conducted by outside consultants. To achieve this objective, several previous feasibility studies on the Suez Canal Development Program have been selected and reviewed here in PART III.

The selected feasibility studies are:

1) Development of Suez Canal Feasibility Study by Maunsell Consultant LTD (1976).
2) Suez Canal Development Feasibility Study by Sogreah Consulting Engineers (1976).
3) Suez Canal Development Feasibility Study by the Japan International Cooperation Agency (1975).
4) Determination of Level and Structures of Dues for Suez Canal by Pacific Consultants International (1975).

These feasibility studies have been handled in two ways, first as individual studies and then through comparisons of them. The summary of both the individual studies and their comparisons are made in accordance with the following context:

1) Introductions and main conclusions.
2) Projects studied.
3) Forecasting the Canal transit volume.
4) Projects evaluation.

Feasibility studies are carried out to evaluate a given project economically or financially by estimating various benefits (revenues) and costs (expenses). General procedure of feasibility studies is as follow:

1) Benefits (revenue) estimation.
2) Costs (expenses) estimation.
3) Project evaluation by using Net Present Value criterion and/or Internal Rate of Return criterion.

Net Present Value criterion measures whether the project gives net present benefits exceeding net present costs. And in the Internal Rate of Return criterion, the evaluation is made by the comparison productivities between the project and the alternatives.

CHAPTER 2 SUMMARY OF INDIVIDUAL STUDIES

2.1 Maunsell's Study

2.1.1 Introduction & Main Conclusions

(1) Objectives

The report aims at determining the best development program for the Suez Canal, the most suitable cross-sectional dimensions, the draught to be adopted and the phasing of expansions from the viewpoint of the SCA. This means it is based not upon Economic Evaluation but Financial Evaluation alone.

(2) Main Conclusions

1) Of all the schemes considered, the one offering the highest net present value to the SCA is a phased program of development to a 53 ft. Canal by January 1979, then to a 68 ft. Canal by January 1983, and subsequently a fully dual Canal by January 1989.

2) For this scheme a high tariff policy aimed primarily at European tanker traffic should be adopted, even at the expense of losing some North American trade.

(3) Methodology

The methodology adopted in this study is shown in Fig. 2.1.

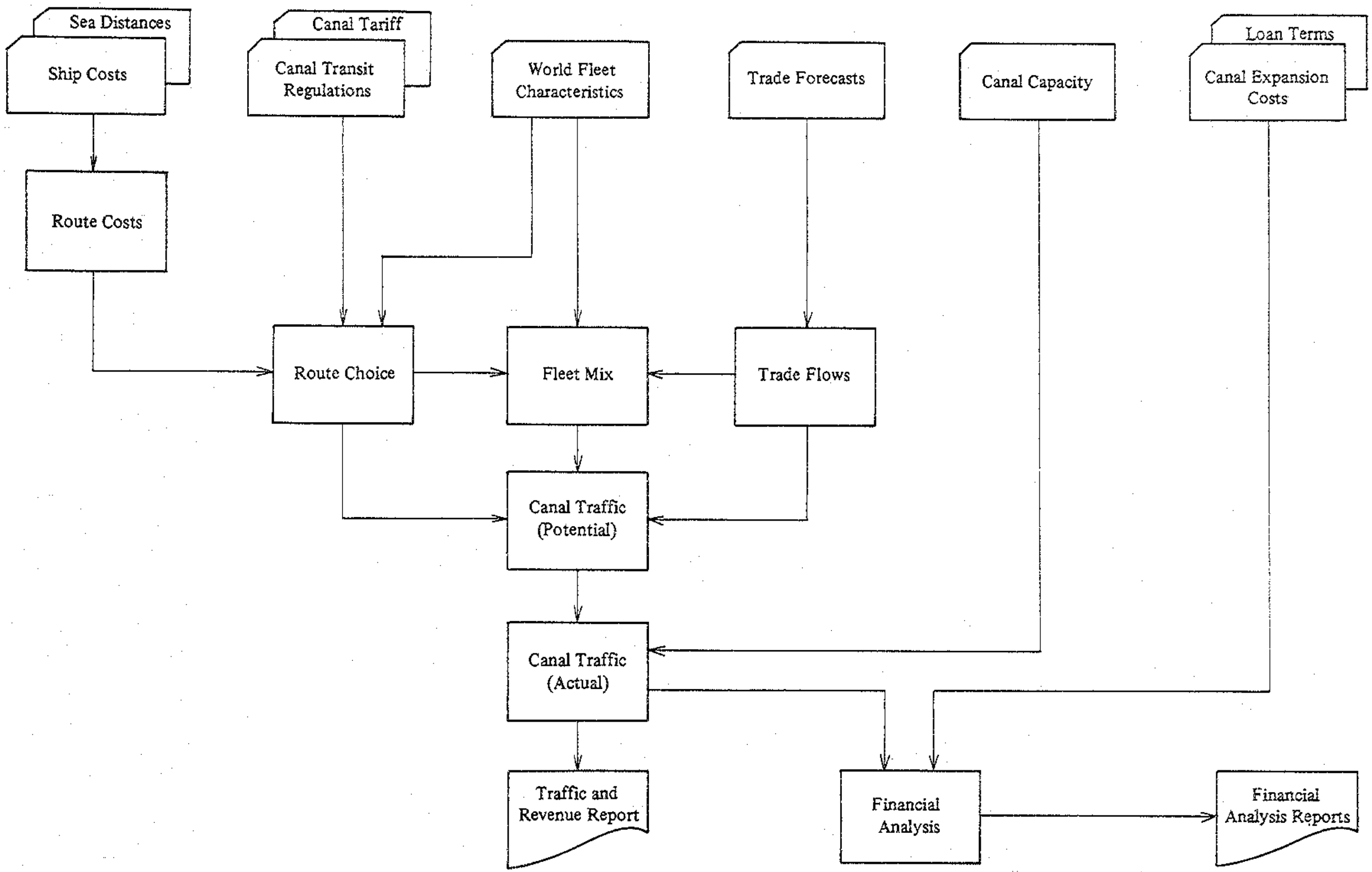


Fig. 2.1 Methodology

Source: Maunsell

2.1.2 Projects studied

Fourteen different development programs were studied. These are listed below:

(1) One-cut Development Programs:

1) 48 ft. Canal by July 1978.
2) 53 ft. Canal by January 1979.
3) 56 ft. Canal by July 1979.
4) 60 ft. Canal by July 1980.
5) 67 ft. Canal by January 1982.
6) 68 ft. Canal by January 1982.
7) 73 ft. Canal by January 1983.

(2) Phased Development Programs:

8) 53 ft. Canal by January 1979,
   67 ft. Canal by January 1983.
9) 48 ft. Canal by July 1978,
   56 ft. Canal by January 1980.
10) 48 ft. Canal by July 1978,
    60 ft. Canal by July 1981.
11) 53 ft. Canal by January 1979,
    60 ft. Canal by January 1981.
12) 53 ft. Canal by January 1979,
    60 ft. Canal by January 1981,
    67 ft. Canal by July 1983.
13) 53 ft. Canal by January 1979,
    68 ft. Canal by January 1983.
14) 56 ft. Canal by July 1979,
    67 ft. Canal by January 1983.

Studies of these programs were based upon the following assumptions:

(1) A 24 hour cycle convoy system would be maintained except for during construction of the by-passes.

(2) Two tariff strategies for crude oil tankers and one for other carriers are assumed as shown in Table 2.1 ~ 2.2

Table 2.1 The Tariffs Used in the Feasibility Study, Crude Oil Tankers, 1976 to 1985 (at current prices)

(a) High Toll Strategy

Crude Oil Tankers DWT	1976 $ SCNT		Upon Opening of First Stage Scheme (1)	1983 (1)	1985 (1)
	Laden	Ballast	$ SCNT	$ SCNT	$ SCNT
less than 60,000	1.84	1.48	3.00	3.67	4.34
90,000	1.84	1.48	2.35	2.69	3.03
140,000	1.84	1.48	2.24	2.52	2.81
225,000	1.84	1.48	2.01	2.18	2.35
265,000	1.84	1.48	1.94	2.08	2.22
350,000	1.84	1.48	1.91	2.03	2.15
450,000	1.84	1.48	1.84	1.92	2.01

(b) Low Toll Strategy

Crude Oil Tankers DWT	1976 $ SCNT		Upon Opening of First Stage Scheme (1)	1983 (1)	1985 (1)
	Laden	Ballast	$ SCNT	$ SCNT	$ SCNT
less than 60,000	1.84	1.48	1.82	1.90	1.98
90,000	1.84	1.48	1.38	1.38	1.38
140,000	1.84	1.48	1.29	1.29	1.29
225,000	1.84	1.48	1.08	1.08	1.08
265,000	1.84	1.48	1.02	1.02	1.02
350,000	1.84	1.48	0.98	0.98	0.98
450,000	1.84	1.48	0.92	0.92	0.92

Note: (1) Dues for laden and ballast legs assumed equal.

Table 2.2 Tariffs Assumed for General Cargo Vessels ($ SCNT)

Year \ Ship	General Cargo Ships		Containerships	
	Laden	Ballast	Laden	Ballast
1976	1.84	1.48	2.03	1.48
Opening of First Stage Scheme	2.43	1.96	2.68	1.96
1983	2.73	2.19	3.00	2.19
1985	3.02	2.43	3.32	2.43

Note: For the period after 1985 it is assumed that tariffs would rise with the general rate of inflation by 7% per year until 1990 and then by 5.5% per year until 2000.

Source: Maunsell

2.1.3 Forecasting Canal Transit Volume

(1) Methodology

See Fig. 2.1.

(2) World Economy and Seaborne Trade

1) Methodology

(a) Oil

In accordance with the procedure as shown in Fig. 2.2, the forecast is based mainly on external documents published by EEC, UN, OECD, Feanley and Egers, SCA Report, Drewly, etc.

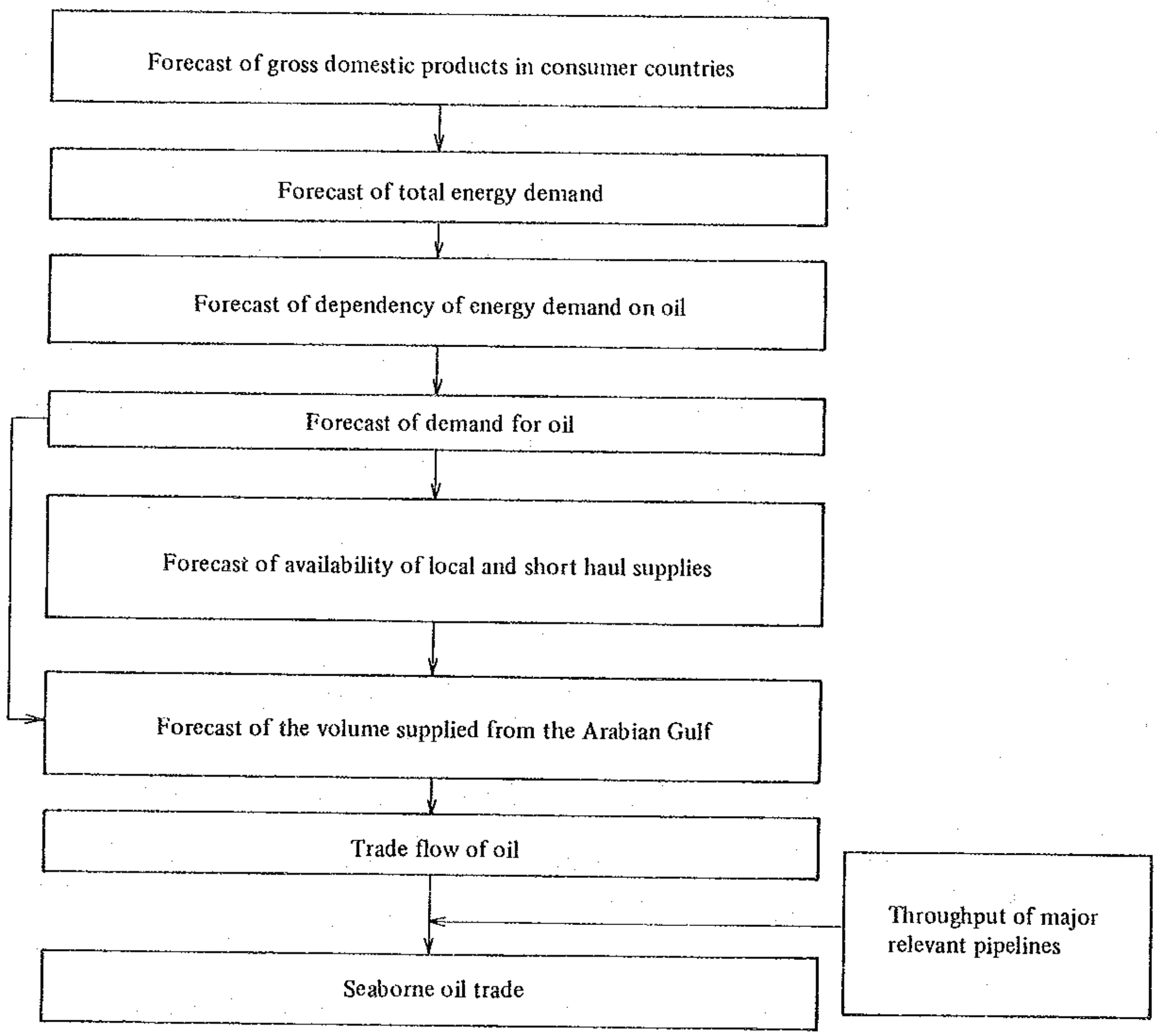


Fig. 2.2 Procedure of Forecasting Oil Seaborne Trade

(b) Dry Cargo

As shown in Fig. 2.3, the forecast of dry cargo is based upon historical analysis and the external documents like in the case of oil.

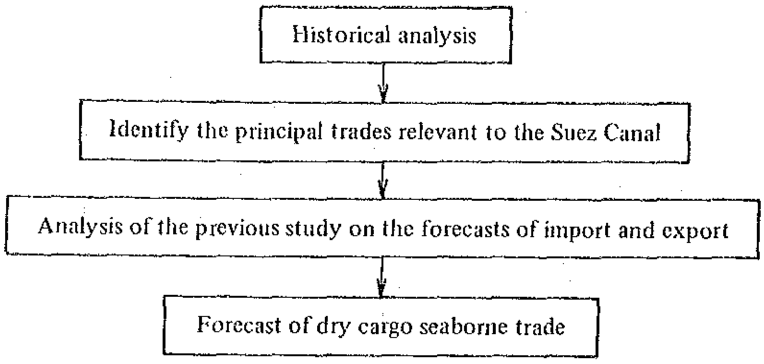


Fig. 2.3 Procedure of Forecasting Dry Cargo Seaborne Trade

2) Results

(a) Oil Table 7 (p. 41, Maunsell Report, vol. 1).
Table 8 (p. 43, Maunsell Report, vol. 1).

(b) Non-oil Table 10 (p. 58, Maunsell Report, vol. 1).
Table 11 (p. 59, Maunsell Report, vol. 1).
Table 12 (p. 60, Maunsell Report, vol. 1).

(3) World Fleet

1) Methodology

The approach adopted involves distinctions between tankers and non-tankers:

(a) projecting the fleet size taking into account deliveries of new tonnage from orders and annual scrapping and losses.

(b) determining the total demand for shipping from forecasts of worldwide growth in seaborne trade.

(c) analyzing and forecasting the state of the world freight market by comparing the forecast demand for and supply of shipping.

2) Results

(a) The current surplus tanker capacity is expected to persist through 1985. By then, however, the demand for and supply of tanker capacity should be in balance.

(b) The date of equilibrium is generally unaffected by the different schemes for the Canal Development Program.

(c) Table 16 ~ 19 (pp. 65 ~ 70, Maunsell Report, vol. 1)

(4) Transportation Cost Analysis

1) Methodology

In this study shipping costs are calculated using 1975 as the base year. These costs are projected to the year 2000 in current price terms and then related to conditions in the shipping market by taking into consideration the response of shipowners in the following way:

(a) full absorption of costs and a return to the owners under equilibrium.
(b) absorption of, at least, voyage and fixed operating costs under a slightly depressed market.
(c) to minimize losses by keeping vessels in operation provided that operating costs are lower than the cost of lay-up or scrapping under seriously depressed conditions.

2) Results
Table 38 ~ 40 (pp. 103 ~ 105, Maunsell Report, vol. 1)
Fig. 11 ~ 17 (pp. 11 ~ 17, Maunsell Report, vol. 1)

(5) Forecasting Canal Traffic
1) Methodology
Distribution of oil tonnage on each trade flow over various vessel sizes and the allocation between the Suez and the Cape routes yields the canal oil traffic. As for the distribution of the fleet on each trade (OD) pair, a kind of time series analysis is adopted for forecasts prior to 1985. After 1985, the minimum and maximum percentage of tonnage is first fixed for each size of vessel, and then the remaining tonnage is distributed on the basis of the lowest cost per cargo ton subject that it is between the given maximum and minimum percentages. Non-oil distribution is described assuming that the present situation will continue until 2000.
Regarding the choice of routes between the Suez Canal and the Cape, a probabilistic approach is used. Its discipline seems to be the least cost but is not described clearly.

2) Results
Table 20 ~ 21 (pp. 72 ~ 73, Maunsell Report, vol. 1)
Appendix B
Fig. 27, 28, 29, 30, 31 (p. 148, Maunsell Report, vol. 1)

2.1.4 Project Evaluation

(1) Methodology
Only a financial appraisal has been carried.

(2) Estimate of Costs
Fig. 36, 37, 39, 40 (p. 162), Maunsell Report, vol. 1

(3) Forecasting Revenues
Fig. 18 (p. 120). Fig 27 ~ 31 (p. 148), Maunsell Report, vol. 1.

(4) Evaluation
Table 58 (p. 172), 59 (p. 175)
Fig. 43 (p. 176), Maunsell Report, vol. 1.

The optional policy described in 2.1.1 (2) has an internal rate of return of 15% above the inflation rate and 1850 millions (US$) of financial net present value.

2.2 Sogreah's Study

2.2.1 Introduction and Main Conclusions

(1) Objectives

The report aims at determining the optimum draughts, cross-section dimensions and phasing of an enlargement of the Suez Canal.

(2) Conclusion

1) The most attractive program is a development in two stages. First, an enlargement to a 53 ft. draught should be completed as soon as possible. Second, an enlargement to 67 ft. should follow immediately and be completed by the end of 1981.

2) The tariff system leading to maximum revenues is indicated below:
$4 ~ 5/SCNRT for up to 60,000 dwt, around $4/SCNRT for 60,000 ~ 150,000 dwt, present tariff up to 1985 and $3 later for 150,000 ~ 250,000 dwt, present tariff for larger than 250,000 dwt.

3) It is recommended that a convoy system based on a 36 hour cycle be adopted by 1981.

(3) Methodology

The report covers all aspects of the development scheme. Among these, Suez Canal transit forecasts and construction cost estimation directly leads to a project evaluation which will optimize the development. The transit forecasts include future seaborne trade, the nature of the future tanker fleet and so on. The estimate of construction costs is obtained by aggregating the various component costs.

2.2.2 Projects Studied

Alternatives for Suez Canal development vary according to the following parameters.

(1) six draughts of 48, 53, 60, 67, 72 and 80 feet.
(2) 24 and 36 hour cycles of operation.
(3) five tariff levels: the existing one, 2, 3, 4 and 5 per SCNRT.

2.2.3 Forecasting the Canal Transit Volume

(1) Methodology

In forecasting the Canal transit volume, vessel types were divided into tanker and dry cargo carrier according to the methodology used. For tanker traffic, the forecast was carried out in two stages. In the first, trade volumes of crude oil and petroleum products were determined. In the second stage, the imports and exports were transposed into maritime traffic flows, taking into account all relevant factors such as the current distribution of the fleet over the various trade routes, maritime transport costs and so on.

Secondly, for dry cargo carriers, the main method was extrapolation of the past relationship between the world volume of general cargo traffic and the volume through the canal.

(2) World Economy and Seaborne Trade

1) Methodology

Seaborne trade was divided into crude oil and dry cargo. To obtain the future seaborne trade of crude oil, the following were analyzed:

a) world energy requirements.
b) oil production-consumption balance for homogeneous areas.
c) oil product deficits (or surpluses) for these areas.
d) inter-area secondary transport modes (mainly pipelines).
e) inter-area seaborne trade.

This analysis was based on various sources such as government agencies' objectives, industrial prospects and so on. However, the report does not refer to the method of using these sources. For the seaborne trade of dry cargo, the forecast was also based on external sources except in the case of general cargo, where time series extrapolations were used.

2) Results

a) Table 16 in Appendix 1 (world energy requirements, 1980 – 1985).
b) Table 19 in Appendix 1 (world oil production, consumption and deficits, 1980 – 1985).
c) Table 21, 22 in Appendix 1 (total inter area oil movements, 1980 – 1985).
d) Table 25, 26 in Appendix 1 (inter-area oil product movements, 1980 – 1985).
e) Table 27 in Appendix 1 (total world energy demand, 1990 – 2000).
f) Table 29 in Appendix 1 (total consumption of crude oil and refined products, 1990 – 2000).
g) Table 38, in Appendix 1 (Net regional Imports or exports of fossil fuels, 1990 – 2000).
h) Table 39 – 44, in Appendix 1 (total inter-area oil movements, 1990 – 2000).
i) Table 45 – 47, in Appendix 1 (total inter-area oil products, 1990 – 2000).

(3) World Fleet

1) Methodology

The method of forecasting the world fleet differs according to the target year. As for the fleet carrying capacity up to 1985, future deliveries are added to the present fleet, but also taking into account scrapping and losses. From 1985, when the tanker market will come to equilibrium, two changes are supposed to occur. One is a general increase in tanker requirements and less scrapping and losses resulting from the equilibrium condition. The other is the greater importance of technological innovations and constraints imposed by environmental or safety considerations.

2) Results

a) Table 48 in Appendix 1 (Oil carrying fleet at the end of 1975).
b) Table 49 in Appendix 1 (New building deliveries).
c) Table 50 in Appendix 1 (Scrapping and losses (From 1976 to 1985)).
d) Figure 19 in Appendix 1 (World Oil Carrying Fleet oversupply).
e) Table 56 in Appendix 1 (Distribution of the world fleet by DWT categories).

(4) Transportation Cost Analysis

1) Methodology

Direct costs (manpower, insurance, maintenance, stores and provisions, general overhead and administrative costs, etc.) and total costs (direct costs plus financial or depreciation costs) are calculated for each round-trip voyage of the relevant trade flows. Hypothetical figures are used on carrier speed, days laid up and days in port for each round trip. However, detailed methods are not mentioned.

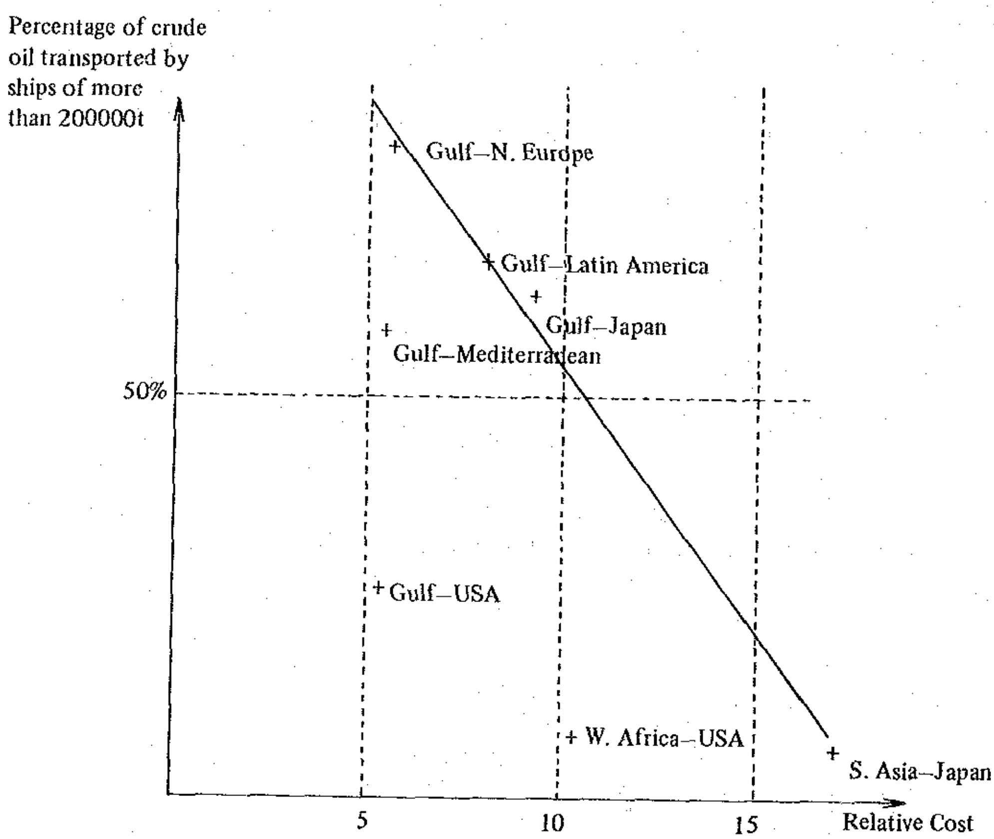
2) Results

a) Table 57 ~ 64 in Appendix 1 (Transport costs on each route relevant to the Suez Canal)

(5) Forecasting of Canal Traffic

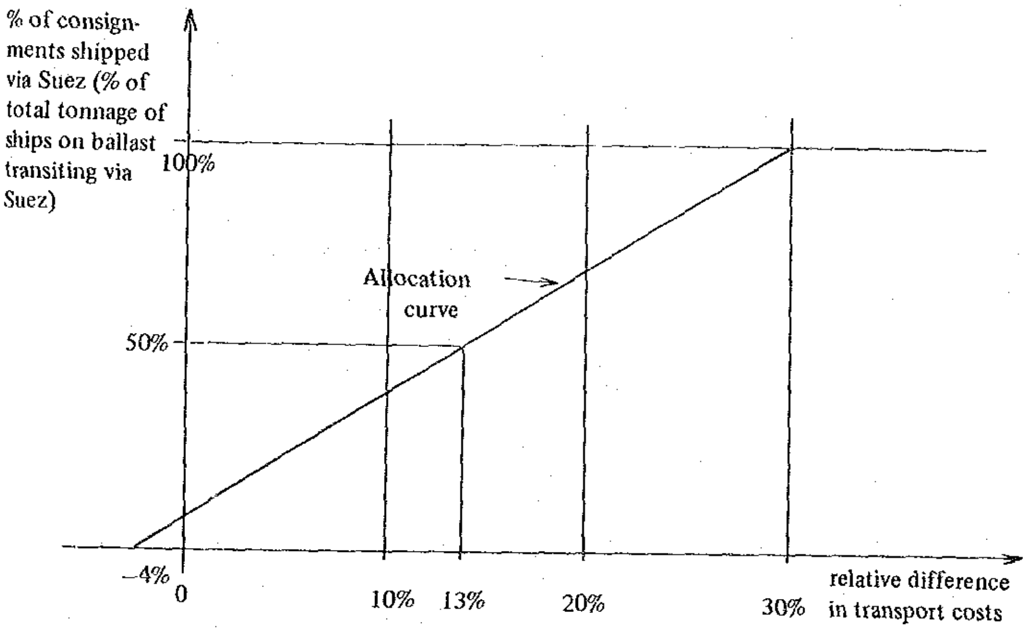
1) Methodology

Distribution of the fleet over the various routes and allocation between the Suez and the Cape give the canal traffic. As for distribution of the fleet, regression analysis is used on the ground that there is a very clear relationship between the transport distance and the degree of dependency on large tankers. The empirical data in Fig. 2.4 shows this relationship. For the forecast years, extrapolation (interpolation) is applied. For the distribution between routes, a special curve is used which gives the proportion for each route reflecting the relative cost differentials (= (Cc – Cs)/Cs), let Cc, Cs the transportation cost via the Cape and via the Suez respectively). Some assumptions are made to draw the curve, but the report does not refer to the justifications for these assumptions.



Source: Sogreah

Fig. 2.4 Percentage of Crude Oil Transported Ships of more than 200,000 dwt in Relation to the Length of Route (Expressed in Terms of the No. of Return Voyages per Year), in 1974



Source: Sogreah

Fig. 2.5 Percentage Allocation of Consignments to the Suez/Cape Routes as a Function of the Relative Difference in Transport Costs

An example of this curve is shown in Fig. 2.5. The procedure for obtaining it seems to fall into two stages. First, the volume of seaborne trade flow is allocated between size categories using results of calculations of the fleet distribution. Secondly, the allocation curve mentioned above gives the traffic volume via the Suez Canal and via the Cape.
For dry cargo traffic, the main methodology is regression analysis, reflecting the fact that world dry cargo traffic is correlated with Suez Canal traffic.

2) Results
   a) Table 67 in Appendix 1 (Distribution of crude oil transport according to tanker size on different routes).
   b) Table 68 ~ 69 Appendix 1 (% of crude oil and products carried by various size classes on various routes).
   c) Table a, b in Final report summary (Forcast traffic through the Suez Canal in number or ship per year).

2.2.4 Project Evaluation

(1) Methodology

The actualization method is used and present values are calculated for various development schemes with actualization rates of 9%, 12%, 15%. The internal rate of return for each scheme is also calculated.

(2) Estimation of Costs

1) Methodology

Cost estimation is based on January 1976 prices. Total costs consist of construction costs and maintenance costs. Construction costs include dredging, bank protection, mooring facilities, navigation control and dry excavation. Maintenance costs are the yearly expense to dredge both the canal itself and the Port Said approach channel. The aggregation of these costs gives the total cost.

2) Results

Table 3 shows the total cost estimation with respect to development schemes.

Table 2.3 Costs Estimation

Construction costs (LE million)

Draughts (ft)	Dredging	Bank protection	East breakwater Mooring facilities	Navigation aids and control*	Dry excavations*	Total
48	278	24	13	14	34	363
53	332	24	13	14	34	417
60	440	24	13	14	34	525
67	559	24	13	14	37	647
72	665	24	13	14	41	757
80	854	24	13	14	50	955

(*) The LE 34 million contract is under way. Corresponding excavations will be completed in 1999.

Maintenance costs (yearly) (LE million)

Draughts (ft)	Port Said channel	Suez Canal	Total
48	0.5	0.63	1.13
53	0.58	0.68	1.26
60	0.68	0.76	1.44
67	0.74	0.83	1.57
72	0.80	0.90	1.70
80	0.90	0.99	1.89

Source: Sogreah

(3) Measuring Revenues and Benefits

1) Methodology

In the report, economic analysis is performed only from the Egyptian point of view. Therefore benefits available from shipping cost savings are not taken into account. Revenues of the SCA are calculated by multiplying SCNRT of transit volume by the tariff. The results of canal traffic forecasts are used.

2) Results
   a) Table at page 27 ~ 29 in Final Report (Potential Oil and Petroleum Product; Traffic Forecasts).
   b) Table at page 34 in Final Report (Receipts from bulk cargo carriers).

(4) Economic Evaluation
1) Methodology
Economic evaluation is made only for Egypt. Since (2) and (3) are economic costs and benefits, net present value and internal rate of return can be calculated from data in (2) and (3).

2) Results
Economic evaluation is performed in many case according to various parameters such as the operating cycle time, the tariff level and so on. An example of these is shown in Table 2.4.
   a) Table on pages 90 ~ 91 (present values of yearly profits & internal rate of return)

Table 2.4 Economic Evaluation (Net Present Value)

Existing tariffs
Convoy cycle: 24 h

(US$ million)

Development scheme retained		48'	53'	60'		67'		73'		80'	
Reference scheme		36'	38'	38'	53'	38'	60'	38'	67'	38'	73'
traffic variant "A"	L = 09%	795	1826	2069	87	2649	423	2720	91	2461	–424
	L = 12%	364	1013	1166	13	1447	144	1469	–116	1227	–378
	L = 15%	135	575	669	–22	813	14	818	–112	601	–331
Internal Rate of Return %		18	25,9	26.8		25.5		25.2		20.8	
traffic variant "B"	L = 09%		1800	9101	142	2689	499	2910	–63	2519	–408
	L = 12%		965	1143	36	1431	209	1573	–101	1207	–375
	L = 15%		523	639	–12	781	73	887	–104	557	–332
Internal Rate of Return %			24.4	25.4		24.7		24.3		24.3	

Note: L = actualization rate.
Source: Sogreah

(5) Financial Analysis
1) Methodology
Financial analysis differs from economic analysis basically in that expenditures and receipts of all kinds are included in the calculation in nominal terms. Then inflation rates, market interest rates for actualization, the conditions of foreign currency loan and so on have to be taken into account. In the report, the following assumptions were made:
   a) prices would increase by 8% on average up to 1980, then by 6% until 1985, and thereafter at a rate of 4%.
   b) rate of interest for foreign currency loans: 6%.

2) Results

The detailed revenues and expenses are shown in the table at the end of Chap. 10 in the final report. But calculations have not been made for present net value and internal rate of return.

2.3 JICA's Study

2.3.1 Introduction and Main Conclusions

(1) Objectives

This report aims at studying the technical and financial feasibility of Phase one of the Suez Canal Development Program (53 feet Canal).

(2) Main Conclusions

Although the First Phase of the Suez Canal Development Program requires a great deal of dredging work, there are hardly any technical problems and it is considered quite possible to complete all the necessary civil engineering work within the scheduled period. The Program has also been judged economically feasible.

(3) Methodology

See Fig. 2.6 below.

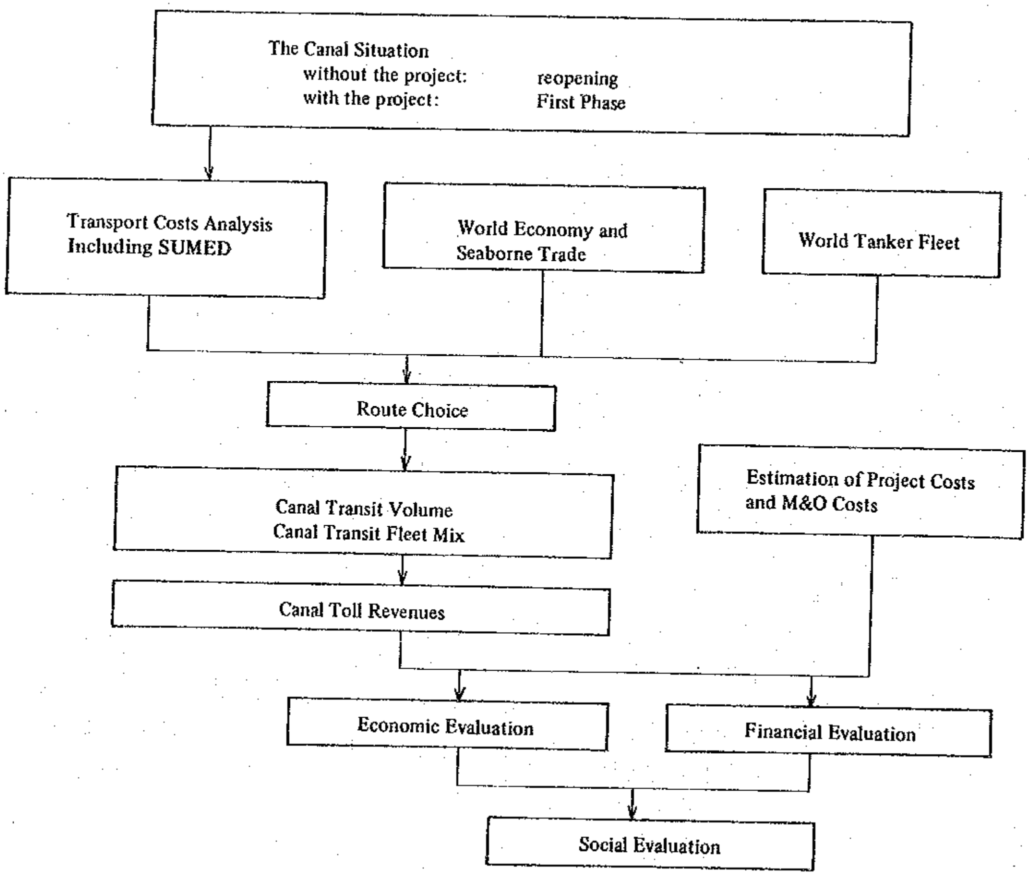


Fig. 2.6 Methodology of JICA's Study

2.3.2 Projects studied

The First Phase of the Suez Canal Development Program envisions the following dimensions.

Characteristics / Development phase	Draught	Size of tankers capable of transit
The reopening	38 feet	60,000 DWT fully laden in ballast 150,000 DWT in ballast
The 1st Phase	53 feet	150,000 DWT fully laden 200,000 DWT in ballast

It is assumed that this project will be completed at the end of 1978.

2.3.3 Forecast of Canal Transit Volume

(1) Methodology

The same methods as described in Fig. 2.6 above were used.

(2) World Economy and Seaborne Trade

1) Methodology

Concerning oil and oil products, it is based on the previous studies such as those by the OECD, EC, Japan Energy Research Institute, etc.

2) Results

Oil supply and demand is projected for Europe, U.S.A. and Japan from 1975 to 1985. The result is shown in Table 9-2-2 ~ 9-2-4 (pp. 164 ~ 166).

(3) World Fleet

1) Methodology

The method here was based upon the John I Jacobs & Company Limited "World Tanker Fleet Review" (31 Dec. 1973).

2) Results

Table 10-2-2 (p. 177)

(4) Transport Cost Analysis

1) Methodology

Selecting Arabian Gulf (A.G.) ~ Genova, A.G. ~ Rotterdam, and A.G. ~ New York as standard OD pairs, this study calculated the transport cost of S/S, C/S, and C/C for each OD pair. No consideration was given to freight market conditions.

2) Results

(a) Transport cost via SUMED is equivalent to the cost of transport via the Canal by a 200,000 DWT tanker. Hence, the 80 million ton of crude oil, the capacity of SUMED, is subtracted in advance from the Canal transit volume.

(b) Other results are shown in the Report in Figs. 8-4-1 ~ 8-4-6 (pp. 141 ~ 144).

(5) Forecasting Canal Traffic

1) Methodology

This study forecasts two cases of canal traffic volume: the case of reopening; and the First Phase of the Development Program. For each case, it adopted the following steps.

(a) All oil products flowing from the Middle East to Europe would be carried by tankers of less than 35,000 DWT via the Canal.

(b) The fleet mix of tankers for each OD pair would be assumed to be the same as the world fleet mix. In addition, the fleet mix for each OD pair was fixed at the 1975 level.

(c) Given the fleet mix of each OD pair, route choices were made based upon the lowest cost principle.

2) Results

See table 10-2-3 ~ 10-2-9.

2.3.4 Project Evaluation

(1) Mehodology

1) Economic Evaluation

It is carried out only from the viewpoint of the Egyptian economy.

2) Financial Evaluation

SCA's financial analysis as a whole instead of the project's commercial profitability analysis.

3) Social Evaluation

Qualitative analysis is applied.

(2) Estimation of Costs

It estimates the total project cost as L.E. 72,352 thousands. Also it estimates the operating and maintenance costs. The results are shown in Table 13-1-2 (p. 250) of the Report.

(3) Measuring Revenues and Benefits

The results are shown in Table 13-1-1 (p. 249) of the Report.

(4) Economic Evaluation

The Internal Rate of Return of the First Phase is 11.5%. Given this value for IRR, this study concluded that the project is economically feasible.

(5) Financial Evaluation

By drawing up the SCA's income and expenditure accounts and putting the SCA sources and application of funds in a table, the report concludes the financial situation of the SCA as very healthy with the project.

2.4 PCI's Study

2.4.1 Introduction & Main Conclusions

(1) Objectives

1) Given that the Canal draught 38 feet and that this allows vessels of 60,000 DWT to transit the Canal fully laden and vessels of up to 150,000 DWT in ballast, this study attempted to determine which structure and level of tariffs would maximize the SCA's gross income from tariffs for the period 1975 ~ 1980.

2) The study also hoped to devise a system of monitoring traffic through the Canal and the Cape, and of periodically reviewing and revising the canal tariffs so that they will continue to maximize the Authority's gross income.

(2) Conclusions

1) The interests of the SCA would be best served by charging a flat-rate of US$1.50 per SNT for ship laden as well as in ballast upon re-opening of the Canal.

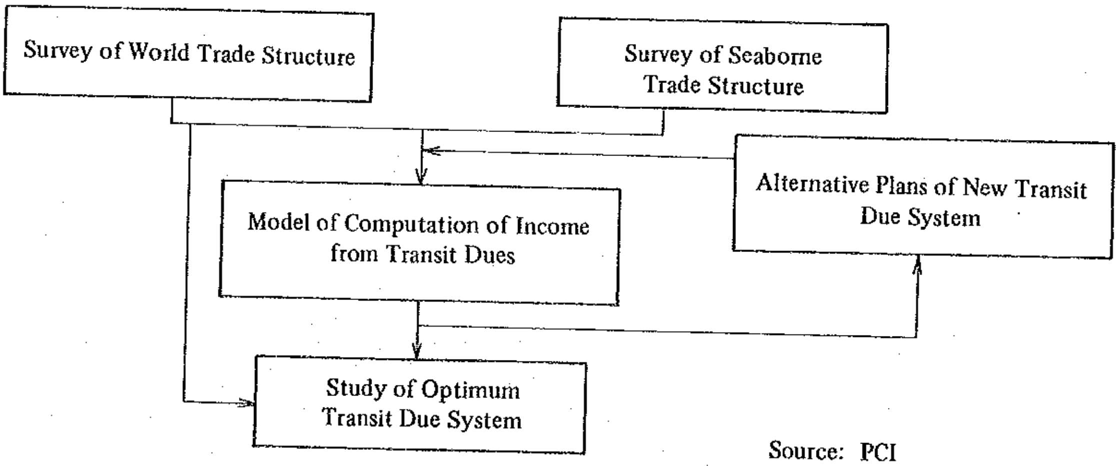
2) In order to be sure that the tariffs will always be kept at a level that will produce the maximum gross income, it is recommended that the SCA:

(a) monitor the two elements which influence ship costs and the savings from fewer voyage days; namely crew wages and bunker costs.

(b) to undertake a basic traffic and tariff study similar to this present study, in order to check whether or not there are any more fundamental changes in the "competitive position" of the Suez Canal. It would seem advisable to carry out this basic review once every year for the first three years after the reopening of the Canal, and every two years thereafter.

(3) Methodology

See Fig. 2.7.



Source: PCI

Fig. 2.7 Basic Structure of the Survey

2.4.2 Project Studied

See Table 2.5.

Table 2.5 Alternative Plans for a New Tariff Structure

(US$/SCNRT)

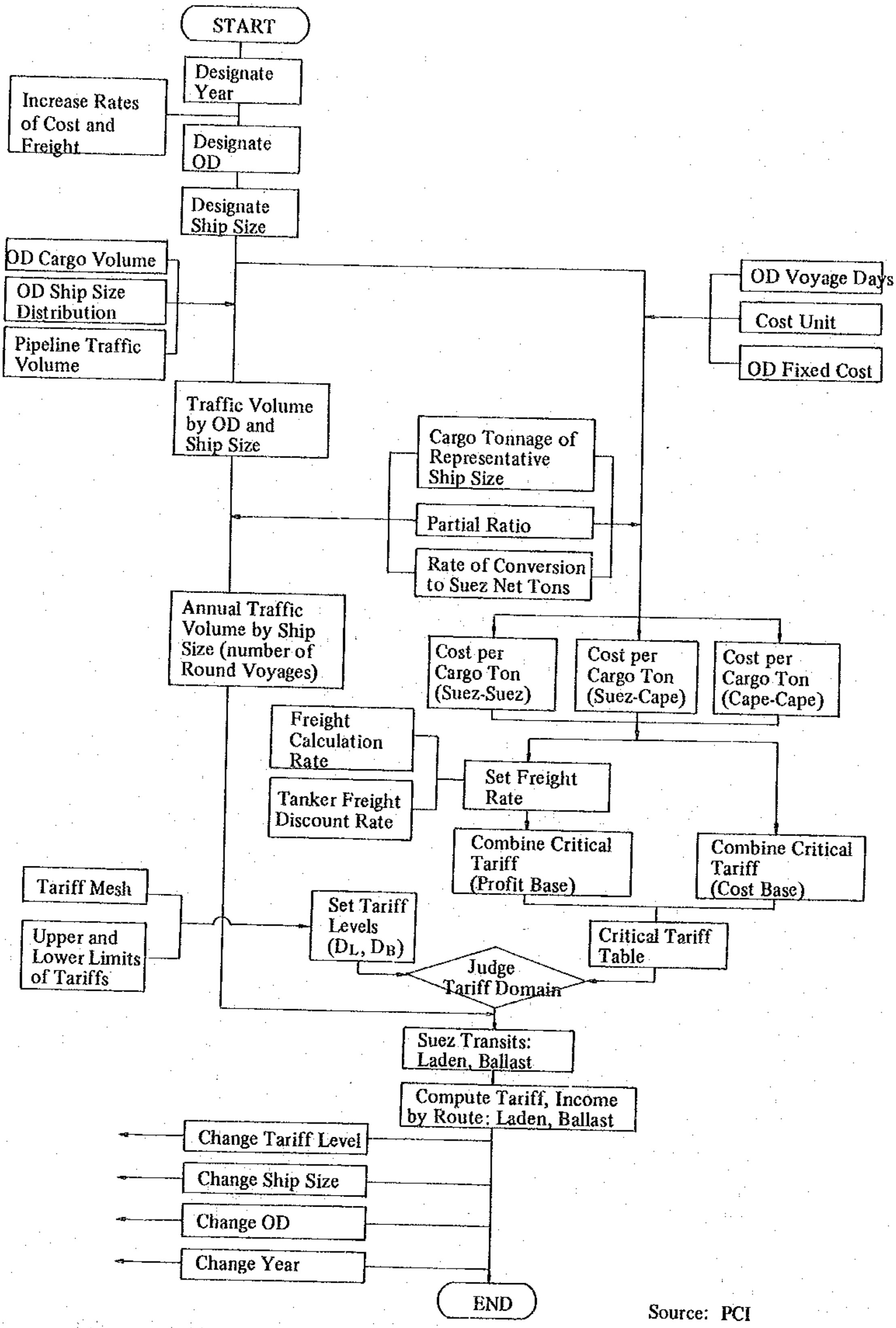
Case No.	Type	Tanker: Tariff Structure	Tanker: D_L	Tanker: D_B	Bulker and Liner (Tariff structure fixed)
I	OD/Vessel Size Variable	o Tariff variable according to to OD and vessel size. o Tariff fixed at 70% of the rate which yields maximum income.	Max. due = D_L = D_B = 5.95, when ss = 1 for Agios. Min. due = D_L = D_B = 1.05, when ss = 3 for Freeport.		2.0
II	OD Variable-1	o Tariff variable according to OD o Tariff for vessels in ballast = Tariff for vessels laden.	(Rotte) 2.5 (Fos) 3.5 (Agios) 3.0 (Freeport) 1.5	2.5 3.0 3.0 1.5	
III	OD Variable-2	o Tariff variable according to OD. o Tariff for vessels in ballast = 50% tariff for vessels laden	(Rotte) 2.5 (Fos) 3.0 (Agios) 3.0 (Freeport) 1.5	1.25 1.5 1.5 0.75	
IV	Flat Rate-1	o Tariff fixed.	1.5	1.5	1.5
V	Flat Rate-2	o Tariff fixed.	2.0	2.0	2.0
VI	Flat Rate-3	o Tariff fixed.	2.5	2.0	2.5
VII	Flat Rate-4	o Tariff fixed.	3.0	1.5	3.0

Source: PCI

2.4.3 Forecasting the Canal Transit Volume

(1) Methodology

See Fig. 6.



Source: PCI

Fig. 2.8 Flow Chart of a Model for Computation of Income from Transit Tariffs

(2) World Economy and Seaborn Trade

1) Methodology

The methodology was based on previous studies such as that of the Japan Energy Economic Research Institute, Westinform Report, Maritime Transport Research, World Economic Research, Drewry and the UN.

2) Assumptions

Five cases were assumed regarding oil flow:
Table A-III-1 (p. 182)

3) Results

a) Oil, Table III-17, p.45.
b) Grain, Table III-24, p. 54.
c) Iron ore, Table III-25, p. 54.
d) Coal, Table II-26, p. 55.
e) Other Bulk Cargoes, III-27, p. 55.
f) General Cargoes, III-28, p.56.

(3) World Fleet

1) Methodology

This was based upon previous studies such as World Tanker Fleet Review by John I. Jacobs, Shipping Statistics and Economics by H. P. Drewry, World Bulk Fleet by Fearnly and Egers Shipping Statistics and Economics, and Lloyd's Register of Shipping – Statistical Table.

2) Results

a) World Fleet
Tables IV-12 ~ IV-14 (pp. 61 ~ 63)

b) Traffic Distribution by Vessel Size
Tankers Table V-2 (p. 84)
Bulkers Table V-5 (p. 88)

(4) Transport Cost Analysis

1) Methodology

This was based primarily upon data from the shipping and shipbuilding industries in Japan. For the process of ship cost calculation, see Fig. A-II-3 (p. 171). No allowance was made for freight market conditions at this stage.

2) Results

a) Tankers Table V-11 (p. 97)
b) Bulkers Table V-12 (p. 98)

(5) Forecasting Canal Traffic

1) Methodology

a) Vessel size distribution on each OD pair based on such data sources as shown in 2.4.3 (3), it seems to be forecasted by simple extrapolation.

b) Route choice

Two kinds of models were constructed for route choices. These depended on two economic bases; a cost basis, and a profit basis.

2) Results

a) Vessel distribution on each OD pair Table V-2 (P.84) and Table V-5 (P.88).

b) Route choice

Fig. VI-1 (p. 101).

c) Number of transits

Tankers Table VI-10.

Bulkers Table VI-12.

2.4.4 Project Evaluation

(1) Methodology

This study first forecasts revenues corresponding to various alternative tariff structures. It then evaluates the tariff structures based on the following criteria:

1) Gross income of the SCA.
2) Number of vessels in transit.
3) Cost and complexity of enforcing the new tariff system.
4) Impact on world seaborn trade (from the standpoint of equity for all OD pairs).
5) Impact on the world shipping industry.
6) Ease of yearly revisions of the tariff.

This report analyses the first two items quantitatively. The others are treated only in qualitative terms.

(2) Estimation of Costs

This study does not estimate the project costs.

(3) Measuring Revenues

Table VI-16 (p. 130)

(4) Economic and Financial Evaluations

Table VI-17 (p. 135)

Case IV ($1.5 per SCRNT for both laden and balast) or Case V ($2.0 for both) is considered to be the most desirable.

See Table VI-17 (p.135).

CHAPTER 3 COMPARISON OF VARIOUS STUDIES

3.1 Comparison of Areas and Project Alternatives Studied

As shown in Table 3.1, Maunsell (1976) and Sogreah (1976) carried out full feasibility studies regarding the First and Second Phases of the Suez Canal Development Program. On the other hand, JICA (1975) dealt with only the First Stage, and PCI (1975) concerned itself with the optimal tariff structure.

In terms of coverage, the Sogreah study is the widest, then Maunsel, JICA and PCI in that order. Compared with the Sogreah study, Maunsell does not analyze alternative convoy systems nor economic feasibility.

Table 3.1 Comparison of Areas Studied

Areas \ Studies	Maunsell	Sogreah	JICA	PCI
Draught	O	O	△ (53')	△ (38')
Phasing	O	O	△ (1980)	△ (1975)
Tariff	O	O	△ (present)	O
Convoy System	△ (present)	O	△ (present)	O
Economic Evaluation	x	O	O	x
Financial Evaluation	O	O	O	O
Sensitivity Analysis	O	O	O	O

O : Determination of optional dimensions
△ : Given the dimensions shown in parentheses.
x : Not considered.

3.2 Comparison of Main Conclusions

The items on which the four studies made recommendations concerned draught, phasing, convoy systems and tariff structures.

Three of the four studies, Maunsell, Sogreah and JICA, recommend that the first phase of the Development Program (53 feet draught) should be carried out as soon as possible. However, as far as the Second Phase is concerned, the opinions of Maunsell and Sogreah showed two points of difference. First, for timing, Maunsell says that the optimal timing would be 1983, but Sogreah says 1981.

The second difference is the choice between a Dual Canal system and, a 36 hour convoy system in order to increase the daily canal capacity. Maunsell selected a strategy where even after completion of a 68 feet canal in 1983, the 24 hour system would be maintained and a dual canal system constructed in 1989. On the other hand, Sogreah recommended enlargement of Canal to a 67 feet draught and, instead of constructing a dual canal, it recommended improvement of the convoy system to 36 hour cycles.

With respect to the tariff structure, Maunsell and Sogreah have the almost same opinion, high tariff for small tankers and an inflation slide system, but PCI had other ideas, i.e. 1.5 US$/ SCNRT. This resulted from the fact that, first PCI performed its investigation under conditions of a 38 feet draught different unlike the former two. Secondly, despite the fact that results of PCI's study were almost the same as the others, PCI adopted a flat tariff system taking into account the cost of executing complicated tariff systems.

Table 3.2 Recommended Policy

Studies / Areas	Maunsell	Sogreah	JICA	PCI
Draught and Phasing	53' (1978) 68' (1983) Dual Canal (1989)	53' (as soon as possible) 67' (1981)	53' (1978)*	38' (1975)*
Tariff	High tariffs for small tankers and inflation slide system	High tariffs for small tankers and inflation slide system	Present*	1.5 $/SCNRT for both laiden and in ballast
Convoy	24 h. system (*)	36 h. system (1981)	24 h. system*	24 h. system*
Economic Evaluation		Recommendable (IRR=25%)	Recommendable (IRR=11.5%)	
Financial Evaluation	Recommendable (IRR=15% above inflation)	Recommendable (Financial Evaluation of SCA as a whole)	Recommendable (Financial Evaluation of SCA as a whole)	Recommendable (Maximum Revenue and other creterion)

Note: (1) * shows exogenously prescribed item.
(2) IRR=internal rate of return

3.3 Comparison of Methodologies

Although the kind of project varies among the four studies, their methodologies are very similar. This can be summarized in Fig.3.1. However, in each stage of the procedure shown in Fig. 3.1 the studies seem to have different approaches as described below.

3.3.1 World Ecobomy and Seaborne Trade Forecasts

(1) Oil

All studies are based on external sources such as OECD, EEC, UN.

(2) Non-oil

All the studies are based on external sources. In addition, however, Sogreah and JICA adopted a kind of time series exterpolation.

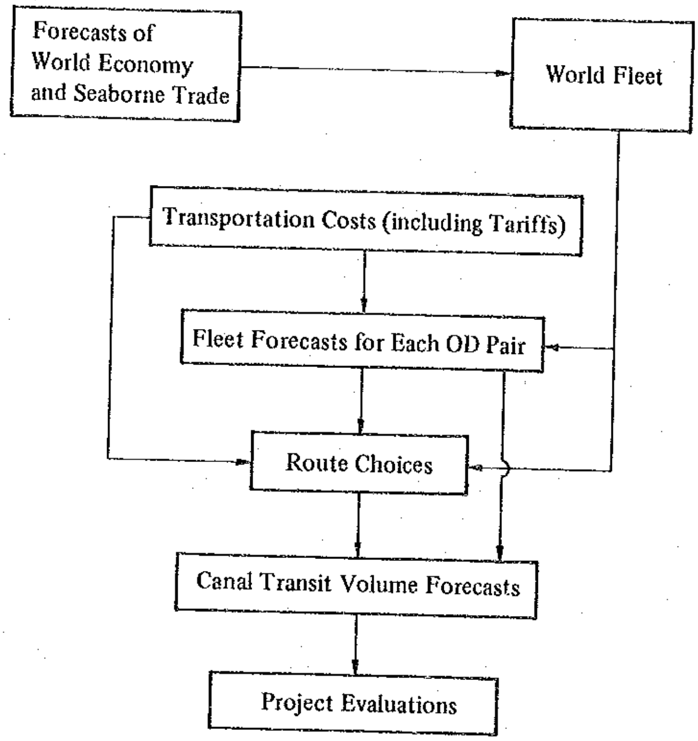


Fig. 3.1 Study Procedures

3.3.2 World Fleet Forecasts

(1) Maunsell and Sogreah used the supply and demand approaches. JICA based its forecast on external sources and PCI adopted a time series analysis.

(2) Only Maunsell analyzed the impact of Canal development on the timing of equilibrium in the freight market. Others did not.

3.3.3 Transportation Cost Analysis and Forecasts

All studies calculated total shipcosts per cargo ton by different routes, by kinds of cargos and by the size of vessels. However, the base year for their estimates varied:

1) Maunsell 1975 base.
2) Sogreah 1976 base.
3) JICA 1974 base (apparently).
4) PCI 1973 base.

3.3.4 Fleet Mix Forecasts for Each OD Pair

This area might be one of the most controversial problems because each study adopted a different approach. Maunsell approach had two steps; first, in order to forecast until 1985, it adopted a kind of extrapolation. After 1975, a least cost criterion model was used given the minimum and maximum percentage of each size of vessel.

Sogreah used a kind of regression analysis based on the observed relationship between transport distance and the extent to which larger tankers might be employed. JICA assumed that the situation prevailing in 1975 would continue until 1985. PCI seems to have carried out an extrapolation based on data for 1972.

3.3.5 Route Choices and Canal Transit Volume Forecasting

Maunsell and Sogreah adopted a probability approach based on lowest cost criterion. Both also took into account the response of shipowners to the freight market situation. However, while Maunsell's lowest cost criterion was used for the range between the given maximum and minimum ratio of route choices, Sogreah made its route choice curve based on relative cost differences.

JICA's approach was a deterministic one based on the lowest cost criterion, but did not take account of the freight market situations.

PCI's model is also deterministic but based on both lowest cost and profit maximization principles.

3.3.6 Project Evaluation

Sogreah and JICA performed not only financial evaluation but also economic evaluations from the viewpoint of the Egyptian economy. The World economy was not taken into consideration, however.

Maunsell and PCI carried out only financial evaluations from the viewpoint of the SCA.

3.4 Comparison of Forecast Results

3.4.1 Oil Seaborne Trade

Table 3.3 shows the volume of seaborne oil trade on three major routes which were forecasted by all four studies. From Table 3.3, it can be said:

(1) With respect to the value of 1980, Sogreah and PCI forecast relatively large number. This was because these two study did not subtract the SUMED throughput. On the other hand, Maunsell and JICA did.

(2) Generally speaking, the trade flow from AG to USA increases. This is due to the oil import policy of the U.S.A.

(3) The value for 1990 and 2000 forecast by Maunsell are relatively close to those predicted by Sogreah.

Table 3.3 Forecast of Seaborne Oil Trade (million tons)

Year	Route	Maunsell**	Sogreah	JICA**	PCI
1975	AG → N/W Europe AG → Mediter AG → USA	245 140 16	323* 139* 62*	260 134 87	298 215 57
1980	AG → N/W Europe AG → Mediter AG → USA	193 137 110	269 209 190	141 128 120	329 238 123
1985	AG → N/W Europe AG → Mediter AG → USA	210 137 120	279 273 235	207 172 101	– – –
1990	AG → N/W Europe AG → Mediter AG → USA	265 180 143	270*** 290*** 155***	– – –	– – –
2000	AG → N/W Europe AG → Mediter AG → USA	389 283 194	310*** 305*** 135***	– – –	– – –

* 1974
** Subtracted SUMED throughput
*** Subtracted Arabian Peninsula pipeline throughput

3.4.2 World Fleet Forecasting

The duration of the current tanker surplus is one of the crucial problems in the feasibility of the Canal Development.

For this tanker market, Maunsell forecast that tanker surplus would continue until 1985 and that around 1985 the market would come to equilibrium. On the other hand, Sogreah forecast the current situation would persist until 1988.

3.4.3 Transit Volume Forecasts

Only Maunsell and Sogreah carried out long range forecasting of Canal transit volume for the period 1980 ~ 2000. Their forecasts are shown in Table 3.4. Transit volume would gradually increase, but Sogreah is more optimistic than Maunsell in terms of both the absolute value and the growth rate.

Table 3.4 Transit Forecasting

	Maunsell	Sogreah
1980	54	65
1985	75	78
1990	74	86
1995	75	94
2000	84	102

Note: (1) Number of ships per day
(2) In the case of the policy recommended by each study.

3.4.4 Project Evaluation

Comparison in terms of project evaluation is very difficult because:

(1) Some studies aimed only financial evaluation.

(2) Each study which carried out financial evaluation made only one of two kinds of financial evaluation, the commercial profitability evaluation of the project, or financial evaluation of the SCA as a whole.

(3) Some studies used current prices and other used real term prices.

For these reasons, only the financial and economic internal rate of return for each studies is listed in Table 3.2.

PART VII

REVIEW OF PREVIOUS STUDIES ON SHIPPING

CHAPTER 1 INTRODUCTION

This part, together with part 6, constitutes the consolidation and analysis of previous study reports related on the "Systems Analysis". The information given in this part on these reports is limited to the minimum necessary to introduce them. To learn about the contents in detail, please refer to the listed original documents themselves.

This part is divided into three chapters, including this one, classifying the market forecast studies into the fields of dry cargo trades (Chapter 2) and tanker trade (Chapter 3). With regard to the liner shipping, particular mention is made here of the recently published "Middle East Liner Shipping: An Economic Analysis of Traffic Services, Ports and Future Prospects" by H.P. Drewry because it is a report on liner ship activities in the Middle Ease region having close relations with the Suez Canal.

CHAPTER 2 DRY BULK TRADE

2.1 Westinform

Title: Bulk Cargoes for the Tramp Trades on less than 39 ft. Draft
– Shipping report number 315 –

Publisher: Westinform

Date of Publication: 1977

Period of Forecast: 1974 ~ 1980

Forecast Items: Forecast of demand for market (a great variety of items) of small and medium dry cargo ships (less than 39 ft. draft).
Items: Foods, agricultural products (grains, wooden products, phosphate, chemicals, fertilizer), industrial materials (iron ore, coal, bauxite, alumina, other mineral ores), and others.

Method of Analysis:

(1) Used O/D matrix as base, taking into consideration trends in production centers and consumer centers.
(2) Analyzed the optimum ship size for each route by taking into consideration routes, port and harbor conditions and economics.

Data Used: Fearnley & Egers and Westinform's own data

Remarks: (1) Ship sizes are classified by draft.
(2) Minor bulk cargoes are taken up in detail.

2.2 Terminal Operator

Title: A Review of the Shipping Market

Publisher: Terminal Operator Limited

Date of Publication: October, 1977

Period of Forecast: 1977 ~ 1980

Forecast Items: Forecast of supply-demand balance of both tanker and dry cargo markets.

Method of Analysis:

(1) Volume of ship supply estimated on the basis of ships on order, ships delivered and ships scrapped each year.
(2) Converted into volume of transport (ton/mile) according to productivity (approximate value) as of 1976.
(3) Growth rates of oil and oil products and dry bulk cargoes and overall growth rate estimated.
(4) Yearly volume of cargo movements (ton/mile) calculated by taking the extension of average distance (100 miles annually).
(5) Supply-demand balance calculated by taking the tanker and dry bulk cargo markets as one.
(6) Combination carriers divided in half for both markets.

Data Used: Fearnley & Egers and OECD

Remarks: (1) Volume of orders placed taken into account.
(2) Tanker and dry bulk cargo markets treated as one.
(3) Suggests need for calculating supply-demand balance of individual markets.

2.3 Alcan

Title: World Ship Charter Market Forecast

Publisher: Alcan Shipping Services

Date of Publication: 1975

Period of Forecast: 1975 ~ 1980

Forecast Items: Forecast of tanker, bulk carrier and general cargo ship markets (including freightage).

Method of Analysis:

(1) Conditions in supply and consumption areas studied by items.

(2) Volume of cargo movements forecast by route and ship size on the basis of O/D matrix.

(3) Tonnage volume estimated by ship size, taking into account ships scheduled for delivery, ships demolished and slippage.

(4) Combination carriers calculated as half, but percentage of division differs according to ship size.

(5) Supply-demand balance forecast by the ship size.

Data Used: UN, Fearnley & Egers

Remarks:

(1) Forecast items are numerous. Forecast of volume of cargo movements is detailed. (Surveys by areas, in particular, are detailed.)

(2) Supply-demand balance calculated by ship size.

(3) General cargo ships included.

(4) Suez Canal cases treated.

(5) Supply-demand of LPG and LNG mentioned.

(6) Method of forecasting maritime cargo movements concrete and easy to understand.

2.4 H.P. Drewry (Large Bulk Carriers)

Title: The Market for Large Bulk Carriers (over 50,000 DWT)
– A Review of Trends in Supply/Demand –

Publisher: H.P. Drewry (Shipping Consultants) Limited

Date of Publication: September 1975

Period of Forecast: 1975 ~ 1979

Forecast Items: Dry bulk carriers: forecast of volume of maritime cargo movements and estimate of necessary tonnage.

Method of Analysis:

(1) Role of large bulk carriers after second half of 1960s, process of development, hull structure, pattern of navigation, marketing, pattern of ship assignment and competitiveness analyzed.

(2) Volume of cargo moved by major bulk carriers and minor bulk carriers forecast.
On the basis of the above, large bulk carriers' transport share and tonnage necessary to keep up with productivity calculated.

(3) Growth rate of cargoes in 1975/79 estimated.

(4) Combination carriers divided by cargo and ship size.

Data Used: F&E and H.P. Drewry

Remarks:

(1) Valuable reference for understanding history of large bulk carriers and their situation today.

(2) Treatment of combination carriers very interesting.

2.5 H.P. Drewry (Handy-Sized Bulk Carriers)

Title: The Market for Handy-Sized Bulk Carriers (20/35,000 DWT)
– A Review of Trends in Supply/Demand –

Publisher: H.P. Drewry (Shipping Consultants) Limited

Date of Publication: November 1974

Period of Forecast: 1974 ~ 1980

Forecast Items: Dry bulk cargo: Forecasts of volume of cargo moved by handy-sized bulk carriers and necessary tonnage.

Method of Analysis:

(1) Market forecast up to 1980 using as reference the records of the past 10 years on the handy-sized bulk carriers' role, process of development, hull structure, dockyards where they were constructed, pattern of navigation, marketing, pattern of ship assignment, and transport activities.

(2) Volume of all items transported by handy-sized bulk carriers forecast from macro viewpoint.

(3) Handy-sized bulk carriers' transport share by item and tonnage necessary to keep up with productivity (ton mile/DWT, annually) calculated by taking into account various conditions.

Data Used: Fearnley & Egers, H.P. Drewry

Remarks: (1) Can learn history and present situation of handy-sized bulk carriers.

(2) Valuable reference in order to understand different uses by item of handy-sized bulk carriers.

2.6 STAL-LAVAL

Title: Marine Market Analysis
– FORECAST; Fleet Development and Newbuilding Requirements –

Publisher: STAL-LAVAL

Date of Publication: March 1978

Period of Forecast: 1978 ~ 1985

Forecast Item: Newbuilding requirements calculated from forecast of maritime cargo moved by containerships (5,000 D/W up), bulk carriers (50,000 D/W up), tankers (50,000 D/W up) and gas carriers (20,000 D/W up).

Method of Analysis:

(1) Macro forecast of maritime cargo movements by item. General cargo and container cargo analyzed in relation to economic growth; iron ore analyzed in relation to raw steel production; grain and other bulk cargoes in relation to projection of long-term trends; and oil in relation to economic growth and consumption co-efficients (taking into account Alaskan and North Sea oil production).

(2) Average transport distance by item calculated to produce ton/mile figures.

(3) Necessary tonnage calculated according to ships' productivity.

(4) Newbuilding requirements calculated in reference to tonnage required, ships on order and ships scrapped.

Data Used: Sources not given.

Remarks: (1) Long-term trends given stress in making macro forecast of maritime cargo movements.
(2) Simple and easy methods of analysis employed.
(3) Estimates of growth rate of cargoes by item and of average transport distance by item helpful.

2.7 H.P. Drewry (Dry Bulk Cargo)

Title: Ocean Trade and Transportation of Dry Bulk Cargo
– A Review of Trends in Major and Minor Bulk Trades 1965 ~ 1985 –

Publisher: H.P. Drewry (Shipping Consultants) Limited

Date of Publication: August 1976

Period of Forecast: 1985

Forecast Items: Forecast of major and minor dry cargo movements and estimate of necessary tonnage by ship size.

Method of Analysis:

(1) Five major dry bulk cargo movements forecast by using O/D matrix on the basis of analysis of condition in consumption and production areas. Minor dry bulk cargo movements forecast on the basis of growth estimates.
(2) Ton/mile figures calculated on the basis of estimated average transport distances.
(3) Demand for bulk carriers by ship size estimated in accordance with transport share of bulk carriers (by item in case of major dry bulk cargoes) and their productivity.

Data Used: Fearnley & Egers, H.P. Drewry

Remarks: (1) Stress given to survey of movements of all dry bulk cargoes.
(2) As many as 20 items of minor bulk cargo, in particular, surveyed.

2.8 Lambert Brothers

Title: Small Bulk Carrier: Supply/Demand Analysis and Forecast: Bulk Carriers of 18,000 ~ 35,000 DWT 1974/1980

Publisher: Lambert Brothers Shipping, Ltd.

Date of Publication: November 1976

Period of Forecast: 1974 ~ 1980

Forecast Items: Estimate of volume of cargoes moved by small bulk carriers calculated and newbuilding requirements.

Method of Analysis:

(1) Trends in demand for small bulk carriers of iron ore and coal analyzed according to places of loading and unloading. Transport share of grain by ship size calculated from total volume of grain cargo movements (on the basis of surveys conducted in the U.S.) and volume of transport by ship size estimated. Growth rates of alumina/bauxite and minor bulk cargoes estimated.
(2) Ton/mile figures converted into necessary tonnage by using productivity.
(3) Newbuilding requirements estimated, taking into account ships scrapped and ships on order, in addition to required tonnage.

Data Used: Sources not given.

Remarks: Volume of scrapped ships calculated according to ship age may make valuable reference.

2.9 Maritime Transport Research

Title: Dry Cargo Ship Demand to 1985 (Vol. 2-6)

Publisher: Maritime Transport Research

Date of Publication: 1976 ~ 1977

Period of Forecast: 1985

Forecast Items: Forecast of volume of maritime cargo movements of foods and drinks, raw materials, manufactures and chemicals; and estimate of tonnage requirements.

Method of Analysis:

(1) Trends in industries and trades at major places of export and import and their past transition analyzed, and estimate made by using O/D matrix.

(2) Tonnage requirements calculated according to bulk carriers and general bulk cargo carriers (containers, tramps and liner ships).

Data Used: UN, Fearnley & Egers, OECD, etc.

Remarks: (1) Trade, industrial and transport analyses by item may be helpful.

(2) Emphasis placed on forecast of volume of maritime cargo movements and matrixes made of 215 items.

(3) Volume of scrapped ships analyzed, effects of market analyzed, and impact of shipbuilding credits analyzed.

CHAPTER 3 TANKER TRADES

3.1 OECD Maritime Transport

Title: Maritime Transport 1976
Publisher: OECD, Maritime Transport Committee
Date of Publication: 1977
Period of Forecast: 1977 ~ 1985
Forecast Item: Supply-demand of oil carriers
Method of Analysis:

(1) OECD "World Energy Outlook" (Paris 1977) referred to in regard to oil transport demand outlook.

(2) Slow steaming and laid-up tankers included in ship supply. As regards combination carriers used as tankers and tankers used for grain trade, volume of scrapping, lost and conversion estimated. As for newbuildings, it is assumed that there will be no new orders.

(3) As for changes in demand, four cases conceivable from different GDP growth rates and energy policies are assumed.

(4) As regards changes in supply, three cases (Cape laden-Suez ballast, Cape both ways or Suez both ways, and maximum utilization of pipelines) conceivable from differences in degree of utilization of Suez and pipelines assumed.

(5) The time for recovery of supply-demand balance forecast by making various combinations of different supply and demand situations.

(6) Reference made to various factors, such as removal of tankers from slow steaming or from lay-up, and increased use of Suez and pipelines during the supply-demand balance recovery period.

Data Used: Mentioned above.

Remarks: Recovery of supply-demand balance forecast on assumption that current energy policies will remain unchanged. However, the moves to study positive energy conservation policy with a view to resolving energy problems, the probability of their execution and their effect on supply-demand balance are explained.

3.2 Exxon Marine

Title: The World Tanker Fleet: Outlook for the Future (Exxon Marine Vol. 22 No. 2)
Publisher: Exxon Corporation
Date of Publication: Autumn 1977
Period of Forecast: 1977 ~ 1985
Forecast Items: Forecast of supply-demand of tankers by ship size, such as VLCC/ULCC (160,000 tons up), large MST (90,000 ~ 160,000 tons), small MST (60,000 ~ 90,000 tons) and product tankers (16,000 ~ 60,000 tons).
Method of Analysis:

(1) For forecasting demand, growth rate of energy consumption estimated, taking into account possible effects of increased production of Alaskan and Mexican oil.

(2) Completion of 2nd Stage Development of Suez anticipated, and sharp increase in capacity of Middle East pipelines assumed.

(3) As regards supply, it is assumed that 50% of combination carriers are engaged

in oil transport. Effects of the U.S. cargo preference legislation and SBT treaty studied.

(4) Technical and economic study made of such surplus relief measures as slow steaming, lay-up and idling. On the basis of these, the supply-demand of tankers by afore-mentioned size for the period until 1985 is projected.

Data Used:

Remarks: (1) Transport capacity of Middle East pipelines – five in use and one under construction – in 1981 and 1985 estimated.

(2) This paper was published in "Exxon Marine", an in-house magazine for personnel of Exxon Corporation and its affiliates.

3.3 Tilney

Title: World Tanker Prospects 1979 ~ 1982

Publisher: Tilney & Co.

Date of Publication: January 1979

Period of Forecast: 1979 ~ 1982

Forecast Item: Forecast of tanker supply-demand.

Method of Analysis:

(1) As for tanker supply, volume of scrapping estimated, judging from age of current ships. Volume of ships on order, year of delivery, volume of laid-up ships and volume of combination carriers engaged in oil trading are forecast.

(2) As for tanker demand, annual oil consumption growth rate in major Free World and developing countries estimated. (In making the estimates, oil consumption in the past, changes in historical pattern, effects of supply pattern on demand, changes in sources of supply, and other factors analyzed.) Trends in crude oil stockpiling (in Japan, U.S., etc.) taken into account.

Data Used: Various shipping publications, and data collected from American and British oil companies and shipping companies.

Remarks: Future new orders are not taken into account.

3.4 Terminal Operators

Title: World Oil Demand and Tanker Markets 1978 ~ 1981

Publisher: Terminal Operators, Ltd.

Period of Forecast: 1978 ~ 1981

Forecast Items: Forecast of supply-demand of crude oil tankers and products tankers

Method of Analysis:

(1) As for demand, detailed analysis made of crude oil production and consumption in 1976, O/D survey made by using trade matrixes compiled for 10 areas, and ton/mile figures were calculated from representative matrix distances. Data on export volume by product and by area available.

(2) Areawise growth rate of oil consumption in 1976 ~ 1981 assumed from growth rates of both GNP and oil consumption in the 1960 ~ 1976 period.

(3) Current oil refining capacity analyzed and future capacity estimated. Volume of import of oil products for consumption within import region estimated.

(4) As for supply, oil products tankers divided by size. Fifty precent of combination carriers added to tonnage of crude oil tankers. Newbuildings in 1977 off-

set by scrapping. Breakdown of laid-up tankers by ship age studied. Lay-up, slow steaming and sub-optimal programming calculated. It was assumed that oil tankers are scrapped after 17 years.

(5) Port and harbor construction projects in the U.S. and Canada, SBT COW, LOT and other factors examined.

Data Used: U.N. Statistical Yearbook, International Petroleum Encyclopedia, Petroleum Economist, J.I. Jacobs' "World Tanker Fleet Review", etc.

Remarks: (1) Detailed study made of both supply and demand sectors.

(2) Analysis of products tankers particularly detailed.

3.5 OECD World Energy Outlook

Title: World Energy Outlook

Publisher: OECD

Date of Publication: 1977

Period of Forecast: 15 years from 1977

Forecast Items: All kinds of energy estimates for OECD and other areas, supply-demand of energy within OECD until 1985, until 1990, and after 1990. Energy estimates for other areas until 1985.

Method of Analysis:

(1) Three cases of economic growth rate assumed. Economic growth rates of OECD until 1985 and energy consumption-GDP co-efficients estimated. Reference made to natural gas and atomic energy in OECD.

(2) World Bank surveys used as base for areas other than OECD.

Data Used: Data each country furnished by various national institutions.

Remarks: Revised edition of OECD "Energy Prospects to 1985" (1975).

3.6 WAES

Title: Energy Global Prospects 1985~2000

Publisher: Workshop on Alternative Energy Strategies (WAES)

Date of Publication: 1977

Period of Forefast: 1985~2000

Forecast Item: Long-term prospects concerning all energy

Method of Analysis:

(1) Fear of unstable supply of oil pointed out and alternative energy sources studied. Alternative energy sources include nuclear energy (including nuclear fusion), coal, natural gas, oil sand, solar energy, wind and tidal energy.

(2) Two or three variations of world economic growth rate, oil prices and national energy policies for 1977~85 prepared in working out future prospects.

(3) Prospects for 1985~2000 worked out, by taking into consideration possible changes not only in economic growth rate and oil prices but also in such factors as discovery of additional oil reserves, production cutbacks by OPEC and increase in coal and nuclear energy supplies. Technical problems, and problems concerning sources of revenue and ecology also analyzed.

(4) Demand-growth rate co-efficient estimated. Consumer activities divided into 69 categories for analysis.

Data Used:

Remarks: Global joint work as regards alternative energy strategies (participated in by Japanese also).

3.7 U.S. Central Intelligence Agency

Title: The International Energy Situation: Outlook to 1985
Publisher: Central Intelligence Agency, U.S. Government
Date of Publication: April 1977
Period of Forecast: 1977~1985
Forecast Item: World energy situation until 1985
Method of Analysis:

(1) Aggregate energy demand in major consumption areas calculated in the light of economic growth rate (estimated by the formula of weighted moving average for four years) after conservation adjustment was made. (View expressed that it is difficult to measure effects of conservation efforts.)
(2) As for supply, energy production of OECD member nations estimated. Possibility of production increase by OPEC, particularly Saudi Arabia, studied.
(3) Production forecasts of North Sea, Alaskan, Mexican, Egyptian and Soviet oil analyzed. Reference made to ecological issues in relation to nuclear energy and coal.

Data Used:
Remarks: An 18-page report. Possibility of supply shortage in near future strongly pointed out.

3.8 Exxon World Energy

Title: World Energy Outlook
Publisher: Exxon Corporation
Date of Publication: April 1978
Period of Forecast: 1978~1990
Forecast Item: World energy forecast until 1990
Method of Analysis:

(1) Forecast made on following premises: (a) Oil price will rise by as much as inflation rate, (b) Economic growth rate will be lower than in the past, (c) Stability of international politics, economy and cooperation will continue, (d) Energy consumer countries will make conservation efforts and step up development of new supply sources, (e) Oil will continue to be a marginal resource and OPEC will continue to produce enough to meet demand.
(2) Outlook of consumption and outlook of production of oil, natural gas, nuclear energy, coal, hydro power, etc. in major energy-consuming countries analyzed in detail.
(3) Increase rate of energy demand calculated from economic growth rates of major energy-consuming countries. Demand volume calculated by multiplying energy demand increase rate by energy conservation rate.

Data Used:
Remarks: Exxon compiles this Energy Outlook once every year. This was compiled as part of the Exxon Background Series.

PART VIII

DATA HANDBOOK

CHAPTER 1 INTRODUCTION

Data handbook is one part of the basic information system. In this data handbook, the basic data to understand the trends and present situations on world economy, trade flow, and maritime transport are summarized. The data are consist of following four categories:

I World Fleet,
II Freight Market,
III Seaborne Shipping,
IV World Economy and Trades.

The data in each category are shown by the form of table or figure with data source.

CHAPTER 2 DATA LIST

In this chapter, we show only the titles of data tables.

LIST OF DATA NAMES

I. World Fleet

II. Freight Market

III. Seaborne Shipping

IV. World Economy and Trades

Data Sources

	Publication	Title (Yearly or Monthly)	Publication 1. Year 2. Month	Containing Data 1. The newest data 2. Covering year
1	United Nations	Statistical Yearbook (Yearly)	1. The next year indicated on the cover 2. Summer	1. The previous year indicated on the cover 2. Last 10 years
2	United Nations	Monthly Bulletin of Statistics (Monthly)	1. – 2. The 21st of the month indicated on the cover	1. The same year indicated on the cover 2. Last 5 years
3	OECD	Economic Outlook (Semi yearly)	1. The same year indicated on the cover 2. July, December	1. The same year indicated on the cover 2. Last 3 years
4	OECD	Maritime Transport (Yearly)	1. The next year indicated on the cover 2. Summer	1. The previous year indicated on the cover 2. Last 3 years
5	FAO	World Grain Trade Statistics (Yearly, but had closed since 1974)	1. Next year indicated on the cover 2. –	1. The previous year indicated on the cover 2. Last 3 years
6	FAO	Monthly Bulletin of statistics (Monthly)	1. The same year indicated on the cover 2. The 5th of the month indicated on the cover	1. The same year indicated on the cover 2. Last 4 years
7	The British Petroleum Company Limited	Statistical Review of the the World Oil Industry (Yearly)	1. The next year indicated on the cover 2. August	1. The same year indicated on the cover 2. Last 11 years
8	Fearnley & Egers Chartering Co., Ltd.	Trades of World Bulk Carriers (Yearly)	1. The next year indicated on the cover 2. March	1. The same year indicated on the cover 2. Last 11 years
9	Panama Canal Company, Panama Zone Government	Annual Report (Yearly)	1. The next year indicated on the cover 2. –	1. The 30th of Sept. of the same year indicated on the cover 2. Last 2~4 years
10	Suez Canal Authority	Suez Canal Report (Yearly)	1. The next year indicated on the cover 2. –	1. The same year indicated on the cover 2. The same year
11	Fearnley & Egers Chartering Co., Ltd.	Review (Yearly)	1. The next year indicated on the cover 2. January	1. The same year indicated on the cover 2. Last 1~8 years
12	Fearnley & Egers Chartering Co., Ltd.	World Bulk Fleet (Semi yearly)	1. The same year & the next year indicated on the cover 2. August & February	1. The same year indicated on the cover 2. Last 1~10 years

Publication		Title (Yearly or Monthly)	Publication 1. Year 2. Month	Containing Data 1. The newest data 2. Covering year
13	Lloyd's Register of Shipping	Statistical Tables (Yearly)	1. The same year indicated on the cover 2. November	1. The same year indicated on the cover 2. Last 1~10 years
14	John I. Jacobs & Co., Ltd.	World Tanker Fleet Review (Semi yearly)	1. The same year & the next year indicated on the cover 2. August & February	1. The same year indicated on the cover 2. Last 1~10 years

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