Appendix A Zone and Commodity Type in the Study

A.1 Zone

North of the Suez Canal

Study Team Code	SCA Code		
	Code	Country	SCA Yearly Report
N.Africa	N01	Egypt (Med.)	East, S.E. Mediterranean
E.Med	N02	Lebanon	East, S.E. Mediterranean
E.Med	N03	Syria	East, S.E. Mediterranean
E.Med	N04	Turkey	East, S.E. Mediterranean
E.Med	N05	Cyprus	East, S.E. Mediterranean
E.Med	N07	Israel (Med.)	East, S.E. Mediterranean
E.Med	N09	Others	East, S.E. Mediterranean
E.Med	N10	Greece	North Mediterranean
E.Med	N11	Albania	North Mediterranean
E.Med	N12	Solvenia/Croatia	North Mediterranean
W.Med	N13	Italy	North Mediterranean
W.Med	N14	France (Med.)	North Mediterranean
E.Med	N15	Malta	North Mediterranean
E.Med	N19	Others	North Mediterranean
W.Med	N20	Spain	West, S.W. Mediterranean
N.Africa	N21	Libya	West, S.W. Mediterranean
N.Africa	N22	Tunisia	West, S.W. Mediterranean
N.Africa	N23	Algeria	West, S.W. Mediterranean
N.Africa	N24	Morocco (Med.)	West, S.W. Mediterranean
N.Africa	N29	Others	West, S.W. Mediterranean
E.Med	N30	Russia (Black S.)	Black Sea
E.Med	N31	Romania	Black Sea
E.Med	N32	Bulgaria	Black Sea
E.Med	N33	Ukrania	Black Sea
E.Med	N34	Gorgia	Black Sea
E.Med	N35	Athrbegan	Black Sea
E.Med	N39	Others	Black Sea
NW.EU	N40	Portugal	North, West Euorpe & U.K.
NW.EU	N41	France (Atlantic)	North, West Euorpe & U.K.
NW.EU	N42	Belgium	North, West Euorpe & U.K.
NW.EU	N43	Netherlands	North, West Euorpe & U.K.
NW.EU	N44	Germany	North, West Euorpe & U.K.
NW.EU	N45	Denmark	North, West Euorpe & U.K.
NW.EU	N46	U.K.	North, West Euorpe & U.K.
NW.EU	N47	Norway	North, West Euorpe & U.K.
NW.EU	N48	Sweden	North, West Euorpe & U.K.
NW.EU	N49	Others	North, West Euorpe & U.K.
NW.EU	N50	Poland	Baltic Sea
NW.EU	N51	Ireland	Baltic Sea
NW.EU	N52	Russia (Baltic)	Baltic Sea
NW.EU	N54	Finland	Baltic Sea
NW.EU	N55	Letwania	Baltic Sea
NW.EU	N56	Latevia	Baltic Sea
NW.EU	N57	Estonia	Baltic Sea
NW.EU	N58	Icelands	Baltic Sea
NW.EU	N59	Others	Baltic Sea
N.America.E	N60	United States	American
N.America.E	N61	Canada	American
CS.America	N62	Mexico	American
CS.America	N63	Cuba	American
CS.America	N64	Panama	American
CS.America	N65	Venezuela	American
CS.America	N66	Brazil	American
CS.America	N67	Ecuador	American
CS.America	N68	El Salvador	American
CS.America	N69	Others	American
N.Africa	N70	Morocco (Atlantic)	Others
W.Africa	N71	Canary Is.	Others
W.Africa	N72	Mauritania	Others
W.Africa	N73	Guinea Bissau	Others
W.Africa	N74	Senegal	Others
W.Africa	N75	Nigeria	Others
W.Africa	N79	Others	Others

South of the Suez Canal

Study Team Code	SCA Code		
	Code	Country	SCA Yearly Report
A.Gulf	S01	Egypt (R.S.)	Red Sea
A.Gulf	S02	Jordan	Red Sea
A.Gulf	S03	Saudi Arabia (R.S.)	Red Sea
A.Gulf	S04	Sudan	Red Sea
A.Gulf	S05	Ethiopia	Red Sea
A.Gulf	S06	Yemen	Red Sea
A.Gulf	S07	Israel (R.S.)	Red Sea
A.Gulf	S08	Dgipouti	Red Sea
A.Gulf	S09	Others	Red Sea
E.Africa	S11	Somalia	East Africa & Aden
E.Africa	S12	Kenya	East Africa & Aden
E.Africa	S13	Tanzania	East Africa & Aden
E.Africa	S14	Mocambique	East Africa & Aden
E.Africa	S15	Madagascar	East Africa & Aden
E.Africa	S16	South Africa	East Africa & Aden
E.Africa	S17	Mauritius	East Africa & Aden
E.Africa	S18	Seychelles	East Africa & Aden
E.Africa	S19	Others	East Africa & Aden
A.Gulf	S20	Iran	Arabian Gulf
A.Gulf	S21	Kuwait	Arabian Gulf
A.Gulf	S22	Iraq	Arabian Gulf
A.Gulf	S23	Saudi Arabia (A.G.)	Arabian Gulf
A.Gulf	S24	Bahrain	Arabian Gulf
A.Gulf	S25	United Arab Emirates	Arabian Gulf
A.Gulf	S26	Qatar	Arabian Gulf
A.Gulf	S28	Oman	Arabian Gulf
A.Gulf	S29	Others	Arabian Gulf
S.Asia	S30	India	South Asia
S.Asia	S31	Pakistan	South Asia
S.Asia	S32	Bangladesh	South Asia
S.Asia	S33	Burma	South Asia
S.Asia	S34	Srilanka	South Asia
S.Asia	S35	Maldive	South Asia
S.Asia	S39	Others	South Asia
SE.Asia	S40	Malaysia	South East Asia
SE.Asia	S41	Thailand	South East Asia
SE.Asia	S42	Campodia	South East Asia
SE.Asia	S43	Indonesia	South East Asia
SE.Asia	S44	Vietnam	South East Asia
SE.Asia	S45	Singapore	South East Asia
SE.Asia	S49	Others	South East Asia
E.Asia	S50	Taiwan	Far East
SE.Asia	S51	Philippines	Far East
E.Asia	S52	China	Far East
E.Asia	S53	Japan	Far East
E.Asia	S54	North Korea	Far East
E.Asia	S55	Russia (Sib.)	Far East
E.Asia	S56	South Korea	Far East
SE.Asia	S57	New Guinea	Far East
E.Asia	S58	Hong Kong	Far East
E.Asia	S59	Others	Far East
Oceania	S60	Australia	Australia
Oceania	S61	New Zealand	Australia
Oceania	S62	Pacific Islands	Australia
Oceania	S69	Others	Australia
	S70	America	Others
	S79	Others	Others

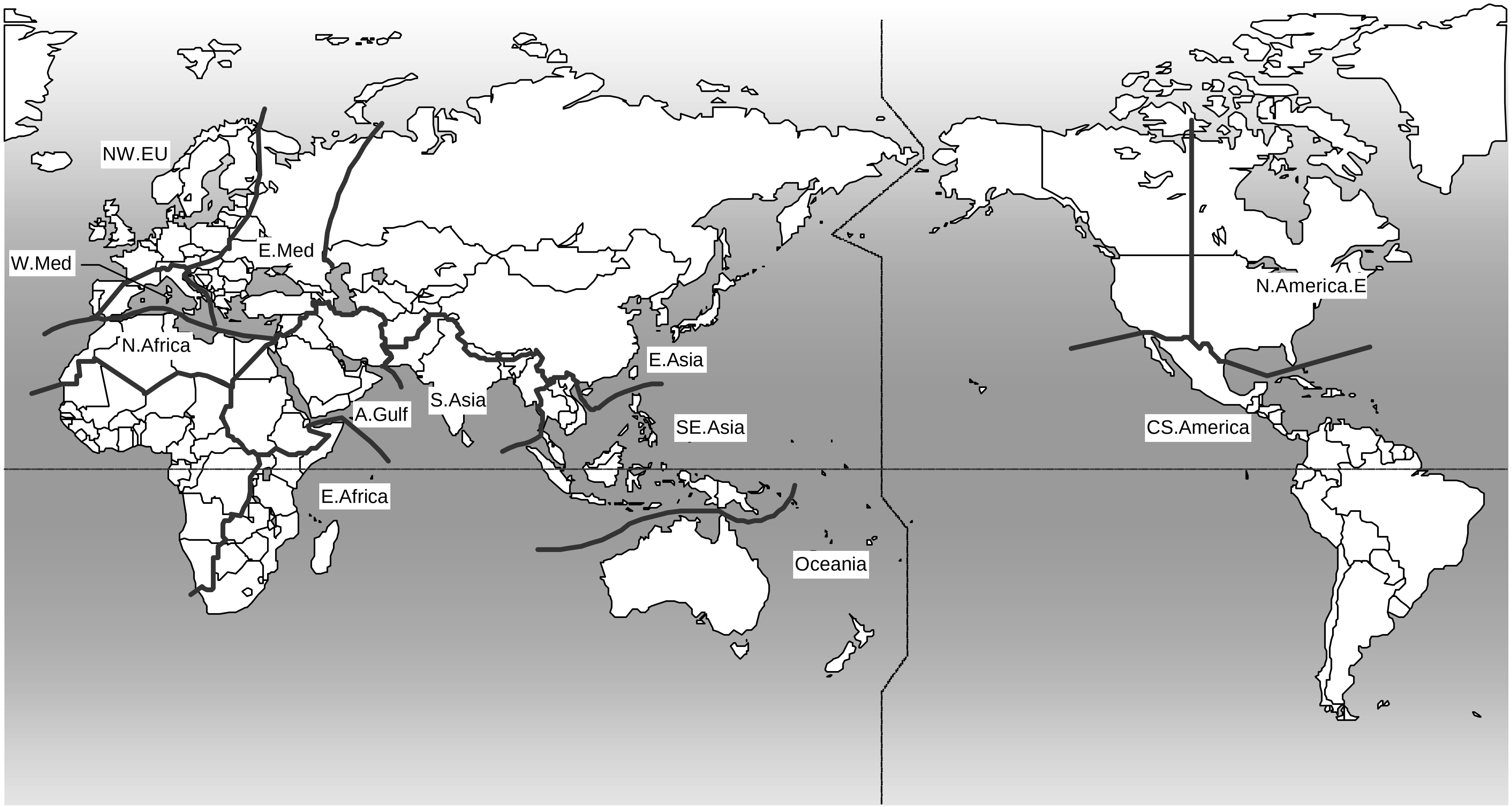


Figure A.1 Zoning for Forecasting

A.2 Commodity code

Study Team code	SCA code		
Commodity	c-code	Commodity	SCA Yearly Report
01.Crude Oil	42_02	Crude Oil	Crude Oil
02.Oil Products	41_03	Petroleum Coke	Other Oil Products
02.Oil Products	41_04	Paraffin Wax	Other Oil Products
02.Oil Products	41_05	Lubricating Oils	Other Oil Products
02.Oil Products	41_99	Petrol Residues (Others)	Other Oil Products
02.Oil Products	42_03	Motor Spirit (Gasoline)	Motor Spirit
02.Oil Products	42_04	Kerosene	Kerosene
02.Oil Products	42_05	Gas Oil & Diesel Oil	Gas Oil & Diesel Oil
02.Oil Products	42_06	Fuel Oils	Fuel Oil
02.Oil Products	42_07	Naphta	Naphta
02.Oil Products	42_99	Mineral Oils (Others)	Other Oil Products
03.LNG/LPG	42_08	LPG	LPG
03.LNG/LPG	42_09	LNG	LNG
04.Chemicals	08_99	Molasses	Food Stuffs
04.Chemicals	10_01	Chemical (sulphur)	Chemicals
04.Chemicals	10_99	Chemical (others)	Chemicals
04.Chemicals	44_02	Castor Oil	Vegetable Oils
04.Chemicals	44_04	Coconut Oil	Vegetable Oils
04.Chemicals	44_06	Cotton Seed Oil	Vegetable Oils
04.Chemicals	44_08	Groundnut Oil	Vegetable Oils
04.Chemicals	44_10	Soya Bean Oil	Vegetable Oils
04.Chemicals	44_22	Palm Oil	Vegetable Oils
04.Chemicals	44_99	Vegetable Oils (Others)	Molasses
05.Grain	06_02	Barley	Cereals
05.Grain	06_10	Maize (corn)	Cereals
05.Grain	06_18	Rice	Cereals
05.Grain	06_19	Rice (meal,bran)	Cereals
05.Grain	06_24	Wheat (unmilled)	Cereals
05.Grain	06_25	Wheat (flour,bran etc.)	Cereals
05.Grain	06_99	Cereals (others)	Cereals
06.Fabricated Metal	47_01	Iron & Steel	Fabricated Metals
06.Fabricated Metal	47_03	Pig Iron	Fabricated Metals
06.Fabricated Metal	47_04	Aluminium	Fabricated Metals
06.Fabricated Metal	47_99	Manufactured Metals	Fabricated Metals
07.Coal & Coke	40_99	Coal & Coke	Coal & Coke
08.Ore	48_05	Bauxite	Ores & Metals
08.Ore	48_08	Chrome Ore	Ores & Metals
08.Ore	48_10	Copper Ore	Ores & Metals
08.Ore	48_11	Copper Metal	Ores & Metals
08.Ore	48_19	Iron Ore	Ores & Metals
08.Ore	48_22	Illmenite & Rutile	Ores & Metals
08.Ore	48_34	Lead Ore	Ores & Metals
08.Ore	48_35	Lead Metal	Ores & Metals
08.Ore	48_42	Manganese Ore	Ores & Metals
08.Ore	48_60	Tin Ore	Ores & Metals
08.Ore	48_65	Zinc Ore	Ores & Metals
08.Ore	48_66	Zinc Metal	Ores & Metals
08.Ore	48_99	Metal (Others)	Ores & Metals
08.Ore	49_99	Minerals, Rocks (Others)	Minerals & Rocks
08.Ore	52_99	Scrap Iron	Minerals & Rocks
08.Ore	54_99	Paper & Cardboard	Minerals & Rocks
08.Ore	55_99	Woodpulp	Minerals & Rocks
09.Fertilizers	36_20	Phosphates	Fertilizers
09.Fertilizers	36_22	Ammonium Sulphate	Fertilizers
09.Fertilizers	36_24	Potassic Fertilizers	Fertilizers
09.Fertilizers	36_26	Ammonium Nitrate	Fertilizers
09.Fertilizers	36_28	Urea	Fertilizers
09.Fertilizers	36_99	Fertilisers (Others)	Fertilizers
10.Automobile	46_02	Motor Vehicles (& Parts)	Machinery & Parts
10.Automobile	46_99	Machinery (Others)	Machinery & Parts
11.Containers	98_99	Containerize Cargo	Containerized Cargo
12.Others	05_99	Honey	Food Stuffs
12.Others	07_99	Sugar	Food Stuffs
12.Others	09_99	Foodstuffs (others)	Food Stuffs
12.Others	14_99	Cement	Cement

Appendix B Forecast Model of Suez Potential Trade

B.1 Introduction

For this Suez Canal study, future trade flows have been estimated using a two phase, multi-step process. Because the Suez Canal handles trade for much of the world economy as well as trade of competitors to rest of the world, one must consider the Canal's position in relation to entire world trade and economy. The first phase of the forecast process is the estimation of the future of world trade as a whole. The world trade forecasts used in the study cover trade in all goods (sea-borne, land and air cargo) for the entire world as the foundation for the Suez Canal trade analysis. The second phase of the forecasting process is the translation of the world trade forecast into the forecast of Suez Canal potential sea-borne trade measured in tons.

A world trade model that comprehensively covers commodity and industrial flows can provide the best planning tool for governments analyzing transportation infrastructure. A model that uses economic activity and conditions statistics can best provide the capability for predicting future purchasing patterns for imports, and therefore exports. Developing this type of model and related databases, however, requires the analyst to solve a number of problems, not the least of which is the insurance of a quality of data that can support this form of economic analysis. In reality developing a world trade model demands that researcher to make a number of difficult choices to insure that the result meets tests of reliability and consistency. Staffs of international trade economists of WEFA, a member consultant of JICA Study Team, have evolved what they believe to be the state-of-the-art in commodity trade forecasting building on years of experience making these choices.

What are these choices? At the start of the process of model development, generalized model structure must be determined. Historical trade data is normally organized in terms of data reporting and trade partner country statistics. Given that the information is collected by statistical organizations in each country there can be a significant degree of dissimilarity between data sources. Despite the fact that bilateral trade data sometimes reveals a significant difference in reported trade of an exporter to an importer compared to an importer from an exporter, analysts have little choice but to rely upon statistical organizations to extract the truth from the flow of goods throughout the world. Fortunately, trade statistics have been improving during the last twenty to thirty years due to the efforts of many government agencies around the world. With the increasing volume of trade and the importance of trade to countries, it is likely that the statistical reliability of trade statistics reporting will continue to improve over time.

The question of forecasting model structure thus needs to be assessed in view of the problems associated with historical trade data. How many countries and regions should be included? Should models reflect the share of total imports and exports of each country or region or reflect a bottom up approach? Should trade be assessed in terms of commodity flow and the resulting balance in worldwide demand and supply or at the individual country level with the total for the commodity determined by the apportioning of the import demand among many competing products? If one follows the former course then there is little control of trade growth since each flow is independent of each other. If one takes the later approach then it is assumed that exports are a reflection of economic choices within a budget constraint. And while the concept of a budget constraint for poorer countries is a reasonable one, such a constraint for the countries with convertible currencies (and free-floating exchange rates) is not appropriate. The trade models use value of goods, rather than other measures, such as weight of goods, as the best way to quantify future commodity demand because consumers make buying decisions based primarily on price, rather than the weight of goods.

In the world trade models for this project, a bottom-up approach was implemented for the forecasts subject to a set of imposed controls. This bottom-up approach assumes that each commodity represents a universe of individual economic decisions by companies and consumers. It is a model that reflects the imperfectly competitive nature and the limited amount of information that may be available on potential suppliers worldwide. In the short run, trade tends to move along pre-defined routes with only a modest ability to shift suppliers quickly. Competition between export sources can be introduced by forcing forecast trade for each exporter to be equal to a separately estimated import demand from a group of exporters as a whole. For example, if one separately estimates exports for each of the OECD countries to Japan and separately estimates the import demand of the Japan from the OECD, an approach to this problem is to scale the model-developed forecasts to the "topline" or OECD-wide estimate of imports. Using this approach differential price and production factors are taken into account as a result of the scaling process since the market shares are determined by the relative competitiveness of each exporter.

To develop a trade model the analyst must determine the geographic and commodity coverage to be included. It is possible that a set of broad trade aggregates may be ideal for models for some studies while for other analysis there needs to be more detail in commodity coverage or in the inter-regional relationships assessed. For this study, the trade models cover the entire trade of the world including the intra-Less-Developed-Country trade between countries and regions. Thus there is a comprehensive amount of country detail incorporated where the total for all trade partners adds up to total world trade without double counting (by definition exports of all countries/regions to the world are exactly equal to imports of all countries/regions from the world).

Because of the size and geography of the North American economy, maritime trade varies by port range. Therefore in the trade model system, sea trade is forecast by six US port coastal ranges: North Atlantic Ocean Ports, South Atlantic Ocean Ports, Gulf of Mexico Ports, Great Lakes Ports, South Pacific Ocean Ports and North Pacific Ocean Ports. Later, in the second phase of forecasting Suez Canal trade, the North Atlantic, South Atlantic and Gulf Coastal regions are combined to form the US East Coast region. This portion of analysis is used in forecasting Suez Potential Cargo.

What kind of economic trade model allows for a full range of possible country sizes and strengths? Can one assume that trade is not a reflection of specific country experience or some generalized model that fails to take into account the exact pattern of investment and consumption? Experience has shown that the common, or framework, model that describes the long-term relationship between trade and economic growth using a cross-country sample rather than a time series offers a better approach to forecasting in that it allows countries to adapt and change over time. The volatility of observed detailed individual trade makes a time series trade model less efficient in deciphering the underlying factors that are at work. A pooled data set combining country specific information over time and multi-country information offers a better system for assessing the factors that are at work. With such a specification, poorer countries can, over time, become richer. As countries move through various stages of economic growth and industry development they have different needs and trade patterns.

In the current model system, each commodity model of world trade model stands alone, defining the interrelationship between exporters and importers trading in a single commodity category. For each commodity, the model measures the global competitive balance between exporters and importers. Unlike other approaches to world trade model development these models do not begin with a top down estimate of total trade demand but rather are built up, in logical steps, from demand and supply to trade partner regions. This way econometric models mostly define import demand and export supply potential. Where separate econometric models are inappropriate due to the sparseness of the data available or the failure to create a statistically significant model using econometric techniques, parameter models are used in relationship with econometric models. In the model equation specification notation, import demand is denoted by saying trade is for country *i*, commodity *k*, and trade partner *j*, as of time period *t*.

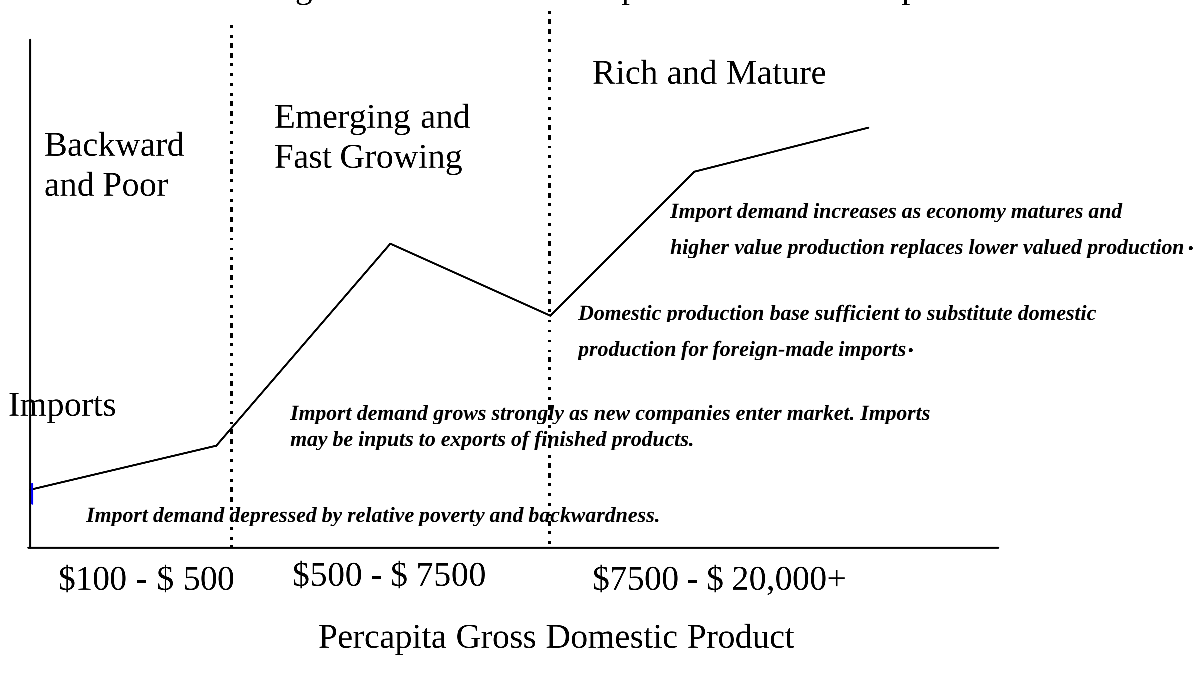
The historical patterns of trade are drawn primarily from detailed, commodity specific, trade data covering 160 countries worldwide developed from United Nations trade information sources by Statistics Canada. This data reflects Statistics Canada's estimates of bilateral flows. The database covers a single direction of trade (e.g. UK imports from Japan are identical to Japanese exports to the UK). All trade models are specified as import demand models. Export supply is derived from import demand from a specific region or country. A 70-country/region matrix of trading partners has been selected. There are approximately 56 countries and 14 additional regions. These countries and regions aggregate to the world (as defined by the initial 160-country set of trade data available in the Statistics Canada data set). The trade data is arranged in a symmetrical data set where there are an equal number of trade partner regions and countries importing and exporting. Import demand equations are estimated based on macroeconomic data, industry data, price data, exchange rate, and exporter performance measures – relative wages and relative rates of productivity growth.

B.2 Theoretical Framework: Evolution in Patterns of International Commodity Trade

The strong growth experienced in the world economy over the period starting in the early 1980's and continuing through 1999 reflects the increasing internationalization of production and supply. Increasingly international trade is less a function of national development as a function of international development. Trade flows are then a direct result of foreign investments and the increasing diffusion of technological information from the more advanced nations to the less advanced ones. As a result, understanding the factors that are driving this revolution and forecasting future patterns of growth must rely upon economic models that are not linear in orientation, i.e. that do not reflect a growth along a single production path, but rather reflect the multiplicity of production paths that are apparent. This is because countries continually leap over others as new investments are made and new enterprises develop using technologies from other countries.

Trade also reflects economic maturity. Countries move through various phases of economic development. Countries move from relatively poor and undeveloped, with imports constrained by capability and financial capital availability; to emerging growth, when imports may increase as they fill in gaps in domestic production that are often oriented towards exports; and through more mature emerging markets, when domestic producers substitute for foreign (import demand may then fall as more local production substitutes for foreign production). Eventually countries finally reach a mature stage in which imports increase as foreign producers replace domestic producers. This later stage reflects the maturity of the production base as it shifts from lower valued to higher valued production and from manufacturing towards more services.

Idealized Stage of Economic Development Model for Import Demand



Source) WEFA, Inc.

Countries and markets tend to reach a point of maturity when consumer markets become saturated. During this later stage there is a replacement of old with new, but little new real growth. These more mature economies also tend to be slower growing ones in terms of population growth, but their absolute volume of demand is such that they buy "more" than others that are faster growing but are currently less well developed. Development stages also dictate the kinds of products that are consumed and the trade relationships established. Economies thus move through phases and these phases are predictable using models that relate these differing patterns of growth.

B.3 The Underlying Quantitative Model

Cross-country models reflect stages of economic development by utilizing information from more than one country in a joint estimation procedure. The advantages of the approach are many, and not the least, is the ability to model these longer-term trends. Short-term patterns, however, may require inputs of more country specific data. As a solution to the conflict between the short-term benefits of a time series model and the long-term power of a cross-country one, the models developed reflect selection of a hybrid specification framework that mixes time series data with cross-country data. Thus all of the trade models are estimated using a pooled cross-sectional data set with 70 countries/regions and eighteen years of international trade data.[1]

The underlying theoretical model is based on a very traditional international trade model form in which import demand is a function of aggregate demand and relative prices for imported products. Trade models are "import-oriented" models with export supply assumed to be rationalized across major regional groupings. An exporter's success in selling depends critically upon their relative prices, productivity trends, and exchange rates. Import demand is determined by personal consumption expenditures, business investment, and consumption structure.

From a point of view of demand for traded commodities or products, nearly all import demand can be defined by domestic economic activity. A simple form of this type of model is:

$$M_{ijk} = (Y_i) = APM_{ijk} * Y_i = \frac{\hat{M}_{ijk}}{\hat{Y}_i} * Y_i$$ where $\hat{M}$ is the mean imports over the period for country i from region j for product k

and $\hat{Y}$ is the mean income over that same period for country i. Y is income or GDP.

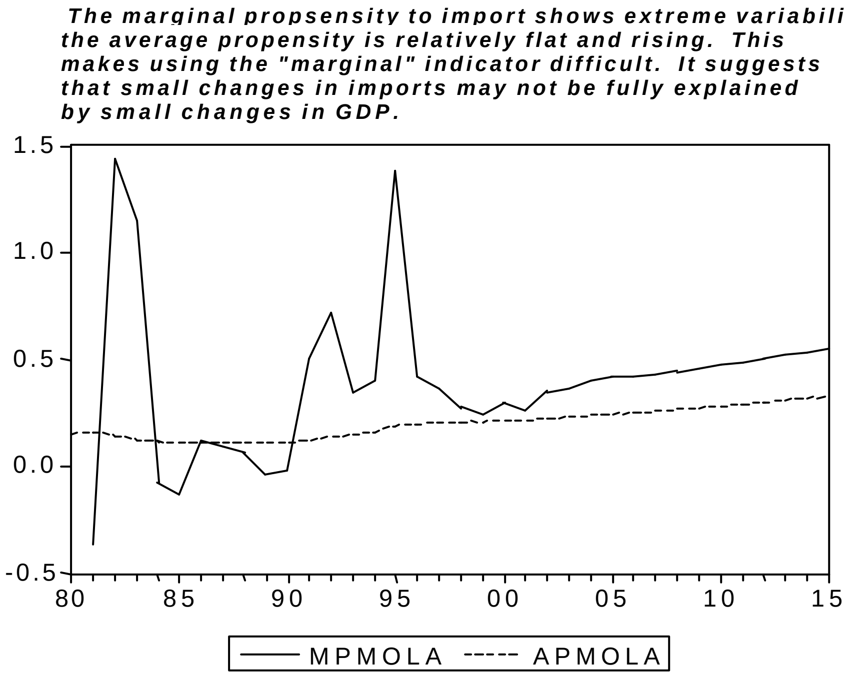
APM is the average propensity to import and it assumes that each additional dollar of income leads to a fixed share of additional imports. A more complex form involves examining the marginal import demand relative to the marginal dollar of income. To do this, one takes the first difference in imports relative to the first difference in income or:

---

[1] This is therefore a 70x 18 sample of data, with potentially 1260 observations. Even with individual country intercepts there are still more than 1100 observations. Few time series models come close in terms of total number of observations. Since the statistical reliability increases as the number of observations increases, in most cases then coefficients are statistically valid even if the t-statistic is less than 2 (greater than 1.5 is generally acceptable).

$$\mathbf{M_{ijkt}} = \mathbf{M_{ijkt-1}} + \mathbf{MPM_{ijk}} * \Delta\mathbf{Y_i} \text{ where } \mathbf{MPMijk} = \frac{\mathbf{M_{ijkt}} - \mathbf{M_{ijkt-1}}}{\mathbf{Y_{it}} - \mathbf{Y_{it-1}}} \text{ and } \Delta\mathbf{Y_i} = \mathbf{Y_{it}} - \mathbf{Y_{it-1}}.$$

Neither APM or MPM are always entirely satisfactory. To understand this, consider the example in the chart below drawn from trade of countries in Latin America. One can see that there is an extreme volatility in the marginal propensity to import (MPMOLA) relative to income. At the same time there is a slow growth in the average propensity to import (APMOLA) showing that it is not a constant but changes over time.



Source)WEFA, Inc analysis for JICA Study Team

Therefore, in order to obtain the most robust theoretical model for determining international trade performance and forecasting it into the future, another approach must be applied. Over the years economists have used a variety of time series estimations to predict import demand. Some have been specific to commodities, some have even modeled groups of countries and cross-country or bilateral trade, but in general there have been few econometric models developed that have used a pooled-cross-sectional-time-series-model framework and are commodity specific and route specific. In developing a more sophisticated model approach structural parameters that impact trade propensities must be taken into account.

Over the period starting in the 1960's and continuing through the 1990's there was a steady increase in the average propensity to import. If one can understand what is behind this trend then it can be understood why international trade has expanded rapidly since the early 1980's.

One way to understand what has happened is to divide APM into its component parts or:

$$\mathbf{APM} = \frac{\mathbf{CG}}{\mathbf{Y}} \times \frac{\mathbf{M}}{\mathbf{CG}}$$ where CG = PG - E + M, where

PG is the production of traded goods, E is exports of traded goods (possibly reduced by a factor to take into account the market-up of exports by the non-manufacturing sectors of the economy), and M is for imports of traded goods.

Trade intensity thus is now defined in terms of share of consumption of traded goods rather than share of total income. In this specification, CG/Y is slowly adjusting as consumption patterns adjust and change. The M/CG term cannot, by definition, exceed 1.0 (although for some countries with significant inflows of transit and re-export trade the share may be quite high. In general small countries tend to have higher import shares than larger ones. This suggests that there is greater specialization.)

There has been a gradual increase in the share of imports to consumption of traded goods. The increase is significant for developed economies such as the US, the UK, and Taiwan. In contrast, take Zimbabwe, where the share of imports to consumption of traded goods has fallen over time due in part to a trade embargo that limited its ability to buy from the world (back when it was known as Rhodesia) and due to its poverty and lack of hard currency to buy foreign imports.

For more advanced nations, like the United Kingdom and the United States, the consumption share of GDP has been flat. An economy like the United States with a significant share of total gross output concentrated in services has seen a relatively smaller share of output that can be impacted by foreign export sales or imports by local companies. In the case of Taiwan, however, imports rapidly increased and improvements in the quality of life have paralleled the increase in consumption of goods that can be traded internationally.

The two ratios thus represent limits. Over time it is expected that the CG/GDP ratio will be flat or decline as service trade takes a larger share of total consumption. It is expected that the MG/CG will reach an asymptotic limit less than 1.0. No country can be 100% specialized. Marginal adjustment in APM that changes in these two ratios induce tends to slow as a country approaches its asymptotic limits. For example, for smaller countries in Western Europe, European Union integration has already led to trade intensity measures that are approaching unity (1.0). Over the past thirty years nearly all trade growth has come in this ratio, as the general trend for most countries for CG/Y is negative.

Next, income can be devided into two parts -- market size and wealth per capita. The shift in demand can be related to market size since larger markets tend to demand more of some products. Larger markets also tend to be more competitive as foreign sellers find it less expensive to penetrate larger markets (the market potential is greater and thus the cost of entry per probable unit of sales is less). The wealth effect on trade is usually positive since wealthier markets attract more foreign suppliers. It may, however, be negative. Wealthier nations may find it impossible to produce lower valued products and thus will turn to imports. Even high technology products can be "low value" in terms of profitable production. An increasingly global production base assures that each trading nation will export products that it has a comparative advantage in (either in terms of land, technology, knowledge, or the skills of its workforce) and import those products for which it has only a limited advantage. Increasingly products are made in one country for export to another with parts produced in a third country.

Using these relationships the simplified import demand model is revised to be as follows:

$$\mathbf{Mikt} = \mathrm{A}\mathbf{i}\left[\frac{\mathbf{CG}}{\mathbf{Y}}\mathbf{it}\right]^{\mathbf{b}1}\left[\frac{\mathbf{MG}}{\mathbf{CG}}\mathbf{it}\right]^{\mathbf{b}2}\left[\frac{\mathbf{GDP}}{\mathbf{N}}\mathbf{it}\right]^{\mathbf{b}3}\mathbf{N}^{\mathbf{b}4}$$

where A is the constant intercept, CG/Y is the average consumption of traded goods to income, MG/CG is the trade intensity measure, N is market size (population), and GDP/N is per capita income or wealth.

This model is non-linear. Each of these "factors" has an impact on the others. The equation can be estimated using a log-log specification. The betas then become point elasticities measuring the rate of change in imports relative to the rate of change in each of the independent variables. The original constant APM occurs when the betas estimated are approximately equal to 1.0. The approximate size of the beta measures the importance of the effect. If trade intensity is of greater importance in explaining import demand then the beta will be greater than 1.0. When the beta is close to zero the net impact of this factor is insignificant and the entire change can be explained by the elements that are non-zero. If b1 and b2 each were equal to 1.0 [2] then the average propensity to import would be exactly equal to $\mathbf{APMikt} = \left[\frac{\mathbf{CG}}{\mathbf{Y}}\mathbf{it}\right]^{1}\left[\frac{\mathbf{MG}}{\mathbf{CG}}\mathbf{it}\right]^{1}$.

Export supply factors influencing trade should be summarized by the relative rate of expansion or contraction of production within the exporting region. A number of structural forms were tested to reflect how changing export supply factors influence the size and direction of growth in regional trade. The system developed, however, models the relative rate of production growth in exporting regions alone. Therefore the world trade models embody structural relationships for production in the exporting region.[3]

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[2] Similarly if b3 and b4 were equal to 1.0 each then the product of Y/N and N would be identical to Y. As it turns out in few cases are these relationships homogeneous of a degree 1.0 that this condition implies. In nearly all cases the impact of economic structure, wealth and market size on trade in a specific, kth, commodity varies.

[3] Ideally, one would include explicit relative wage and relative productivity measures in the supply potential portion of the analysis. However, these prove to be too difficult to include. By scaling export supply for all regions j to import demand from the world, a control is

The import model, however, has been formulated to mirror the short term patterns in market demand as reflected by the demand for consumer products (personal consumption expenditures) and investment goods (business fixed investment spending). The relative price term adjusts import demand to reflect cross-price relationships between exporter and importers. Import price changes alone, however, are assumed sufficient to adjust import demand. Efforts to compare import prices to domestic prices tend to yield poor results primarily because of the problem of finding comparable price measures for both the exporter and the importer. Moreover, trade tends to "fill-in" thus small changes in prices of traded goods can lead to larger adjustments in trade. In general, however, price elasticities calculated using this approach are consistent with a priori expectations and fall within a range of -2 to 0.

B.4 Translating Nominal US Dollar Trade into Real Volume Trade Using Price and Exchange Rate Indices

One of the difficult challenges in international trade forecasting involves selecting a useful common measurement for comparing real growth across countries and between regions. Econometric models are typically estimated in terms of real volume measures with prices assumed to be external or exogenously given. Given that nominal dollar amounts tend to reflect exchange rate changes that may, or may not, impact real demand for the products, there can be an extreme volatility in the nominal values where there is only a limited volatility in the real volumes. This differential becomes even more apparent when one compares country 1 to country 2 especially if exchange rates have changed radically over time. The volatility of exchange rates over the last twenty years makes using nominal US dollar trade data problematic. Even if there were no change in the real volume of trade, there would be large swings in the reported nominal dollar value of trade due entirely to the variance in exchange rates.

Prices are both descriptive of the current value and also structurally important, describing the behavior of consumers as they change. To find a common denominator for all countries in order to do a proper comparison then two elements need be considered:

1. Commodity price changes; and
2. Exchange rates.

The United States dollar is typically used as a measure of trade and economic performance. Assuming that if prices are in US dollars, then it must be that the dollar/local currency rate holds constant over time so that the volatile nature of the dollar's rise and fall is avoided. This can be implemented throught the development of a measure that reflects dollars converted as of a certain point in time. This has been done by taking out of the nominal dollar value of country trade the changes that have occurred since that time in both commodity prices and exchange rates.

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imposed that allows for export market shares among suppliers to shift over time.

A standardized approach to adjustment of trade value to volume has been developed that takes into account both commodity prices (in terms of US dollars as measured using Standard International Trade Classification commodity-based export and import price indices) and cross-exchange rates. Individual country differences in price inflation relative to US prices are taken into account using export price indices. Two principals have guide the approach:

1. Real changes in commodity prices should be captured in any price index applied;

2. Exchange rate changes should not be introduced mechanically, in order to avoid assuming the full effect of the change in international prices are passed onto buyers by sellers.

The lack of fully consistent, trade specific prices for commodities in the world has led to the development of a hybrid methodology using United States price statistics, exchange rates, and general export price indices for exporting countries and regions. These created measures are specific to OECD and selected emerging markets (with generally convertible currencies) but are not used to convert exports of other less developed countries as these countries are assumed to be price takers, and their trade volumes reflect US dollar price adjustments only (not exchange rates).

Import demand price indices are generally based on United States Bureau of Labor Statistics trade price indices. These indices are developed using survey data from US importers and exporters, and the indices are commodity specific. The indices are not, however, specific to any one trade partner country or region. Import demand price forecasts are based on forecasts derived from United States inter-industry models and reflect the macroeconomic developments and factors specific to related industries. To understand the impact of US dollar changes on Japan's exports to the world, exchange rates and Japanese export price adjustments need to be taken into account as well. In the case of Japan, for example, export price trends have often been counter to exchange rate trends. Export prices in yen-denominated terms have been observed to fall even as the yen/$ rate appreciated. If the rate of adjustment are of an equal amount (in opposite directions) then the net impact of the yen's appreciation in terms of export volume is zero. Thus the volume exported from Japan as reported may be greater than it would have been if only the exchange rate adjustment and commodity price changes had been applied to the nominal dollar trade value.

While the approach used in making international trade flow data consistent in real volume measures may appear to be somewhat complex, it offers the advantage of being consistent across countries and regions. It also allows for differential impacts associated with domestic price inflation (or deflation). Given the importance of the United States market or competing against US dollar-denominated exports, US commodity price trends appear to offer a consistent set of price indices for deflating nominal value data.

$$IX_{jk} = \frac{ICUS_k \bullet \frac{ITX_j}{IUS}}{IEXRj},$$

where IX is the export price index for country j for commodity k;

ICUS is the commodity price index from US data for commodity k with a base1987 = 1.0;

ITX is the country specific export price index (local currency)for country j with a base1987 = 1.0;

IUS is the general price inflation index for the United States with a base1987 = 1.0;

IEXR is the index of exchange rate for country j in LC/$ terms with a base1987 = 1.0.

Here, IX is used to deflate the nominal dollar trade of the importing country. The nominal dollar trade reflects exchange rate adjustments in each importing country or region. Thus the resulting real imports reflect a real, 1987 base volume of trade taking out both exchange rate adjustments and commodity price trends.

$$\mathbf{M_{ijk}} = \frac{\mathbf{NM_{ijk}}}{\mathbf{IX_{jk}}},$$

where

M is the real imports of country i from region / country j of product k;

NM is the nominal imports in US dollars of country i from region / country j of product k;

IX is the export price index for the jth exporter to all countries for product k.

When a currency appreciates relative to the dollar the export price index increases. If the importer's currency is also appreciating, so that the nominal dollar imports of that country are greater, then the impact of the appreciation on the exporting country and the resulting rise in the price index is reduced. The higher dollar value of the reported imports and the greater value in the price index cancel out. The adjustment of the commodity price for product k is designed to relate the export price of the exporter to the US general price level. For example, when the mid-1980's the yen appreciated against the dollar the Japanese export price declined (in yen terms). The reduction in the export price countered the appreciation in the yen/$ exchange rate (fewer yen per dollar).

For less developed country exporters it is assumed that each importer's own dollar (nominal dollar) volume may be properly deflated with the general price inflation in US dollars. This assumes that LDC exporters are price takers and that they regulate their exchange rates to insure that their exports remain competitive in terms of the general inflation rate in the US market. Thus when a local economy is inflating rapidly it is assumed that the export price in dollars adjusts as the country's own exchange rate devalues in line with the internal inflation rate. To the extent that this does not occur the exporter would find itself priced out of the market unless they are prepared to subsidize exports. In either case they cannot sell their products at prices above the rate of US price inflation for the commodity in question.

B.5 The Structure of world trade forecasting model

Each trade represents a single commodity trade flow. These are not top down models but rather are built up from the sum of their pieces. Total world trade is the result of the interaction of 4,830 individual trade routes for each of the 77 commodities that make up the full sample. Each commodity's trade model is independently developed and for the most part importer-exporter relationships are independently forecast. At the commodity level, however, there are controls imposed to insure consistency with past periods and reasonable forecasts for future period growth.

Each model includes a fully described set of historical and trade data for the 70 countries and regions (56 countries and 14 regions). There are 70 reporter regions and countries and 70 partner regions and countries, thus the resulting model reflects a bilateral matrix of world trade. Unlike earlier generation trade models, this model system covers all reported trade flows and is based on data derived from a 160 country sample of trade data (collected annually by the United Nations). These historical statistics represent a universe of information drawn from sometimes conflicting sources. To insure consistency, the models rely upon the basic core UN trade data as supplied by Statistics Canada and reported as a unidirectional matrix of trade, i.e. only one direction of trade information is reported for each country pair (160 x 160).

The advantages of this are several. In developing models for international trade, consistency is important and trade data often is inconsistent. This is especially true with respect to bilateral trade where reported Chinese imports from France may not be fully consistent with French reported exports to China. It makes the development of a trade model less complex in that each flow is independent of each other.

B.6 THE FORECAST PROCESS: The Multistage Approach to World Trade Forecast Models

For world trade forecasting, a pooled time series cross sectional database is used for the econometric model development. Estimations depend upon a weighted Generalized Least Squares estimation using weights derived from the co-variance matrix estimated in the initial pass.[4] Pooled cross-sectional time series models combine information on many countries while allowing for generally consistent estimators to be developed across a shortened time period. At the present time, however, the system uses data starting in 1980 through 1998/99[5]. There are 18 to 19 observations available for each

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[4] The generalized least squares approach allows for individual series to be estimated efficiently in a pooled estimation. Individual country differences remain a challenge; these are taken care of through a set of individual country intercepts and using a weighted least squares approach. The weights for the second iteration are drawn from the initial errors. This correction for the implied heteroskadasticity insures that the estimators in the equation are generally unbiased by differences in individual country sample data.

[5] At the present time Statistics Canada data is available through 1998 for all countries (with few exceptions). WEFA made consistent Statistics Canada United Nations 1998 data filling in holes in individual series to insure consistency. Also, 1999 data from US Department of Commerce data base for US trade routes has been applied. The trade model reflects the most

country pair included in the trade model. In most cases there are a minimum of over 1100 observations in the data sample for each pooled cross-sectional time series model estimated.[6]

In a cross-sectional model one looks primarily at longer term trends in a country's demand for imports. Future trade of a poorer country should roughly follow the path identified by the richer countries. Cross-country models tend to reflect the stage of economic development of the countries in the sample set and thus allow for a shift in demand to occur as countries pass from one stage to another.

Separate country intercepts reduce the degree of heteroskadasticity within the sample thus allowing each country to reflect its average size as a starting point.

There are three different types of independent variables employed:

1. Coefficients specific to that country or group of countries;
2. Coefficients common to the set of all countries; and
3. Specific intercepts.

In general, each equation has the following form:

$\mathbf{M}_{jk} = \Phi_i \mathbf{k} + \mathrm{B}\mathbf{X} + \mathrm{A}_i \mathbf{X}_i$ where i is the importing country for which there is a single intercept term for each (A), k is the product type and j is the partner region. The beta represents the generalized coefficients jointly estimated, while the Φ is the coefficient for importer and region specific variables. In general, region specific variables are used for differential price effects. In the historical data, there are sometimes quite different reactions to changes in import prices among countries and regions.

B.7 Econometric Specification for Import Demand Models

The econometric model specified utilizes the following key variables. These can be divided between structural variables that apply across all importers in a general way, macroeconomic variables that reflect short-term factors, relative price variables, and partner region production factors.

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recent data available on a global basis.

[6] There are some trade flows which are sparse. For each flow a test of available data is applied and if the size of the data sample is insufficient then alternatives to the econometric estimation are used to forecast the trade.

Independent Variable	Description of Variable	Type of Effect
CGSH	Apparent Consumption share of traded products relative to total apparent consumption. Total apparent consumption reflects gross output for goods and services less exports plus imports of traded goods.	**Structural Parameter**
MGCG	Import share of apparent consumption of traded goods. Reflects trade concentration of overall economy.	**Structural Parameter**
PCONPOP87	Personal Consumption Per Capita of Goods and Services in 1987 $US.	**Demand Variable**
INV87	Investment in 1987 $US.	**Demand Variable**
Import Price	Import price index reflecting cross-exchange rates and commodity price.	**Price Variable**
POP	Population	**Market Size**
Consumption/Production	Consumption of Commodity relative to growth in Domestic Production	**Demand-Supply Relationship in Importing Market**
Production of Commodity	Exporter's production of commodity. This reflects the supply potential of the partner or export region.	**Supply Variable**

The model allows for separation of regional impacts. This is addressed in two ways. One way assumes that there is a significant, but gradually adjusting, factor that serves as a linkage between two estimated coefficients. This is implemented through a variable that gradually adjusts in relationship to the rate of growth in per capita income. When percapita income is less than $US 20,000 (1987 $US) per year this variable takes on a value between zero and 1.0. When per capita income is greater than $20,000 the variable is equal to 1.0. This variable is called an income adjustment factor. By estimating coefficients that apply across all countries and also a separate coefficient that is pre-multiplied by this factor (from just greater than zero to 1.0 maximum) it is then possible to differentiate the elasticity impact between poor and rich nations over time.

$$\mathbf{M_{ijk}} = \mathbf{A_{ijk}} + \mathbf{b_1}\ln(\mathbf{I_i}) + \mathbf{b_2}\ln(\mathbf{I_i})*\mathbf{IA_i} + \mathbf{b_3}\ln(\mathbf{CGSH_i}) + \mathbf{b_4}\ln(\mathbf{CGSH_i})*\mathbf{IA_i} + \mathbf{b_5}\ln(\mathbf{MGCG_i})$$
$$+ \mathbf{b_6}\ln(\mathbf{MGCG_i})*\mathbf{IA_i} + \mathbf{b_7}\ln(\mathbf{PCONPOP}87) + \mathbf{b_8}\ln(\mathbf{PCONPOP}87)^2 + \mathbf{b}9\ln(\mathbf{PCONPOP}87)*\mathbf{IAi} + \mathbf{c}\ln(\mathbf{Pij}) +$$
$$\sum_{\mathbf{m}=1}^{\mathbf{M}} \mathbf{c_m}\ln(\mathbf{P_{ij}})*\mathbf{D_m} + \mathbf{e_1}\ln(\mathbf{POP_i}) + \mathbf{e_1}\ln(\mathbf{POP_i})^2 + \mathbf{f}_1\ln(\mathbf{CONSUMP/PROD})_{\mathbf{ik}} + \mathbf{f}_2\ln(\mathbf{CONSUMP/PROD})_{\mathbf{ik}}*\mathbf{IA_i}$$
$$+ \mathbf{g_1}\ln(\mathbf{PROD_{jk}}), \textbf{where}$$

M is imports of the ith country from the jth partner region of the kth commodity/industry category;
I is the investment by business, government, and individuals in new capital equipment, buildings, and infrastructure;

IA is the dynamic adjustment factor based on the ratio of percapita GDP (Y/N). The variable is always greater than zero but may be equal to 1.0 when the percapita income of the country or region exceeds $ 20,000. A moving average is used to insure a smooth transition.

CGSH is the consumption of traded goods share of total apparent consumption. Total apparent consumption is the sum of gross output for goods and services less exports plus imports of traded products.

MGCG is the imports of traded goods as a share of the consumption of traded goods, i.e. the trade intensity of the importer i.

P is the price of the exported commodity in the importing region or country, i.e. price of exports of commodity k from region j in importer i. It represents the combination of the US dollar commodity price of k, the exchange rate of the jth region, an adjustment to the commodity price to represent the differential inflation between the jth market and the US market, and the importer's exchange rate.

PCONPOP87 is the percapita consumption expenditure for the ith region.

$PCONPOP87^2$ The joint elasticity reflects the combination of $\mathbf{b}_7 + 2\mathbf{b}_8 * \ln(\mathbf{PCONPOP}_\mathbf{i}) + \mathbf{b}_9 * \mathbf{IA}_\mathbf{i}$, where IA takes on a value of between just greater than zero and 1.0 depending upon the relative wealth.

Dm is a set of instrumental variables for the following price setting regions: US, Japan, Western Europe, Newly Industrialized Economies (Hong Kong, Korea, and Taiwan), and Other Developed Economies. Each variable takes on a value of either zero or 1.0. This allows for a differentiation in the price effect between these markets with a general price impact assumed for the all other markets. The price elasticity is the sum of the coefficient $c+c_m$, where m represents one of the five regions.

CONSUM/PROD is the consumption of commodity k for country i (production less exports plus imports) over the production of commodity k for country i. When this ratio is increasing import demand should increase, when it declines domestic production may be impacting imports and reducing the relative rate of import growth.

PROD is the production of the jth country of commodity k. It measures the general strength of the domestic economy as an exporter.

The joint elasticity for personal consumption expenditures varies across countries and regions. For example, the elasticity for radio, TV and communications equipment (basically dominated by trade in telecommunications equipment) for the United States varies between 1.6 and 1.5. The elasticity for China for this same type of imports is between 2.6 and 2.4. Zimbabwe, in Africa, has an import demand elasticity of between 2.35 and 2.2, while Costa Rica an elasticity of between 3.5 and 3.3. (The second number represents the elasticity as of 2015 based on the forecast for total personal consumption expenditure.) What is clear is that there is a wide range between countries and regions and that in this case the marginal rate of growth in import demand declines, thus for each additional 1% in personal consumption the resulting import demand growth will moderate as time passes and the size of the personal consumption expenditure pool becomes larger.

B.8 An Alternative World Trade Model for Forecasting Import Demand

For some trades there is no structural model that fairly measures trade performance. This problem may affect all commodities in an importer-exporter pair or it may be specific to a set of goods within that pair for which there is insufficient data or where the econometric specification inaccurately portrays the pattern of actual trade.[7] For trade routes that do not meet the test of accuracy expected an alternative model specification is applied.

The Parametric Market Share World Trade Model

The trade models cover 4830 potential routes. It is thus not surprising that there are some numbers of these cells that are relatively sparse. For trade routes where the econometric fit of the equation is weak, alternative methods are used that relate the market share of each individual partner region or country with the import demand apparent from the world as a single region. A less complex econometric approach is used to develop the alternative estimates of import demand for each specific region. This approach utilizes information drawn from the pure econometric model. To do this effectively, for each partner country in the sample of trade data, a ratio is created which is the share for each reporter country of its imports from each partner region relative to its imports from the world. By definition, the market shares sum to 1.0.

[7] In many cases trade has been wildly erratic swinging up and down by often more than 50%. In such cases an alternative, less dynamic, approach is introduced that relies upon the relationship between the importer-exporter country trade and the importer-world trade. The later is estimated in all cases by an econometric model, therefore it will reflect the "general" pattern of growth in the economy as a whole and from the world in general. Specific regional detail is taken into account in the trend variables, i.e. the changing share of the partner in terms of the whole region.

$$\mathbf{MS_{ijk}} = \frac{\mathbf{M_{ijk}}}{\mathbf{M_{iwk}}},$$

$$\sum_{\mathbf{j}=1}^{\mathbf{J}} \mathbf{MS_{ijk}}, = 1.0$$

where i is the importer, j is the partner region, k is the commodity, and w is the World Market.

If one can forecast the rate of growth in MS over time then M_P can be forecast, the propensity model forecast for imports M from region *j* of product *k*, by multiplying MS_{ijk} by M_{iwk}. The approach that is taken is to transform MS into a logit function so that the share approaches the asymptotic limit of unity or zero more slowly.

$$\log\left(\frac{\mathbf{MS_{ijkt}}}{1-\mathbf{MS_{ijkt}}}\right) = \mathbf{Aijk} + \mathbf{a}1\log\left(\frac{\mathbf{MSijkt}-1}{1-\mathbf{MSijkt}-1}\right) + \mathbf{bi}(\mathbf{Time}),$$

where A is the constant term for each ith importer, logit(MS) is lagged one time period, and bi is the individual time trend for each logit function for each importing country / region i.

The import demand forecast using the propensity model is then the forecast for MS and the forecast for M_w. There are limits set on the projected rate of growth (from the logit model) in the MS variable at plus or minus 4% per year as a further check.

$$\mathbf{M_{Pijk}} = \mathbf{MS_{ijkt}} * \mathbf{M_{ikw}}, \text{ where } -4\% \leq \dot{\mathbf{MS}}_{\mathbf{ijkt}} \leq 4\%.$$

B.9 Integration of Econometric and Propensity Projections of World Trade: A Self-Adjusting Forecasting Approach

Because of the large number of trade flows forecast and their interdependence, it is critical that the world trade models incorporate internal tests and limits to insure that valid, reasonable forecasts are developed. Since logarithmic forms used in the econometric models are sometimes explosive, limits are imposed in the models assuring the quality of the forecasts developed.

The testing is done through a self-contained expert system. A set of decision rules continuously checks the forecast results against past trends in trade. Whenever a preliminary flow is found to be moving erratically, an alternative, more stable, method is substituted.

The model system incorporates a hierarchy of estimation choices. If there are sufficient observations, then econometric models are estimated. If, however, there are insufficient degrees of freedom for accurate statistical models to be developed, then alternative, non-econometric approaches can be used. Or if the volume of trade is particularly small or erratic, then non-econometric approaches may again be favored.

If an econometric model is sufficiently accurate, as judged by the Standard Error of the base equation (an initial test for statistical accuracy), then the equation's forecasting accuracy is tested against the actual experience within the historical period in order to determine for which countries and regions forecasts based on the cross-country model should be utilized and for which countries and regions alternative, parametric, specifications need be applied.

For use in the forecast accuracy testing, an average error over the period (the cumulative average percentage deviation of the forecast from the actual) for each reporter is estimated. The pooled cross-sectional model technique allows the easy separation of each of the 70-country/region reporters once the multi-country model is estimated.

$$e_{ijk} = \frac{\dfrac{\sum_{1982-1994}(\mathbf{M}_{ijk} - \hat{\mathbf{M}}_{ijk})}{\mathbf{n}}}{\dfrac{\sum_{1982-94}\mathbf{M}_{ijk}}{\mathbf{n}}}, \text{where n = number of observations for the period 1982-94.}$$

If the error for country i from region j for product *k* calculated over the forecast interval (1980-98) is over a pre-determined limit – MaxError – then the propensity model forecast is used in place of the econometric forecast. When the standard error for the country is less than MaxError, but greater than MinError, then the non-econometrically determined estimate of trade is used. For the forecasts, a MinError of 2% and a MaxError of 4% are used. A formula is used to fix the weights:

ADJUST = (Standard Error - MinError)/(MaxError-MinError)

From this formula the Standard Error for the equation is tested. If it is low enough, then the majority of the influence will be derived from the econometric specification. If, on the other hand, the Standard Error is closer to the MaxError then the opposite is the case.

If the standard error of the equation is less than the MinError, then only the origninal trade forecast is utilized. In this case the forecast then depends solely on the econometric results.

B.10 Final World Trade Forecast Adjustment and Testing

No model produces uniformly consistent results. Forecasting is an art as much as a craft. International trade data is usually quite volatile with swings of sometimes more than 50% in either direction. It has also been growing strongly for the last twenty years with worldwide growth in the 6% range – more than twice the rate of growth in GDP. Differences in trade flows between trade partners can also be dramatic. This is especially true given the large number of trading country partners that are taken into account of in the model procedures.

To insure that the forecasts reflect reality, limits are imposed to smooth out the peaks and troughs experienced in the forecast interval. When growth exceeds 20% (+ or -), an adjustment factor is applied to reduce the implied growth. A smaller adjustment factor is applied when the forecast trade is greater than 12% but less than 20% (+ or -).

B.11 Conversion of World Trade Forecast to Transportation Volume Measures

As explained previously, the results of the world trade models are produced first using units of the value of commodity trade. The final step in the world trade forecasting process is the translation of the forecast value data into transportation mode volume measures. From the future value of trade, the tonnage of trade moving by sea, by land (railroad, truck or pipeline) or by air is estimated using a data base of ton per value factors and mode share information. The value to ton conversion factors are derived from recent historical trade statistics that report both the value and volume of trade, by transportation mode, by trading country pairs and commodity. This data permits the translation to be done at the detailed level of trade, using the different transportation characteristics of individual commodity groups shipped on different trade routes. The resulting sea-borne, air-borne, and overland trade tonnage forecasts reflect individual patterns of commodity and trading country transportation.

For sea-borne trade, commodity value to tonnage translation is made with factors that also incorporate information on the type of vessel service including tanker cargo, container cargo and general cargo. This sea-borne tonnage information is used subsequently in the estimation of the Suez Canal trade in the second phase of the forecasting process.

B.12 The Suez Canal trade forecast process

After completion of the world trade forecasts, the second phase of the forecast process is translation of world trade into measures of future trade for the Suez Canal. In this phase of the forecasting, the Suez Canal trade by commodity and trade route is calculated for sea-borne trade in tons. For use by the consultant analysts in subsequent project tasks, the Suez Canal Routes and Commodity categories were mapped to the world trade forecast dimensions using detailed historical trade statistics. The Suez Canal regions have been defined using groupings of individual countries. The Suez Canal commodity categories have been defined using underlying historic patterns of trade, collected and reported using the four-digit Standard International Trade Classification of commodities.

The sea-borne tonnage portion of world trade includes containerized cargo, which, for the Suez Canal historical statistics, does not have underlying detail on what goods are in the containers. In order to forecast the future containerized tonnage for the Suez Canal on a comparable basis, the world trade forecast sea-borne tonnage was disaggregated into containerized and non-containerized tonnage, by commodity group.

(This world trade is that portion of world trade that is not shipped primarily overland between countries (by truck, rail or pipeline) or by air.) Therefore, sea-borne containerized trade tonnage for Suez Canal was estimated for each commodity category, for each trade route. The remainder of Suez Canal sea-borne trade tonnage is termed the non-containerized tons. Finally, the containerized tons were aggregated with non-containerized tons for total sea-borne Suez Canal tons.

The output of this phase of the process is the Suez Canal sea-borne tonnage portion of total world trade historically from 1980 to 1999 and forecast out to 2020.

B.13 Summary

The world trade model specification used for this study incorporates a balance between sectoral detail and regional detail. The forecasts are based on a robust statistical model specification that provides a strong foundation for projecting past and future trends in world and Suez Canal trade. The trade models used capture emerging industrial and technology patterns (as they are represented by the exportering country production of traded commodities) in order to reflect the direction that future growth will take. The baseline sea-trade tonnage forecasts for the Suez Canal in this study have been produced using a robust and comprehensive approach to long-term trade forecasting. The historic patterns in the model data are consistent with observed world and Suez Canal trade and shipments. The sea-borne commodity trade tonnage forecast for Suez Canal is consistent with the trade outlook for each commodity category forecast worldwide.

In summary, the world and Suez Canal trade forecasts developed using this model process reflect the current reality—the current period's trade, the impact of past trends in trade and WEFA's latest forecasts for macroeconomic and industry factors that influence trade, and allowing the models to project future growth. Unlike simpler trade models that rely only upon time series estimates, this model process is based on a more sophisticated approach to trade forecasting. The long-term pattern of trade includes dynamic shifts between patterns of trade between individual countries and trade partner regions. The baseline trade forecast for Suez Canal traffic represents the best estimate of the potential future demand for trade, incorporating as much information as can be assembled to support the trade forecast modeling process.

World Trade Model Region Classification (70 Exporting Regions to 70 Importing Regions)

REGION NAME	/ COUNTRY NAME
DEVELOPED COUNTRIES	
North America	U.S.
	Canada
Asia	Japan
Europe	Germany
	France
	U.K.
	Italy
	Austria
	Belgium
	Denmark
	Finland
	Greece
	Ireland
	Netherlands
	Norway
	Portugal
	Spain
	Sweden
	Switzerland
	Turkey
	Other Western Europe
Oceania	Australia
	New Zealand

REGION NAME	/ COUNTRY NAME
EMERGING MARKETS/DEVELOPING COUNTRIES	
Asia	Hong Kong
	South Korea
	Taiwan
	China
	Indonesia
	Malaysia
	Philippines
	Singapore
	Thailand
	Vietnam
Indian Subcontinent	India
	Pakistan
	Other Indian Subcontinent
Latin America	Argentina
	Brazil
	Venezuela
	Other East Coast of S. America
	Chile
	Colombia
	Peru
	Other West Coast of S. America
	Mexico
	Caribbean Basin
	Central America
CIS/Eastern Europe	Bulgaria
	Czech Republic
	Hungary
	Poland
	Romania
	Russian Federation
	Slovak Republic
	Other Southeast CIS
	Other Western CIS
	The Baltic States
Mediterranean	Mediterranean
Middle East	Egypt
	Israel
	Saudi Arabia
	United Arab Emirates
	Other Persian Gulf + Jordan
Africa	Northern Africa
	Kenya
	Other Eastern Africa
	Western Africa
	South Africa
	Other Southern Africa
Other	Other Region

World Trade Model Commodity Category Classifications

ISIC Code	Description	Manufacturing (continued)	
Primary		C3513	Synthetic Resins
C1	Agriculture, Hunting, Forestry, Fishing	C3521	Paints, Varnishes and Lacquers
C1A	Grain	C3522	Drugs and Medicines
C1B	Oil Seeds	C3523	Soap and Cleaning Preparations
C1C	Vegetables, Fruits and Eggs - req Refrigeration	C3529	Chemical Products, nec.
C1D	Vegetables and Fruits - non-Refrigerated	C353	Petroleum Refineries
C1E	Cork and Wood	C354	Petroleum and Coal Products
C1F	Natural Rubber	C354A	Briquettes, Lignite, Peat and Coke
C1G	Cotton	C354B	Residual Petroleum Products
C1H	Other Raw Textile Materials	C355	Rubber Products
C1I	Other Agriculture	C356	Plastic Products, nec.
C2	Mining and Quarrying	C361	Pottery, China etc.
C2A	Stone, Clay and Other Crude Minerals	C362	Glass and Products
C2B	Crude Fertilizers	C369	Non-Metallic Products, nec.
C2C	Ores	C371	Iron and Steel
C2D	Coal and Coke	C372	Non-Ferrous Metals
C2E	Crude Petroleum	C381	Metal Products
C2F	Natural Gas	C3821	Engines and Turbines
C2G	Scrap	C3822	Agricultural Machinery
Manufacturing		C3823	Metal and Wood Working Machinery
C311	Food	C3824	Special Industrial Machinery
C311A	Meat/Dairy/Fish Requiring Refrigeration	C3825	Office and Computing Machinery
C311B	Other Meat/Dairy/Fish/Fruit/Vegetables	C3829	Machinery and Equipment, nec.
C311C	Sugar	C3831	Electrical Industrial Machinery
C311D	Animal Feed	C3832	Radio, TV and Communications Equipment
C311E	Animal and Vegetable Oils	C3832A	Radio and TV
C311F	Other Food	C3832B	Semi-conductors, Electronic Tubes, etc
C313	Beverages	C3832C	Other Communications Equipment
C314	Tobacco	C3833	Electrical Appliances and Houseware
C321	Textiles	C3839	Electrical Apparatus, nec.
C322	Wearing Apparel	C3841	Shipbuilding and Repairing
C323	Leather and Products	C3842	Railroad Equipment
C324	Footwear	C3843	Motor Vehicles and Parts
C331	Wood Products	C3843A	Motor Vehicles
C332	Furniture and Fixtures	C3843B	Parts of Motor Vehicles
C341	Paper and Products	C3844	Motorcycles and Bicycles
C341A	Waste Paper	C3845	Aircraft
C341B	Pulp	C3849	Transport Equipment, nec.
C341C	Paper and Paperboard and Products	C3851	Professional Equipment
C342	Printing and Publishing	C3852	Photographic and Optical Goods
C3511	Basic Industrial Chemicals	C3853	Watches and Clocks
C3511A	Organic Chemicals	C390	Other Manufacturing, nes.
C3511B	Inorganic Chemicals		
C3512	Fertilizers and Pesticides		

Appendix C Theory and Parameters of Potential Cargo Forecast Model

C.1 Total trade

There are some factors that will affect the future trade of commodity. Economic growth rate was picked up out of them to be used for the analysis. Much previous research and many surveys confirm that the economic growth rate is the best variable that is strongly related to demand.

Of course, the economic growth rate alone is not enough to forecast the future trade. Other factors are reflected in the parameter that is called elasticity. Elasticity is the relation between the demand growth rate and the economic growth rate.

Let $\quad {}_nDR = \sqrt[t]{{}_nD / {}_nd} - 1$

,where

n : commodity type

nDR : annual growth rate of commodity type n

nD: import of all zones (total trade) in a target year

nd: import of all zones (total trade) in a base year

t : difference of years between a target year and a base year

This growth rate is generally proportional to the economic growth rate. This coefficient is the elasticity.

${}_nE = {}_nDR / G$ ....Eq(1)

,where

nE: elasticity of commodity type n

G: economic growth rate of the world

The world economic growth rate was set 3.10%. This value was taken from the future forecast by the World Bank. (See Appendix A of ANNEX III)

Table C.1.1 Annual Economic Growth Rate (-2020)

Zone	%/year
World	3.10

The elasticity was calculated from this economic growth rate and the forecast of Suez Potential Cargo. Note that the potential cargo that will be analyzed here should include the possible cargos excluded in Chapter3. These cargo are Crude Oil that will use pipelines and Containerized Cargo that will use trans-Pacific route. This is potential cargo in the wide sense.
The estimated elasticity is listed in Table C.1.2.

Table C.1.2 Elasticity of Trade to Economic Growth Rate

Commodity	Elasticity
01.Crude Oil	0.10
02.Oil Products	0.59
03.LPG/LNG	0.02
04.Chemicals	1.74
05.Grain	0.52
06.Fablicated Metal	2.04
07.Coal & Coke	0.30
08.Ores	0.98
09.Fertilizers	1.05
10.Automobile	0.94
11.Containerized cargo	1.80
12.Others	1.73

In general, trade increases according to the growth of the economy, and the elasticity is from 0.5 to 2.0. However, some trades across the Suez Canal is found that will not increase so much in spite of the economic growth of the demand regions.

These values are the reflection of the future trade and commodity production that is explained. In roughly saying, Crude Oil and LPG/LNG will not increase so much because Europe will shift the source of commodity. Europe will import Crude Oil from the North Sea and other regions.
Oil Product will also have many places for production by installations of new refinery factories. The trade will not grow as much as the growth of economy.
Chemicals, Fabricated Metals, and Ores are the resources of economic growth, and have strong relation with economic growth. The speed of the growth of trade exceeds the growth of world economy. Asian growth will much impact on the future trade.
Containerized cargo will also grow.

C.2 Trade of regions

The similar analysis can be made for import of each region. Regional economic growth in the future was set as Table C.2.1. This GDP is based on the scenario of the forecast of Suez Potential Trade in Chapter 2.

Table C.2.1 Annual Regional Economic Growth Rate (-2020)

Zone	%/year
01.CS.America	3.79
02.N.Amrica.E	2.77
03.NW.Europe	2.39
04.W.Med	4.25
05.N.Africa	4.00
06.E.Med	4.34
07.E.Africa	4.87
08.A.Gulf	4.00
09.S.Asia	6.86
10.SE.Asia	5.57
11.E.Asia	4.00
12.Oceania	3.60

Then, let $\quad {}_nDR_j = \sqrt[t]{{}_nD_j / {}_nd_j} - 1$

,where

n : commodity type

j: zone

nDRj: annual import growth rate of commodity type n in zone j

nDj: import of zone j in a target year

ndj: import of zone j in a base year

t : difference of years between a target year and a base year

This growth rate ${}_nDR_j$ is proportional to the economic growth rate in zone j. The regional elasticity is obtained by Eq(2).

$${}_nOE_j = {}_nDR_j / G_j \quad \text{...Eq(2)}$$

,where

nOEj: elasticity of import of commodity type n in zone j

G: regional economic growth rate in zone j

Similarly, elasticity of export can be obtained. Export is not proportional to the economic growth especially for non-industrialized good. However, it is still helpful to know the future export.

Let $_nOR_i = \sqrt[t]{_nO_i / _no_i} - 1$

,where

n : commodity type

j: zone

nORi: annual export growth rate of commodity type n in zone i

nOij: export of zone i in a target year

noi: export of zone i in a base year

t : difference of years between a target year and a base year

This growth rate $_nOR_i$ is proportional to the economic growth rate in zone i. The regional elasticity is obtained in Eq(3)

$$_nOE_i = {_nOR_i} / G_i \quad \text{..Eq(3)}$$

,where

$_nOE_i$: elasticity of export of commodity type n in zone i

G_i: regional economic growth rate in zone i

The values of the elasticity are listed in .Table C.2.2 and Table C.2.3.

Table C.2.2 Elasticity of Suez Potential Trade by Commodity: Import

	01.CS.America	02.N.Amrica.E	03.NW.Europe	04.W.Med	05.N.Africa	06.E.Med	07.E.Africa	08.A.Gulf	09.S.Asia	10.SE.Asia	11.E.Asia	12.Oceania	Total
01.Crude Oil	0.33	0.00	0.41	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.57	0.00	0.10
02.Oil Products	1.43	1.05	0.00	0.24	0.15	0.00	0.00	0.00	0.27	0.06	0.00	0.00	0.59
03.LPG/LNG	0.00	0.89	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
04.Chemicals	0.97	1.04	1.97	1.04	1.08	0.77	0.31	0.79	1.06	1.13	1.23	0.61	1.74
05.Grain	0.00	1.10	2.41	1.14	1.01	0.68	0.00	0.38	0.04	0.38	0.00	0.00	0.52
06.Fabricated Metal	0.00	2.11	1.54	1.17	1.25	0.66	0.42	0.92	0.66	1.53	1.24	1.06	2.04
07.Coal & Coke	0.00	0.87	0.40	0.23	0.50	0.15	0.00	0.00	0.00	0.10	0.37	0.29	0.30
08.Ores	0.00	2.92	1.29	0.73	1.54	0.49	0.00	0.17	0.43	1.20	0.88	0.89	0.98
09.Fertilizer	0.00	0.18	0.91	0.28	1.62	0.29	0.33	0.73	0.43	0.79	0.11	0.34	1.05
10.Automobile	0.00	1.08	0.76	0.45	0.52	0.00	0.00	1.11	0.98	1.51	1.12	1.04	0.94
11.Containerized Cargo	0.00	2.30	2.67	1.38	1.48	1.00	0.60	0.81	0.69	1.26	1.06	1.03	1.80
12.Others	0.00	2.61	3.31	1.56	1.42	1.13	0.69	0.60	0.60	1.07	0.93	1.00	1.73

Table C.2.3 Elasticity of Suez Potential Trade by Commodity: Export

	01.CS.America	02.N.Amrica.E	03.NW.Europe	04.W.Med	05.N.Africa	06.E.Med	07.E.Africa	08.A.Gulf	09.S.Asia	10.SE.Asia	11.E.Asia	12.Oceania	Total
01.Crude Oil	1.08	0.00	0.00	0.00	0.53	0.00	0.00	0.05	0.00	1.28	0.00	0.27	0.10
02.Oil Products	0.46	0.12	0.00	0.00	0.10	0.00	0.00	0.04	0.18	0.78	0.00	0.00	0.59
03.LPG/LNG	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.03	0.49	0.35	0.00	0.00	0.02
04.Chemicals	2.39	1.84	1.38	1.21	1.94	1.34	1.84	0.35	0.71	1.09	0.07	0.60	1.74
05.Grain	0.00	0.73	0.00	0.00	0.99	0.02	0.65	0.00	0.77	1.09	0.00	0.00	0.52
06.Fabricated Metal	0.00	2.02	1.74	1.16	1.57	1.81	0.00	0.16	0.81	0.86	0.60	0.28	2.04
07.Coal & Coke	0.00	0.19	0.00	0.00	0.00	1.10	0.00	0.00	0.41	0.50	0.04	0.00	0.30
08.Ores	0.00	0.69	0.69	0.56	0.67	2.15	0.00	0.63	1.14	1.24	0.00	0.53	0.98
09.Fertilizer	0.00	0.95	0.81	0.81	0.81	0.90	2.11	0.10	0.33	1.13	0.00	0.11	1.05
10.Automobile	0.00	1.82	2.11	1.44	0.92	1.54	1.37	1.90	1.25	0.74	0.41	1.42	0.94
11.Containerized Cargo	0.00	2.21	2.11	0.94	1.13	1.39	1.66	0.71	1.13	1.34	0.60	1.11	1.80
12.Others	0.00	1.41	1.35	0.76	0.73	0.93	1.08	0.39	0.75	1.57	0.08	0.84	1.73

C.3 Equations

The future cargo was calculated along the flowchart in Figure C.3.1.

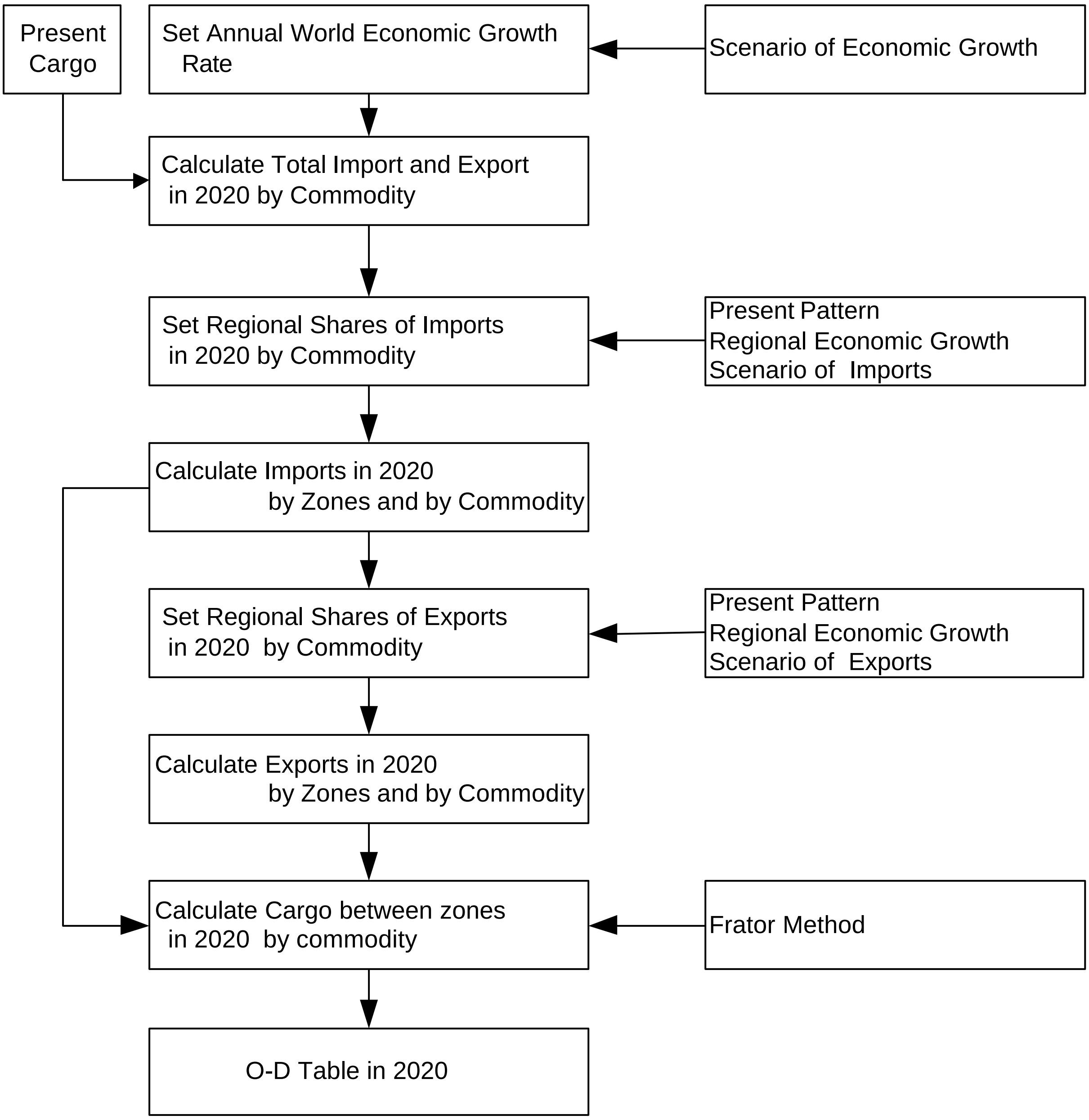

Figure C.3.1 Flowchart of Cargo Forecasting Model

There are 4 steps for actual calculation

(1) Step1: Total Import

Eq(1) is the equation to calculate the future import .

$$ {}_nD = (1 + {}_nE \times G)^t \times {}_nd \text{ ....Eq(1)} $$

,where

n : commodity type

nD: import of all zones (total trade)

nd: import in a base year

nE: elasticity

G: economic growth rate of the world

t : difference of years between a target year and a base year

Economic growth rate is forecasted by some international organization such as the World Bank and OECD.

(2) Step2: Import to each zone

The future import of each zone is calculated in Eq(2).

$$ {}_nD_j = {}_nP_j \times {}_nD \text{ ....Eq(2)} $$

,where

j: zone of import

nDj: import in zone j

nPj: share of import in zone j

The key process in this step is to set the share of the demand in each zone (${}_nP_j$). It is determined with the scenario consideration.
3 kinds of shares will be helpful to set the future share under a given future scenario.

1. Present pattern
2. Future pattern by a large-scale forecast
3. Future share calculation with future regional GDP

The last share is calculated with regional elasticity and GDP by Eq(3).

$$ {}_n\hat{P}_j = {}_n\hat{D}_j / \sum_j {}_n\hat{D}_j \text{ ....Eq(3)} $$

$$ {}_n\hat{D}_j = (1 + {}_nDE_j \times G_j)^t \times {}_nd_j $$

,where

Gj : economic growth rate in zone j

${}_n\hat{D}_j$: tentative import to zone j (by the regional elasticity method)

${}_n\hat{P}_j$:share of import to zone j by elasticity method

(3) Step3: Export from each zone

Eq(4) is an equation to calculate the future export from each zone.

$$ {}_nO_i = {}_nS_i \times {}_nO \quad \text{.......................................Eq(4)} $$

,where

i: zone of export

nOi: export from zone i

nO: export all zones (total trade) (=nD)

nSj: share of export from zone j

While an economic growth rate is a key factor for imports, exports of a region are not necessary related to the economic growth rate of the region. One of the factors affecting exporting regions is the distance to the demand regions. Another example is the ability to produce commodities. Customary-trade is another important factors of export.

It is difficult to construct a numerical model that includes all these factors. Therefore in the operational model, the share of the export in each zone (${}_nS_i$) is set by the similar consideration to Step3. The references for setting the future share are:

1. Present pattern
2. Future pattern by a large-scale forecast
3. Future share calculation with future regional GDP

As mentioned above, the elasticity of GDP is not necessary suitable for export, especially for export of resources, it will helpful for considerations.
The last share is calculated with regional elasticity and GDP by Eq(5).

$$ {}_n\hat{S}_i = {}_n\hat{O}_i / \sum_i {}_n\hat{O}_i \quad \text{.........................Eq(5)} $$

$$ {}_n\hat{O}_j = \left(1 + {}_nOE_i \times G_i\right)^t \times {}_no_i $$

,where

Gi : economic growth rate in zone i

${}_n\hat{O}_i$: tentative export from zone i (by the regional elasticity method)

${}_n\hat{S}_i$:share of export from zone i by elasticity method

(4) Step4: Cargo between zones

After the imports and exports of each zone are established, Frator Method is applied.

The concept of Frator Method is as follows:

If the growth of exporting ability is the same as the present ability in all zones, the pattern of imports to zone j from zone i is the same as the present pattern,

i.e. For import zone j, the share of export zone i will be $t_{ij} / \sum_i t_{ij}$

,where tij is the present trade from zone i to zone j

But the growth of export will be not equal in all zones.

Therefore, the actual share will be $\left(FA_i \times t_{ij}\right) / \sum_i \left(FA_i \times t_{ij}\right)$

,where FAi is a coefficient of exporting growth of zone i

The growth of import will also not equal in all zone. Import is expressed with a coefficient of importing ability.

import to zone j will be $FB_j \times \sum_i t_{ij}$

,where FBj is a coefficient of importing growth of zone j

From above equations, the future trade from zone i to zone j will be

$$T_{ij} = \left\{ \left(FA_i \times t_{ij}\right) / \sum_i \left(FA_i \times t_{ij}\right) \right\} \times FB_j \times \sum_i t_{ij} \quad \ldots\ldots \text{Eq(6)}$$

Similarly, if the growth of importing ability is the same as the present ability in all zones, the pattern of exports from zone i to zone j is the same as the present pattern,

i.e. For export zone i, thee share of import zone j will be $t_{ij} / \sum_j t_{ij}$

But the growth of import will not be equal in all zones.

Therefore, the actual share will be $\left(FB_j \times t_{ij}\right) / \sum_j \left(FB_j \times t_{ij}\right)$

,where FBj is defined above.

The growth of export will also not equal in all zone. Export is expressed with a coefficient of exporting ability.

export from zone i will be $FA_i \times \sum_j t_{ij}$

,where FAi is defined above.

From above equations, the future trade will be

$$T_{ij} = \left\{ \left(FB_j \times t_{ij}\right) / \sum_j \left(FB_i \times t_{ij}\right) \right\} \times FA_i \times \sum_j t_{ij} \quad \ldots\ldots \text{Eq(7)}$$

T_{ij} in Eq(6) is the trade from the view of import zones, and T_{ij} in Eq(7) is the trade from

the view of exporting zones. These T_{ij} 's should be the same value.
Therefore the actual value is assumed the average of both Tij

$$T_{ij} = \left(TA_{ij} + TB_{ij}\right)/2 \text{ ....Eq(8)}$$

, where TA_{ij} : T_{ij} in Eq(6)
TB_{ij}: T_{ij} in Eq(7)

Eq(8) is calculated with Eq(6) and Eq(8). Then,

$$T_{ij} = \frac{1}{2} \times \left\langle \left\{ \left(FA_i \times t_{ij}\right) / \sum_i \left(FA_i \times t_{ij}\right) \right\} \times FB_j \times \sum_i t_{ij} + \left\{ \left(FB_j \times t_{ij}\right) / \sum_j FB_j \times t_{ij} \right\} \times FA_i \times \sum_j t_{ij} \right\rangle$$

$$= \frac{1}{2} \times \left\{ \sum_i t_{ij} / \sum_i \left(FA_i \times t_{ij}\right) + \sum_j t_{ij} / \sum_j FB_j \times t_{ij} \right\} \times FA_i \times FB_j \times t_{ij}$$

$$= \frac{1}{2} \times \left(LB_j + LA_i\right) \times FA_i \times FB_j \times t_{ij} \text{ ....Eq(9)}$$

, where $LB_j = \sum_i t_{ij} / \sum_i \left(FA_i \times t_{ij}\right)$
$LA_i = \sum_j t_{ij} / \sum_j \left(FB_j \times t_{ij}\right)$

The result of calculation in Eq(9) should be equal to the sum of the imports or the sum the imports that are calculated in step2 or step3.
i.e. $\sum_j T_{ij} = O_i$ and $\sum_i T_{ij} = D_j$ ....Eq(10)

Eq(10) should be satisfied but actually the left term is not equal to the right term.
Therefore , the above procedure (Eq(6) to Eq(9)) is repeated up to Eq(10) is satisfied.
(this condition means that FA_i and FB_j converge to 1.0)

The procedure to calculate the trade is Figure C.3.2

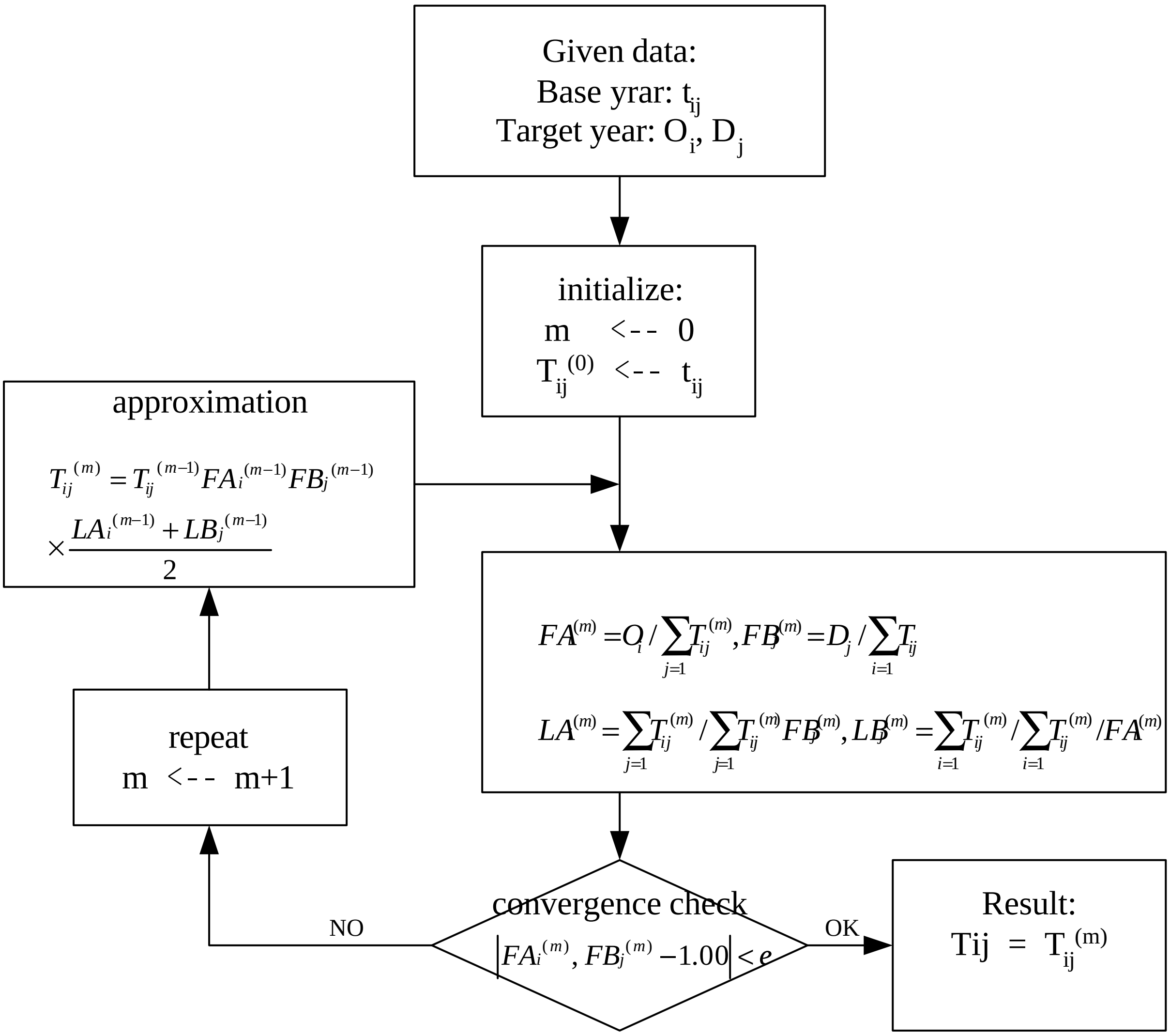

Figure C.3.2 Procedure to Calculate Trade

(based on Frator Method)

C.4 Parameter

The regional shares are the Parameters for the operational forecasting model. They are listed in Table C.4.1 and Table C.4.2.

Other parameters are world GDP, Regional GDPs, and Elasticity that has been listed in Table C.1.1, Table C.2.1 and Table C.2.2, respectively.

If the future GDP is revised in future, the future Suez Potential Cargo can be re-forecast by using these parameters.

If the structure of the world economy changes in future, it may be needed that the elasticity is revised

Table C.4.1 Regional Share of Import

Ref 1 ------ Actual Regional Share of Import:1998

	01.CS.America	02.N.Amrica.E	03.NW.Europe	04.W.Med	05.N.Africa	06.E.Med	07.E.Africa	08.A.Gulf	09.S.Asia	10.SE.Asia	11.E.Asia	12.Oceania	Total
01.Crude Oil	2%	32%	30%	9%	4%	20%	0%	0%	0%	1%	2%	0%	100%
02.Oil Products	17%	20%	15%	5%	0%	17%	0%	2%	2%	13%	9%	0%	100%
03.LPG/LNG	31%	5%	3%	27%	1%	30%	0%	0%	0%	1%	3%	0%	100%
04.Chemicals	4%	11%	11%	4%	1%	5%	0%	4%	19%	23%	17%	1%	100%
05.Grain	0%	0%	4%	0%	1%	3%	1%	22%	13%	41%	13%	0%	100%
06.Fabricated Metal	0%	6%	13%	3%	1%	12%	1%	13%	8%	40%	3%	1%	100%
07.Coal & Coke	0%	3%	30%	36%	1%	29%	0%	0%	0%	1%	0%	0%	100%
08.Ores	0%	1%	47%	21%	0%	25%	0%	3%	0%	3%	0%	0%	100%
09.Fertilizer	0%	4%	0%	0%	0%	0%	0%	3%	23%	47%	11%	11%	100%
10.Automobile	0%	21%	33%	3%	2%	16%	1%	8%	1%	4%	8%	3%	100%
11.Containerized Cargo	0%	10%	24%	3%	2%	12%	1%	6%	3%	15%	21%	2%	100%
12.Others	0%	3%	16%	13%	11%	7%	1%	30%	6%	7%	7%	0%	100%

Ref 2 ----- By Regional Elasticity Method - Regional Share of Import : 2020

	01.CS.America	02.N.Amrica.E	03.NW.Europe	04.W.Med	05.N.Africa	06.E.Med	07.E.Africa	08.A.Gulf	09.S.Asia	10.SE.Asia	11.E.Asia	12.Oceania	Total
01.Crude Oil	3%	29%	34%	8%	3%	19%	0%	0%	0%	1%	3%	0%	100%
02.Oil Products	34%	23%	10%	4%	0%	11%	0%	2%	2%	9%	6%	0%	100%
03.LPG/LNG	29%	9%	3%	28%	1%	28%	0%	0%	0%	0%	2%	0%	100%
04.Chemicals	3%	6%	10%	3%	1%	3%	0%	2%	28%	28%	15%	1%	100%
05.Grain	0%	1%	9%	1%	2%	4%	0%	21%	10%	44%	9%	0%	100%
06.Fabricated Metal	0%	5%	8%	2%	1%	6%	0%	8%	5%	63%	2%	1%	100%
07.Coal & Coke	0%	4%	30%	36%	1%	28%	0%	0%	0%	1%	0%	0%	100%
08.Ores	0%	2%	47%	21%	0%	21%	0%	2%	0%	6%	0%	0%	100%
09.Fertilizer	0%	2%	0%	0%	0%	0%	0%	3%	22%	59%	6%	7%	100%
10.Automobile	0%	21%	26%	3%	2%	9%	0%	11%	1%	12%	12%	4%	100%
11.Containerized Cargo	0%	11%	29%	4%	3%	10%	1%	4%	2%	20%	16%	1%	100%
12.Others	0%	4%	28%	16%	11%	6%	0%	16%	5%	8%	5%	0%	100%

Ref 3 ----- By a large-Scale Model - Regional share of Import : 2020

	01.CS.America	02.N.Amrica.E	03.NW.Europe	04.W.Med	05.N.Africa	06.E.Med	07.E.Africa	08.A.Gulf	09.S.Asia	10.SE.Asia	11.E.Asia	12.Oceania	Total
01.Crude Oil	3%	28%	35%	9%	2%	19%	0%	0%	0%	1%	3%	0%	100%
02.Oil Products	36%	25%	9%	4%	0%	8%	0%	2%	2%	9%	6%	0%	100%
03.LPG/LNG	26%	9%	3%	29%	1%	29%	0%	0%	0%	0%	2%	0%	100%
04.Chemicals	3%	6%	10%	3%	1%	3%	0%	2%	28%	28%	15%	1%	100%
05.Grain	0%	1%	9%	1%	2%	5%	0%	22%	10%	46%	5%	0%	100%
06.Fabricated Metal	0%	5%	8%	2%	1%	6%	0%	8%	5%	63%	2%	1%	100%
07.Coal & Coke	0%	4%	30%	36%	1%	28%	0%	0%	0%	1%	0%	0%	100%
08.Ores	0%	2%	47%	21%	0%	21%	0%	2%	0%	6%	0%	0%	100%
09.Fertilizer	0%	2%	0%	0%	0%	0%	0%	3%	22%	59%	6%	7%	100%
10.Automobile	0%	21%	26%	3%	2%	8%	0%	11%	1%	12%	12%	4%	100%
11.Containerized Cargo	0%	11%	29%	4%	3%	10%	1%	4%	2%	20%	16%	1%	100%
12.Others	0%	4%	28%	16%	11%	6%	0%	16%	5%	8%	5%	0%	100%

Table C.4.2 Regional Share of Export

	01.CS.America	02.N.Amrica.E	03.NW.Europe	04.W.Med	05.N.Africa	06.E.Med	07.E.Africa	08.A.Gulf	09.S.Asia	10.SE.Asia	11.E.Asia	12.Oceania	Total
01.Crude Oil	1%	0%	1%	0%	0%	1%	0%	96%	0%	0%	0%	0%	100%
02.Oil Products	3%	9%	3%	1%	2%	8%	0%	39%	0%	31%	3%	0%	100%
03.LPG/LNG	0%	2%	0%	0%	1%	0%	0%	94%	0%	1%	0%	1%	100%
04.Chemicals	4%	22%	11%	7%	17%	4%	0%	9%	1%	15%	10%	1%	100%
05.Grain	0%	53%	15%	6%	0%	17%	0%	0%	3%	4%	0%	3%	100%
06.Fabricated Metal	0%	1%	13%	2%	0%	50%	0%	1%	5%	15%	11%	2%	100%
07.Coal & Coke	0%	1%	0%	0%	0%	0%	40%	0%	0%	28%	0%	30%	100%
08.Ores	0%	0%	5%	0%	0%	1%	18%	1%	7%	6%	0%	62%	100%
09.Fertilizer	0%	15%	14%	2%	16%	49%	0%	5%	0%	0%	0%	0%	100%
10.Automobile	0%	5%	18%	1%	0%	1%	0%	0%	0%	2%	72%	0%	100%
11.Containerized Cargo	0%	8%	15%	12%	4%	10%	1%	2%	4%	25%	19%	2%	100%
12.Others	0%	4%	21%	11%	3%	12%	2%	9%	6%	26%	6%	1%	100%

Ref 5 ----- By Regional Elasticity Method - Regional Share of Export : 2020

	01.CS.America	02.N.Amrica.E	03.NW.Europe	04.W.Med	05.N.Africa	06.E.Med	07.E.Africa	08.A.Gulf	09.S.Asia	10.SE.Asia	11.E.Asia	12.Oceania	Total
01.Crude Oil	3%	0%	1%	0%	0%	1%	0%	93%	0%	1%	0%	0%	100%
02.Oil Products	3%	7%	2%	1%	1%	5%	0%	26%	0%	52%	2%	0%	100%
03.LPG/LNG	0%	2%	0%	0%	1%	0%	0%	94%	0%	2%	0%	1%	100%
04.Chemicals	9%	20%	7%	6%	27%	5%	0%	4%	1%	17%	3%	0%	100%
05.Grain	0%	56%	10%	4%	0%	12%	0%	0%	6%	9%	0%	2%	100%
06.Fabricated Metal	0%	1%	8%	1%	0%	68%	0%	0%	4%	11%	5%	1%	100%
07.Coal & Coke	0%	1%	0%	0%	0%	0%	33%	0%	0%	42%	0%	24%	100%
08.Ores	0%	0%	4%	0%	0%	4%	9%	1%	19%	14%	0%	49%	100%
09.Fertilizer	0%	13%	10%	2%	16%	56%	0%	3%	0%	0%	0%	0%	100%
10.Automobile	0%	7%	28%	3%	0%	3%	0%	0%	1%	2%	55%	0%	100%
11.Containerized Cargo	0%	8%	14%	9%	3%	11%	1%	1%	5%	37%	10%	2%	100%
12.Others	0%	3%	13%	7%	2%	9%	2%	4%	5%	52%	2%	1%	100%

Ref 6 ----- By a large-Scale Model - Regional share of Export : 2020

	01.CS.America	02.N.Amrica.E	03.NW.Europe	04.W.Med	05.N.Africa	06.E.Med	07.E.Africa	08.A.Gulf	09.S.Asia	10.SE.Asia	11.E.Asia	12.Oceania	Total
01.Crude Oil	3%	0%	1%	0%	0%	1%	0%	94%	0%	1%	0%	0%	100%
02.Oil Products	3%	7%	1%	0%	2%	5%	0%	27%	0%	53%	1%	0%	100%
03.LPG/LNG	0%	1%	0%	0%	1%	0%	0%	95%	0%	2%	0%	0%	100%
04.Chemicals	9%	20%	7%	6%	27%	5%	0%	4%	1%	17%	3%	0%	100%
05.Grain	0%	58%	9%	4%	0%	12%	0%	0%	6%	9%	0%	2%	100%
06.Fabricated Metal	0%	1%	8%	1%	0%	68%	0%	0%	4%	11%	5%	1%	100%
07.Coal & Coke	0%	1%	0%	0%	0%	0%	33%	0%	0%	42%	0%	24%	100%
08.Ores	0%	0%	4%	0%	0%	4%	9%	1%	19%	14%	0%	49%	100%
09.Fertilizer	0%	13%	10%	2%	16%	56%	0%	3%	0%	0%	0%	0%	100%
10.Automobile	0%	7%	28%	3%	0%	3%	0%	0%	1%	2%	55%	0%	100%
11.Containerized Cargo	0%	8%	14%	9%	3%	11%	1%	1%	5%	37%	10%	2%	100%
12.Others	0%	3%	13%	7%	2%	9%	2%	4%	5%	52%	2%	1%	100%

Appendix D Parameters of the Shipping Cost Function

This is the appendix of Chapter 4. The route choice model uses shipping cost function to forecast Suez transit. In this Appendix, the parameters of the function are listed.

D.1 Data Source

Table D.1.1 Data source

	SCNT/ DWT Ratio	Load Factor	Contract Price	Manning cost	Other Managing Cost	Fuel Consumption	Speed
Crude Oil Tanker	S	S	D	D	D	D,C	D,F
Other Tanker	S	S	F	D	D	C	F
Bulk Carrier	S	S	D	D	D	D,C	D,F
General Cargo	S	S	D	D	D	D,C	D,F
Containership	S	S	F	D	D	D,C	D
Car Carrier	S	S	F	D	D	C	F

Note) S:SCA transit database, D:Drewery "Ship Costs", C:Clarksons Register CD, F:Fairplay RegisterCD

D.2 Parameters of transits

(1) SCNT/ DWT Ratio

Table D.2.1 SCNT/ DWT Ratio by Vessel Type in 2020

SCNT/ DWT Ratio

V-Type	Ratio (SCNT/ DWT)
Crude Oil Tankers	0.5010
Tankers (Products)	0.5290
Tankers (LNG)	1.2450
Tankers (LPG)	0.7390
Tankers (Chemicals)	0.5270
Tankers (Others)	0.5140
Bulk Carriers	0.5095
General Cargo Ships	0.6381
Containerships	0.6160
Car Carriers	2.6634

Source) SCA transit database in 1997-1999
The same values are assumed in 2020 and 1997-1999

(2) Load Factor

Table D.2.2 Load Factor by Vessel Type in 2020

Load Factor

V-Type	Load Factor
Crude Oil Tankers	90.6%
Tankers (Products)	81.2%
Tankers (LNG)	72.8%
Tankers (LPG)	72.8%
Tankers (Chemicals)	82.8%
Tankers (Others)	75.0%
Bulk Carriers	83.2%
General Cargo Ships	63.1%
Containerships	59.6%
Car Carriers	28.3%

Source) SCA transit database in 1997-1999

The same values are assumed in 2020 and 1997-1999

(3) Contract Price

Table D.2.3 Contract Price by Vessel Type (Y2000 Price)

Contract Price (million US$)

V-Type	V-Size(1000DWT) 0-25	25-50	50-75	75-100	100-125	125-150	150-200	200-250	250-300	300+
Crude Oil Tankers	18.2	22.9	28.6	34.5	40.6	44.9	48.0	64.9	75.2	78.3
Tankers (Products)	18.2	26.1	33.2	39.8	46.7	56.6	58.7	-	-	-
Tankers (LNG)	111.0	151.5	183.9	-	-	-	-	-	-	-
Tankers (LPG)	28.8	56.2	71.1	-	-	-	-	-	-	-
Tankers (Chemicals)	25.3	35.8	48.6	67.3	75.0	-	-	-	-	-
Tankers (Others)	17.8	22.9	27.8	33.7	-	-	-	-	-	-
Bulk Carriers	15.1	17.6	21.9	23.9	29.8	33.4	37.2	43.7	-	-
General Cargo Ships	10.2	24.5	34.0	-	-	-	-	-	-	-
Containerships	26.1	46.7	66.1	92.5	124.2	-	-	-	-	-
Car Carriers	36.8	60.7	121.6	-	-	-	-	-	-	-

Note) " - " is not calculated

Source) JICA study team based on Drewery and Fairplay's database etc.

(4) Daily Manning (cost for crews)

Table D.2.4 Daily Manning Cost by Vessel Type (Y2000 Price)

Daily Manning (cost for crews)										(US$/day)
	V-Size(1000DWT)									
V-Type	0-25	25-50	50-75	75-100	100-125	125-150	150-200	200-250	250-300	300+
Crude Oil Tankers	2,210	2,217	2,225	2,233	2,242	2,249	2,253	2,278	2,292	2,297
Tankers (Products)	2,209	2,218	2,226	2,233	2,240	2,251	2,253	-	-	-
Tankers (LNG)	2,211	2,218	2,224	-	-	-	-	-	-	-
Tankers (LPG)	2,210	2,219	2,223	-	-	-	-	-	-	-
Tankers (Chemicals)	2,211	2,217	2,224	2,234	2,238	-	-	-	-	-
Tankers (Others)	2,209	2,217	2,224	2,232	-	-	-	-	-	-
Bulk Carriers	1,745	1,753	1,766	1,772	1,789	1,800	1,812	1,832	-	-
General Cargo Ships	1,741	1,752	1,759	-	-	-	-	-	-	-
Containerships	2,293	2,904	3,478	4,261	5,203	-	-	-	-	-
Car Carriers	2,230	2,596	3,527	-	-	-	-	-	-	-

Note) " - " is not calculated
Source) JICA study team based on Drewery

(5) Other Direct Managing Cost (insurance, repair and others)

Table D.2.5 Other Direct Managing Cost by Vessel Type (Y2000 Price)

Other Direct Managing Cost (insurance, repair and so on)										(US$/day)
	V-Size(1000DWT)									
V-Type	0-25	25-50	50-75	75-100	100-125	125-150	150-200	200-250	250-300	300+
Crude Oil Tankers	2,530	2,803	3,130	3,470	3,825	4,077	4,255	5,238	5,833	6,014
Tankers (Products)	2,509	2,852	3,157	3,441	3,739	4,167	4,259	-	-	-
Tankers (LNG)	2,556	2,859	3,102	-	-	-	-	-	-	-
Tankers (LPG)	2,539	2,882	3,069	-	-	-	-	-	-	-
Tankers (Chemicals)	2,572	2,801	3,083	3,493	3,662	-	-	-	-	-
Tankers (Others)	2,507	2,800	3,081	3,427	-	-	-	-	-	-
Bulk Carriers	1,939	2,093	2,356	2,478	2,834	3,057	3,288	3,683	-	-
General Cargo Ships	1,867	2,087	2,232	-	-	-	-	-	-	-
Containerships	2,323	3,055	3,743	4,681	5,810	-	-	-	-	-
Car Carriers	2,248	2,686	3,801	-	-	-	-	-	-	-

Note) " - " is not calculated
Source) JICA study team based on Drewery

(6) Fuel Consumption Rate in Ocean

Table D.2.6 Fuel Consumption Rate in Ocean by Vessel Type in 2020

Fuel Consumption Rate in Ocean (ton/day)

V-Type	V-Size(1000DWT) 0-25	25-50	50-75	75-100	100-125	125-150	150-200	200-250	250-300	300+
Crude Oil Tankers	33.9	37.2	41.2	45.3	49.6	52.7	54.9	66.8	74.0	76.3
Tankers (Products)	14.7	24.8	33.8	42.2	51.0	63.6	66.3	-	-	-
Tankers (LNG)	55.1	102.9	141.1	-	-	-	-	-	-	-
Tankers (LPG)	18.4	39.3	50.8	-	-	-	-	-	-	-
Tankers (Chemicals)	19.7	33.0	49.3	73.1	82.9	-	-	-	-	-
Tankers (Others)	33.6	37.1	40.6	44.8	-	-	-	-	-	-
Bulk Carriers	23.6	28.0	35.5	39.0	49.2	55.5	62.1	73.4	-	-
General Cargo Ships	20.8	59.5	85.2	-	-	-	-	-	-	-
Containerships	73.8	103.8	132.1	170.5	216.9	-	-	-	-	-
Car Carriers	45.0	59.7	97.3	-	-	-	-	-	-	-

Note) " - " is not calculated

Source) JICA study team based on Drewery and Clarkson's database etc.

Estimated from recent vessels

(7) Fuel Consumption Rate at Port

Table D.2.7 Fuel Consumption Rate at Port by Vessel Type in 2020

Fuel Consumption at Port (ton/day)

V-Type	V-Size(1000DWT) 0-25	25-50	50-75	75-100	100-125	125-150	150-200	200-250	250-300	300+
Crude Oil Tankers	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Tankers (Products)	0.2	0.2	0.2	0.3	0.3	0.3	0.3	-	-	-
Tankers (LNG)	0.5	0.8	1.0	-	-	-	-	-	-	-
Tankers (LPG)	0.2	0.3	0.4	-	-	-	-	-	-	-
Tankers (Chemicals)	0.2	0.3	0.3	0.4	0.5	-	-	-	-	-
Tankers (Others)	0.4	0.3	0.3	0.3	-	-	-	-	-	-
Bulk Carriers	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	-	-
General Cargo Ships	0.2	0.5	0.6	-	-	-	-	-	-	-
Containerships	0.7	0.8	0.9	1.1	1.2	-	-	-	-	-
Car Carriers	0.4	0.5	0.7	-	-	-	-	-	-	-

Note) " - " is not calculated

Source) JICA study team based on Drewery and Clarkson's database etc.

Estimated from recent vessels

(8) Voyage Speed

Table D.2.8 Voyage Speed by Vessel Type in 2020

Voyage Speed (kt)

V-Type	V-Size(1000DWT) 0-25	25-50	50-75	75-100	100-125	125-150	150-200	200-250	250-300	300+
Crude Oil Tankers	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
Tankers (Products)	13.1	14.4	14.9	15.2	15.4	15.6	15.7	-	-	-
Tankers (LNG)	15.7	17.4	18.8	-	-	-	-	-	-	-
Tankers (LPG)	15.0	16.5	16.9	-	-	-	-	-	-	-
Tankers (Chemicals)	14.0	14.9	15.5	16.0	16.1	-	-	-	-	-
Tankers (Others)	14.0	14.0	14.0	14.0	-	-	-	-	-	-
Bulk Carriers	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	-	-
General Cargo Ships	13.3	14.7	15.1	-	-	-	-	-	-	-
Containerships	18.7	21.4	22.8	24.1	25.1	-	-	-	-	-
Car Carriers	18.7	19.6	20.8	-	-	-	-	-	-	-

Note) " - " is not calculated

Source) JICA study team based on Drewery and Fairplay's database etc.
Estimated from recent vessels

(9) The shipping cost function

C = A + B x D + Esc (USD/ton)

,where C : shipping cost of cargo of a trip (US$/ton)

A : coefficient of independent on the distance (constant)(US$/ton)

B : coefficient of dependent on the distance (constant) (US$/ton-mile)

D : distance of one trip (from an origin to destination)(mile)

Esc : additional cost of the Suez route (US$/ton)

1) Shipping Cost function (USD/ton)

Table D.2.9 Shipping Cost B by Vessel Type in 2020

(Y2000 Price)

Shipping Cost 'B' (dependent on the distance) (US$/ton-1000mile)

V-Type	V-Size(1000DWT) 0-25	25-50	50-75	75-100	100-125	125-150	150-200	200-250	250-300	300+
Crude Oil Tankers	3.774	1.448	0.928	0.722	0.611	0.561	0.534	0.444	0.415	0.408
Tankers (Products)	4.486	1.372	0.970	0.807	0.711	0.629	0.616	-	-	-
Tankers (LNG)	10.884	4.809	3.597	-	-	-	-	-	-	-
Tankers (LPG)	4.513	2.080	1.796	-	-	-	-	-	-	-
Tankers (Chemicals)	3.287	1.798	1.334	1.083	1.027	-	-	-	-	-
Tankers (Others)	5.404	1.758	1.176	0.895	-	-	-	-	-	-
Bulk Carriers	1.845	1.122	0.748	0.668	0.537	0.492	0.459	0.421	-	-
General Cargo Ships	3.558	2.073	1.842	-	-	-	-	-	-	-
Containerships	4.246	2.690	2.259	1.992	1.832	-	-	-	-	-
Car Carriers	13.674	11.335	9.633	-	-	-	-	-	-	-

Table D.2.10 Shipping Cost EscL for a Laden Vessel

(Y2000 Price)

Shipping Cost ‘EscL’ (additional cost of the Suez route) (US$/ton)

V-Type	V-Size(1000DWT) 0-25	25-50	50-75	75-100	100-125	125-150	150-200	200-250	250-300	300+
Crude Oil Tankers	5.781	3.652	2.671	2.190	1.932	1.814	1.799	1.568	1.471	1.448
Tankers (Products)	7.436	4.256	3.284	2.888	2.651	2.523	2.488	-	-	-
Tankers (LNG)	15.060	10.135	8.978	-	-	-	-	-	-	-
Tankers (LPG)	9.096	6.095	5.426	-	-	-	-	-	-	-
Tankers (Chemicals)	6.525	4.819	3.932	3.391	3.270	-	-	-	-	-
Tankers (Others)	8.640	5.110	4.160	3.627	-	-	-	-	-	-
Bulk Carriers	5.302	4.012	2.735	2.437	1.937	1.837	1.701	1.592	-	-
General Cargo Ships	9.649	6.625	5.769	-	-	-	-	-	-	-
Containerships	9.393	7.436	6.869	6.838	6.736	-	-	-	-	-
Car Carriers	48.643	42.758	34.992	-	-	-	-	-	-	-

Table D.2.11 Shipping Cost EscB for a In-ballast Vessel

(Y2000 Price)

Shipping Cost ‘EscB’ (additional cost of the Suez route) (US$/ton)

V-Type	V-Size(1000DWT) 0-25	25-50	50-75	75-100	100-125	125-150	150-200	200-250	250-300	300+
Crude Oil Tankers	5.004	3.145	2.298	1.884	1.662	1.561	1.496	1.281	1.243	1.225

2) Shipping Cost function (USD/SCNT)

Table D.2.12 Shipping Cost B by Vessel Type in 2020

(Y2000 Price)

Shipping Cost 'B' (dependent on the distance) (US$/SCNT-1000mile)

V-Type	V-Size (SCNT)															
	2500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	55,000	70,000	90,000	110,000	135,000	160,000	190,000	220,000
Crude Oil Tankers	14.951	7.724	5.315	4.111	2.906	2.304	1.702	1.401	1.155	1.014	0.899	0.826	0.765	0.723	0.688	0.662
Tankers (Products)	14.056	7.060	4.818	3.722	2.646	2.118	1.597	1.339	1.130	1.010	0.912	0.849	0.796	0.758	0.726	0.703
Tankers (LNG)	37.098	19.092	13.084	10.074	7.056	5.537	4.002	3.220	2.560	2.168	1.833	1.606	1.405	1.258	1.123	1.018
Tankers (LPG)	14.117	7.321	5.158	4.102	3.066	2.556	2.049	1.796	1.587	1.466	1.365	1.299	1.242	1.202	1.166	1.139
Tankers (Chemicals)	14.710	7.627	5.364	4.257	3.169	2.633	2.102	1.836	1.617	1.491	1.386	1.317	1.258	1.216	1.180	1.152
Tankers (Others)	10.805	5.403	3.602	2.701	1.801	1.351	0.900	0.675	0.491	0.386	0.300	0.246	0.200	0.169	0.142	0.123
Bulk Carriers	10.752	5.599	3.882	3.023	2.164	1.735	1.306	1.091	0.915	0.815	0.733	0.681	0.638	0.608	0.582	0.564
General Cargo Ships	8.113	4.643	3.527	2.977	2.429	2.154	1.874	1.729	1.605	1.530	1.465	1.421	1.381	1.351	1.324	1.303
Containerships	15.813	7.831	5.462	4.334	3.235	2.687	2.121	1.818	1.544	1.366	1.202	1.083	0.972	0.885	0.804	0.739
Car Carriers	10.750	5.624	4.002	3.212	2.438	2.056	1.676	1.485	1.326	1.234	1.156	1.104	1.059	1.027	0.998	0.976

Table D.2.13 Shipping Cost EscL for a Laden Vessel

(Y2000 Price)

Shipping Cost 'EscL' (additional cost of the Suez route) (US$/SCNT)

V-Type	V-Size (SCNT)															
	2500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	55,000	70,000	90,000	110,000	135,000	160,000	190,000	220,000
Crude Oil Tankers	5.342	2.799	1.951	1.527	1.103	0.892	0.680	0.574	0.487	0.438	0.493	0.528	0.478	0.443	0.414	0.392
Tankers (Products)	5.322	2.803	1.963	1.543	1.123	0.914	0.704	0.599	0.513	0.464	0.519	0.554	0.504	0.470	0.440	0.419
Tankers (LNG)	12.866	6.664	4.597	3.564	2.530	2.014	1.783	1.453	1.183	1.029	0.903	0.823	0.756	0.711	0.672	0.643
Tankers (LPG)	5.662	3.067	2.202	1.769	1.337	1.121	1.190	1.011	0.864	0.780	0.711	0.668	0.631	0.606	0.585	0.570
Tankers (Chemicals)	5.615	3.014	2.147	1.713	1.280	1.063	0.846	0.738	0.649	0.599	0.653	0.687	0.636	0.601	0.571	0.550
Tankers (Others)	4.506	2.318	1.589	1.224	0.859	0.677	0.495	0.403	0.329	0.286	0.347	0.385	0.338	0.306	0.278	0.258
Bulk Carriers	4.527	2.373	1.656	1.297	0.938	0.759	0.579	0.490	0.416	0.374	0.436	0.475	0.428	0.395	0.368	0.348
General Cargo Ships	3.783	2.081	1.514	1.230	0.946	0.804	0.662	0.591	0.533	0.500	0.568	0.611	0.568	0.538	0.513	0.494
Containerships	4.732	2.742	2.074	1.736	1.393	1.215	1.027	0.924	0.829	0.766	0.801	0.818	0.747	0.694	0.645	0.607
Car Carriers	4.312	2.412	1.779	1.463	1.146	0.988	0.830	0.751	0.686	0.649	0.715	0.756	0.711	0.680	0.654	0.635

Table D.2.14 Shipping Cost EscB for a In-ballast Vessel

(Y2000 Price)

Shipping Cost 'EscB' (additional cost of the Suez route) (US$/SCNT)

V-Type	V-Size (SCNT)															
	2500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	55,000	70,000	90,000	110,000	135,000	160,000	190,000	220,000
Crude Oil Tankers	4.877	2.557	1.784	1.398	1.012	0.818	0.625	0.529	0.450	0.405	0.368	0.344	0.389	0.365	0.345	0.331
Tankers (Products)	4.859	2.561	1.795	1.412	1.029	0.837	0.646	0.550	0.472	0.427	0.390	0.367	0.411	0.388	0.368	0.354
Tankers (LNG)	11.374	5.896	4.070	3.157	2.244	1.787	1.617	1.317	1.072	0.932	0.818	0.745	0.684	0.643	0.607	0.581
Tankers (LPG)	5.153	2.789	2.001	1.607	1.213	1.016	1.105	0.935	0.796	0.717	0.652	0.611	0.576	0.553	0.532	0.518
Tankers (Chemicals)	5.112	2.743	1.954	1.559	1.164	0.967	0.769	0.670	0.590	0.544	0.506	0.482	0.526	0.502	0.482	0.467
Tankers (Others)	4.154	2.142	1.471	1.136	0.801	0.633	0.465	0.382	0.313	0.274	0.242	0.221	0.268	0.247	0.228	0.215
Bulk Carriers	4.173	2.190	1.530	1.199	0.869	0.704	0.539	0.456	0.389	0.350	0.318	0.298	0.345	0.324	0.306	0.292
General Cargo Ships	3.531	1.938	1.407	1.141	0.876	0.743	0.610	0.543	0.489	0.458	0.433	0.416	0.466	0.447	0.431	0.419
Containerships	4.253	2.411	1.794	1.483	1.167	1.004	0.834	0.741	0.657	0.602	0.551	0.514	0.542	0.504	0.469	0.442
Car Carriers	3.826	2.063	1.475	1.181	0.887	0.741	0.594	0.520	0.460	0.426	0.398	0.380	0.429	0.409	0.392	0.379

Appendix E Basic Structure Model

E.1 Introduction

This model is developed to forecast the demand of Suez Canal Transit Cargo, number of vessels, and Canal revenue. As the model is named "Basic Structure", this model is quite simple and is easy to understand. The structure of this model has different structure from "Intensive Structure Model" in the main part of this study report.

The objective of model is to check the effectiveness of "Intensive Structure Model". This model also easily interpolates the demand in any year such as 2005,2010,2015, and 2020.

"Intensive Structure Model" in the chapters in this report can treat the following factors that will affect the Canal demand.

- Origin and destination of cargo
- Shipping cost including Toll
- Vessel size distribution

But Basic Structure Model cannot use these factors for forecasting.
The merits of Basic Structure Model are:.

1) Input the number of year, then the baseline demand in any year can be estimated
2) Tutorial and support for the understanding of basic relations of cargo and transit

E.2 Forecasting Procedure

This model starts from present cargo volume by type of cargo and direction. (See Figure E.2.1)

The procedure has the following stages.

1. Future cargo by commodity
2. Future cargo by vessel type
3. Future SCNT & DWT by vessel type
4. Fleet mix of north & southbound and check the maximum capable size of vessel for Tanker
5. Number of Transit by direction and by laden/in-ballast
6. Canal revenue by vessel type

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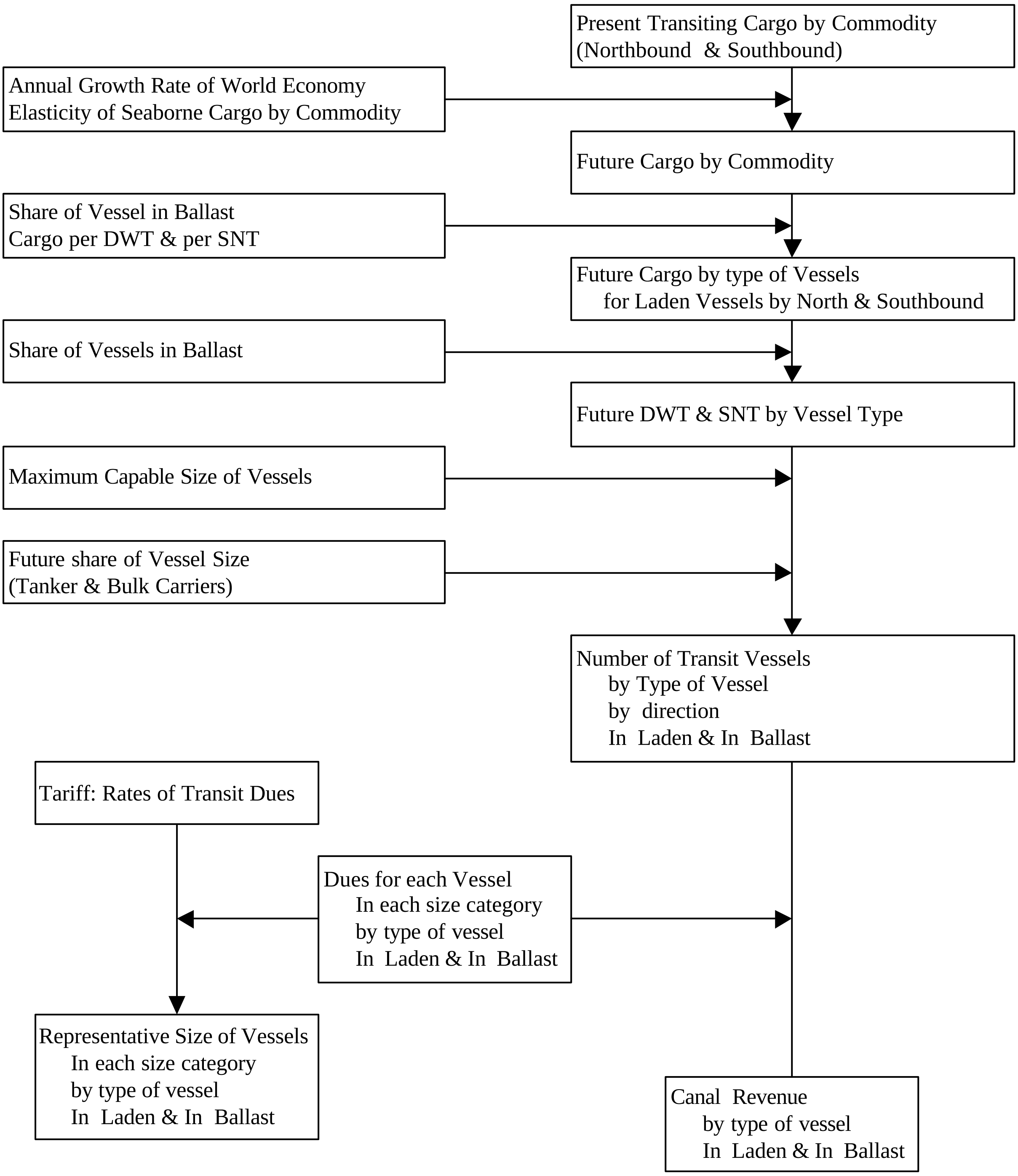

Figure E.2.1 Forecasting Procedure of Cargo, SNT, DWT, Number of Vessel and Canal Revenue

E.3 Future Cargo by Commodity

Future Cargo is estimate based on the annual growth rate of Potential Cargo that was forecast in a large-scale model.

V2020 = V1999*r^21

,where r is the annual growth rate of the cargo. (Table E.3.1)

Table E.3.1 The annual growth rate

(1999-2020)

	Southbound	Northbound	Total
01.Crude Oil	1.014	1.003	1.003
02.Oil Products	1.002	1.023	1.018
03.LNG/LPG	0.992	1.001	1.001
04.Chemicals	1.061	1.039	1.054
05.Grain	1.012	1.045	1.016
06.Steel	1.072	1.040	1.063
07.Coal & Coke	1.005	1.009	1.009
08.Ores & Metals	1.043	1.029	1.030
09.Fertilizers	1.033	1.007	1.032
10.Automobile	1.052	1.018	1.029
11.Others	1.052	1.059	1.056
12.Containers	1.035	1.068	1.054
Total	1.045	1.023	1.029

The result of the calculation (V2020) is the next Table.

Table E.3.2 The result of the forecast (2020)

Forecast : Cargo Ton by Cargo Type 2020 (1000Ton)

Cargo Type	Southbound	Northbound	Total
Crude Oil	457	9,791	10,248
Moter Spirit	196	4,584	4,781
Kerosene	0	170	170
Gas Oil & Diesel Oil	416	3,755	4,171
Fuel Oil	1,149	1,021	2,170
Naphtha	1,617	23	1,640
LPG	1,101	1,378	2,480
LNG	0	1,287	1,287
Others	451	675	1,126
Oil & Products : Sub-total	5,388	22,685	28,073
Cereals	25,801	5,355	31,156
Fertilizer	34,934	1,655	36,589
Fabricated Metals	94,376	8,263	102,639
Cement	266	11,074	11,340
Chemicals	22,914	9,013	31,927
Coal & Coke	310	29,111	29,421
Food Stuffs	2,945	3,206	6,151
Machinerry & parts	3,062	4,218	7,280
Starch & Farinas	0	6,619	6,619
Minerals & Rocks	499	2,702	3,202
Ores & metals	4,696	24,591	29,287
Oil Seeds	6,642	4,966	11,608
Wood,Timber & Lumber	1,029	3,941	4,970
Molasses	1,072	3,607	4,678
Vegetable Oils	2,153	9,389	11,543
Containerrized Cargo	137,119	247,863	384,982
Others	18,878	16,548	35,426
Other Goods : Sub-total	356,696	392,122	748,818
Grand Total	362,084	414,807	776,891

E.4 Future Cargo by Vessel Type

Future Cargo is estimated by using the Cargo share of loaded vessel types from SCA data.

$$VCi = \sum_{j} (Sij * Cj)$$

Cj : Cargo Volume of type j
VCi : Cargo loaded by vessel type i
Sij : Cargo share of loaded in vessel type i

Table E.4.1 is the result of the calculation.

Table E.4.1 Cargo Ton by Laden Vessels

Cargo Ton by Laden Vessels			2020
	Southbound	Northbound	Total
Tankers	30,308	37,685	67,992
Bulk Carr.	156,251	94,268	250,518
Comb. Carr.	1,361	1,550	2,910
General Cargo	31,063	22,360	53,423
Containership	134,894	243,624	378,517
Lash Ship	1,393	371	1,764
Ro/Ro	2,366	1,670	4,036
Car Carr.	2,742	10,714	13,456
Passenger Ship	0	0	0
Warships	0	153	153
Other Ships	1,708	299	2,007
TOTAL	362,085	412,692	774,777

E.5 Future SCNT

Next Step is estimating SCNT of Laden vessels by the average cargo ton per SCNT.

SCNT of laden vessels = (Cargo Ton)×(SCNT/cargo ton–ratio)

SCNT/cargo ton–ratio is listed in Table E.5.1.

Table E.5.1 Cargo-SCNT for Laden Vessels

Cargo/SCNT for Laden Vessels			
	Southbound	Northbound	Total
Tankers	1.39	1.43	1.41
Bulk Carr.	1.58	1.63	1.60
Comb. Carr.	1.45	1.56	1.50
General Cargo	1.06	0.92	1.00
Containership	0.79	0.73	0.76
Lash Ship	0.81	0.88	0.85
Ro/Ro	0.51	0.31	0.42
Car Carr.	0.12	0.17	0.15
Passenger Ship	0.00	0.00	0.00
Warships	0.02	0.42	0.41
Other Ships	0.61	0.68	0.63
TOTAL	0.75	0.75	1.50

The result of the calculation (SCNT of laden vessels) is Table E.5.2.

Table E.5.2 Net-ton for Laden Vessels

Net-ton by Laden Vesels			(1000Ton)
	Southbound	Northbound	Total
Tankers	21,754	26,441	48,195
Bulk Carr.	98,648	58,007	156,655
Comb. Carr.	940	994	1,934
General Cargo	29,271	24,197	53,468
Containership	171,702	334,106	505,808
Lash Ship	1,719	420	2,139
Ro/Ro	4,609	5,406	10,015
Car Carr.	22,010	63,710	85,720
Passenger Ship	2	0	2
Warships	0	363	363
Other Ships	2,809	442	3,250
TOTAL	353,463	514,086	867,549

Share of SCNT of Laden vessels were used to estimate Total SCNT. In this step, vessel sizes were considered for Tanker, because the canal size and S/S, S/C should be considered.

Table E.5.3 Net-ton by Vessels

	(1000Ton)								2020
	Laden			In ballast			Total		
	Southbound	Northbound	Total	Southbound	Northbound	Total	Southbound	Northbound	Total
Tankers	21,754	26,441	48,195	45,693	9,792	55,486	67,447	36,233	103,681
Bulk Carr.	98,648	58,007	156,655	636	3,053	3,689	99,284	61,060	160,344
Comb. Carr.	940	994	1,934	2,162	444	2,605	3,102	1,437	4,539
General Cargo	29,271	24,197	53,468	790	1,297	2,087	30,061	25,494	55,555
Containership	171,702	334,106	505,808	1,586	384	1,970	173,288	334,490	507,778
Lash Ship	1,719	420	2,139	58	0	58	1,778	420	2,197
Ro/Ro	4,609	5,406	10,015	287	366	653	4,896	5,772	10,668
Car Carr.	22,010	63,710	85,720	15,858	88	15,946	37,868	63,798	101,666
Passenger Ship	2	0	2	1	1	2	2	1	3
Warships	0	363	363	204	159	363	205	522	727
Other Ships	2,809	442	3,250	1,062	1,040	2,103	3,871	1,482	5,353
TOTAL	353,463	514,086	867,549	68,338	16,624	84,962	421,801	530,710	952,511

SCNT was converted to the number of vessels and revenues were calculated from SCNT and toll.

E.6 Final Result in 2020 by Basic Structure Model

Table E.6.1 Estimated Canal NET Ton (1000)

	SCNT(1000)			
	Laden	In Ballast	Total	1999
Tankers	48,195	55,486	103,681	67,872
Bulk Carr.	156,655	3,689	160,344	73,610
Comb. Carr.	1,934	2,605	4,539	2,260
General Cargo	53,468	2,087	55,555	18,874
Containership	505,808	1,970	507,778	168,245
Lash Ship	2,139	58	2,197	1,129
Ro/Ro	10,015	653	10,668	3,890
Car Carr.	85,720	15,946	101,666	43,283
Passenger Ship	2	2	3	1,769
Warships	363	363	727	1,369
Other Ships	3,250	2,103	5,353	2,693
Total	867,549	84,962	952,511	384,994

Table E.6.2 Estimated Number of Ships

	2020 (Ships)			
	Laden	In Ballast	Total	Actual 1999
Tankers	2,446	1,033	3,479	1987
Bulk Carr.	5,966	200	6,166	2805
Comb. Carr.	45	33	78	42
General Cargo	5,925	231	6,156	2153
Containership	10,442	41	10,483	4375
Lash Ship	76	2	78	40
Ro/Ro	564	37	601	219
Car Carr.	1,842	343	2,184	930
Passenger Ship	0	0	0	118
Warships	40	40	80	150
Other Ships	810	524	1,334	671
Total	28,155	2,484	30,640	13490

Table E.6.3 Estimated Transit Revenue from Toll:(SDR)

	2020 (000SDR)		
	Laden	In Ballast	Total
Tankers	194,017	107,081	301,099
Bulk Carr.	530,494	13,938	544,432
Comb. Carr.	5,499	4,351	9,850
General Cargo	312,308	12,795	325,103
Containership	1,661,054	6,442	1,667,496
Lash Ship	8,798	204	9,002
Ro/Ro	48,499	2,778	51,277
Car Carr.	284,522	45,047	329,568
Passenger Ship	8	7	14
Warships	2,115	1,798	3,913
Other Ships	23,433	12,889	36,322
Total	3,070,748	207,330	3,278,078

Appendix F

Transit Forecasting Model

Program Manual

June 2001

JICA Study Team on
THE EFFECTIVE MANAGEMENT SYSTEM OF THE SUEZ CANAL
IN THE ARAB REPUBLIC OF EGYPT

Preface

This program package was developed for the Suez Canal Authority to forecast the transits in the future.

Japan International Cooperation Agency (JICA) sponsored this package under the technical cooperation program of the Government of Japan. The development of the package was the joint –work of the SCA staffs and JICA Study Team members.

The major purpose of the development of this program is technical training as well as forecasting.
All programs are very open for the analysis and the future changes.
JICA Study Team hopes that SCA staffs will learn forecast methods from this program and will modify the necessity change in the future work.

The JICA Study Team members who are in charge of this development are:

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All of them are from Mitsubishi Research Institute, Inc. Tokyo, JAPAN

If you have some questions, please contact them. It will be their pleasure to support SCA Staffs.

Chapter 1 Structure of the Package

This package has 3 programs and 1 data file and 1 supplemental data file. All of them are written in Excel Sheets.

1. Potential Cargo Forecast
   This program is used to calculate the future potential cargo volumes.

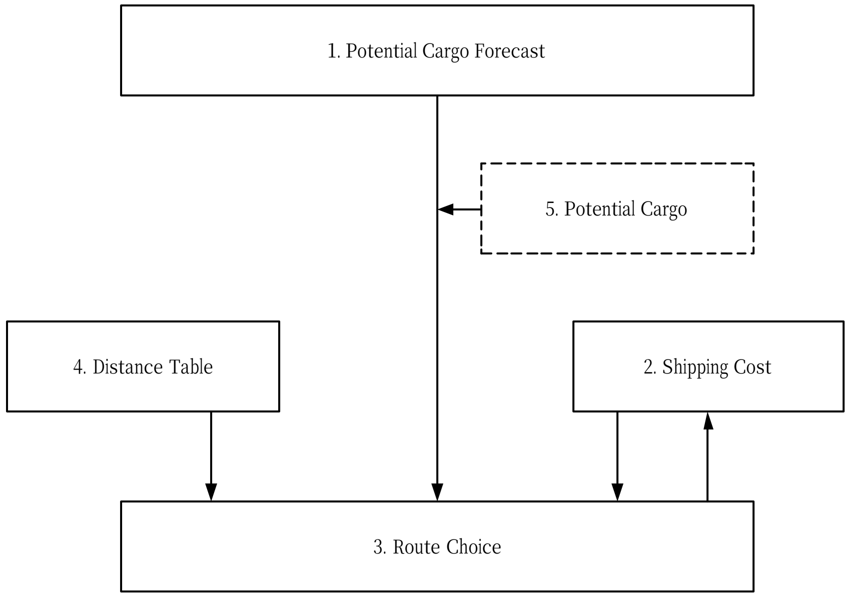
2. Shipping Cost
   This program is used to calculate the shipping cost co-efficient.

3. Route Choice
   This program is used to calculate the future transits and revenue.

4. Distance Table
   This data file shows the distances between zones, and is used as an input of Route Choice program.

5. Potential Cargo
   This data file is a supplemental file that is not used in the standard forecast procedure. This data is the potential cargo in 2020 that was calculated from the output of a large-scale forecasting model. This data was used to develop "Potential Cargo Forecast". And was also used to obtain the numerical result of the forecast written in the Study Report.

These files are linked as described below.



Note) "5. Potential Cargo is an alternative data source of "1. Potential Cargo Forecast"

Chapter 2 Procedure of Forecasting

The following are the standard procedure of forecasting.

Step 1

Open “PotentialCargoForecast.xls”, “ShippingCost.xls”, “RouteChoice.xls”, and “DistanceTable.xls”

Step2

Work in “potentialCargoForecast.xls”

Step3

Work in “RouteChoice.xls”

If you don’t need forecasting the Potential Cargo, the following steps are more convenient.

Step1

Open “PotentialCargo.xls”, “ShippingCost.xls”, “RouteChoice.xls”, and “DistanceTable.xls”

Step2

Work in “RouteChoice.xls”

The procedure in each program is described in the next chapters.

Chapter 3 Program "Potential Cargo Forecast"

3.1 Purpose of the program:

This program calculates the future Suez Potential Cargo in target year. Default target year is 2020.

3.2 Inputs, Outputs, and Parameters

3.2.1 Input

1. Target Year
2. Annual GDP growth rate
3. Regional share of import by commodity
4. Regional share of export by commodity
5. Deductive Cargo Volume

3.2.2 Output

1. O-D table of Suez Potential Cargo (for input of Route Choice Model)

3.2.3 Parameters

1. Electricity of trade growth for each commodity (constant)
2. Regional elasticity of trade growth for each commodity. (constant)
3. Regional GDP growth rate (can be changed as inputs)

3.3 Procedure of forecast in this program

(1) Step1

Input the average world annual growth rate and a target year of forecast in EXCEL Sheet "Total Trade".

Then, total import (= total export) is automatically calculated.

(2) Step2

Input the regional shares of import in EXCEL Sheet "Shares". Then import of each region is automatically calculated.

The regional shares of import have to be set based on your idea. Three kinds of information are provided for setting it.

1. Present regional shares of import (1998)
2. Trend regional shares of import (2020)
3. Regional shares of import estimated by regional elasticity method

No.1 and No.2 are already fixed. No.3 is derived from the future regional GDP growth rates that can be changed after new values are provided.

(3) Step3

Input the regional shares of export in EXCEL Sheet "Shares". Then export of each region is automatically calculated.

The regional shares of export have to be set based on your idea. Three kinds of information are provided foe setting them.

1. Present regional shares of export (1998)
2. Trend regional shares of export (2020)
3. Regional shares of import estimated by regional elasticity method

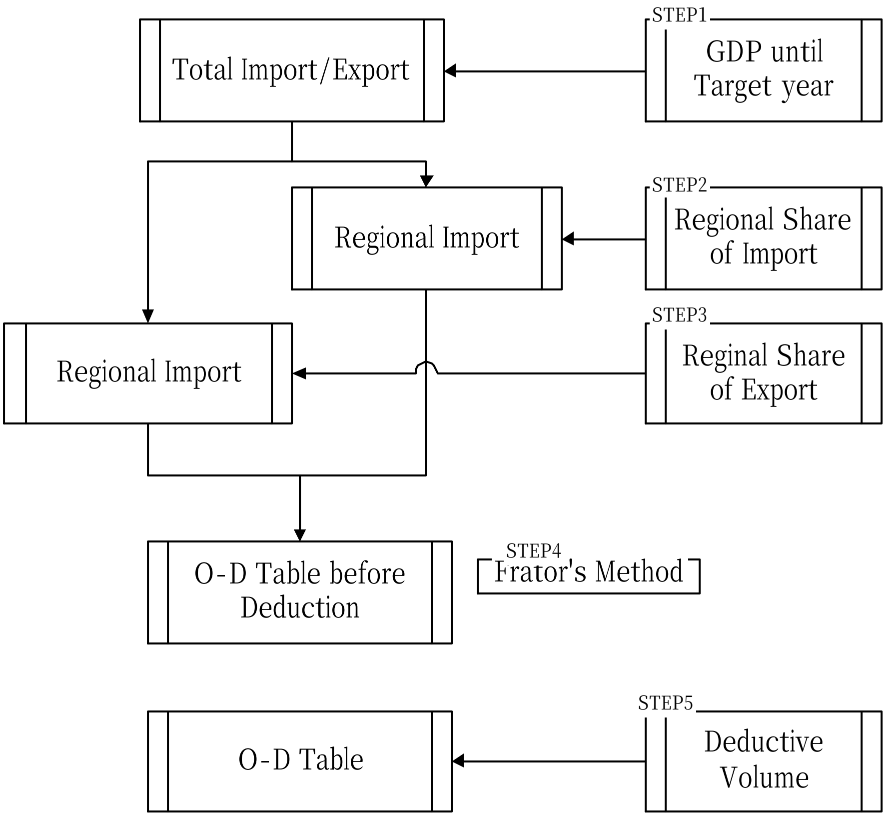
No.1 and No.2 are already fixed. No.3 is derived from the future regional GDP growth rates that can be changed after new values are provided.

(4) Step4

Push a button "Run" in the EXCEL Sheet "Before Deduction". Then O-Ds are calculated by Frator's Method. This O-D includes Crude Oil via pipeline and other volume that should be deducted.

(5) Step5

Input the cargo volume that should be deducted in Excel Sheet "Deduction". The deducted cargo is the cargo that will not use the Suez Canal.



3.4 Structure of Excel Sheet

3.4.1 Sheet "Cargo Base"

Suez potential cargo O-D in 1998 and estimated potential cargo O-D in 2020 by a large-scale forecasting model are listed. These tables are bases of the forecasting.
All of the values in this sheet are constant and should not be changes.

3.4.2 Sheet "Elasticity"

This sheet contains elasticity of total trade and regional import and regional import.
Elasticity is treated as constant and should not be changed. However, if the actual trade and the forecast trade are compared after a few years, elasticity may be revised.

3.4.3 Sheet "TotalTrade"

Input the average annual GDP growth rate. Then total import (=total export) is calculated in this sheet. You can input a new target year if you want to change 2020.

3.4.4 Sheet "Shares"

This sheet is a worksheet for a use. A User has to set regional shares of import and export based on his expertise. To set shares, 3 types of shares are listed for each of import and export.
The 1st share is the actual share in 1998. The 2nd share is the share that is estimated by regional GDP. The 3rd share is the share estimated by a large-scale model. 1st one and 3rd one are fixed values, and 2nd one is changed according to change of regional GDP growth rates that are input at the top of this sheet.
A user should fill values in the bottom matrixes in the sheet. If a user doesn't input any value in this sheet, the 2nd shares are set as the default shares.

3.4.5 Sheet "Import-Export"

This sheet shows the result of calculation. Import and export of a region are calculated from total trade and shares. There is no input in this sheet.

3.4.6 Sheet" BeforeDeduction"

Push a button "Run", then OD is calculated. This OD includes some additional volume, such as crude oil via pipeline and container cargo via the Panama Canal.

3.4.7 Sheet "Deduction"

This sheet contains the volume that should be deducted from the sheet "OD before deduction".
Input the volume in each sell if you have to deduct some volumes.

3.4.8 Sheet "Forecast"

This sheet is the output of this program.

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3.4.9 Sheet "tentative"

This sheet calculated tentative import and export by regional elasticity. This sheet is used only for inner calculation.

Chapter 4 Program "Shipping Cost"

4.1 Purpose of the program

This program calculates shipping cost of a unit volume of cargo on model vessels.

4.2 Inputs, Outputs, and Parameters

4.2.1 Input

There is no input variable in this program.
But Program "Route Choice" is linked to this program. When the representative vessel size of each size category is altered in "Route Choice", the output of "Shipping Cost " automatically changed

4.2.2 Output

Output of this program is shipping cost co-efficient per cargo ton
B: shipping cost that is dependent on distance ($ /ton-mile)
EcsL: additional cost via the Suez Canal on a laden vessel ($ / ton)
EcsB: additional cost via the Suez Canal on in-ballast vessel ($ / ton)
(EcsB is a virtual cost for the route choice because in-ballast vessels carry no cargo)
These outputs are the inputs of Program "Route Choice"

Adding to the above shipping cost co-efficient that is used in "Route Choice", the shipping cost co-efficient by SCNT class is calculated for your reference.
The unit of this cost co-efficient is $/SCNT-mile or $/SCNT.

4.2.3 Parameters

There are many parameters in this program. These parameters can be changed after new information is gotten. The explanation of parameters is described in the next section.

4.3 Structure of Excel Sheet

4.3.1 Sheet " Parameter1"

(1)Table P1-1 Common Constants

This Table has common parameters for shipping cost calculations.

variable	value	unit	Note
Fr	5.0%		Fitting out expense rate
IR	7.0%		Interest Rate
YD	15	year	Term of depreciation
Rd	9.0%		Depreciation rate
OD	345	days/year	Operating Days
PB	100	US$/ton	Bunker oil price
EX	1.30	USD/SDR	Exchange Rate USD/SDR
DSL1	15.0	hour(s)	Waiting for Entering S.C.
DSL2	7.0	hour(s)	Going via S.C. in excess
DsuezL	0.92	days	Additional days at Suez Canal
DSB1	12.0	hour(s)	Waiting for Entering S.C.
DSB2	7.0	hour(s)	Going via S.C. in excess
DsuezB	0.79	days	Additional days at Suez Canal (In-Ballast)
CA	4,500	US$/voyage	Agency , pilot, boatman , and others
CP	0.13	US$/SCNT	Port authority cost
CBD	1.0	US$/TEU-day	Daily Container Box Capital Cost
NCR	0.088	TEU/SCNT	Nominal Capacity Ratio
LFC	80.0%		Load Factor of Container Box
CI	1,000	US$/ton	Commodity Inventory Cost
RIT	30%		Ratio of Inventory Cost Target Container
CCD x RIT	0.058	US$/ton-day	Average Daily Commodity Inventory Cost
CI2	10,000	US$/Car	Commodity Inventory Cost (Car)
TPC	1	ton/Car	Ton per a Car
CAD	1.918	US$/ton-day	Daily Commodity Inventory Cost (Car)

(Notes)

1. Rd is the depreciation date that is automatically calculated from Interest Rate(IR) and Term of Depreciation(YD).
2. DsuezB and DsuezL are additional days at the Suez Canal and are sum of the waiting hours at the entrance of the Canal and extra time through the Canal caused by low voyage speed.
3. CCD is the Daily Commodity Inventory Cost of Containership and is automatically calculated from CI and RI. CCD x RIT is the Average Daily Commodity Inventory Cost and is the multiplication of CCD and RIT.
4. CAD is the Daily Commodity Inventory Cost of Car Carrier and is automatically calculated from CI2 , TPC, and RI.

(2)Table P1-2 and Table P1-3

Table P1-2 is a Toll table for laden vessels.
Table P1-3 is a Toll table for in-ballast vessels.

Present Toll values are used for default in the program.

(3)Table P1-4,5,6

Table P1-4,5,6 shows the fee of tugboats.

4.3.2 Sheet " Parameter2"

(1)Table P2-1D Representative Vessel Size of each Class

Table P2-1D is setting for default use. This Table is linked to Excel Book of Route Choice Program.

You can input other sizes in the Route Choice Program. Then the value reflects on this sheet automatically. Or you can input them in Table Input2-1Y of this Program directly. Note that if you input them in this sheet directly, the values in the Route Choice Program are not be changed.

(2)Table P2－2D SCNT/DWT Ratio

Table P2-2D was calculated by the following equations. These equations were developed based on SCA database 1997-1999.

(SCNT/DWT-Ratio) = a * DWT + b

The values of a and b are listed in the left table of Table P2-2D
You can input new parameters (a,b) in this table to get new values for Table P2-2D. The value is automatically placed in Table P2-2D
You can also input new ratios in Table P2-2Y directly. If you input values in Table P2-2Y, the new values have the priority.

(3) Table P2－3D Load Factor

Table P2-3D was calculated by the following equations. These equations were developed based on SCA database 1997-1999.

Load Factor (LF) = a * DWT + b

The values of a and b are listed in the left table of Table P2-3D
You can input new parameters (a,b) in this table to get new values for Table P2-3D. The value is automatically placed in Table P2-3D

You can also input new ratios in Table P2-3Y directly. If you input values in Table P2-3Y, the new values have the priority.

(4)Table P2－4D Contract Price

Table P2-4D was calculated by the following equations. These equations were developed based on Drewery's Ship Cost, Fairplay's CD and other source (Japanese).

Contract Price (P) = a * DWT + b

The values of a and b are listed in the left table of Table P2-4D
You can input new parameters (a,b) in this table to get new values for Table P2-4D. The value is automatically placed in Table P2-4D
You can also input new ratios in Table P2-4Y directly. If you input values in Table P2-4Y, the new values have the priority.

(5)Table P2－5D Daily Manning Cost

Table P2-5D was calculated by the following equations. These equations were developed based on Drewery's Ship Cost.

Daily Manning Cost = a * DWT + b

The values of a and b are listed in the left table of Table P2-5D
You can input new parameters (a,b) in this table to get new values for Table P2-5D. The value is automatically placed in Table P2-5D
You can also input new ratios in Table P2-5Y directly. If you input values in Table P2-5Y, the new values have the priority.
You can input new parameters (a,b) in the above table or input directly new ratios in Table P2-5Y.

(6)Table P2－6D Other Manning Cost

Table P2-6D was calculated by the following equations. These equations were developed based on Drewery's Ship Cost.

Other Manning Cost = a * DWT + b

The values of a and b are listed in the left table of Table P2-6D
You can input new parameters (a,b) in this table to get new values for Table P2-6D. The value is automatically placed in Table P2-6D
You can also input new ratios in Table P2-6Y directly. If you input values in Table P2-6Y, the new values have the priority.
You can input new parameters (a,b) in the above table or input directly new ratios in Table P2-6Y.

(7)Table P2－7D Speed

Table P2-7D was calculated by the following equations. These equations were developed based on Fairplay's CD and Drewery's CD .

Speed (SP) = a * DWT + b or a * Ln(DWT) + b

The values of a and b are listed in the left table of Table P2-7D
You can input new parameters (a,b) in this table to get new values for Table P2-7D. The value is automatically placed in Table P2-7D
You can also input new ratios in Table P2-7Y directly. If you input values in Table P2-7Y, the new values have the priority.
You can input new parameters (a,b) in the above table or input directly new ratios in Table P2-7Y.

(8)Table P2－8D Fuel Consumption Rate at Sea

Table P2-8D was calculated by the following equations. These equations were developed based on Drewey's Ship Cost and Clarkson's CD

Fuel Consumption Rate (FCS) = a * DWT + b

The values of a and b are listed in the left table of Table P2-8D
You can input new parameters (a,b) in this table to get new values for Table P2-8D. The value is automatically placed in Table P2-8D
You can also input new ratios in Table P2-8Y directly. If you input values in Table P2-8Y, the new values have the priority.
You can input new parameters (a,b) in the above table or input directly new ratios in Table P2-8Y.

(9)Table P2－9D Fuel Consumption Rate at Port

Table P2-9D was calculated by the following equations. These equations were developed based on Port Investment Manual by Ministry of Land ,Infrastructure, and Transport of Japan.

Fuel Consumption Rate at Port (FCP) / Fuel Consumption Rate at Sea (FCS)
= a * Ln(DWT) + b

The values of a and b are listed in the left table of Table P2-9D
You can input new parameters (a,b) in this table to get new values for Table P2-9D. The value is automatically placed in Table P2-9D
You can also input new ratios in Table P2-9Y directly. If you input values in Table P2-9Y, the new values have the priority.
You can input new parameters (a,b) in the above table or input directly new ratios in Table P2-9Y.

4.3.3 Sheet"Output"

"Output" has 6 Tables. 3 Tables are used for route choice program and the rest are the references for tariff setting system.

4.3.4 Other Sheets

Other sheets are used for calculation for each vessel type. No input is necessary in these sheets.

4.4 Theoretical background and explanation of parameters

Shipping cost of a unit volume of cargo is the sum of managing cost and voyage cost.

The days for a trip is calculated in Eq(1)

DV = Dsea + Dport + Dsuez

=(D / Sp) x (1 / 24) + Dport + Dsuez ....(1)

,where DV : days for one trip

Dsea : days in ocean

Dport : days at load and unload ports

Dsuez : additional days at Suez Canal (=0 if the Cape route is chosen)

D : distance of one trip (from an origin to a destination) (mile)

Sp : voyage speed (miles/hr)

Managing cost per day is calculated in Eq(2).

CMD = (1+Fr) x P x Rd / 345 + a + b + c + d + e + f ....(2)

,where CMD : managing cost allocated for a day (USD/day)

P : Contract price (USD/ship)

Fr : Fitting out expense rate

Rd : Depreciation rate

345 : days of voyages of a vessel

a : Manning (cost for crews) (USD/day)

b : H & M (insurance for hull and machinery) (USD/day)

c : P & I (insurance for protection and indemnity)(USD/day)

d : R & M(cost for repair and maintenance) (USD/day)

e : S & M(cost for supplies and lubricating oils)(USD/day)

f :Administration (cost for company and land operation)(USD/day)

Then the managing cost for a trip is the multiplication of cost per day and days of a trip as Eq(3)

CM = CMD x DV ....(3)

,where CM : Managing cost for a trip(USD)

Voyage cost is the sum of voyage cost in ocean, voyage cost at ports, and toll charge, and other charges.

CV = CBsea + CBport + Toll + OC

= FCS x Dsea x PB + FCP x Dport x PB +Toll + OC ....(4)

,where CV : Voyage cost for a trip(USD)

CBsea :Bunker oil cost in ocean (USD)

CBport :Bunker oil cost at ports (USD)

Toll :Toll of Suez Canal (=0 if the Cape route is chosen)(USD)
OC :Other charges for passing through the Canal(USD)
FCS :Fuel consumption rate in ocean (ton/day)
FCP :Fuel consumption rate at ports (ton/day)
PB :Bunker Oil Price(USD/ton)

In the program, Toll is based on the present toll table.
Surcharges and discounts are calculated in the program "Route Choice".
Other charges (OC) are Tugboats, Agent, Pilots and others, and the fee to Port Autholity.

Total cost for a trip is the sum of CM and CV, and is calculated by Eqs(1) to (4).

CT = CM + CV ....(5)
,where CT : total cost for a trip(USD)

There are special costs for Containership. One is the container box capital cost, and another is the commodity inventory cost.
The container box itself has a value and is a cost component for a ship operator. Commodity in a container box, of course, has a value and is transport time is a loss for a shipper. These cost are calculated by Eq(6).

CIV = CB + CI
= CBD x LFC x TEU x DV
+ CCD x RIT x (RDWT x LF) x DV ...……….(6)
,where CIV : Inventory cost for a trip (USD)
CB : Container box capital cost (USD)
CI : Commodity inventory cost (USD)
CBD : Daily container box capital cost per TEU (USD/day-TEU)
LFC :Load factor of container box
TEU : Capacity of a containership (TEU)
CCD : Daily commodity inventory cost per ton (USD/day-ton)
RIT :Ratio of containers whose inventory is considered.
RDWT : vessel size (DWT)
LF : load factor

Thus, Eq(5) is revised to Eq(7) for Containership
CT = CM + CV + CIV ……………………………..………………..…….(7)

Pure Car Carrier has the similar additional cost.
CAV = CAD x RDWT x LF x DV...……………………………..(8)

,where CAV : Inventory cost for a trip (USD)
CAD : Daily commodity inventory cost per ton (USD/day-ton)

Thus, Eq(5) is revised to Eq(9) for Car Carrier

CT = CM + CV + CAV ……………………………………..…………(9)

Shipping cost of a unit of cargo is derived from this total cost and the volume on a vessel.

C = CT / (RDWT x LF) .... (10)
= B x D + A + Esc

, where C : shipping cost of cargo of a trip (USD/ton)
A : coefficient(constant)(USD/ton)
B : coefficient(constant)(USD/ton-mile)
Esc : additional cost of the Suez route (USD/ton)

Now, Eq(10) is used to choose a vessel route. Assume DS is the distance via Suez, and DC is the distance via Cape.

If B x DC + A > B x DS + A + Esc, then Suez is selected.
If B x DC + A < B x DS + A + Esc, then Cape is selected.

This condition is equivalent to the following expression.
If B x (DC – DS) > Esc, then Suez is selected. Otherwise, Cape is selected.

The difference of distance DD that is calculated from the equation B x DD = Esc is the break-even distance. If DC – DS > DD, then Suez is selected. If DC – DS < DD, then Cape is selected.

The coefficients B and Esc are the key parameters to determine the voyage route. B and Esc are derived from Eqs(1) to (10).

For Vessels other than Containership

B = (CMD + FCS x PB) / (SP x 24 x RDWT x LF) ($ / ton-mile)
Esc = ((CMD + FCP x PB) x Dsuez +Toll + OC)) / (RDWT x LF) ($ / ton)

For Containership

B = (CMD + FCS x PB + CBD x LFC x TEU) / (SP x 24 x RDWT x LF)
+ (CCD x RIT) / (SP x 24) ($/ton-mile)
Esc = ((CMD + FCP x PB + CBD x LFC x TEU) x Dsuez +Toll + OC)) / (RDWT x LF)
+ CCD x RIT x Dsuez ($ / ton)

For Car Carrier

B = (CMD + FCS x PB) / (SP x 24 x RDWT x LF) + CAV / (SP x 24) ($/ton-mile)
Esc = ((CMD + FCP x PB) x Dsuez +Toll + OC)) / (RDWT x LF) + CAV x Dsuez
($ / ton)

Chapter 5 Program “Route Choice”

5.1 Purpose of the program:

This program calculates the future transits of the Suez Canal and revenues from transits.

5.2 Inputs, Outputs, and Parameters

5.2.1 Input

Suez Potential Cargo

5.2.2 Output

1. Transit Cargo Volumes through the Canal
2. Transits (number of vessels) through the Canal
3. Revenues of SCA
4. Benefits of the shippers (Shipping cost savings)

5.2.3 Parameters

There are many parameters in this program. You can change some of these parameters according to the new information or your own scenario.
The explanation of parameters is described in the next section.

5.3 Procedure of forecast in this program

The first step is the import Suez Potential Cargo from the excel program “PotentialCargo Forecast.xls” or the excel data sheet “PotentialCargo.xls”. The former is the forecast program of potential cargo. The latter is the revised output of a large-scale forecast model whose target year is 2020.
The next step is to get the result. The transits and other outputs are calculated automatically and listed in excel sheets in forms of tables and graphs.
If you change some parameters, these changes will be automatically reflected to the output.

5.4 Structure of Excel Sheets

5.4.1 Sheet ”INPUT”

This sheet consists of potential cargo volume from other files.
There are two sources providing the data. One is the forecast in 2020 by a large-scale model. Another is the forecast by the forecast program whose target year is changeable.
You can choose either of them by pushing a button “INPUT” or “INPUT2”.

The right tables of the potential cargo tables are used to deduct some volumes from potential cargo. Input values in cells of these tables only if you want to deduct some volume, such as cargo on passenger vessels. Cargo on Ro/Ro Ships is already input as default.
The results of the deduction are on the extreme right tables in this sheet, named “Major Vessels’ Potential Cargo Ton by Commodity”. These tables are used as the input of the

following transit calculation. They are automatically transferred to the table in the Sheet of "Pote", which is mentioned bellow.

5.4.2 Sheet "Pote"

This sheet converts cargo volume by commodity type to cargo volume by vessel type. The vessel type matrixes are used for the conversion.

Two Vessel Type Matrixes are provided for convenience: Matrix (1) and Matrix (0).

Table "Potential Cargo V-T Matrix Dummy" is used to determine which table is used for each route. Matrix (1) is used for the routes "dummy=1". Matrix (0) is used for the routes "dummy=0".

In the default setting, these two matrixes are used to distinguish the distributions of General Cargo Carrier. General Cargo Carrier is not used in Matrix (1) and "1" is input for long-haul routes in VT Matrix Dummy Table. This means that General Cargo Ships will remain only on short distance routes in the future.

The extreme right tables in this sheet are the output of this sheet.

5.4.3 Sheet "Crud", "Prod", …., "CarC"

These sheets are the main parts of the route choice model.

These sheets calculate transits and other outputs such as revenues.

They are prepared for Crude Oil Tankers, Products Tankers, LPG Tankers, LNG Tankers, Chemical Tankers, Other Tankers, Bulk Carriers, General Cargo Ships, Containerships and Car Carriers. Other vessel types are mentioned in the next section.

Calculation procedures go from the left side of the sheet to the right. Each part of them is as follows;

Potential Cargo OD

The output of Sheet "Pote" is copied.

Fleet Mix

Fleet mix of each route is given in these tables. These fleet mix patterns are dependent on routes. The routes are classified by the Distance Range.

The right tables of the fleet mix matrixes are the input area of the Distance Range Index for each route.

The fleet mix of each OD is copied from the fleet mix list that is placed at the bottom of the sheet according to the above index.

The fleet mix list at the bottom of the sheet is colored with light blue. You can input the fleet-mix in this table based on your scenario.

Potential Cargo OD by V-size

These tables are the cargo volumes on vessels of each size. They are calculated from the above potential cargo and fleet-mix.

Shipping Cost

These tables are the shipping cost coefficients of each vessel size. This table links to the program "ShippingCost.xls". You can change the representative vessel sizes, which are the average sizes of the corresponding size range, by filling the values in the light blue cells in these tables.

Note that you must open the "ShippingCost.xls" file before you input the values. If you do, the shipping cost coefficients are automatically calculated and return to these tables.

Distance Table

Data of these tables are copied from the distance tables in the "DistanceTable.xls" file.

Discount

Data of these tables consist of the discount rates of each route.

For example, if there is 20% discount in a route, the corresponding cells are filled with "20%", and if there is 20% surcharge, you must input "-20%" in the corresponding cells. And if no discount is applied, the data will be "0" or just blank.

These discount rates are applied to the cost saving calculation for the route choice.

Shipping Cost Saving

Shipping cost saving ($/ton) is calculated from the above shipping cost coefficients and distance tables.

Transit Cargo Ton

Transit cargo ton is derived from the potential cargo tables if the above Shipping Cost Saving is positive.

Transit(laden)

Transit number for each route is calculated from the Transit Cargo Ton divided by the average cargo volume of each size of the laden vessel. Average cargo volumes are calculated in the "ShippingCost.xls" file and linked to this program.

In-Ballast/Laden Ratio (Other than Crude Oil Tankers)

These tables are used for calculating the transit number of the in-ballast vessels other than Crude Oil Tankers.

The default ratio is already filled with the actual data of the Suez Canal transit database from 1997 to 1999, and you can change these data according to your scenario.

Transit(in-ballast)

Transit of in-ballast vessel is calculated in these tables.

Vessels other than Crude Oil Tankers use in-ballast/laden ratio. For example, (In-ballast vessels number of northbound) = (Laden vessels

number of southbound) * (in-ballast/laden ratio).
Route choice of Crude Oil Tankers is determined on the round trip basis. Therefore, in-ballast vessels number can be calculated in the route choice procedures, so the above In-Ballast/Laden Ratio tables are not applied.

SCNT

SCNT of each route is calculated from transits and average SCNT data. Average SCNT data is calculated in the ”ShippingCost.xls” file and linked to this program.

Revenue

Revenue of each route is calculated from transits and average tolls of each vessel size. Average tolls are calculated in the ”ShippingCost.xls” file and linked to this program.
Discount rates are multiplied if discounts exist.

Benefit

This output means the benefits of the ship operators. These are the total cost savings of the ship operators who use the Suez Canal instead of the Cape route.
Therefore the higher the toll of the Suez Canal gets, the smaller the benefits for the operators become. So if there are no or very small benefits, the toll of the Suez Canal may be to high for the operators.

5.4.4 Sheet ”Othe”

This sheet calculates transits, revenues, and benefits of other vessels, such as Combined Carriers, LASH Ships, Ro/Ro Ships, Passenger Ships, War Ships and Others.
The Transit Cargo Volume of these vessel types are filled with the estimated data directly, which are the result of the forecast from the present pattern and the future scenario of each vessel types.The reason is that they are relatively small.
However, you can calculate the cargo volumes and transits based on the fleet-mix distribution. The tables are prepared for the normal procedures of calculation.

As the default, data of Passenger Ship and War Ship are just the average of 1997-1999 actual transits.

Ro/Ro Ship is the same but this vessels type is different from the former two types on that the cargo volumes are deducted from the potential cargo at the first stage (Sheet “INPUT”) and added to Ro/Ro Ship in this sheet.

The default settings of the “Others” are as follows.
They are Yachts, Fishery ships, and special vessels. “Others” in SCA transit database

1997-1999 carried some general cargo and other cargo such as food staffs. It was presumed in this study that these cargos would be carried on the normal cargo carriers. Therefore, the following vessels were picked up the “real other vessels”:

Vessels whose cargo was not specified.

Vessels carrying fish & shellfish

Vessels carrying machinery(others)

In-ballast “real other vessels” were estimated in the proportion to laden “real other vessels” and the rest of laden “Others”

The average of these “real other vessels” in 1997-1999 was used as the future transits of “Others”.

5.4.5 Sheet ”Output 1””Output2”

The results of calculation are listed in tables on these sheets.

Some graphs are shown in other sheets.