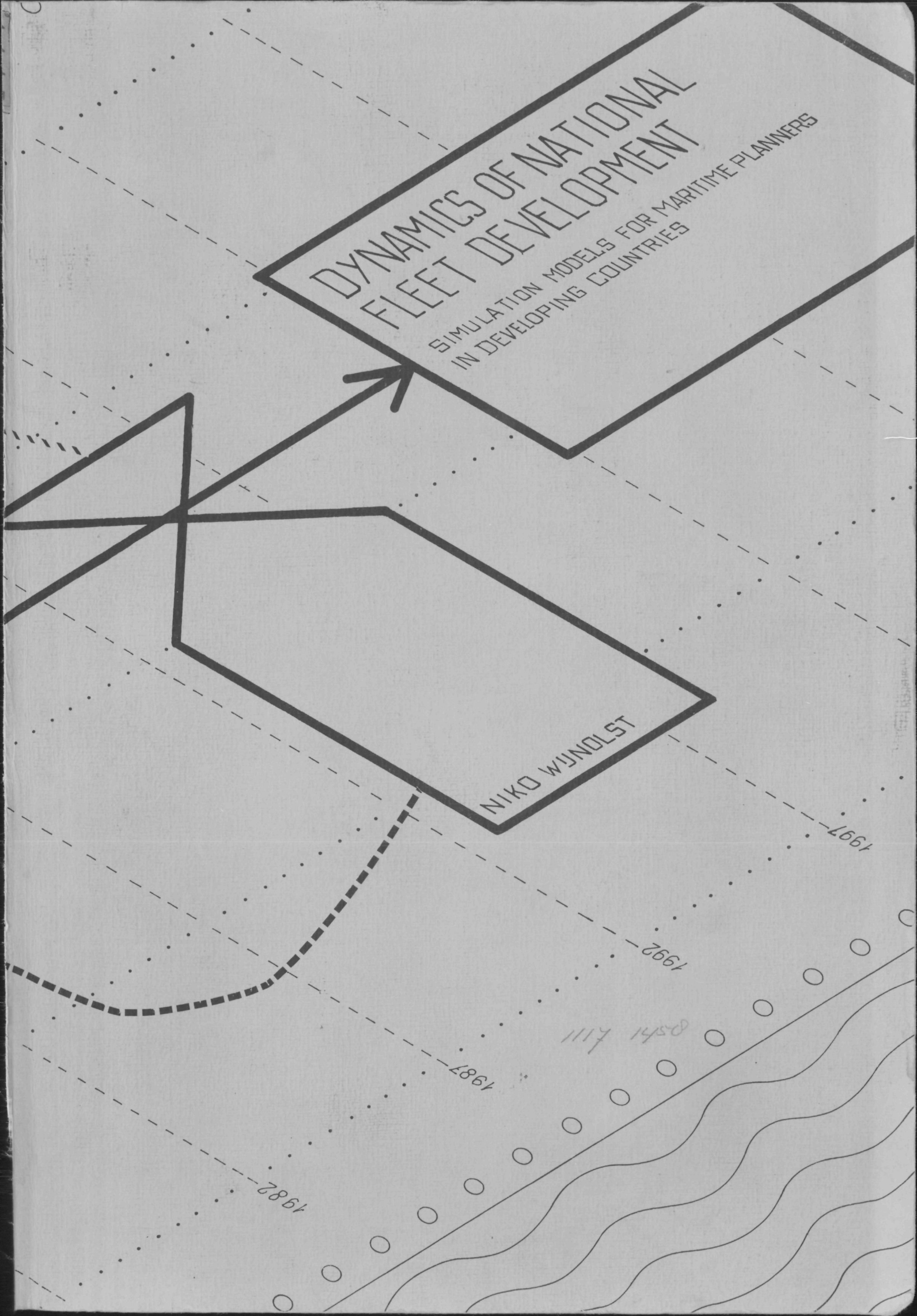
DYNAMICS OF NATIONAL FLEET DEVELOPMENT

SIMULATION MODELS FOR MARITIME PLANNERS IN DEVELOPING COUNTRIES

NIKO WIJNOLST



DYNAMICS OF NATIONAL FLEET DEVELOPMENT

simulation models for maritime planners in developing countries

PROEFSCHRIFT

TER VERKRIJGING VAN DE GRAAD VAN DOCTOR IN DE TECHNISCHE WETENSCHAPPEN AAN DE TECHNISCHE HOGESCHOOL DELFT, OP GEZAG VAN DE RECTOR MAGNIFICUS PROF. IR. L. HUISMAN, VOOR EEN KOMMISSIE AANGEWEZEN DOOR HET KOLLEGE VAN DEKANEN TE VERDEDIGEN OP MAANDAG 20 JUNI 1977 DES MIDDAGS OM 16.00 UUR

door

NIKO WIJNOLST

civiel ingenieur

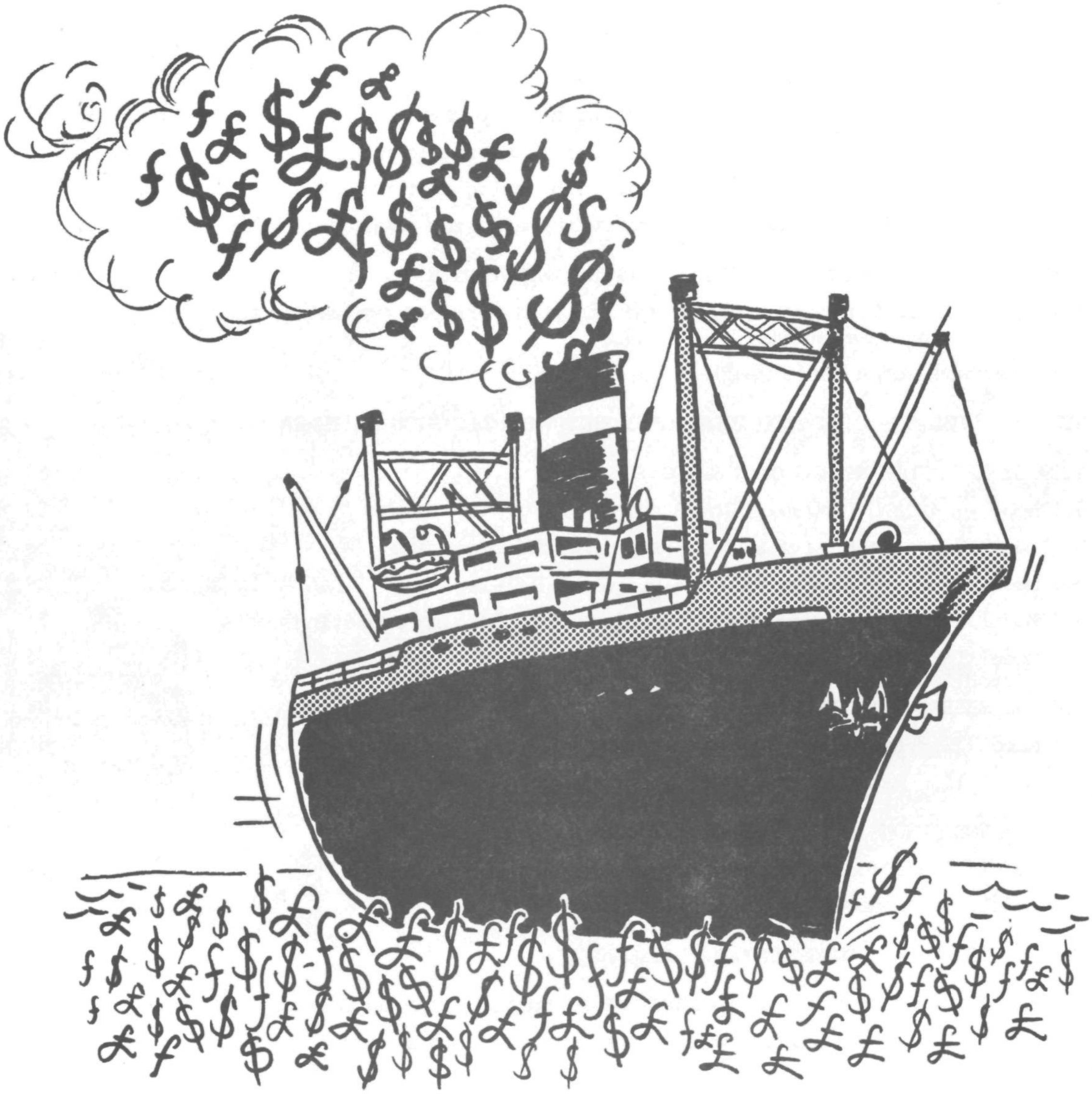
geboren te Rotterdam

DIT PROEFSCHRIFT IS GOEDGEKEURD DOOR DE
PROMOTOR PROF. IR. N. DIJKSHOORN

to Véronique,
whose
feedback system
is
more important
to me
than the ones found
in
any simulation
model

illustrations Rob Gorter, Schiedam

Contents



PREFACE

The distribution of world ship tonnage shows little correlation with the seaborne export and import cargo flows from the individual countries. The discrepancy is particularly large in the case of developing countries (see Appendix C). This has led to a resolution at UNCTAD-III (Santiago, 1972) in which is stated that the developing countries should own at least 10 percent of the world fleet by 1980[1).]

In the past years the developing countries have indeed expanded their fleets (in absolute terms), but their share in the world tonnage declined. Apparently, the establishment and expansion of national fleets is more easily said than done.

Most developing countries start out in shipping by establishing liner fleets. Although many books[2)] have been written on this subject, there exist few publications which provide guidelines and quantitative methods for the evaluation of shipping projects in developing countries. In fact, only the Shipping Secretariat of UNCTAD has published reports on this matter[3)]. However, in none of the publications liner shipping is looked upon as a system with dynamic properties. For this reason I decided to develop a simulation model of national fleet development. With the help of this model the maritime planner in a developing country can evaluate shipping projects at the company and national level.

The approach to modelbuilding which is used in this study, is called 'system dynamics'[4)], a method developed by J.W. Forrester.

My early ideas on the model concepts are published in a number of articles[5)]. In 1976 I worked in Kenya and was able to gather information[6)] on the national fleet development plans of that country. On this basis I constructed the present models. Although most of the data is from the real world, it was inevitable that numerous assumptions had to be made.

) see Appendix D

Chapter 1 - INTRODUCTION

1.1 OVERVIEW

This thesis presents system dynamics models of national liner shipping in developing countries. The purpose of the models is:

. to create insight in the system of liner shipping,

. to simulate potential liner shipping development and the quantitative effects at the company level and the national economy level of a developing country.

Thus, the maritime planner in a developing country, who evaluates the establishment or expansion of a national liner fleet, can address three kinds of questions to the models:

. what are the impacts over time of a liner fleet with a pre-determined number of ships at the company level and the national economy level,

. what is the potential development of the liner fleet and what are the impacts at the company level and the national economy level, when the developing country decides to adopt cargo reservation measures as proposed in the Code of Conduct-1975,[7)]

. what are the impacts at the company and national economy level of changes in the parameters of the liner shipping system, such as freight rates, load factors, loans on ships, growth of national exports and imports, level of cargo reservation, etc.

The models provide the maritime planner with a tool with which he can evaluate shipping projects in an instant, provided the necessary information is available (a tool which up to now did not exist). Although the models are processed in a computer, the required knowledge of mathematics and computers for understanding the model structure is nil. Only the writing of the model equations in the simulation language DYNAMO requires knowledge of the elementary rules of algebra.

The models are presented according to the 'educational approach'. This means that the base-model of 1 ship (model 1), is built up step by step to a complicated endogenous fleet expansion model (model 15), in order to show the simplicity of each model extension. The maritime planner can thus choose the elements which are relevant to his study and put them together.

Model 16 contains a simple port model which enables the calculation of port congestion costs. Its purpose is to draw the attention of the maritime planner to the economic costs of congestion in the national port(s), and to show him the order of magnitude in money terms. In this light national port investments might have priority over national fleet investments.

Chapter 1 provides an introduction to the model structure and a preview of the model behaviour.

Chapter 2 - 8 examines the structure of the models and the output in detail.

Chapter 9 analyzes the effects of changes in parameters on the overall performance of the models, and selects variables which are most relevant to the attainment of the national objectives.

Chapter 10 discusses the limits of the models and the possibilities for application outside liner shipping.

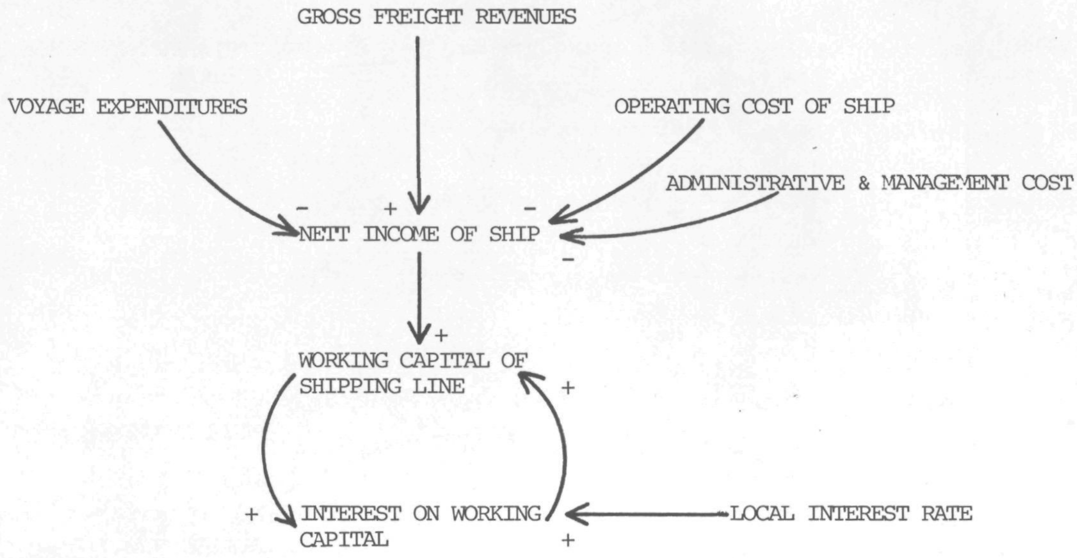
Chapter 11 provides guidelines for the execution of national fleet development studies.

Chapter 12 contains the conclusions.

1.2 INTRODUCTION TO MODEL STRUCTURE

The structure of the models is illustrated with the help of causal-loop diagrams. These causal-loops show the aggregated functioning of the models. A detailed description of each model can be found in the following chapters.

model 1 - cash flow model of 1 ship



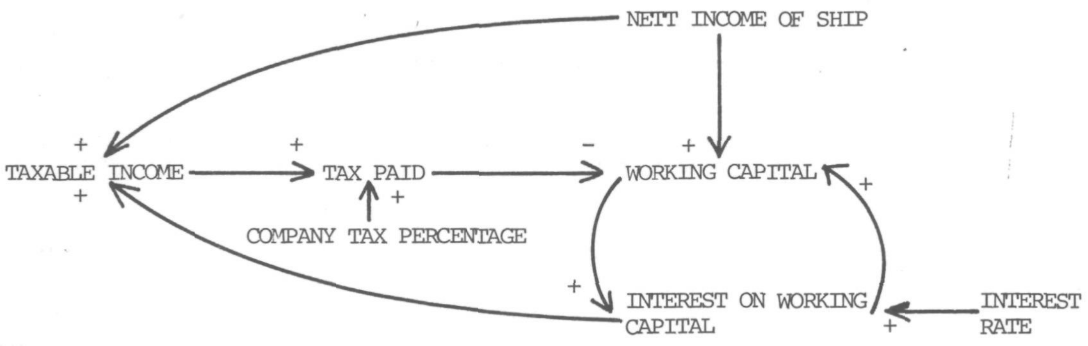
A government-owned company buys one ship and starts a liner service between the country under study in Africa and NW Europe. The ship is purchased with money borrowed on the local capital market. The nett income of the ship is used for the repayment of the borrowed sum and the interest. When the borrowed sum is paid back, the surplus will not be invested in more ships, but lent to other businesses which pay an interest rate equal to the local interest rate.

The nett income of the ship increases with an increase of the gross freight revenues; it decreases with an increase in the voyage expenditures, the operating cost of the ship, and the administrative and management cost. The working capital increases with an increase in income of the ship,and the interest on the working capital. The interest increases with an increase in the local interest rate.

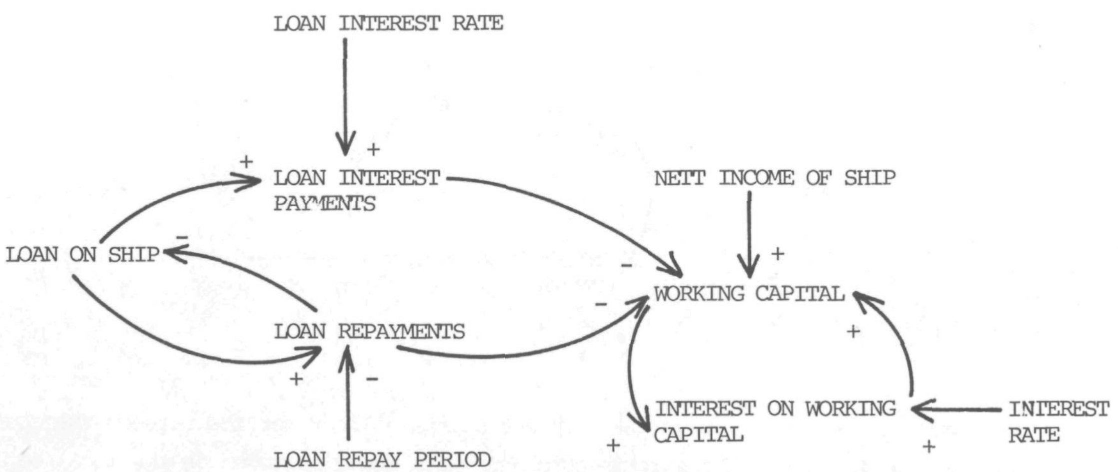
N.B. The polarity of the causal influence is indicated by a + or - near the head of the arrow. A positive polarity means that an increase in the first element will cause an increase in the second (and a decrease will cause a decrease). A negative polarity signifies that an increase in the first element will produce a decrease in the second (and a decrease will produce an increase).

model 2 - cash flow model of 1 ship with tax payments

The only difference with model 1 is that the shipping line is treated as a private company which has to pay tax. The taxable income is determined by the nett income of the ship and the interest paid/received on the working capital of the shipping line. The tax paid depends on the taxable income and the company tax percentage in the country concerned.

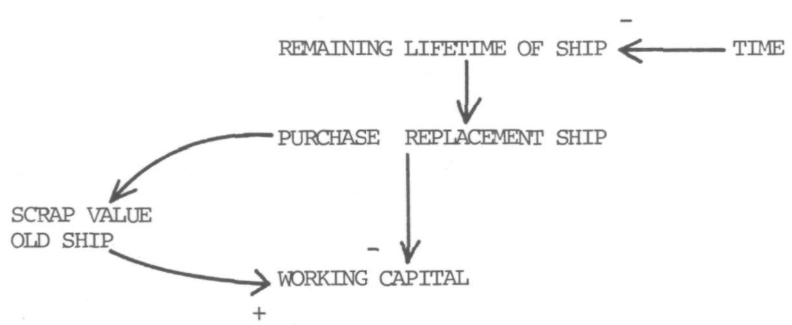


model 3 - cash flow model of 1 ship financed by a loan



The difference with model 1 is that the ship is purchased with the help of a loan from abroad. The loan covers a large part of the purchase price of the ship; the rest of the money is borrowed on the local capital market. The loan must be repaid within a certain period. Every year an equal part of the loan must be repaid. Over the remaining loan interest must be paid.
When the loan increases,the loan interest payments and the loan repayments increase. When the loan repayments increase, the loan decreases; an increase in the repay period decreases the annual loan repayments; an increase in the loan interest rate increases the loan interest payments; an increase in the loan interest payments and the loan repayments, decreases the working capital.

model 4 - cash flow model of 1 ship with replacement of ship



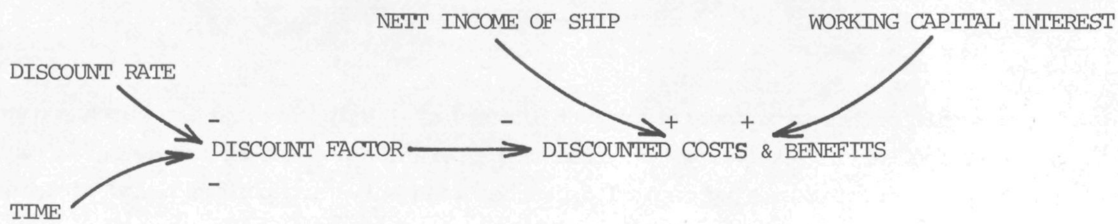
The model is identical with model 1, except that the ship must be replaced after a number of years. This number of years depends on the remaining lifetime of the ship at the moment of purchase.
The old ship has a certain scrap value, which increases the working capital; the purchase of the replacement ship decreases the working capital.

model 5 - cash flow model of 1 ship; it has no structural changes, only parameter changes.

model 6 - cash flow model of 1 ship with decision criteria

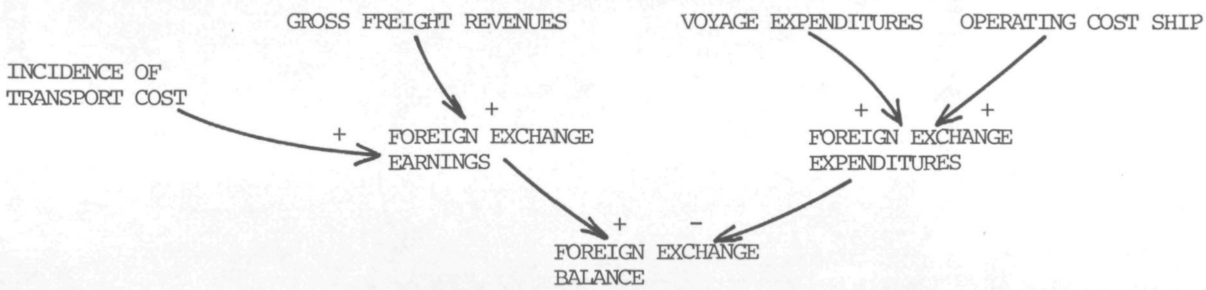
A shipping project, like any project in a developing country, will be tested against the national objectives. The impact of a shipping line on the national objectives cannot often be measured directly but only indirectly, using indicators. The calculation structure of three indicators is presented below; the other indicators are discussed in the following chapters.

a) discounted costs and benefits



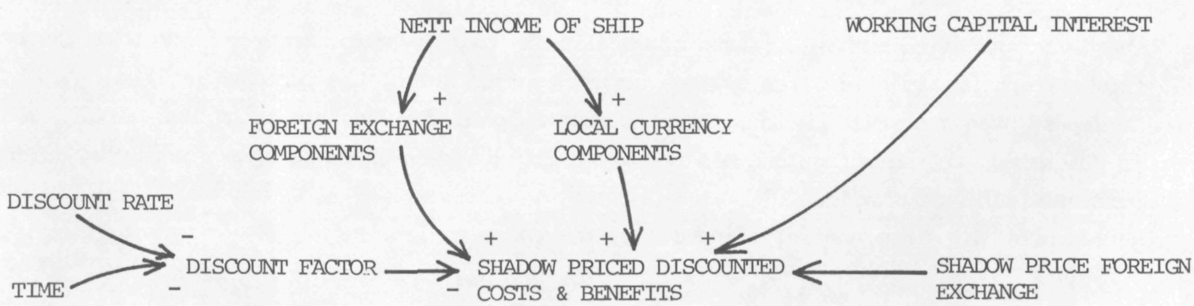
The nett income of the ship and the interest on the working capital are discounted with a discount factor to the base-year. The discount factor decreases with an increase of the discount rate and with an increase in time.

b) foreign exchange balance



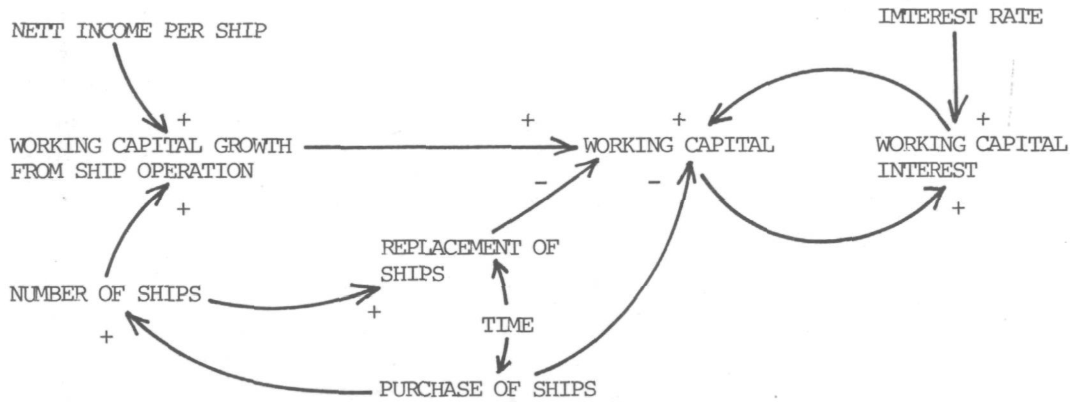
The foreign exchange earnings at the national level are determined by the gross freight revenues of the shipping line and the incidence of transport cost of the commodities which are shipped. The voyage expenditures and the operating cost of the ship determine the foreign exchange expenditures. The foreign exchange balance is the difference between earnings and expenditures.

c) shadow priced discounted costs and benefits



The nett income of the ship is separated in foreign exchange and local currency components. The foreign exchange components are multiplied with a shadow price of foreign exchange before they are discounted.

model 7 - cash flow model of 6 ships

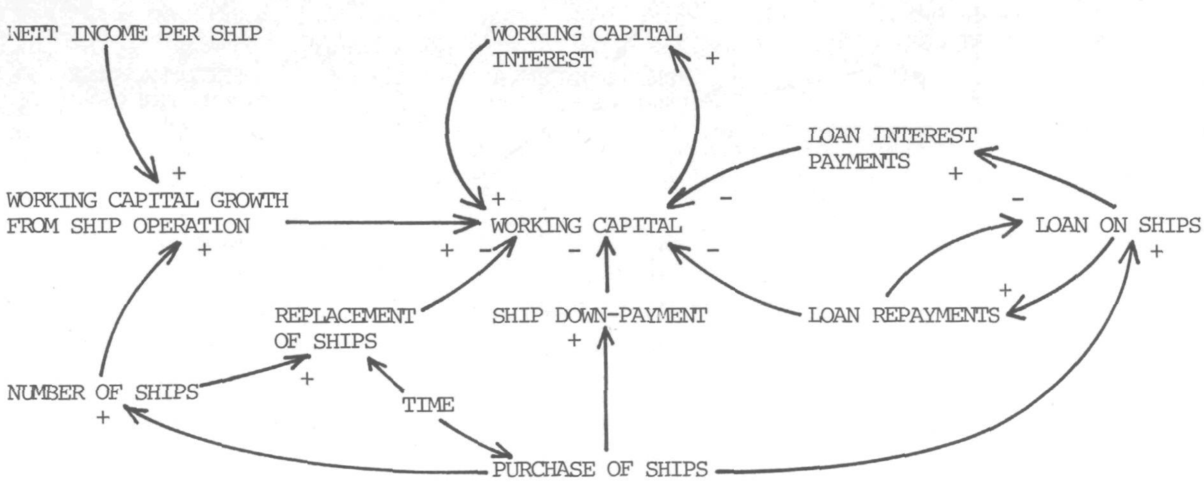


The only difference with model 4 is that instead of 1 ship, 6 ships are purchased and brought into service. The working capital growth from ship operation depends on the number of ships and the nett income per ship. The working capital decreases when ships are purchased and replaced.

model 8 - cash flow model of 6 ships of different age

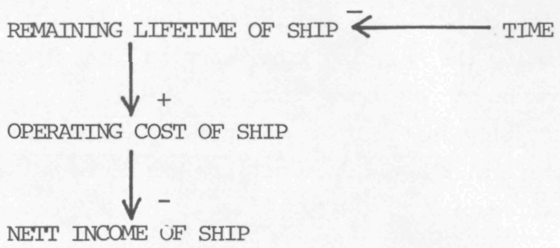
The ships in model 7 are completely identical. The ships in model 8 are identical as far as load capacity, load factor, etc. is concerned, but their age and purchase price differ. The model contains an ageing mechanism for each ship separately.

model 9 - cash flow model of 6 ships financed by loans



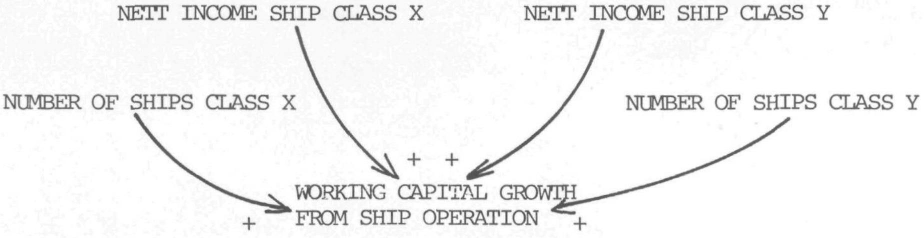
The difference with the assumptions of model 8 is that the ships are purchased with the help of loans from abroad. The loan is given up to a certain percentage of the purchase price of the ship, and must be repaid over a certain period. Interest must be paid over the remaining loan amount. When the ship is purchased, the shipping line has to make a down-payment which is equal to the difference between purchase price and the loan.
Replacement ships are entirely financed by the shipping line.

model 10 - cash flow model of 6 ships with changing operating cost



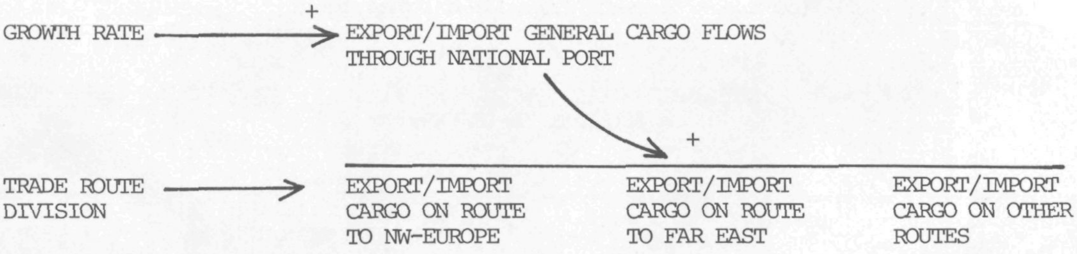
When a ship ages, the operating cost like maintenance and repairs on board, generally increase. Although this increase is not spectacular, the increase will decrease the nett income of the ship. The model assumptions are identical to the ones of model 8.

model 11 - cash flow model of 6 ships of class x and y



A liner fleet usually consists of ships of different tonnage, and thus with different freight revenues, voyage expenditures, operating cost, etc.
Any combination of ship classes can be implemented in the model. This model is an example with two ship classes, called x and y.
The model assumptions are identical to the ones of model 8.

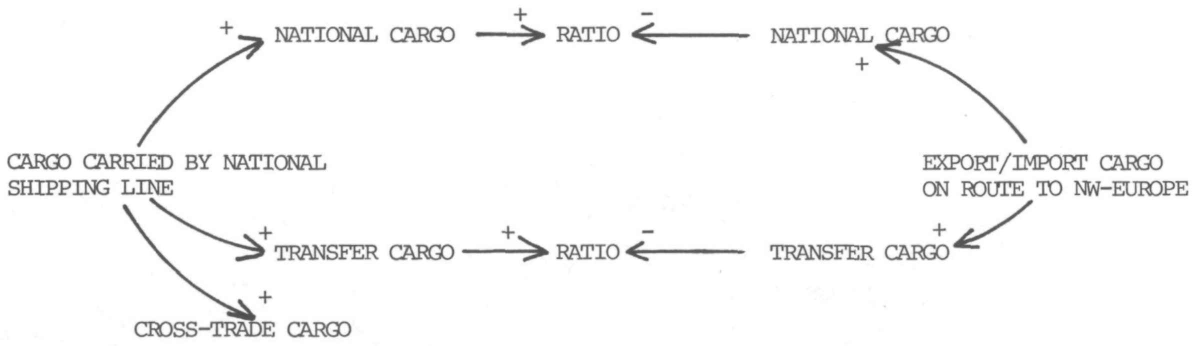
model 12 - model of seaborne trade flows through national port



The developing country under study has one main ocean port. The seaborne trade flows through this port are relevant for a national shipping line, as they give an indication of the potential cargo market. When these flows are small/big then the fleet size of the national shipping line will probably become small/big. Thus, the export and import cargo flows through the national port determine indirectly the upper limit of the fleet size, as the shipping line cannot transport more than the share it can claim according to its cargo reservation policy. Forecasts of seaborne trade flows are thus essential for the assessment of the potential development of the national shipping line. However, the construction of a trade forecasting model in a developing country is quite difficult. But the purpose of the simulation models is to show the dynamics of national fleet development and not to construct an elaborate trade forecasting model. In order to show the impact of different forecasts on the development of the national shipping line, a simple model which can generate a number of scenario's of

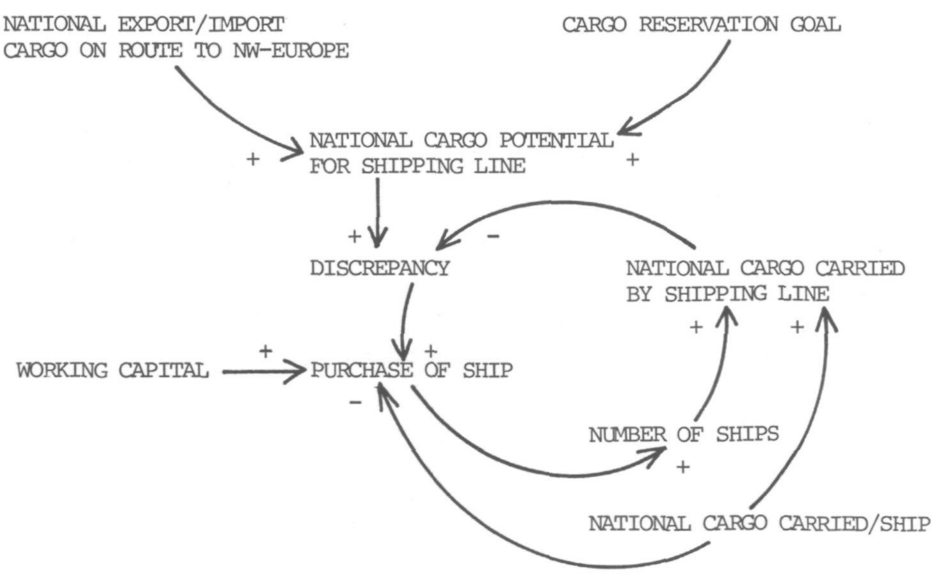
realistic development patterns of seaborne trade flows through the national port will suffice.
The national shipping line is only interested in general cargo trades. The two major general cargo trade routes are to NW-Europe and the Far East; the other trades are too small to be of interest.
For the time being the shipping line wants to participate in the NW-Europe trade, but it is interested in the development of the other routes.
The total cargo flow in the base-year grows annually with a certain percentage. Scenario's are made of this growth rate. The total cargo flow has to be divided into three categories: NW-Europe, Far East, and Other routes.

model 13 - national shipping line's share of national seaborne trade



The export/import cargo on the route to NW-Europe through the national port, can be divided into two flows: national cargo (cargo with origin or destination the country under study) and transfer cargo (cargo which passes through the national port to and from land-locked neighbouring countries).
The ships of the national shipping line will transport besides national cargo, transfer cargo and cross-trade cargo (between ports within the range of the national port).
The ratio of the national cargo carried by the shipping line and the national cargo flows through the national port on the route to NW-Europe is, in comparison with the cargo reservation goal of the country, an indicator for the potential fleet development. This information will be used in the endogenous fleet expansion model 14.

model 14 - cash flow model of endogenous fleet expansion 1

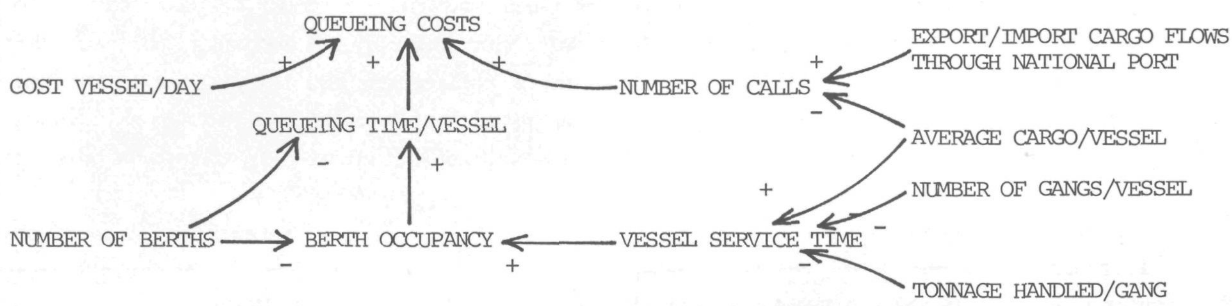


In the model 1 - 11 the fleet expansion decision is made exogenously. This means that there is no mechanism in the model that determines, depending on developments within the model, the expansion of the national fleet. The disadvantage of the exogenously determined fleet expansion is that no direct relation is made with the potential fleet expansion, which in turn is related to the national cargo potential. The latter is determined by the volume of national exports and imports and the cargo reservation goal. The number of ships in the fleet and the national cargo carried per ship determine the national cargo carried by the shipping line. The discrepancy between the national cargo potential and the national cargo carried determines the purchase of new ships. If the discrepancy is bigger than the national cargo carried/ship/year, a new ship is purchased, at least, when there is enough working capital available to finance such an expenditure. As the imbalance in imports and exports in the country under study is rather small, the difference in ship-productivity for exports and imports is ignored.

model 15 - cash flow model of endogenous fleet expansion 2

Model 15 is an extension of model 14 with the following elements: loans on the ships, changing operating cost of the ships, ships of class x and y. The causal-loop diagram of this model is a combination of the ones shown under models 9, 10, 11, and 14.

model 16 - model of ship queueing cost in national port



Many ports in developing countries suffer from congestion. A persistent congestion will increase the freight rates for goods which are shipped to and from the country. The national economic costs are thus not limited to the port, but also affect the rest of the economy. The purpose of the model is to provide the maritime planner with a simple tool that can give him an indication of the occurrence of port congestion, and the order of magnitude of the costs involved.

Description of the causal-loop diagram.

The volume of export and import cargo flows through the national port determines, together with the average cargo per vessel, the number of calls in the port. The average cargo per vessel, together with the number of gang-shifts per vessel and the tonnage handled per gang, determines the vessel service time. The vessel service time and the number of berths in the port determine the berth occupancy. The berth occupancy and the number of berths determine the queueing time per vessel. The queueing time per vessel, the number of calls and the cost per vessel per day, determine the queueing cost in the port.

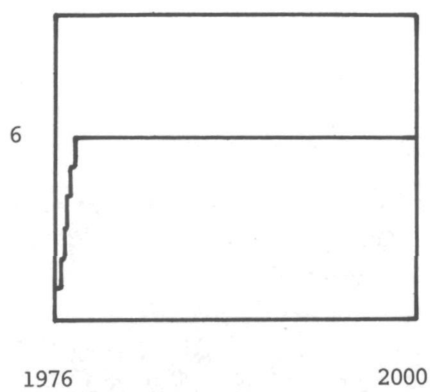
1.3 PREVIEW OF MODEL BEHAVIOUR

Some output of two models will be presented in order to show briefly the kind of results that can be expected in the following chapters.

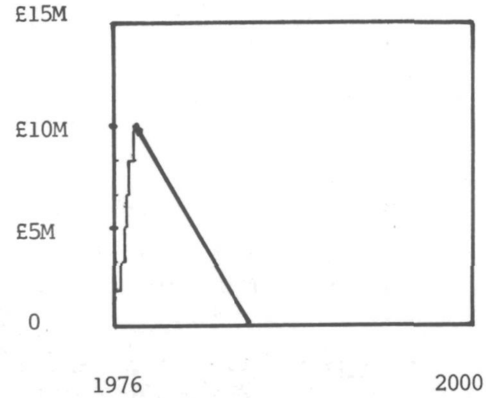
model 9 - cash flow model of 6 ships of different age, financed by loans

The ships are purchased at intervals of one quarter of a year. The total loan on the ships increases likewise. Each loan is repaid over a period of 8 years.

number of ships

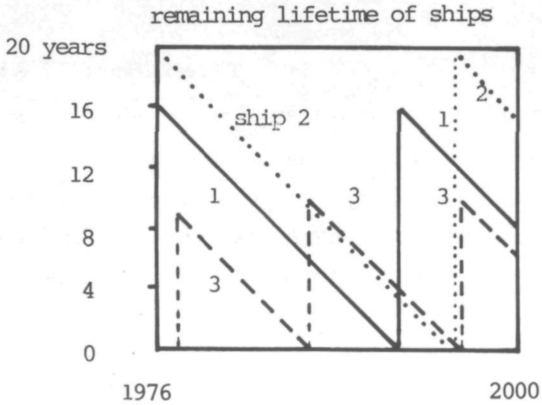


total loan on ships

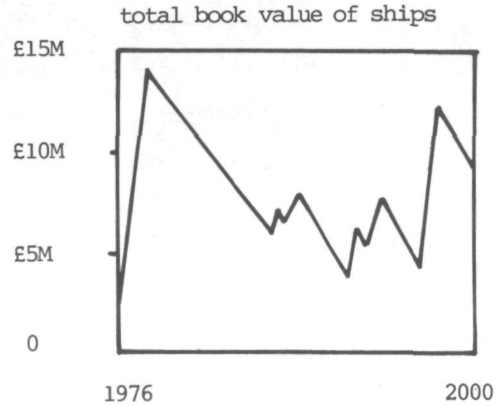


The ships have different ages at the moment of purchase. After a number of years each ship must be replaced by another (second-hand) one. The model contains an ageing mechanism for each ship. The 'remaining lifetime' of the ships and the moment of replacement are illustrated in the graph below (left). The total book value of the 6 ships changes with the ageing and replacement process. With a straight line depreciation the total book value varies as indicated in the graph below (right).

remaining lifetime of ships

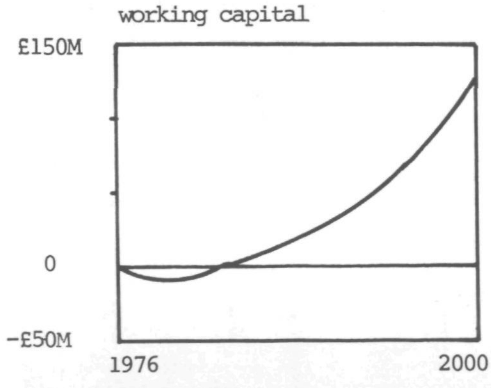


total book value of ships

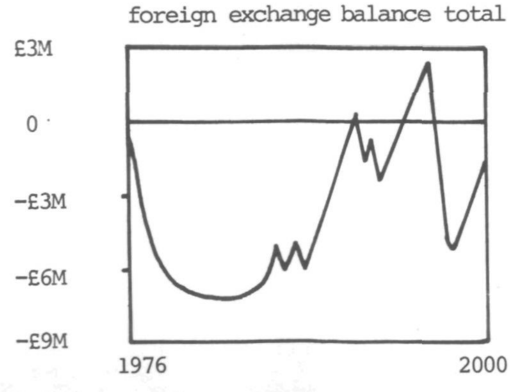


The figure on the left shows the development of the working capital of the shipping line. The one on the right shows the foreign exchange balance total, the sum of all the foreign exchange earnings and expenditures at the national level.

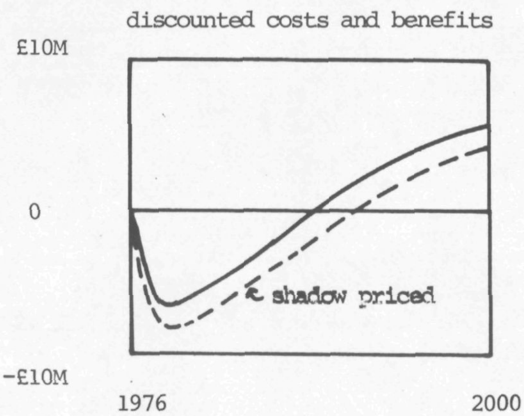
working capital

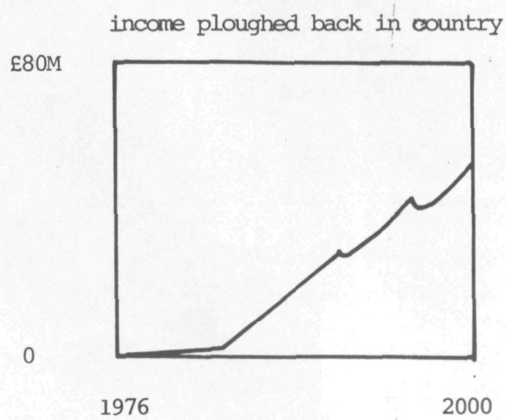


foreign exchange balance total



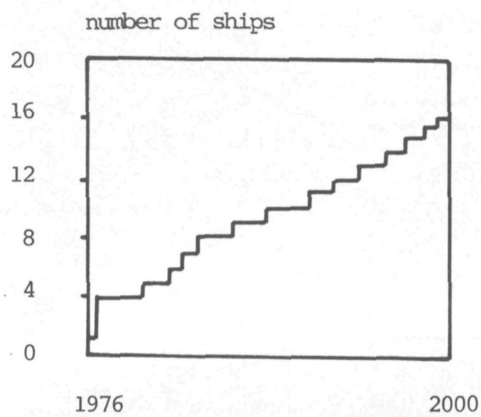
The figure on the left shows the discounted costs and benefits and the shadow priced discounted costs and benefits (foreign exchange) discounted at a rate of 16 percent per year. The one on the right shows the total amount of expenditures and profits of the shipping line which are ploughed back into the economy of the country. (see Chapter 4)

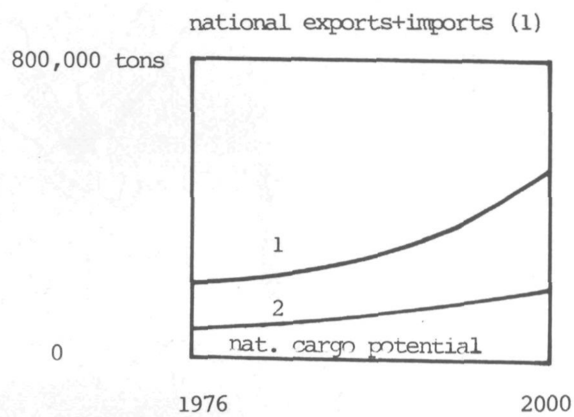




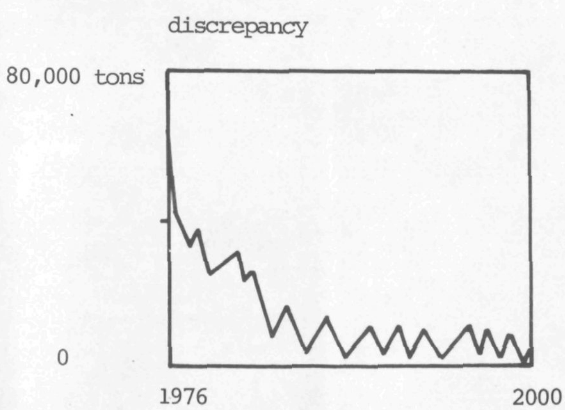
model 14 - cash flow model of endogenous fleet expansion 1

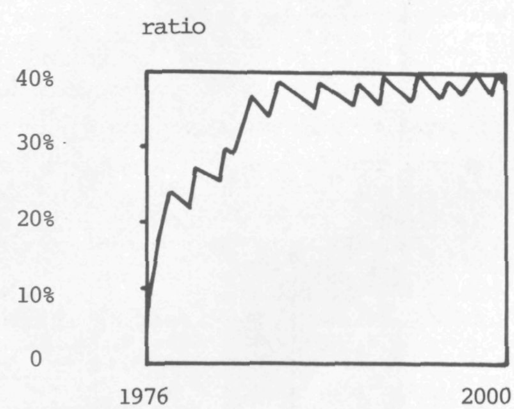
The number of ships in the fleet of the shipping line increases with an increase in the national import and export cargo flows.





The discrepancy between the national cargo potential (= cargo reservation x national exports+imports) and the national cargo carried by the shipping line decreases over time. The ratio of the national cargo carried by the shipping line and the national cargo potential almost reaches the cargo reservation goal (40 percent).





The other figures are similar to the ones shown under model 9.


STEP 1

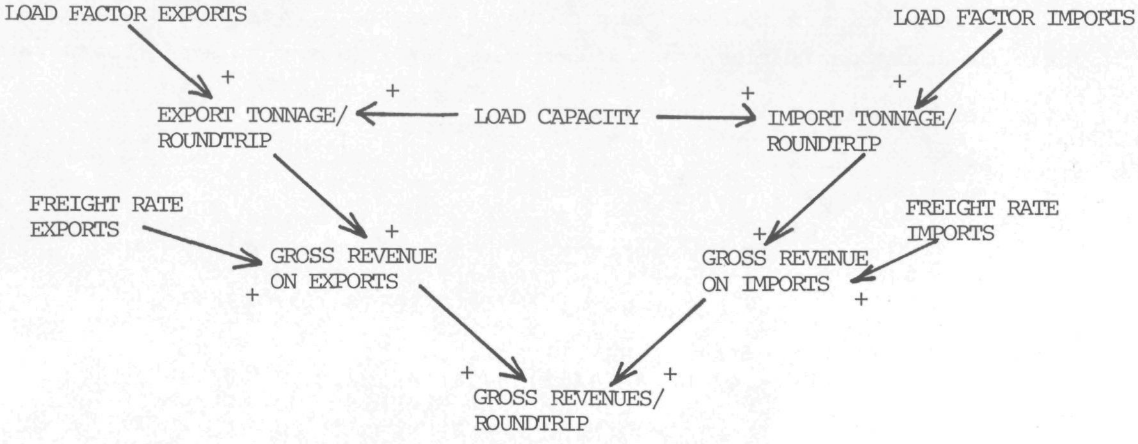
MODELBUILDING STEP BY STEP

Chapter 2 - STEP 1: CASH FLOW MODELS OF 1 SHIP

2.1 MODEL 1 - CASH FLOW MODEL OF 1 SHIP

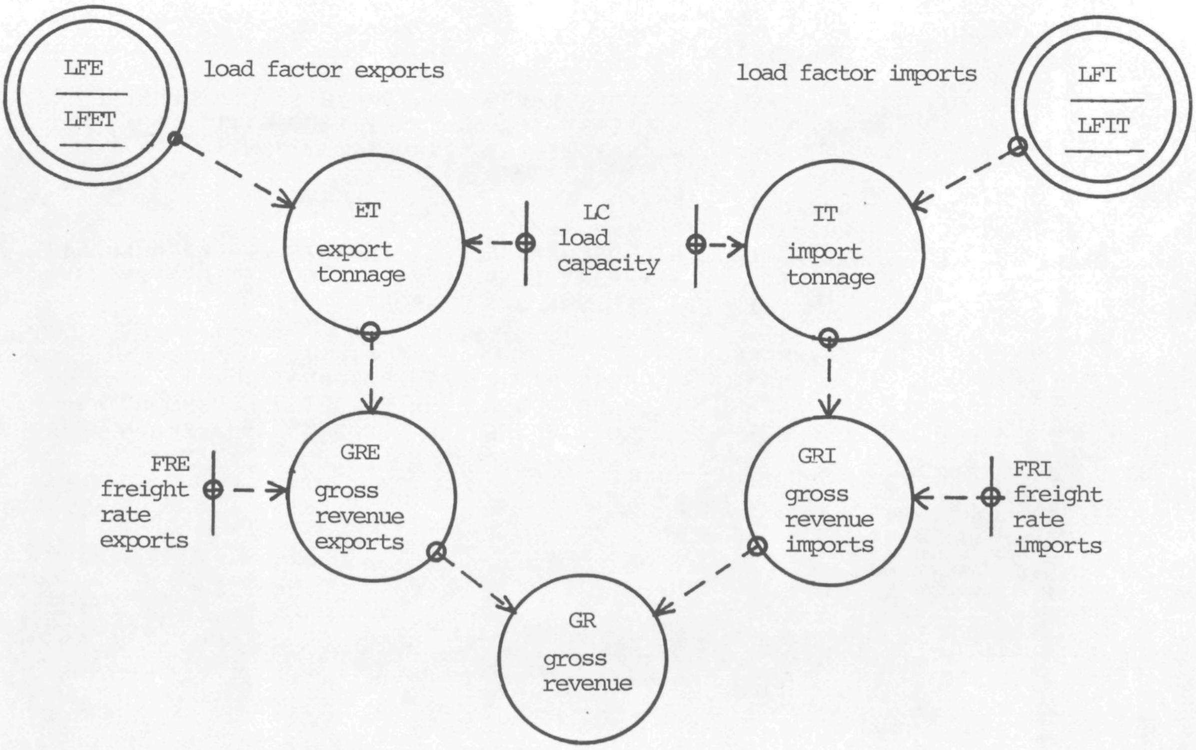
The causal-loop diagram of the model can be found in paragraph 1.2.
The calculation structure of the variables 'gross freight revenues' and 'voyage expenditures' will be shown in more detail.

. gross freight revenues: calculation structure



The words 'exports/imports' are used instead of north- and southbound etc.
The export tonnage/ship/roundtrip depends on the load capacity and the load factor of the ship.
The export tonnage multiplied by the average freight rate of exports gives the gross revenue on exports/roundtrip. The same calculation procedure applies to gross revenues on imports.
The gross revenues on exports plus imports make up the total gross revenues per ship per roundtrip.

. gross freight revenues: dynamo-flow diagram



. gross freight revenues: parameter values

The unit of time in the calculations is a quarter of a year. The time-horizon of the calculations is 1976 - 2000, 24 years or 96 quarters.

The unit of money is the local £ currency.

All values remain constant over time, unless stated otherwise.

The load capacity of the ship is 14,000 metric tons. The load factor of the ship is assumed to be 40 percent at the start of the operation and will increase up to 80 percent over 8 quarters, and remain constant thereafter.

The average freight rate of exports is £25/ton and the average freight rate of imports is £35/ton. The difference between the two is explained by the nature of the commodities shipped in this trade. The export commodities of the developing country usually have a low value in relation to their weight/ volume; the import commodities have a higher value, and thus have a higher freight rate.

. gross freight revenues: documentor listing

```
ET.K=LC*LFE.K
LC=14000
     ET      - EXPORT TONNAGE /SHIP/ROUNDTRIP   TONS
     LC      - LOAD CAPACITY OF SHIP  TONS
     LFE     - LOAD FACTOR EXPORTS  DIM'LESS

LFE.K=TABLE(LFET,TIME.K,0,96,8)
LFET=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
     LFE     - LOAD FACTOR EXPORTS  DIM'LESS
     TABLE   - DYNAMO FUNCTION - SEE MANUAL
     LFET    - LOAD FACTOR EXPORTS TABLE

IT.K=LC*LFI.K
     IT      - IMPORT TONNAGE /SHIP/ROUNDTRIP   TONS
     LC      - LOAD CAPACITY OF SHIP  TONS
     LFI     - LOAD FACTOR IMPORTS  DIM'LESS

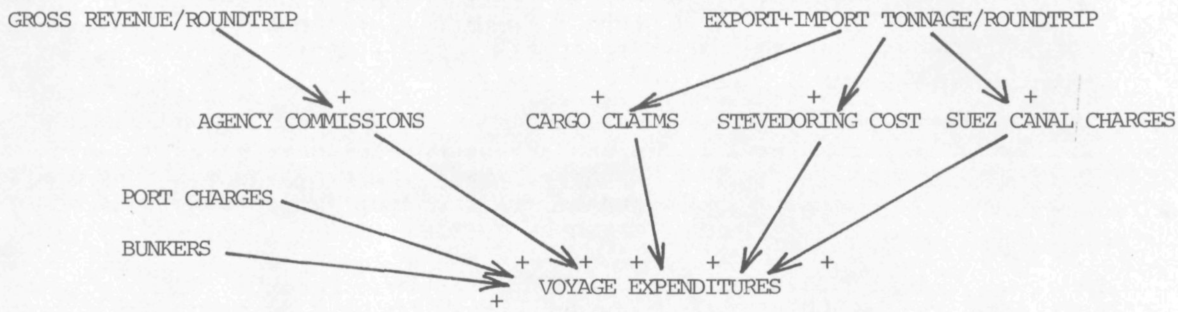
LFI.K=TABLE(LFIT,TIME.K,0,96,8)
LFIT=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
     LFI     - LOAD FACTOR IMPORTS  DIM'LESS
     TABLE   - DYNAMO FUNCTION - SEE MANUAL
     LFIT    - LOAD FACTOR IMPORTS TABLE

GRE.K=ET.K*FRE
FRE=25
     GRE     - GROSS REVENUE ON EXPORTS/SHIP/ROUNDTRIP  £
     ET      - EXPORT TONNAGE /SHIP/ROUNDTRIP   TONS
     FRE     - FREIGHT RATE EXPORTS  £/TON

GRI.K=IT.K*FRI
FRI=35
     GRI     - GROSS REVENUE ON IMPORTS /SHIP/ROUNDTRIP  £
     IT      - IMPORT TONNAGE /SHIP/ROUNDTRIP   TONS
     FRI     - FREIGHT RATE IMPORTS   £/TON

GR.K=GRE.K+GRI.K
     GR      - GROSS REVENUE/SHIP/ROUNDTRIP  £
     GRE     - GROSS REVENUE ON EXPORTS/SHIP/ROUNDTRIP  £
     GRI     - GROSS REVENUE ON IMPORTS /SHIP/ROUNDTRIP  £
```

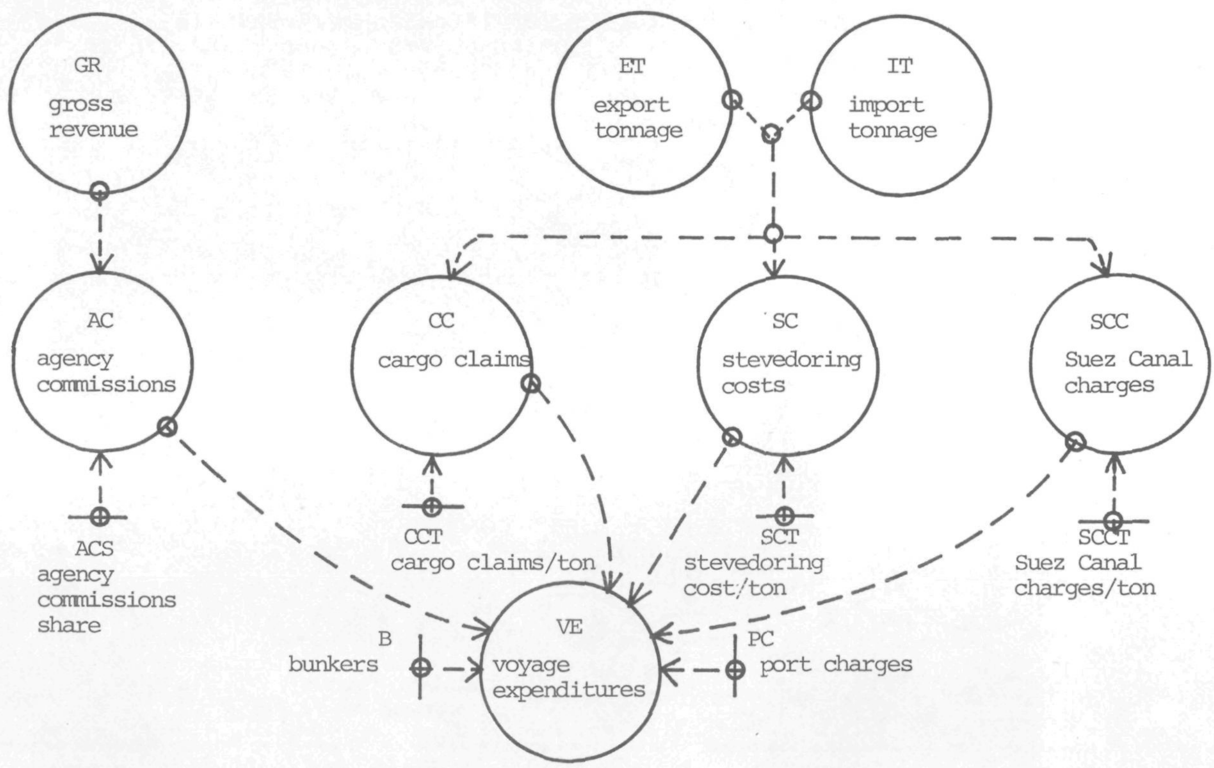
. voyage expenditures: calculation structure



The agency commissions are a percentage of the gross freight revenues. The cargo claims, stevedoring costs and Suez Canal charges can be expressed in £/ton and are thus dependent upon the export+import tonnage per ship per roundtrip.

The port charges and bunkers are fixed amounts, as they are related to the characteristics (size, speed) of the ship.

. voyage expenditures: dynamo-flow diagram



. voyage expenditures: parameter values

The agency commissions share is put at 5.5 percent of the gross freight revenues. The stevedoring cost per ton is on the average £6.25 (the cost per ton is higher in NW-Europe than in the national port). The cargo claims are on the average £0.4 per ton, and the Suez Canal charges are £1 per ton. The port charges and bunkers per roundtrip are £45,000 and £58,000 respectively.

. voyage expenditures: documentor listing

```
AC.K=GR.K*ACS
ACS=.055
    AC       - AGENCY COMMISIONS/SHIP/ROUNDTRIP  £
    GR       - GROSS REVENUE/SHIP/ROUNDTRIP  £
    ACS      - AGENCY COMMISSIONS SHARE   DIM'LESS
```

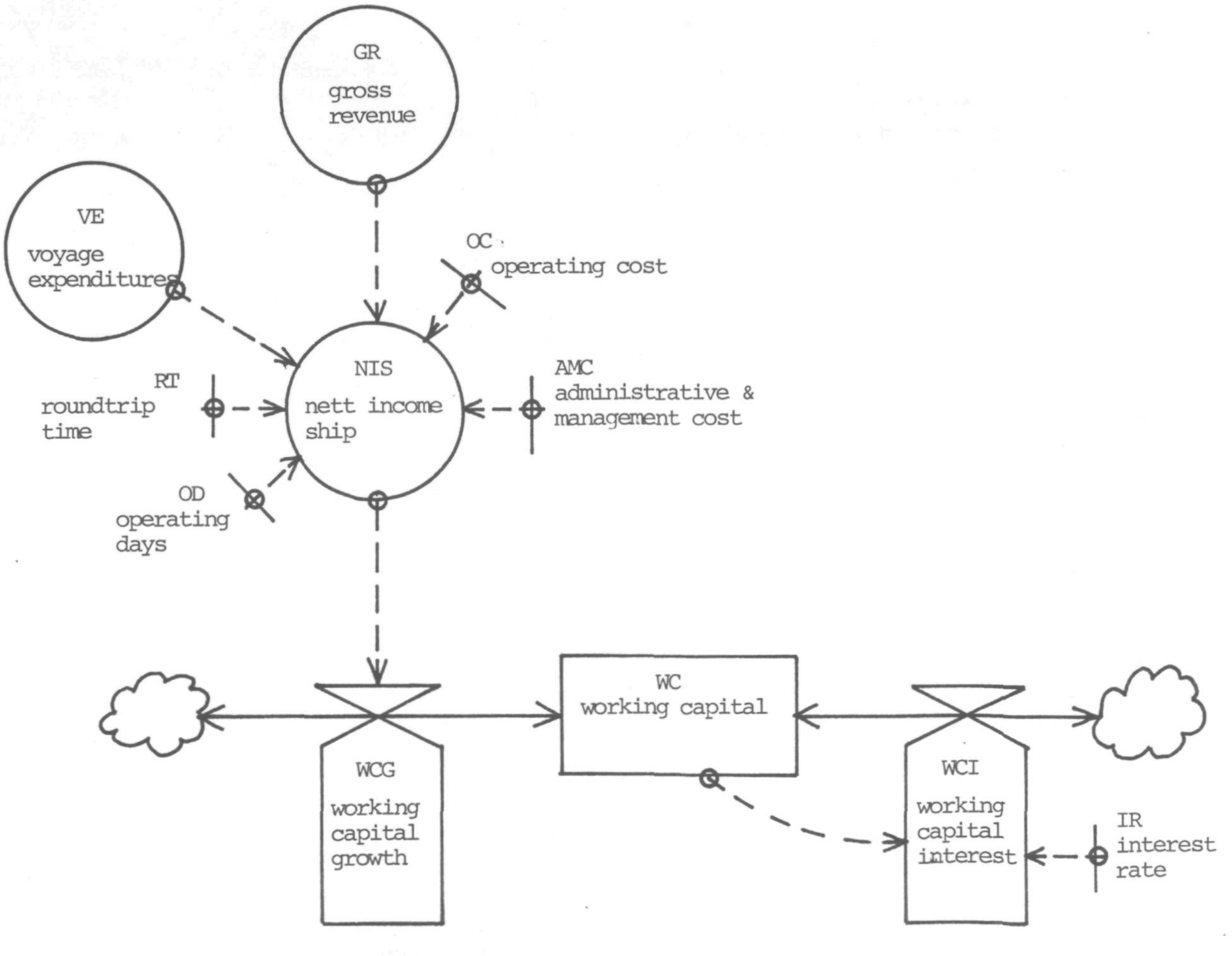
```
SC.K=(ET.K+IT.K)*SCT
SCT=6.25
    SC      - STEVEDORING COST/SHIP/ROUNDTRIP  $
    ET      - EXPORT TONNAGE /SHIP/ROUNDTRIP   TONS
    IT      - IMPORT TONNAGE /SHIP/ROUNDTRIP   TONS
    SCT     - STEVEDORING COST/TON  $

CC.K=(ET.K+IT.K)*CCT
CCT=.4
    CC      - CARGO CLAIMS/SHIP/ROUNDTRIP  $
    ET      - EXPORT TONNAGE /SHIP/ROUNDTRIP   TONS
    IT      - IMPORT TONNAGE /SHIP/ROUNDTRIP   TONS
    CCT     - CARGO CLAIMS/TON   $

SCC.K=(ET.K+IT.K)*SCCT
SCCT=1
B=58000
PC=45000
    SCC     - SUEZ CANAL CHARGES/SHIP/ROUNDTRIP  $
    ET      - EXPORT TONNAGE /SHIP/ROUNDTRIP   TONS
    IT      - IMPORT TONNAGE /SHIP/ROUNDTRIP   TONS
    SCCT    - SUEZ CANAL CHARGES/TON   $
    B       - BUNKERS/SHIP/ROUNDTRIP  $
    PC      - PORT CHARGES /SHIP/ROUNDTRIP   $

VE.K=AC.K+SC.K+CC.K+SCC.K+B+PC
    VE      - VOYAGE EXPENDITURES/SHIP  $
    AC      - AGENCY COMMISIONS/SHIP/ROUNDTRIP  $
    SC      - STEVEDORING COST/SHIP/ROUNDTRIP  $
    CC      - CARGO CLAIMS/SHIP/ROUNDTRIP  $
    SCC     - SUEZ CANAL CHARGES/SHIP/ROUNDTRIP  $
    B       - BUNKERS/SHIP/ROUNDTRIP  $
    PC      - PORT CHARGES /SHIP/ROUNDTRIP   $
```

. model 1: dynamo-flow diagram



. parameter values

The nett income of the ship per quarter of a year is arrived at by multiplying the difference between the gross revenue and voyage expenditures, by the ratio of the number of operating days of the ship per quarter and the roundtrip time. The operating days of the ship are 350 per year or 87.5 per quarter. The roundtrip time is 118 days.

Besides, the operating cost of the ship (£110,000 per quarter) and the administrative and management cost (£20,000 per quarter) must be deducted.

The local interest rate is 12 percent per year or 3 percent per quarter.

. documentor listing

```
NIS.K=(((GR.K-VE.K)*OD)/RT)-OC-AMC
OD=87.5
RT=118
OC=110000
AMC=20000
    NIS      - NETT INCOME SHIP    £/QUARTER
    GR       - GROSS REVENUE/SHIP/ROUNDTRIP  £
    VE       - VOYAGE EXPENDITURES/SHIP  £
    OD       - OPERATING DAYS OF SHIP   DAYS/QUARTER
    RT       - ROUNDTRIP TIME   DAYS
    OC       - OPERATING COST OF SHIP  £/QUARTER
    AMC      - ADMINISTRATIVE £ MANAGEMENT COST   £/
                 QUARTER

WC.K=WC.J+DT*(WCG.JK+WCI.JK)
WC=-PPS
PPS=2.5E6
    WC       - WORKING CAPITAL  £
    DT       - COMPUTATION INTERVAL  QUARTER
    WCG      - WORKING CAPITAL GROWTH   £/QUARTER
    WCI      - WORKING CAPITAL INTEREST  £/QUARTER
    PPS      - PURCHASE PRICE SHIP £

WCG.KL=CLIP(NIS.K,0,TIME.K,DT)
    WCG      - WORKING CAPITAL GROWTH   £/QUARTER
    CLIP     - DYNAMO FUNCTION - SEE MANUAL
    NIS      - NETT INCOME SHIP   £/QUARTER
    DT       - COMPUTATION INTERVAL  QUARTER

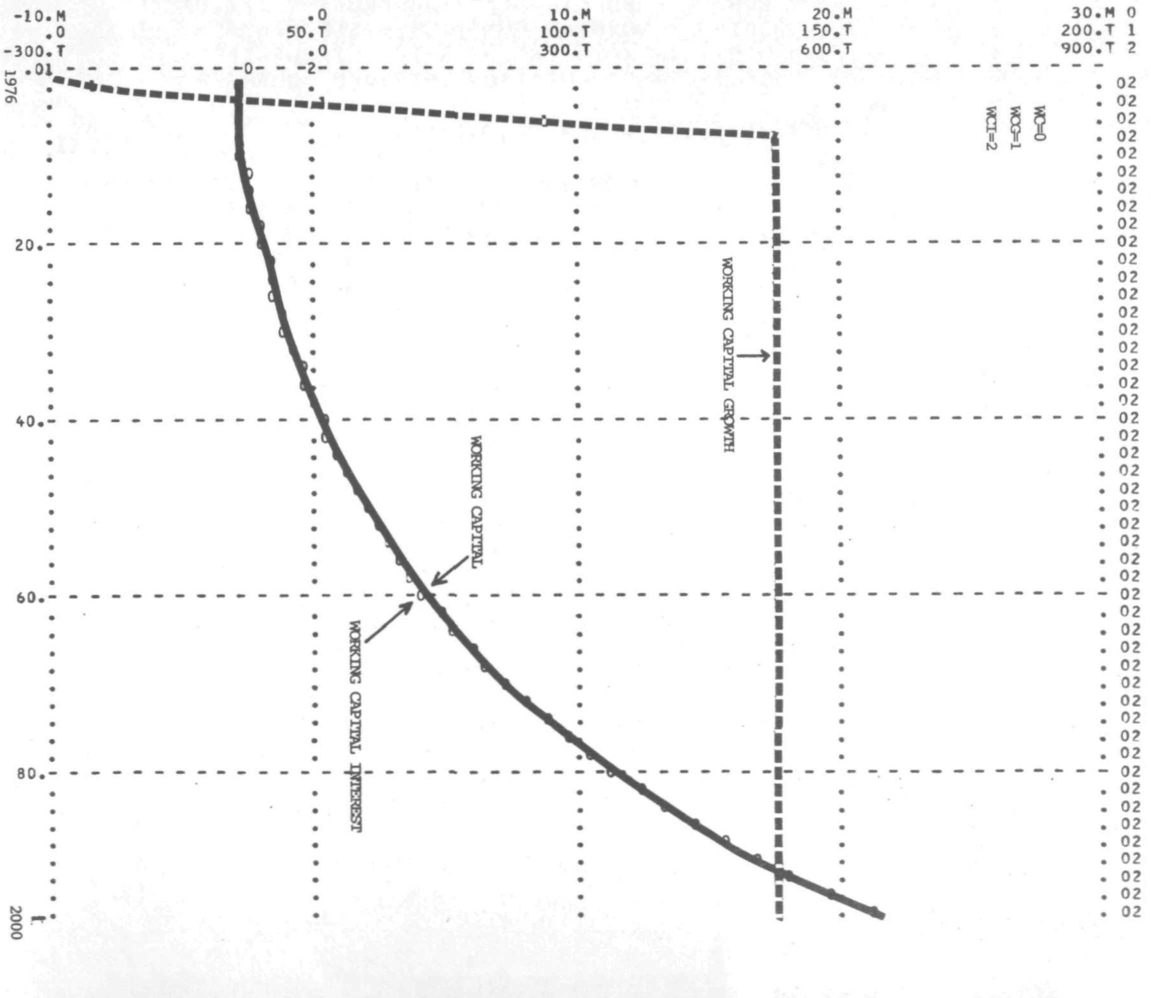
WCI.KL=CLIP((WC.K*IR),0,TIME.K,DT)
IR=.03
    WCI      - WORKING CAPITAL INTEREST  £/QUARTER
    CLIP     - DYNAMO FUNCTION - SEE MANUAL
    WC       - WORKING CAPITAL  £
    IR       - INTEREST RATE   %/QUARTER
    DT       - COMPUTATION INTERVAL  QUARTER
```

. model listing and output (following page)

```
*  MODEL 1 - CASH FLOW MODEL OF 1 SHIP
NOTE   NETT INCOME/SHIP/QUARTER
A   ET.K=LC*LFE.K
C   LC=14000
A   LFE.K=TABLE(LFET,TIME.K,0,96,8)
T   LFET=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A   IT.K=LC*LFI.K
A   LFI.K=TABLE(LFIT,TIME.K,0,96,8)
T   LFIT=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A   GRE.K=ET.K*FRE
C   FRE=25
A   GRI.K=IT.K*FRI
C   FRI=35
A   GR.K=GRE.K+GRI.K
A   AC.K=GR.K*ACS
C   ACS=.055
A   SC.K=(ET.K+IT.K)*SCT
C   SCT=6.25
A   CC.K=(ET.K+IT.K)*CCT
C   CCT=.4
A   SCC.K=(ET.K+IT.K)*SCCT
C   SCCT=1
C   B=58000
C   PC=45000
A   VE.K=AC.K+SC.K+CC.K+SCC.K+B+PC
A   NIS.K=(((GR.K-VE.K)*OD)/RT)-OC-AMC
C   OD=87.5
C   RT=118
C   OC=110000
C   AMC=20000
NOTE   WORKING CAPITAL
L   WC.K=WC.J+DT*(WCG.JK+WCI.JK)
N   WC=-PPS
C   PPS=2.5E6
R   WCG.KL=CLIP(NIS.K,0,TIME.K,DT)
R   WCI.KL=CLIP((WC.K*IR),0,TIME.K,DT)
C   IR=.03
SPEC   LENGTH=96/DT=.25/PRTPER=2/PLTPER=2
PRINT   WC,WCG,WCI,GR,VE
PLOT   WC/WCG/WCI
RUN
```

MODEL 1 - CASH FLOW MODEL OF 1 SHIP

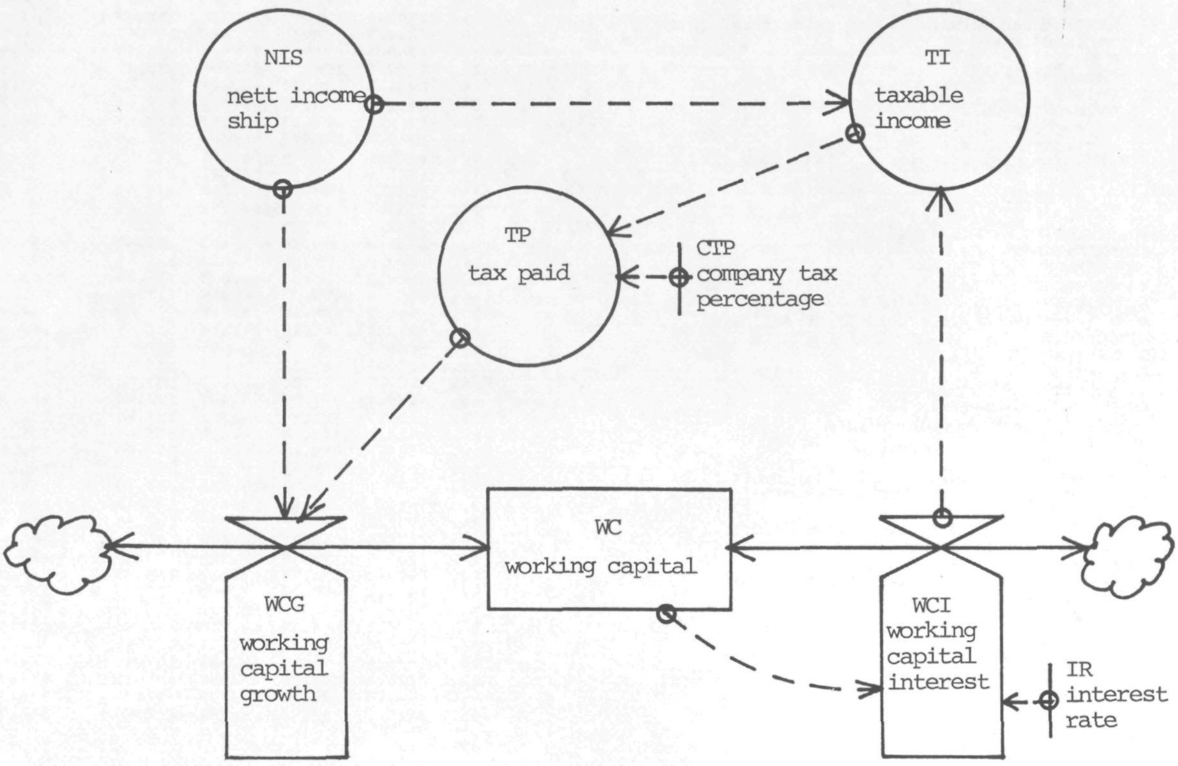
TIME E+00	WC E+06	WCG E+03	WCI E+03	GR E+03	VE E+03
.0	-2.500	.00	.00	336.00	207.16
2.	-2.658	8.52	-79.73	420.00	233.20
4.	-2.766	51.50	-82.97	504.00	259.24
6.	-2.792	94.47	-83.77	588.00	285.28
8.	-2.732	137.45	-81.96	672.00	311.32
10.	-2.618	137.45	-78.54	672.00	311.32
12.	-2.497	137.45	-74.92	672.00	311.32
14.	-2.369	137.45	-71.06	672.00	311.32
16.	-2.232	137.45	-66.97	672.00	311.32
18.	-2.088	137.45	-62.63	672.00	311.32
20.	-1.934	137.45	-58.02	672.00	311.32
22.	-1.771	137.45	-53.13	672.00	311.32
24.	-1.598	137.45	-47.94	672.00	311.32
26.	-1.414	137.45	-42.42	672.00	311.32
28.	-1.219	137.45	-36.57	672.00	311.32
30.	-1.012	137.45	-30.35	672.00	311.32
32.	-.792	137.45	-23.76	672.00	311.32
34.	-.558	137.45	-16.75	672.00	311.32
36.	-.311	137.45	-9.32	672.00	311.32
38.	-.047	137.45	-1.42	672.00	311.32
40.	.232	137.45	6.96	672.00	311.32
42.	.528	137.45	15.85	672.00	311.32
44.	.843	137.45	25.29	672.00	311.32
46.	1.177	137.45	35.32	672.00	311.32
48.	1.532	137.45	45.96	672.00	311.32
50.	1.909	137.45	57.26	672.00	311.32
52.	2.308	137.45	69.25	672.00	311.32
54.	2.733	137.45	81.99	672.00	311.32
56.	3.183	137.45	95.50	672.00	311.32
58.	3.662	137.45	109.85	672.00	311.32
60.	4.170	137.45	125.09	672.00	311.32
62.	4.709	137.45	141.26	672.00	311.32
64.	5.281	137.45	158.43	672.00	311.32
66.	5.888	137.45	176.65	672.00	311.32
68.	6.533	137.45	196.00	672.00	311.32
70.	7.218	137.45	216.54	672.00	311.32
72.	7.945	137.45	238.35	672.00	311.32
74.	8.717	137.45	261.50	672.00	311.32
76.	9.536	137.45	286.07	672.00	311.32
78.	10.405	137.45	312.16	672.00	311.32
80.	11.329	137.45	339.86	672.00	311.32
82.	12.309	137.45	369.26	672.00	311.32
84.	13.349	137.45	400.47	672.00	311.32
86.	14.454	137.45	433.61	672.00	311.32
88.	15.626	137.45	468.78	672.00	311.32
90.	16.871	137.45	506.13	672.00	311.32
92.	18.192	137.45	545.77	672.00	311.32
94.	19.595	137.45	587.85	672.00	311.32
96.	21.084	137.45	632.53	672.00	311.32



2.2 MODEL 2 - CASH FLOW MODEL OF 1 SHIP WITH TAX PAYMENTS

The causal-loop diagram of the model can be found in paragraph 1.2

The figure below is the dynamo-flow diagram of the working capital sector of model 1, extended with the tax payment auxiliaries.



. parameter values

The company tax percentage is 45.

The other parameter values are identical with the ones of model 1.

As the model looks only at cash-flows, the ship is considered entirely depreciated at the moment of purchase.

. documentor listing of the relevant equations

```
WCG.KL=CLIP((NIS.K-TP.K),0,TIME.K,DT)
     WCG      - WORKING CAPITAL GROWTH    f/QUARTER
     CLIP     - DYNAMO FUNCTION - SEE MANUAL
     NIS      - NETT INCOME SHIP   f/QUARTER
     TP       - TAX PAYMENTS  f/QUARTER
     DT       - COMPUTATION INTERVAL  QUARTER

TI.K=CLIP((NIS.K+WCI.JK),0,TIME.K,DT)
     TI       - TAXABLE INCOME  f
     CLIP     - DYNAMO FUNCTION - SEE MANUAL
     NIS      - NETT INCOME SHIP   f/QUARTER
     WCI      - WORKING CAPITAL INTEREST  f/QUARTER
     DT       - COMPUTATION INTERVAL  QUARTER

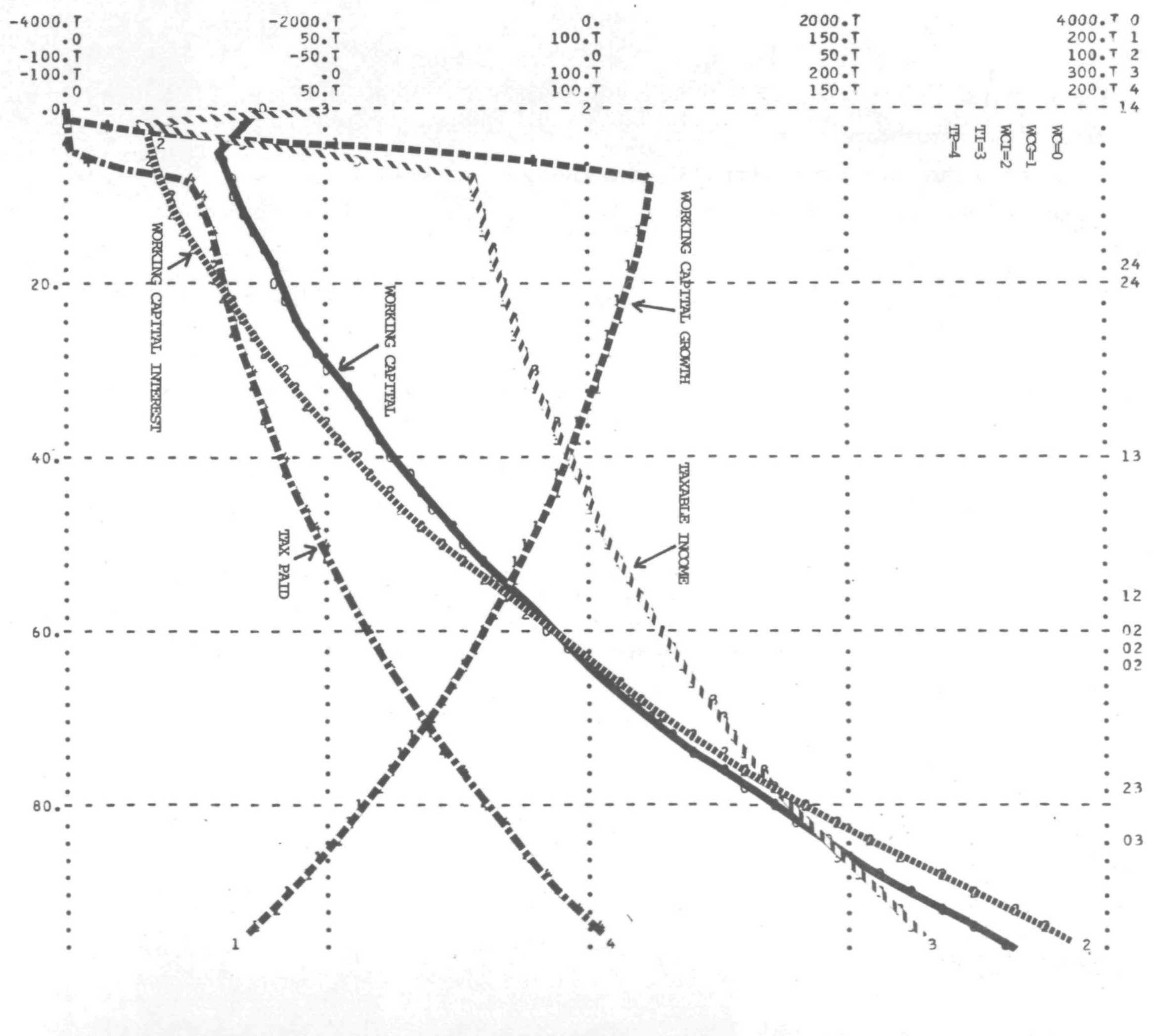
TP.K=CLIP((CTP*TI.K),0,TI.K,0)
CTP=.45
     TP       - TAX PAYMENTS  f/QUARTER
     CLIP     - DYNAMO FUNCTION - SEE MANUAL
     CTP      - COMPANY TAX PERCENTAGE  DIM'LESS
     TI       - TAXABLE INCOME  f
```

MODEL 2 - 1 SHIP WITH TAX PAYMENTS

```
*   MODEL 2 - 1 SHIP WITH TAX PAYMENTS
NOTE  NETT INCOME/SHIP/QUARTER
A   ET.K=LC*LFE.K
C   LC=14000
A   LFE.K=TABLE(LFET,TIME.K,0,96,8)
T   LFET=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A   IT.K=LC*LFI.K
A   LFI.K=TABLE(LFIT,TIME.K,0,96,8)
T   LFIT=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A   GRE.K=ET.K*FRE
C   FRE=25
A   GRI.K=IT.K*FRI
C   FRI=35
A   GR.K=GRE.K+GRI.K
A   AC.K=GR.K*ACS
C   ACS=.055
A   SC.K=(ET.K+IT.K)*SCT
C   SCT=6.25
A   CC.K=(ET.K+IT.K)*CCT
C   CCT=.4
A   SCC.K=(ET.K+IT.K)*SCCT
C   SCCT=1
C   B=58000
C   PC=45000
A   VE.K=AC.K+SC.K+CC.K+SCC.K+B+PC
A   NIS.K=(((GR.K-VE.K)*OD)/RT)-OC-AMC
C   OD=87.5
C   RT=118
C   OC=110000
C   AMC=20000
NOTE  WORKING CAPITAL
L   WC.K=WC.J+DT*(WCG.JK+WCI.JK)
N   WC=-PPS
C   PPS=2.5E6
• R   WCG.KL=CLIP((NIS.K-TP.K),0,TIME.K,DT)
R   WCI.KL=CLIP((WC.K*IR),0,TIME.K,DT)
C   IR=.03
• A   TI.K=CLIP((NIS.K+WCI.JK),0,TIME.K,DT)
• A   TP.K=CLIP((CTP*TI.K),0,TI.K,0)
• C   CTP=.45
SPEC  LENGTH=96/DT=.25/PRTPER=2/PLTPER=2
PRINT  WC,WCG,WCI,NIS,TI,TP
PLOT  WC/WCG/WCI/TI/TP
RUN
```

MODEL 2 - 1 SHIP WITH TAX PAYMENTS

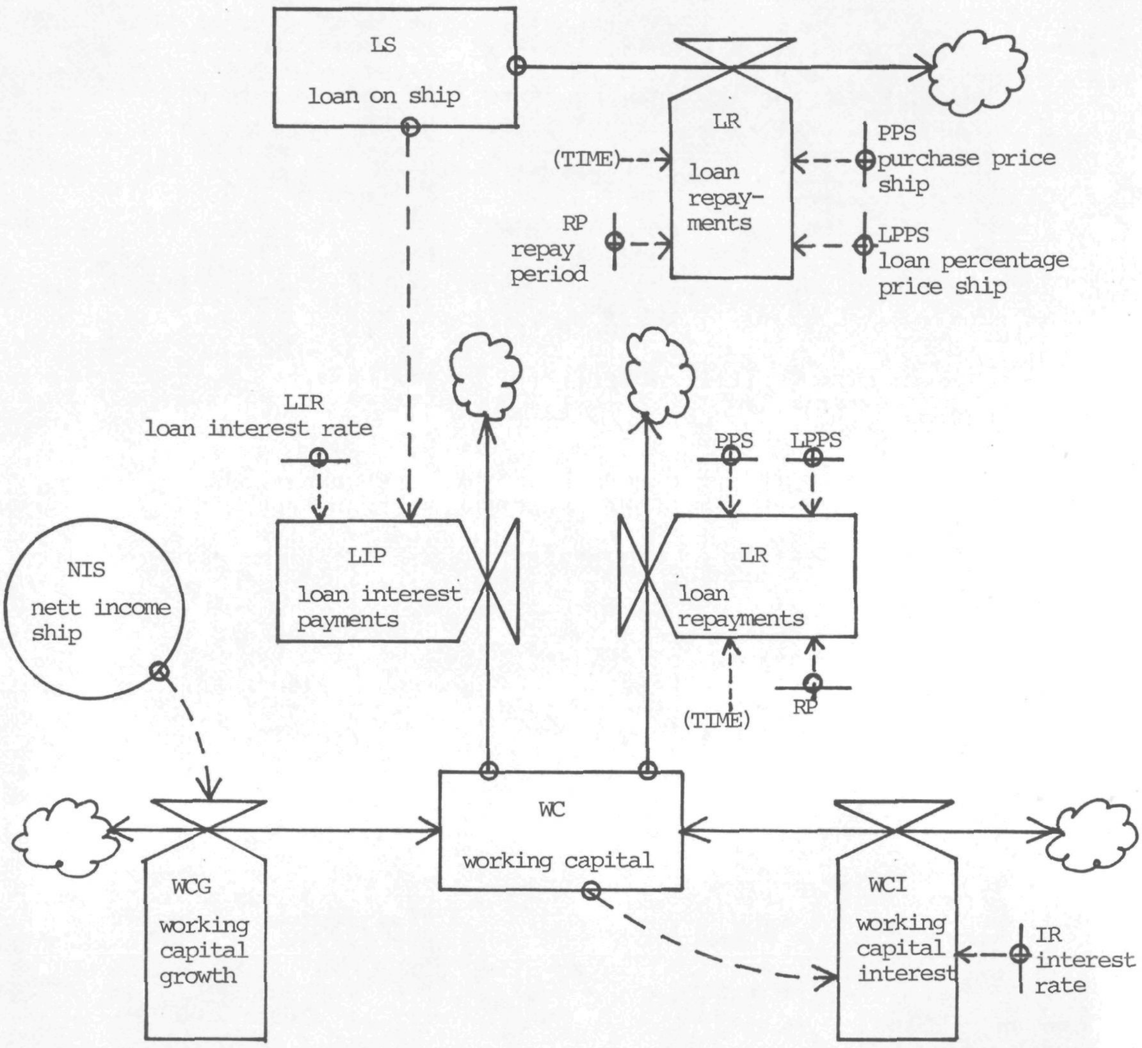
TIME E+00	WC E+03	WCG E+03	WCI E+03	NIS E+03	TI E+03	TP E+03
.0	-2500.0	.00	.000	-34.46	.00	.00
2.	-2657.7	8.52	-79.732	8.52	-70.65	.00
4.	-2765.8	51.50	-82.974	51.50	-31.20	.00
6.	-2792.8	89.67	-83.785	94.47	10.67	4.80
8.	-2760.0	112.95	-82.799	137.45	54.45	24.50
10.	-2698.8	112.14	-80.963	137.45	56.26	25.32
12.	-2635.5	111.29	-79.065	137.45	58.15	26.17
14.	-2570.1	110.41	-77.103	137.45	60.10	27.05
16.	-2502.5	109.50	-75.076	137.45	62.12	27.95
18.	-2432.7	108.56	-72.980	137.45	64.21	28.89
20.	-2360.5	107.59	-70.814	137.45	66.36	29.86
22.	-2285.8	106.59	-68.575	137.45	68.59	30.87
24.	-2208.7	105.55	-66.261	137.45	70.90	31.90
26.	-2129.0	104.48	-63.869	137.45	73.28	32.98
28.	-2046.6	103.37	-61.397	137.45	75.74	34.08
30.	-1961.4	102.22	-58.842	137.45	78.29	35.23
32.	-1873.4	101.04	-56.201	137.45	80.92	36.41
34.	-1782.4	99.82	-53.471	137.45	83.64	37.64
36.	-1688.3	98.55	-50.650	137.45	86.45	38.90
38.	-1591.1	97.25	-47.733	137.45	89.35	40.21
40.	-1490.6	95.89	-44.719	137.45	92.35	41.56
42.	-1386.8	94.50	-41.603	137.45	95.45	42.95
44.	-1279.4	93.06	-38.383	137.45	98.66	44.40
46.	-1168.5	91.56	-35.055	137.45	101.98	45.89
48.	-1053.8	90.02	-31.615	137.45	105.40	47.43
50.	-935.3	88.43	-28.059	137.45	108.94	49.02
52.	-812.8	86.78	-24.384	137.45	112.60	50.67
54.	-686.2	85.08	-20.585	137.45	116.39	52.37
56.	-555.3	83.32	-16.659	137.45	120.30	54.13
58.	-420.0	81.50	-12.601	137.45	124.34	55.95
60.	-280.2	79.62	-8.407	137.45	128.51	57.83
62.	-135.7	77.68	-4.071	137.45	132.83	59.77
64.	13.6	75.67	.409	137.45	137.29	61.78
66.	168.0	73.60	5.041	137.45	141.91	63.86
68.	327.6	71.45	9.828	137.45	146.67	66.00
70.	492.5	69.23	14.776	137.45	151.60	68.22
72.	663.0	66.94	19.890	137.45	156.69	70.51
74.	839.2	64.57	25.176	137.45	161.96	72.88
76.	1021.3	62.12	30.639	137.45	167.40	75.33
78.	1209.5	59.59	36.286	137.45	173.02	77.86
80.	1404.1	56.98	42.123	137.45	178.84	80.48
82.	1605.2	54.27	48.156	137.45	184.84	83.18
84.	1813.0	51.48	54.391	137.45	191.05	85.97
86.	2027.9	48.59	60.836	137.45	197.47	88.86
88.	2249.9	45.61	67.497	137.45	204.11	91.85
90.	2479.4	42.52	74.383	137.45	210.96	94.93
92.	2716.6	39.33	81.499	137.45	218.05	98.12
94.	2961.8	36.03	88.855	137.45	225.38	101.42
96.	3215.2	32.63	96.457	137.45	232.95	104.83



2.3 MODEL 3 - CASH FLOW MODEL OF 1 SHIP FINANCED BY A LOAN

The causal-loop diagram of the model can be found in paragraph 1.2.

The figure below is the dynamo-flow diagram of the working capital sector and the loan sector.



. parameter values

The loan percentage of the purchase price of the ship is 75.percent. The loan interest rate is 8 percent per year or 2 percent per quarter.

The loan is repaid over 32 quarters. Each 4 quarters 1/8 of the loan is repaid. In dynamo this is done with a pulse function. This function gives a pulse with the height 1/8 over the computation interval DT.

. documentor listing of the relevant equations

```
WC.K=WC.J+DT*(WCG.JK+WCI.JK-LR.JK-LIP.JK)
WC=-(1-LPPS)*PPS
LPPS=.75
PPS=2.5E6
     WC        - WORKING CAPITAL  ƒ
     DT        - COMPUTATION INTERVAL  QUARTER
     WCG       - WORKING CAPITAL GROWTH    ƒ/QUARTER
     WCI       - WORKING CAPITAL INTEREST  ƒ/QUARTER
     LR        - LOAN REPAYMENT  ƒ/QUARTER
     LIP       - LOAN INTEREST PAYMENT  ƒ/QUARTER
     LPPS      - LOAN PERCENTAGE PER SHIP    DIM'LESS
     PPS       - PURCHASE PRICE SHIP ƒ

LS.K=LS.J+DT*(-LR.JK/DT)
LS=LPPS*PPS
     LS        - LOAN ON SHIP    ƒ
     DT        - COMPUTATION INTERVAL  QUARTER
     LR        - LOAN REPAYMENT  ƒ/QUARTER
     LPPS      - LOAN PERCENTAGE PER SHIP    DIM'LESS
     PPS       - PURCHASE PRICE SHIP ƒ

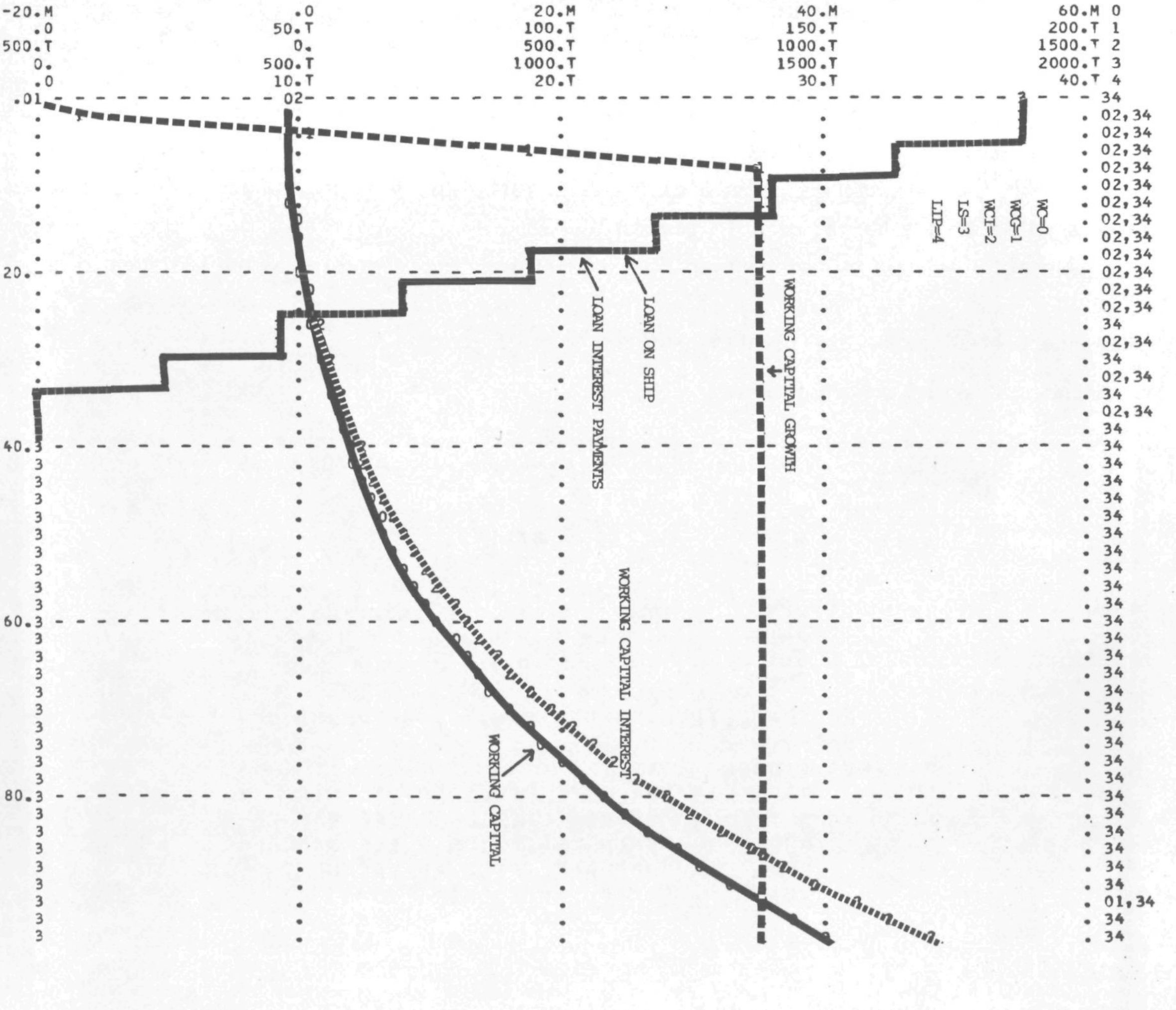
LR.KL=CLIP(((PULSE((1/RP),4,4))*LPPS*PPS),0,32,
  TIME.K)
RP=8
     LR        - LOAN REPAYMENT  ƒ/QUARTER
     CLIP      - DYNAMO FUNCTION - SEE MANUAL
     PULSE     - DYNAMO FUNCTION - SEE MANUAL
     RP        - REPAY PERIOD     YEARS
     LPPS      - LOAN PERCENTAGE PER SHIP    DIM'LESS
     PPS       - PURCHASE PRICE SHIP ƒ

LIP.KL=LS.K*LIR
LIR=.02
     LIP       - LOAN INTEREST PAYMENT  ƒ/QUARTER
     LS        - LOAN ON SHIP   ƒ
     LIR       - LOAN INTEREST RATE  %/QUARTER
```

```
*  MODFL 3 - 1 SHIP FINANCED BY A LOAN
NOTE  NETT INCOME/SHIP/QUARTER
A  FT.K=LC*LFE.K
C  LC=14000
A  LFE.K=TABLE(LFET,TIME.K,0,96,8)
T  LFFT=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A  IT.K=LC*LFI.K
A  LFI.K=TABLE(LFIT,TIME.K,0,96,8)
T  LFIT=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A  GRE.K=FT.K*FRE
C  FRE=25
A  GRI.K=IT.K*FRI
C  FRI=35
A  GR.K=GRF.K+GRI.K
A  AC.K=GR.K*ACS
C  ACS=.055
A  SC.K=(FT.K+IT.K)*SCT
C  SCT=6.25
A  CC.K=(FT.K+IT.K)*CCT
C  CCT=.4
A  SCC.K=(FT.K+IT.K)*SCCT
C  SCCT=1
C  B=58000
C  PC=45000
A  VE.K=AC.K+SC.K+CC.K+SCC.K+B+PC
A  NIS.K=(((GR.K-VE.K)*OD)/RT)-OC-AMC
C  OD=87.5
C  RT=118
C  OC=110000
C  AMC=20000
NOTF  WORKING CAPITAL
• L  WC.K=WC.J+DT*(WCG.JK+WCI.JK-LR.JK-LIP.JK)
• N  WC=-(1-LPPS)*PPS
• C  LPPS=.75
  C  PPS=2.5F6
  R  WCG.KL=CLIP(NIS.K,0,TIME.K,DT)
  R  WCI.KL=CLIP((WC.K*IR),0,TIME.K,DT)
  C  IR=.03
• L  LS.K=LS.J+DT*(-LR.JK/DT)
• N  LS=LPPS*PPS
• R  LR.KL=CLIP(((PULSE((1/RP),4,4))*LPPS*PPS),0,32,TIME.K)
• C  RP=8
• R  LIP.KL=LS.K*LIR
• C  LIR=.02
SPEC  LENGTH=96/DT=.25/PRTPER=2/PLTPER=2
PRINT  WC,WCG,WCI,LS,LR,LIP
PLOT  WC/WCG/WCI/LS/LIP
RUN
```

MODEL 3 - 1 SHIP FINANCED BY A LOAN

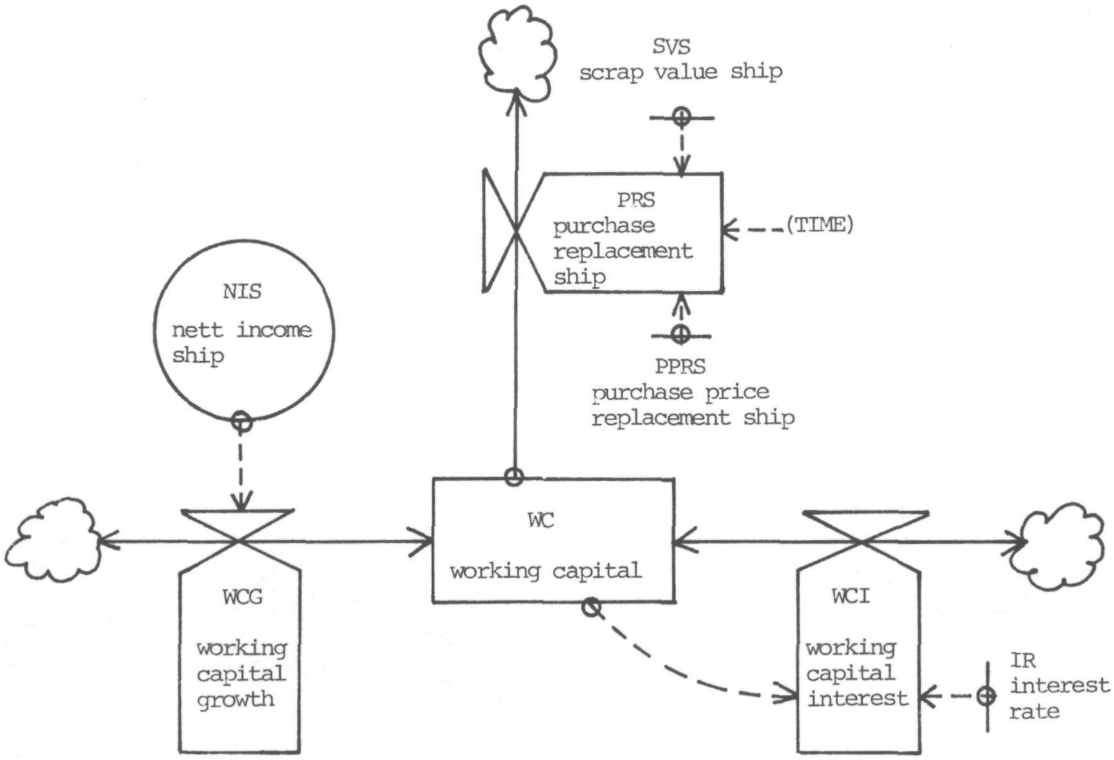
TIME E+00	WC E+06	WCG E+03	WCI E+03	LS E+03	LR E+03	LIP E+03
.0	-.625	.00	.0	1875.0	.00	37.500
2.	-.759	8.52	-22.8	1875.0	.00	37.500
4.	-.827	51.50	-24.8	1875.0	234.38	37.500
6.	-.865	94.47	-25.9	1640.6	.00	32.812
8.	-.753	137.45	-22.6	1640.6	234.38	32.812
10.	-.638	137.45	-19.1	1406.3	.00	28.125
12.	-.453	137.45	-13.6	1406.3	234.38	28.125
14.	-.309	137.45	-9.3	1171.9	.00	23.437
16.	-.094	137.45	-2.8	1171.9	234.38	23.437
18.	.081	137.45	2.4	937.5	.00	18.750
20.	.329	137.45	9.9	937.5	234.38	18.750
22.	.540	137.45	16.2	703.1	.00	14.062
24.	.827	137.45	24.8	703.1	234.38	14.062
26.	1.077	137.45	32.3	468.8	.00	9.375
28.	1.407	137.45	42.2	468.8	234.38	9.375
30.	1.703	137.45	51.1	234.4	.00	4.687
32.	2.081	137.45	62.4	234.4	234.38	4.687
34.	2.428	137.45	72.8	.0	.00	.000
36.	2.860	137.45	85.8	.0	.00	.000
38.	3.318	137.45	99.5	.0	.00	.000
40.	3.805	137.45	114.1	.0	.00	.000
42.	4.321	137.45	129.6	.0	.00	.000
44.	4.870	137.45	146.1	.0	.00	.000
46.	5.452	137.45	163.6	.0	.00	.000
48.	6.070	137.45	182.1	.0	.00	.000
50.	6.726	137.45	201.8	.0	.00	.000
52.	7.423	137.45	222.7	.0	.00	.000
54.	8.162	137.45	244.9	.0	.00	.000
56.	8.947	137.45	268.4	.0	.00	.000
58.	9.781	137.45	293.4	.0	.00	.000
60.	10.665	137.45	320.0	.0	.00	.000
62.	11.604	137.45	348.1	.0	.00	.000
64.	12.602	137.45	378.0	.0	.00	.000
66.	13.660	137.45	409.8	.0	.00	.000
68.	14.784	137.45	443.5	.0	.00	.000
70.	15.977	137.45	479.3	.0	.00	.000
72.	17.243	137.45	517.3	.0	.00	.000
74.	18.587	137.45	557.6	.0	.00	.000
76.	20.014	137.45	600.4	.0	.00	.000
78.	21.529	137.45	645.9	.0	.00	.000
80.	23.138	137.45	694.1	.0	.00	.000
82.	24.845	137.45	745.4	.0	.00	.000
84.	26.658	137.45	799.7	.0	.00	.000
86.	28.582	137.45	857.5	.0	.00	.000
88.	30.625	137.45	918.7	.0	.00	.000
90.	32.793	137.45	983.8	.0	.00	.000
92.	35.096	137.45	1052.9	.0	.00	.000
94.	37.540	137.45	1126.2	.0	.00	.000
96.	40.134	137.45	1204.0	.0	.00	.000



2.4 MODEL 4 - CASH FLOW MODEL OF 1 SHIP WITH REPLACEMENT OF SHIP

The causal-loop diagram of the model can be found in paragraph 1.2.

The figure below is the dynamo-flow diagram of the working capital sector.



. parameter values

The ship is purchased second-hand. At that moment it has a 'remaining lifetime' of 64 quarters. Thus, a replacement ship must be purchased after this period.

The equation of the rate PRS contains a clip and a pulse function. The result is that after 64 quarters a pulse with a height of 1 is given.

The purchase price of the replacement ship is £4 million, and the scrap value of the old ship is £250,000.

The other parameter values are identical to the ones of model 1.

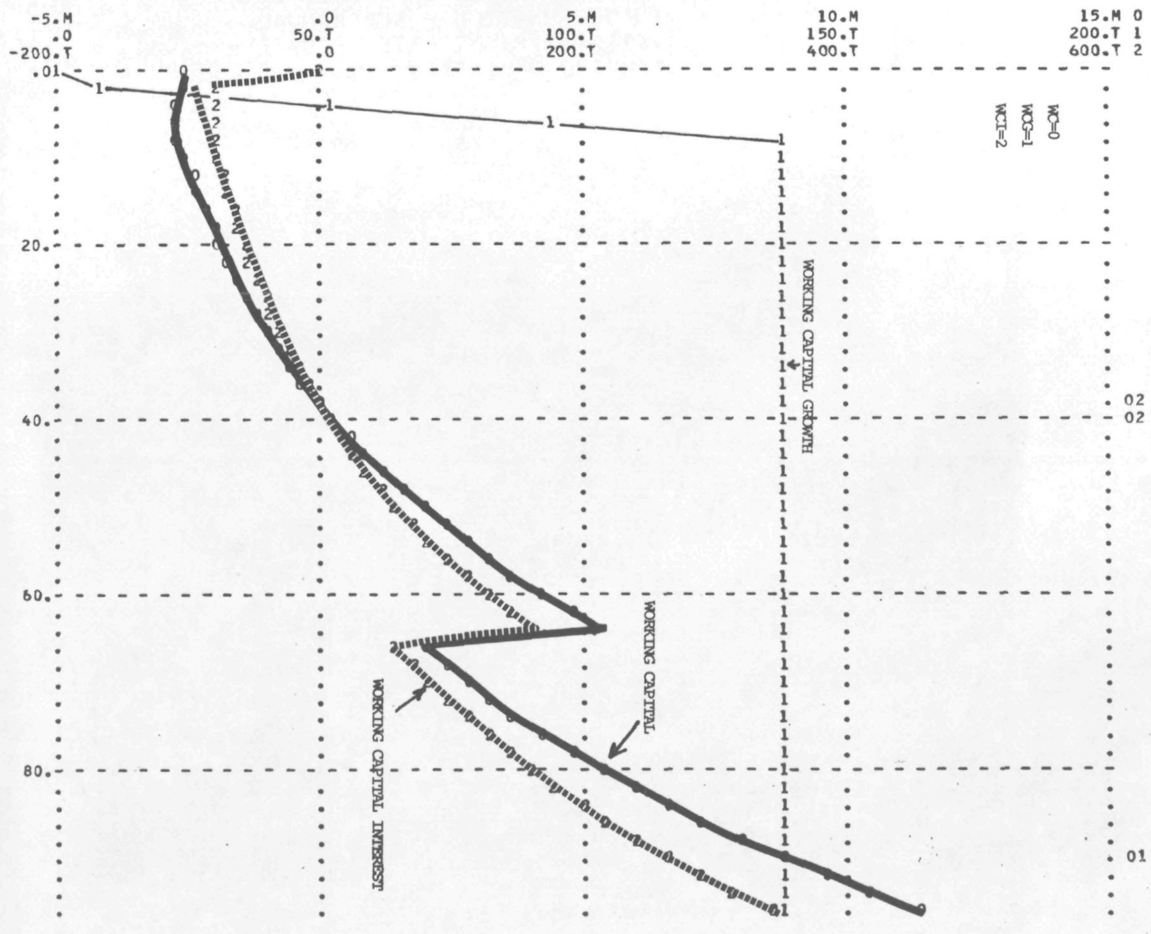
. documentor listing of relevant equations

```
WC.K=WC.J+DT*(WCG.JK+WCI.JK-PRS.JK/DT)
WC=-PPS
PPS=2.5E6
     WC       - WORKING CAPITAL  £
     DT       - COMPUTATION INTERVAL   QUARTER
     WCG      - WORKING CAPITAL GROWTH    £/QUARTER
     WCI      - WORKING CAPITAL INTEREST   £/QUARTER
     PRS      - PURCHASE REPLACEMENT SHIP    £
     PPS      - PURCHASE PRICE SHIP £

PRS.KL=(CLIP(0,PULSE(1,64,1),TIME.K,65))*(PPRS-SVS)
PPRS=4E6
SVS=250000
     PRS      - PURCHASE REPLACEMENT SHIP    £
     CLIP     - DYNAMO FUNCTION - SEE MANUAL
     PULSE    - DYNAMO FUNCTION - SEE MANUAL
     PPRS     - PURCHASE PRICE REPLACEMENT SHIP   £
     SVS      - SCRAP VALUE SHIP  £
```

```
*  MODEL 4 - 1 SHIP WITH REPLACEMENT OF SHIP
NOTE  NETT INCOME/SHIP/QUARTER
A  ET.K=LC*LFE.K
C  LC=14000
A  LFE.K=TABLE(LFET,TIME.K,0,96,8)
T  LFET=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A  IT.K=LC*LFI.K
A  LFI.K=TABLE(LFIT,TIME.K,0,96,8)
T  LFIT=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A  GRE.K=ET.K*FRE
C  FRE=25
A  GRI.K=IT.K*FRI
C  FRI=35
A  GR.K=GRE.K+GRI.K
A  AC.K=GR.K*ACS
C  ACS=.055
A  SC.K=(ET.K+IT.K)*SCT
C  SCT=6.25
A  CC.K=(ET.K+IT.K)*CCT
C  CCT=.4
A  SCC.K=(ET.K+IT.K)*SCCT
C  SCCT=1
C  B=58000
C  PC=45000
A  VE.K=AC.K+SC.K+CC.K+SCC.K+B+PC
A  NIS.K=(((GR.K-VE.K)*OD)/RT)-OC-AMC
C  OD=87.5
C  RT=118
C  OC=110000
C  AMC=20000
NOTE  WORKING CAPITAL
• L  WC.K=WC.J+DT*(WCG.JK+WCI.JK-PRS.JK/DT)
N  WC=-PPS
C  PPS=2.5E6
R  WCG.KL=CLIP(NIS.K,0,TIME.K,DT)
R  WCI.KL=CLIP((WC.K*IR),0,TIME.K,DT)
C  IR=.03
• R  PRS.KL=(CLIP(0,PULSE(1,64,1),TIME.K,65))*(PPRS-SVS)
• C  PPRS=4E6
• C  SVS=250000
SPEC  LENGTH=96/DT=.25/PRTPER=2/PLTPER=2
PRINT  WC,WCG,WCI
PLOT  WC/WCG/WCI
RUN
```

TIME	WC	WCG	WCI
E+00	E+06	E+03	E+03
.0	-2.500	.00	.00
2.	-2.658	8.52	-79.73
4.	-2.766	51.50	-82.97
6.	-2.792	94.47	-83.77
8.	-2.732	137.45	-81.96
10.	-2.618	137.45	-78.54
12.	-2.497	137.45	-74.92
14.	-2.369	137.45	-71.06
16.	-2.232	137.45	-66.97
18.	-2.088	137.45	-62.63
20.	-1.934	137.45	-58.02
22.	-1.771	137.45	-53.13
24.	-1.598	137.45	-47.94
26.	-1.414	137.45	-42.42
28.	-1.219	137.45	-36.57
30.	-1.012	137.45	-30.35
32.	-.792	137.45	-23.76
34.	-.558	137.45	-16.75
36.	-.311	137.45	-9.32
38.	-.047	137.45	-1.42
40.	.232	137.45	6.96
42.	.528	137.45	15.85
44.	.843	137.45	25.29
46.	1.177	137.45	35.32
48.	1.532	137.45	45.96
50.	1.909	137.45	57.26
52.	2.308	137.45	69.25
54.	2.733	137.45	81.99
56.	3.183	137.45	95.50
58.	3.662	137.45	109.85
60.	4.170	137.45	125.09
62.	4.709	137.45	141.26
64.	5.281	137.45	158.43
66.	1.937	137.45	58.11
68.	2.339	137.45	70.16
70.	2.765	137.45	82.95
72.	3.217	137.45	96.52
74.	3.698	137.45	110.94
76.	4.208	137.45	126.24
78.	4.749	137.45	142.48
80.	5.324	137.45	159.72
82.	5.934	137.45	178.03
84.	6.582	137.45	197.46
86.	7.270	137.45	218.09
88.	8.000	137.45	239.99
90.	8.775	137.45	263.24
92.	9.598	137.45	287.93
94.	10.471	137.45	314.13
96.	11.398	137.45	341.95



2.5 MODEL 5 - CASH FLOW MODEL OF 1 SHIP WITH PARAMETER CHANGES

All the parameters of model 1 can be changed and their impacts calculated by simply replacing a few punchcards. This process is easy to illustrate but contributes little to a better understanding. Therefore, it is limited to only one example: instead of constant freight rates, fluctuating freight rates. Dynamo provides a function NORMRN which generates random numbers normally distributed with a certain mean and a standard deviation. The numbers do not exceed 2.4 standard deviation. The constant freight rates of model 1 are taken as mean, and the standard deviation is £3/ton.

. documentor listing of relevant equations

```
GRE.K=ET.K*FRE.K
    GRE      - GROSS REVENUE ON EXPORTS/SHIP/ROUNDTRIP
    ET       - EXPORT TONNAGE /SHIP/ROUNDTRIP   TONS
    FRE      - FREIGHT RATE EXPORTS   £/TON

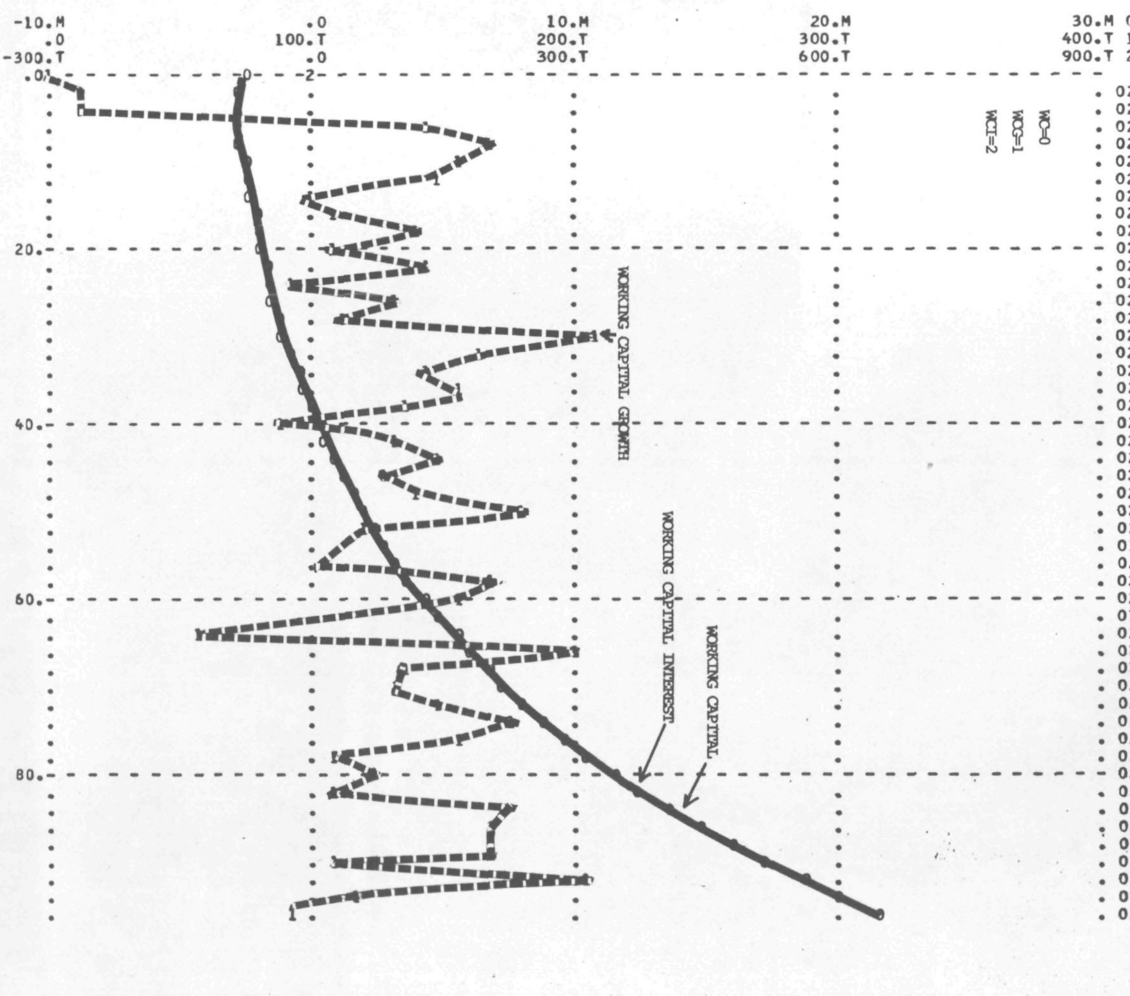
FRE.K=NORMRN(AFRE,STDV)
AFRE=25
STDV=3
    FRE      - FREIGHT RATE EXPORTS   £/TON
    NORMRN   - DYNAMO FUNCTION - SEE MANUAL
    AFRE     - AVERAGE FREIGHT RATE EXPORTS
    STDV     - STANDARD DEVIATION

GRI.K=ET.K*FRI.K
    GRI      - GROSS REVENUE ON IMPORTS /SHIP/ROUNDTRIP
    ET       - EXPORT TONNAGE /SHIP/ROUNDTRIP   TONS
    FRI      - FREIGHT RATE IMPORTS    £/TON

FRI.K=NORMRN(AFRI,STDV)
AFRI=35
    FRI      - FREIGHT RATE IMPORTS    £/TON
    NORMRN   - DYNAMO FUNCTION - SEE MANUAL
    AFRI     - AVERAGE FREIGHT RATE IMPORTS
    STDV     - STANDARD DEVIATION
```

```
*  MODEL 5 - 1 SHIP WITH PARAMETER CHANGES
NOTE
• NOTE   FLUCTUATING FREIGHT RATES
NOTE
NOTE   NETT INCOME/SHIP/QUARTER
A   ET.K=LC*LFE.K
C   LC=14000
A   LFE.K=TABLE(LFET,TIME.K,0,96,8)
T   LFET=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A   IT.K=LC*LFI.K
A   LFI.K=TABLE(LFIT,TIME.K,0,96,8)
T   LFIT=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
• A   GRE.K=ET.K*FRE.K
• A   FRE.K=NORMRN(AFRE,STDV)
• C   AFRE=25
• C   STDV=3
• A   GRI.K=ET.K*FRI.K
• A   FRI.K=NORMRN(AFRI,STDV)
• C   AFRI=35
A   GR.K=GRE.K+GRI.K
A   AC.K=GR.K*ACS
C   ACS=.055
A   SC.K=(ET.K+IT.K)*SCT
C   SCT=6.25
A   CC.K=(ET.K+IT.K)*CCT
C   CCT=.4
A   SCC.K=(ET.K+IT.K)*SCCT
C   SCCT=1
C   B=58000
C   PC=45000
A   VE.K=AC.K+SC.K+CC.K+SCC.K+B+PC
A   NIS.K=(((GR.K-VE.K)*OD)/RT)-OC-AMC
C   OD=87.5
C   RT=118
C   OC=110000
C   AMC=20000
NOTE   WORKING CAPITAL
L   WC.K=WC.J+DT*(WCG.JK+WCI.JK)
N   WC=-PPS
C   PPS=2.5E6
R   WCG.KL=CLIP(NIS.K,0,TIME.K,DT)
R   WCI.KL=CLIP((WC.K*IR),0,TIME.K,DT)
C   IR=.03
SPEC   LENGTH=96/DT=.25/PRTPER=2/PLTPER=2
PRINT   WC,WCG,WCI
PLOT   WC/WCG/WCI
RUN
```

TIME E+00	WC E+06	WCG E+03	WCI E+03
.0	-2.500	.00	.00
2.	-2.670	13.79	-80.11
4.	-2.797	10.62	-83.91
6.	-2.809	143.80	-84.28
8.	-2.715	166.58	-81.46
10.	-2.569	154.91	-77.06
12.	-2.435	146.98	-73.05
14.	-2.293	101.40	-68.80
16.	-2.182	108.17	-65.45
18.	-2.066	140.06	-61.97
20.	-1.932	108.24	-57.95
22.	-1.771	145.20	-53.13
24.	-1.590	93.90	-47.70
26.	-1.451	132.55	-43.54
28.	-1.253	113.69	-37.60
30.	-1.024	206.53	-30.73
32.	-.808	164.63	-24.23
34.	-.575	145.30	-17.24
36.	-.309	156.49	-9.28
38.	-.036	135.39	-1.07
40.	.257	89.54	7.70
42.	.561	130.64	16.82
44.	.858	149.72	25.74
46.	1.199	127.36	35.96
48.	1.557	138.83	46.70
50.	1.949	181.95	58.48
52.	2.389	118.39	71.68
54.	2.804	126.68	84.11
56.	3.248	105.54	97.43
58.	3.777	168.97	113.30
60.	4.283	155.70	128.48
62.	4.864	146.02	145.92
64.	5.437	57.83	163.11
66.	5.999	199.76	179.96
68.	6.653	137.93	199.58
70.	7.333	133.32	219.99
72.	8.063	147.44	241.90
74.	8.853	176.31	265.58
76.	9.697	157.15	290.92
78.	10.596	109.71	317.88
80.	11.579	124.58	347.37
82.	12.562	108.42	376.85
84.	13.626	170.65	408.78
86.	14.774	167.02	443.23
88.	15.983	169.48	479.48
90.	17.289	109.74	518.68
92.	18.636	202.59	559.08
94.	20.060	117.14	601.81
96.	21.585	90.15	647.55




QUICK-
STEP

Chapter 3 - QUICK STEP: PROJECT EVALUATION OF SHIPPING INVESTMENTS

Many developing countries have published Development Plans. These plans are attempts to define a planning strategy which, given the scarce resources, fulfills best the objectives of the country. Of course, if there were no limitation to the resources available, there would hardly be a need for planning, project selection and project evaluation. The same holds for a country that has no objectives; in that case any project will do.
Project evaluation at the national level is often called social cost benefit analysis (SCBA).
One of the main problems that the project evaluator encounters in doing SCBA is the fact that market prices in developing countries do not always reflect the true opportunity cost values of inputs and outputs of a particular investment. Alternative values or 'shadow prices' have to be used in preference to market prices. Focal points of shadow pricing in SCBA are foreign exchange, unskilled labour, transfer payments, consumption and investment.
The adjustments to market prices can be made in a variety of ways. Many project analysts make ad hoc adjustments as best as they can in a fairly unsystematic way. However, in recent years, two methods have been promoted by the international financing agencies which attempt to approach SCBA in a systematic way: the UNIDO and Little & Mirrlees methods. Although both of these systems seek in principle to take account of the same types of necessary adjustment, they differ in their choice of numeraire, the basic unit in which all costs and benefits of a project should be expressed for social appraisal.
Paragraph 3.1 contains a brief description of both methods and discusses the applicability to the evaluation of shipping investments in developing countries.
Paragraph 3.2 discusses the objectives of a national fleet in a developing country, and formulates indicators for the measurement of the impact of a national fleet on these national objectives.

3.1 THE APPLICABILITY OF THE UNIDO AND LITTLE & MIRRLEES EVALUATION METHODS TO SHIPPING INVESTMENTS.[10)]

The UNIDO method[9)] takes aggregate consumption benefits as its basis of value. This means that all values should be expressed in terms of domestic prices, which reflect consumer willingness-to-pay for consumption. Under this system a premium is added to foreign exchange effects, reflecting the fact that they may be under-valued in domestic market prices, whilst a 'negative-cost' premium is applied to unskilled labour to allow for the extent to which wages exceed opportunity costs. Subsequently, an 'investment premium' is applied to all increases or decreases in savings made by different classes of beneficiary as a result of the project to reflect the fact that savings are more valuable than increased present consumption.
The Little & Mirrlees method[8)] for project appraisal takes as its numeraire disposable income in the hands of government, valued on the basis of world prices for internationally tradable goods. It is assumed that marginal resources freely available to the government will be used for investment or for some purpose which is valued as highly as increased investment. Thus, all tradable commodities used or produced by the project are valued on the basis of their border prices as imports or exports. Non-tradable inputs are valued at their costs of production, which are (through analysis) expressed in terms of border prices and domestic factor payments. Unskilled labour is valued on the basis of its opportunity cost, but the value of the benefits in terms of increased consumption accruing to people is reduced to allow for the fact that incremental consumption is less valuable than investment. Savings, which are equated directly with investment, are not counted as cost. As a result of these adjustments, non-tradable commodities that do not contain subsidies in their price structure are given a social cost lower than their market prices.

The two approaches for social cost benefit analysis have been particularly designed for use in the appraisal of industrial projects. Although shipping is often called an industry, its characteristics differ widely from land-based industries. Some of these differences are:
. the product of shipping is a service (transportation) which is difficult to compare with any other

industrial product,

. there are few domestic inputs in the production of the service: the ships are often purchased abroad, like most of the bunkers, spare parts, etc.,

. the service is sold on an international market to relatively few shippers of goods (the consumers of the service).

Confrontation of the characteristics of shipping with the basic priciples of the UNIDO and Little & Mirrlees approach to SCBA, reveals some interesting aspects:

- UNIDO method: The willingness-to-pay for the shipping service exists, but it works indirectly. The liner ship transports general cargo which is usually consumer goods of high value. The transport cost form a small percentage of the total sales price of the goods on the market. The willingness-to-pay of the consumer is thus not a measure for the willingness-to-pay for the transport service, but for the willingness-to-pay of the goods as such.

One might argue that one should look at the shippers' (exporters, importers) willingness-to-pay. But it is easy to prove that the shippers will only export or import when there is a demand for their products, thus when the consumers are willing to pay. The willingness-to-pay for shipping services is thus difficult to compare with the willingness-to-pay for consumer and producer goods as defined in the UNIDO-method.

- Little & Mirrlees method: all tradable goods used or produced by the project are valued on the basis of their border prices as imports or exports. For a shipping investment this is almost a trivial exercise, as most of the 'goods' used and produced are already expressed in border prices as they are purchased and/or sold on the international market.

The two factors make it less attractive to follow the guidelines for evaluation of the UNIDO and Little & Mirrlees approaches in the case of shipping investments. Therefore, another procedure for evaluation is adopted which is discussed in the following paragraph.

3.2 OBJECTIVES OF A NATIONAL FLEET

The importance of transportation to a country's economy and development has often been stated, nevertheless, the emergence of shipping fleets in many, previously non-maritime countries is not so widely understood. According to the UNCTAD report 'Establishment or expansion of merchant marines in developing countries' four factors appear to have been responsible:[11)]

. the disruption of shipping services caused by withdrawal of tonnage from commercial services during the second world war,

. the balance of payments problems in the years following the second world war placed a premium on the saving of foreign exchange and gave rise to a great number of bilateral arrangements, many of which contained a shipping clause,

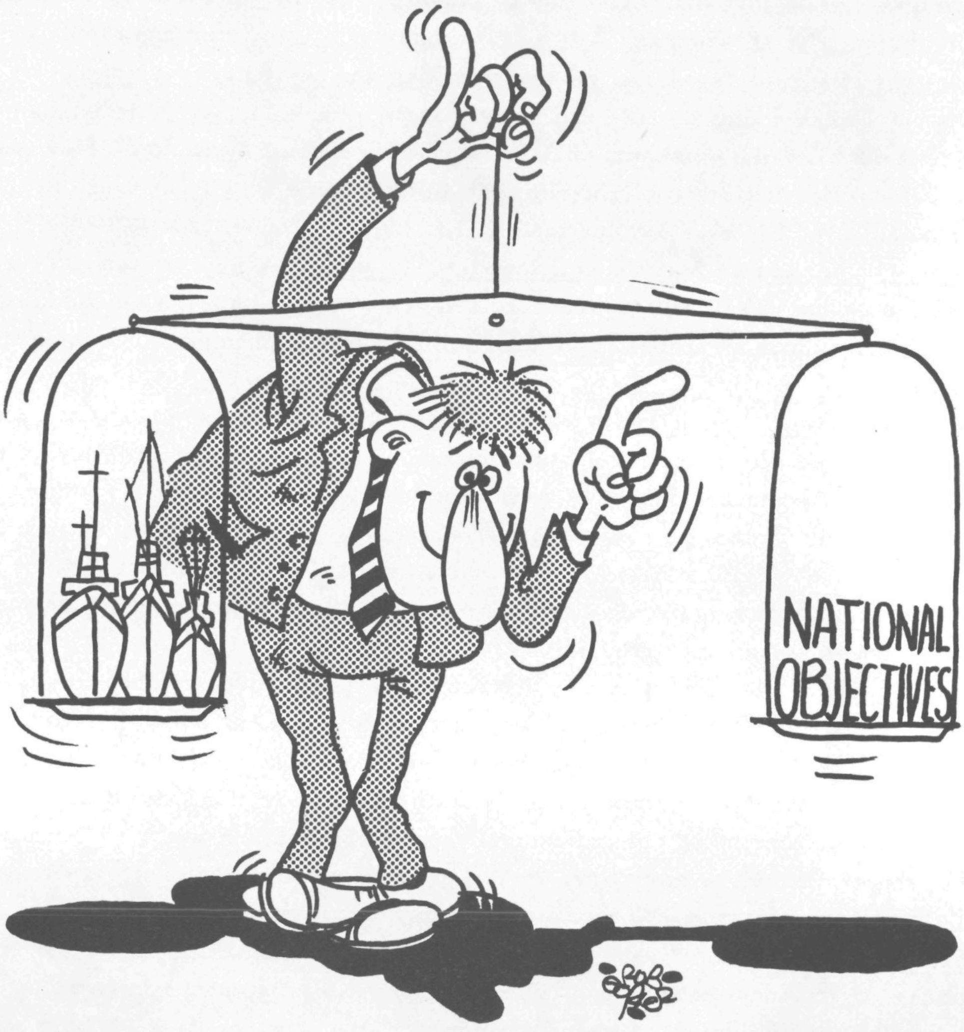
. the attainment of independence by colonial territories and the consequent emergence of national consciousness,

. the conscious efforts being made by countries with low capital income to develop and diversify their economies.

In general, the objectives for the establishment of a national fleet by a developing country can be formulated as follows:

1. contribution to national income creation; under this heading fall the effects of the initial investment in ships (if domestic resources are used) and the wages and profits which arise from the operation of the national fleet.

2. foreign exchange earnings; The aim of relieving pressure on the balance of payments has ranked high among the aims which has led, and will lead, developing countries to establish shipping fleets. The reason is that all countries must seek to attain and maintain equilibrium in the balance of payments, and shipping is one of the industries that is supposed to earn or save a lot of foreign exchange.


NATIONAL
OBJECTIVES

3. employment; Shipping investments create relatively little employment in comparison with other industries (a high capital/employment ratio). On the other hand, this employment is a diversification which is often needed, because the economies of the developing countries are heavily influenced by conditions in comparatively few markets with the result that unfavourable developments in these can have widespread consequences. However, diversification of employment does not necessarily entail the establishment of a national merchant marine. To some extent the employment market for seamen is international in nature.

4. influence on conference decisions; The suspicion that countries have of shipowners operating in liner conference trades to their ports, may be compared with the more widely known attitude to cartels in industry. It is sometimes felt by developing countries that the element of monopoly power inherent in the conference system, together with the particular cost structure of liner shipping, gives shipowners a considerable discretion in the rate policy they choose to follow. These countries consider that the existence of liner services operated by national flag vessels is a means of ensuring that the discretionary element in conference tariffs is exercised in a way that is more favourable, or at least not detrimental, to their seaborne trade.[12)]

5. avoidence of disruptions of services during hostilities; In major wars services are disrupted and freight rates rise due to the difficulties and dangers of operation. The availability of a national fleet during such periods is an important factor for countries that are not themselves involved in the hostilities.

6. reduction of economic dependence; A country having no fleet of its own is entirely at the mercy of shipowners of other flags for the flow of its trade. Commercial profitability is the primary consideration of an individual shipowner, and thus, should services to a given country not prove profitable enough for various reasons, there is always the possibility that the service might be withdrawn or provided in old or unsuitable vessels, or only at a very high price, thereby jeopardizing that country's foreign trade. By having its own merchant fleet a country can minimize this ever present risk to its foreign trade.

7. promotion of exports; A country may try to establish a new market for a product, or expand an existing one. It is usually necessary to lower the price of the commodity in order to achieve these results. However, profit margins are small on most of the exports of developing countries (primary commodities). Therefore, the transport costs must be lowered. As transport cost of primary commodities make up a great portion of the c.i.f. price, a small reduction may cause a relatively big increase in the export of the commodity. In the end this may result in an overall increase in the income of the country, although the shipping activity itself may show a deficit.

8. economic integration; This objective may comprise integration within a country and between neighbouring countries (regional integration). Integration within a country can be illustrated by Indonesia; without a national fleet the 3000 populated islands of the archipelago would have a structure like sand grains without cement. Some countries have a long coastline in relation to their area, e.g. Chile and Australia, and thus coastal shipping becomes an essential element in the transportation system of the country.

Countries may establish regional shipping consortia which stimulate regional economic co-operation and integration.

9. realisation of comparative advantages; It is obvious that trade is advantageous when absolute differences exist in cost of production and also when there are relative cost differences between countries. This latter is defined as the comparative cost principle. Stuchtey[13)] has investigated as to whether these advantages exist between countries in the field of shipping. After some empirical research into the cost structure of shipping in a great number of countries, he councludes, with many reservations: ' .. at this moment none of the developing countries seem to have a comparative costs advantage compared to the traditional maritime countries'.

10. stimulation of forward and backward linkages of the shipping industry; The positive effect of the establishment of a national fleet on the country's economy need not be limited to shipping only, but may also stimulate the development of related industries like ship repairing and -construction.

In order to evaluate national fleet projects on the national level, all the impacts of these projects on the above mentioned national objectives must be established. As most of the impacts can not be measured directly, it is necessary to develop indicators for each objective. The indicators are discussed below.

1. contribution to national income creation; A government that is considering whether to establish or expand shipping operations must spend considerable sums on the acquisition of tonnage. Additional expenditures will be called for throughout the working life of the vessels to cover operating costs. Equally, the operation of the vessels will give rise to a stream of revenues during each year of the vessel's life in the form of freight earnings. The basic question that confronts the management of a shipping enterprise in the field of investment evaluation is whether the difference between these streams of costs and benefits over the life of the ship are sufficiently large to justify the expenditure involved in the acquisition of the vessel. In order to make costs and benefits which arise at different points in time suitable for comparison, they have to be discounted to a base-year. In the model the discounted costs and benefits are calculated over the time-horizon of the project, and it will be used as the indicator for the attainment of the income-creation objective.
2. foreign exchange earnings; A national fleet project creates foreign exchange earnings and expenditures, and thus has an impact on the balance of payments of the country. The problem is to identify the possible sources for improvement to the balance of payments from the establishment of a national fleet. The subject is complex, as the potential nett gain is the sum of many actual flows of payments and receipts recorded in the balance of payments accounts, as well as many other flows which do not appear in that account as such. In order to establish the impact of a national fleet project on the foreign exchange objective, every expenditure and earning must be analysed and divided in domestic currency and foreign exchange components. In the model this is done, not only on a year to year basis, but over the time-horizon of the shipping project as well.
1. + 2. shadow priced discounted costs and benefits; The market price of foreign currency is the exchange rate. If the exchange rate between two countries' currencies were free to seek its own level, it would move to that value at which the demand of one country for the goods of the other equaled the demand of the latter for the goods of the former. However, in the real world exchange rates are not free to respond to supply and demand in this manner. For a variety of reasons, governments attempt to stabilize their exchange rates. Given a fixed market exchange rate, it is possible for one country's currency to become'overvalued' relative to another's. That is, at the market exchange rate, the citizens of the overvalued currency country desire to spend or invest more of their money in another country than the citizens of the latter country wish to spend in the former. Such a country is said to have a balance of payments deficit. What has happened is that the social cost to this economy of utilizing a unit of foreign currency is greater than the market price. Foreign currency has been underpriced.
One way of compensating the underpricing of foreign exchange in social cost-benefit analysis is the use of shadow or accounting prices for foreign exchange. In the country under study, the World Bank has determined a shadow price of 130% for the foreign exchange. If, for example, the official exchange rate for US$ 1 is 0.5 local £, the shadow priced equivalent will be US$ 1 = 1.3 x £0.5=£0.65. The shadow price is thus 30% higher than the official exchange rate.
In the model the costs and benefits which arise from the purchase and operation of the ships are separated in local currency and foreign exchange elements. The foreign exchange elements are multiplied by the shadow price of foreign exchange and these modified costs and benefits are discounted. This is an important indicator for a developing country.
3. employment; There are two types of employment opportunities generated by a national shipping line, resulting from the manning of the ships and the administrative and management staff. Both are calculated in the model.

shadow pricing foreign exchange

4. + 5. influence on conference decisions / avoidance of disruption of services; a big national fleet is more likely to have influence on the decision making within a conference, than a small one. Likewise, the disruption of services is less likely with a big national fleet.
The indicator which can be used to measure the relative size of the national fleet is the ratio of the national exports and imports which can potentially be carried by the national fleet, and the national exports and imports on the trade route. The model calculates this ratio.
6. reduction of economic dependence; the two indicators which can be used to measure the extent of economic dependence are the ones formulated under 2. (foreign exchange) and 4. + 5. (transport potential of national fleet).
7. promotion of exports; a national shipping line can be used for export promotion by means of charging lower freight rates to national exporters. It is useful to know the extent to which the projected freight rates can be lowered, without jeopardizing the national economic profitability and viability of the national shipping line.
If one accepts the shadow priced internal rate of return of the shipping project as the criterion for national profitability, then by lowering the freight rate for national exports, one can make this rate equal to the social rate of discount of the country (a lower freight rate for national exports gives lower freight revenues, and consequently lower discounted benefits). The ratio of the 'low' freight rate and the average freight rate of exports used in the conference, is an indicator for the export promotion objective. With the help of the model this indicator can be calculated.
8. economic integration; a measure for economic integration is rather difficult to define. At the most one can look at the contribution of the national shipping line to the transport of exports and imports to and from neighbouring countries. This can take two forms: transfer cargo to land-locked neighbouring countries, and cross-trade cargo to and from neighbouring countries with ports in the same range. The bigger the total tonnage of transfer and cross-trade cargo, the bigger the contribution of the national shipping line to the economic integration objective. The model calculates the quantities of transfer and cross-trade cargo.
9. realisation of comparative advantages; an indicator for this objective can be deduced from a comparison between the cost structure of the national shipping line and the other ship operators in the conference. As the data on other shipping companies are not available, the comparative costs advantage can only be proved by experience. If the conference members have to increase the freight rates regularly in order to stay in business, while the national shipping line makes a good return on investment without these frequent increases, then it may be concluded that there exists a comparative costs advantage.
10. stimulation of forward and backward linkages; the level of domestic expenditures and profits ploughed back in the country by the national shipping line can be used as an indicator for this objective, For a complete assessment of the impact of these money flows, one should also include the multiplier effects on the rest of the economy. This is almost impossible. Therefore, the model will only calculate the sum of all expenditures and profits from the shipping line which are ploughed back into the economy of the country.


STEP 2

Chapter 4 - STEP 2: MODEL 6 - CASH FLOW MODEL OF 1 SHIP WITH DECISION CRITERIA

Model 6 is model 1 extended with four national objective indicators or so-called decision criteria. (models 7,13 and 14 contain the other indicators).

The four decision criteria will be further discussed below.

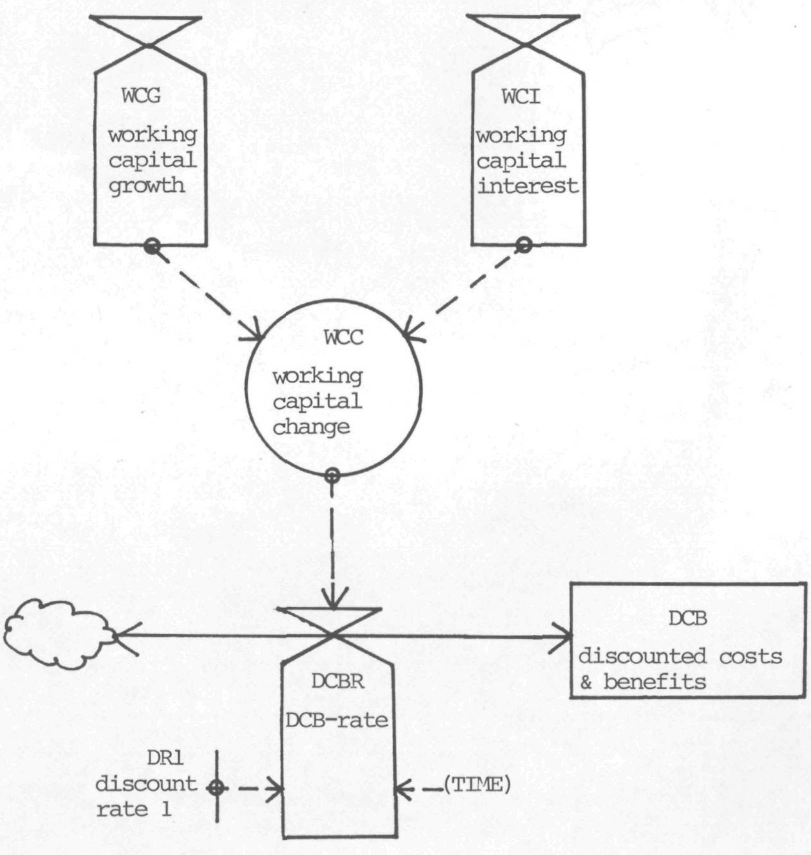
a. discounted costs and benefits

The principle of discounting is illustrated with the following example:

present value at the end of 1976 = discount factor (0.636) x freight revenue shipping line in 1980 (£1,180,000) = £ 750,480

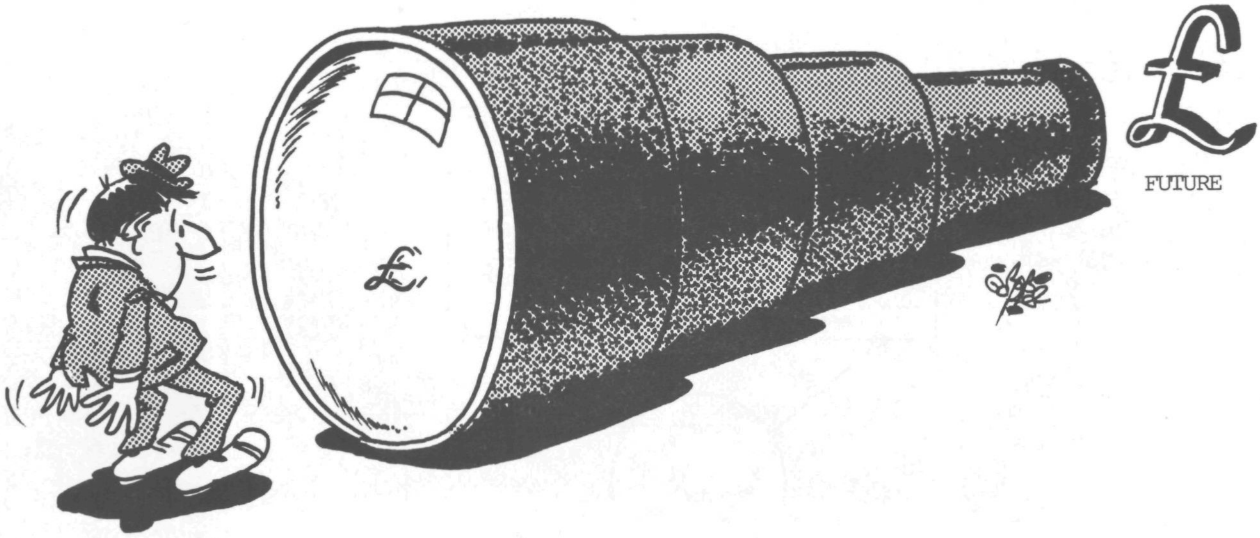
$$\text{discount factor} = \frac{1}{(1 + \text{discount rate})^{\text{time (years)}}} = \frac{1}{(1 + 0.12)^4} = 0.636$$

The 'working capital growth' and the ' working capital interest' as defined in model 1, make up together the 'working capital change'. This variable is discounted according to the above-mentioned principle. The dynamo flow diagram of this calculation procedure is:



. parameter values

The initial value of the level DCB is equal to the purchase price of the ship. The value of the level at the end of the calculation period is equal to the nett present value of the project. The discount rate is put at 4 %/quarter (≈ 16%/year).



discounting

. documentor listing

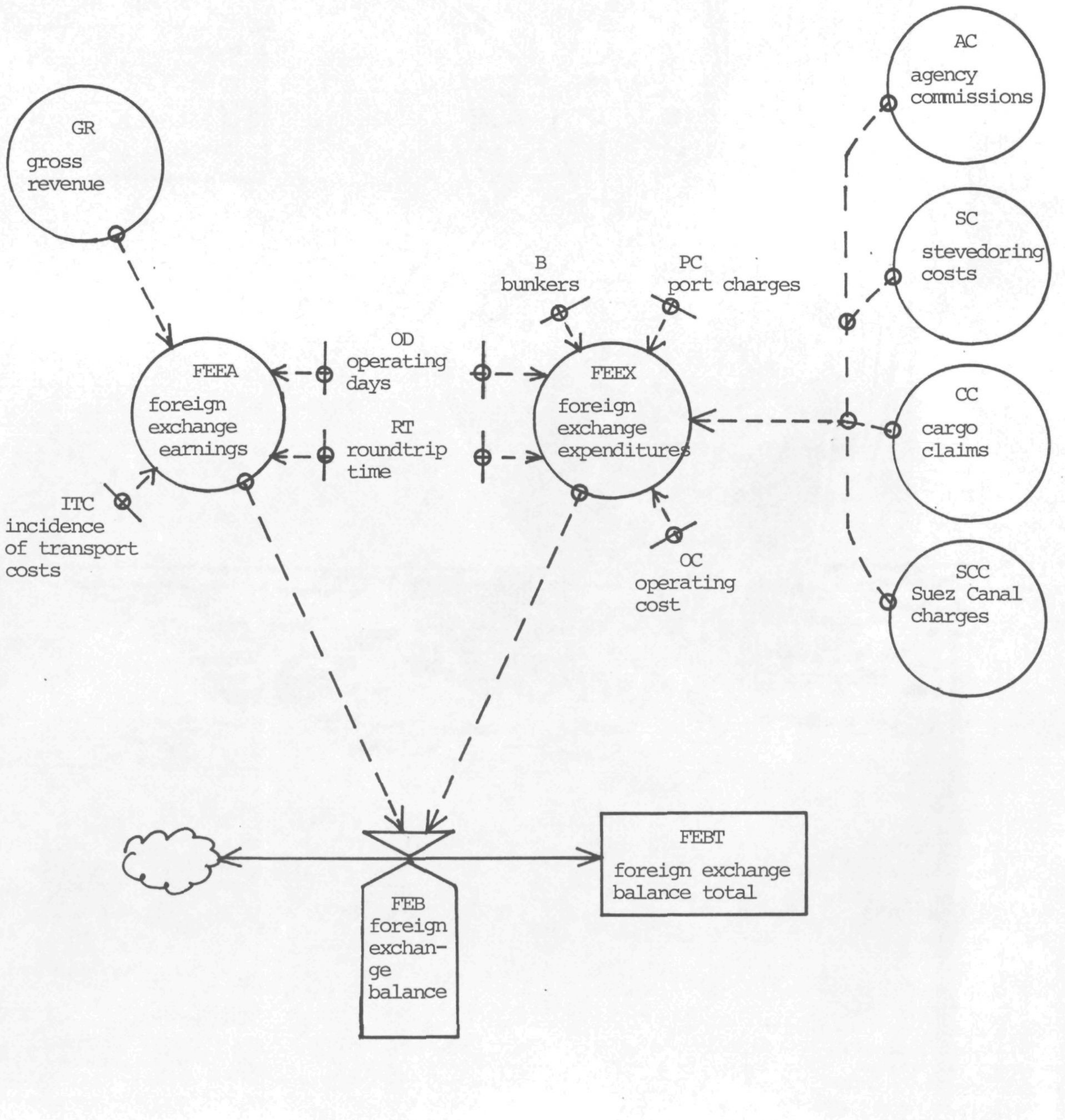
```
DCB.K=DCB.J+DT*DCBR.JK
DCB=-PPS
    DCB      - DISCOUNTED COSTS AND BENEFITS  ƒ
    DCBR     - DCB-RATE    ƒ/QUARTER
    PPS      - PURCHASE PRICE SHIP ƒ

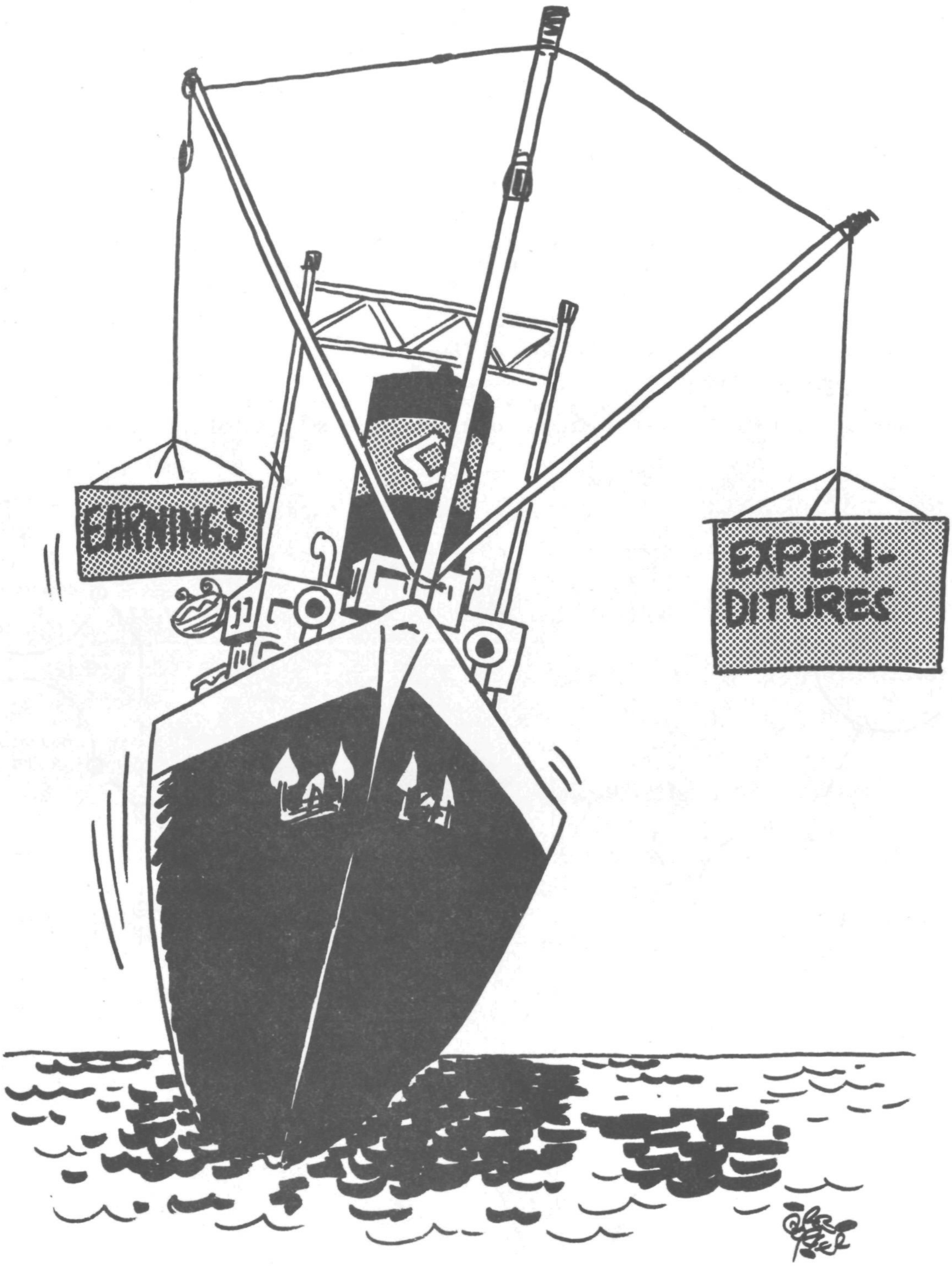
DCBR.KL=(WCC.K/(EXP(TIME.K*LOGN(1+DR1))))
    DCBR     - DCB-RATE    ƒ/QUARTER
    WCC      - WORKING CAPITAL CHANGE   ƒ/QUARTER
    EXP      - DYNAMO FUNCTION - SEE MANUAL
    DR1      - DISCOUNT RATE 1    %/QUARTER

WCC.K=WCG.JK+WCI.JK
DR1=.04
    WCC      - WORKING CAPITAL CHANGE   ƒ/QUARTER
    WCG      - WORKING CAPITAL GROWTH   ƒ/QUARTER
    WCI      - WORKING CAPITAL INTEREST   ƒ/QUARTER
    DR1      - DISCOUNT RATE 1    %/QUARTER
```

b. <u>foreign exchange balance</u>

The figure below is the dynamo-flow diagram of the foreign exchange balance calculation.




EARNINGS
EXPEN-
DITURES

. parameter values

The foreign exchange balance total is the sum of the foreign exchange balances of each quarter. The initial value is equal to the purchase price of the ship. The balance is determined by the quarterly foreign exchange earnings and expenditures. The foreign exchange earnings are determined by the gross freight revenues and the incidence of transport cost. The latter is the proportion of the transport cost (freight rates) of the commodities shipped, which is carried by the developing country. As the incidence of transport costs is a very important parameter in the model, it will be discussed at the end of this paragraph. In the model it is assumed that the incidence of transport cost is 70%.

The foreign exchange expenditures from the operation of the ship are estimated to be:

. 50 % of the agency commissions
. 70 % of the stevedoring costs and cargo claims
. 90 % of the operating cost of the ship
. 100 % of the Suez Canal charges, bunkers, and port charges (port charges have to be paid by the ship in foreign ports, but the domestic port will loose the foreign exchange from foreign ships, which are substituted by the national ship).

. documentor listing

```
FEBT.K=FEBT.J+DT*FEB.JK
FEBT=-PPS
    FEBT    - FOREIGN EXCHANGE BALANCE TOTAL  ƒ
    FEB     - FOREIGN EXCHANGE BALANCE  ƒ/QUARTER
    PPS     - PURCHASE PRICE SHIP ƒ

FEB.KL=CLIP((FEEA.K-FEEX.K),0,TIME.K,DT)
    FEB     - FOREIGN EXCHANGE BALANCE  ƒ/QUARTER
    FEEA    - FOREIGN EXCHANGE EARNINGS  ƒ/QUARTER
    FEEX    - FOREIGN EXCHANGE EXPENDITURES  ƒ/QUARTER

FEEA.K=(GR.K*ITC*OD)/RT
ITC=.7
    FEEA    - FOREIGN EXCHANGE EARNINGS  ƒ/QUARTER
    GR      - GROSS REVENUE/SHIP/ROUNDTRIP  ƒ
    ITC     - INCIDENCE OF TRANSPORT COST  %
    OD      - OPERATING DAYS OF SHIP   DAYS/QUARTER
    RT      - ROUNDTRIP TIME   DAYS

FEEX.K=(OD/RT)*(PC+B+.7*SC.K+.7*CC.K+.5*AC.K+SCC.K)
  +.9*OC
    FEEX    - FOREIGN EXCHANGE EXPENDITURES  ƒ/QUARTER
    OD      - OPERATING DAYS OF SHIP   DAYS/QUARTER
    RT      - ROUNDTRIP TIME   DAYS
    PC      - PORT CHARGES /SHIP/ROUNDTRIP  ƒ
    B       - BUNKERS/SHIP/ROUNDTRIP  ƒ
    SC      - STEVEDORING COST/SHIP/ROUNDTRIP  ƒ
    CC      - CARGO CLAIMS/SHIP/ROUNDTRIP  ƒ
    AC      - AGENCY COMMISIONS/SHIP/ROUNDTRIP  ƒ
    SCC     - SUEZ CANAL CHARGES/SHIP/ROUNDTRIP  ƒ
    OC      - OPERATING COST OF SHIP  ƒ/QUARTER
```

++ <u>The incidence of transport costs</u>

source: UNCTAD - Freight markets and the level and structure of freight rates; E.69.II.D.13, Chapter VII [14)]

The term 'incidence' refers to the question who bears the transport cost in a trading transaction. The party which pays for the transport does not necessarily bear the transport cost. The question who pays is one of a formal arrangement between buyer and seller. The question who bears the transport cost, or where the incidence of the cost lies, depends upon the elasticities of demand and supply.

In discussing the incidence of transport costs as expressed in the freight rates (transport prices) paid, one is concerned with the level of costs ruling at any time and the way in which their final impact is felt on the f.o.b. or the c.i.f. price respectively. Clearly, the difference between the f.o.b. and the c.i.f. price is always equal to the transport costs, if they embrace all the costs, including insurance, involved in transporting the goods from seller to buyer. The incidence of these costs is given by the relation between c.i.f. and f.o.b. prices and the price which would rule without transport costs. Both the level of transport costs and how they are determined are completely independent of their incidence.

Transport costs are paid by the shipper, i.e, the exporter for the goods shipped c.i.f., and the importer for goods shipped f.o.b. The person who makes the freight payment to the shipping line is not, however, necessarily the person who bears the freight cost. Other things being equal, and at the simplest level, the exporter will be regarded as bearing the transport cost if the price of the goods in the selling market is unaffected by the level of transport costs, so that the receipts of the producer are reduced by those costs below the price ruling in the export market (see figure 1). Similarly, the importer will be regarded as bearing the cost of transport if the price of the commodity would be the same in the export market, irrespective of the level of transport costs; and so the price in the import market is equal to the f.o.b. price plus the cost of transport (see figure 2) The important point here is to identify the factors which determine whether the importer or the exporter bears the cost of transport, apart from the question who actually pays the carrier.

Figure 1: Incidence of freight rates where supply is completely inelastic with respect to price

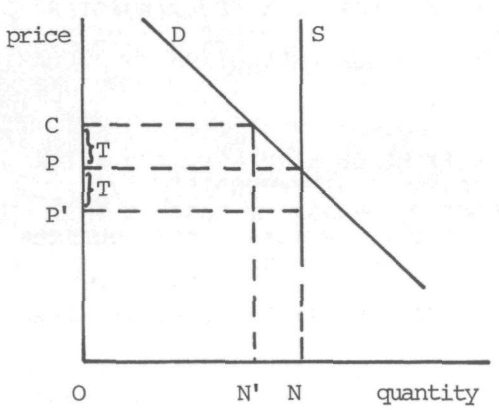


Figure 2: Incidence of freight rates where demand is completely inelastic with respect to price

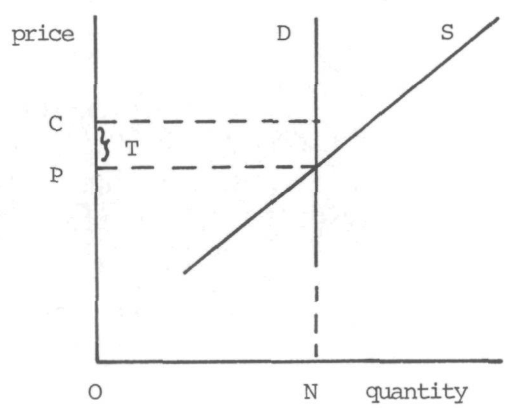


Figure 1. The quantity to be supplied is fixed in the short run at ON. From the diagram it can be seen that if there were no transport costs, the quantity ON would be sold at a price of OP. If transport costs are now introduced, it is clear that they will have no effect on the price. Suppose transport costs are T per unit and an attempt is made to add these to the price by raising it from OP to OC. Then demand would fall to ON', but since supply would remain at ON, there would be no equilibrium. Price would fall back to OP. This would be the c.i.f. price. The f.o.b. price to the supplier would then be OP', where PP' = T. In other words, the supplier bears the whole of the freight cost.

Figure 2. The quantity demanded at all prices is ON. The price at which ON will be supplied is OP and, in the absence of transport costs, this is the price which will rule in the market. If transport costs of T per unit are now introduced, the addition of these to the market price by raising it from OP to OC will not affect the quantity demanded. In this situation, OP becomes the f.o.b. price and OC the c.i.f. price, with the purchaser bearing the whole of the transport cost.

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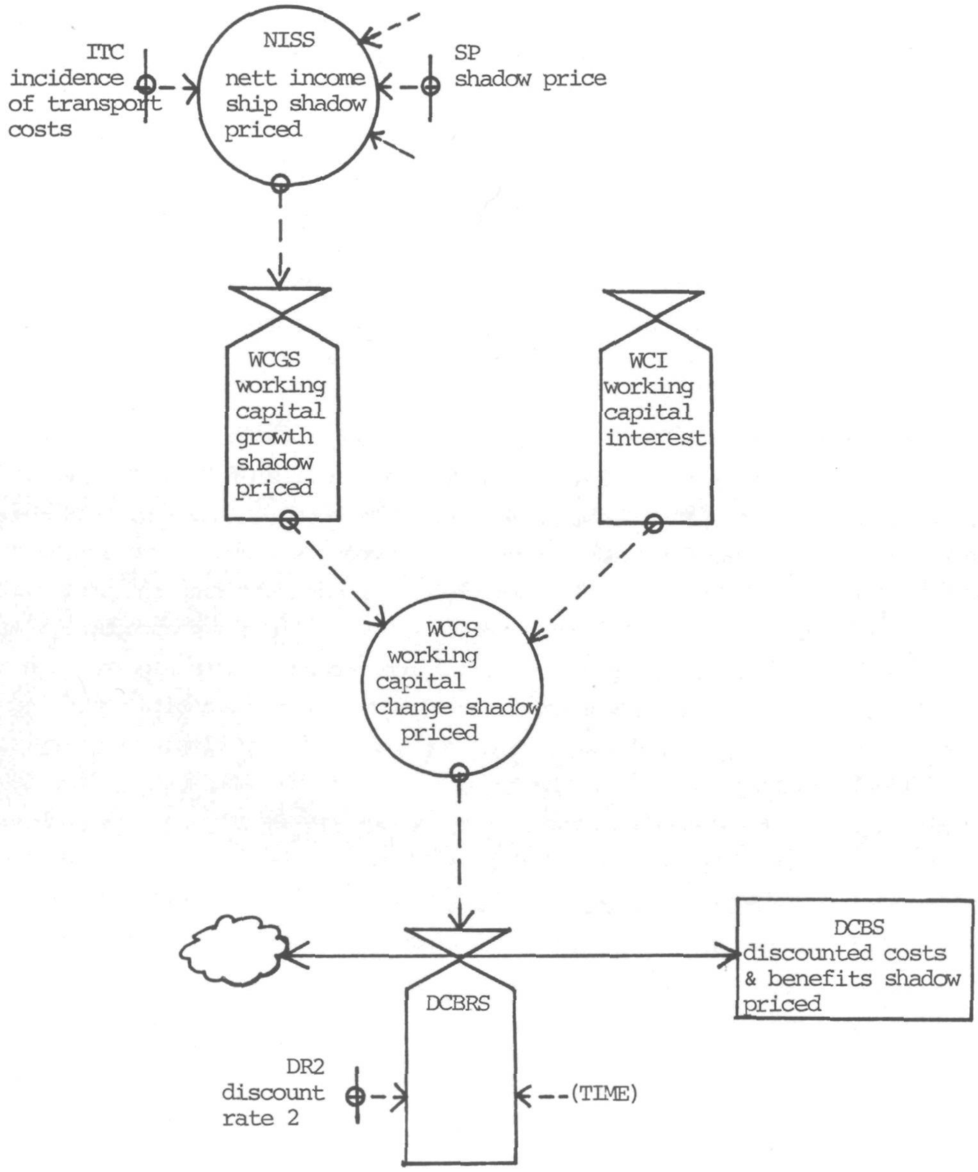
In practice, complete inelasticity of supply or of demand is most unusual, and these extreme or limiting cases are useful only to indicate tendencies. In practice, the freight cost will be shared between seller and buyer, the precise extent of the sharing depending on the relevant elasticities of demand and supply.

For many of the world's agricultural products, on which developing countries rely for much of their export earnings, supply elasticities are low in the short run because the supply is mainly determined by the ammount sown, itself likely to be heavily influenced by prices in the previous crop year and by weather and other conditions which determine the yield per hectare. Although overall demand elasticities for most of these commodities are also low, the elasticity of demand facing the individual supplier or the whole group of suppliers in a single country is likely to be relatively high unless that country is the only source of supply and there is no ready substitute for the commodity. Most primary commodities are produced from a number of sources or there are substitutes for them, the growing range of synthetics being particularly important in this respect. The supplier in these cases therefore normally bears the bulk of the transport costs and any increase in these costs is matched by an almost equal decline in his nett receipts per unit sold; in other words, an increase in transport costs, other things remaining equal, has more effect on lowering f.o.b. prices than on raising c.i.f. prices.

Although the elasticities of demand for many manufactured products tend to be relatively high in developing countries, they remain lower than the elasticities of their supply to the countries concerned. Thus the major part of the freight rates is borne by the importers and, compared with the 'no transport cost' price, the landed price of the products increases more than the ex-works price is reduced. Relatively elastic supplies are typical in manufacturing industries since, in the short run, costs per unit do not normally vary greatly as output levels change over a wide range of output. In developing countries, the demand for manufactured products has a high price elasticity in the consumer goods range, but normally a low price elasticity in the capital goods range, since these are necessary for development. However, since any individual developing country normally accounts for a relatively small proportion of the total market of any manufacturer in a developed country, the supply elasticity of these goods to the developing country is usually very much higher than the demand elasticity. It might be expected that the fact that buyers in these countries are able to choose between the products of a large number of different manufacturers in developed countries would give the products of each individual producer high elasticity of demand in the market. In practice, however, the position is less favourable. Because the overall market is relatively small, it is generally uneconomic for a large number of manufacturers to establish distribution channels in each developing country. The result is that once one or two manufacturers have established export connections in a particular developing country, it ceases to be economical for other manufacturers of simular products to enter the market in competition. The result is that the demand for the product of any individual manufacturer is, in its elasticity, very close to the entire demand for the product.

c. <u>shadow priced discounted costs and benefits</u>

The figure below is the dynamo-flow diagram of the shadow priced discounted costs and benefits calculation. All the foreign exchange elements in the costs and benefits have been multiplied by the shadow price of 1.3. The equations are a combination of the ones mentioned under a. and b.



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```
DCBS.K=DCBS.J+DT*DCBRS.JK
DCBS=-SP*PPS
SP=1.3
    DCBS    - DISCOUNTED COSTS AND BENEFITS SHADOW PRICED
              ƒ
    DCBRS   - DCB-RATE SHADOW PRICED   ƒ/QUARTER
    SP      - SHADOW PRICE   DIM'LESS
    PPS     - PURCHASE PRICE SHIP ƒ

DCBRS.KL=(WCCS.K/(EXP(TIME.K*LOGN(1+DR2))))
DR2=.04
    DCBRS   - DCB-RATE SHADOW PRICED   ƒ/QUARTER
    WCCS    - WORKING CAPITAL CHANGE SHADOW PRICED  ƒ
    EXP     - DYNAMO FUNCTION - SEE MANUAL
    DR2     - DISCOUNT RATE 2 %
```

```
WCCS.K=WCGS.JK+WCI.JK
   WCCS    - WORKING CAPITAL CHANGE SHADOW PRICED  ƒ
   WCGS    - WORKING CAPITAL GROWTH SHADOW PRICED  ƒ
   WCI     - WORKING CAPITAL INTEREST  ƒ/QUARTER

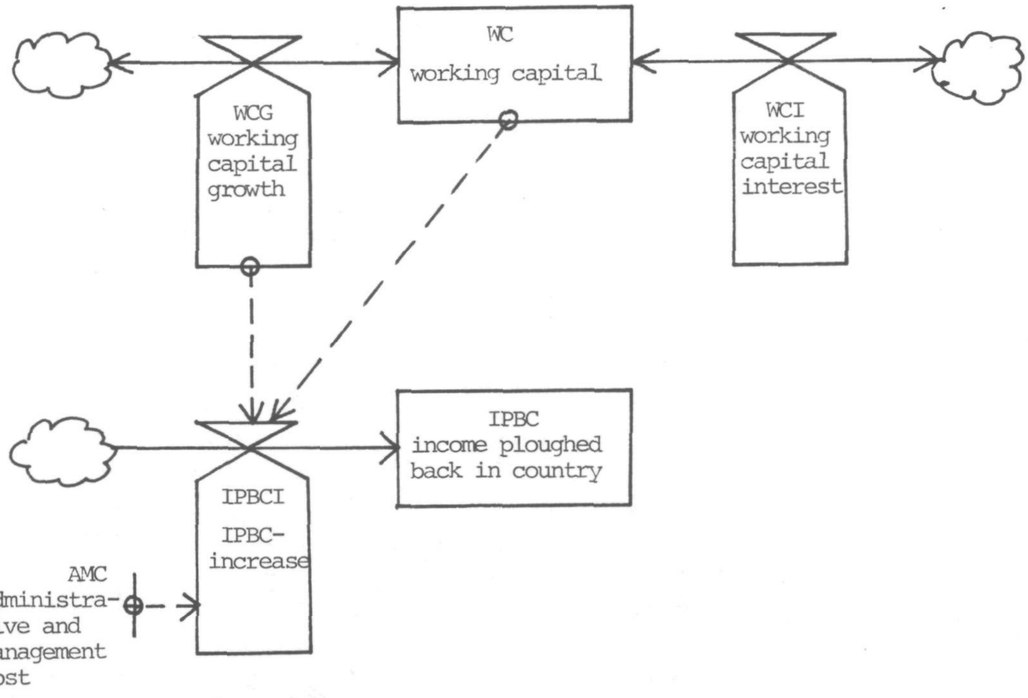
WCGS.KL=CLIP(NISS.K,0,TIME.K,DT)
   WCGS    - WORKING CAPITAL GROWTH SHADOW PRICED  ƒ
   NISS    - NETT INCOME/SHIP SHADOW PRICED   ƒ

NISS.K=(((SP*(GR.K*ITC-B-PC-.5*AC.K-.7*CC.K-.7*
  SC.K-SCC.K)+(1-ITC)*GR.K-.5*AC.K-.3*CC.K-.3*SC.K)
  *OD)/RT)-(SP*.9+.1)*OC
   NISS    - NETT INCOME/SHIP SHADOW PRICED   ƒ
   SP      - SHADOW PRICE  DIM'LESS
   GR      - GROSS REVENUE/SHIP/ROUNDTRIP  ƒ
   ITC     - INCIDENCE OF TRANSPORT COST  %
   B       - BUNKERS/SHIP/ROUNDTRIP  ƒ
   PC      - PORT CHARGES /SHIP/ROUNDTRIP  ƒ
   AC      - AGENCY COMMISIONS/SHIP/ROUNDTRIP  ƒ
   CC      - CARGO CLAIMS/SHIP/ROUNDTRIP  ƒ
   SC      - STEVEDORING COST/SHIP/ROUNDTRIP  ƒ
   SCC     - SUEZ CANAL CHARGES/SHIP/ROUNDTRIP  ƒ
   OD      - OPERATING DAYS OF SHIP   DAYS/QUARTER
   RT      - ROUNDTRIP TIME    DAYS
   OC      - OPERATING COST OF SHIP  ƒ/QUARTER
```

d. <u>income ploughed back in country</u>

There are two types of impacts from the establishment and operation of the national shipping line:
1. expenditures in the country which would not have taken place without the national shipping line;
The expenditures which are grouped under the headings ' stevedoring costs, agency commissions, cargo claims, bunkers, and port charges' will also be made in the case where the national cargo is carried by foreign shipping lines. There is no difference in the with and without situation.
Approximately 25% of the operating cost of the ship consists of wages of the crew. As the country has no adequate personnel to man the ship, it has to hire expatriates for the officer jobs. It is estimated that therefore only 10% will be spent in the country. This expenditure is probably of the same magnitude as the expenditures in the national port by the foreign sailors on ships which are now substituted by national ships. The difference between the with and without situation is so small that it is ignored.
Consequently, only the administrative and management cost are expenditures which would not have taken place without a national shipping line.
2. investment of the profits of the national shipping line in the country;
More important than the direct expenditures from the operation of the fleet, are the profits of the national shipping line which are ploughed back into the economy of the country.
When the shipping line is established, the working capital is borrowed on the local capital market. Up to the moment that all this money is repaid, the contribution of the shipping line to the economy is not spectacular, as it is quite likely that there are many investment opportunities in the country that can repay an interest of 12%/year over the borrowed sum. When all the local capital is paid back, the profits of the line are income that would not have been generated without the national shipping line.

The model calculates the administrative and management cost and the nett profits which are ploughed back into the economy over the time-horizon of the project. The dynamo-flow diagram of the calculation is presented on the following page.



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```
IPBC.K=IPBC.J+DT*IPBCI.JK
IPBC=0
    IPBC    - INCOME PLOUGHED BACK IN COUNTRY  $
    IPBCI   - IPBC-INCREASE  $/QUARTER

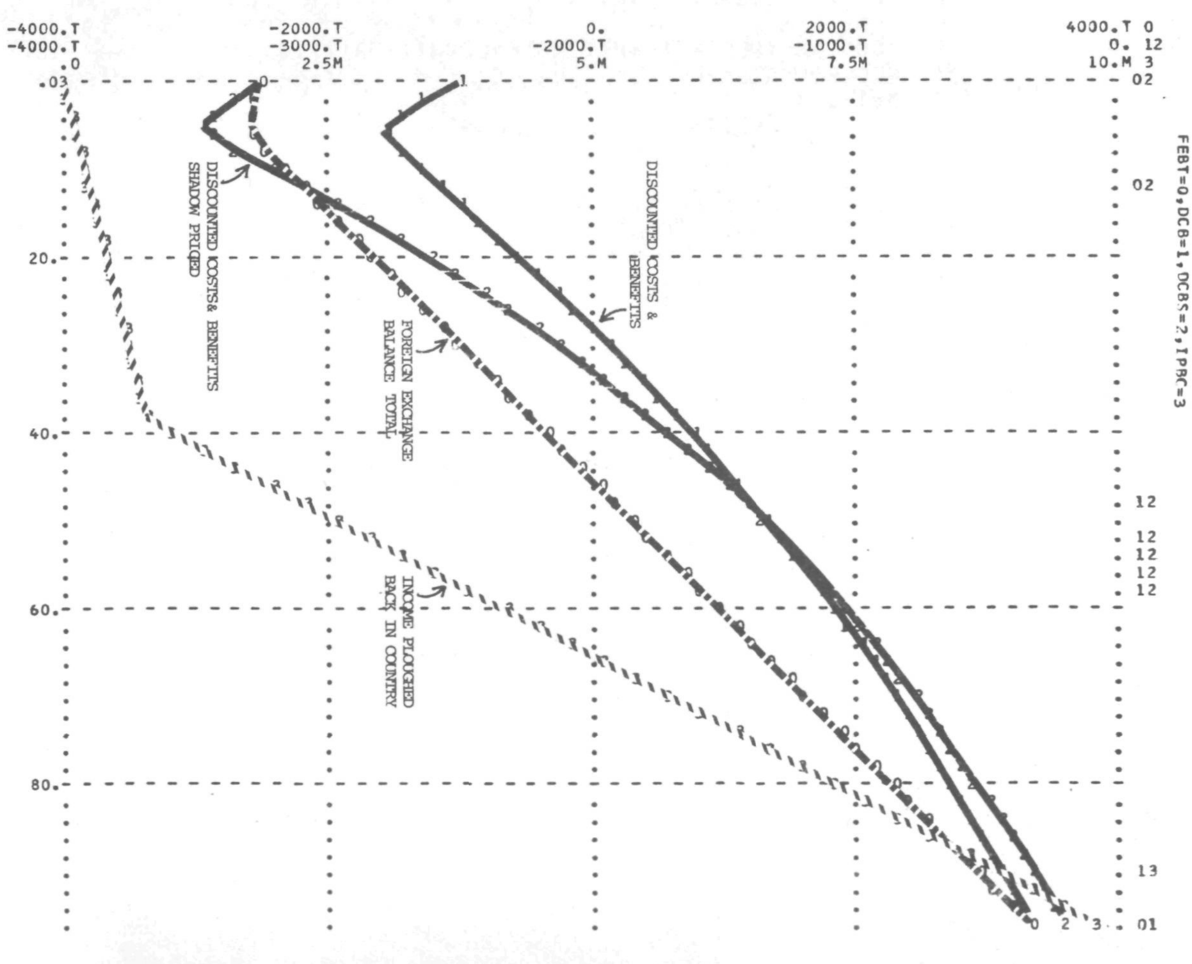
IPBCI.KL=CLIP(WCG.JK,0,WC.K,0)+AMC
    IPBCI   - IPBC-INCREASE  $/QUARTER
    WCG     - WORKING CAPITAL GROWTH   $/QUARTER
    WC      - WORKING CAPITAL  $
    AMC     - ADMINISTRATIVE & MANAGEMENT COST   $/
                  QUARTER
```

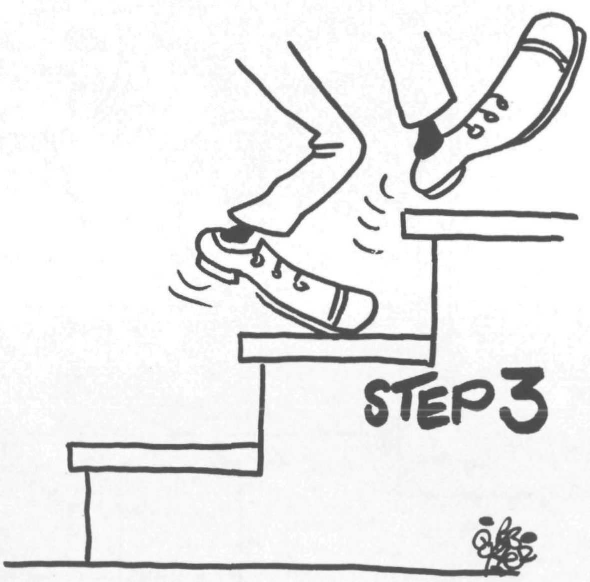
```
*  MODEL 6 - 1 SHIP WITH DECISION CRITERIA
NOTE   NETT INCOME/SHIP/QUARTER
A   ET.K=LC*LFE.K
C   LC=14000
A   LFE.K=TABLE(LFET,TIME.K,0,96,8)
T   LFET=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A   IT.K=LC*LFI.K
A   LFI.K=TABLE(LFIT,TIME.K,0,96,8)
T   LFIT=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A   GRE.K=ET.K*FRE
C   FRE=25
A   GRI.K=IT.K*FRI
C   FRI=35
A   GR.K=GRE.K+GRI.K
A   AC.K=GR.K*ACS
C   ACS=.055
A   SC.K=(ET.K+IT.K)*SCT
C   SCT=6.25
A   CC.K=(ET.K+IT.K)*CCT
C   CCT=.4
A   SCC.K=(ET.K+IT.K)*SCCT
C   SCCT=1
C   B=58000
C   PC=45000
A   VE.K=AC.K+SC.K+CC.K+SCC.K+B+PC
A   NIS.K=(((GR.K-VE.K)*OD)/RT)-OC-AMC
C   OD=87.5
C   RT=118
C   OC=110000
C   AMC=20000
NOTE   WORKING CAPITAL
L   WC.K=WC.J+DT*(WCG.JK+WCI.JK)
N   WC=-PPS
C   PPS=2.5E6
R   WCG.KL=CLIP(NIS.K,0,TIME.K,DT)
R   WCI.KL=CLIP((WC.K*IR),0,TIME.K,DT)
C   IR=.03
NOTE   DECISION CRITERIA
NOTE   -1- DISCOUNTED COSTS AND BENEFITS
L   DCB.K=DCB.J+DT*DCBR.JK
N   DCB=-PPS
R   DCBR.KL=(WCC.K/(EXP(TIME.K*LOGN(1+DR1))))
A   WCC.K=WCG.JK+WCI.JK
C   DR1=.04
NOTE   -2- FOREIGN EXCHANGE BALANCE
L   FEBT.K=FEBT.J+DT*FEB.JK
N   FEBT=-PPS
R   FEB.KL=CLIP((FEEA.K-FEEX.K),0,TIME.K,DT)
A   FEEA.K=(GR.K*ITC*OD)/RT
C   ITC=.7
A   FEEX.K=(OD/RT)*(PC+B+.7*SC.K+.7*CC.K+.5*AC.K+SCC.K)+.9*OC
NOTE   -3- SHADOW PRICED DISCOUNTED COSTS AND BENEFITS
L   DCBS.K=DCBS.J+DT*DCBRS.JK
N   DCBS=-SP*PPS
C   SP=1.3
R   DCBRS.KL=(WCCS.K/(EXP(TIME.K*LOGN(1+DR2))))
C   DR2=.04
A   WCCS.K=WCGS.JK+WCI.JK
```

```
R   WCGS.KL=CLIP(NISS.K,0,TIME.K,DT)
A   NISS.K=(((SP*(GR.K*ITC-B-PC-.5*AC.K-.7*CC.K-.7*SC.K-SCC.K)+
X   (1-ITC)*GR.K-.5*AC.K-.3*CC.K-.3*SC.K)*OD)/RT)-(SP*.9+.1)*OC
NOTE   -4- INCOME PLOUGHED BACK IN COUNTRY
L   IPBC.K=IPBC.J+DT*IPBCI.JK
N   IPBC=0
R   IPBCI.KL=CLIP(WCG.JK,0,WC.K,0)+AMC
SPEC   LENGTH=96/DT=.25/PRTPER=2/PLTPER=2
PRINT   WC,WCG,WCI,FEBT,DCB,DCBS,IPBC
PLOT   WC/WCG/WCI
PLOT   FEBT/DCB,DCBS/IPBC
RUN
```

MODEL 6 - 1 SHIP WITH DECISION CRITERIA

TIME E+00	WC E+06	WCG E+03	WCI E+03	FEBT E+03	DCB E+03	DCBS E+03	IPBC E+03
.0	-2.500	.00	.00	-2500.0	-2500.0	-3250.0	.0
2.	-2.658	8.52	-79.73	-2569.5	-2633.0	-3372.2	40.0
4.	-2.766	51.50	-82.97	-2592.4	-2738.8	-3450.5	80.0
6.	-2.792	94.47	-83.77	-2555.0	-2769.7	-3441.1	120.0
8.	-2.732	137.45	-81.96	-2457.3	-2732.7	-3353.0	160.0
10.	-2.618	137.45	-78.54	-2325.7	-2653.8	-3218.2	200.0
12.	-2.497	137.45	-74.92	-2194.1	-2575.5	-3087.9	240.0
14.	-2.369	137.45	-71.06	-2062.5	-2498.5	-2963.0	280.0
16.	-2.232	137.45	-66.97	-1930.9	-2423.0	-2843.2	320.0
18.	-2.088	137.45	-62.63	-1799.3	-2349.0	-2728.1	360.0
20.	-1.934	137.45	-58.02	-1667.7	-2276.2	-2617.4	400.0
22.	-1.771	137.45	-53.13	-1536.0	-2204.8	-2511.0	440.0
24.	-1.598	137.45	-47.94	-1404.4	-2134.8	-2408.5	480.0
26.	-1.414	137.45	-42.42	-1272.8	-2066.0	-2309.8	520.0
28.	-1.219	137.45	-36.57	-1141.2	-1998.5	-2214.6	560.0
30.	-1.012	137.45	-30.35	-1009.6	-1932.3	-2122.7	600.0
32.	-.792	137.45	-23.76	-878.0	-1867.3	-2034.0	640.0
34.	-.558	137.45	-16.75	-746.4	-1803.4	-1948.3	680.0
36.	-.311	137.45	-9.32	-614.8	-1740.8	-1865.4	720.0
38.	-.047	137.45	-1.42	-483.2	-1679.3	-1785.2	760.0
40.	.232	137.45	6.96	-351.6	-1619.0	-1707.5	1006.2
42.	.528	137.45	15.85	-220.0	-1559.7	-1632.3	1321.1
44.	.843	137.45	25.29	-88.4	-1501.6	-1559.4	1636.0
46.	1.177	137.45	35.32	43.2	-1444.5	-1488.6	1950.9
48.	1.532	137.45	45.96	174.8	-1388.5	-1420.0	2265.8
50.	1.909	137.45	57.26	306.4	-1333.6	-1353.3	2580.7
52.	2.308	137.45	69.25	438.0	-1279.6	-1288.6	2895.6
54.	2.733	137.45	81.99	569.6	-1226.7	-1225.6	3210.5
56.	3.183	137.45	95.50	701.3	-1174.7	-1164.4	3525.4
58.	3.662	137.45	109.85	832.9	-1123.7	-1104.9	3840.3
60.	4.170	137.45	125.09	964.5	-1073.6	-1046.9	4155.2
62.	4.709	137.45	141.26	1096.1	-1024.5	-990.4	4470.1
64.	5.281	137.45	158.43	1227.7	-976.2	-935.5	4785.0
66.	5.888	137.45	176.65	1359.3	-928.9	-881.9	5099.9
68.	6.533	137.45	196.00	1490.9	-882.4	-829.6	5414.8
70.	7.218	137.45	216.54	1622.5	-836.8	-778.7	5729.7
72.	7.945	137.45	238.35	1754.1	-792.1	-729.0	6044.6
74.	8.717	137.45	261.50	1885.7	-748.1	-680.5	6359.5
76.	9.536	137.45	286.07	2017.3	-705.0	-633.2	6674.5
78.	10.405	137.45	312.16	2148.9	-662.7	-586.9	6989.4
80.	11.329	137.45	339.86	2280.5	-621.1	-541.8	7304.3
82.	12.309	137.45	369.26	2412.1	-580.4	-497.7	7619.2
84.	13.349	137.45	400.47	2543.7	-540.3	-454.6	7934.1
86.	14.454	137.45	433.61	2675.3	-501.1	-412.5	8249.0
88.	15.626	137.45	468.78	2806.9	-462.5	-371.3	8563.9
90.	16.871	137.45	506.13	2938.5	-424.7	-331.0	8878.8
92.	18.192	137.45	545.77	3070.1	-387.5	-291.6	9193.7
94.	19.595	137.45	587.85	3201.7	-351.1	-253.1	9508.6
96.	21.084	137.45	632.53	3333.3	-315.3	-215.4	9823.5

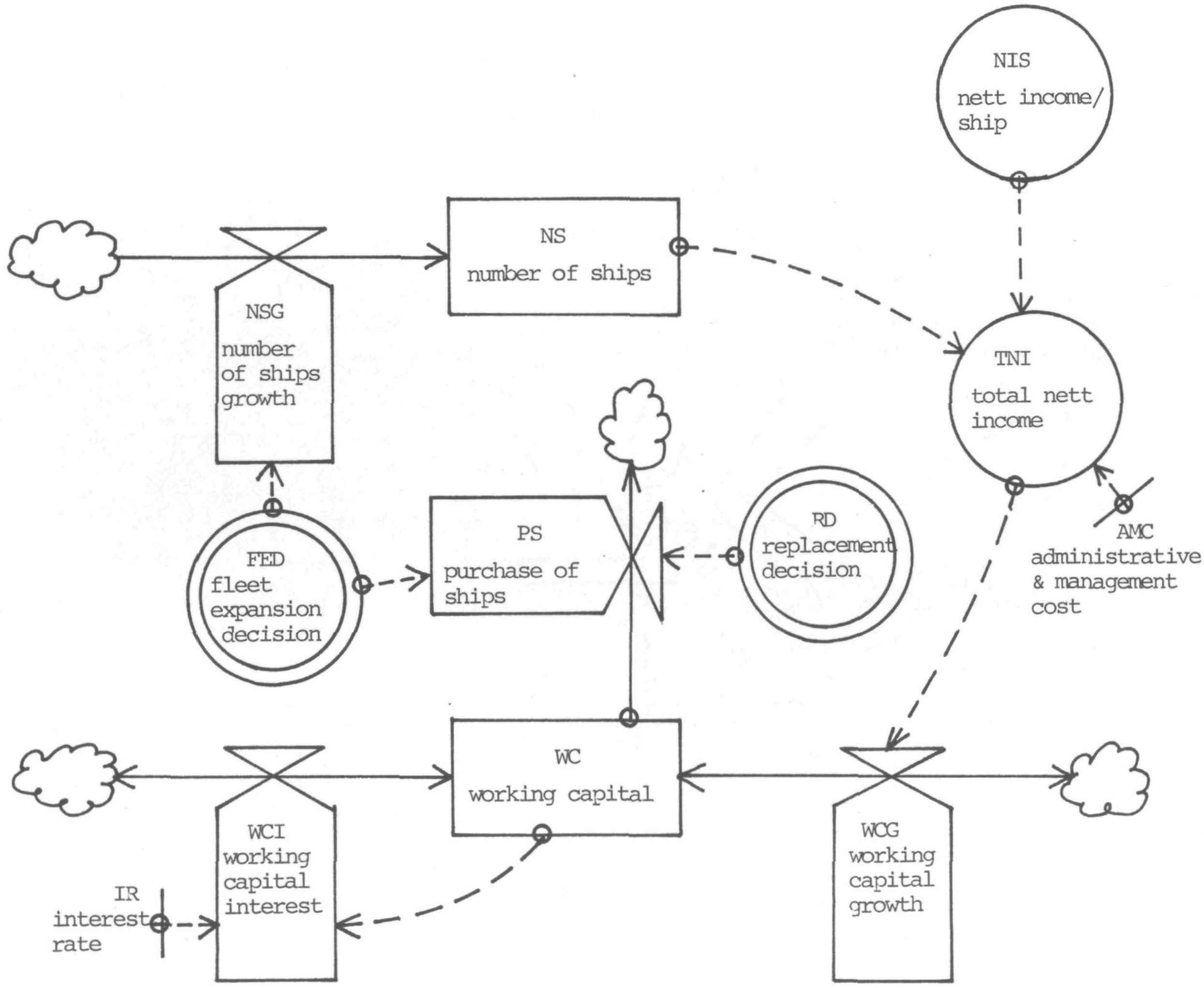



STEP 3

Chapter 5 - STEP 3: CASH FLOW MODELS OF 6 SHIPS

5.1 MODEL 7 - CASH FLOW MODEL OF 6 SHIPS

The only difference with the assumptions of model 1 is that instead of one ship 6 ships are purchased and brought into service. This number corresponds with the cargo potential of the national shipping line, given the existing seaborne trade flows through the national port to and from NW-Europe. In model 14 the number of ships will be determined endogenously within the model.
The ships are all identical with the standard ship of model 1. Each ship is purchased second-hand at intervals of one quarter. All ships must be replaced after 16 years (remaining lifetime at the moment of purchase). The replacement ships are also identical with the standard ship. The scrap value of the old ships is not anymore used in the calculations of the following models.
The figure below shows the dynamo-flow diagram of the part of the model that differs from model 1.



The number of ships increases through the fleet expansion decision. The total nett income of the shipping line depends on the number of ships, the nett income per ship and the administrative and management cost.
The working capital increases if the total nett income shows a surplus; it decreases when ships are purchased; it increases or decreases as a result of interest payments on the working capital.

. documentor listing of the relevant equations

```
NS.K=NS.J+DT*NSG.JK
NS=1
     NS        - NUMBER OF SHIPS
     NSG       - NUMBER OF SHIPS GROWTHRATE

NSG.KL=FED.K/DT
     NSG       - NUMBER OF SHIPS GROWTHRATE
     FED       - FLEET EXPANSION DECISION

FED.K=CLIP(0,PULSE(1,1,1),TIME.K,6)
     FED       - FLEET EXPANSION DECISION


TNI.K=NS.K*NIS.K-AMC
AMC=94000
     TNI       - TOTAL NETT INCOME      ƒ/QUARTER
     NS        - NUMBER OF SHIPS
     NIS       - NETT INCOME SHIP     ƒ/QUARTER
     AMC       - ADMINISTRATIVE ƒ MANAGEMENT COST    ƒ/
                   QUARTER


WC.K=WC.J+DT*(WCG.JK+WCI.JK-(PS.JK/DT)-PRS.JK/DT)
WC=-PPS
     WC        - WORKING CAPITAL  ƒ
     WCG       - WORKING CAPITAL GROWTH    ƒ/QUARTER
     WCI       - WORKING CAPITAL INTEREST  ƒ/QUARTER
     PS        - PURCHASE OF SHIPS   ƒ
     PRS       - PURCHASE REPLACEMENT SHIPS   ƒ
     PPS       - PURCHASE PRICE SHIP ƒ

PS.KL=FED.K*PPS
     PS        - PURCHASE OF SHIPS   ƒ
     FED       - FLEET EXPANSION DECISION
     PPS       - PURCHASE PRICE SHIP ƒ

PRS.KL=RD.K*PPS
     PRS       - PURCHASE REPLACEMENT SHIPS   ƒ
     RD        - REPLACEMENT DECISION
     PPS       - PURCHASE PRICE SHIP ƒ

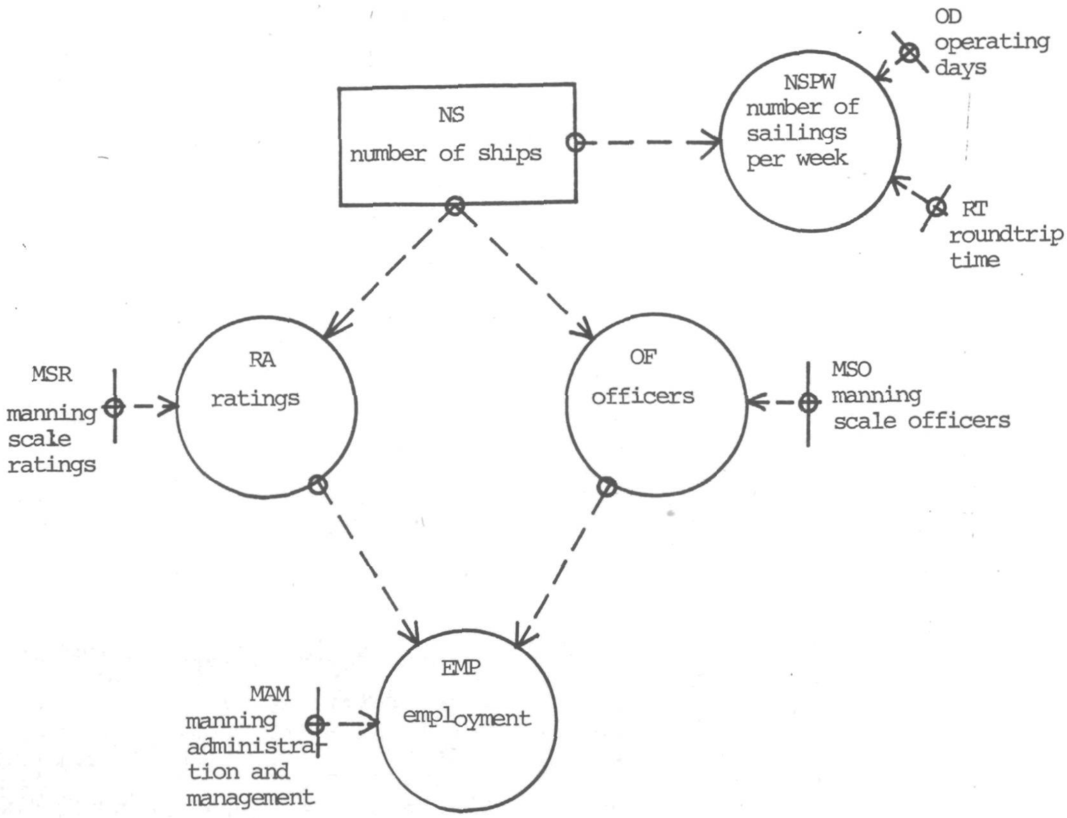
RD.K=CLIP(0,PULSE(1,64,1),TIME.K,70)
PPS=2.5E6
     RD        - REPLACEMENT DECISION
     PPS       - PURCHASE PRICE SHIP ƒ
```

Model 7 contains two more decision criteria: employment of the shipping line, and the number of sailings per week.

A shipping line creates employment opportunities on board the ships, and through its land organisation. The crew of one ship consists of 18 officers and 22 ratings. The land organisation consists of 50 people.

The number of sailings per week is an important indicator for the service level that the national shipping line can offer to its shippers.

The dynamo-flow diagram of both calculations is presented on the following page.



. documentor listing

```
EMP.K=RA.K+OF.K+MAM
     EMP     - EMPLOYMENT OF SHIPPING LINE
     RA      - RATINGS
     OF      - OFFICERS
     MAM     - MANNING ADMINISTRATION & MANAGEMENT

RA.K=NS.K*MSR
MSR=22
     RA      - RATINGS
     NS      - NUMBER OF SHIPS
     MSR     - MANNING SCALE RATINGS

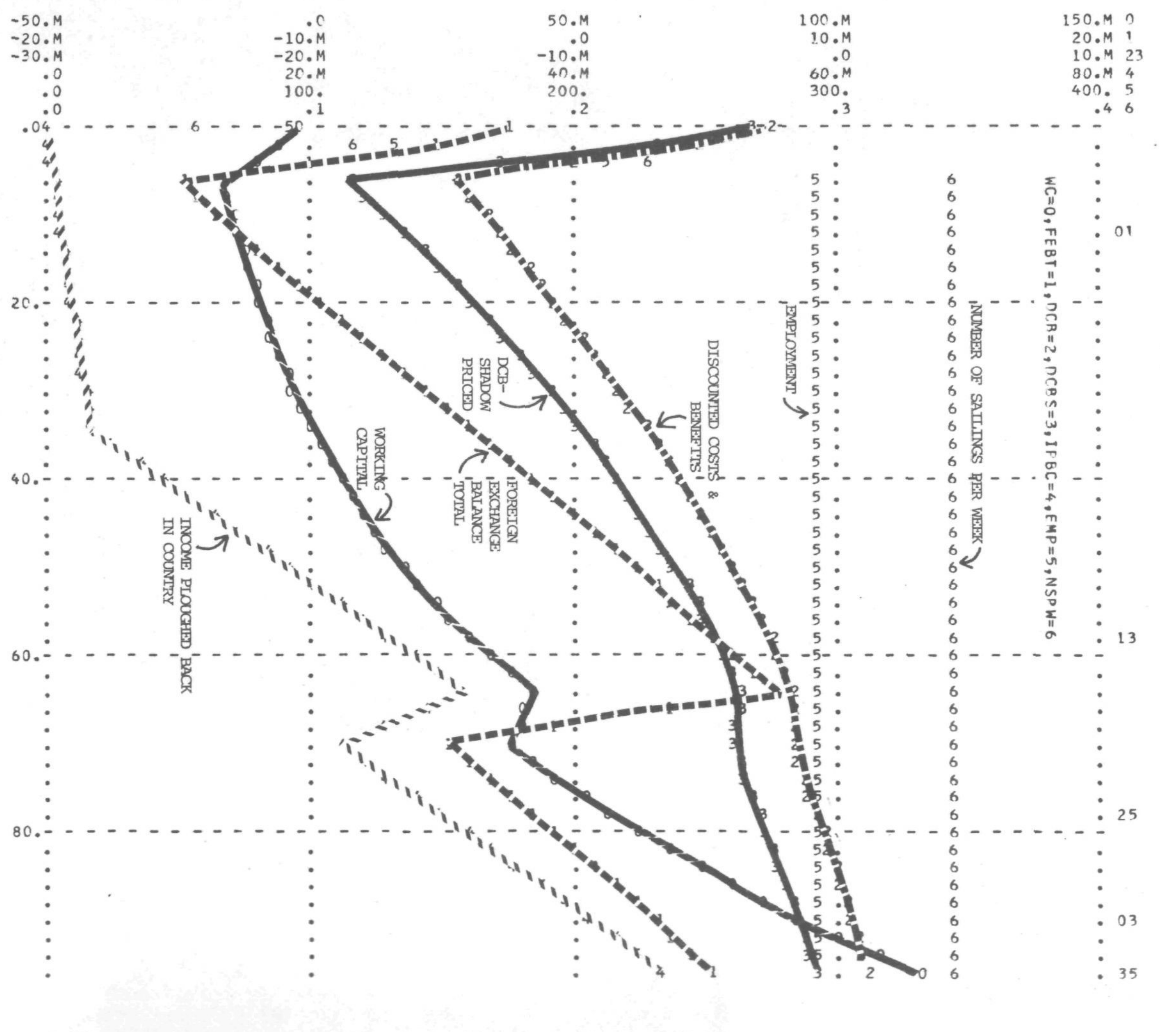
OF.K=NS.K*MSO
MSO=18
MAM=50
     OF      - OFFICERS
     NS      - NUMBER OF SHIPS
     MSO     - MANNING SCALE OFFICERS
     MAM     - MANNING ADMINISTRATION & MANAGEMENT

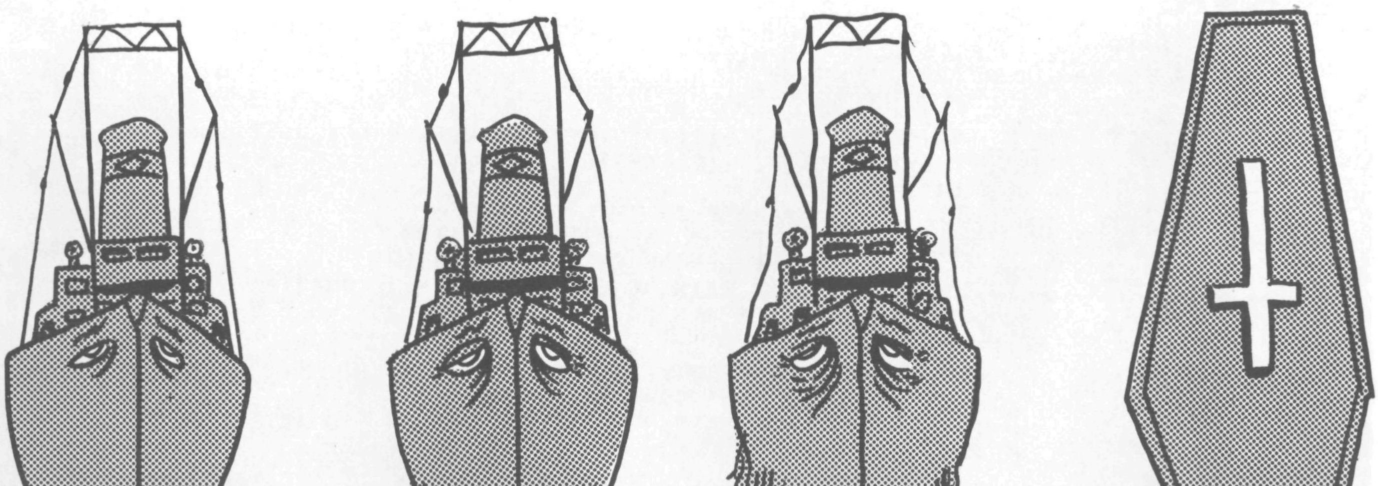
NSPW.K=(NS.K*OD/RT)/13
     NSPW    - NUMBER OF SAILINGS PER WEEK
     NS      - NUMBER OF SHIPS
     OD      - OPERATING DAYS OF SHIP    DAYS/QUARTER
     RT      - ROUNDTRIP TIME    DAYS
```

```
*  MODEL 7 - CASH FLOW MODEL OF 6 SHIPS
NOTE  NUMBER OF SHIPS IN FLEET
L   NS.K=NS.J+DT*NSG.JK
N   NS=1
R   NSG.KL=FED.K/DT
A   FED.K=CLIP(0,PULSE(1,1,1),TIME.K,6)
NOTE  NETT INCOME/SHIP/QUARTER
A   FT.K=LC*LFE.K
C   LC=14000
A   LFE.K=TABLE(LFET,TIME.K,0,96,8)
T   LFET=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A   IT.K=LC*LFI.K
A   LFI.K=TABLE(LFIT,TIME.K,0,96,8)
T   LFIT=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A   GRE.K=FT.K*FRE
C   FRE=25
A   GRI.K=IT.K*FRI
C   FRI=35
A   GR.K=GRE.K+GRI.K
A   AC.K=GR.K*ACS
C   ACS=.055
A   SC.K=(FT.K+IT.K)*SCT
C   SCT=6.25
A   CC.K=(FT.K+IT.K)*CCT
C   CCT=.4
A   SCC.K=(FT.K+IT.K)*SCCT
C   SCCT=1
C   B=58000
C   PC=45000
A   VE.K=AC.K+SC.K+CC.K+SCC.K+B+PC
A   NIS.K=(((GR.K-VE.K)*OD)/RT)-OC
C   OD=87.5
C   RT=118
C   OC=110000
NOTE  NETT INCOME SHIPPING LINE OPERATIONS
A   TNI.K=NS.K*NIS.K-AMC
C   AMC=94000
NOTE  WORKING CAPITAL
L   WC.K=WC.J+DT*(WCG.JK+WCI.JK-(PS.JK/DT)-PRS.JK/DT)
N   WC=-PPS
R   WCG.KL=CLIP(TNI.K,0,TIME.K,DT)
R   WCI.KL=CLIP((WC.K*IR),0,TIME.K,DT)
C   IR=.03
R   PS.KL=FED.K*PPS
R   PRS.KL=RD.K*PPS
A   RD.K=CLIP(0,PULSE(1,64,1),TIME.K,70)
C   PPS=2.5E6
NOTE  DECISION CRITERIA
NOTE -1- DISCOUNTED COSTS AND BENEFITS
L   DCB.K=DCB.J+DT*DCBR.JK
N   DCB=-PPS
R   DCBR.KL=(WCC.K/(EXP(TIME.K*LOGN(1+DR1))))
A   WCC.K=WCG.JK+WCI.JK-(PS.JK/DT)-PRS.JK/DT
C   DR1=.04
NOTE -2- FOREIGN EXCHANGE BALANCE
L   FEBT.K=FEBT.J+DT*FEB.JK
N   FEBT=-PPS
R   FEB.KL=CLIP((FEEA.K-FEEX.K),0,TIME.K,DT)
A   FEEA.K=(NS.K*GR.K*ITC*OD)/RT
C   ITC=.7
A   FEEX.K=(PS.JK/DT)+(PRS.JK/DT)+((NS.K*OD)/RT)*
X   (PC+B+.5*AC.K+.7*SC.K+.7*CC.K+SCC.K)+NS.K*.9*OC
NOTE -3- SHADOW PRICED DISCOUNTED COSTS AND BENEFITS
L   DCBS.K=DCBS.J+DT*DCBRS.JK
N   DCBS=-SP*PPS
C   SP=1.3
R   DCBRS.KL=(WCCS.K/(EXP(TIME.K*LOGN(1+DR2))))
C   DR2=.04
A   WCCS.K=WCGS.JK+WCI.JK-SP*((PS.JK/DT)+(PRS.JK/DT))
R   WCGS.KL=CLIP(TNIS.K,0,TIME.K,DT)
A   TNIS.K=NISS.K*NS.K-AMC
A   NISS.K=(((SP*(GR.K*ITC-B-PC-.5*AC.K-SCC.K-.7*CC.K-.7*SC.K)+
X   (1-ITC)*GR.K-.5*AC.K-.3*SC.K-.3*CC.K)*OD)/RT)-(SP*.9+.1)*OC
NOTE  -4- INCOME PLOUGHED BACK IN COUNTRY
L   IPBC.K=IPBC.J+DT*(IPBCI.JK-IPBCD.JK)
N   IPBC=0
R   IPBCI.KL=CLIP(WCG.JK,0,WC.K,0)+AMC
R   IPBCD.KL=PRS.JK/DT
NOTE -5- EMPLOYMENT OF SHIPPING LINE
A   EMP.K=RA.K+OF.K+MAM
A   RA.K=NS.K*MSR
C   MSR=22
A   OF.K=NS.K*MSO
C   MSO=18
C   MAM=50
NOTE -6- NUMBER OF SAILINGS PER WEEK
A   NSPW.K=(NS.K*OD/RT)/13
SPEC   LENGTH=96/DT=.25/PRTPER=2/PLTPER=2
PRINT   WC,WCG,WCI,PS,PRS,FEBT,DCB,DCBS,IPBC,EMP,OF
PRINT   RA,NSPW
PLOT   WC/FEBT/DCB,DCBS/IPBC/EMP/NSPW
RUN
```

MODEL 7 - CASH FLOW MODEL OF 6 SHIPS

TIME E+00	WC E+06	WCG E+03	WCI E+03	PS E+03	PRS E+03	FEBT E+06	DCB E+06	DCBS E+06	IPBC E+06	EMP E+00	OF E+00	RA E+00	NSPW E+00
.0	-2.50	.00	.0	.0	.0	-2.500	-2.500	-3.250	.000	90.00	18.00	22.00	.05704
2.	-5.33	-36.97	-160.0	2500.0	.0	-5.094	-5.150	-6.637	.188	130.00	36.00	44.00	.11408
4.	-10.72	191.98	-321.5	2500.0	.0	-10.158	-9.996	-12.851	.376	210.00	72.00	88.00	.22816
6.	-15.78	592.85	-473.3	.0	.0	-14.951	-14.247	-18.309	.564	290.00	108.00	132.00	.34224
8.	-15.30	850.72	-459.1	.0	.0	-14.365	-13.939	-17.877	.752	290.00	108.00	132.00	.34224
10.	-14.50	850.72	-435.0	.0	.0	-13.575	-13.381	-17.153	.940	290.00	108.00	132.00	.34224
12.	-13.64	850.72	-409.3	.0	.0	-12.786	-12.828	-16.445	1.128	290.00	108.00	132.00	.34224
14.	-12.74	850.72	-382.2	.0	.0	-11.996	-12.285	-15.760	1.316	290.00	108.00	132.00	.34224
16.	-11.78	850.72	-353.3	.0	.0	-11.206	-11.753	-15.095	1.504	290.00	108.00	132.00	.34224
18.	-10.75	850.72	-322.6	.0	.0	-10.417	-11.230	-14.449	1.692	290.00	108.00	132.00	.34224
20.	-9.67	850.72	-290.1	.0	.0	-9.627	-10.716	-13.823	1.880	290.00	108.00	132.00	.34224
22.	-8.52	850.72	-255.6	.0	.0	-8.837	-10.213	-13.215	2.068	290.00	108.00	132.00	.34224
24.	-7.30	850.72	-218.9	.0	.0	-8.048	-9.718	-12.624	2.256	290.00	108.00	132.00	.34224
26.	-6.00	850.72	-180.0	.0	.0	-7.258	-9.233	-12.049	2.444	290.00	108.00	132.00	.34224
28.	-4.62	850.72	-138.7	.0	.0	-6.469	-8.756	-11.490	2.632	290.00	108.00	132.00	.34224
30.	-3.16	850.72	-94.8	.0	.0	-5.679	-8.289	-10.946	2.820	290.00	108.00	132.00	.34224
32.	-1.61	850.72	-48.3	.0	.0	-4.889	-7.830	-10.417	3.008	290.00	108.00	132.00	.34224
34.	.04	850.72	1.2	.0	.0	-4.100	-7.380	-9.901	3.196	290.00	108.00	132.00	.34224
36.	1.79	850.72	53.6	.0	.0	-3.310	-6.938	-9.399	5.085	290.00	108.00	132.00	.34224
38.	3.64	850.72	109.3	.0	.0	-2.520	-6.504	-8.909	6.975	290.00	108.00	132.00	.34224
40.	5.62	850.72	168.5	.0	.0	-1.731	-6.078	-8.432	8.864	290.00	108.00	132.00	.34224
42.	7.71	850.72	231.3	.0	.0	-.941	-5.660	-7.966	10.754	290.00	108.00	132.00	.34224
44.	9.93	850.72	297.9	.0	.0	-.151	-5.250	-7.512	12.643	290.00	108.00	132.00	.34224
46.	12.29	850.72	368.7	.0	.0	.638	-4.847	-7.068	14.533	290.00	108.00	132.00	.34224
48.	14.79	850.72	443.8	.0	.0	1.428	-4.452	-6.635	16.422	290.00	108.00	132.00	.34224
50.	17.45	850.72	523.5	.0	.0	2.217	-4.064	-6.212	18.311	290.00	108.00	132.00	.34224
52.	20.27	850.72	608.2	.0	.0	3.007	-3.683	-5.799	20.201	290.00	108.00	132.00	.34224
54.	23.27	850.72	698.0	.0	.0	3.797	-3.309	-5.396	22.090	290.00	108.00	132.00	.34224
56.	26.45	850.72	793.4	.0	.0	4.586	-2.942	-5.002	23.980	290.00	108.00	132.00	.34224
58.	29.82	850.72	894.7	.0	.0	5.376	-2.582	-4.616	25.869	290.00	108.00	132.00	.34224
60.	33.41	850.72	1002.2	.0	.0	6.166	-2.229	-4.239	27.758	290.00	108.00	132.00	.34224
62.	37.21	850.72	1116.4	.0	.0	6.955	-1.882	-3.871	29.648	290.00	108.00	132.00	.34224
64.	41.25	850.72	1237.5	.0	2500.0	7.745	-1.542	-3.510	31.537	290.00	108.00	132.00	.34224
66.	40.35	850.72	1210.4	.0	2500.0	3.534	-1.614	-3.682	28.427	290.00	108.00	132.00	.34224
68.	39.39	850.72	1181.7	.0	2500.0	-.676	-1.685	-3.845	25.316	290.00	108.00	132.00	.34224
70.	38.37	850.72	1151.1	.0	.0	-4.886	-1.754	-4.000	22.206	290.00	108.00	132.00	.34224
72.	42.48	850.72	1274.4	.0	.0	-4.097	-1.501	-3.732	24.095	290.00	108.00	132.00	.34224
74.	46.84	850.72	1405.3	.0	.0	-3.307	-1.253	-3.470	25.984	290.00	108.00	132.00	.34224
76.	51.48	850.72	1544.3	.0	.0	-2.517	-1.009	-3.214	27.874	290.00	108.00	132.00	.34224
78.	56.39	850.72	1691.8	.0	.0	-1.728	-.770	-2.963	29.763	290.00	108.00	132.00	.34224
80.	61.61	850.72	1848.4	.0	.0	-.938	-.535	-2.717	31.653	290.00	108.00	132.00	.34224
82.	67.16	850.72	2014.7	.0	.0	-.148	-.304	-2.476	33.542	290.00	108.00	132.00	.34224
84.	73.04	850.72	2191.2	.0	.0	.641	-.078	-2.241	35.431	290.00	108.00	132.00	.34224
86.	79.29	850.72	2378.6	.0	.0	1.431	.144	-2.010	37.321	290.00	108.00	132.00	.34224
88.	85.92	850.72	2577.5	.0	.0	2.220	.362	-1.784	39.210	290.00	108.00	132.00	.34224
90.	92.96	850.72	2788.7	.0	.0	3.010	.576	-1.563	41.100	290.00	108.00	132.00	.34224
92.	100.43	850.72	3012.9	.0	.0	3.800	.786	-1.346	42.989	290.00	108.00	132.00	.34224
94.	108.36	850.72	3250.9	.0	.0	4.589	.993	-1.134	44.878	290.00	108.00	132.00	.34224
96.	116.78	850.72	3503.5	.0	.0	5.379	1.195	-.926	46.768	290.00	108.00	132.00	.34224




1980
1985
1989
1994

5.2 MODEL 8 - CASH FLOW MODEL OF 6 SHIPS OF DIFFERENT AGE

The difference with the assumptions of model 7 is that the ships which are purchased have different ages and prices. Each ship is replaced by an identical ship, in terms of size, price, remaining lifetime at the moment of purchase.

The fleet expansion and replacement mechanism works as follows.

The remaining lifetime of each ship, expressed in quarters, is made a level (S1=ship 1). The fleet expansion decision activates the rates of these levels in sequence. This rate gets a value equal to the remaining lifetime of the ship at the moment of purchase. Every quarter the ageing rate decreases the level with 1 quarter. When the remaining lifetime of the ship has finally reached the value of 1 quarter, the ship must be replaced. In the model this is automatically done as soon as the level S reaches the value 1 quarter. The rate gets at that moment a value equal to the remaining lifetime of the ship that is purchased.

The figure on the following page shows the ageing mechanism of the ships and the working capital sector.

. documentor listing of the relevant equations

```
S1.K=S1.J+DT*((R1.JK/DT)-AR1.JK)
S1=LTS1
LTS1=64
     S1       - REMAINING LIFETIME SHIP 1  QUARTERS
     R1       - RATE 1
     AR1      - AGEING RATE 1
     LTS1     - LIFETIME SHIP 1    QUARTERS

R1.KL=SWITCH(LTS1,0,(S1.K-1))
     R1       - RATE 1
     LTS1     - LIFETIME SHIP 1    QUARTERS
     S1       - REMAINING LIFETIME SHIP 1  QUARTERS

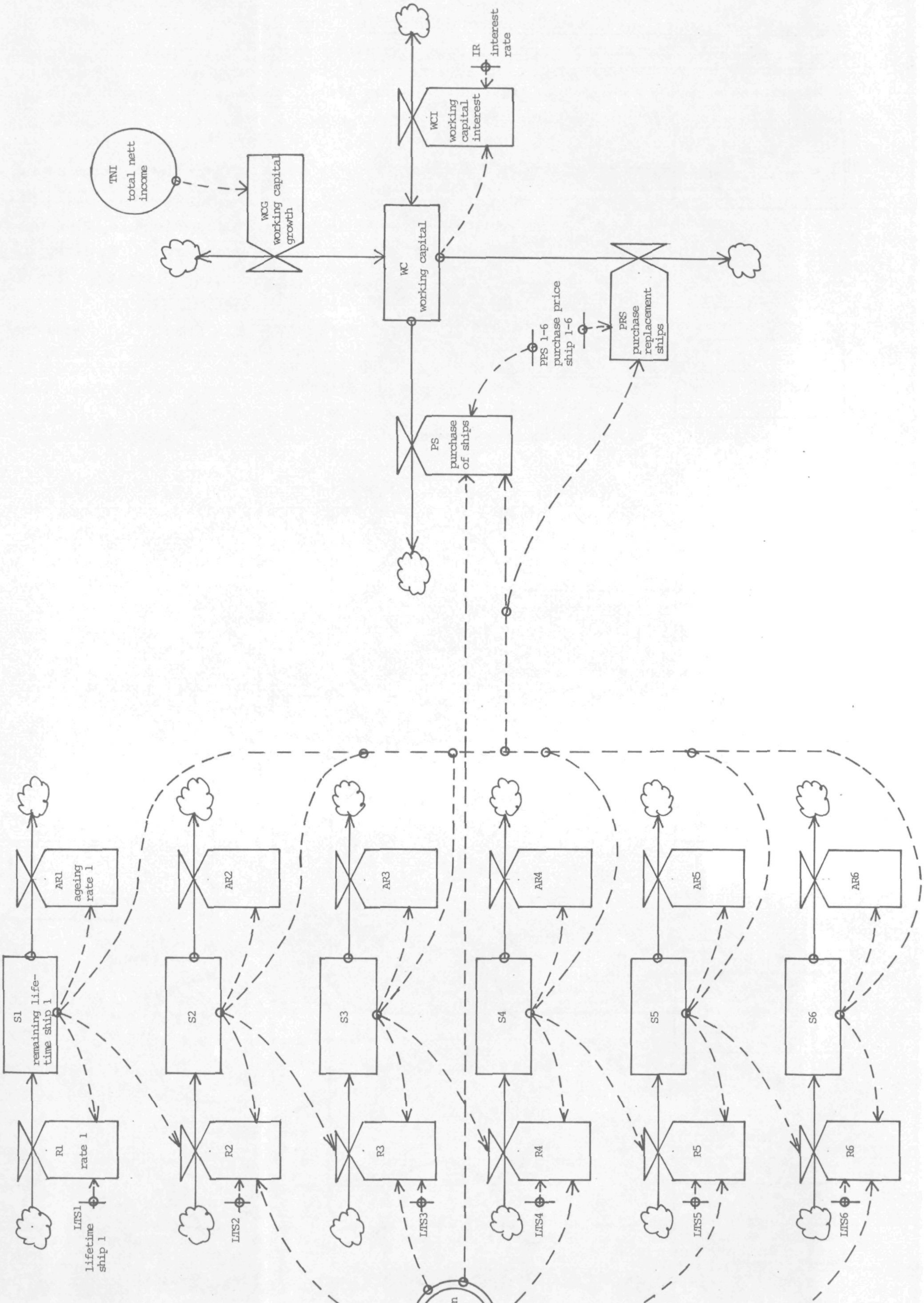
AR1.KL=1
     AR1      - AGEING RATE 1

S2.K=S2.J+DT*((R2.JK/DT)-AR2.JK)
S2=0
     S2       - REMAINING LIFETIME SHIP 2   QUARTERS
     R2       - RATE 2
     AR2      - AGEING RATE 2

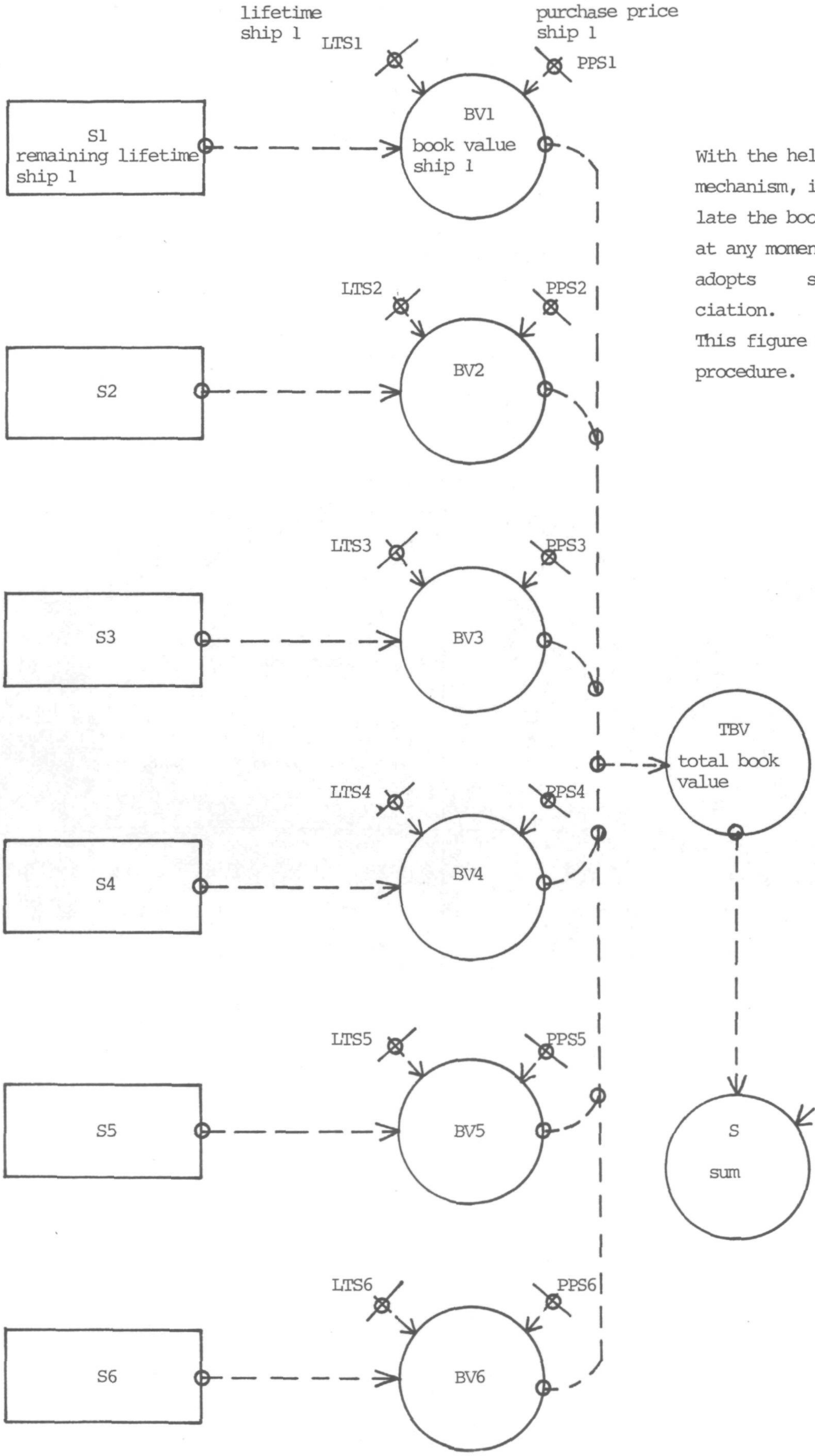
R2.KL=SWITCH((CLIP((FED.K*LTS2),0,S1.K,1)),0,S2.K)+
  SWITCH(LTS2,0,(S2.K-1))
LTS2=80
     R2       - RATE 2
     FED      - FLEET EXPANSION DECISION
     LTS2     - LIFETIME SHIP 2   QUARTERS
     S1       - REMAINING LIFETIME SHIP 1  QUARTERS
     S2       - REMAINING LIFETIME SHIP 2   QUARTERS

AR2.KL=CLIP(1,0,S2.K,1)
     AR2      - AGEING RATE 2
     S2       - REMAINING LIFETIME SHIP 2   QUARTERS
```

etc., etc.


TNI
total nett income
WCG
working capital growth
WC
working capital
WCI
working capital interest
IR
interest rate
PPS 1-6
purchase price ship 1-6
PRS
purchase replacement ships
PS
purchase of ships
S1
remaining life-time ship 1
AR1
ageing rate 1
R1
rate 1
LTS1
lifetime ship 1
S2
AR2
R2
LTS2
S3
AR3
R3
LTS3
S4
AR4
R4
LTS4
S5
AR5
R5
LTS5
S6
AR6
R6
LTS6
FED
fleet expansion decision

Dynamo-flow diagram of the book-value calculation of the ships



With the help of the ageing mechanism, it is simple to calculate the book value of the ships at any moment, at least if one adopts straight line depreciation.
This figure illustrates the procedure.

. documentor listing

```
BV1.K=PPS1*S1.K/LTS1
    BV1      - BOOK VALUE SHIP 1    f
    PPS1     - PURCHASE PRICE SHIP 1     f
    S1       - REMAINING LIFETIME SHIP 1  QUARTERS
    LTS1     - LIFETIME SHIP 1    QUARTERS

BV2.K=PPS2*S2.K/LTS2
    BV2      - BOOK VALUE SHIP 2    f
    PPS2     - PURCHASE PRICE SHIP 2     f
    S2       - REMAINING LIFETIME SHIP 2    QUARTERS
    LTS2     - LIFETIME SHIP 2    QUARTERS

BV3.K=PPS3*S3.K/LTS3
    BV3      - BOOK VALUE SHIP 3    f
    PPS3     - PURCHASE PRICE SHIP 3     f
    S3       - REMAINING LIFETIME SHIP 3    QUARTERS
    LTS3     - LIFETIME SHIP 3    QUARTERS

BV4.K=PPS4*S4.K/LTS4
    BV4      - BOOK VALUE SHIP 4    f
    PPS4     - PURCHASE PRICE SHIP 4     f
    S4       - REMAINING LIFETIME SHIP 4    QUARTERS
    LTS4     - LIFETIME SHIP 4    QUARTERS

BV5.K=PPS5*S5.K/LTS5
    BV5      - BOOK VALUE SHIP 5    f
    PPS5     - PURCHASE PRICE SHIP 5     f
    S5       - REMAINING LIFETIME  SHIP 5    QUARTERS
    LTS5     - LIFETIME SHIP 5  QUARTERS

BV6.K=PPS6*S6.K/LTS6
    BV6      - BOOK VALUE SHIP 6    f
    PPS6     - PURCHASE PRICE SHIP 6     f
    S6       - REMAINING LIFETIME SHIP 6    QUARTERS
    LTS6     - LIFETIME SHIP 6    QUARTERS

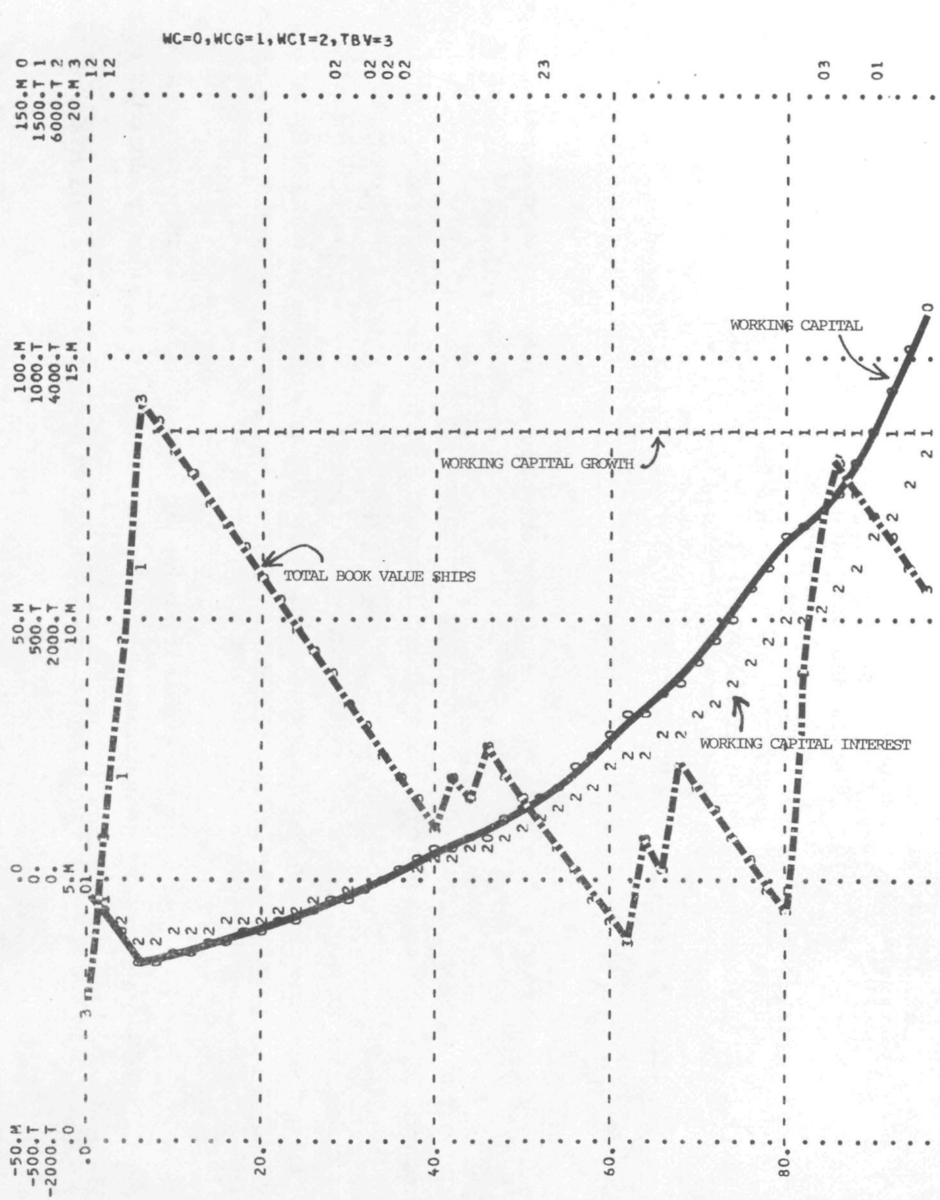
TBV.K=BV1.K+BV2.K+BV3.K+BV4.K+BV5.K+BV6.K
    TBV      - TOTAL BOOK VALUE OF SHIPS  f
    BV1      - BOOK VALUE SHIP 1    f
    BV2      - BOOK VALUE SHIP 2    f
    BV3      - BOOK VALUE SHIP 3    f
    BV4      - BOOK VALUE SHIP 4    f
    BV5      - BOOK VALUE SHIP 5    f
    BV6      - BOOK VALUE SHIP 6    f

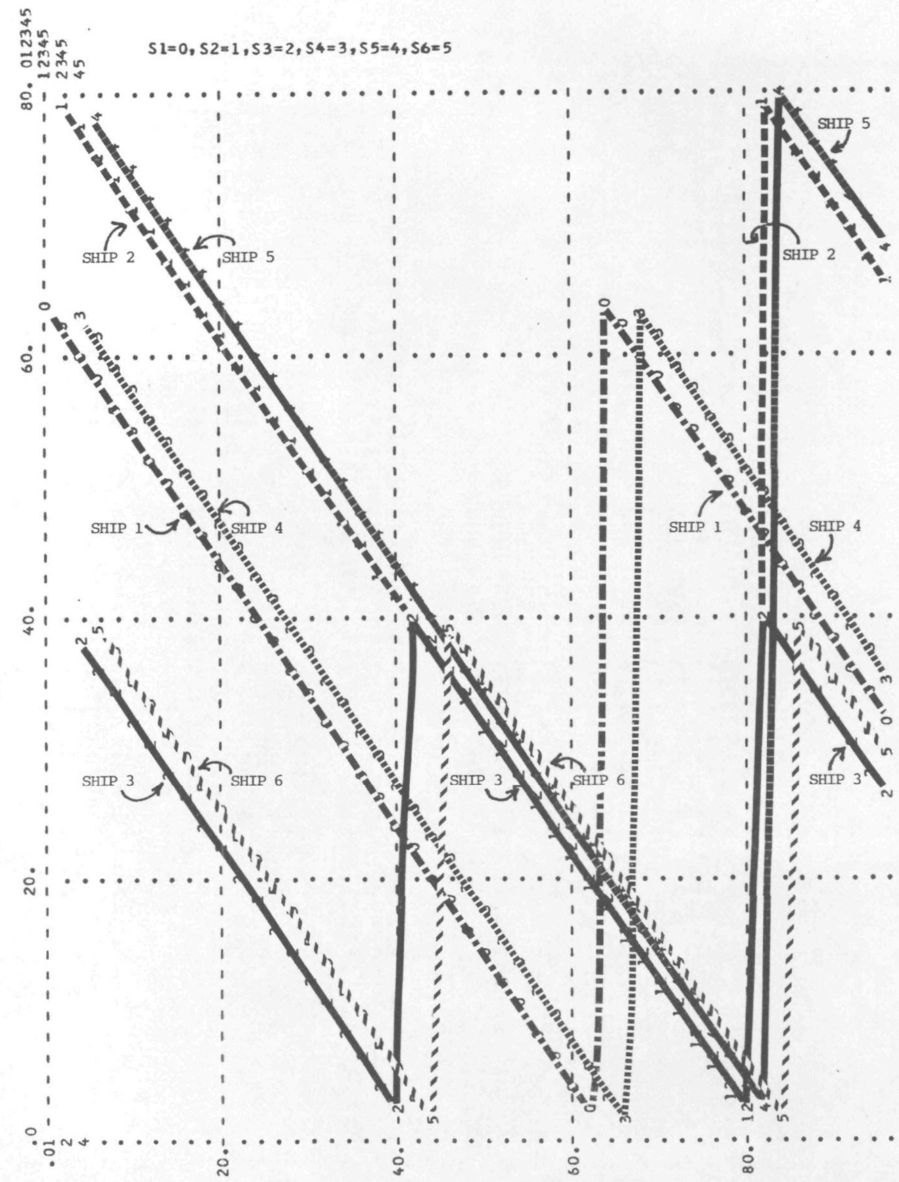
S.K=WC.K+TBV.K
    S        - SUM   f
    WC       - WORKING CAPITAL  f
    TBV      - TOTAL BOOK VALUE OF SHIPS  f
```

```
*    MODEL 8 - 6 SHIPS OF DIFFERENT AGE
NOTE   NUMBER OF SHIPS IN FLEET
L   NS.K=NS.J+DT*NSG.JK
N   NS=1
R   NSG.KL=FED.K/DT
A   FED.K=CLIP(0,PULSE(1,1,1),TIME.K,6)
NOTE   NETT INCOME/SHIP/QUARTER
A   FT.K=LC*LFE.K
C   LC=14000
A   LFE.K=TABLE(LFET,TIME.K,0,96,8)
T   LFET=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A   IT.K=LC*LFI.K
A   LFI.K=TABLE(LFIT,TIME.K,0,96,8)
T   LFIT=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A   GRE.K=FT.K*FRE
C   FRE=25
A   GRI.K=IT.K*FRI
C   FRI=35
A   GR.K=GRE.K+GRI.K
A   AC.K=GR.K*ACS
C   ACS=.055
A   SC.K=(FT.K+IT.K)*SCT
C   SCT=6.25
A   CC.K=(FT.K+IT.K)*CCT
C   CCT=.4
A   SCC.K=(FT.K+IT.K)*SCCT
C   SCCT=1
C   B=58000
C   PC=45000
A   VE.K=AC.K+SC.K+CC.K+SCC.K+B+PC
A   NIS.K=(((GR.K-VE.K)*OD)/RT)-OC
C   OD=87.5
C   RT=118
C   OC=110000
NOTE   TOTAL NETT INCOME OF SHIPPING OPERATIONS
A   TNI.K=NIS.K*NS.K-AMC
C   AMC=94000
NOTE   WORKING CAPITAL
L   WC.K=WC.J+DT*(WCG.JK+WCI.JK-(PS.JK/DT)-PRS.JK/DT)
N   WC=-PPS1
R   WCG.KL=CLIP(TNI.K,0,TIME.K,DT)
R   WCI.KL=CLIP((WC.K*IR),0,TIME.K,DT)
C   IR=.03
R   PS.KL=SWITCH((CLIP((FED.K*PPS2),0,S1.K,1)),0,S2.K)+
X   SWITCH((CLIP((FED.K*PPS3),0,S2.K,1)),0,S3.K)+
X   SWITCH((CLIP((FED.K*PPS4),0,S3.K,1)),0,S4.K)+
X   SWITCH((CLIP((FED.K*PPS5),0,S4.K,1)),0,S5.K)+
X   SWITCH((CLIP((FED.K*PPS6),0,S5.K,1)),0,S6.K)
R   PRS.KL=SWITCH(PPS1,0,(S1.K-1))+SWITCH(PPS2,0,(S2.K-1))+
X   SWITCH(PPS3,0,(S3.K-1))+SWITCH(PPS4,0,(S4.K-1))+
X   SWITCH(PPS5,0,(S5.K-1))+SWITCH(PPS6,0,(S6.K-1))
C   PPS1=2.5E6
C   PPS2=3.5E6
C   PPS3=1.5E6
C   PPS4=2.5E6
C   PPS5=3.5E6
C   PPS6=1.5E6
NOTE   AGEING MECHANISM OF SHIPS
L   S1.K=S1.J+DT*((R1.JK/DT)-AR1.JK)
N   S1=LTS1
C   LTS1=64
R   R1.KL=SWITCH(LTS1,0,(S1.K-1))
R   AR1.KL=1
L   S2.K=S2.J+DT*((R2.JK/DT)-AR2.JK)
N   S2=0
R   R2.KL=SWITCH((CLIP((FED.K*LTS2),0,S1.K,1)),0,S2.K)+
X   SWITCH(LTS2,0,(S2.K-1))
C   LTS2=80
R   AR2.KL=CLIP(1,0,S2.K,1)
L   S3.K=S3.J+DT*((R3.JK/DT)-AR3.JK)
N   S3=0
R   R3.KL=SWITCH((CLIP((FED.K*LTS3),0,S2.K,1)),0,S3.K)+
X   SWITCH(LTS3,0,(S3.K-1))
C   LTS3=40
R   AR3.KL=CLIP(1,0,S3.K,1)
L   S4.K=S4.J+DT*((R4.JK/DT)-AR4.JK)
N   S4=0
R   R4.KL=SWITCH((CLIP((FED.K*LTS4),0,S3.K,1)),0,S4.K)+
X   SWITCH(LTS4,0,(S4.K-1))
C   LTS4=64
R   AR4.KL=CLIP(1,0,S4.K,1)
L   S5.K=S5.J+DT*((R5.JK/DT)-AR5.JK)
N   S5=0
R   R5.KL=SWITCH((CLIP((FED.K*LTS5),0,S4.K,1)),0,S5.K)+
X   SWITCH(LTS5,0,(S5.K-1))
C   LTS5=80
R   AR5.KL=CLIP(1,0,S5.K,1)
L   S6.K=S6.J+DT*((R6.JK/DT)-AR6.JK)
N   S6=0
R   R6.KL=SWITCH((CLIP((FED.K*LTS6),0,S5.K,1)),0,S6.K)+
X   SWITCH(LTS6,0,(S6.K-1))
C   LTS6=40
R   AR6.KL=CLIP(1,0,S6.K,1)
NOTE   BOOK VALUE OF FLEET (STRAIGHT LINE DEPRECIATION)
A   BV1.K=PPS1*S1.K/LTS1
A   BV2.K=PPS2*S2.K/LTS2
A   BV3.K=PPS3*S3.K/LTS3
A   BV4.K=PPS4*S4.K/LTS4
A   BV5.K=PPS5*S5.K/LTS5
A   BV6.K=PPS6*S6.K/LTS6
A   TBV.K=BV1.K+BV2.K+BV3.K+BV4.K+BV5.K+BV6.K
A   S.K=WC.K+TBV.K
SPEC   LENGTH=96/DT=.25/PRTPER=2/PLTPER=2
PRINT   WC,WCG,WCI,PS,PRS,S1,S2,S3,S4,S5
PRINT   S6,TBV,S
PLOT   WC/WCG/WCI/TBV
PLOT   S1,S2,S3,S4,S5,S6
RUN
```

MODEL 8 - 6 SHIPS OF DIFFERENT AGE

TIME	WC	WCG	WCI	PS	PRS	S1	S2	S3	S4	S5	S6	TBV	S
E+00	E+06	E+03	E+03	E+03	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+06	E+06
.0	-2.50	.00	.0	.0	0.	64.000	.000	.000	.000	.000	.000	2.500	.00
2.	-6.36	-36.97	-190.7	1500.0	0.	62.000	79.250	.000	.000	.000	.000	5.889	-.47
4.	-10.75	191.98	-322.5	3500.0	0.	60.000	77.250	38.250	63.250	.000	.000	9.629	-1.12
6.	-15.84	592.85	-475.3	.0	0.	58.000	75.250	36.250	61.250	78.250	39.250	14.205	-1.64
8.	-15.37	850.72	-461.1	.0	0.	56.000	73.250	34.250	59.250	76.250	37.250	13.724	-1.65
10.	-14.57	850.72	-437.1	.0	0.	54.000	71.250	32.250	57.250	74.250	35.250	13.243	-1.33
12.	-13.72	850.72	-411.7	.0	0.	52.000	69.250	30.250	55.250	72.250	33.250	12.761	-.96
14.	-12.82	850.72	-384.6	.0	0.	50.000	67.250	28.250	53.250	70.250	31.250	12.280	-.54
16.	-11.86	850.72	-355.9	.0	0.	48.000	65.250	26.250	51.250	68.250	29.250	11.799	-.07
18.	-10.85	850.72	-325.4	.0	0.	46.000	63.250	24.250	49.250	66.250	27.250	11.318	.47
20.	-9.77	850.72	-293.1	.0	0.	44.000	61.250	22.250	47.250	64.250	25.250	10.836	1.07
22.	-8.62	850.72	-258.7	.0	0.	42.000	59.250	20.250	45.250	62.250	23.250	10.355	1.73
24.	-7.41	850.72	-222.3	.0	0.	40.000	57.250	18.250	43.250	60.250	21.250	9.874	2.47
26.	-6.12	850.72	-183.6	.0	0.	38.000	55.250	16.250	41.250	58.250	19.250	9.393	3.27
28.	-4.75	850.72	-142.5	.0	0.	36.000	53.250	14.250	39.250	56.250	17.250	8.911	4.16
30.	-3.29	850.72	-98.8	.0	0.	34.000	51.250	12.250	37.250	54.250	15.250	8.430	5.14
32.	-1.75	850.72	-52.5	.0	0.	32.000	49.250	10.250	35.250	52.250	13.250	7.949	6.20
34.	-.11	850.72	-3.3	.0	0.	30.000	47.250	8.250	33.250	50.250	11.250	7.468	7.36
36.	1.63	850.72	48.9	.0	0.	28.000	45.250	6.250	31.250	48.250	9.250	6.986	8.61
38.	3.48	850.72	104.3	.0	0.	26.000	43.250	4.250	29.250	46.250	7.250	6.505	9.98
40.	5.44	850.72	163.1	.0	0.	24.000	41.250	2.250	27.250	44.250	5.250	6.024	11.46
42.	6.00	850.72	179.9	.0	0.	22.000	39.250	40.250	25.250	42.250	3.250	7.043	13.04
44.	8.11	850.72	243.4	.0	0.	20.000	37.250	38.250	23.250	40.250	1.250	6.561	14.67
46.	8.79	850.72	263.7	.0	0.	18.000	35.250	36.250	21.250	38.250	39.250	7.580	16.37
48.	11.08	850.72	332.3	.0	0.	16.000	33.250	34.250	19.250	36.250	37.250	7.099	18.18
50.	13.51	850.72	405.2	.0	0.	14.000	31.250	32.250	17.250	34.250	35.250	6.618	20.12
52.	16.09	850.72	482.6	.0	0.	12.000	29.250	30.250	15.250	32.250	33.250	6.136	22.22
54.	18.82	850.72	564.7	.0	0.	10.000	27.250	28.250	13.250	30.250	31.250	5.655	24.48
56.	21.73	850.72	651.9	.0	0.	8.000	25.250	26.250	11.250	28.250	29.250	5.174	26.90
58.	24.81	850.72	744.4	.0	0.	6.000	23.250	24.250	9.250	26.250	27.250	4.693	29.51
60.	28.09	850.72	842.7	.0	0.	4.000	21.250	22.250	7.250	24.250	25.250	4.211	32.30
62.	31.57	850.72	947.0	.0	0.	2.000	19.250	20.250	5.250	22.250	23.250	3.730	35.30
64.	32.70	850.72	981.0	.0	0.	64.000	17.250	18.250	3.250	20.250	21.250	5.749	38.45
66.	36.46	850.72	1093.9	.0	0.	62.000	15.250	16.250	1.250	18.250	19.250	5.268	41.73
68.	37.84	850.72	1135.2	.0	0.	60.000	13.250	14.250	63.250	16.250	17.250	7.286	45.13
70.	41.92	850.72	1257.5	.0	0.	58.000	11.250	12.250	61.250	14.250	15.250	6.805	48.72
72.	46.25	850.72	1387.4	.0	0.	56.000	9.250	10.250	59.250	12.250	13.250	6.324	52.57
74.	50.84	850.72	1525.3	.0	0.	54.000	7.250	8.250	57.250	10.250	11.250	5.843	56.68
76.	55.72	850.72	1671.6	.0	0.	52.000	5.250	6.250	55.250	8.250	9.250	5.361	61.08
78.	60.90	850.72	1827.0	.0	0.	50.000	3.250	4.250	53.250	6.250	7.250	4.880	65.78
80.	66.40	850.72	1991.9	.0	0.	48.000	1.250	2.250	51.250	4.250	5.250	4.399	70.80
82.	67.05	850.72	2011.5	.0	0.	46.000	79.250	40.250	49.250	2.250	3.250	8.918	75.97
84.	69.38	850.72	2081.3	.0	0.	44.000	77.250	38.250	47.250	80.250	1.250	11.936	81.31
86.	73.83	850.72	2214.8	.0	0.	42.000	75.250	36.250	45.250	78.250	39.250	12.955	86.78
88.	80.12	850.72	2403.7	.0	0.	40.000	73.250	34.250	43.250	76.250	37.250	12.474	92.60
90.	86.80	850.72	2604.1	.0	0.	38.000	71.250	32.250	41.250	74.250	35.250	11.993	98.80
92.	93.90	850.72	2816.9	.0	0.	36.000	69.250	30.250	39.250	72.250	33.250	11.511	105.41
94.	101.43	850.72	3042.8	.0	0.	34.000	67.250	28.250	37.250	70.250	31.250	11.030	112.46
96.	109.42	850.72	3282.7	.0	0.	32.000	65.250	26.250	35.250	68.250	29.250	10.549	119.97


WC=0,WCG=1,WCI=2,TBV=3
WORKING CAPITAL
WORKING CAPITAL GROWTH
TOTAL BOOK VALUE SHIPS
WORKING CAPITAL INTEREST


S1=0,S2=1,S3=2,S4=3,S5=4,S6=5
SHIP 2
SHIP 5
SHIP 1
SHIP 4
SHIP 3
SHIP 6

5.3 MODEL 9 - CASH FLOW MODEL OF 6 SHIPS OF DIFFERENT AGE, FINANCED BY LOANS

The causal-loop diagram of the model can be found in paragraph 1.2.
The dynamo-flow diagram is presented on the following page.

. parameter values

The loan on each ship is made a level. The fleet expansion decision gives the levels a value equal to the purchase price of the ship multiplied by the loan percentage. The loan percentage is 75 percent of the purchase price. The loan is repaid over 32 quarters. It is assumed that the repayments take place continuously, e.g. every quarter 1/32 is repaid.

The sum of all the loan repayments LR decreases the working capital. Likewise, the loan interest payments, which is the product of the sum of all ship loans and the loan interest rate. The latter is 2 percent per quarter.

The other assumptions are identical with the ones of model 8.

. documentor listing of the relevant equations

```
WC.K=WC.J+DT*(WCG.JK+WCI.JK-(SDP.JK/DT)-(PRS.JK/DT)
  -LR.JK-LIP.JK)
WC=-(1-LPPS)*PPS1
    WC      - WORKING CAPITAL  ƒ
    WCG     - WORKING CAPITAL GROWTH   ƒ/QUARTER
    WCI     - WORKING CAPITAL INTEREST  ƒ/QUARTER
    SDP     - SHIP DOWN PAYMENT  ƒ
    PRS     - PURCHASE REPLACEMENT SHIPS  ƒ
    LR      - LOAN REPAYMENT   ƒ/QUARTER
    LIP     - LOAN INTEREST PAYMENT    ƒ/QUARTER
    LPPS    - LOAN PERCENTAGE PER SHIP  DIM'LESS
    PPS1    - PURCHASE PRICE SHIP 1     ƒ

SDP.KL=SWITCH(0,(PPS2-LS2I.JK),LS2I.JK)+SWITCH(0,    21, R
  (PPS3-LS3I.JK),LS3I.JK)+SWITCH(0,(PPS4-LS4I.JK),
  LS4I.JK)+SWITCH(0,(PPS5-LS5I.JK),LS5I.JK)+
  SWITCH(0,(PPS6-LS6I.JK),LS6I.JK)
    SDP     - SHIP DOWN PAYMENT  ƒ
    PPS2    - PURCHASE PRICE SHIP 2     ƒ
    LS2I    - LOAN SHIP 2 INCREASE  ƒ
    PPS3    - PURCHASE PRICE SHIP 3     ƒ
    LS3I    - LOAN SHIP 3 INCREASE  ƒ
    PPS4    - PURCHASE PRICE SHIP 4     ƒ
    LS4I    - LOAN SHIP 4 INCREASE  ƒ
    PPS5    - PURCHASE PRICE SHIP 5     ƒ
    LS5I    - LOAN SHIP 5  INCREASE  ƒ
    PPS6    - PURCHASE PRICE SHIP 6     ƒ
    LS6I    - LOAN SHIP 6 INCREASE  ƒ

PRS.KL=SWITCH(PPS1,0,(S1.K-1))+SWITCH(PPS2,0,(S2.K- 22, R
  1))+SWITCH(PPS3,0,(S3.K-1))+SWITCH(PPS4,0,(S4.K-
  1))+SWITCH(PPS5,0,(S5.K-1))+SWITCH(PPS6,0,(S6.K-
  1))
    PRS     - PURCHASE REPLACEMENT SHIPS  ƒ
    PPS1    - PURCHASE PRICE SHIP 1    ƒ
    S1      - REMAINING LIFETIME SHIP 1  QUARTERS
    PPS2    - PURCHASE PRICE SHIP 2    ƒ
    S2      - REMAINING LIFETIME SHIP 2   QUARTERS
    PPS3    - PURCHASE PRICE SHIP 3    ƒ
    S3      - REMAINING LIFETIME SHIP 3   QUARTERS
    PPS4    - PURCHASE PRICE SHIP 4    ƒ
    S4      - REMAINING LIFETIME SHIP 4   QUARTERS
    PPS5    - PURCHASE PRICE SHIP 5    ƒ
    S5      - REMAINING LIFETIME  SHIP 5   QUARTERS
    PPS6    - PURCHASE PRICE SHIP 6    ƒ
    S6      - REMAINING LIFETIME SHIP 6   QUARTERS
```

```
LR.KL=LS1R.JK+LS2R.JK+LS3R.JK+LS4R.JK+LS5R.JK+
  LS6R.JK
    LR      - LOAN REPAYMENT   ƒ/QUARTER
    LS1R    - LOAN SHIP 1 REPAYMENT  ƒ/QUARTER
    LS2R    - LOAN SHIP 2 REPAYMENT  ƒ/QUARTER
    LS3R    - LOAN SHIP 3 REPAYMENT  ƒ/QUARTER
    LS4R    - LOAN SHIP 4 REPAYMENT  ƒ/QUARTER
    LS5R    - LOAN SHIP 5 REPAYMENT  ƒ/QUARTER
    LS6R    - LOAN SHIP 6 REPAYMENT  ƒ/QUARTER

LIP.KL=LIR*LS.K
LIR=.02
    LIP     - LOAN INTEREST PAYMENT   ƒ/QUARTER
    LIR     - LOAN INTEREST RATE   %/QUARTER
    LS      - LOAN ON SHIPS   ƒ

LS.K=LS1.K+LS2.K+LS3.K+LS4.K+LS5.K+LS6.K
    LS      - LOAN ON SHIPS   ƒ
    LS1     - LOAN SHIP 1  ƒ
    LS2     - LOAN SHIP 2  ƒ
    LS3     - LOAN SHIP 3  ƒ
    LS4     - LOAN SHIP 4  ƒ
    LS5     - LOAN SHIP 5  ƒ
    LS6     - LOAN SHIP 6  ƒ

LS1.K=LS1.J+DT*((LS1I.JK/DT)-LS1R.JK)
LS1=LPPS*PPS1
LPPS=.75
    LS1     - LOAN SHIP 1  ƒ
    LS1I    - LOAN SHIP 1 INCREASE ƒ
    LS1R    - LOAN SHIP 1 REPAYMENT  ƒ/QUARTER
    LPPS    - LOAN PERCENTAGE PER SHIP  DIM'LESS
    PPS1    - PURCHASE PRICE SHIP 1     ƒ

LS1I.KL=0
    LS1I    - LOAN SHIP 1 INCREASE ƒ

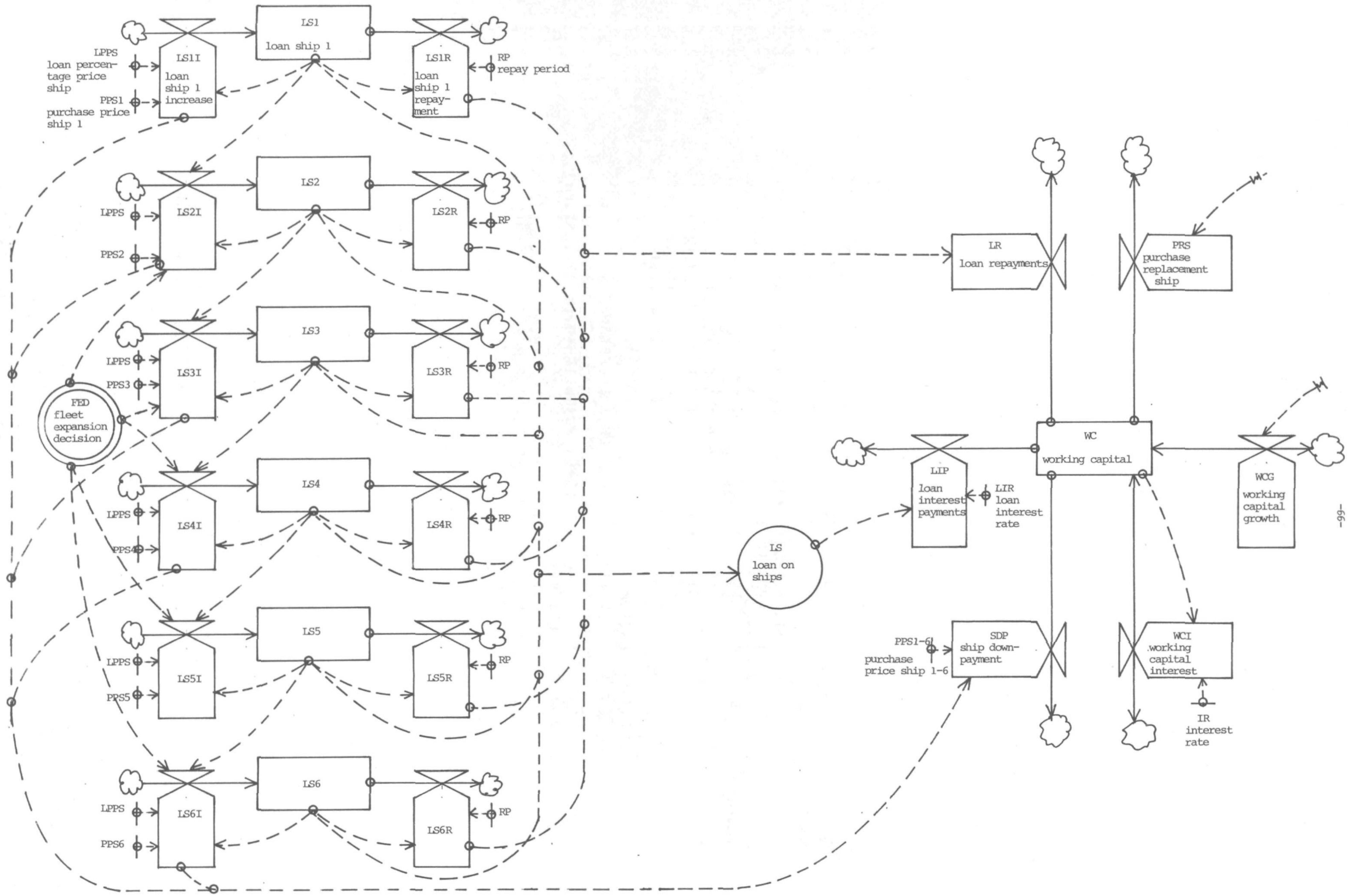
LS1R.KL=LPPS*PPS1*CLIP((SWITCH(0,(1/RP),LS1.K)),0,
  LS1.K,.2)
    LS1R    - LOAN SHIP 1 REPAYMENT  ƒ/QUARTER
    LPPS    - LOAN PERCENTAGE PER SHIP  DIM'LESS
    PPS1    - PURCHASE PRICE SHIP 1     ƒ
    LS1     - LOAN SHIP 1  ƒ

LS2.K=LS2.J+DT*((LS2I.JK/DT)-LS2R.JK)
LS2=0
    LS2     - LOAN SHIP 2  ƒ
    LS2I    - LOAN SHIP 2 INCREASE  ƒ
    LS2R    - LOAN SHIP 2 REPAYMENT  ƒ/QUARTER

LS2I.KL=SWITCH((CLIP((FED.K*LPPS*PPS2),0,LS1.K,1))
  ,0,LS2.K)
    LS2I    - LOAN SHIP 2 INCREASE  ƒ
    FED     - FLEET EXPANSION DECISION
    LPPS    - LOAN PERCENTAGE PER SHIP  DIM'LESS
    PPS2    - PURCHASE PRICE SHIP 2     ƒ
    LS1     - LOAN SHIP 1  ƒ
    LS2     - LOAN SHIP 2  ƒ

LS2R.KL=LPPS*PPS2*CLIP((SWITCH(0,(1/RP),LS2.K)),0,
  LS2.K,.2)
    LS2R    - LOAN SHIP 2 REPAYMENT  ƒ/QUARTER
    LPPS    - LOAN PERCENTAGE PER SHIP  DIM'LESS
    PPS2    - PURCHASE PRICE SHIP 2     ƒ
    LS2     - LOAN SHIP 2  ƒ
```

etc., etc.


LS1
loan ship 1
LS1I
loan ship 1 increase
LPPS
loan percentage price ship
PPS1
purchase price ship 1
LS1R
loan ship 1 repayment
RP
repay period
LS2
LS2I
LS2R
PPS2
LS3
LS3I
LS3R
PPS3
LS4
LS4I
LS4R
PPS4
LS5
LS5I
LS5R
PPS5
LS6
LS6I
LS6R
PPS6
FED
fleet expansion decision
LR
loan repayments
PRS
purchase replacement ship
WC
working capital
LIP
loan interest payments
LIR
loan interest rate
WCG
working capital growth
LS
loan on ships
SDP
ship down-payment
PPS1-6
purchase price ship 1-6
WCI
working capital interest
IR
interest rate

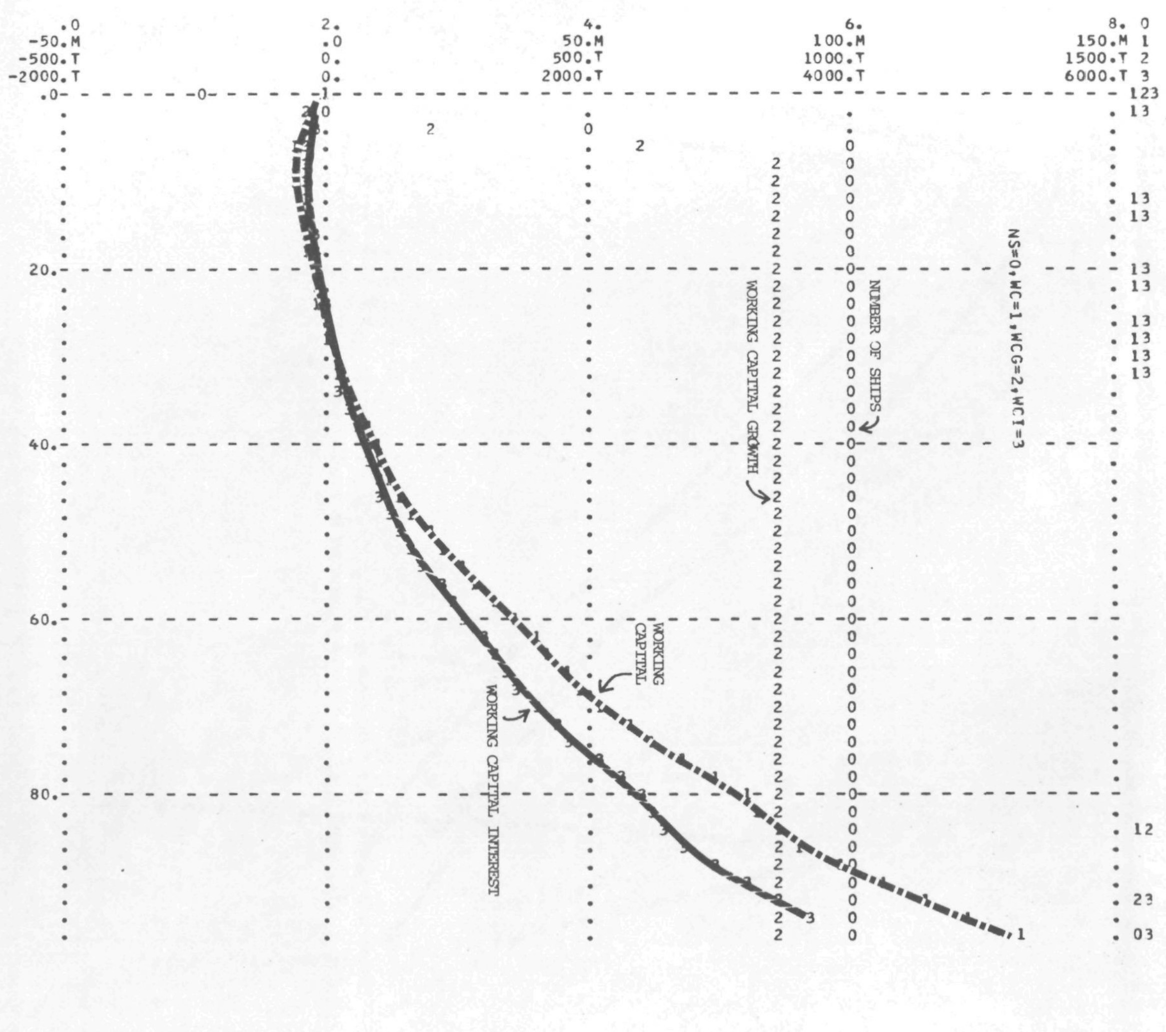
```
* MODEL 9 - 6 SHIPS FINANCED BY LOANS
NOTE  NUMBER OF SHIPS IN FLEET
L  NS.K=NS.J+DT*NSG.JK
N  NS=1
R  NSG.KL=FED.K/DT
A  FED.K=CLIP(0,PULSE(1,1,1),TIME.K,6)
NOTE  NETT INCOME/SHIP/QUARTER
A  FT.K=LC*LFE.K
C  LC=14000
A  LFE.K=TABLE(LFET,TIME.K,0,96,8)
T  LFET=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A  IT.K=LC*LFI.K
A  LFI.K=TABLE(LFIT,TIME.K,0,96,8)
T  LFIT=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A  GRE.K=FT.K*FRE
C  FRE=25
A  GRI.K=IT.K*FRI
C  FRI=35
A  GR.K=GRE.K+GRI.K
A  AC.K=GR.K*ACS
C  ACS=.055
A  SC.K=(FT.K+IT.K)*SCT
C  SCT=6.25
A  CC.K=(FT.K+IT.K)*CCT
C  CCT=.4
A  SCC.K=(FT.K+IT.K)*SCCT
C  SCCT=1
C  B=58000
C  PC=45000
A  VE.K=AC.K+SC.K+CC.K+SCC.K+B+PC
A  NIS.K=(((GR.K-VE.K)*OD)/RT)-OC
C  OD=87.5
C  RT=118
C  OC=110000
NOTE TOTAL NETT INCOME OF SHIPPING OPERATIONS
A  TNI.K=NIS.K*NS.K-AMC
C  AMC=94000
NOTE  WORKING CAPITAL
L  WC.K=WC.J+DT*(WCG.JK+WCI.JK-(SDP.JK/DT)-(PRS.JK/DT)-LR.JK-LIP.JK)
N  WC=-(1-LPPS)*PPS1
R  WCG.KL=CLIP(TNI.K,0,TIME.K,DT)
R  WCI.KL=CLIP((WC.K*IR),0,TIME.K,DT)
C  IR=.03
R  SDP.KL=SWITCH(0,(PPS2-LS2I.JK),LS2I.JK)+
X  SWITCH(0,(PPS3-LS3I.JK),LS3I.JK)+SWITCH(0,(PPS4-LS4I.JK),LS4I.JK)+
X  SWITCH(0,(PPS5-LS5I.JK),LS5I.JK)+SWITCH(0,(PPS6-LS6I.JK),LS6I.JK)
R  PRS.KL=SWITCH(PPS1,0,(S1.K-1))+SWITCH(PPS2,0,(S2.K-1))+
X  SWITCH(PPS3,0,(S3.K-1))+SWITCH(PPS4,0,(S4.K-1))+
X  SWITCH(PPS5,0,(S5.K-1))+SWITCH(PPS6,0,(S6.K-1))
R  LR.KL=LS1R.JK+LS2R.JK+LS3R.JK+LS4R.JK+LS5R.JK+LS6R.JK
R  LIP.KL=LIR*LS.K
C  LIR=.02
C  PPS1=2.5E6
C  PPS2=3.5E6
C  PPS3=1.5E6
C  PPS4=2.5E6
C  PPS5=3.5E6
C  PPS6=1.5E6
NOTE  LOAN SECTOR
A  LS.K=LS1.K+LS2.K+LS3.K+LS4.K+LS5.K+LS6.K
L  LS1.K=LS1.J+DT*((LS1I.JK/DT)-LS1R.JK)
N  LS1=LPPS*PPS1
C  LPPS=.75
R  LS1I.KL=0
R  LS1R.KL=LPPS*PPS1*CLIP((SWITCH(0,(1/RP),LS1.K)),0,LS1.K,.2)
L  LS2.K=LS2.J+DT*((LS2I.JK/DT)-LS2R.JK)
N  LS2=0
R  LS2I.KL=SWITCH((CLIP((FED.K*LPPS*PPS2),0,LS1.K,1)),0,LS2.K)
R  LS2R.KL=LPPS*PPS2*CLIP((SWITCH(0,(1/RP),LS2.K)),0,LS2.K,.2)
L  LS3.K=LS3.J+DT*((LS3I.JK/DT)-LS3R.JK)
N  LS3=0
R  LS3I.KL=SWITCH((CLIP((FED.K*LPPS*PPS3),0,LS2.K,1)),0,LS3.K)
R  LS3R.KL=LPPS*PPS3*CLIP((SWITCH(0,(1/RP),LS3.K)),0,LS3.K,.2)
L  LS4.K=LS4.J+DT*((LS4I.JK/DT)-LS4R.JK)
N  LS4=0
R  LS4I.KL=SWITCH((CLIP((FED.K*LPPS*PPS4),0,LS3.K,1)),0,LS4.K)
R  LS4R.KL=LPPS*PPS4*CLIP((SWITCH(0,(1/RP),LS4.K)),0,LS4.K,.2)
L  LS5.K=LS5.J+DT*((LS5I.JK/DT)-LS5R.JK)
N  LS5=0
R  LS5I.KL=SWITCH((CLIP((FED.K*LPPS*PPS5),0,LS4.K,1)),0,LS5.K)
R  LS5R.KL=LPPS*PPS5*CLIP((SWITCH(0,(1/RP),LS5.K)),0,LS5.K,.2)
L  LS6.K=LS6.J+DT*((LS6I.JK/DT)-LS6R.JK)
N  LS6=0
R  LS6I.KL=SWITCH((CLIP((FED.K*LPPS*PPS6),0,LS5.K,1)),0,LS6.K)
R  LS6R.KL=LPPS*PPS6*CLIP((SWITCH(0,(1/RP),LS6.K)),0,LS6.K,.2)
C  RP=32
NOTE  AGEING MECHANISM OF SHIPS
L  S1.K=S1.J+DT*((R1.JK/DT)-AR1.JK)
N  S1=LTS1
C  LTS1=64
R  R1.KL=SWITCH(LTS1,0,(S1.K-1))
R  AR1.KL=1
L  S2.K=S2.J+DT*((R2.JK/DT)-AR2.JK)
N  S2=0
R  R2.KL=SWITCH((CLIP((FED.K*LTS2),0,S1.K,1)),0,S2.K)+
X  SWITCH(LTS2,0,(S2.K-1))
C  LTS2=80
R  AR2.KL=CLIP(1,0,S2.K,1)
L  S3.K=S3.J+DT*((R3.JK/DT)-AR3.JK)
N  S3=0
R  R3.KL=SWITCH((CLIP((FED.K*LTS3),0,S2.K,1)),0,S3.K)+
X  SWITCH(LTS3,0,(S3.K-1))
C  LTS3=40
R  AR3.KL=CLIP(1,0,S3.K,1)
L  S4.K=S4.J+DT*((R4.JK/DT)-AR4.JK)
N  S4=0
R  R4.KL=SWITCH((CLIP((FED.K*LTS4),0,S3.K,1)),0,S4.K)+
X  SWITCH(LTS4,0,(S4.K-1))
C  LTS4=64
R  AR4.KL=CLIP(1,0,S4.K,1)
L  S5.K=S5.J+DT*((R5.JK/DT)-AR5.JK)
N  S5=0
R  R5.KL=SWITCH((CLIP((FED.K*LTS5),0,S4.K,1)),0,S5.K)+
X  SWITCH(LTS5,0,(S5.K-1))
C  LTS5=80
R  AR5.KL=CLIP(1,0,S5.K,1)
L  S6.K=S6.J+DT*((R6.JK/DT)-AR6.JK)
N  S6=0
R  R6.KL=SWITCH((CLIP((FED.K*LTS6),0,S5.K,1)),0,S6.K)+
X  SWITCH(LTS6,0,(S6.K-1))
C  LTS6=40
R  AR6.KL=CLIP(1,0,S6.K,1)
NOTE  DECISION CRITERIA
NOTE -1- DISCOUNTED COSTS AND BENEFITS
L  DCB.K=DCB.J+DT*DCBR.JK
N  DCB=-PPS1
R  DCBR.KL=(WCC.K/(EXP(TIME.K*LOGN(1+DR1))))
A  WCC.K=WCG.JK+WCI.JK-(SDP.JK/DT)-(PRS.JK/DT)-LR.JK-LIP.JK
C  DR1=.04
NOTE  -2- FOREIGN EXCHANGE BALANCE
L  FEBT.K=FEBT.J+DT*FEB.JK
N  FEBT=-(1-LPPS)*PPS1
R  FEB.KL=CLIP((FEEA.K-FEEX.K),0,TIME.K,DT)
A  FEEA.K=(NS.K*GR.K*ITC*OD)/RT
C  ITC=.7
A  FEEX.K=(SDP.JK/DT)+(PRS.JK/DT)+LR.JK+LIP.JK+((NS.K*OD)/RT)*
X  (PC+B+.7*SC.K+.7*CC.K+.5*AC.K+SCC.K)+NS.K*.9*OC
NOTE -3- SHADOW PRICED COSTS AND BENEFITS
L  DCBS.K=DCBS.J+DT*DCBRS.JK
N  DCBS=-SP*(1-LPPS)*PPS1-LPPS*PPS1
C  SP=1.3
R  DCBRS.KL=(WCCS.K/(EXP(TIME.K*LOGN(1+DR2))))
C  DR2=.04
A  WCCS.K=WCGS.JK+WCI.JK-SP*((SDP.JK/DT)+(PRS.JK/DT)+LR.JK+LIP.JK)
R  WCGS.KL=CLIP(TNIS.K,0,TIME.K,DT)
A  TNIS.K=NISS.K*NS.K-AMC
A  NISS.K=(((SP*(GR.K*ITC-B-PC-.5*AC.K-.7*SC.K-.7*CC.K-SCC.K)+
X  (1-ITC)*GR.K-.5*AC.K-.3*SC.K-.3*CC.K)*OD)/RT)-(SP*.9+.1)*OC
NOTE -4- INCOME PLOUGHED BACK IN COUNTRY
L  IPBC.K=IPBC.J+DT*(IPBCI.JK-IPBCD.JK/DT)
N  IPBC=0
R  IPBCI.KL=CLIP(WCG.JK,0,WC.K,0)+AMC
R  IPBCD.KL=CLIP((SDP.JK+PRS.JK),0,WC.K,0)
SPEC  LENGTH=96/DT=.25/PRTPER=2/PLTPER=2
PRINT  NS,WC,WCG,WCI,SDP,PRS,LR,LIP,LS1
PRINT  LS2,LS3,LS4,LS5,LS6,LS,FEBT,DCB,DCBS,IPBC
PLOT  NS/WC/WCG/WCI
PLOT  LS/LP/LIP
PLOT  DCB,DCBS/FEBT/IPBC
RUN
```

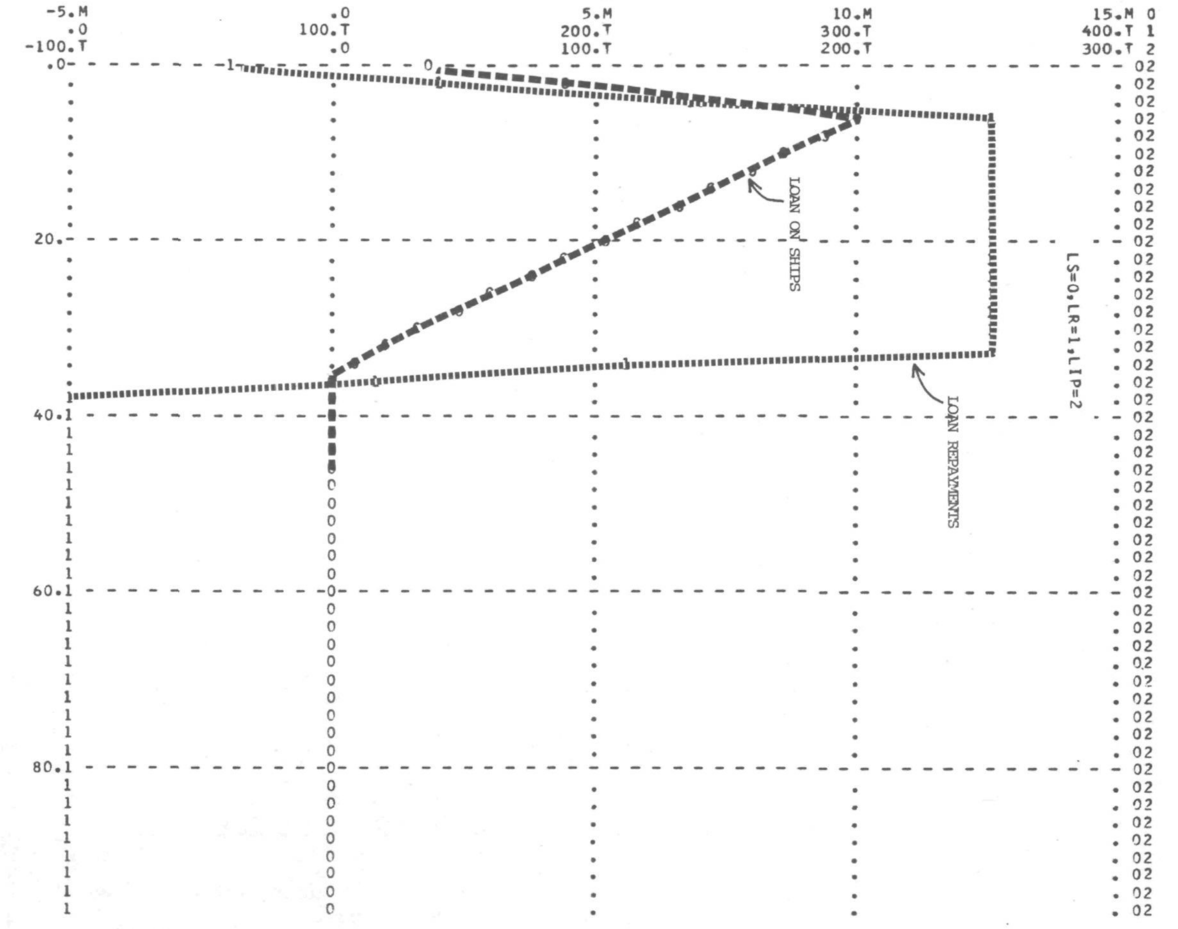
MODEL 9 - 6 SHIPS FINANCED BY LOANS

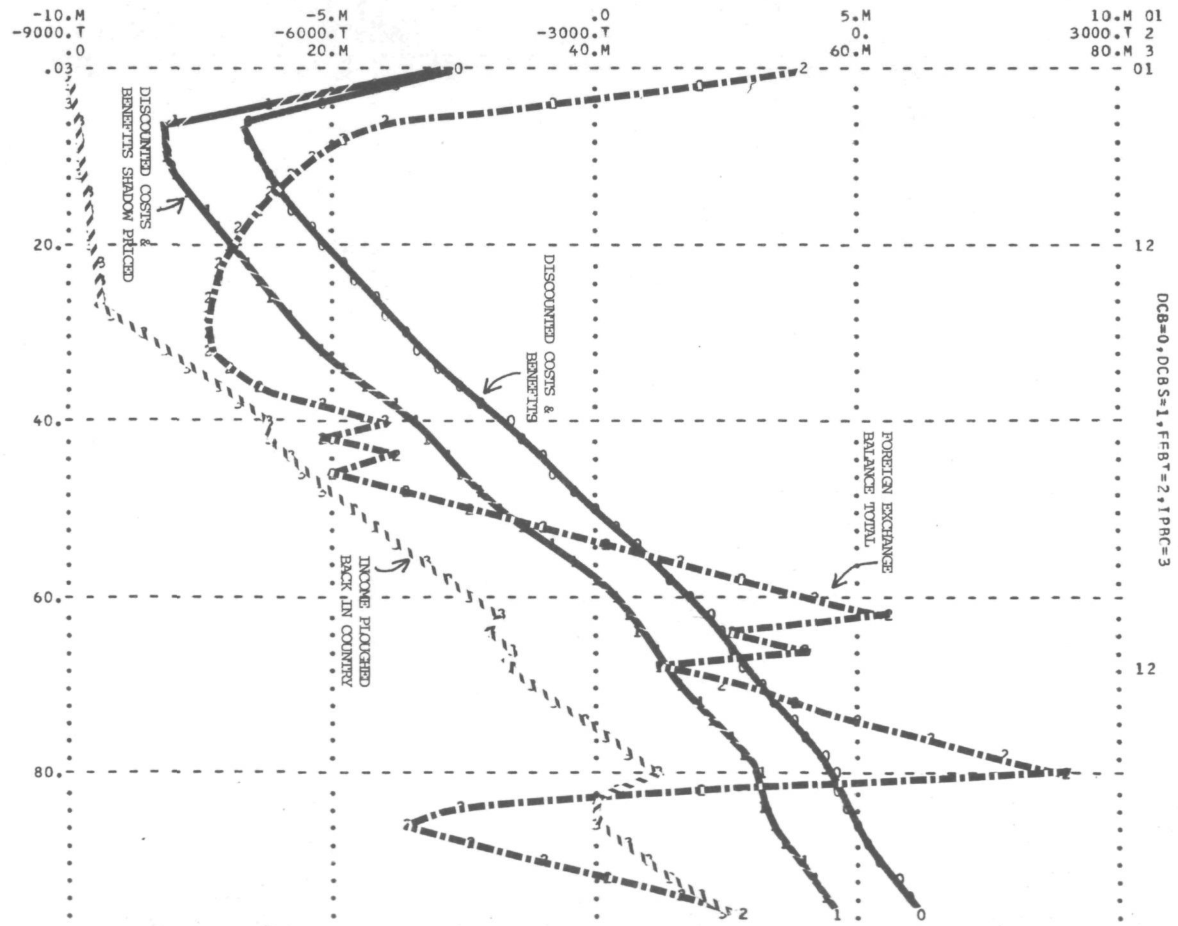
TIME	NS LS	WC FEBT	WCG DCB	WCI DCBS	SDP IPBC	PRS	LR	LIP	LS1	LS2	LS3	LS4	LS5	LS6
E+00	E+00 E+06	E+06 E+03	E+03 E+03	E+03 E+03	E+00 E+06	E+00	E+03	E+03	E+03	E+03	E+03	E+03	E+03	E+03
.0	1.0000 1.875	-.63 -625.0	.00 -2500.0	.0 -2687.5	0. .000	0.	58.59	37.50	1875.0	.0	.0	.0	.0	.0
2.	2.0000 4.321	-1.97 -1806.9	-36.97 -3714.6	-59.0 -4240.8	0. .188	0.	140.63	86.43	1757.8	2563.5	.0	.0	.0	.0
4.	4.0000 6.935	-3.59 -3431.9	191.98 -5162.4	-107.7 -6125.4	0. .376	0.	234.38	138.69	1640.6	2399.4	1063.5	1831.1	.0	.0
6.	6.0000 10.046	-5.32 -5415.2	592.85 -6632.4	-159.7 -8099.2	0. .564	0.	351.56	200.92	1523.4	2235.3	993.2	1713.9	2481.4	1098.6
8.	6.0000 9.343	-5.33 -5925.3	850.72 -6689.2	-159.8 -8283.9	0. .752	0.	351.56	186.85	1406.2	2071.3	922.8	1596.7	2317.4	1028.3
10.	6.0000 8.640	-5.00 -6203.7	850.72 -6469.5	-150.0 -8124.4	0. .940	0.	351.56	172.79	1289.0	1907.2	852.5	1479.5	2153.3	958.0
12.	6.0000 7.936	-4.63 -6454.0	850.72 -6229.3	-138.8 -7933.3	0. 1.128	0.	351.56	158.73	1171.8	1743.2	782.2	1362.3	1989.3	887.7
14.	6.0000 7.233	-4.20 -6676.1	850.72 -5976.0	-126.0 -7720.3	0. 1.316	0.	351.56	144.67	1054.7	1579.1	711.9	1245.1	1825.2	817.4
16.	6.0000 6.530	-3.72 -6870.2	850.72 -5711.4	-111.6 -7488.2	0. 1.504	0.	351.56	130.60	937.5	1415.0	641.6	1127.9	1661.1	747.1
18.	6.0000 5.827	-3.18 -7036.1	850.72 -5436.7	-95.4 -7239.2	0. 1.692	0.	351.56	116.54	820.3	1251.0	571.3	1010.7	1497.1	676.8
20.	6.0000 5.124	-2.58 -7173.8	850.72 -5153.4	-77.3 -6975.6	0. 1.880	0.	351.56	102.48	703.1	1086.9	501.0	893.5	1333.0	606.4
22.	6.0000 4.421	-1.91 -7283.5	850.72 -4862.5	-57.2 -6699.3	0. 2.068	0.	351.56	88.42	585.9	922.8	430.7	776.3	1168.9	536.1
24.	6.0000 3.718	-1.17 -7365.0	850.72 -4565.2	-35.1 -6412.0	0. 2.256	0.	351.56	74.35	468.7	758.8	360.3	659.1	1004.9	465.8
26.	6.0000 3.015	-.36 -7418.4	850.72 -4262.6	-10.7 -6115.5	0. 2.444	0.	351.56	60.29	351.5	594.7	290.0	542.0	840.8	395.5
28.	6.0000 2.311	.53 -7443.7	850.72 -3955.5	16.0 -5811.0	0. 3.483	0.	351.56	46.23	234.3	430.6	219.7	424.8	676.7	325.2
30.	6.0000 1.608	1.51 -7440.9	850.72 -3644.7	45.3 -5500.0	0. 5.372	0.	351.56	32.17	117.2	266.6	149.4	307.6	512.7	254.9
32.	6.0000 .905	2.57 -7409.9	850.72 -3331.1	77.2 -5183.7	0. 7.262	0.	351.56	18.10	.0	102.5	79.1	190.4	348.6	184.6
34.	6.0000 .381	3.88 -7244.1	850.72 -2986.0	116.3 -4824.9	0. 9.151	0.	210.94	7.62	.0	.0	8.8	73.2	184.6	114.3
36.	6.0000 .064	5.50 -6828.4	850.72 -2581.6	165.1 -4388.9	0. 11.040	0.	117.19	1.29	.0	.0	.0	.0	20.5	43.9
38.	6.0000 .000	7.49 -6163.0	850.72 -2124.6	224.7 -3885.0	0. 12.930	0.	.00	.00	.0	.0	.0	.0	.0	.0
40.	6.0000 .000	9.70 -5373.4	850.72 -1647.6	290.9 -3356.4	0. 14.819	0.	.00	.00	.0	.0	.0	.0	.0	.0
42.	6.0000 .000	10.52 -6083.8	850.72 -1476.1	315.6 -3225.6	0. 15.209	0.	.00	.00	.0	.0	.0	.0	.0	.0
44.	6.0000 .000	12.91 -5294.1	850.72 -1033.9	387.4 -2739.3	0. 17.098	0.	.00	.00	.0	.0	.0	.0	.0	.0
46.	6.0000 .000	13.89 -6004.5	850.72 -871.4	416.6 -2614.6	0. 17.488	0.	.00	.00	.0	.0	.0	.0	.0	.0
48.	6.0000 .000	16.49 -5214.8	850.72 -460.6	494.7 -2166.1	0. 19.377	0.	.00	.00	.0	.0	.0	.0	.0	.0
50.	6.0000 .000	19.25 -4425.2	850.72 -57.4	577.6 -1728.1	0. 21.266	0.	.00	.00	.0	.0	.0	.0	.0	.0
52.	6.0000 .000	22.19 -3635.6	850.72 338.4	665.6 -1300.1	0. 23.156	0.	.00	.00	.0	.0	.0	.0	.0	.0
54.	6.0000 .000	25.30 -2845.9	850.72 726.8	759.0 -881.9	0. 25.045	0.	.00	.00	.0	.0	.0	.0	.0	.0
56.	6.0000 .000	28.60 -2056.3	850.72 1108.0	858.1 -473.1	0. 26.935	0.	.00	.00	.0	.0	.0	.0	.0	.0
58.	6.0000 .000	32.11 -1266.6	850.72 1482.2	963.4 -73.5	0. 28.824	0.	.00	.00	.0	.0	.0	.0	.0	.0
60.	6.0000 .000	35.84 -477.0	850.72 1849.4	1075.1 317.3	0. 30.713	0.	.00	.00	.0	.0	.0	.0	.0	.0
62.	6.0000 .000	39.79 312.6	850.72 2209.9	1193.8 699.5	0. 32.603	0.	.00	.00	.0	.0	.0	.0	.0	.0
64.	6.0000 .000	41.43 -1397.7	850.72 2351.4	1243.0 798.4	0. 31.992	0.	.00	.00	.0	.0	.0	.0	.0	.0
66.	6.0000 .000	45.73 -608.1	850.72 2686.4	1372.0 1152.0	0. 33.882	0.	.00	.00	.0	.0	.0	.0	.0	.0
68.	6.0000 .000	47.68 -2318.4	850.72 2824.2	1430.4 1251.7	0. 33.271	0.	.00	.00	.0	.0	.0	.0	.0	.0

MODEL 9 - 6 SHIPS FINANCED BY LOANS

TIME	NS	WC	WCG	WCI	SDP	PRS	LR	LIP	LS1	LS2	LS3	LS4	LS5	LS6
	LS	FEBT	DCB	DCBS	IPBC									
70.	6.0000	52.36	850.72	1570.9	0.	0.	.00	.00	.0	.0	.0	.0	.0	.0
	.000	-1528.8	3136.2	1579.6	35.160									
72.	6.0000	57.34	850.72	1720.1	0.	0.	.00	.00	.0	.0	.0	.0	.0	.0
	.000	-739.2	3442.4	1900.5	37.050									
74.	6.0000	62.62	850.72	1878.5	0.	0.	.00	.00	.0	.0	.0	.0	.0	.0
	.000	50.5	3742.9	2214.7	38.939									
76.	6.0000	68.22	850.72	2046.6	0.	0.	.00	.00	.0	.0	.0	.0	.0	.0
	.000	840.1	4037.9	2522.3	40.829									
78.	6.0000	74.17	850.72	2225.1	0.	0.	.00	.00	.0	.0	.0	.0	.0	.0
	.000	1629.8	4327.4	2823.4	42.718									
80.	6.0000	80.48	850.72	2414.5	0.	0.	.00	.00	.0	.0	.0	.0	.0	.0
	.000	2419.4	4611.6	3118.3	44.608									
82.	6.0000	82.01	850.72	2460.2	0.	0.	.00	.00	.0	.0	.0	.0	.0	.0
	.000	-1791.0	4674.3	3127.9	41.497									
84.	6.0000	85.25	850.72	2557.5	0.	0.	.00	.00	.0	.0	.0	.0	.0	.0
	.000	-4501.3	4802.5	3225.5	39.886									
86.	6.0000	90.68	850.72	2720.4	0.	0.	.00	.00	.0	.0	.0	.0	.0	.0
	.000	-5211.7	4994.8	3409.9	40.276									
88.	6.0000	98.01	850.72	2940.4	0.	0.	.00	.00	.0	.0	.0	.0	.0	.0
	.000	-4422.1	5235.9	3658.9	42.165									
90.	6.0000	105.80	850.72	3173.9	0.	0.	.00	.00	.0	.0	.0	.0	.0	.0
	.000	-3632.4	5472.5	3902.8	44.055									
92.	6.0000	114.06	850.72	3421.8	0.	0.	.00	.00	.0	.0	.0	.0	.0	.0
	.000	-2842.8	5704.7	4141.7	45.944									
94.	6.0000	122.83	850.72	3685.0	0.	0.	.00	.00	.0	.0	.0	.0	.0	.0
	.000	-2053.1	5932.7	4375.9	47.833									
96.	6.0000	132.15	850.72	3964.4	0.	0.	.00	.00	.0	.0	.0	.0	.0	.0
	.000	-1263.5	6156.4	4605.4	49.723									




-5.M .0 -100.T
.0 100.T .0
5.M 200.T 100.T
10.M 300.T 200.T
15.M 0 400.T 1 300.T 2
LOAN ON SHIPS
LOAN REPAYMENTS
LS=0,LR=1,LIP=2


-10.M -9000.T .0
-5.M -6000.T 20.M
.0 -3000.T 40.M
5.M 0. 60.M
10.M 01 3000.T 2 80.M 3
DISCOUNTED COSTS & BENEFITS SHADOW PRICED
DISCOUNTED COSTS & BENEFITS
FOREIGN EXCHANGE BALANCE TOTAL
INCOME PLOUGHED BACK IN COUNTRY
DCB=0,DCBS=1,FFBT=2,IPRC=3

5.4 MODEL 10 - CASH FLOW MODEL OF 6 SHIPS WITH CHANGING OPERATING COSTS

The causal-loop diagram of the model can be found in paragraph 1.2,
The dynamo-flow diagram of the changing operating costs section is presented on the following page.

. parameter values

The ships have an average lifetime of 100 quarters. The operating costs are constant for ships younger than 60 quarters, but they increase with 10 percent for ships older than 60 quarters.
In the model, the mechanism works as follows: when the remaining lifetime of the ship is bigger than 41 quarters, the operating costs are equal to the standard operating cost (£110,000/quarter); as soon as the remaining lifetime is less than 41 quarters, the operating costs are 1.1 x the standard operating cost.
As a consequence of the changing operating costs, the nett income of each ship has to be calculated separately.
The other assumptions are identical with the ones of model 8.

. documentor listing of the relevant equations

```
NIS1.K=(((GR.K-VE.K)*OD)/RT)-OCS1.K
     NIS1     - NETT INCOME SHIP 1    £/QUARTER
     GR       - GROSS REVENUE/SHIP/ROUNDTRIP  £
     VE       - VOYAGE EXPENDITURES/SHIP  £
     OD       - OPERATING DAYS OF SHIP    DAYS/QUARTER
     RT       - ROUNDTRIP TIME    DAYS
     OCS1     - OPERATING COST SHIP 1    £/QUARTER

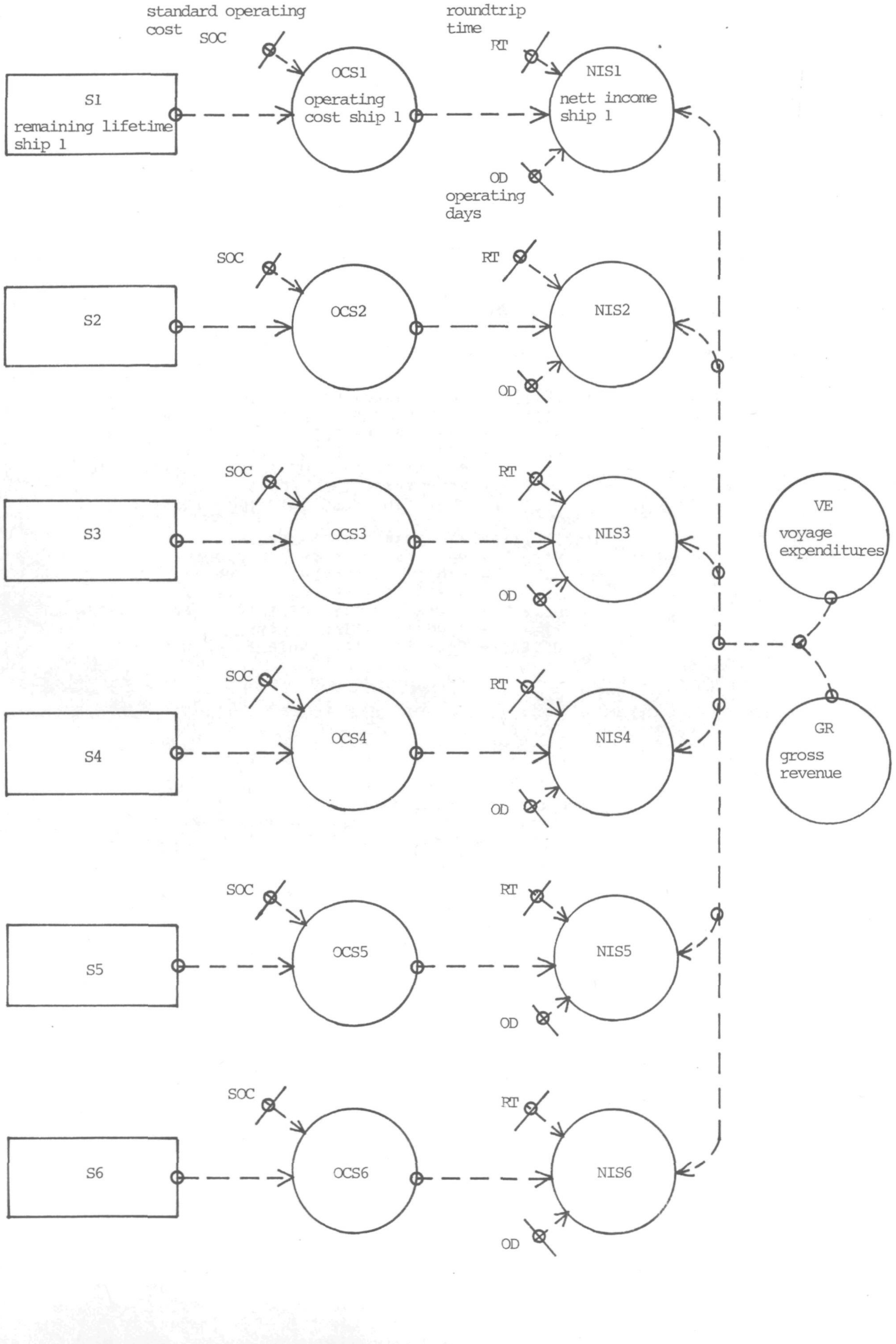
NIS2.K=(((GR.K-VE.K)*OD)/RT)-OCS2.K
     NIS2     - NETT INCOME SHIP 2    £/QUARTER
     GR       - GROSS REVENUE/SHIP/ROUNDTRIP  £
     VE       - VOYAGE EXPENDITURES/SHIP  £
     OD       - OPERATING DAYS OF SHIP    DAYS/QUARTER
     RT       - ROUNDTRIP TIME    DAYS
     OCS2     - OPERATING COST SHIP 2    £/QUARTER
```

etc., etc.

```
OCS1.K=CLIP(SOC,1.1*SOC,S1.K,41)
     OCS1     - OPERATING COST SHIP 1    £/QUARTER
     SOC      - STANDARD OPERATING COST    £/QUARTER
     S1       - REMAINING LIFETIME SHIP 1   QUARTERS

OCS2.K=CLIP(SOC,1.1*SOC,S2.K,41)
     OCS2     - OPERATING COST SHIP 2    £/QUARTER
     SOC      - STANDARD OPERATING COST    £/QUARTER
     S2       - REMAINING LIFETIME SHIP 2    QUARTERS
```

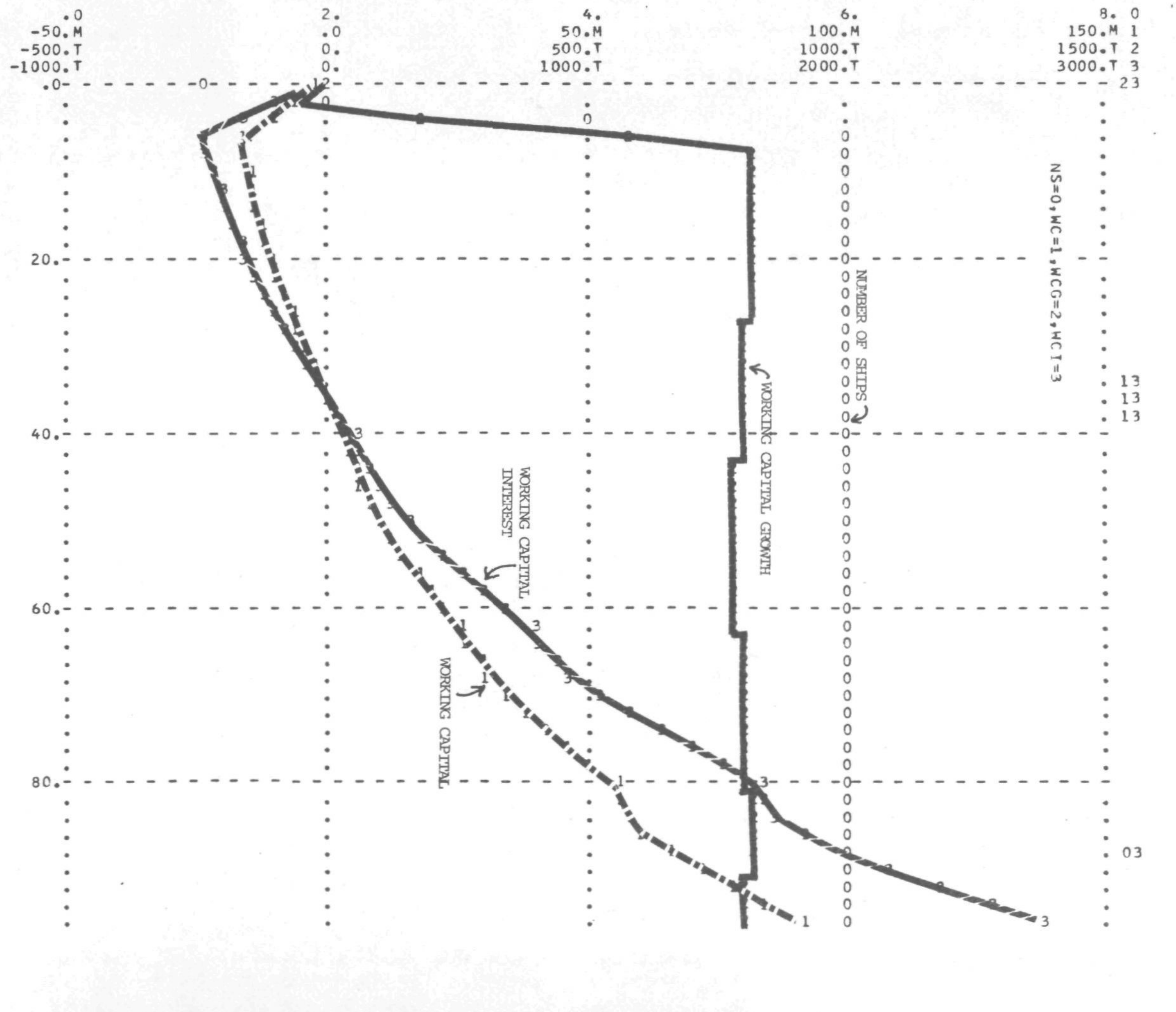
etc., etc.


standard operating cost
SOC
roundtrip time
RT
S1
remaining lifetime ship 1
OCS1
operating cost ship 1
NIS1
nett income ship 1
OD
operating days
SOC
RT
S2
OCS2
NIS2
OD
SOC
RT
S3
OCS3
NIS3
OD
VE
voyage expenditures
SOC
RT
S4
OCS4
NIS4
OD
GR
gross revenue
SOC
RT
S5
OCS5
NIS5
OD
SOC
RT
S6
OCS6
NIS6
OD

```
*    MODEL 10 - 6 SHIPS, CHANGING OPERATING COSTS
NOTE   NUMBER OF SHIPS IN FLEET
L    NS.K=NS.J+DT*NSG.JK
N    NS=1
R    NSG.KL=FED.K/DT
A    FED.K=CLIP(0,PULSE(1,1,1),TIME.K,6)
NOTE   NETT INCOME/SHIP/QUARTER
A    FT.K=LC*LFE.K
C    LC=14000
A    LFE.K=TABLE(LFET,TIME.K,0,96,8)
T    LFET=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A    IT.K=LC*LFI.K
A    LFI.K=TABLE(LFIT,TIME.K,0,96,8)
T    LFIT=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A    GRE.K=FT.K*FRE
C    FRE=25
A    GRI.K=IT.K*FRI
C    FRI=35
A    GR.K=GRE.K+GRI.K
A    AC.K=GR.K*ACS
C    ACS=.055
A    SC.K=(FT.K+IT.K)*SCT
C    SCT=6.25
A    CC.K=(FT.K+IT.K)*CCT
C    CCT=.4
A    SCC.K=(FT.K+IT.K)*SCCT
C    SCCT=1
C    B=58000
C    PC=45000
A    VE.K=AC.K+SCC.K+CC.K+SC.K+B+PC
A    NIS1.K=(((GR.K-VE.K)*OD)/RT)-OCS1.K
A    NIS2.K=(((GR.K-VE.K)*OD)/RT)-OCS2.K
A    NIS3.K=(((GR.K-VE.K)*OD)/RT)-OCS3.K
A    NIS4.K=(((GR.K-VE.K)*OD)/RT)-OCS4.K
A    NIS5.K=(((GR.K-VE.K)*OD)/RT)-OCS5.K
A    NIS6.K=(((GR.K-VE.K)*OD)/RT)-OCS6.K
C    OD=87.5
C    RT=118
A    OCS1.K=CLIP(SOC,1.1*SOC,S1.K,41)
A    OCS2.K=CLIP(SOC,1.1*SOC,S2.K,41)
A    OCS3.K=CLIP(SOC,1.1*SOC,S3.K,41)
A    OCS4.K=CLIP(SOC,1.1*SOC,S4.K,41)
A    OCS5.K=CLIP(SOC,1.1*SOC,S5.K,41)
A    OCS6.K=CLIP(SOC,1.1*SOC,S6.K,41)
C    SOC=110000
NOTE   TOTAL NETT INCOME SHIPPING OPERATIONS
A    TNI.K=NIS1.K+SWITCH(0,NIS2.K,S2.K)+SWITCH(0,NIS3.K,S3.K)+
X    SWITCH(0,NIS4.K,S4.K)+SWITCH(0,NIS5.K,S5.K)+SWITCH(0,NIS6.K,S6.K)-
X    AMC
C    AMC=94000
NOTE   WORKING CAPITAL
L    WC.K=WC.J+DT*(WCG.JK+WCI.JK-(PS.JK/DT)-PRS.JK/DT)
N    WC=-PPS1
R    WCG.KL=CLIP(TNI.K,0,TIME.K,DT)
R    WCI.KL=CLIP((WC.K*IR),0,TIME.K,DT)
C    IR=.03
R    PS.KL=SWITCH((CLIP((FED.K*PPS2),0,S1.K,1)),0,S2.K)+
X    SWITCH((CLIP((FED.K*PPS3),0,S2.K,1)),0,S3.K)+
X    SWITCH((CLIP((FED.K*PPS4),0,S3.K,1)),0,S4.K)+
X    SWITCH((CLIP((FED.K*PPS5),0,S4.K,1)),0,S5.K)+
X    SWITCH((CLIP((FED.K*PPS6),0,S5.K,1)),0,S6.K)
R    PRS.KL=SWITCH(PPS1,0,(S1.K-1))+SWITCH(PPS2,0,(S2.K-1))+
X    SWITCH(PPS3,0,(S3.K-1))+SWITCH(PPS4,0,(S4.K-1))+
X    SWITCH(PPS5,0,(S5.K-1))+SWITCH(PPS6,0,(S6.K-1))
C    PPS1=2.5E6
C    PPS2=3.5E6
C    PPS3=1.5E6
C    PPS4=2.5E6
C    PPS5=3.5E6
C    PPS6=1.5E6
NOTE   AGEING MECHANISM OF SHIPS
L    S1.K=S1.J+DT*((R1.JK/DT)-AR1.JK)
N    S1=LTS1
C    LTS1=64
R    R1.KL=SWITCH(LTS1,0,(S1.K-1))
R    AR1.KL=1
L    S2.K=S2.J+DT*((R2.JK/DT)-AR2.JK)
N    S2=0
R    R2.KL=SWITCH((CLIP((FED.K*LTS2),0,S1.K,1)),0,S2.K)+
X    SWITCH(LTS2,0,(S2.K-1))
C    LTS2=80
R    AR2.KL=CLIP(1,0,S2.K,1)
L    S3.K=S3.J+DT*((R3.JK/DT)-AR3.JK)
N    S3=0
R    R3.KL=SWITCH((CLIP((FED.K*LTS3),0,S2.K,1)),0,S3.K)+
X    SWITCH(LTS3,0,(S3.K-1))
C    LTS3=40
R    AR3.KL=CLIP(1,0,S3.K,1)
L    S4.K=S4.J+DT*((R4.JK/DT)-AR4.JK)
N    S4=0
R    R4.KL=SWITCH((CLIP((FED.K*LTS4),0,S3.K,1)),0,S4.K)+
X    SWITCH(LTS4,0,(S4.K-1))
C    LTS4=64
R    AR4.KL=CLIP(1,0,S4.K,1)
L    S5.K=S5.J+DT*((R5.JK/DT)-AR5.JK)
N    S5=0
R    R5.KL=SWITCH((CLIP((FED.K*LTS5),0,S4.K,1)),0,S5.K)+
X    SWITCH(LTS5,0,(S5.K-1))
C    LTS5=80
R    AR5.KL=CLIP(1,0,S5.K,1)
L    S6.K=S6.J+DT*((R6.JK/DT)-AR6.JK)
N    S6=0
R    R6.KL=SWITCH((CLIP((FED.K*LTS6),0,S5.K,1)),0,S6.K)+
X    SWITCH(LTS6,0,(S6.K-1))
C    LTS6=40
R    AR6.KL=CLIP(1,0,S6.K,1)
SPEC   LENGTH=96/DT=.25/PRTPER=2/PLTPER=2
PRINT   NS,WC,WCG,WCI,PS,PRS
PRINT   NIS1,NIS2,NIS3,NIS4,NIS5,NIS6
PLOT   NS/WC/WCG/WCI
RUN
```

MODEL 10 - 6 SHIPS, CHANGING OPERATING COSTS

TIME E+00	NS E+00	WC E+06	WCG E+03	WCI E+03	PS E+03	PRS E+00	NIS1 E+03	NIS2 E+03	NIS3 E+03	NIS4 E+03	NIS5 E+03	NIS6 E+03
.0	1.0000	-2.500	.00	.0	.0	0.	-14.46	-25.46	-25.46	-25.46	-25.46	-25.46
2.	2.0000	-6.356	-36.97	-190.7	1500.0	0.	28.52	28.52	17.52	17.52	17.52	17.52
4.	4.0000	-10.769	180.98	-323.1	3500.0	0.	71.50	71.50	60.50	71.50	60.50	60.50
6.	6.0000	-15.894	570.85	-476.8	.0	0.	114.47	114.47	103.47	114.47	114.47	103.47
8.	6.0000	-15.472	828.72	-464.1	.0	0.	157.45	157.45	146.45	157.45	157.45	146.45
10.	6.0000	-14.723	828.72	-441.7	.0	0.	157.45	157.45	146.45	157.45	157.45	146.45
12.	6.0000	-13.928	828.72	-417.9	.0	0.	157.45	157.45	146.45	157.45	157.45	146.45
14.	6.0000	-13.085	828.72	-392.5	.0	0.	157.45	157.45	146.45	157.45	157.45	146.45
16.	6.0000	-12.189	828.72	-365.7	.0	0.	157.45	157.45	146.45	157.45	157.45	146.45
18.	6.0000	-11.238	828.72	-337.2	.0	0.	157.45	157.45	146.45	157.45	157.45	146.45
20.	6.0000	-10.229	828.72	-306.9	.0	0.	157.45	157.45	146.45	157.45	157.45	146.45
22.	6.0000	-9.158	828.72	-274.7	.0	0.	157.45	157.45	146.45	157.45	157.45	146.45
24.	6.0000	-8.028	817.72	-240.9	.0	0.	146.45	157.45	146.45	157.45	157.45	146.45
26.	6.0000	-6.844	817.72	-205.3	.0	0.	146.45	157.45	146.45	157.45	157.45	146.45
28.	6.0000	-5.603	806.72	-168.1	.0	0.	146.45	157.45	146.45	146.45	157.45	146.45
30.	5.0000	-4.292	806.72	-128.8	.0	0.	146.45	157.45	146.45	146.45	157.45	146.45
32.	6.0000	-2.900	806.72	-87.0	.0	0.	146.45	157.45	146.45	146.45	157.45	146.45
34.	6.0000	-1.422	806.72	-42.7	.0	0.	146.45	157.45	146.45	146.45	157.45	146.45
36.	6.0000	.147	806.72	4.4	.0	0.	146.45	157.45	146.45	146.45	157.45	146.45
38.	6.0000	1.812	806.72	54.4	.0	0.	146.45	157.45	146.45	146.45	157.45	146.45
40.	6.0000	3.580	806.72	107.4	.0	0.	146.45	157.45	146.45	146.45	157.45	146.45
42.	6.0000	3.918	795.72	117.5	.0	0.	146.45	146.45	146.45	146.45	157.45	146.45
44.	6.0000	5.788	784.72	173.6	.0	0.	146.45	146.45	146.45	146.45	146.45	146.45
46.	6.0000	6.186	784.72	185.6	.0	0.	146.45	146.45	146.45	146.45	146.45	146.45
48.	6.0000	8.179	784.72	245.4	.0	0.	146.45	146.45	146.45	146.45	146.45	146.45
50.	6.0000	10.294	784.72	308.8	.0	0.	146.45	146.45	146.45	146.45	146.45	146.45
52.	6.0000	12.539	784.72	376.2	.0	0.	146.45	146.45	146.45	146.45	146.45	146.45
54.	6.0000	14.923	784.72	447.7	.0	0.	146.45	146.45	146.45	146.45	146.45	146.45
56.	6.0000	17.453	784.72	523.6	.0	0.	146.45	146.45	146.45	146.45	146.45	146.45
58.	6.0000	20.140	784.72	604.2	.0	0.	146.45	146.45	146.45	146.45	146.45	146.45
60.	6.0000	22.991	784.72	689.7	.0	0.	146.45	146.45	146.45	146.45	146.45	146.45
62.	6.0000	26.019	784.72	780.6	.0	0.	146.45	146.45	146.45	146.45	146.45	146.45
64.	6.0000	26.684	795.72	800.5	.0	0.	157.45	146.45	146.45	146.45	146.45	146.45
66.	6.0000	29.962	795.72	898.9	.0	0.	157.45	146.45	146.45	146.45	146.45	146.45
68.	6.0000	30.844	806.72	925.3	.0	0.	157.45	146.45	146.45	157.45	146.45	146.45
70.	6.0000	34.400	806.72	1032.0	.0	0.	157.45	146.45	146.45	157.45	146.45	146.45
72.	6.0000	38.175	806.72	1145.3	.0	0.	157.45	146.45	146.45	157.45	146.45	146.45
74.	6.0000	42.183	806.72	1265.5	.0	0.	157.45	146.45	146.45	157.45	146.45	146.45
76.	6.0000	46.438	806.72	1393.1	.0	0.	157.45	146.45	146.45	157.45	146.45	146.45
78.	6.0000	50.955	806.72	1528.6	.0	0.	157.45	146.45	146.45	157.45	146.45	146.45
80.	6.0000	55.750	806.72	1672.5	.0	0.	157.45	146.45	146.45	157.45	146.45	146.45
82.	6.0000	55.674	817.72	1670.2	.0	0.	157.45	157.45	146.45	157.45	146.45	146.45
84.	6.0000	57.235	828.72	1717.1	.0	0.	157.45	157.45	146.45	157.45	157.45	146.45
86.	6.0000	60.894	828.72	1826.8	.0	0.	157.45	157.45	146.45	157.45	157.45	146.45
88.	6.0000	66.338	817.72	1990.1	.0	0.	146.45	157.45	146.45	157.45	157.45	146.45
90.	6.0000	72.103	817.72	2163.1	.0	0.	146.45	157.45	146.45	157.45	157.45	146.45
92.	6.0000	78.207	806.72	2346.2	.0	0.	146.45	157.45	146.45	146.45	157.45	146.45
94.	6.0000	84.681	806.72	2540.4	.0	0.	146.45	157.45	146.45	146.45	157.45	146.45
96.	6.0000	91.553	806.72	2746.6	.0	0.	146.45	157.45	146.45	146.45	157.45	146.45



5.5 MODEL 11 - CASH FLOW MODEL OF 6 SHIPS OF CLASS X AND Y

The causal-loop diagram of the model can be found in paragraph 1.2.
The dynamo-flow diagram of the nett income per ship of class x calculation is presented on the following page.

. parameter values
The load capacity of ship x (14,000 tons) is identical to the ones used in all previous models.
The class y ship has a smaller load capacity: 11,000 tons. The flow diagram also represents the calculation structure of the nett income of ship y, by simply changing the letter x in y.
The first, third and fifth ship which are purchased, are of class x. The second, fourth and sixth ship are of class y.

. documentor listing of the relevant equations

```
NS.K=NSX.K+NSY.K
     NS      - NUMBER OF SHIPS
     NSX     - NUMBER OF SHIPS CLASS X
     NSY     - NUMBER OF SHIPS CLASS Y

NSX.K=NSX.J+DT*NSXR.JK
NSX=1
     NSX     - NUMBER OF SHIPS CLASS X
     NSXR    - NUMBER OF SHIPS CLASS X RATE

NSXR.KL=SWITCH((FED.K/DT),0,(NSX.K-NSY.K))
     NSXR    - NUMBER OF SHIPS CLASS X RATE
     FED     - FLEET EXPANSION DECISION
     NSX     - NUMBER OF SHIPS CLASS X
     NSY     - NUMBER OF SHIPS CLASS Y

NSY.K=NSY.J+DT*NSYR.JK
NSY=0
     NSY     - NUMBER OF SHIPS CLASS Y
     NSYR    - NUMBER OF SHIPS CLASS Y RATE

NSYR.KL=SWITCH(0,(FED.K/DT),(NSX.K-NSY.K))
     NSYR    - NUMBER OF SHIPS CLASS Y RATE
     FED     - FLEET EXPANSION DECISION
     NSX     - NUMBER OF SHIPS CLASS X
     NSY     - NUMBER OF SHIPS CLASS Y

FED.K=CLIP(0,PULSE(1,1,1),TIME.K,6)
     FED     - FLEET EXPANSION DECISION

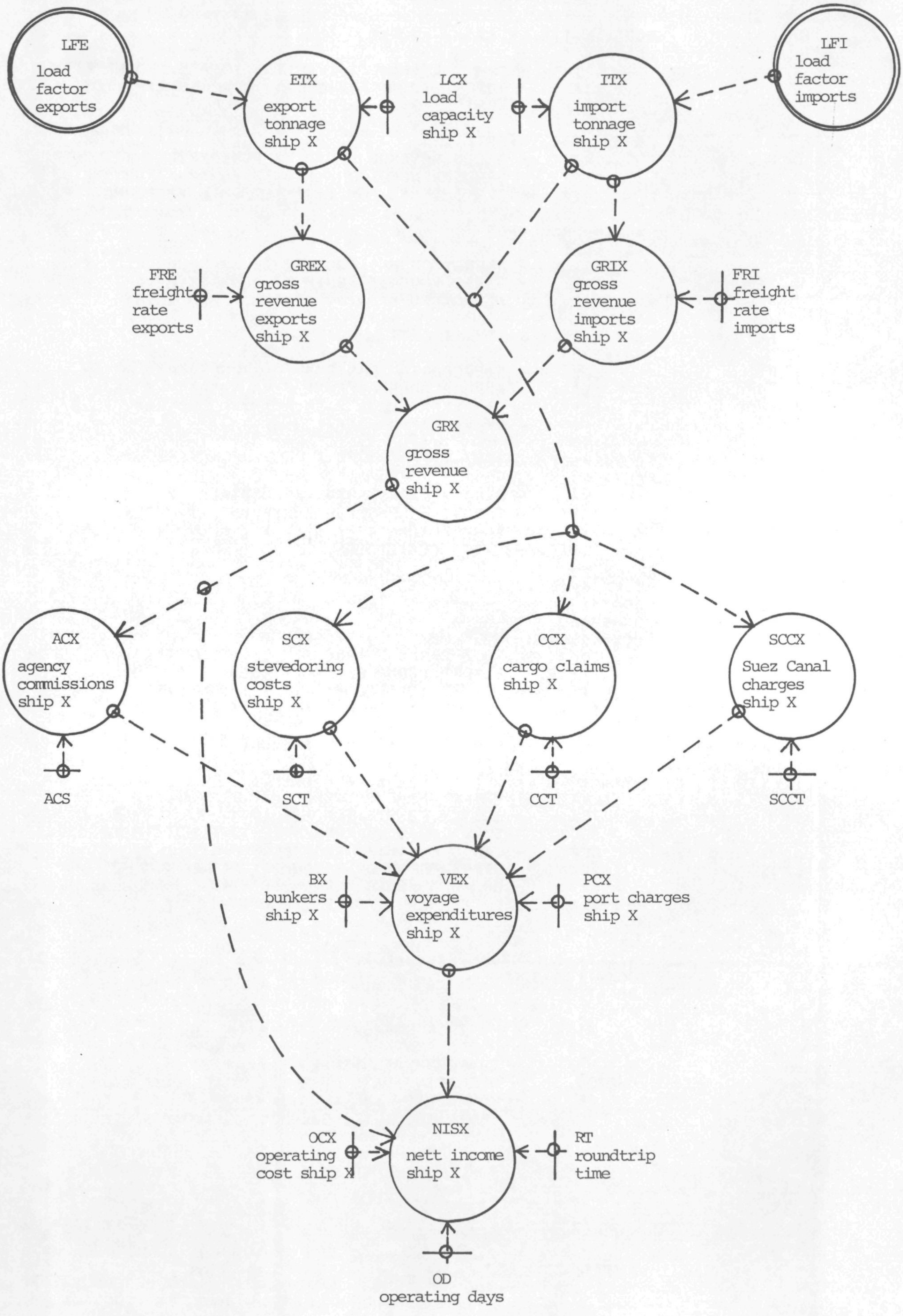
ETX.K=LCX*LFE.K
LCX=14000
     ETX     - EXPORT TONNAGE/SHIP X/ROUNDTRIP   TONS
     LCX     - LOAD CAPACITY SHIP X    TONS
     LFE     - LOAD FACTOR EXPORTS   DIM'LESS

LFE.K=TABHL(LFET,TIME.K,0,96,8)
LFET=.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
     LFE     - LOAD FACTOR EXPORTS   DIM'LESS
     LFET    - LOAD FACTOR EXPORTS TABLE

ITX.K=LCX*LFI.K
     ITX     - IMPORT TONNAGE / SHIP X / ROUNDTRIP   TONS
     LCX     - LOAD CAPACITY SHIP X    TONS
     LFI     - LOAD FACTOR IMPORTS   DIM'LESS

LFI.K=TABHL(LFIT,TIME.K,0,96,8)
LFIT=.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
     LFI     - LOAD FACTOR IMPORTS   DIM'LESS
     LFIT    - LOAD FACTOR IMPORTS TABLE

GREX.K=ETX.K*FRE
FRE=25
     GREX    - GROSS REVENUE ON EXPORTS /SHIP X/ROUNDTRIPƒ
     ETX     - EXPORT TONNAGE/SHIP X/ROUNDTRIP   TONS
     FRE     - FREIGHT RATE EXPORTS   ƒ/TON
```


LFE
load
factor
exports
ETX
export
tonnage
ship X
LCX
load
capacity
ship X
ITX
import
tonnage
ship X
LFI
load
factor
imports
FRE
freight
rate
exports
GREX
gross
revenue
exports
ship X
GRIX
gross
revenue
imports
ship X
FRI
freight
rate
imports
GRX
gross
revenue
ship X
ACX
agency
commissions
ship X
SCX
stevedoring
costs
ship X
CCX
cargo claims
ship X
SCCX
Suez Canal
charges
ship X
ACS
SCT
CCT
SCCT
BX
bunkers
ship X
VEX
voyage
expenditures
ship X
PCX
port charges
ship X
OCX
operating
cost ship X
NISX
nett income
ship X
RT
roundtrip
time
OD
operating days

```
GRIX.K=ITX.K*FRI
FRI=35
    GRIX    - GROSS REVENUEON IMPORTS /SHIP X/ ROUNDTRIPƒ
    ITX     - IMPORT TONNAGE / SHIP X / ROUNDTRIP  TONS
    FRI     - FREIGHT RATE IMPORTS     ƒ/TON

GRX.K=GREX.K+GRIX.K
    GRX     - GROSS REVENUE /SHIP X/ ROUNDTRIP  ƒ
    GREX    - GROSS REVENUE ON EXPORTS /SHIP X/ROUNDTRIPƒ
    GRIX    - GROSS REVENUEON IMPORTS /SHIP X/ ROUNDTRIPƒ

ACX.K=GRX.K*ACS
ACS=.055
    ACX     - AGENCY COMMISSIONS /SHIP X/ ROUNDTRIP  ƒ
    GRX     - GROSS REVENUE /SHIP X/ ROUNDTRIP  ƒ
    ACS     - AGENCY COMMISSIONS SHARE    DIM'LESS

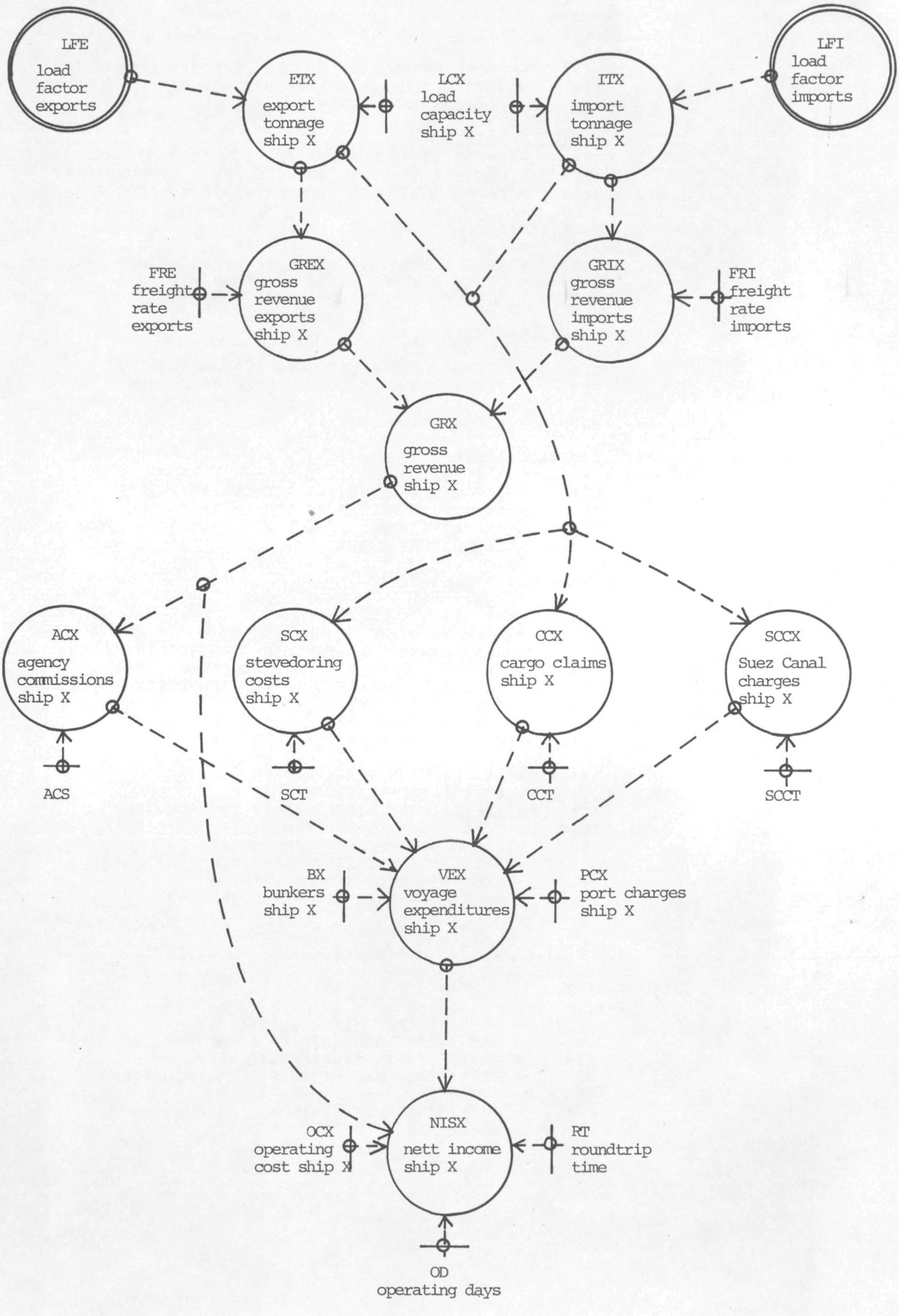
SCX.K=(ETX.K+ITX.K)*SCT
SCT=6.25
    SCX     - STEVEDORING COSTS/SHIP X/ROUNDTRIP  ƒ
    ETX     - EXPORT TONNAGE/SHIP X/ROUNDTRIP  TONS
    ITX     - IMPORT TONNAGE / SHIP X / ROUNDTRIP  TONS
    SCT     - STEVEDORING COST/TON  ƒ

CCX.K=(ETX.K+ITX.K)*CCT
CCT=.4
    CCX     - CARGO CLAIMS/SHIP X/ROUNDTRIP  ƒ
    ETX     - EXPORT TONNAGE/SHIP X/ROUNDTRIP  TONS
    ITX     - IMPORT TONNAGE / SHIP X / ROUNDTRIP  TONS
    CCT     - CARGO CLAIMS/TON   ƒ

SCCX.K=(ETX.K+ITX.K)*SCCT
SCCT=1
BX=58000
PCX=45000
    SCCX    - SUEZ CANAL CHARGES/SHIP X/ROUNDTRIP  ƒ
    ETX     - EXPORT TONNAGE/SHIP X/ROUNDTRIP  TONS
    ITX     - IMPORT TONNAGE / SHIP X / ROUNDTRIP  TONS
    SCCT    - SUEZ CANAL CHARGES/TON   ƒ
    BX      - BUNKERS /SHIP X/ROUNDTRIP  ƒ
    PCX     - PORT CHARGES/SHIP X/ROUNDTRIP  ƒ

VEX.K=ACX.K+SCCX.K+CCX.K+SCX.K+BX+PCX
    VEX     - VOYAGE EXPENDITURES/SHIP X  ƒ
    ACX     - AGENCY COMMISSIONS /SHIP X/ ROUNDTRIP  ƒ
    SCCX    - SUEZ CANAL CHARGES/SHIP X/ROUNDTRIP  ƒ
    CCX     - CARGO CLAIMS/SHIP X/ROUNDTRIP  ƒ
    SCX     - STEVEDORING COSTS/SHIP X/ROUNDTRIP  ƒ
    BX      - BUNKERS /SHIP X/ROUNDTRIP  ƒ
    PCX     - PORT CHARGES/SHIP X/ROUNDTRIP  ƒ

NISX.K=(((GRX.K-VEX.K)*OD)/RT)-OCX
OCX=110000
OD=87.5
RT=118
    NISX    - NETT INCOME/SHIP X/QUARTER  ƒ
    GRX     - GROSS REVENUE /SHIP X/ ROUNDTRIP  ƒ
    VEX     - VOYAGE EXPENDITURES/SHIP X  ƒ
    OD      - OPERATING DAYS OF SHIP    DAYS/QUARTER
    RT      - ROUNDTRIP TIME    DAYS
    OCX     - OPERATING COSTS SHIP X     ƒ/QUARTER
```


LFE
load
factor
exports
ETX
export
tonnage
ship X
LCX
load
capacity
ship X
ITX
import
tonnage
ship X
LFI
load
factor
imports
FRE
freight
rate
exports
GREX
gross
revenue
exports
ship X
GRIX
gross
revenue
imports
ship X
FRI
freight
rate
imports
GRX
gross
revenue
ship X
ACX
agency
commissions
ship X
SCX
stevedoring
costs
ship X
CCX
cargo claims
ship X
SCCX
Suez Canal
charges
ship X
ACS
SCT
CCT
SCCT
BX
bunkers
ship X
VEX
voyage
expenditures
ship X
PCX
port charges
ship X
OCX
operating
cost ship X
NISX
nett income
ship X
RT
roundtrip
time
OD
operating days

```
GRIX.K=ITX.K*FRI
FRI=35
    GRIX    - GROSS REVENUEON IMPORTS /SHIP X/ ROUNDTRIP$
    ITX     - IMPORT TONNAGE / SHIP X / ROUNDTRIP  TONS
    FRI     - FREIGHT RATE IMPORTS    $/TON

GRX.K=GREX.K+GRIX.K
    GRX     - GROSS REVENUE /SHIP X/ ROUNDTRIP  $
    GREX    - GROSS REVENUE ON EXPORTS /SHIP X/ROUNDTRIP$
    GRIX    - GROSS REVENUEON IMPORTS /SHIP X/ ROUNDTRIP$

ACX.K=GRX.K*ACS
ACS=.055
    ACX     - AGENCY COMMISSIONS /SHIP X/ ROUNDTRIP  $
    GRX     - GROSS REVENUE /SHIP X/ ROUNDTRIP  $
    ACS     - AGENCY COMMISSIONS SHARE    DIM'LESS

SCX.K=(ETX.K+ITX.K)*SCT
SCT=6.25
    SCX     - STEVEDORING COSTS/SHIP X/ROUNDTRIP  $
    ETX     - EXPORT TONNAGE/SHIP X/ROUNDTRIP  TONS
    ITX     - IMPORT TONNAGE / SHIP X / ROUNDTRIP  TONS
    SCT     - STEVEDORING COST/TON  $

CCX.K=(ETX.K+ITX.K)*CCT
CCT=.4
    CCX     - CARGO CLAIMS/SHIP X/ROUNDTRIP  $
    ETX     - EXPORT TONNAGE/SHIP X/ROUNDTRIP  TONS
    ITX     - IMPORT TONNAGE / SHIP X / ROUNDTRIP  TONS
    CCT     - CARGO CLAIMS/TON   $

SCCX.K=(ETX.K+ITX.K)*SCCT
SCCT=1
BX=58000
PCX=45000
    SCCX    - SUEZ CANAL CHARGES/SHIP X/ROUNDTRIP  $
    ETX     - EXPORT TONNAGE/SHIP X/ROUNDTRIP  TONS
    ITX     - IMPORT TONNAGE / SHIP X / ROUNDTRIP  TONS
    SCCT    - SUEZ CANAL CHARGES/TON  $
    BX      - BUNKERS /SHIP X/ROUNDTRIP  $
    PCX     - PORT CHARGES/SHIP X/ROUNDTRIP  $

VEX.K=ACX.K+SCCX.K+CCX.K+SCX.K+BX+PCX
    VEX     - VOYAGE EXPENDITURES/SHIP X  $
    ACX     - AGENCY COMMISSIONS /SHIP X/ ROUNDTRIP  $
    SCCX    - SUEZ CANAL CHARGES/SHIP X/ROUNDTRIP  $
    CCX     - CARGO CLAIMS/SHIP X/ROUNDTRIP  $
    SCX     - STEVEDORING COSTS/SHIP X/ROUNDTRIP  $
    BX      - BUNKERS /SHIP X/ROUNDTRIP  $
    PCX     - PORT CHARGES/SHIP X/ROUNDTRIP  $

NISX.K=(((GRX.K-VEX.K)*OD)/RT)-OCX
OCX=110000
OD=87.5
RT=118
    NISX    - NETT INCOME/SHIP X/QUARTER  $
    GRX     - GROSS REVENUE /SHIP X/ ROUNDTRIP  $
    VEX     - VOYAGE EXPENDITURES/SHIP X  $
    OD      - OPERATING DAYS OF SHIP   DAYS/QUARTER
    RT      - ROUNDTRIP TIME    DAYS
    OCX     - OPERATING COSTS SHIP X    $/QUARTER
```

```
*  MODEL 11 - 6 SHIPS OF CLASS X & Y
NOTE   NUMBER OF SHIPS
A  NS.K=NSX.K+NSY.K
L  NSX.K=NSX.J+DT*NSXR.JK
N  NSX=1
R  NSXR.KL=SWITCH((FED.K/DT),0,(NSX.K-NSY.K))
L  NSY.K=NSY.J+DT*NSYR.JK
N  NSY=0
R  NSYR.KL=SWITCH(0,(FED.K/DT),(NSX.K-NSY.K))
A  FED.K=CLIP(0,PULSE(1,1,1),TIME.K,6)
NOTE   NETT INCOME/SHIP X /QUARTER
A  ETX.K=LCX*LFE.K
C  LCX=14000
A  LFE.K=TABHL(LFET,TIME.K,0,96,8)
T  LFET=.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A  ITX.K=LCX*LFI.K
A  LFI.K=TABHL(LFIT,TIME.K,0,96,8)
T  LFIT=.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A  GREX.K=ETX.K*FRE
C  FRE=25
A  GRIX.K=ITX.K*FRI
C  FRI=35
A  GRX.K=GREX.K+GRIX.K
A  ACX.K=GRX.K*ACS
C  ACS=.055
A  SCX.K=(ETX.K+ITX.K)*SCT
C  SCT=6.25
A  CCX.K=(ETX.K+ITX.K)*CCT
C  CCT=.4
A  SCCX.K=(ETX.K+ITX.K)*SCCT
C  SCCT=1
C  BX=58000
C  PCX=45000
A  VEX.K=ACX.K+SCCX.K+CCX.K+SCX.K+BX+PCX
A  NISX.K=(((GRX.K-VEX.K)*OD)/RT)-OCX
C  OCX=110000
C  OD=87.5
C  RT=118
NOTE   NETT INCOME/ SHIP Y / QUARTER
A  ETY.K=LCY*LFE.K
C  LCY=11000
A  ITY.K=LCY*LFI.K
A  GREY.K=ETY.K*FRE
A  GRIY.K=ITY.K*FRI
A  GRY.K=GREY.K+GRIY.K
A  ACY.K=GRY.K*ACS
A  CCY.K=(ETY.K+ITY.K)*CCT
A  SCY.K=(ETY.K+ITY.K)*SCT
A  SCCY.K=(ETY.K+ITY.K)*SCCT
C  BY=50000
C  PCY=40000
A  VEY.K=ACY.K+SCCY.K+CCY.K+SCY.K+BY+PCY
A  NISY.K=(((GRY.K-VEY.K)*OD)/RT)-OCY
C  OCY=95000
NOTE   TOTAL INCOME SHIPPING OPERATIONS
A  TNI.K=NISX.K*SWITCH(0,1,S1.K)+NISY.K*SWITCH(0,1,S2.K)+
X  NISX.K*SWITCH(0,1,S3.K)+NISY.K*SWITCH(0,1,S4.K)+
X  NISX.K*SWITCH(0,1,S5.K)+NISY.K*SWITCH(0,1,S6.K)-AMC
C  AMC=94000
```

```
NOTE   WORKING CAPITAL
L  WC.K=WC.J+DT*(WCG.JK+WCI.JK-(PS.JK/DT)-PRS.JK/DT)
N  WC=-PPS1
R  WCG.KL=CLIP(TNI.K,0,TIME.K,DT)
R  WCI.KL=CLIP((WC.K*IR),0,TIME.K,DT)
C  IR=.03
R  PS.KL=SWITCH((CLIP((FED.K*PPS2),0,S1.K,1)),0,S2.K)+
X  SWITCH((CLIP((FED.K*PPS3),0,S2.K,1)),0,S3.K)+
X  SWITCH((CLIP((FED.K*PPS4),0,S3.K,1)),0,S4.K)+
X  SWITCH((CLIP((FED.K*PPS5),0,S4.K,1)),0,S5.K)+
X  SWITCH((CLIP((FED.K*PPS6),0,S5.K,1)),0,S6.K)
R  PRS.KL=SWITCH(PPS1,0,(S1.K-1))+SWITCH(PPS2,0,(S2.K-1))+
X  SWITCH(PPS3,0,(S3.K-1))+SWITCH(PPS4,0,(S4.K-1))+
X  SWITCH(PPS5,0,(S5.K-1))+SWITCH(PPS6,0,(S6.K-1))
C  PPS1=2.5E6
C  PPS2=3.5E6
C  PPS3=1.5E6
C  PPS4=2.5E6
C  PPS5=3.5E6
C  PPS6=1.5E6
NOTE   AGEING MECHANISM OF SHIPS
L  S1.K=S1.J+DT*((R1.JK/DT)-AR1.JK)
N  S1=LTS1
C  LTS1=64
R  R1.KL=SWITCH(LTS1,0,(S1.K-1))
R  AR1.KL=1
L  S2.K=S2.J+DT*((R2.JK/DT)-AR2.JK)
N  S2=0
R  R2.KL=SWITCH((CLIP((FED.K*LTS2),0,S1.K,1)),0,S2.K)+
X  SWITCH(LTS2,0,(S2.K-1))
C  LTS2=80
R  AR2.KL=CLIP(1,0,S2.K,1)
L  S3.K=S3.J+DT*((R3.JK/DT)-AR3.JK)
N  S3=0
R  R3.KL=SWITCH((CLIP((FED.K*LTS3),0,S2.K,1)),0,S3.K)+
X  SWITCH(LTS3,0,(S3.K-1))
C  LTS3=40
R  AR3.KL=CLIP(1,0,S3.K,1)
L  S4.K=S4.J+DT*((R4.JK/DT)-AR4.JK)
N  S4=0
R  R4.KL=SWITCH((CLIP((FED.K*LTS4),0,S3.K,1)),0,S4.K)+
X  SWITCH(LTS4,0,(S4.K-1))
C  LTS4=64
R  AR4.KL=CLIP(1,0,S4.K,1)
L  S5.K=S5.J+DT*((R5.JK/DT)-AR5.JK)
N  S5=0
R  R5.KL=SWITCH((CLIP((FED.K*LTS5),0,S4.K,1)),0,S5.K)+
X  SWITCH(LTS5,0,(S5.K-1))
C  LTS5=80
R  AR5.KL=CLIP(1,0,S5.K,1)
L  S6.K=S6.J+DT*((R6.JK/DT)-AR6.JK)
N  S6=0
R  R6.KL=SWITCH((CLIP((FED.K*LTS6),0,S5.K,1)),0,S6.K)+
X  SWITCH(LTS6,0,(S6.K-1))
C  LTS6=40
R  AR6.KL=CLIP(1,0,S6.K,1)
SPEC  LENGTH=96/DT=.25/PRTPER=2/PLTPER=2
PRINT  NS,NSX,NSY,WC,WCG,WCI,PS,PRS,NISX,NISY
PLOT  NS/WC/WCG/WCI
RUN
```

MODEL 11 - 6 SHIPS OF CLASS X & Y

TIME	NS	NSX	NSY	WC	WCG	WCI	PS	PRS	NISX	NISY
E+00	E+00	E+00	E+00	E+06	E+03	E+03	E+03	E+00	E+03	E+03
.0	1.0000	1.0000	.0000	-2.500	.00	.0	.0	0.	157.45	108.42
2.	2.0000	1.0000	1.0000	-6.018	171.87	-180.5	1500.0	0.	157.45	108.42
4.	4.0000	2.0000	2.0000	-9.809	437.74	-294.3	3500.0	0.	157.45	108.42
6.	6.0000	3.0000	3.0000	-14.373	703.60	-431.2	.0	0.	157.45	108.42
8.	6.0000	3.0000	3.0000	-13.814	703.60	-414.4	.0	0.	157.45	108.42
10.	6.0000	3.0000	3.0000	-13.220	703.60	-396.6	.0	0.	157.45	108.42
12.	6.0000	3.0000	3.0000	-12.589	703.60	-377.7	.0	0.	157.45	108.42
14.	6.0000	3.0000	3.0000	-11.920	703.60	-357.6	.0	0.	157.45	108.42
16.	6.0000	3.0000	3.0000	-11.210	703.60	-336.3	.0	0.	157.45	108.42
18.	6.0000	3.0000	3.0000	-10.456	703.60	-313.7	.0	0.	157.45	108.42
20.	6.0000	3.0000	3.0000	-9.655	703.60	-289.6	.0	0.	157.45	108.42
22.	6.0000	3.0000	3.0000	-8.805	703.60	-264.1	.0	0.	157.45	108.42
24.	6.0000	3.0000	3.0000	-7.903	703.60	-237.1	.0	0.	157.45	108.42
26.	6.0000	3.0000	3.0000	-6.945	703.60	-208.3	.0	0.	157.45	108.42
28.	6.0000	3.0000	3.0000	-5.928	703.60	-177.8	.0	0.	157.45	108.42
30.	6.0000	3.0000	3.0000	-4.848	703.60	-145.4	.0	0.	157.45	108.42
32.	6.0000	3.0000	3.0000	-3.702	703.60	-111.1	.0	0.	157.45	108.42
34.	6.0000	3.0000	3.0000	-2.486	703.60	-74.6	.0	0.	157.45	108.42
36.	6.0000	3.0000	3.0000	-1.194	703.60	-35.8	.0	0.	157.45	108.42
38.	6.0000	3.0000	3.0000	.177	703.60	5.3	.0	0.	157.45	108.42
40.	6.0000	3.0000	3.0000	1.633	703.60	49.0	.0	0.	157.45	108.42
42.	6.0000	3.0000	3.0000	1.656	703.60	49.7	.0	0.	157.45	108.42
44.	6.0000	3.0000	3.0000	3.202	703.60	96.1	.0	0.	157.45	108.42
46.	6.0000	3.0000	3.0000	3.275	703.60	98.3	.0	0.	157.45	108.42
48.	6.0000	3.0000	3.0000	4.922	703.60	147.7	.0	0.	157.45	108.42
50.	6.0000	3.0000	3.0000	6.670	703.60	200.1	.0	0.	157.45	108.42
52.	6.0000	3.0000	3.0000	8.525	703.60	255.8	.0	0.	157.45	108.42
54.	6.0000	3.0000	3.0000	10.495	703.60	314.9	.0	0.	157.45	108.42
56.	6.0000	3.0000	3.0000	12.586	703.60	377.6	.0	0.	157.45	108.42
58.	6.0000	3.0000	3.0000	14.806	703.60	444.2	.0	0.	157.45	108.42
60.	6.0000	3.0000	3.0000	17.163	703.60	514.9	.0	0.	157.45	108.42
62.	6.0000	3.0000	3.0000	19.665	703.60	590.0	.0	0.	157.45	108.42
64.	6.0000	3.0000	3.0000	19.764	703.60	592.9	.0	0.	157.45	108.42
66.	6.0000	3.0000	3.0000	22.426	703.60	672.8	.0	0.	157.45	108.42
68.	6.0000	3.0000	3.0000	22.628	703.60	679.1	.0	0.	157.45	108.42
70.	6.0000	3.0000	3.0000	25.477	703.60	764.3	.0	0.	157.45	108.42
72.	6.0000	3.0000	3.0000	28.491	703.60	854.7	.0	0.	157.45	108.42
74.	6.0000	3.0000	3.0000	31.691	703.60	950.7	.0	0.	157.45	108.42
76.	6.0000	3.0000	3.0000	35.087	703.60	1052.6	.0	0.	157.45	108.42
78.	6.0000	3.0000	3.0000	38.693	703.60	1160.8	.0	0.	157.45	108.42
80.	6.0000	3.0000	3.0000	42.522	703.60	1275.6	.0	0.	157.45	108.42
82.	6.0000	3.0000	3.0000	41.402	703.60	1242.1	.0	0.	157.45	108.42
84.	6.0000	3.0000	3.0000	41.845	703.60	1255.3	.0	0.	157.45	108.42
86.	6.0000	3.0000	3.0000	44.298	703.60	1328.9	.0	0.	157.45	108.42
88.	6.0000	3.0000	3.0000	48.472	703.60	1454.1	.0	0.	157.45	108.42
90.	6.0000	3.0000	3.0000	52.902	703.60	1587.1	.0	0.	157.45	108.42
92.	6.0000	3.0000	3.0000	57.605	703.60	1728.2	.0	0.	157.45	108.42
94.	6.0000	3.0000	3.0000	62.598	703.60	1878.0	.0	0.	157.45	108.42
96.	6.0000	3.0000	3.0000	67.899	703.60	2037.0	.0	0.	157.45	108.42


STEP
4

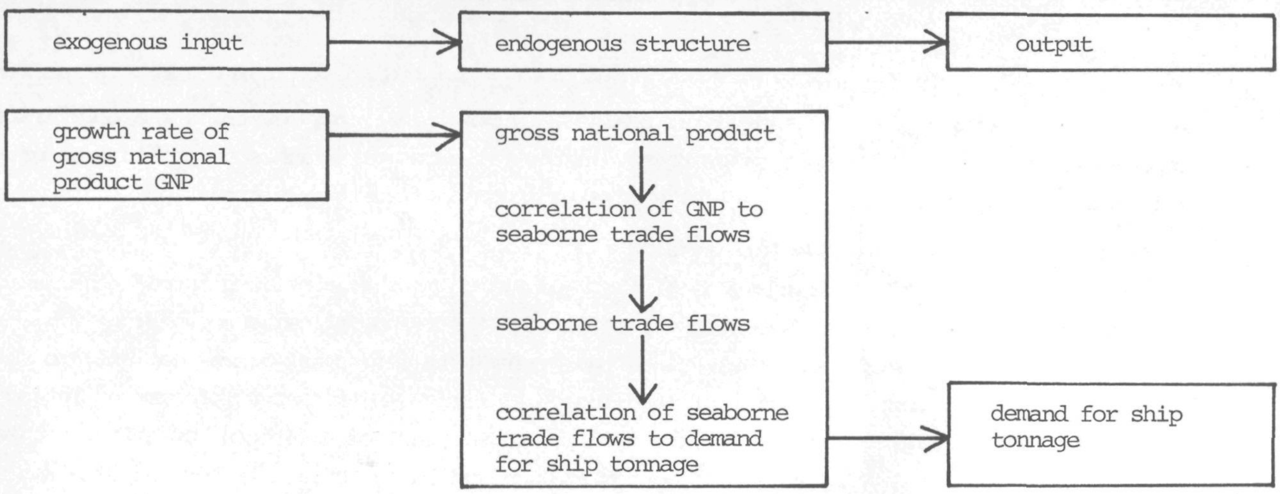
Chapter 6 - STEP 4: SEABORNE TRADE MODELS

6.1 MODEL 12 - SEABORNE TRADE FORECASTING MODEL

The importance of the relation between export and import cargo flows through the national port and the potential development of the national shipping line is discussed in Chapter 1. Forecasts of seaborne trade flows are thus essential for the assessment of the possibilities of the national shipping line. However, the construction of a forecasting model of seaborne trade in a developing country is quite difficult. In order to understand the problems, it is necessary to understand the calculation structure of forecasting models. Paragraph a discusses the structure of maritime forecasts; paragraph b discusses the problems associated with the construction of a seaborne trade model in the country under study; finally, paragraph c presents a scenario model of seaborne trade.

a. The structure of a typical maritime forecast [15]

The calculation structure of a typical maritime forecast is schematically:



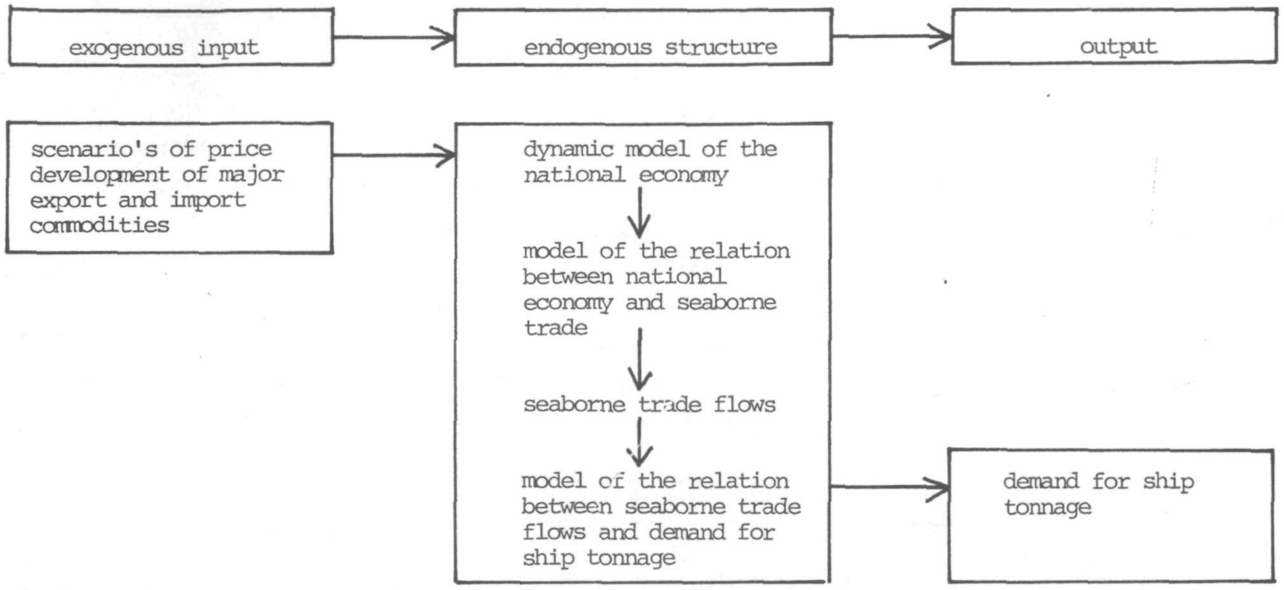
In order to calculate the output of the model, the demand for ship tonnage, assumptions have to be made on:

- the growth rate of the gross national product of the country in future years,
- the correlation of gross national product and seaborne trade flows,
- the correlation of seaborne trade flows to demand for ship tonnage.

The output of this kind of forecasts becomes exponentially unreliable with an increase of the time-horizon of the forecast, as:

- the assumptions about the growth rates of the economy become more and more unreliable,
- the correlation of GNP to seaborne trade flows is not static over time; the composition of export and import flows will change,
- the correlation between seaborne trade and demand for ship tonnage will change with a change in the composition of seaborne trade and a change in trade routes.

The major uncertainty in long-term forecasts is the development of the economy. The growth rate of the GNP is usually determined by extrapolating a series of growth rates from previous years. But since the sudden awareness of the limits to our earthly resources in 1972, and the coinciding increase in oil prices/availability, this procedure has been labelled unsatisfactory. A way out of this dilemma is to develop a completely endogenous model of the national economy, in which only the world prices of major export and import commodities are exogenous inputs. This implies that one has to make long term scenario's for the price development of these commodities. The calculation structure of such a forecasting model is schematically:



Although it is possible to construct such a forecasting model, witnessing the Mesarović-Pestel world model, it takes a lot of man-years. Besides, in many developing countries the data basis is completely insufficient for such an exercise. In the following paragraph some problems associated with the application of this theoretically ideal concept on a real-world situation is discussed.

b. Problems with seaborne trade forecasts

The construction of a forecasting model of the export and import cargo flows through the national port of the developing country under study, is difficult for the following reasons:

. regional transport function of the national port. The port serves as gateway not only to the country itself, but also to a number of land-locked countries in Africa. A forecast of future trade flows must thus include an analysis of the economic development of all these countries. A huge task.

. statistics. In most developing countries the statistical basis is rather poor and does not allow the construction of origin-destination matrices of trade flows. Without a proper analysis of the present flows, forecasting of future patterns is virtually impossible, at least in the case of general cargo.

. world commodity prices. Economic growth of most developing countries is largely dependent upon the development of world prices of their exports (coffee, tea, copper, soda ash, etc.) and imports (oil, fertilizer, industrial goods). In the past these prices have not been very stable resulting in an equally unstable growth pattern of the economies. Inspite of the efforts within UNCTAD, it seems for the time being quite unrealistic to make any scenario of long term price development, and likewise of the economic development in the countries concerned.

. inland transportation. The road and rail systems play an important role in the inland transportation of national and transfer exports and imports. In the developing country under study, the investment in the railways has almost stopped in recent years. This has lead to severe capacity problems, which has a negative feedback on the development of exports and imports. Thus, a good inland transportation system is a prerequisite for the economic development.

. port infrastructure. Without adequate berthing and handling facilities in the national port, an expansion of the cargo flows is impossible. In most developing countries increases in seaborne trade have lead to port congestion.

Improvement of the port productivity by means of new handling equipment, better organization, additional general cargo and bulk handling terminals, is therefore a prerequisite for growth of the export and import cargo flows.

. politics. Political factors play an important role in the development of transfer trade flows through the national port. Political developments are difficult to foresee and their implications on trade flows even more.

The list of problems must look rather depressing to a transport planner who has to make a seaborne trade forecasting model. However, it is his task to find a compromise between theoretical demands and practical possibilities. The solution to this problem lies with the role of the seaborne trade forecasting model in the overall model of national fleet development. The purpose of the overall model is to create insights into the dynamics of national fleet development. It is therefore not the goal to develop a very elaborate forecasting model, but to show in the first place the impact of different seaborne trade forecasts on the development of the national shipping line. For this reason it will suffice to make a simple model that can generate a number of scenario's of realistic development patterns of seaborne trade flows through the national port.

c. Scenario model of seaborne trade flows through the national port

The model is made of general cargo export and import flows, as only general cargo is of interest to liner shipping.

The scenario model should be able to make projections of the development of total seaborne trade by country of origin and destination. However, the statistics usually do not provide this information (only in £), so special surveys have to be carried out in order to establish the breakdown of exports and imports in tonnages in a certain year, by trade route.

In the case of the developing country under study, a shipping study has been carried out which provides such a breakdown for the year 1973. The two major trade routes that can be distinguished are to NW-Europe and the Far East; the other minor trade routes are grouped under the heading 'Other routes'. The calculation structure of the seaborne trade forecasting model can be found in paragraph 1.2. The dynamo-flow diagram is presented on the following page.

. parameter values

The exports and imports though the national port in 1976 (time=0) are 275,000 tons and 250,000 tons per quarter of a year respectively. The growthrate of these flows is assumed to be 1%/quarter. The division of exports and imports by trade routes is in 1973:

	trade route	percentage exports	percentage imports	total
no. 1	NW-Europe	46	54	100%
no. 2	Far East	25	31	100%
no. 3	Other routes	29	15	100%

The division is held constant during the calculation period by lack of better information. It will be clear that any assumption about growth rates and trade route division can easily be tested on its consequences.

. documentor listing

```
E.K=E.J+DT*EG.JK
E=1.1E6
     E        - EXPORTS    TONS/QUARTER
     EG       - EXPORTS GROWTH    TONS/QUARTER

EG.KL=E.K*EGR.K/100
     EG       - EXPORTS GROWTH    TONS/QUARTER
     E        - EXPORTS    TONS/QUARTER
     EGR      - EXPORTS GROWTH RATE    %/QUARTER

EGR.K=TABLE(EGRT,TIME.K,0,96,96)
EGRT=1/1
     EGR      - EXPORTS GROWTH RATE    %/QUARTER
     EGRT     - EXPORTS GROWTH RATE TABLE

E1.K=PE1*E.K
PE1=.46
     E1       - EXPORTS ON ROUTE 1    TONS/QUARTER
     PE1      - PERCENTAGE OF EXPORTS ON ROUTE 1    DIM'LESS
     E        - EXPORTS    TONS/QUARTER
```

```
E2.K=PE2*E.K
PE2=.25
    E2      - EXPORTS ON ROUTE 2   TONS/QUARTER
    PE2     - PERCENTAGE EXPORTS ON ROUTE 2   DIM'LESS
    E       - EXPORTS   TONS/QUARTER

E3.K=PE3*E.K
PE3=.29
    E3      - EXPORTS ON ROUTE 3   TONS/QUARTER
    PE3     - PERCENTAGE EXPORTS ON ROUTE 3   DIM'LESS
    E       - EXPORTS   TONS/QUARTER

I.K=I.J+DT*IG.JK
I=1E6
    I       - 3  IMPORTS ON ROUTE 3   TONS/QUARTER
    IG      - IMPORTS GROWTH   TONS/QUARTER

IG.KL=I.K*IGR.K/100
    IG      - IMPORTS GROWTH   TONS/QUARTER
    I       - 3  IMPORTS ON ROUTE 3   TONS/QUARTER
    IGR     - IMPORTS GROWTH RATE   %/QUARTER

IGR.K=TABLE(IGRT,TIME.K,0,96,96)
IGRT=1/1
    IGR     - IMPORTS GROWTH RATE   %/QUARTER
    IGRT    - IMPORTS GROWTH RATE TABLE

I1.K=PI1*I.K
PI1=.54
    I1      - IMPORTS ON ROUTE 1   TONS/QUARTER
    PI1     - PERCENTAGE IMPORTS ON ROUTE 1   DIM'LESS
    I       - 3  IMPORTS ON ROUTE 3   TONS/QUARTER

I2.K=PI2*I.K
PI2=.31
    I2      - IMPORTS ON ROUTE 2   TONS/QUARTER
    PI2     - PERCENTAGE IMPORTS ON ROUTE 2   DIM'LESS
    I       - 3  IMPORTS ON ROUTE 3   TONS/QUARTER

I3.K=PI3*I.K
PI3=.15
    PI3     - PERCENTAGE IMPORTS ON ROUTE 3   DIM'LESS
    I       - 3  IMPORTS ON ROUTE 3   TONS/QUARTER

EI.K=E.K+I.K
    EI      - EXPORTS + IMPORTS   TONS/QUARTER
    E       - EXPORTS   TONS/QUARTER
    I       - 3  IMPORTS ON ROUTE 3   TONS/QUARTER

EIR.K=E.K/I.K
    EIR     - EXPORTS/IMPORTS RATIO   DIM'LESS
    E       - EXPORTS   TONS/QUARTER
    I       - 3  IMPORTS ON ROUTE 3   TONS/QUARTER
```

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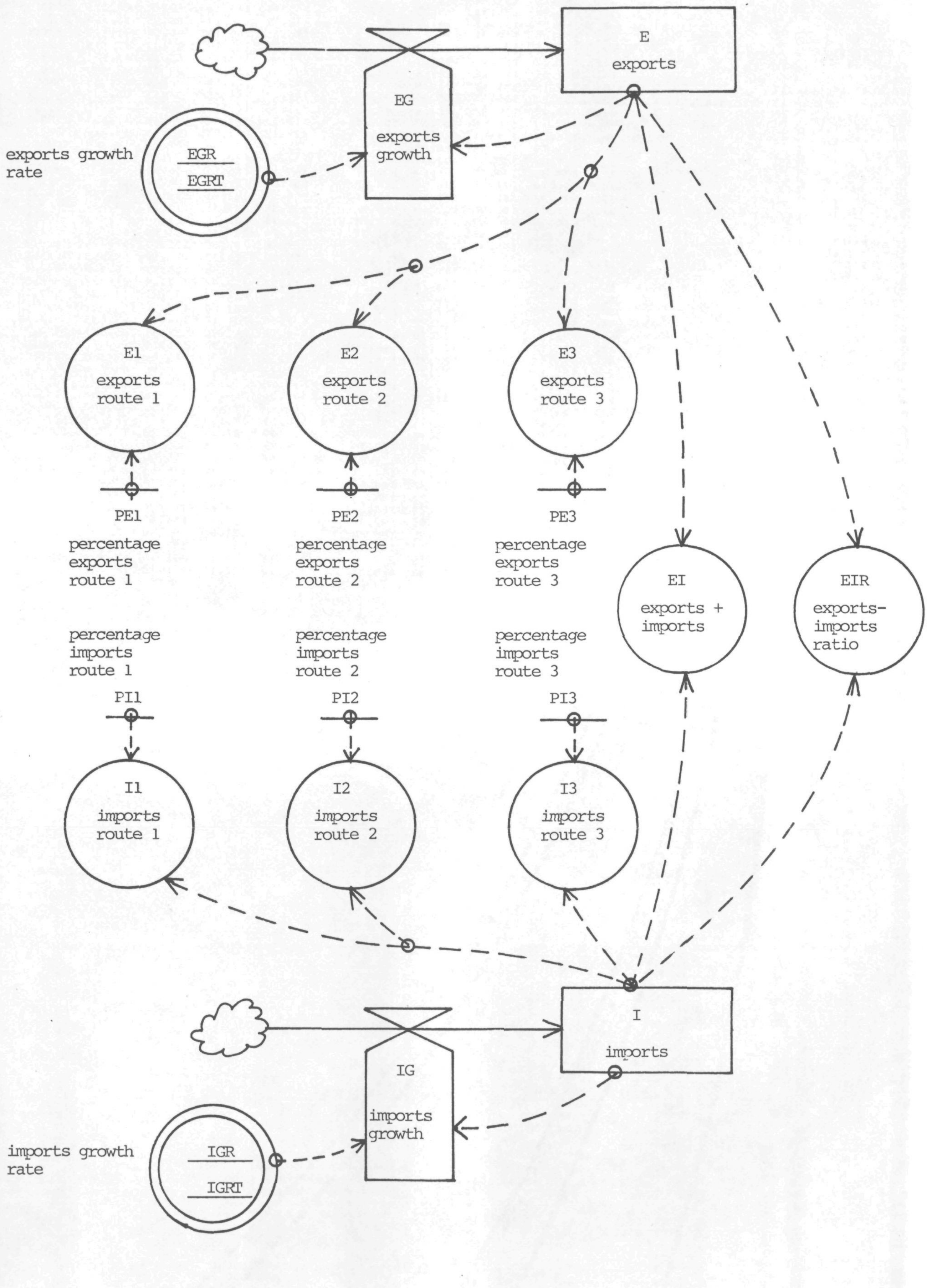
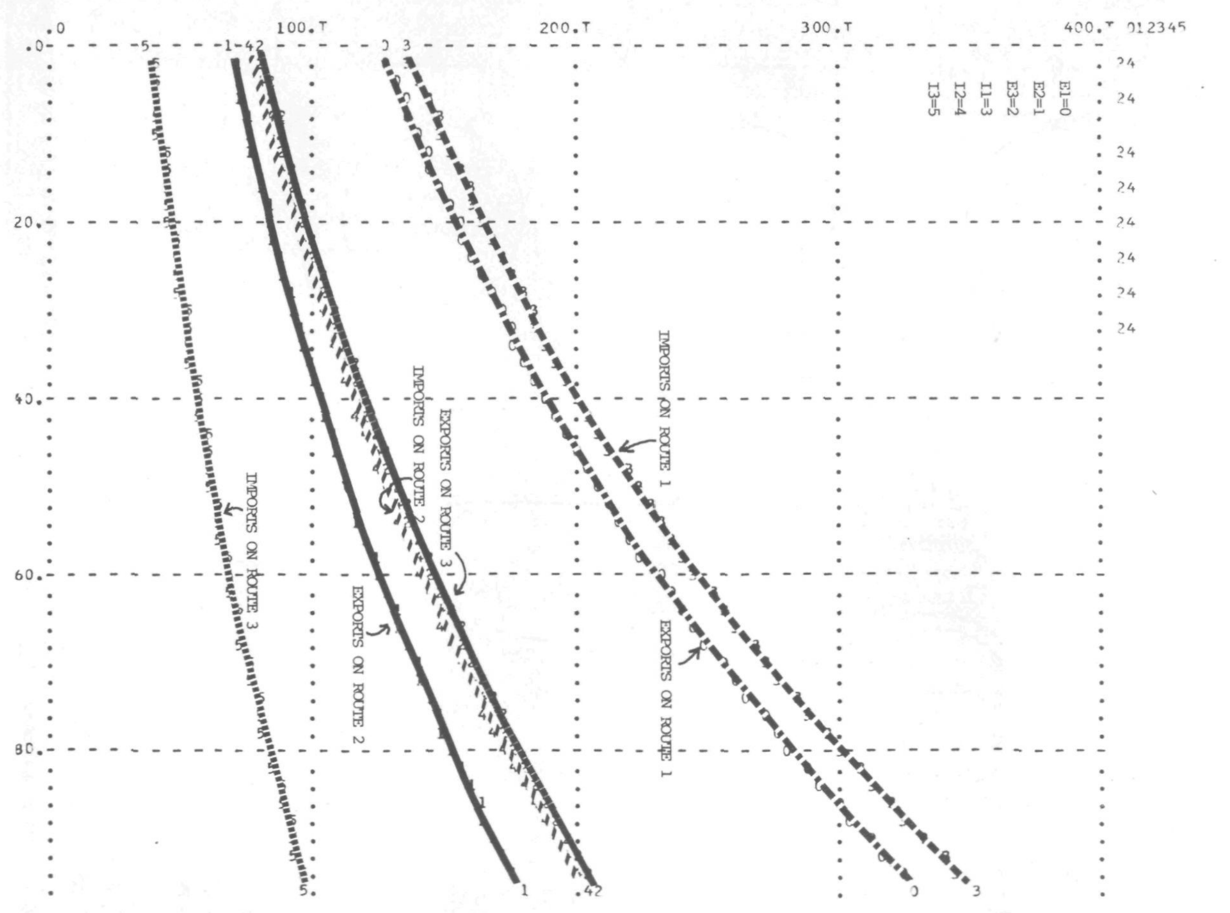

E
exports
EG
exports growth
exports growth rate
EGR
EGRT
E1
exports route 1
E2
exports route 2
E3
exports route 3
PE1
percentage exports route 1
PE2
percentage exports route 2
PE3
percentage exports route 3
EI
exports + imports
EIR
exports-imports ratio
percentage imports route 1
percentage imports route 2
percentage imports route 3
PI1
PI2
PI3
I1
imports route 1
I2
imports route 2
I3
imports route 3
I
imports
IG
imports growth
imports growth rate
IGR
IGRT

```
*    MODEL 12
NOTE    EXPORTS
L    E.K=E.J+DT*EG.JK
N    E=275000
R    EG.KL=E.K*EGR.K/100
A    EGR.K=TABLE(EGRT,TIME.K,0,96,96)
T    EGRT=1/1
A    E1.K=PE1*E.K
C    PE1=.46
A    E2.K=PE2*E.K
C    PE2=.25
A    E3.K=PE3*E.K
C    PE3=.29
NOTE    IMPORTS
L    I.K=I.J+DT*IG.JK
N    I=250000
R    IG.KL=I.K*IGR.K/100
A    IGR.K=TABLE(IGRT,TIME.K,0,96,96)
T    IGRT=1/1
A    I1.K=PI1*I.K
C    PI1=.54
A    I2.K=PI2*I.K
C    PI2=.31
A    I3.K=PI3*I.K
C    PI3=.15
NOTE    EXPORTS+IMPORTS
A    EI.K=E.K+I.K
A    EIR.K=E.K/I.K
SPEC    LENGTH=96/DT=.25/PRTPER=2/PLTPER=2
PRINT    E,E1,E2,E3,I,I1,I2,I3,EI,EIR
PLOT    E,I,EI/EIR
PLOT    E1,E2,E3,I1,I2,I3
RUN    GROWTH 1% PER QUARTER
```

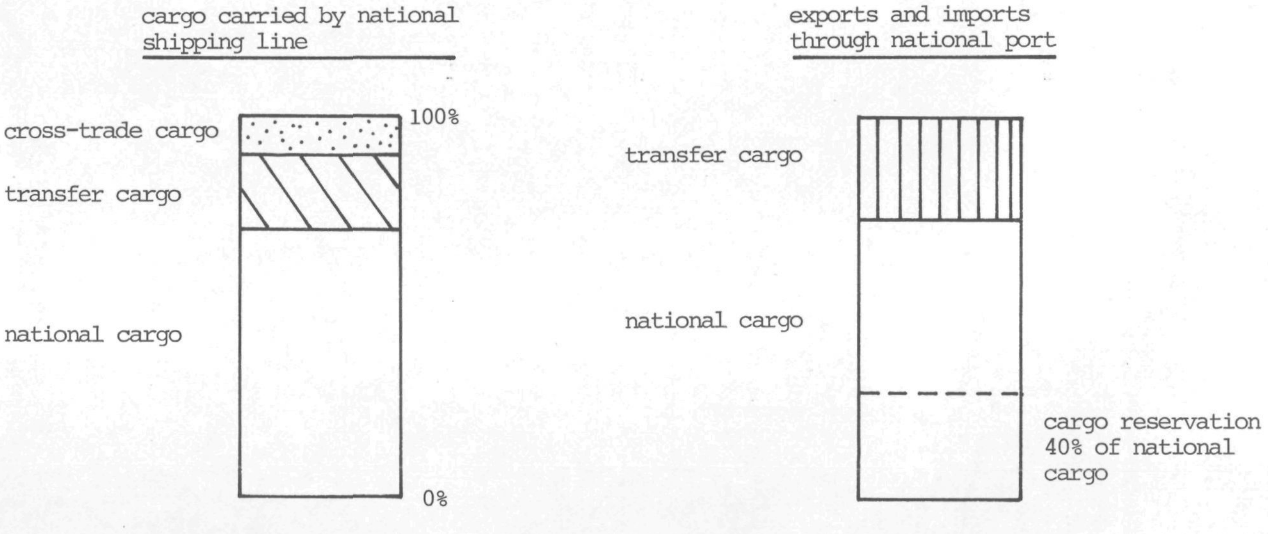
MODEL 12 - EXPORTS-IMPORTS THROUGH NAT. PORT GROWTH 1% PER QUARTER

TIME	E	E1	E2	E3	I	I1	I2	I3	EI	EIR
E+00	E+03	E+03	E+03	E+03	E+03	E+03	E+03	E+03	E+03	E+00
.0	275.00	126.50	68.75	79.75	250.00	135.00	77.50	37.500	525.0	1.1000
2.	280.55	129.05	70.14	81.36	255.04	137.72	79.06	38.257	535.6	1.1000
4.	286.21	131.66	71.55	83.00	260.19	140.50	80.66	39.028	546.4	1.1000
6.	291.98	134.31	73.00	84.67	265.44	143.34	82.29	39.816	557.4	1.1000
8.	297.87	137.02	74.47	86.38	270.79	146.23	83.95	40.619	568.7	1.1000
10.	303.88	139.79	75.97	88.13	276.26	149.18	85.64	41.439	580.1	1.1000
12.	310.01	142.61	77.50	89.90	281.83	152.19	87.37	42.275	591.8	1.1000
14.	316.27	145.48	79.07	91.72	287.52	155.26	89.13	43.127	603.8	1.1000
16.	322.65	148.42	80.66	93.57	293.32	158.39	90.93	43.998	616.0	1.1000
18.	329.16	151.41	82.29	95.46	299.23	161.59	92.76	44.885	628.4	1.1000
20.	335.80	154.47	83.95	97.38	305.27	164.85	94.63	45.791	641.1	1.1000
22.	342.57	157.58	85.64	99.35	311.43	168.17	96.54	46.715	654.0	1.1000
24.	349.49	160.76	87.37	101.35	317.71	171.57	98.49	47.657	667.2	1.1000
26.	356.54	164.01	89.13	103.40	324.12	175.03	100.48	48.619	680.7	1.1000
28.	363.73	167.32	90.93	105.48	330.66	178.56	102.51	49.599	694.4	1.1000
30.	371.07	170.69	92.77	107.61	337.33	182.16	104.57	50.600	708.4	1.1000
32.	378.55	174.13	94.64	109.78	344.14	185.84	106.68	51.621	722.7	1.1000
34.	386.19	177.65	96.55	112.00	351.08	189.58	108.84	52.662	737.3	1.1000
36.	393.98	181.22	98.50	114.26	358.17	193.41	111.03	53.725	752.1	1.1000
38.	401.93	184.89	100.48	116.56	365.39	197.31	113.27	54.809	767.3	1.1000
40.	410.04	188.62	102.51	118.91	372.76	201.29	115.56	55.915	782.8	1.1000
42.	418.31	192.42	104.58	121.31	380.28	205.35	117.89	57.043	798.6	1.1000
44.	426.75	196.31	106.69	123.76	387.96	209.50	120.27	58.194	814.7	1.1000
46.	435.36	200.27	108.84	126.26	395.78	213.72	122.69	59.368	831.1	1.1000
48.	444.15	204.31	111.04	128.80	403.77	218.04	125.17	60.565	847.9	1.1000
50.	453.11	208.43	113.28	131.40	411.92	222.43	127.69	61.787	865.0	1.1000
52.	462.25	212.63	115.56	134.05	420.23	226.92	130.27	63.034	882.5	1.1000
54.	471.58	216.92	117.89	136.76	428.70	231.50	132.90	64.306	900.3	1.1000
56.	481.09	221.30	120.27	139.52	437.35	236.17	135.58	65.603	918.4	1.1000
58.	490.80	225.77	122.70	142.33	446.18	240.94	138.31	66.927	937.0	1.1000
60.	500.70	230.32	125.17	145.20	455.18	245.80	141.11	68.277	955.9	1.1000
62.	510.80	234.97	127.70	148.13	464.36	250.76	143.95	69.654	975.2	1.1000
64.	521.10	239.71	130.28	151.12	473.73	255.81	146.86	71.060	994.8	1.1000
66.	531.62	244.54	132.90	154.17	483.29	260.98	149.82	72.493	1014.9	1.1000
68.	542.34	249.48	135.59	157.28	493.04	266.24	152.84	73.956	1035.4	1.1000
70.	553.29	254.51	138.32	160.45	502.99	271.61	155.93	75.448	1056.3	1.1000
72.	564.45	259.65	141.11	163.69	513.13	277.09	159.07	76.970	1077.6	1.1000
74.	575.84	264.88	143.96	166.99	523.49	282.68	162.28	78.523	1099.3	1.1000
76.	587.45	270.23	146.86	170.36	534.05	288.39	165.56	80.107	1121.5	1.1000
78.	599.31	275.68	149.83	173.80	544.82	294.20	168.90	81.723	1144.1	1.1000
80.	611.40	281.24	152.85	177.31	555.82	300.14	172.30	83.372	1167.2	1.1000
82.	623.73	286.92	155.93	180.88	567.03	306.20	175.78	85.054	1190.8	1.1000
84.	636.32	292.71	159.08	184.53	578.47	312.37	179.33	86.770	1214.8	1.1000
86.	649.16	298.61	162.29	188.25	590.14	318.68	182.94	88.521	1239.3	1.1000
88.	662.25	304.64	165.56	192.05	602.05	325.11	186.63	90.307	1264.3	1.1000
90.	675.61	310.78	168.90	195.93	614.19	331.66	190.40	92.129	1289.8	1.1000
92.	689.24	317.05	172.31	199.88	626.58	338.36	194.24	93.988	1315.8	1.1000
94.	703.15	323.45	175.79	203.91	639.23	345.18	198.16	95.884	1342.4	1.1000
96.	717.34	329.97	179.33	208.03	652.12	352.15	202.16	97.818	1369.5	1.1000



6.2 MODEL 13 - NATIONAL SHIPPING LINE'S SHARE OF TRADE

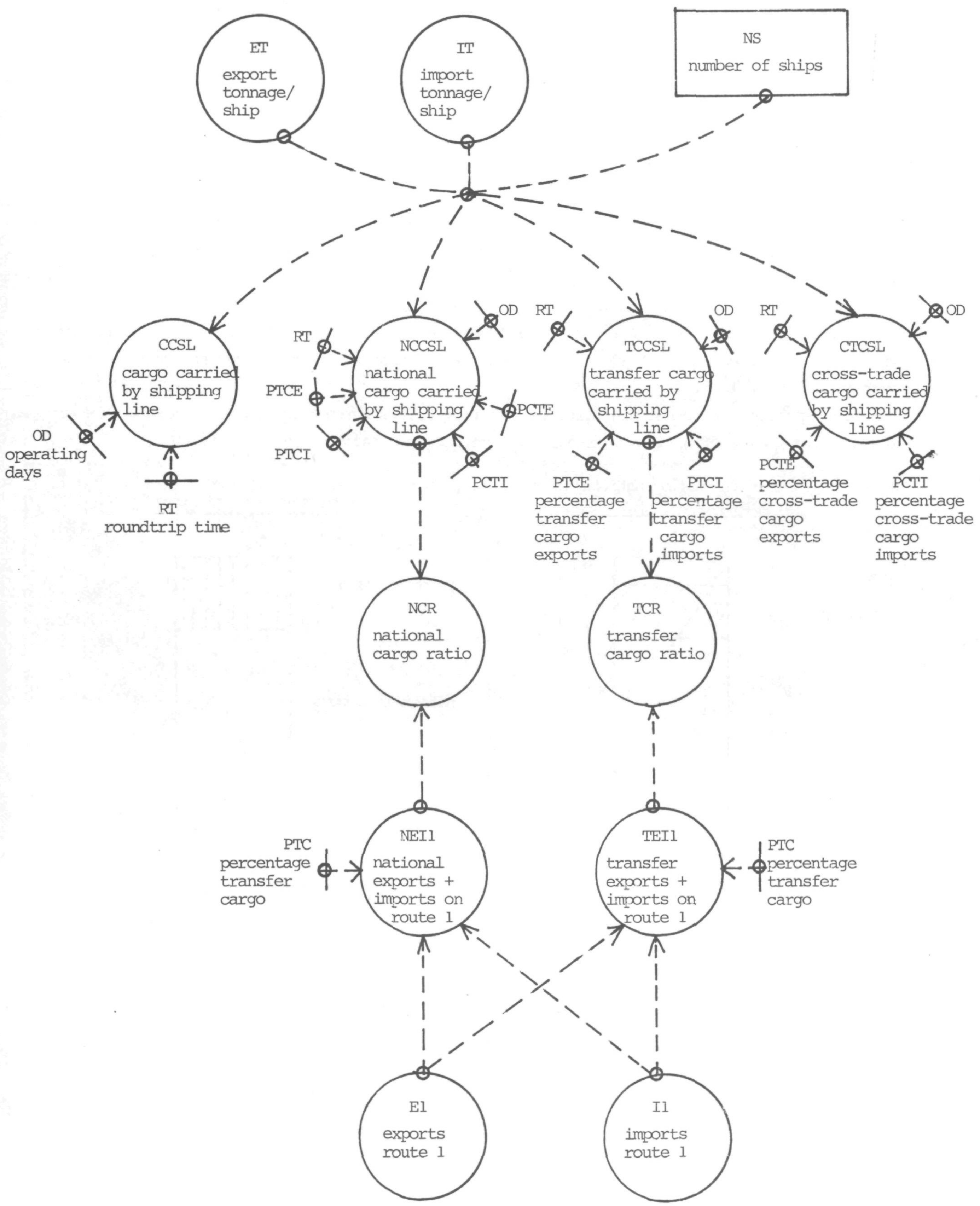
Any fleet development plan of the national shipping line must be based on a projection of the potential cargo that the line can transport. The potential cargo exists of national cargo, transfer cargo (to and from land-locked neighbouring countries) and cross-trade cargo (between ports which are in the same range as the national port).
The national cargo determines to a large extent the potential cargo. However, the national shipping line can not ship all the national cargo. According to the Code of Conduct for liner conferences, the developing country can reserve upto 40 percent of its national exports and imports for the national shipping line (nsl).
The amount of transfer cargo onboard the nsl-ships depends to a large extent on the magnitude of the flow of transfer cargo through the national port. If this flow is substantial, than it is likely that the national shipping line will carry a substantial amount of transfer cargo.
The amount of cross-trade cargo that the nsl-ships will carry is small in comparison with the amounts of national cargo and transfer cargo. It should be kept in mind that for both transfer cargo and cross-trade cargo the market share of the national shipping line must be won in competition with the other lines in the trade, as the government cannot exten the cargo reservation policy over these trade flows.
The cargo carried by the shipping line and the cargo flows through the national port can be divided into the categories of national, transfer and cross-trade cargo:



The dynamo-flow diagram of the relevant part of the model which calculates the tonnages of national, transfer and cross-trade cargo onboard the nsl-ships is presented on the following page.
The rest of the model is identical with a part of model 6 and model 12 entirely.

. parameter values

The calculations are only made for one route: no.1 NW-Europe, as the national shipping line will only operate in this trade.
The national cargo as percentage of the cargo carried by the shipping line is 70 for both exports and imports. The transfer cargo as percentage of the cargo carried is 20 and the cross-trade cargo is 10 percent of the cargo carried for both exports and imports. These percentages are held constant over the calculation period.
The transfer cargo trade flows through the national port as percentage of the total export and import flows, is 30. This percentage is held constant over time.



ET
export tonnage/ ship
IT
import tonnage/ ship
NS
number of ships
CCSL
cargo carried by shipping line
OD
operating days
RT
roundtrip time
NCCSL
national cargo carried by shipping line
RT
PTCE
PTCI
OD
PCTE
PCTI
TCCSL
transfer cargo carried by shipping line
RT
OD
PTCE
percentage transfer cargo exports
PTCI
percentage transfer cargo imports
CTCSL
cross-trade cargo carried by shipping line
RT
OD
PCTE
percentage cross-trade cargo exports
PCTI
percentage cross-trade cargo imports
NCR
national cargo ratio
TCR
transfer cargo ratio
NEI1
national exports + imports on route 1
PTC
percentage transfer cargo
TEI1
transfer exports + imports on route 1
PTC
percentage transfer cargo
E1
exports route 1
I1
imports route 1

. documentor listing of the relevant equations

```
CCSL.K=NS.K*(((ET.K+IT.K)*OD)/RT)
    CCSL    - CARGO CARRIED BY SHIPPING LINE   TONS/
                QUARTER
    NS      - NUMBER OF SHIPS
    ET      - EXPORT TONNAGE /SHIP/ROUNDTRIP   TONS
    IT      - IMPORT TONNAGE /SHIP/ROUNDTRIP   TONS
    OD      - OPERATING DAYS OF SHIP    DAYS/QUARTER
    RT      - ROUNDTRIP TIME    DAYS

NCCSL.K=NS.K*((((1-PTTE-PCTE)*ET.K+(1-PTTI-PCTI)*
  IT.K)*OD)/RT)
    NCCSL   - NATIONAL CARGO CARRIED BY SHIPPING LINE
                TONS/QUARTER
    NS      - NUMBER OF SHIPS
    PCTE    - PERCENTAGE CROSS TRADE OF EXPORTS   DIM'LESS
    ET      - EXPORT TONNAGE /SHIP/ROUNDTRIP   TONS
    PCTI    - PERCENTAGE CROSS-TRADE OF IMPORTS   DIM'LESS
    IT      - IMPORT TONNAGE /SHIP/ROUNDTRIP   TONS
    OD      - OPERATING DAYS OF SHIP    DAYS/QUARTER
    RT      - ROUNDTRIP TIME    DAYS
    PTCE    - PERCENTAGE TRANSFER CARGO OF EXPORTS    DIM'
                LESS
    PTCI    - PERCENTAGE TRANSFER CARGO OF IMPORTS    DIM'
                LESS

TCCSL.K=NS.K*(((PTCE*ET.K+PTCI*IT.K)*OD)/RT)
    TCCSL   - TRANSFER CARGO CARRIED BY SHIPPING LINE
                TONS/QUARTER
    NS      - NUMBER OF SHIPS
    PTCE    - PERCENTAGE TRANSFER CARGO OF EXPORTS    DIM'
                LESS
    ET      - EXPORT TONNAGE /SHIP/ROUNDTRIP   TONS
    PTCI    - PERCENTAGE TRANSFER CARGO OF IMPORTS    DIM'
                LESS
    IT      - IMPORT TONNAGE /SHIP/ROUNDTRIP   TONS

CTCCSL.K=NS.K*(((PCTE*ET.K+PCTI*IT.K)*OD)/RT)
    CTCCSL  - CROSS TRADE CARGO CARRIED BY SHIPPING LINE
                TONS/QUARTER
    NS      - NUMBER OF SHIPS
    PCTE    - PERCENTAGE CROSS TRADE OF EXPORTS   DIM'LESS
    ET      - EXPORT TONNAGE /SHIP/ROUNDTRIP   TONS
    PCTI    - PERCENTAGE CROSS-TRADE OF IMPORTS   DIM'LESS
    IT      - IMPORT TONNAGE /SHIP/ROUNDTRIP   TONS

NEI1.K=(E1.K+I1.K)*(1-PTC)
PTC=.3
    NEI1    - NATIONAL EXPORTS+IMPORTS ON ROUTE 1    TONS/
                QUARTER
    E1      - EXPORTS ON ROUTE 1    TONS/QUARTER
    I1      - IMPORTS ON ROUTE 1    TONS/QUARTER
    PTC     - PERCENTAGE TRANSFER CARGO    DIM'LESS

TEI1.K=(E1.K+I1.K)*PTC
    TEI1    - TRANSFER EXPORTS AND IMPORTS ON ROUTE 1
                TONS/QUARTER
    E1      - EXPORTS ON ROUTE 1    TONS/QUARTER
    I1      - IMPORTS ON ROUTE 1    TONS/QUARTER
    PTC     - PERCENTAGE TRANSFER CARGO    DIM'LESS

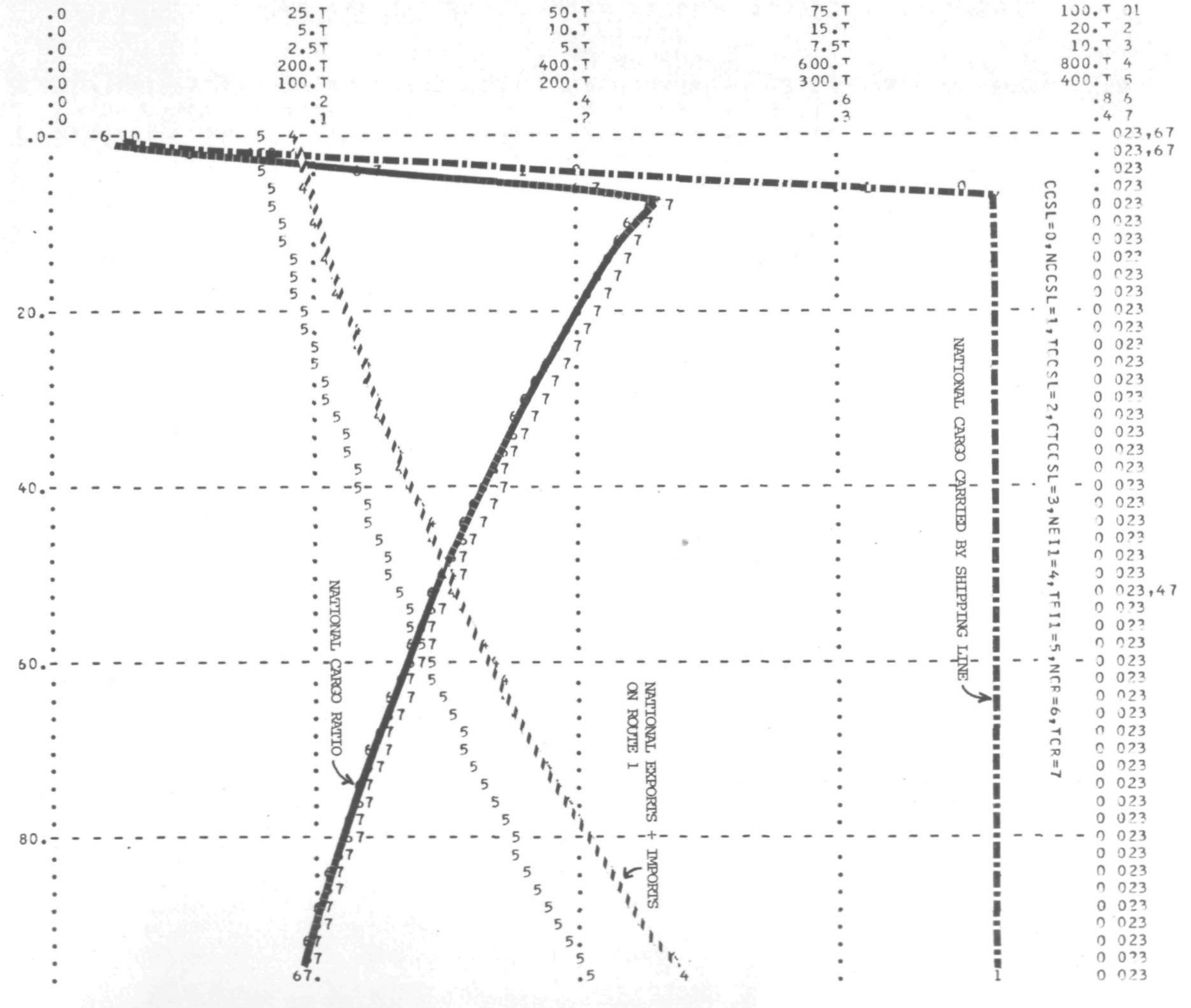
NCR.K=NCCSL.K/NEI1.K
    NCR     - NATIONAL CARGO CARRIED BY SHIPPING LINE /
                NATIONAL EXPORTS AND IMPORTS ON ROUTE 1
                RATIO
    NCCSL   - NATIONAL CARGO CARRIED BY SHIPPING LINE
                TONS/QUARTER
    NEI1    - NATIONAL EXPORTS+IMPORTS ON ROUTE 1    TONS/
                QUARTER

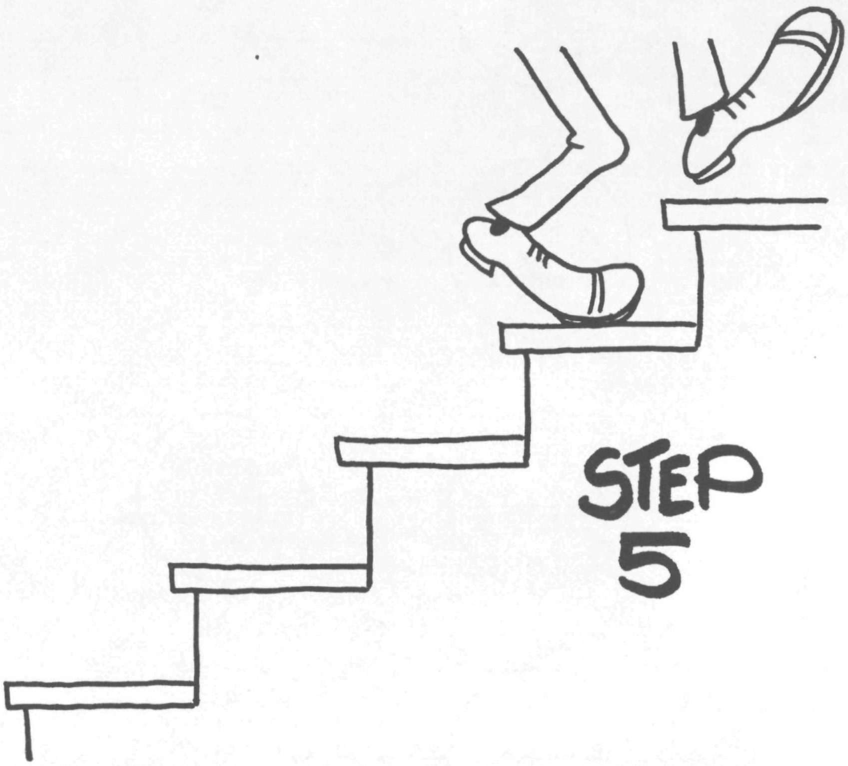
TCR.K=TCCSL.K/TEI1.K
    TCR     - TRANSFER CARGO CARRIED BY SHIPPING LINE /
                TRANSFER EXPORTS AND IMPORTS ON ROUTE 1
                RATIO
    TCCSL   - TRANSFER CARGO CARRIED BY SHIPPING LINE
                TONS/QUARTER
    TEI1    - TRANSFER EXPORTS AND IMPORTS ON ROUTE 1
                TONS/QUARTER
```

```
  *   MODEL 13 - NSL SHARE OF TRADE
• A   CCSL.K=NS.K*(((ET.K+IT.K)*OD)/RT)
• A   NCCSL.K=NS.K*((((1-PTTE-PCTE)*ET.K+(1-PTTI-PCTI)*IT.K)*OD)/RT)
• C   PTCE=.2
• C   PCTE=.1
• C   PTCI=.2
• C   PCTI=.1
• A   TCCSL.K=NS.K*(((PTCE*ET.K+PTCI*IT.K)*OD)/RT)
• A   CTCCSL.K=NS.K*(((PCTE*ET.K+PCTI*IT.K)*OD)/RT)
• A   NEI1.K=(E1.K+I1.K)*(1-PTC)
• C   PTC=.3
• A   TEI1.K=(E1.K+I1.K)*PTC
• A   NCR.K=NCCSL.K/NEI1.K
• A   TCR.K=TCCSL.K/TEI1.K
  NOTE   NUMBER OF SHIPS
  L   NS.K=NS.J+DT*NSG.JK
  N   NS=1
  R   NSG.KL=FED.K/DT
  A   FED.K=CLIP(0,PULSE(1,1,1),TIME.K,6)
  A   ET.K=LC*LFE.K
  C   LC=14000
  A   LFE.K=TABLE(LFET,TIME.K,0,96,8)
  T   LFET=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
  A   IT.K=LC*LFI.K
  A   LFI.K=TABLE(LFIT,TIME.K,0,96,8)
  T   LFIT=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
  C   OD=87.5
  C   RT=118
  NOTE   EXPORTS-IMPORTS MODEL
  NOTE   EXPORTS
  L   E.K=E.J+DT*EG.JK
  N   E=275000
  R   EG.KL=E.K*EGR.K/100
  A   EGR.K=TABLE(EGRT,TIME.K,0,96,96)
  T   EGRT=1/1
  A   E1.K=PE1*E.K
  C   PE1=.46
  A   E2.K=PE2*E.K
  C   PE2=.25
  A   E3.K=PE3*E.K
  C   PE3=.29
  NOTE   IMPORTS
  L   I.K=I.J+DT*IG.JK
  N   I=250000
  R   IG.KL=I.K*IGR.K/100
  A   IGR.K=TABLE(IGRT,TIME.K,0,96,96)
  T   IGRT=1/1
  A   I1.K=PI1*I.K
  C   PI1=.54
  A   I2.K=PI2*I.K
  C   PI2=.31
  A   I3.K=PI3*I.K
  C   PI3=.15
  NOTE   EXPORTS+IMPORTS
  A   EI.K=E.K+I.K
  A   EIR.K=E.K/I.K
  SPEC   LENGTH=96/DT=.25/PRTPER=2/PLTPER=2
  PRINT   CCSL,NCCSL,TCCSL,CTCCSL,NEI1,TEI1,NCR,TCR
  PLOT   CCSL/NCCSL/TCCSL/CTCCSL/NEI1/TEI1/NCR/TCR
  RUN
```

MODEL 13 - NSL SHARE OF TRADE

TIME E+00	CCSL E+03	NCCSL E+03	TCCSL E+03	CTCCSL E+00	NEI1 E+03	TEI1 E+03	NCR E+00	TCR E+00
.0	8.305	7.475	1.661	830.5	183.05	78.45	.04083	.02117
2.	20.763	18.686	4.153	2076.3	186.74	80.03	.10006	.05189
4.	49.830	44.847	9.966	4983.0	190.51	81.65	.23541	.12206
6.	87.203	78.483	17.441	8720.3	194.35	83.29	.40381	.20939
8.	99.661	89.695	19.932	9966.1	198.28	84.98	.45238	.23457
10.	99.661	89.695	19.932	9966.1	202.28	86.69	.44343	.22993
12.	99.661	89.695	19.932	9966.1	206.36	88.44	.43466	.22538
14.	99.661	89.695	19.932	9966.1	210.52	90.22	.42606	.22092
16.	99.661	89.695	19.932	9966.1	214.77	92.04	.41764	.21655
18.	99.661	89.695	19.932	9966.1	219.10	93.90	.40938	.21227
20.	99.661	89.695	19.932	9966.1	223.52	95.79	.40128	.20807
22.	99.661	89.695	19.932	9966.1	228.03	97.73	.39335	.20396
24.	99.661	89.695	19.932	9966.1	232.63	99.70	.38557	.19992
26.	99.661	89.695	19.932	9966.1	237.32	101.71	.37794	.19597
28.	99.661	89.695	19.932	9966.1	242.11	103.76	.37047	.19210
30.	99.661	89.695	19.932	9966.1	247.00	105.86	.36314	.18830
32.	99.661	89.695	19.932	9966.1	251.98	107.99	.35596	.18457
34.	99.661	89.695	19.932	9966.1	257.06	110.17	.34892	.18092
36.	99.661	89.695	19.932	9966.1	262.25	112.39	.34202	.17734
38.	99.661	89.695	19.932	9966.1	267.54	114.66	.33526	.17384
40.	99.661	89.695	19.932	9966.1	272.94	116.97	.32863	.17040
42.	99.661	89.695	19.932	9966.1	278.44	119.33	.32213	.16703
44.	99.661	89.695	19.932	9966.1	284.06	121.74	.31576	.16373
46.	99.661	89.695	19.932	9966.1	289.79	124.20	.30951	.16049
48.	99.661	89.695	19.932	9966.1	295.64	126.70	.30339	.15731
50.	99.661	89.695	19.932	9966.1	301.60	129.26	.29739	.15420
52.	99.661	89.695	19.932	9966.1	307.69	131.87	.29151	.15115
54.	99.661	89.695	19.932	9966.1	313.90	134.53	.28575	.14816
56.	99.661	89.695	19.932	9966.1	320.23	137.24	.28009	.14523
58.	99.661	89.695	19.932	9966.1	326.69	140.01	.27456	.14236
60.	99.661	89.695	19.932	9966.1	333.28	142.84	.26913	.13955
62.	99.661	89.695	19.932	9966.1	340.01	145.72	.26380	.13679
64.	99.661	89.695	19.932	9966.1	346.87	148.66	.25859	.13408
66.	99.661	89.695	19.932	9966.1	353.86	151.66	.25347	.13143
68.	99.661	89.695	19.932	9966.1	361.00	154.72	.24846	.12883
70.	99.661	89.695	19.932	9966.1	368.29	157.84	.24355	.12628
72.	99.661	89.695	19.932	9966.1	375.72	161.02	.23873	.12379
74.	99.661	89.695	19.932	9966.1	383.30	164.27	.23401	.12134
76.	99.661	89.695	19.932	9966.1	391.03	167.58	.22938	.11894
78.	99.661	89.695	19.932	9966.1	398.92	170.97	.22484	.11659
80.	99.661	89.695	19.932	9966.1	406.97	174.41	.22040	.11428
82.	99.661	89.695	19.932	9966.1	415.18	177.93	.21604	.11202
84.	99.661	89.695	19.932	9966.1	423.56	181.52	.21177	.10980
86.	99.661	89.695	19.932	9966.1	432.10	185.19	.20758	.10763
88.	99.661	89.695	19.932	9966.1	440.82	188.92	.20347	.10550
90.	99.661	89.695	19.932	9966.1	449.71	192.73	.19945	.10342
92.	99.661	89.695	19.932	9966.1	458.79	196.62	.19550	.10137
94.	99.661	89.695	19.932	9966.1	468.04	200.59	.19164	.09937
96.	99.661	89.695	19.932	9966.1	477.48	204.64	.18785	.09740



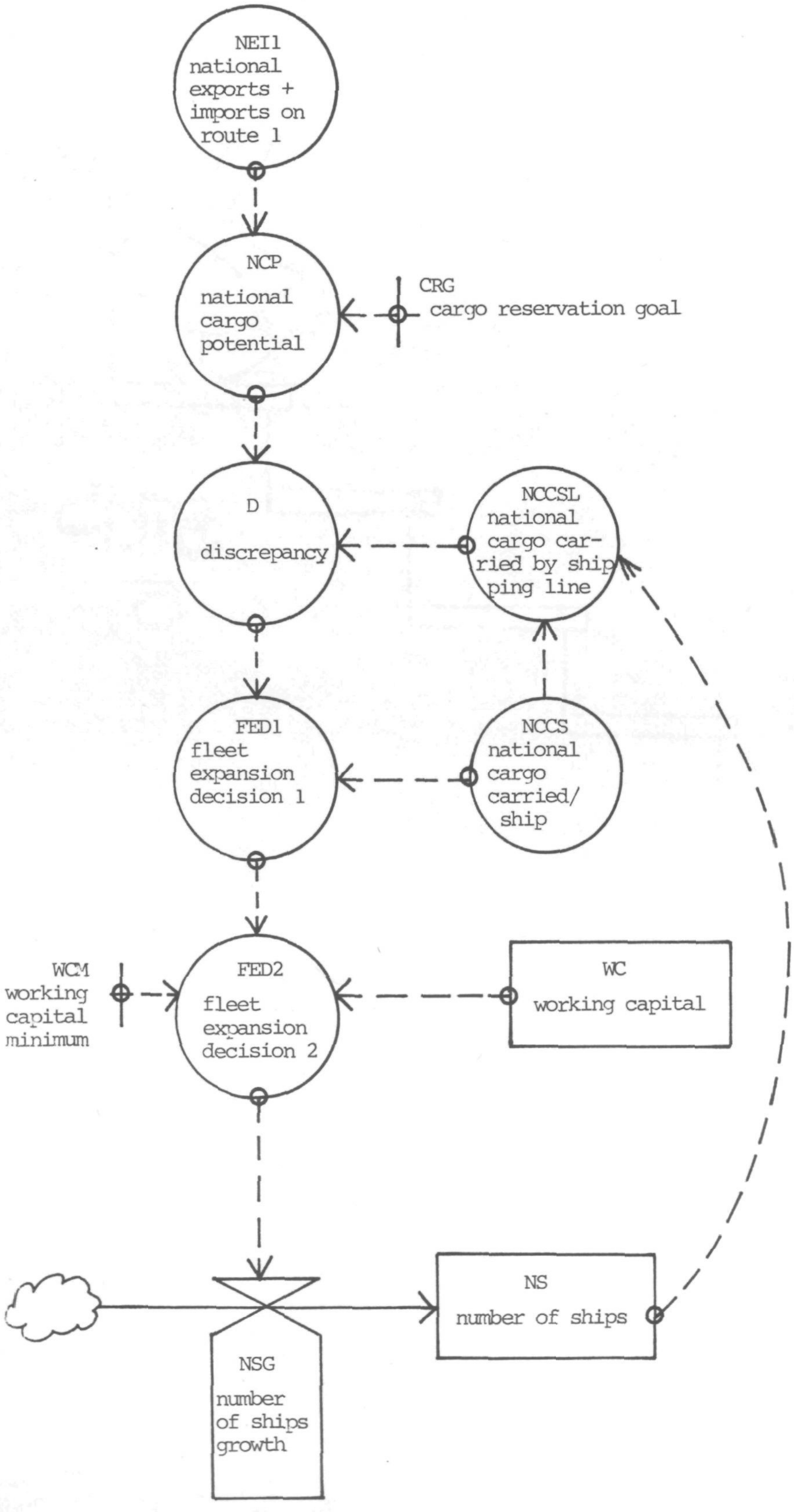

STEP
5

Chapter 7 - STEP 5: ENDOGENOUS FLEET EXPANSION MODELS

7.1 MODEL 14 - ENDOGENOUS FLEET EXPANSION 1

The causal-loop diagram of the model can be found in paragraph 1.2.

The dynamo-flow diagram of the fleet expansion mechanism is presented below. The rest of the model is identical with the models 8 and 13.



. parameter values

The cargo reservation goal is 40 percent. The number of ships does not increase if the working capital is below - £10 million (working capital minimum).

The maximum number of ships over the calculation period 1976 - 2000 must be calculated roughly in advance, as the ageing mechanism in the model requires a level for each ship in the fleet. This rough calculation is made by dividing 40 percent of the national exports and imports in the year 2000 and the national cargo carried per ship per year.

The administrative and management cost increase with an increase in the number of ships.

. documentor listing of the relevant equations

```
NEI1.K=(E1.K+I1.K)*(1-PTT)
PTT=.3
    NEI1     - NATIONAL EXPORTS+IMPORTS ON ROUTE 1     TONS/
                  QUARTER

NCP.K=NEI1.K*CRG
CRG=.4
    NCP      - NATIONAL CARGO POTENTIAL   TONS/QUARTER
    NEI1     - NATIONAL EXPORTS+IMPORTS ON ROUTE 1     TONS/
                  QUARTER
    CRG      - CARGO RESERVATION GOAL   PERCENTAGE

D.K=NCP.K-NCCSL.K
    D        - DISCREPANCY    TONS /QUARTER
    NCP      - NATIONAL CARGO POTENTIAL   TONS/QUARTER
    NCCSL    - NATIONAL CARGO CARRIED BY SHIPPING LINE
                  TONS/QUARTER

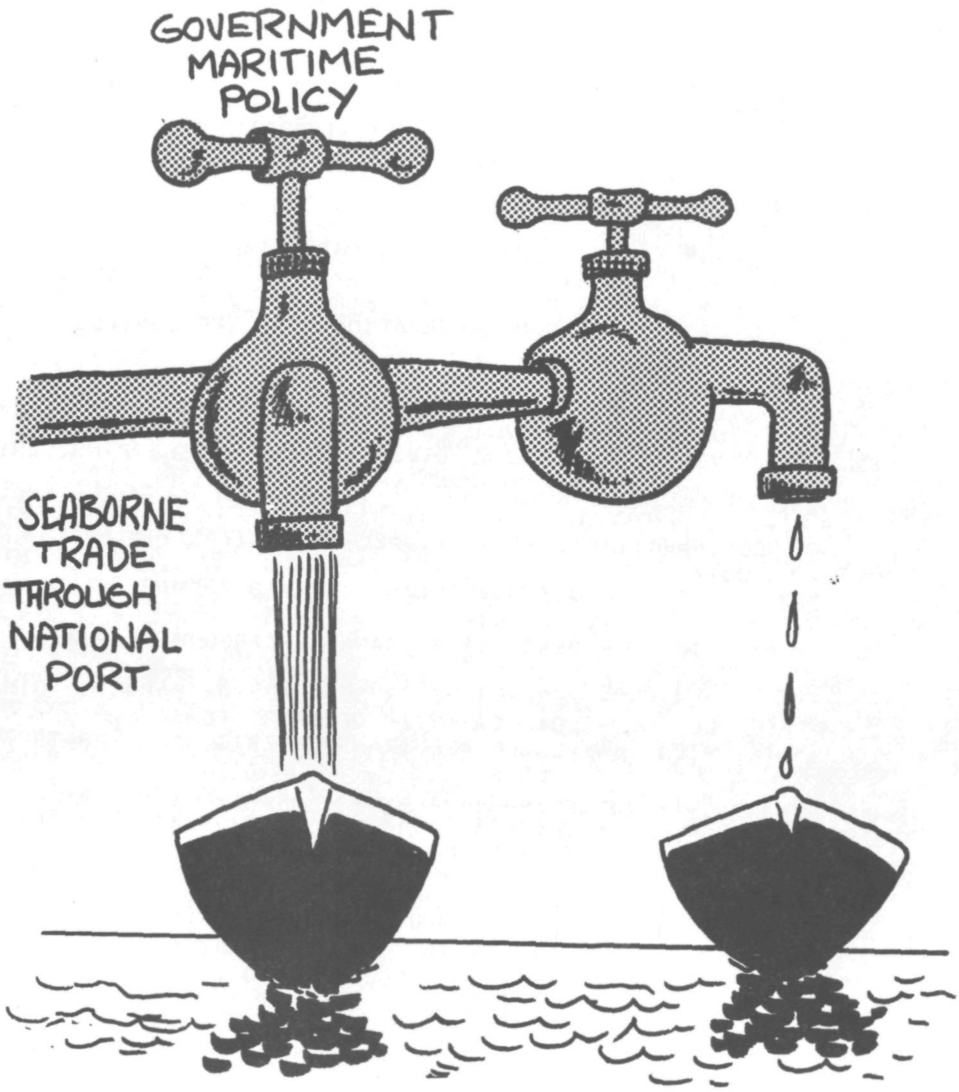
NCCS.K=(((1-PTCE-PCTE)*.8*LC+(1-PTCI-PCTI)*.8*LC)*
  OD)/RT
    NCCS     - NATIONAL CARGO CARRIED / SHIP    TONS/
                  QUARTER
    PTCE     - PERCENTAGE TRANSFER CARGO OF EXPORTS    DIM'
                  LESS
    PCTE     - PERCENTAGE CROSS TRADE OF EXPORTS   DIM'LESS
    LC       - LOAD CAPACITY OF SHIP   TONS
    PTCI     - PERCENTAGE TRANSFER CARGO OF IMPORTS    DIM'
                  LESS
    PCTI     - PERCENTAGE CROSS-TRADE OF IMPORTS   DIM'LESS
    OD       - OPERATING DAYS OF SHIP    DAYS/QUARTER
    RT       - ROUNDTRIP TIME    DAYS

FED1.K=CLIP(1,0,(D.K/NCCS.K),1)
    FED1     - FLEET EXPANSION DECISION 1
    D        - DISCREPANCY    TONS /QUARTER
    NCCS     - NATIONAL CARGO CARRIED / SHIP    TONS/
                  QUARTER

FED2.K=CLIP(FED1.K,0,WC.K,WCM)
WCM=-10E6
    FED2     - FLEET EXPANSION DECISION 2
    FED1     - FLEET EXPANSION DECISION 1
    WC       - WORKING CAPITAL   £
    WCM      - WORKING CAPITAL MINIMUM    £
```

Another decision criterion is introduced: the transport independence indicator

```
TII.K=NS.K*((2*.9*LC*OD)/RT)/NEI1.K
    TII      - TRANSPORT INDEPENDENCE INDICATOR    DIM'LESS
    NS       - NUMBER OF SHIPS
    LC       - LOAD CAPACITY OF SHIP   TONS
    OD       - OPERATING DAYS OF SHIP    DAYS/QUARTER
    RT       - ROUNDTRIP TIME    DAYS
    NEI1     - NATIONAL EXPORTS+IMPORTS ON ROUTE 1     TONS/
                  QUARTER
```



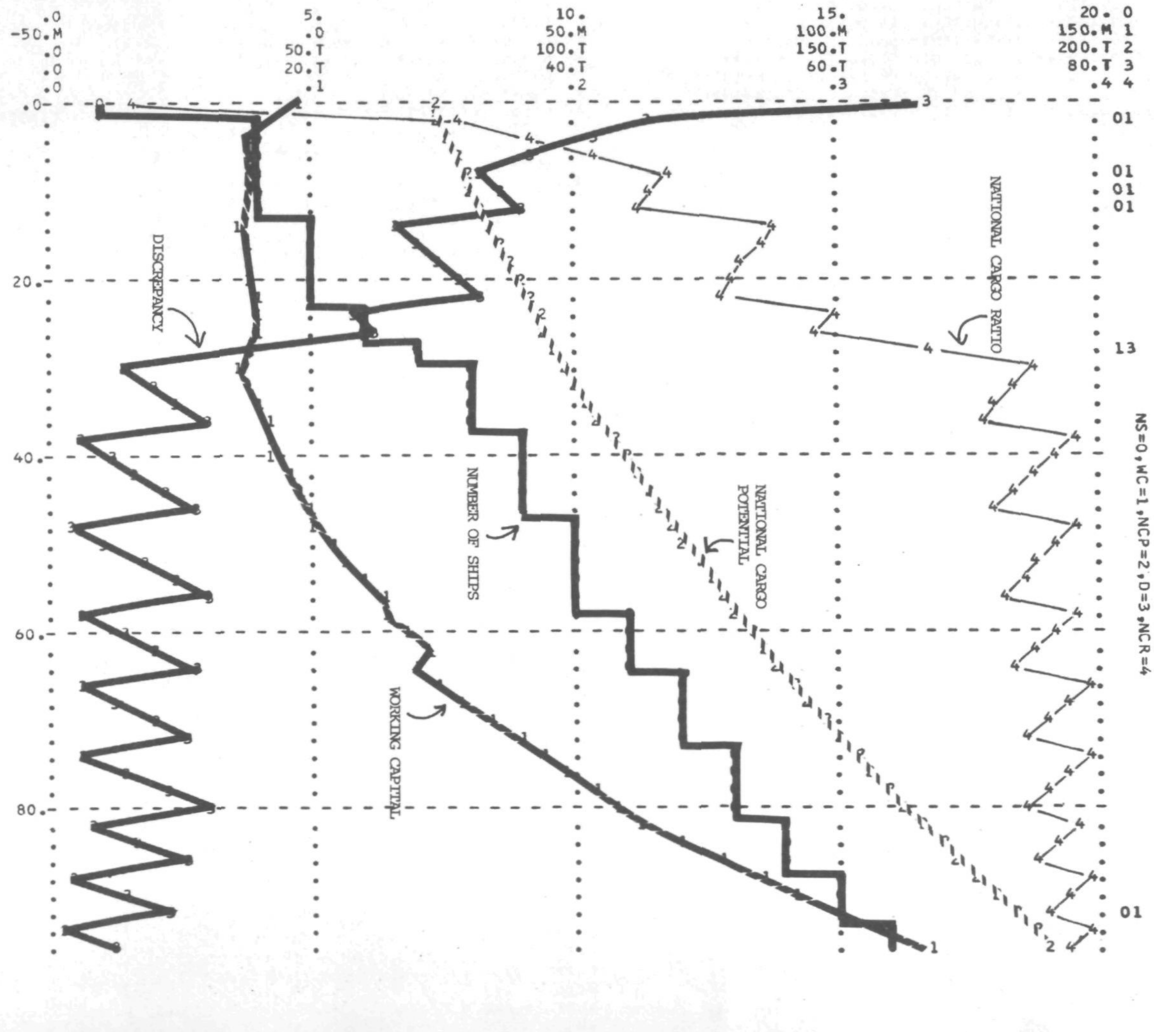
national shipping line

```
*  MODEL 14 - ENDOGENOUS FLEET EXPANSION 1
NOTE  NUMBER OF SHIPS
L  NS.K=NS.J+DT*NSG.JK
N  NS=1
R  NSG.KL=FED2.K/DT
NOTE  NETT INCOME /SHIP/QUARTER
NOTE
A  ET.K=LC*LFE.K
C  LC=14000
A  LFE.K=TABHL(LFET,TIME.K,0,96,8)
T  LFET=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A  IT.K=LC*LFI.K
A  LFI.K=TABHL(LFIT,TIME.K,0,96,8)
T  LFIT=.4/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A  GRE.K=ET.K*FRE
C  FRE=25
A  GRI.K=IT.K*FRI
C  FRI=35
A  GR.K=GRE.K+GRI.K
A  AC.K=GR.K*ACS
C  ACS=.055
A  SC.K=(ET.K+IT.K)*SCT
C  SCT=6.25
A  CC.K=(ET.K+IT.K)*CCT
C  CCT=.4
A  SCC.K=(ET.K+IT.K)*SCCT
C  SCCT=1
C  B=58000
C  PC=45000
A  VE.K=AC.K+SCC.K+CC.K+SC.K+B+PC
A  NIS.K=(((GR.K-VE.K)*OD)/RT)-OC
C  OD=87.5
C  RT=118
C  OC=110000
NOTE  TOTAL NETT INCOME SHIPPING OPERATIONS
A  TNI.K=NIS.K*NS.K-AMC.K
A  AMC.K=94000+94000*CLIP(((NS.K-6)/12),0,NS.K,6)
NOTE  WORKING CAPITAL
L  WC.K=WC.J+DT*(WCG.JK+WCI.JK-(PS.JK/DT)-(PRS.JK/DT))
N  WC=-PPS1
R  WCG.KL=CLIP(TNI.K,0,TIME.K,DT)
R  WCI.KL=CLIP((WC.K*IR),0,TIME.K,DT)
C  IR=.03
R  PS.KL=SWITCH((CLIP((FED2.K*PPS2),0,S1.K,1)),0,S2.K)+
X  SWITCH((CLIP((FED2.K*PPS3),0,S2.K,1)),0,S3.K)+
X  SWITCH((CLIP((FED2.K*PPS4),0,S3.K,1)),0,S4.K)+
X  SWITCH((CLIP((FED2.K*PPS5),0,S4.K,1)),0,S5.K)+
X  SWITCH((CLIP((FED2.K*PPS6),0,S5.K,1)),0,S6.K)+
X  SWITCH((CLIP((FED2.K*PPS7),0,S6.K,1)),0,S7.K)+
X  SWITCH((CLIP((FED2.K*PPS8),0,S7.K,1)),0,S8.K)+
X  SWITCH((CLIP((FED2.K*PPS9),0,S8.K,1)),0,S9.K)+
X  SWITCH((CLIP((FED2.K*PPS10),0,S9.K,1)),0,S10.K)+
X  SWITCH((CLIP((FED2.K*PPS11),0,S10.K,1)),0,S11.K)+
X  SWITCH((CLIP((FED2.K*PPS12),0,S11.K,1)),0,S12.K)+
X  SWITCH((CLIP((FED2.K*PPS13),0,S12.K,1)),0,S13.K)+
X  SWITCH((CLIP((FED2.K*PPS14),0,S13.K,1)),0,S14.K)+
X  SWITCH((CLIP((FED2.K*PPS15),0,S14.K,1)),0,S15.K)+
X  SWITCH((CLIP((FED2.K*PPS16),0,S15.K,1)),0,S16.K)

R  PRS.KL=SWITCH(PPS1,0,(S1.K-1))+SWITCH(PPS2,0,(S2.K-1))+
X  SWITCH(PPS3,0,(S3.K-1))+SWITCH(PPS4,0,(S4.K-1))+
X  SWITCH(PPS5,0,(S5.K-1))+SWITCH(PPS6,0,(S6.K-1))+
X  SWITCH(PPS7,0,(S7.K-1))+SWITCH(PPS8,0,(S8.K-1))+
X  SWITCH(PPS9,0,(S9.K-1))+SWITCH(PPS10,0,(S10.K-1))+
X  SWITCH(PPS11,0,(S11.K-1))+SWITCH(PPS12,0,(S12.K-1))+
X  SWITCH(PPS13,0,(S13.K-1))+SWITCH(PPS14,0,(S14.K-1))+
X  SWITCH(PPS15,0,(S15.K-1))+SWITCH(PPS16,0,(S16.K-1))
C  PPS1=2.5E6
C  PPS2=3.5E6
C  PPS3=1.5E6
C  PPS4=2.5E6
C  PPS5=3.5E6
C  PPS6=1.5E6
C  PPS7=2.5E6
C  PPS8=3.5E6
C  PPS9=1.5E6
C  PPS10=2.5E6
C  PPS11=3.5E6
C  PPS12=1.5E6
C  PPS13=2.5E6
C  PPS14=3.5E6
C  PPS15=1.5E6
C  PPS16=2.5E6
NOTE  AGEING MECHANISM OF SHIPS
L  S1.K=S1.J+DT*((R1.JK/DT)-AR1.JK)
N  S1=LTS1
C  LTS1=64
R  R1.KL=SWITCH(LTS1,0,(S1.K-1))
R  AR1.KL=1
L  S2.K=S2.J+DT*((R2.JK/DT)-AR2.JK)
N  S2=0
R  R2.KL=SWITCH((CLIP((FED2.K*LTS2),0,S1.K,1)),0,S2.K)+
X  SWITCH(LTS2,0,(S2.K-1))
C  LTS2=80
R  AR2.KL=CLIP(1,0,S2.K,1)
L  S3.K=S3.J+DT*((R3.JK/DT)-AR3.JK)
N  S3=0
R  R3.KL=SWITCH((CLIP((FED2.K*LTS3),0,S2.K,1)),0,S3.K)+
X  SWITCH(LTS3,0,(S3.K-1))
C  LTS3=40
R  AR3.KL=CLIP(1,0,S3.K,1)
L  S4.K=S4.J+DT*((R4.JK/DT)-AR4.JK)
N  S4=0
R  R4.KL=SWITCH((CLIP((FED2.K*LTS4),0,S3.K,1)),0,S4.K)+
X  SWITCH(LTS4,0,(S4.K-1))
C  LTS4=64
R  AR4.KL=CLIP(1,0,S4.K,1)
L  S5.K=S5.J+DT*((R5.JK/DT)-AR5.JK)
N  S5=0
R  R5.KL=SWITCH((CLIP((FED2.K*LTS5),0,S4.K,1)),0,S5.K)+
X  SWITCH(LTS5,0,(S5.K-1))
C  LTS5=80
R  AR5.KL=CLIP(1,0,S5.K,1)
L  S6.K=S6.J+DT*((R6.JK/DT)-AR6.JK)
N  S6=0
R  R6.KL=SWITCH((CLIP((FED2.K*LTS6),0,S5.K,1)),0,S6.K)+
X  SWITCH(LTS6,0,(S6.K-1))
C  LTS6=40
R  AR6.KL=CLIP(1,0,S6.K,1)
L  S7.K=S7.J+DT*((R7.JK/DT)-AR7.JK)
N  S7=0
R  R7.KL=SWITCH((CLIP((FED2.K*LTS7),0,S6.K,1)),0,S7.K)+
X  SWITCH(LTS7,0,(S7.K-1))
R  AR7.KL=CLIP(1,0,S7.K,1)
C  LTS7=64
L  S8.K=S8.J+DT*((R8.JK/DT)-AR8.JK)
N  S8=0
R  R8.KL=SWITCH((CLIP((FED2.K*LTS8),0,S7.K,1)),0,S8.K)+
X  SWITCH(LTS8,0,(S8.K-1))
R  AR8.KL=CLIP(1,0,S8.K,1)
C  LTS8=80
L  S9.K=S9.J+DT*((R9.JK/DT)-AR9.JK)
N  S9=0
R  R9.KL=SWITCH((CLIP((FED2.K*LTS9),0,S8.K,1)),0,S9.K)+
X  SWITCH(LTS9,0,(S9.K-1))
R  AR9.KL=CLIP(1,0,S9.K,1)
C  LTS9=40
L  S10.K=S10.J+DT*((R10.JK/DT)-AR10.JK)
N  S10=0
R  R10.KL=SWITCH((CLIP((FED2.K*LTS10),0,S9.K,1)),0,S10.K)+
X  SWITCH(LTS10,0,(S10.K-1))
R  AR10.KL=CLIP(1,0,S10.K,1)
C  LTS10=64
L  S11.K=S11.J+DT*((R11.JK/DT)-AR11.JK)
N  S11=0
R  R11.KL=SWITCH((CLIP((FED2.K*LTS11),0,S10.K,1)),0,S11.K)+
X  SWITCH(LTS11,0,(S11.K-1))
R  AR11.KL=CLIP(1,0,S11.K,1)
C  LTS11=80
L  S12.K=S12.J+DT*((R12.JK/DT)-AR12.JK)
N  S12=0
R  R12.KL=SWITCH((CLIP((FED2.K*LTS12),0,S11.K,1)),0,S12.K)+
X  SWITCH(LTS12,0,(S12.K-1))
R  AR12.KL=CLIP(1,0,S12.K,1)
L  S13.K=S13.J+DT*((R13.JK/DT)-AR13.JK)
C  LTS12=40
N  S13=0
R  R13.KL=SWITCH((CLIP((FED2.K*LTS13),0,S12.K,1)),0,S13.K)+
X  SWITCH(LTS13,0,(S13.K-1))
R  AR13.KL=CLIP(1,0,S13.K,1)
C  LTS13=64
L  S14.K=S14.J+DT*((R14.JK/DT)-AR14.JK)
N  S14=0
R  R14.KL=SWITCH((CLIP((FED2.K*LTS14),0,S13.K,1)),0,S14.K)+
X  SWITCH(LTS14,0,(S14.K-1))
R  AR14.KL=CLIP(1,0,S14.K,1)
C  LTS14=80
L  S15.K=S15.J+DT*((R15.JK/DT)-AR15.JK)
N  S15=0
R  R15.KL=SWITCH((CLIP((FED2.K*LTS15),0,S14.K,1)),0,S15.K)+
X  SWITCH(LTS15,0,(S15.K-1))
R  AR15.KL=CLIP(1,0,S15.K,1)
C  LTS15=40
L  S16.K=S16.J+DT*((R16.JK/DT)-AR16.JK)
N  S16=0
R  R16.KL=SWITCH((CLIP((FED2.K*LTS16),0,S15.K,1)),0,S16.K)+
X  SWITCH(LTS16,0,(S16.K-1))
R  AR16.KL=CLIP(1,0,S16.K,1)
C  LTS16=64
NOTE  FLEET EXPANSION MECHANISM
A  NCP.K=NEI1.K*CRG
C  CRG=.4
A  D.K=NCP.K-NCCSL.K
A  NCCS.K=(((1-PTCE-PCTE)*.8*LC+(1-PTCI-PCTI)*.8*LC)*OD)/RT
A  FED1.K=CLIP(1,0,(D.K/NCCS.K),1)
A  FED2.K=CLIP(FED1.K,0,WC.K,WCM)
C  WCM=-10E6
NOTE  SHIPPING LINE'S SHARE OF TRADE
A  CCSL.K=NS.K*((ET.K+IT.K)*OD)/RT
A  NCCSL.K=NS.K*(((1-PTCE-PCTE)*ET.K+(1-PTCI-PCTI)*IT.K)*OD)/RT
A  TCCSL.K=NS.K*((PTCE*ET.K+PTCI*IT.K)*OD)/RT
A  CTCCSL.K=NS.K*((PCTE*ET.K+PCTI*IT.K)*OD)/RT
C  PTCE=.2
C  PCTE=.1
C  PTCI=.2
C  PCTI=.1
A  NEI1.K=(E1.K+I1.K)*(1-PTC)
C  PTC=.3
A  TEI1.K=(E1.K+I1.K)*PTC
A  NCR.K=NCCSL.K/NEI1.K
A  TCR.K=TCCSL.K/TEI1.K
NOTE  EXPORTS/IMPORTS MODEL
NOTE  EXPORTS
L  E.K=E.J+DT*EG.JK
N  E=275000
R  EG.KL=E.K*EGR.K/100
A  EGR.K=TABLE(EGRT,TIME.K,0,96,96)
T  EGRT=1/1
A  E1.K=PE1*E.K
C  PE1=.46
A  E2.K=PE2*E.K
C  PE2=.25
A  E3.K=PE3*E.K
C  PE3=.29
NOTE  IMPORTS
L  I.K=I.J+DT*IG.JK
N  I=250000
R  IG.KL=I.K*IGR.K/100
A  IGR.K=TABLE(IGRT,TIME.K,0,96,96)
T  IGRT=1/1
A  I1.K=PI1*I.K
C  PI1=.54
A  I2.K=PI2*I.K
C  PI2=.31
A  I3.K=PI3*I.K
C  PI3=.15
NOTE  EXPORTS + IMPORTS
A  EI.K=E.K+I.K
A  EIR.K=E.K/I.K
NOTE  TRANSPORT INDEPENDENCE INDICATOR
A  TII.K=NS.K*((2*.9*LC*OD)/RT)/NEI1.K
SPEC  LENGTH=96/DT=.25/PRTPER=2/PLTPER=2
PRINT  NS,WC,WCG,WCI,PS,D,NCP,NEI1,NCR,TCR
PRINT  TII
PLOT  NS/WC/NCP/D/NCR
RUN
```

MODEL 14 - ENDOGENOUS FLEET EXPANSION 1

TIME	NS	WC	WCG	WCI	PS	D	NCP	NEI1	NCR	TCR	TII
E+00	E+00	E+06	E+03	E+03	E+03	E+03	E+03	E+03	E+00	E+00	E+00
.0	1.000	-2.50	.0	.0	3500.0	67.406	73.22	183.05	.03176	.02117	.10208
2.	4.000	-10.60	20.1	-318.0	.0	45.629	74.70	186.74	.15566	.10377	.40026
4.	4.000	-11.06	192.0	-331.8	.0	41.323	76.20	190.51	.18309	.12206	.39234
6.	4.000	-11.19	363.9	-335.8	.0	37.047	77.74	194.35	.20939	.13959	.38459
8.	4.000	-10.98	535.8	-329.5	.0	32.802	79.31	198.28	.23457	.15638	.37698
10.	4.000	-10.56	535.8	-316.8	.0	34.402	80.91	202.28	.22993	.15328	.36952
12.	4.000	-10.11	535.8	-303.3	.0	36.034	82.54	206.36	.22538	.15025	.36222
14.	5.000	-13.06	693.3	-391.9	.0	26.072	84.21	210.52	.27615	.18410	.44382
16.	5.000	-12.45	693.3	-373.4	.0	27.771	85.91	214.77	.27069	.18046	.43504
18.	5.000	-11.79	693.3	-353.7	.0	29.504	87.64	219.10	.26534	.17689	.42644
20.	5.000	-11.09	693.3	-332.8	.0	31.272	89.41	223.52	.26009	.17339	.41800
22.	5.000	-10.35	693.3	-310.6	.0	33.076	91.21	228.03	.25495	.16996	.40974
24.	6.000	-10.98	850.7	-329.4	.0	23.289	93.05	232.63	.29989	.19992	.48196
26.	6.000	-9.91	850.7	-297.3	2500.0	25.167	94.93	237.32	.29396	.19597	.47243
28.	7.000	-11.14	1000.3	-334.2	.0	15.455	96.84	242.11	.33617	.22411	.54027
30.	8.000	-13.27	1150.0	-398.2	.0	5.782	98.80	247.00	.37659	.25106	.60524
32.	8.000	-11.73	1150.0	-351.9	.0	7.775	100.79	251.98	.36914	.24610	.59327
34.	8.000	-10.09	1150.0	-302.7	.0	9.808	102.83	257.06	.36184	.24123	.58154
36.	8.000	-8.35	1150.0	-250.5	1500.0	11.883	104.90	262.25	.35469	.23646	.57004
38.	9.000	-7.82	1299.6	-234.5	.0	2.372	107.02	267.54	.39113	.26076	.62861
40.	9.000	-7.14	1299.6	-214.2	.0	4.531	109.18	272.94	.38340	.25560	.61618
42.	9.000	-4.91	1299.6	-147.4	.0	6.734	111.38	278.44	.37582	.25054	.60399
44.	9.000	-2.55	1299.6	-76.4	.0	8.981	113.62	284.06	.36838	.24559	.59205
46.	9.000	-.04	1299.6	-1.1	.0	11.273	115.92	289.79	.36110	.24073	.58034
48.	10.000	.23	1449.2	6.8	.0	1.985	118.26	295.64	.39329	.26219	.63207
50.	10.000	3.21	1449.2	96.4	.0	4.371	120.64	301.60	.38551	.25701	.61957
52.	10.000	6.39	1449.2	191.7	.0	6.805	123.08	307.69	.37788	.25192	.60731
54.	10.000	9.76	1449.2	292.7	.0	9.288	125.56	313.90	.37041	.24694	.59530
56.	10.000	13.33	1449.2	400.0	3500.0	11.821	128.09	320.23	.36309	.24206	.58353
58.	11.000	13.71	1598.8	411.3	.0	2.778	130.68	326.69	.39150	.26100	.62919
60.	11.000	17.84	1598.8	535.2	.0	5.415	133.31	333.28	.38375	.25584	.61675
62.	11.000	22.22	1598.8	666.6	.0	8.104	136.00	340.01	.37616	.25078	.60455
64.	11.000	20.25	1598.8	607.4	.0	10.848	138.75	346.87	.36873	.24582	.59259
66.	12.000	23.38	1748.4	701.5	.0	2.020	141.55	353.86	.39429	.26286	.63368
68.	12.000	28.41	1748.4	852.4	.0	4.876	144.40	361.00	.38649	.25766	.62115
70.	12.000	33.75	1748.4	1012.6	.0	7.789	147.31	368.29	.37885	.25257	.60887
72.	12.000	39.42	1748.4	1182.6	.0	10.762	150.29	375.72	.37136	.24757	.59682
74.	13.000	43.02	1898.1	1290.5	.0	2.167	153.32	383.30	.39435	.26290	.63377
76.	13.000	48.04	1898.1	1441.2	.0	5.260	156.41	391.03	.38655	.25770	.62124
78.	13.000	54.90	1898.1	1646.9	.0	8.416	159.57	398.92	.37890	.25260	.60895
80.	13.000	57.11	1898.1	1713.3	3500.0	11.635	162.79	406.97	.37141	.24761	.59691
82.	14.000	61.11	2047.7	1833.2	.0	3.292	166.07	415.18	.39207	.26138	.63011
84.	14.000	69.07	2047.7	2072.2	.0	6.643	169.42	423.56	.38432	.25621	.61765
86.	14.000	77.53	2047.7	2326.0	.0	10.061	172.84	432.10	.37672	.25114	.60544
88.	15.000	85.09	2197.3	2552.8	.0	1.921	176.33	440.82	.39564	.26376	.63585
90.	15.000	92.31	2197.3	2769.3	.0	5.478	179.88	449.71	.38782	.25855	.62328
92.	15.000	99.01	2197.3	2970.2	.0	9.108	183.51	458.79	.38015	.25343	.61095
94.	16.000	107.14	2346.9	3214.1	.0	1.183	187.22	468.04	.39747	.26498	.63880
96.	16.000	118.55	2346.9	3556.6	.0	4.960	190.99	477.48	.38961	.25974	.62616



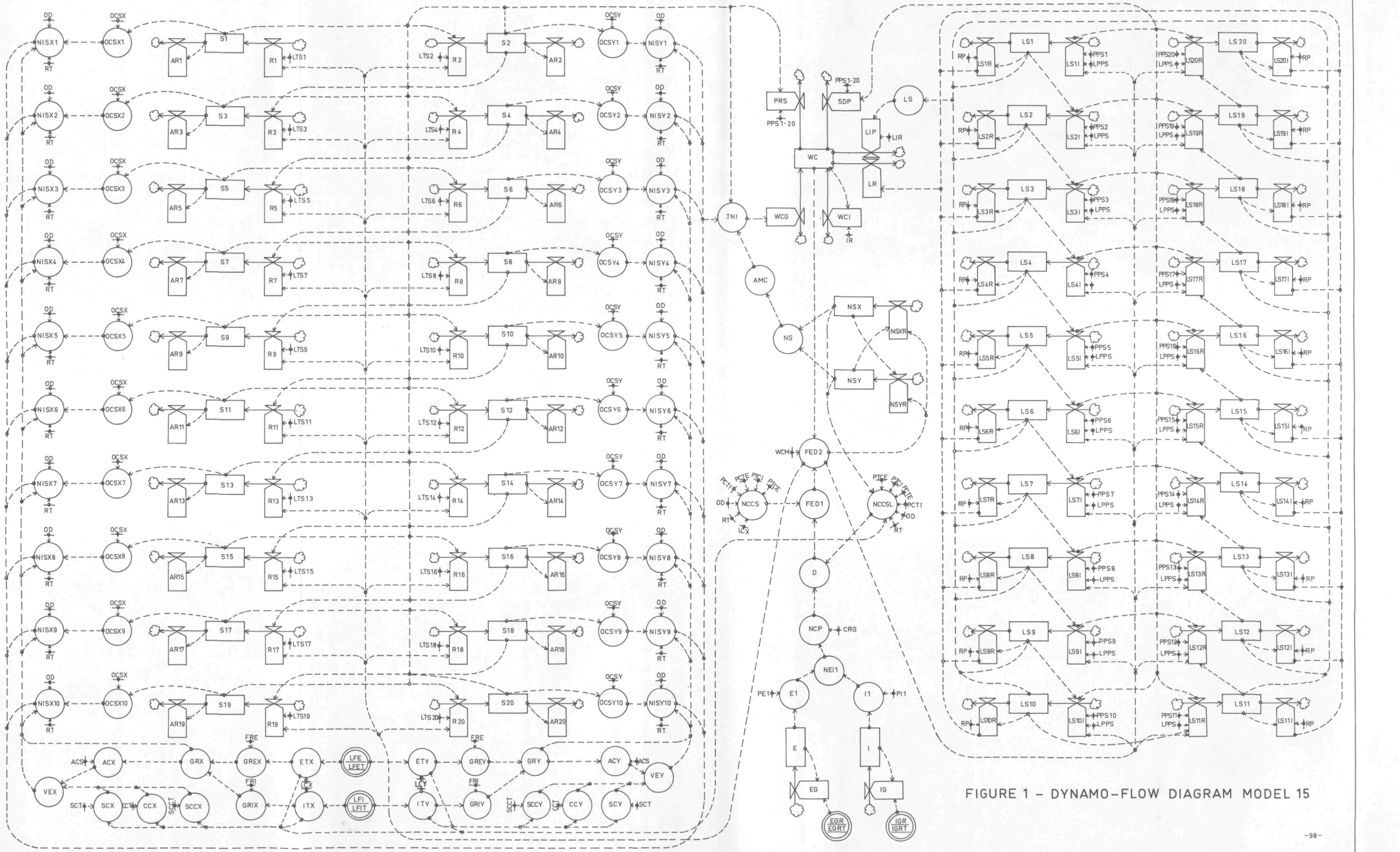


FIGURE 1 - DYNAMO-FLOW DIAGRAM MODEL 15

7.2 MODEL 15 - ENDOGENOUS FLEET EXPANSION 2

This model is a combination of models 9, 10, 11, and 14.

Figure 1 is the dynamo-flow diagram of the model. Figure 2 represents the flow diagrams of the decision criteria.

Note that the ships of class x and y are purchased alternatingly.

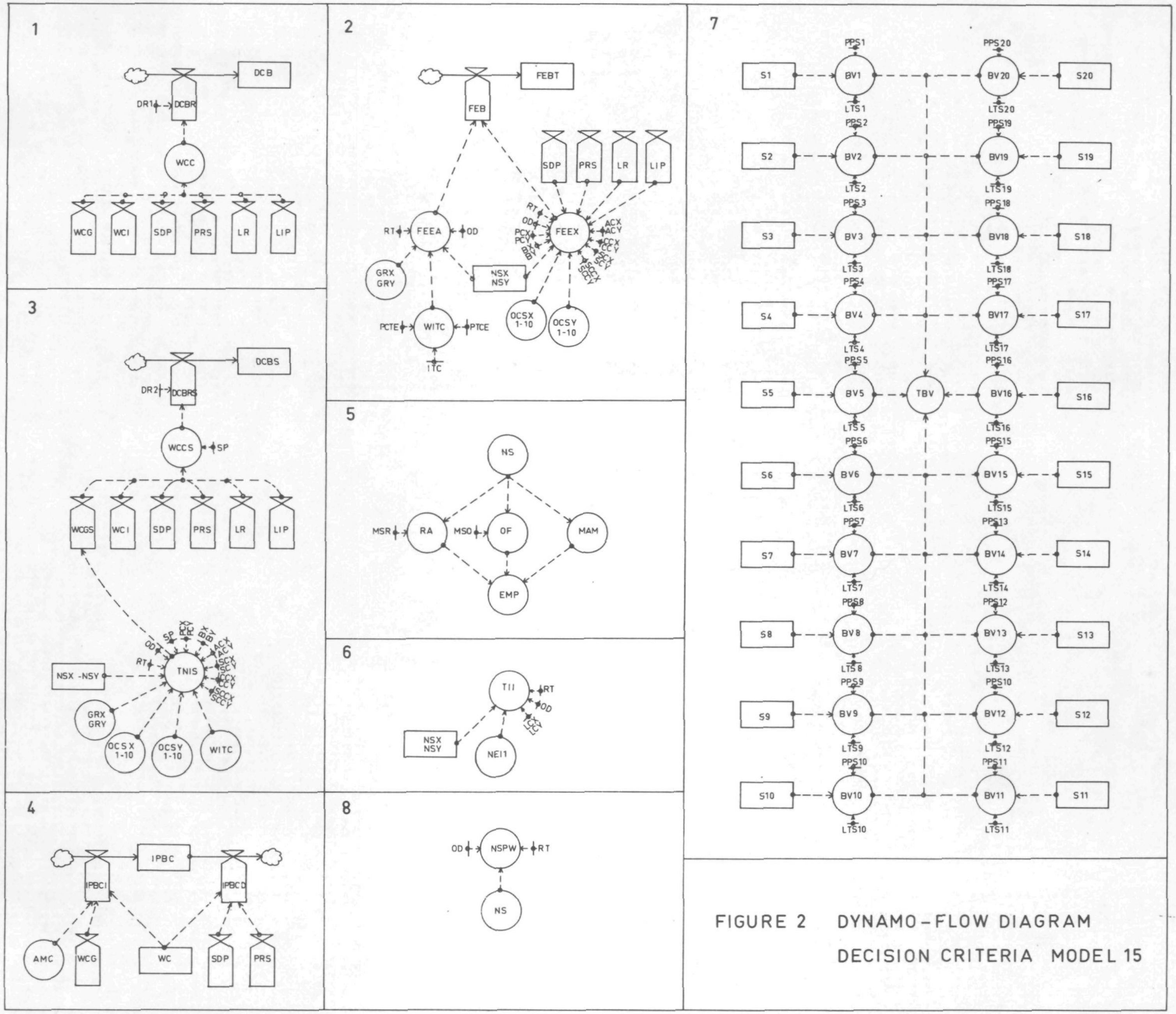


FIGURE 2 DYNAMO-FLOW DIAGRAM

DECISION CRITERIA MODEL 15

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*  MODEL 15 - ENDOGENOUS FLEET EXPANSION 2
NOTE  NUMBER OF SHIPS
A   NS.K=NSX.K+NSY.K
L   NSX.K=NSX.J+DT*NSXP.JK
N   NSX=1
R   NSXP.KL=SWITCH((FED2.K/DT),0,(NSX.K-NSY.K))
L   NSY.K=NSY.J+DT*NSYR.JK
N   NSY=0
R   NSYP.KL=SWITCH(0,(FED2.K/DT),(NSX.K-NSY.K))
NOTE  NETT INCOME/SHIP X /QUARTER
A   ETX.K=LCX*LFE.K
C   LCX=14000
A   LFE.K=TABHL(LFET,TIME.K,0,96,8)
T   LFET=.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A   ITX.K=LCX*LFI.K
A   LFI.K=TABHL(LFIT,TIME.K,0,96,8)
T   LFIT=.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
A   GREX.K=ETX.K*FRE
C   FRE=25
A   GRIX.K=ITX.K*FRI
C   FRI=35
A   GRX.K=GREX.K+GRIX.K
A   ACX.K=GRX.K*ACS
C   ACS=.055
A   SCX.K=(ETX.K+ITX.K)*SCT
C   SCT=6.25
A   CCX.K=(ETX.K+ITX.K)*CCT
C   CCT=.4
A   SCCX.K=(ETX.K+ITX.K)*SCCT
C   SCCT=1
C   BX=58000
C   PCX=45000
A   VEX.K=ACX.K+SCCX.K+CCX.K+SCX.K+BX+PCX
A   NISX1.K=(((GRX.K-VEX.K)*DD)/RT)-DCSX1.K
A   NISX2.K=(((GRX.K-VEX.K)*DD)/RT)-DCSX2.K
A   NISX3.K=(((GRX.K-VEX.K)*DD)/RT)-DCSX3.K
A   NISX4.K=(((GRX.K-VEX.K)*DD)/RT)-DCSX4.K
A   NISX5.K=(((GRX.K-VEX.K)*DD)/RT)-DCSX5.K
A   NISX6.K=(((GRX.K-VEX.K)*DD)/RT)-DCSX6.K
A   NISX7.K=(((GRX.K-VEX.K)*DD)/RT)-DCSX7.K
A   NISX8.K=(((GRX.K-VEX.K)*DD)/RT)-DCSX8.K
A   NISX9.K=(((GRX.K-VEX.K)*DD)/RT)-DCSX9.K
A   NISX10.K=(((GRX.K-VEX.K)*DD)/RT)-DCSX10.K
C   DD=87.5
C   RT=118
A   DCSX1.K=CLIP(SDCX,1.1*SDCX,S1.K,41)
A   DCSX2.K=CLIP(SDCX,1.1*SDCX,S3.K,41)
A   DCSX3.K=CLIP(SDCX,1.1*SDCX,S5.K,41)
A   DCSX4.K=CLIP(SDCX,1.1*SDCX,S7.K,41)
A   DCSX5.K=CLIP(SDCX,1.1*SDCX,S9.K,41)
A   DCSX6.K=CLIP(SDCX,1.1*SDCX,S11.K,41)
A   DCSX7.K=CLIP(SDCX,1.1*SDCX,S13.K,41)
A   DCSX8.K=CLIP(SDCX,1.1*SDCX,S15.K,41)
A   DCSX9.K=CLIP(SDCX,1.1*SDCX,S17.K,41)
A   DCSX10.K=CLIP(SDCX,1.1*SDCX,S19.K,41)
C   SDCX=110000
NOTE  NETT INCOME/ SHIP Y / QUARTER
A   ETY.K=LCY*LFE.K
C   LCY=11000
A   ITY.K=LCY*LFI.K
A   GREY.K=ETY.K*FRE
A   GRIY.K=ITY.K*FRI
A   GRY.K=GREY.K+GRIY.K
A   ACY.K=GRY.K*ACS
A   CCY.K=(ETY.K+ITY.K)*CCT
A   SCY.K=(ETY.K+ITY.K)*SCT
A   SCCY.K=(ETY.K+ITY.K)*SCCT
C   BY=50000
C   PCY=40000
A   VEY.K=ACY.K+SCCY.K+CCY.K+SCY.K+BY+PCY
A   NISY1.K=(((GRY.K-VEY.K)*DD)/RT)-DCSY1.K
A   NISY2.K=(((GRY.K-VEY.K)*DD)/RT)-DCSY2.K
A   NISY3.K=(((GRY.K-VEY.K)*DD)/RT)-DCSY3.K
A   NISY4.K=(((GRY.K-VEY.K)*DD)/RT)-DCSY4.K
A   NISY5.K=(((GRY.K-VEY.K)*DD)/RT)-DCSY5.K
A   NISY6.K=(((GRY.K-VEY.K)*DD)/RT)-DCSY6.K
A   NISY7.K=(((GRY.K-VEY.K)*DD)/RT)-DCSY7.K
A   NISY8.K=(((GRY.K-VEY.K)*DD)/RT)-DCSY8.K
A   NISY9.K=(((GRY.K-VEY.K)*DD)/RT)-DCSY9.K
A   NISY10.K=(((GRY.K-VEY.K)*DD)/RT)-DCSY10.K
A   DCSY1.K=CLIP(SDCY,1.1*SDCY,S2.K,41)
A   DCSY2.K=CLIP(SDCY,1.1*SDCY,S4.K,41)
A   DCSY3.K=CLIP(SDCY,1.1*SDCY,S6.K,41)
A   DCSY4.K=CLIP(SDCY,1.1*SDCY,S8.K,41)
A   DCSY5.K=CLIP(SDCY,1.1*SDCY,S10.K,41)
A   DCSY6.K=CLIP(SDCY,1.1*SDCY,S12.K,41)
A   DCSY7.K=CLIP(SDCY,1.1*SDCY,S14.K,41)
A   DCSY8.K=CLIP(SDCY,1.1*SDCY,S16.K,41)
A   DCSY9.K=CLIP(SDCY,1.1*SDCY,S18.K,41)
A   DCSY10.K=CLIP(SDCY,1.1*SDCY,S20.K,41)
C   SDCY=95000
NOTE  TOTAL NETT INCOME
A   TNI.K=NISX1.K*SWITCH(0,1,S1.K)+NISY1.K*SWITCH(0,1,S2.K)+
X   NISX2.K*SWITCH(0,1,S3.K)+NISY2.K*SWITCH(0,1,S4.K)+
X   NISX3.K*SWITCH(0,1,S5.K)+NISY3.K*SWITCH(0,1,S6.K)+
X   NISX4.K*SWITCH(0,1,S7.K)+NISY4.K*SWITCH(0,1,S8.K)+
X   NISX5.K*SWITCH(0,1,S9.K)+NISY5.K*SWITCH(0,1,S10.K)+
X   NISX6.K*SWITCH(0,1,S11.K)+NISY6.K*SWITCH(0,1,S12.K)+
X   NISX7.K*SWITCH(0,1,S13.K)+NISY7.K*SWITCH(0,1,S14.K)+
X   NISX8.K*SWITCH(0,1,S15.K)+NISY8.K*SWITCH(0,1,S16.K)+
X   NISX9.K*SWITCH(0,1,S17.K)+NISY9.K*SWITCH(0,1,S18.K)+
X   NISX10.K*SWITCH(0,1,S19.K)+NISY10.K*SWITCH(0,1,S20.K)-AMC.K
A   AMC.K=94000+94000*CLIP(((NS.K-6)/12),0,NS.K,6)
NOTE  WORKING CAPITAL
L   WC.K=WC.J+DT*(WCG.JK+WCI.JK-(SDP.JK/DT)-(PRS.JK/DT)-LR.JK-LIP.JK)
N   WC=-(1-LFPS)*PPS1
R   WCG.KL=CLIP(TNI.K,0,TIME.K,DT)
R   WCI.KL=CLIP((WC.K*IR),0,TIME.K,DT)
C   IR=.03
R   SDP.KL=SWITCH(0,(PPS2-LS2I.JK),LS2I.JK)+
X   SWITCH(0,(PPS3-LS3I.JK),LS3I.JK)+SWITCH(0,(PPS4-LS4I.JK),LS4I.JK)+
X   SWITCH(0,(PPS5-LS5I.JK),LS5I.JK)+SWITCH(0,(PPS6-LS6I.JK),LS6I.JK)+
X   SWITCH(0,(PPS7-LS7I.JK),LS7I.JK)+SWITCH(0,(PPS8-LS8I.JK),LS8I.JK)+
X   SWITCH(0,(PPS9-LS9I.JK),LS9I.JK)+SWITCH(0,(PPS10-LS10I.JK),LS10I.JK)+
X   SWITCH(0,(PPS11-LS11I.JK),LS11I.JK)+
X   SWITCH(0,(PPS12-LS12I.JK),LS12I.JK)+
```

```
ACS      AGENCY COMMISIONS SHARE OF GROSS REVENUE  %
           ,DIM'LESS
ACX      AGENCY COMMISSIONS /SHIP X/ ROUNDTRIP  $
ACY      AGENCY COMMISSIONS /SHIP Y/ ROUNDTRIP  $
AMC      ADMINISTRATIVE $ MANAGEMENT COST    $/
           QUARTER
AR1      AGEING RATE 1
AR10     AGEING RATE 10
AR11     AGEING RATE 11
AR12     AGEING RATE 12
AR13     AGEING RATE 13
AR14     AGEING RATE 14
AR15     AGEING RATE 15
AR16     AGEING RATE 16
AR17     AGEING RATE 17
AR18     AGEING RATE 18
AR19     AGEING RATE 19
AR2      AGEING RATE 2
AR20     AGEING RATE 20
AR3      AGEING RATE 3
AR4      AGEING RATE 4
AR5      AGEING RATE 5
AR6      AGEING RATE 6
AR7      AGEING RATE 7
AR8      AGEING RATE 8
AR9      AGEING RATE 9
BV1      BOOK VALUE SHIP 1   $
BV10     BOOK VALUE SHIP 10   $
BV11     BOOK VALUE SHIP 11   $
BV12     BOOK VALUE SHIP 12   $
BV13     BOOK VALUE SHIP 13   $
BV14     BOOK VALUE SHIP 14   $
BV15     BOOK VALUE SHIP 15   $
BV16     BOOK VALUE SHIP 16   $
BV17     BOOK VALUE SHIP 17   $
BV18     BOOK VALUE SHIP 18   $
BV19     BOOK VALUE SHIP 19   $
BV2      BOOK VALUE SHIP 2   $
BV20     BOOK VALUE SHIP 20   $
BV3      BOOK VALUE SHIP 3   $
BV4      BOOK VALUE SHIP 4   $
BV5      BOOK VALUE SHIP 5   $
BV6      BOOK VALUE SHIP 6   $
BV7      BOOK VALUE SHIP 7   $
BV8      BOOK VALUE SHIP 8   $
BV9      BOOK VALUE SHIP 9   $
BX       BUNKERS /SHIP X/ROUNDTRIP   $
BY       BUNKERS /SHIP Y/ROUNDTRIP   $
CCSL     CARGO CARRIED BY SHIPPING LINE   TONS/
           QUARTER
CCT      CARGO CLAIMS/TON   $/TON
CCX      CARGO CLAIMS/SHIP X/ROUNDTRIP   $
CCY      CARGO CLAIMS/SHIP Y/ROUNDTRIP   $
CRG      CARGO RESERVATION GOAL   PERCENTAGE
CTCCSL   CROSS TRADE CARGO CARRIED BY SHIPPING LINE
           TONS/QUARTER
D        DISCREPANCY   TONS /QUARTER
DCB      DISCOUNTED COSTS AND BENEFITS   $
DCBR     DCB-RATE    $/QUARTER
DCBRS    DCB-RATE SHADOW PRICED   $/QUARTER
DCBS     DISCOUNTED COSTS AND BENEFITS SHADOW PRICED
           $
DR1      DISCOUNT RATE 1    %/QUARTER
DR2      DISCOUNT RATE 2 %/QUARTER
E        EXPORTS      TONS/QUARTER
EG       EXPORTS GROWTH    TONS/QUARTER
EGR      EXPORTS GROWTH RATE    %/QUARTER
EGRT     EXPORTS GROWTH RATE TABLE
EI       EXPORTS + IMPORTS     TONS/QUARTER
EIR      EXPORTS/IMPORTS RATIO    DIM'LESS
EMP      EMPLOYMENT OF SHIPPING LINE
ETX      EXPORT TONNAGE/SHIP X/ROUNDTRIP   TONS
ETY      EXPORT TONNAGE/SHIP Y/ROUNDTRIP   TONS
E1       EXPORTS ON ROUTE 1    TONS/QUARTER
E2       EXPORTS ON ROUTE 2    TONS/QUARTER
E3       EXPORTS ON ROUTE 3    TONS/QUARTER
FEB      FOREIGN EXCHANGE BALANCE   $/QUARTER
FEBT     FOREIGN EXCHANGE BALANCE TOTAL   $
FED1     FLEET EXPANSION DECISION 1
FED2     FLEET EXPANSION DECISION 2
FEEA     FOREIGN EXCHANGE EARNINGS   $/QUARTER
FEEX     FOREIGN EXCHANGE EXPENDITURES   $/QUARTER
FRE      FREIGHT RATE OF EXPORTS   $/TON
FRI      FREIGHT RATE OF IMPORTS   $/TON
GREX     GROSS REVENUE ON EXPORTS /SHIP X/ROUNDTRIP$
GREY     GROSS REVENUE ON EXPORTS /SHIP Y/ROUNDTRIP$
GRIX     GROSS REVENUEON IMPORTS /SHIP X/ ROUNDTRIP$
GRIY     GROSS REVENUEON IMPORTS /SHIP Y/ ROUNDTRIP$
GRX      GROSS REVENUE /SHIP X/ ROUNDTRIP   $
GRY      GROSS REVENUE /SHIP Y/ ROUNDTRIP   $
I        3  IMPORTS ON ROUTE 3    TONS/QUARTER
IG       IMPORTS GROWTH    TONS/QUARTER
IGR      IMPORTS GROWTH RATE     %/QUARTER
IGRT     IMPORTS GROWTH RATE TABLE
IPBC     INCOME PLOUGHED BACK IN COUNTRY   $
IPBCD    INCOME PLOUGHED BACK IN COUNTRY DECREASE $/
           QUARTER
IPBCI    IPBC-INCREASE   $/QUARTER
IR       INTEREST RATE    %/QUARTER
ITC      INCIDENCE OF TRANSPORT COST   %
ITX      IMPORT TONNAGE / SHIP X / ROUNDTRIP   TONS
ITY      IMPORT TONNAGE / SHIP Y / ROUNDTRIP   TONS
I1       IMPORTS ON ROUTE 1    TONS/QUARTER
I2       IMPORTS ON ROUTE 2    TONS/QUARTER
LCX      LOAD CAPACITY SHIP X     TONS
LCY      LOAD CAPACITY SHIP Y     TONS
LFE      LOAD FACTOR EXPORTS   DIM'LESS
LFET     LOAD FACTOR EXPORTS TABLE
LFI      LOAD FACTOR IMPORTS   DIM'LESS
LFIT     LOAD FACTOR IMPORTS TABLE
LIP      LOAN INTEREST PAYMENTS   $/QUARTER
LIR      LOAN INTEREST RATE   DIM'LESS
```

```
X   SWITCH(0,(PPS13-LS13I.JK),LS13I.JK)+
X   SWITCH(0,(PPS14-LS14I.JK),LS14I.JK)+
X   SWITCH(0,(PPS15-LS15I.JK),LS15I.JK)+
X   SWITCH(0,(PPS16-LS16I.JK),LS16I.JK)+
X   SWITCH(0,(PPS17-LS17I.JK),LS17I.JK)+
X   SWITCH(0,(PPS18-LS18I.JK),LS18I.JK)+
X   SWITCH(0,(PPS19-LS19I.JK),LS19I.JK)+
X   SWITCH(0,(PPS20-LS20I.JK),LS20I.JK)
R   PRS.KL=SWITCH(PPS1,0,(S1.K-1))+SWITCH(PPS2,0,(S2.K-1))+
X   SWITCH(PPS3,0,(S3.K-1))+SWITCH(PPS4,0,(S4.K-1))+
X   SWITCH(PPS5,0,(S5.K-1))+SWITCH(PPS6,0,(S6.K-1))+
X   SWITCH(PPS7,0,(S7.K-1))+SWITCH(PPS8,0,(S8.K-1))+
X   SWITCH(PPS9,0,(S9.K-1))+SWITCH(PPS10,0,(S10.K-1))+
X   SWITCH(PPS11,0,(S11.K-1))+SWITCH(PPS12,0,(S12.K-1))+
X   SWITCH(PPS13,0,(S13.K-1))+SWITCH(PPS14,0,(S14.K-1))+
X   SWITCH(PPS15,0,(S15.K-1))+SWITCH(PPS16,0,(S16.K-1))+
X   SWITCH(PPS17,0,(S17.K-1))+SWITCH(PPS18,0,(S18.K-1))+
X   SWITCH(PPS19,0,(S19.K-1))+SWITCH(PPS20,0,(S20.K-1))
R   LR.KL=LS1R.JK+LS2R.JK+LS3R.JK+LS4R.JK+LS5R.JK+LS6R.JK+LS7R.JK+
X   LS8R.JK+LS9R.JK+LS10R.JK+LS11R.JK+LS12R.JK+LS13R.JK+LS14R.JK+
X   LS15R.JK+LS16R.JK+LS17R.JK+LS18R.JK+LS19R.JK+LS20R.JK
R   LIP.KL=LIR*LS.K
C   LIR=.02
NOTE   PRICE OF SHIPS IN ORDER OF PURCHASE
C   PPS1=3.5E6
C   PPS2=2E6
C   PPS3=1.5E6
C   PPS4=3E6
C   PPS5=2.5E6
C   PPS6=1E6
C   PPS7=3.5E6
C   PPS8=2E6
C   PPS9=1.5E6
C   PPS10=3E6
C   PPS11=2.5E6
C   PPS12=1E6
C   PPS13=3.5E6
C   PPS14=2E6
C   PPS15=1.5E6
C   PPS16=3E6
C   PPS17=2.5E6
C   PPS18=1E6
C   PPS19=3.5E6
C   PPS20=2E6
NOTE   LOAN SECTOR
A   LS.K=LS1.K+LS2.K+LS3.K+LS4.K+LS5.K+LS6.K+LS7.K+LS8.K+LS9.K+LS10.K+
X   LS11.K+LS12.K+LS13.K+LS14.K+LS15.K+LS16.K+LS17.K+LS18.K+LS19.K+LS20.K
L   LS1.K=LS1.J+DT*((LS1I.JK/DT)-LS1R.JK)
N   LS1=LPPS*PPS1
C   LPPS=.75
R   LS1I.KL=0
R   LS1R.KL=LPPS*PPS1*CLIP((SWITCH(0,(1/RP),LS1.K)),0,LS1.K,.5E5)
C   RP=32
L   LS2.K=LS2.J+DT*((LS2I.JK/DT)-LS2R.JK)
N   LS2=0
R   LS2I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS2),0,LS1.K,1)),0,LS2.K)
R   LS2R.KL=LPPS*PPS2*CLIP((SWITCH(0,(1/RP),LS2.K)),0,LS2.K,.5E5)
L   LS3.K=LS3.J+DT*((LS3I.JK/DT)-LS3R.JK)

N   LS3=0
R   LS3I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS3),0,LS2.K,1)),0,LS3.K)
R   LS3R.KL=LPPS*PPS3*CLIP((SWITCH(0,(1/RP),LS3.K)),0,LS3.K,.5E5)
L   LS4.K=LS4.J+DT*((LS4I.JK/DT)-LS4R.JK)
N   LS4=0
R   LS4I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS4),0;LS3.K,1)),0,LS4.K)
R   LS4R.KL=LPPS*PPS4*CLIP((SWITCH(0,(1/RP),LS4.K)),0,LS4.K,.5E5)
L   LS5.K=LS5.J+DT*((LS5I.JK/DT)-LS5R.JK)
N   LS5=0
R   LS5I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS5),0,LS4.K,1)),0,LS5.K)
R   LS5R.KL=LPPS*PPS5*CLIP((SWITCH(0,(1/RP),LS5.K)),0,LS5.K,.5E5)
L   LS6.K=LS6.J+DT*((LS6I.JK/DT)-LS6R.JK)
N   LS6=0
R   LS6I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS6),0,LS5.K,1)),0,LS6.K)
R   LS6R.KL=LPPS*PPS6*CLIP((SWITCH(0,(1/RP),LS6.K)),0,LS6.K,.5E5)
L   LS7.K=LS7.J+DT*((LS7I.JK/DT)-LS7R.JK)
N   LS7=0
R   LS7I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS7),0,LS6.K,1)),0,LS7.K)
R   LS7R.KL=LPPS*PPS7*CLIP((SWITCH(0,(1/RP),LS7.K)),0,LS7.K,.5E5)
L   LS8.K=LS8.J+DT*((LS8I.JK/DT)-LS8R.JK)
N   LS8=0
R   LS8I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS8),0,LS7.K,1)),0,LS8.K)
R   LS8R.KL=LPPS*PPS8*CLIP((SWITCH(0,(1/RP),LS8.K)),0,LS8.K,.5E5)
L   LS9.K=LS9.J+DT*((LS9I.JK/DT)-LS9R.JK)
N   LS9=0
R   LS9I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS9),0,LS8.K,1)),0,LS9.K)
R   LS9R.KL=LPPS*PPS9*CLIP((SWITCH(0,(1/RP),LS9.K)),0,LS9.K,.5E5)
L   LS10.K=LS10.J+DT*((LS10I.JK/DT)-LS10R.JK)
N   LS10=0
R   LS10I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS10),0,LS9.K,1)),0,LS10.K)
R   LS10R.KL=LPPS*PPS10*CLIP((SWITCH(0,(1/RP),LS10.K)),0,LS10.K,.5E5)
L   LS11.K=LS11.J+DT*((LS11I.JK/DT)-LS11R.JK)
N   LS11=0
R   LS11I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS11),0,LS10.K,1)),0,LS11.K)
R   LS11R.KL=LPPS*PPS11*CLIP((SWITCH(0,(1/RP),LS11.K)),0,LS11.K,.5E5)
L   LS12.K=LS12.J+DT*((LS12I.JK/DT)-LS12R.JK)
N   LS12=0
R   LS12I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS12),0,LS11.K,1)),0,LS12.K)
R   LS12R.KL=LPPS*PPS12*CLIP((SWITCH(0,(1/RP),LS12.K)),0,LS12.K,.5E5)
L   LS13.K=LS13.J+DT*((LS13I.JK/DT)-LS13R.JK)
N   LS13=0
R   LS13I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS13),0,LS12.K,1)),0,LS13.K)
R   LS13R.KL=LPPS*PPS13*CLIP((SWITCH(0,(1/RP),LS13.K)),0,LS13.K,.5E5)
L   LS14.K=LS14.J+DT*((LS14I.JK/DT)-LS14R.JK)
N   LS14=0
R   LS14I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS14),0,LS13.K,1)),0,LS14.K)
R   LS14R.KL=LPPS*PPS14*CLIP((SWITCH(0,(1/RP),LS14.K)),0,LS14.K,.5E5)
L   LS15.K=LS15.J+DT*((LS15I.JK/DT)-LS15R.JK)
N   LS15=0
R   LS15I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS15),0,LS14.K,1)),0,LS15.K)
R   LS15R.KL=LPPS*PPS15*CLIP((SWITCH(0,(1/RP),LS15.K)),0,LS15.K,.5E5)
L   LS16.K=LS16.J+DT*((LS16I.JK/DT)-LS16R.JK)
```

```
LPPS     LOAN PERCENTAGE PER SHIP     DIM'LESS
LR       LOAN REPAYMENTS     ƒ/QUARTER
LS       LOAN ON SHIPS  ƒ
LS1      LOAN ON SHIP 1  ƒ
LS1I     LOAN SHIP 1  INCREASE   ƒ
LS1R     LOAN SHIP 1  REPAYMENT   ƒ/QUARTER
LS10     LOAN ON SHIP 10  ƒ
LS10I    LOAN SHIP 10  INCREASE   ƒ
LS10R    LOAN SHIP 10 REPAYMENT   ƒ/QUARTER
LS11     LOAN ON SHIP 11   ƒ
LS11I    LOAN SHIP 11  INCREASE   ƒ
LS11R    LOAN SHIP 11 REPAYMENT   ƒ/QUARTER
LS12     LOAN ON SHIP 12   ƒ
LS12I    LOAN SHIP 12  INCREASE   ƒ
LS12R    LOAN SHIP 12 REPAYMENT   ƒ/QUARTER
LS13     LOAN ON SHIP 13   ƒ
LS13I    LOAN SHIP 13  INCREASE   ƒ
LS13R    LOAN SHIP 13 REPAYMENT   ƒ/QUARTER
LS14     LOAN ON SHIP 14   ƒ
LS14I    LOAN SHIP 14  INCREASE   ƒ
LS14R    LOAN SHIP 14 REPAYMENT   ƒ/QUARTER
LS15     LOAN ON SHIP 15   ƒ
LS15I    LOAN SHIP 15  INCREASE   ƒ
LS15R    LOAN SHIP 15 REPAYMENT   ƒ/QUARTER
LS16     LOAN ON SHIP 16   ƒ
LS16I    LOAN SHIP 16  INCREASE   ƒ
LS16R    LOAN SHIP 16 REPAYMENT   ƒ/QUARTER
LS17     LOAN ON SHIP 17   ƒ
LS17I    LOAN SHIP 17  INCREASE   ƒ
LS17R    LOAN SHIP 17 REPAYMENT   ƒ/QUARTER
LS18     LOAN ON SHIP 18   ƒ
LS18I    LOAN SHIP 18  INCREASE   ƒ
LS18R    LOAN SHIP 18 REPAYMENT   ƒ/QUARTER
LS19     LOAN ON SHIP 19   ƒ
LS19I    LOAN SHIP 19  INCREASE   ƒ
LS19R    LOAN SHIP 19 REPAYMENT   ƒ/QUARTER
LS2      LOAN ON SHIP 2   ƒ
LS2I     LOAN SHIP 2   INCREASE   ƒ
LS2R     LOAN SHIP 2   REPAYMENT   ƒ/QUARTER
LS20     LOAN ON SHIP 20   ƒ
LS20I    LOAN SHIP 20    ƒ
LS20R    LOAN SHIP 20 REPAYMENT    ƒ/QUARTER
LS3      LOAN ON SHIP 3   ƒ
LS3I     LOAN SHIP 3   INCREASE   ƒ
LS3R     LOAN SHIP 3   REPAYMENT   ƒ/QUARTER
LS4      LOAN ON SHIP 4   ƒ
LS4I     LOAN SHIP 4   INCREASE   ƒ
LS4R     LOAN SHIP 4   REPAYMENT   ƒ/QUARTER
LS5      LOAN ON SHIP 5   ƒ
LS5I     LOAN SHIP 5   INCREASE   ƒ
LS5R     LOAN SHIP 5   REPAYMENT   ƒ/QUARTER
LS6      LOAN ON SHIP 6   ƒ
LS6I     LOAN SHIP 6   INCREASE   ƒ
LS6R     LOAN SHIP 6   REPAYMENT   ƒ/QUARTER
LS7      LOAN ON SHIP 7   ƒ
LS7I     LOAN SHIP 7   INCREASE   ƒ
LS7R     LOAN SHIP 7   REPAYMENT   ƒ/QUARTER
LS8      LOAN ON SHIP 8   ƒ
LS8I     LOAN SHIP 8   INCREASE   ƒ
LS8R     LOAN SHIP 8   REPAYMENT   ƒ/QUARTER
LS9      LOAN ON SHIP 9   ƒ
LS9I     LOAN SHIP 9   INCREASE   ƒ
LS9R     LOAN SHIP 9   REPAYMENT   ƒ/QUARTER
LTS1     LIFETIME SHIP 1    QUARTERS
LTS10    LIFETIME SHIP 10    QUARTERS
LTS11    LIFETIME SHIP 11    QUARTERS
LTS12    LIFETIME SHIP 12    QUARTERS
LTS13    LIFETIME SHIP 13    QUARTERS
LTS14    LIFETIME SHIP 14    QUARTERS
LTS15    LIFETIME SHIP 15    QUARTERS
LTS16    LIFETIME SHIP  16    QUARTER
LTS17    LIFETIME SHIP  17    QUARTER
LTS18    LIFETIME SHIP  18    QUARTER
LTS19    LIFETIME SHIP  19    QUARTER
LTS2     LIFETIME SHIP 2   QUARTERS
LTS20    LIFETIME SHIP  20   QUARTER
LTS3     LIFETIME SHIP 3   QUARTERS
LTS4     LIFETIME SHIP 4   QUARTERS
LTS5     LIFETIME SHIP 5  QUARTERS
LTS6     LIFETIME SHIP 6   QUARTERS
LTS7     LIFETIME SHIP 7  QUARTERS
LTS8     LIFETIME SHIP 8  QUARTERS
LTS9     LIFETIME SHIP 9  QUARTERS
MAM      MANNING ADMINISTRATION & MANAGEMENT
MSO      MANNING SCALE OFFICERS
MSR      MANNING SCALE RATINGS
NCCS     NATIONAL CARGO CARRIED / SHIP    TONS/
           QUARTER
NCCSL    NATIONAL CARGO CARRIED BY SHIPPING LINE
           TONS/QUARTER
NCP      NATIONAL CARGO POTENTIAL   TONS/QUARTER
NCR      NATIONAL CARGO CARRIED BY SHIPPING LINE /
           NATIONAL EXPORTS AND IMPORTS ON ROUTE 1
           RATIO
NEI1     NATIONAL EXPORTS+IMPORTS ON ROUTE 1    TONS/
           QUARTER
NISX1    NETT INCOME SHIP X 1      ƒ/ROUNDTRIP
NISX10   NETT INCOME SHIP X 10     ƒ/ROUNDTRIP
NISX2    NETT INCOME SHIP X 2      ƒ/ROUNDTRIP
NISX3    NETT INCOME SHIP X 3      ƒ/ROUNDTRIP
NISX4    NETT INCOME SHIP X 4      ƒ/ROUNDTRIP
NISX5    NETT INCOME SHIP X 5      ƒ/ROUNDTRIP
NISX6    NETT INCOME SHIP X 6      ƒ/ROUNDTRIP
NISX7    NETT INCOME SHIP X 7      ƒ/ROUNDTRIP
NISX8    NETT INCOME SHIP X 8      ƒ/ROUNDTRIP
NISX9    NETT INCOME SHIP X 9      ƒ/ROUNDTRIP
NISY1    NETT INCOME SHIP Y 1    ƒ/ROUNDTRIP
NISY10   NETT INCOME SHIP Y 10   ƒ/ROUNDTRIP
NISY2    NETT INCOME SHIP Y 2    ƒ/ROUNDTRIP
NISY3    NETT INCOME SHIP Y 3    ƒ/ROUNDTRIP
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N   LS16=0
R   LS16I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS16),0,LS15.K,1)),0,LS16.K)
R   LS16R.KL=LPPS*PPS16*CLIP((SWITCH(0,(1/RP),LS16.K)),0,LS16.K,.5E5)
L   LS17.K=LS17.J+DT*((LS17I.JK/DT)-LS17R.JK)
N   LS17=0
R   LS17I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS17),0,LS16.K,1)),0,LS17.K)
R   LS17R.KL=LPPS*PPS17*CLIP((SWITCH(0,(1/RP),LS17.K)),0,LS17.K,.5E5)
L   LS18.K=LS18.J+DT*((LS18I.JK/DT)-LS18R.JK)
N   LS18=0
R   LS18I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS18),0,LS17.K,1)),0,LS18.K)
R   LS18R.KL=LPPS*PPS18*CLIP((SWITCH(0,(1/RP),LS18.K)),0,LS18.K,.5E5)
L   LS19.K=LS19.J+DT*((LS19I.JK/DT)-LS19R.JK)
N   LS19=0
R   LS19I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS19),0,LS18.K,1)),0,LS19.K)
R   LS19R.KL=LPPS*PPS19*CLIP((SWITCH(0,(1/RP),LS19.K)),0,LS19.K,.5E5)
L   LS20.K=LS20.J+DT*((LS20I.JK/DT)-LS20R.JK)
N   LS20=0
R   LS20I.KL=SWITCH((CLIP((FED2.K*LPPS*PPS20),0,LS19.K,1)),0,LS20.K)
R   LS20R.KL=LPPS*PPS20*CLIP((SWITCH(0,(1/RP),LS20.K)),0,LS20.K,.5E5)
NOTE   AGEING MECHANISM OF SHIPS
L   S1.K=S1.J+DT*((R1.JK/DT)-AR1.JK)
N   S1=LTS1
R   R1.KL=SWITCH(LTS1,0,(S1.K-1))
R   AR1.KL=1
C   LTS1=80
L   S2.K=S2.J+DT*((R2.JK/DT)-AR2.JK)
N   S2=0
R   R2.KL=SWITCH((CLIP((FED2.K*LTS2),0,S1.K,1)),0,S2.K)+
X   SWITCH(LTS2,0,(S2.K-1))
R   AR2.KL=CLIP(1,0,S2.K,1)
C   LTS2=64
L   S3.K=S3.J+DT*((R3.JK/DT)-AR3.JK)
N   S3=0
R   R3.KL=SWITCH((CLIP((FED2.K*LTS3),0,S2.K,1)),0,S3.K)+
X   SWITCH(LTS3,0,(S3.K-1))
R   AR3.KL=CLIP(1,0,S3.K,1)
C   LTS3=40
L   S4.K=S4.J+DT*((R4.JK/DT)-AR4.JK)
N   S4=0
R   R4.KL=SWITCH((CLIP((FED2.K*LTS4),0,S3.K,1)),0,S4.K)+
X   SWITCH(LTS4,0,(S4.K-1))
R   AR4.KL=CLIP(1,0,S4.K,1)
C   LTS4=80
L   S5.K=S5.J+DT*((R5.JK/DT)-AR5.JK)
N   S5=0
R   R5.KL=SWITCH((CLIP((FED2.K*LTS5),0,S4.K,1)),0,S5.K)+
X   SWITCH(LTS5,0,(S5.K-1))
R   AR5.KL=CLIP(1,0,S5.K,1)
C   LTS5=64
L   S6.K=S6.J+DT*((R6.JK/DT)-AR6.JK)
N   S6=0
R   R6.KL=SWITCH((CLIP((FED2.K*LTS6),0,S5.K,1)),0,S6.K)+
X   SWITCH(LTS6,0,(S6.K-1))
R   AR6.KL=CLIP(1,0,S6.K,1)
C   LTS6=40
L   S7.K=S7.J+DT*((R7.JK/DT)-AR7.JK)
N   S7=0
R   R7.KL=SWITCH((CLIP((FED2.K*LTS7),0,S6.K,1)),0,S7.K)+
X   SWITCH(LTS7,0,(S7.K-1))
R   AR7.KL=CLIP(1,0,S7.K,1)
C   LTS7=80
L   S8.K=S8.J+DT*((R8.JK/DT)-AR8.JK)
N   S8=0
R   R8.KL=SWITCH((CLIP((FED2.K*LTS8),0,S7.K,1)),0,S8.K)+
X   SWITCH(LTS8,0,(S8.K-1))
R   AR8.KL=CLIP(1,0,S8.K,1)
C   LTS8=64
L   S9.K=S9.J+DT*((R9.JK/DT)-AR9.JK)
N   S9=0
R   R9.KL=SWITCH((CLIP((FED2.K*LTS9),0,S8.K,1)),0,S9.K)+
X   SWITCH(LTS9,0,(S9.K-1))
R   AR9.KL=CLIP(1,0,S9.K,1)
C   LTS9=40
L   S10.K=S10.J+DT*((R10.JK/DT)-AR10.JK)
N   S10=0
R   R10.KL=SWITCH((CLIP((FED2.K*LTS10),0,S9.K,1)),0,S10.K)+
X   SWITCH(LTS10,0,(S10.K-1))
R   AR10.KL=CLIP(1,0,S10.K,1)
C   LTS10=80
L   S11.K=S11.J+DT*((R11.JK/DT)-AR11.JK)
N   S11=0
R   R11.KL=SWITCH((CLIP((FED2.K*LTS11),0,S10.K,1)),0,S11.K)+
X   SWITCH(LTS11,0,(S11.K-1))
R   AR11.KL=CLIP(1,0,S11.K,1)
C   LTS11=64
L   S12.K=S12.J+DT*((R12.JK/DT)-AR12.JK)
N   S12=0
R   R12.KL=SWITCH((CLIP((FED2.K*LTS12),0,S11.K,1)),0,S12.K)+
X   SWITCH(LTS12,0,(S12.K-1))
R   AR12.KL=CLIP(1,0,S12.K,1)
C   LTS12=40
L   S13.K=S13.J+DT*((R13.JK/DT)-AR13.JK)
N   S13=0
R   R13.KL=SWITCH((CLIP((FED2.K*LTS13),0,S12.K,1)),0,S13.K)+
X   SWITCH(LTS13,0,(S13.K-1))
R   AR13.KL=CLIP(1,0,S13.K,1)
C   LTS13=80
L   S14.K=S14.J+DT*((R14.JK/DT)-AR14.JK)
N   S14=0
R   R14.KL=SWITCH((CLIP((FED2.K*LTS14),0,S13.K,1)),0,S14.K)+
X   SWITCH(LTS14,0,(S14.K-1))
R   AR14.KL=CLIP(1,0,S14.K,1)
C   LTS14=64
L   S15.K=S15.J+DT*((R15.JK/DT)-AR15.JK)
N   S15=0
R   R15.KL=SWITCH((CLIP((FED2.K*LTS15),0,S14.K,1)),0,S15.K)+
X   SWITCH(LTS15,0,(S15.K-1))
R   AR15.KL=CLIP(1,0,S15.K,1)
C   LTS15=40
L   S16.K=S16.J+DT*((R16.JK/DT)-AR16.JK)
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NISY4    NETT INCOME SHIP Y 4      $/ROUNDTRIP
NISY5    NETT INCOME SHIP Y 5      $/ROUNDTRIP
NISY6    NETT INCOME SHIP Y 6      $/ROUNDTRIP
NISY7    NETT INCOME SHIP Y 7      $/ROUNDTRIP
NISY8    NETT INCOME SHIP Y 8      $/ROUNDTRIP
NISY9    NETT INCOME SHIP Y 9      $/ROUNDTRIP
NS       NUMBER OF SHIPS
NSPW     NUMBER OF SAILINGS PER WEEK
NSX      NUMBER OF SHIPS CLASS X
NSXR     NUMBER OF SHIPS CLASS X RATE
NSY      NUMBER OF SHIPS CLASS Y
NSYR     NUMBER OF SHIPS CLASS Y RATE
OCSX1    OPERATING COST OF SHIP X 1     $/QUARTER
OCSX10   OPERATING COST OF SHIP X 10    $/QUARTER
OCSX2    OPERATING COST OF SHIP X 2     $/QUARTER
OCSX3    OPERATING COST OF SHIP X 3     $/QUARTER
OCSX4    OPERATING COST OF SHIP X 4     $/QUARTER
OCSX5    OPERATING COST OF SHIP X 5     $/QUARTER
OCSX6    OPERATING COST OF SHIP X 6     $/QUARTER
OCSX7    OPERATING COST OF SHIP X 7     $/QUARTER
OCSX8    OPERATING COST OF SHIP X 8     $/QUARTER
OCSX9    OPERATING COST OF SHIP X 9     $/QUARTER
OCSY1    OPERATING COST SHIP Y 1     $/QUARTER
OCSY10   OPERATING COST SHIP Y 10    $/QUARTER
OCSY2    OPERATING COST SHIP Y 2     $/QUARTER
OCSY3    OPERATING COST SHIP Y 3     $/QUARTER
OCSY4    OPERATING COST SHIP Y 4     $/QUARTER
OCSY5    OPERATING COST SHIP Y 5     $/QUARTER
OCSY6    OPERATING COST SHIP Y 6     $/QUARTER
OCSY7    OPERATING COST SHIP Y 7     $/QUARTER
OCSY8    OPERATING COST SHIP Y 8     $/QUARTER
OCSY9    OPERATING COST SHIP Y 9     $/QUARTER
OD       OPERATING DAYS OF SHIP    DAYS/QUARTER
OF       OFFICERS
PCTE     PERCENTAGE CROSS TRADE OF EXPORTS   DIM'LESS
PCTI     PERCENTAGE CROSS-TRADE OF IMPORTS   DIM'LESS
PCX      PORT CHARGES/SHIP X/ROUNDTRIP  $
PCY      PORT CHARGES/SHIP Y/ROUNDTRIP  $
PE1      PERCENTAGE OF EXPORTS ON ROUTE 1    DIM'LESS
PE2      PERCENTAGE EXPORTS ON ROUTE 2    DIM'LESS
PE3      PERCENTAGE EXPORTS ON ROUTE 3    DIM'LESS
PI1      PERCENTAGE IMPORTS ON ROUTE 1     DIM'LESS
PI2      PERCENTAGE IMPORTS ON ROUTE 2    DIM'LESS
PI3      PERCENTAGE IMPORTS ON ROUTE 3    DIM'LESS
PPS1     PURCHASE PRICE SHIP 1 (CLASS X)   $
PPS10    PURCHASE PRICE SHIP 10  (CLASS Y)   $
PPS11    PURCHASE PRICE SHIP 11  (CLASS X)   $
PPS12    PURCHASE PRICE SHIP 12  (CLASS Y)   $
PPS13    PURCHASE PRICE SHIP 13  (CLASS X)   $
PPS14    PURCHASE PRICE SHIP 14  (CLASS Y)   $
PPS15    PURCHASE PRICE SHIP 15  (CLASS X)   $
PPS16    PURCHASE PRICE SHIP 16  (CLASS Y)   $
PPS17    PURCHASE PRICE SHIP 17  (CLASS X)   $
PPS18    PURCHASE PRICE SHIP 18  (CLASS Y)   $
PPS19    PURCHASE PRICE SHIP 19  (CLASS X)   $
PPS2     PURCHASE PRICE SHIP 2   (CLASS Y)   $
PPS20    PURCHASE PRICE SHIP 20  (CLASS Y)   $
PPS3     PURCHASE PRICE SHIP 3 (CLASS X)   $
PPS4     PURCHASE PRICE SHIP 4   (CLASS Y)   $
PPS5     PURCHASE PRICE SHIP 5 (CLASS X)   $
PPS6     PURCHASE PRICE SHIP 6   (CLASS Y)   $
PPS7     PURCHASE PRICE SHIP 7 (CLASS X)   $
PPS8     PURCHASE PRICE SHIP 8   (CLASS Y)   $
PPS9     PURCHASE PRICE SHIP 9 (CLASS X)   $
PRS      PURCHASE REPLACEMENT SHIPS  $
PTC      PERCENTAGE TRANSFER CARGO   DIM'LESS
PTCE     PERCENTAGE TRANSFER CARGO OF EXPORTS   DIM'
           LESS
PTCI     PERCENTAGE TRANSFER CARGO OF IMPORTS   DIM'
           LESS
RA       RATINGS
RT       ROUNDTRIP TIME  DAYS
R1       RATE 1
R10      RATE 10
R11      RATE 11
R12      RATE 12
R13      RATE 13
R14      RATE 14
R15      RATE 15
R16      RATE 16
R17      RATE 17
R18      RATE 18
R19      RATE 19
R2       RATE 2
R20      RATE 20
R3       RATE 3
R4       RATE 4
R5       RATE 5
R6       RATE 6
R7       RATE 7
R8       RATE 8
R9       RATE 9
SCCT     SUEZ CANAL CHARGES/TON  $/TON
SCCX     SUEZ CANAL CHARGES/SHIP X/ROUNDTRIP  $
SCCY     SUEZ CANAL CHARGES/SHIP Y/ROUNDTRIP  $
SCT      STEVEDORING COST/TON  $/TON
SCX      STEVEDORING COSTS/SHIP X/ROUNDTRIP  $
SCY      STEVEDORING COSTS/SHIP Y/ROUNDTRIP  $
SDP      SHIP DOWN PAYMENTS   $
SOCX     STANDARD OPERATING COST    $/QUARTER
SOCY     STANDARD OPERATING COST    $/QUARTER
SP       SHADOW PRICE  DIM'LESS
S1       REMAINING LIFETIME SHIP 1  QUARTERS
S10      REMAINING LIFETIME SHIP 10    QUARTERS
S11      REMAINING LIFETIME SHIP 11    QUARTERS
S12      REMAINING LIFETIME SHIP 12    QUARTERS
S13      REMAINING LIFETIME SHIP 13    QUARTERS
S14      REMAINING LIFETIME SHIP 14    QUARTERS
S15      REMAINING LIFETIME SHIP 15    QUARTERS
S16      REMAINING LIFETIME SHIP 16    QUARTERS
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N   S16=0
R   R16.KL=SWITCH((CLIP((FED2.K*LTS16),0,S15.K,1)),0,S16.K)+
X   SWITCH(LTS16,0,(S16.K-1))
R   AR16.KL=CLIP(1,0,S16.K,1)
C   LTS16=80
L   S17.K=S17.J+DT*((R17.JK/DT)-AR17.JK)
N   S17=0
R   R17.KL=SWITCH((CLIP((FED2.K*LTS17),0,S16.K,1)),0,S17.K)+
X   SWITCH(LTS17,0,(S17.K-1))
R   AR17.KL=CLIP(1,0,S17.K,1)
C   LTS17=64
L   S18.K=S18.J+DT*((R18.JK/DT)-AR18.JK)
N   S18=0
R   R18.KL=SWITCH((CLIP((FED2.K*LTS18),0,S17.K,1)),0,S18.K)+
X   SWITCH(LTS18,0,(S18.K-1))
R   AR18.KL=CLIP(1,0,S18.K,1)
C   LTS18=40
L   S19.K=S19.J+DT*((R19.JK/DT)-AR19.JK)
N   S19=0
R   R19.KL=SWITCH((CLIP((FED2.K*LTS19),0,S18.K,1)),0,S19.K)+
X   SWITCH(LTS19,0,(S19.K-1))
R   AR19.KL=CLIP(1,0,S19.K,1)
C   LTS19=80
L   S20.K=S20.J+DT*((R20.JK/DT)-AR20.JK)
N   S20=0
R   R20.KL=SWITCH((CLIP((FED2.K*LTS20),0,S19.K,1)),0,S20.K)+
X   SWITCH(LTS20,0,(S20.K-1))
R   AR20.KL=CLIP(1,0,S20.K,1)
C   LTS20=64
NOTE   FLEET EXPANSION MECHANISM
A   NCP.K=NEI1.K*CRG
C   CRG=.4
A   D.K=NCP.K-NCCSL.K
A   NCCS.K=(((1-PTCE-PCTE)*.8*LCX+(1-PTCI-PCTI)*.8*LCX)*OD)/RT
A   FED1.K=CLIP(1,0,(D.K/NCCS.K),1)
A   FED2.K=CLIP(FED1.K,0,WC.K,WCM)
C   WCM=-10E6
NOTE   SHIPPING LINE'S SHARE OF TRADE
A   CCSL.K=((NSX.K*(ETX.K+ITX.K)+NSY.K*(ETY.K+ITY.K))*OD)/RT
A   NCCSL.K=((NSX.K*((1-PTCE-PCTE)*ETX.K+(1-PTCI-PCTI)*ITX.K)+NSY.K*
X   ((1-PTCE-PCTE)*ETY.K+(1-PTCI-PCTI)*ITY.K))*OD)/RT
A   TCCSL.K=((NSX.K*(PTCE*ETX.K+PTCI*ITX.K)+NSY.K*(PTCE*ETY.K+PTCI*
X   ITY.K))*OD)/RT
A   CTCCSL.K=((NSX.K*(PCTE*ETX.K+PCTI*ITX.K)+NSY.K*(PCTE*ETY.K+PCTI*
X   ITY.K))*OD)/RT
C   PTCE=.2
C   PCTE=.1
C   PTCI=.2
C   PCTI=.1
A   NEI1.K=(E1.K+I1.K)*(1-PTC)
C   PTC=.3
A   TEI1.K=(E1.K+I1.K)*PTC
A   NCR.K=NCCSL.K/NEI1.K
A   TCR.K=TCCSL.K/TEI1.K
NOTE   EXPORTS/IMPORTS MODEL
NOTE   EXPORTS
L   E.K=E.J+DT*EG.JK
N   E=275000
R   EG.KL=E.K*EGR.K/100
A   EGR.K=TABLE(EGRT,TIME.K,0,96,96)
T   EGRT=1/1
A   E1.K=PE1*E.K
C   PE1=.46
A   E2.K=PE2*E.K
C   PE2=.25
A   E3.K=PE3*E.K
C   PE3=.29
NOTE   IMPORTS
L   I.K=I.J+DT*IG.JK
N   I=250000
R   IG.KL=I.K*IGR.K/100
A   IGR.K=TABLE(IGRT,TIME.K,0,96,96)
T   IGRT=1/1
A   I1.K=PI1*I.K
C   PI1=.54
A   I2.K=PI2*I.K
C   PI2=.31
A   I3.K=PI3*I.K
C   PI3=.15
NOTE   EXPORTS + IMPORTS
A   EI.K=E.K+I.K
A   EIR.K=E.K/I.K
NOTE   DECISION CRITERIA
NOTE -1- DISCOUNTED COSTS AND BENEFITS
L   DCB.K=DCB.J+DT*DCBR.JK
N   DCB=-PPS1
R   DCBR.KL=(WCC.K/(EXP(TIME.K*LOGN(1+DR1))))
A   WCC.K=WCG.JK+WCI.JK-(SDP.JK/DT)-(PRS.JK/DT)-LR.JK-LIP.JK
C   DR1=.04
NOTE -2- FOREIGN EXCHANGE BALANCE
L   FEBT.K=FEBT.J+DT*FEB.JK
N   FEBT=-(1-LPPS)*PPS1
R   FEB.KL=CLIP((FEEA.K-FEEX.K),0,TIME.K,DT)
A   FEEA.K=(((NSX.K*GRX.K+NSY.K*GRY.K)*WITC.K)*OD)/RT
A   WITC.K=((ITC*(1-PTCE-PCTE))+PTCE+PCTE)
C   ITC=.7
A   FEEX.K=(SDP.JK/DT)+(PRS.JK/DT)+LR.JK+LIP.JK+((NSX.K*OD)/RT)*
X   (PCX+BX+.7*SCX.K+.7*CCX.K+.5*ACX.K+SCCX.K)+
X   .9*(OCSX1.K+SWITCH(0,OCSX2.K,S3.K)+SWITCH(0,OCSX3.K,S5.K)+
X   SWITCH(0,OCSX4.K,S7.K)+SWITCH(0,OCSX5.K,S9.K)+
X   SWITCH(0,OCSX6.K,S11.K)+SWITCH(0,OCSX7.K,S13.K)+
X   SWITCH(0,OCSX8.K,S15.K)+SWITCH(0,OCSX9.K,S17.K)+
X   SWITCH(0,OCSX10.K,S19.K))+
X   ((NSY.K*OD)/RT)*(PCY+BY+.7*SCY.K+.7*CCY.K+.5*ACY.K+SCCY.K)+
X   .9*(SWITCH(0,OCSY1.K,S2.K)+SWITCH(0,OCSY2.K,S4.K)+
X   SWITCH(0,OCSY3.K,S6.K)+SWITCH(0,OCSY4.K,S8.K)+
X   SWITCH(0,OCSY5.K,S10.K)+SWITCH(0,OCSY6.K,S12.K)+
X   SWITCH(0,OCSY7.K,S14.K)+SWITCH(0,OCSY8.K,S16.K)+
X   SWITCH(0,OCSY9.K,S13.K)+SWITCH(0,OCSY10.K,S20.K))
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S17     REMAINING LIFETIME SHIP 17   QUARTERS
S18     REMAINING LIFETIME SHIP 18   QUARTERS
S19     REMAINING LIFETIME SHIP 19   QUARTERS
S2      REMAINING LIFETIME SHIP 2   QUARTERS
S20     REMAINING LIFETIME SHIP 20   QUARTERS
S3      REMAINING LIFETIME SHIP 3   QUARTERS
S4      REMAINING LIFETIME SHIP 4   QUARTERS
S5      REMAINING LIFETIME  SHIP 5   QUARTERS
S6      REMAINING LIFETIME SHIP 6   QUARTERS
S7      REMAINING LIFETIME SHIP 7   QUARTERS
S8      REMAINING LIFETIME SHIP 8   QUARTERS
S9      REMAINING LIFETIME SHIP 9   QUARTERS
TBV     TOTAL BOOK VALUE OF SHIPS  $
TCCSL   TRANSFER CARGO CARRIED BY SHIPPING LINE
          TONS/QUARTER
TCR     TRANSFER CARGO CARRIED BY SHIPPING LINE /
          TRANSFER EXPORTS AND IMPORTS ON ROUTE 1
          RATIO
TEI1    TRANSFER EXPORTS AND IMPORTS ON ROUTE 1
          TONS/QUARTER
TII     TRANSPORT INDEPENDENCE INDICATOR   DIM'LESS
TNI     TOTAL NETT INCOME   $/QUARTER
TNIS    TOTAL NETT INCOME SHADOW PRICED   $/QUARTER
VEX     VOYAGE EXPENDITURES/SHIP X  $
VEY     VOYAGE EXPENDITURES/SHIP Y  $
WC      WORKING CAPITAL  $
WCC     WORKING CAPITAL CHANGE  $/QUARTER
WCCS    WORKING CAPITAL CHANGE SHADOW PRICED  $/
          QUARTER
WCG     WORKING CAPITAL GROWTH   $/QUARTER
WCGS    WORKING CAPITAL GROWTH SHADOW PRICED  $/
          QUARTER
WCI     WORKING CAPITAL INTEREST  $/QUARTER
WCM     WORKING CAPITAL MINIMUM   $
WITC    WEIGHTED INCIDENCE OF TRANSPORT COST
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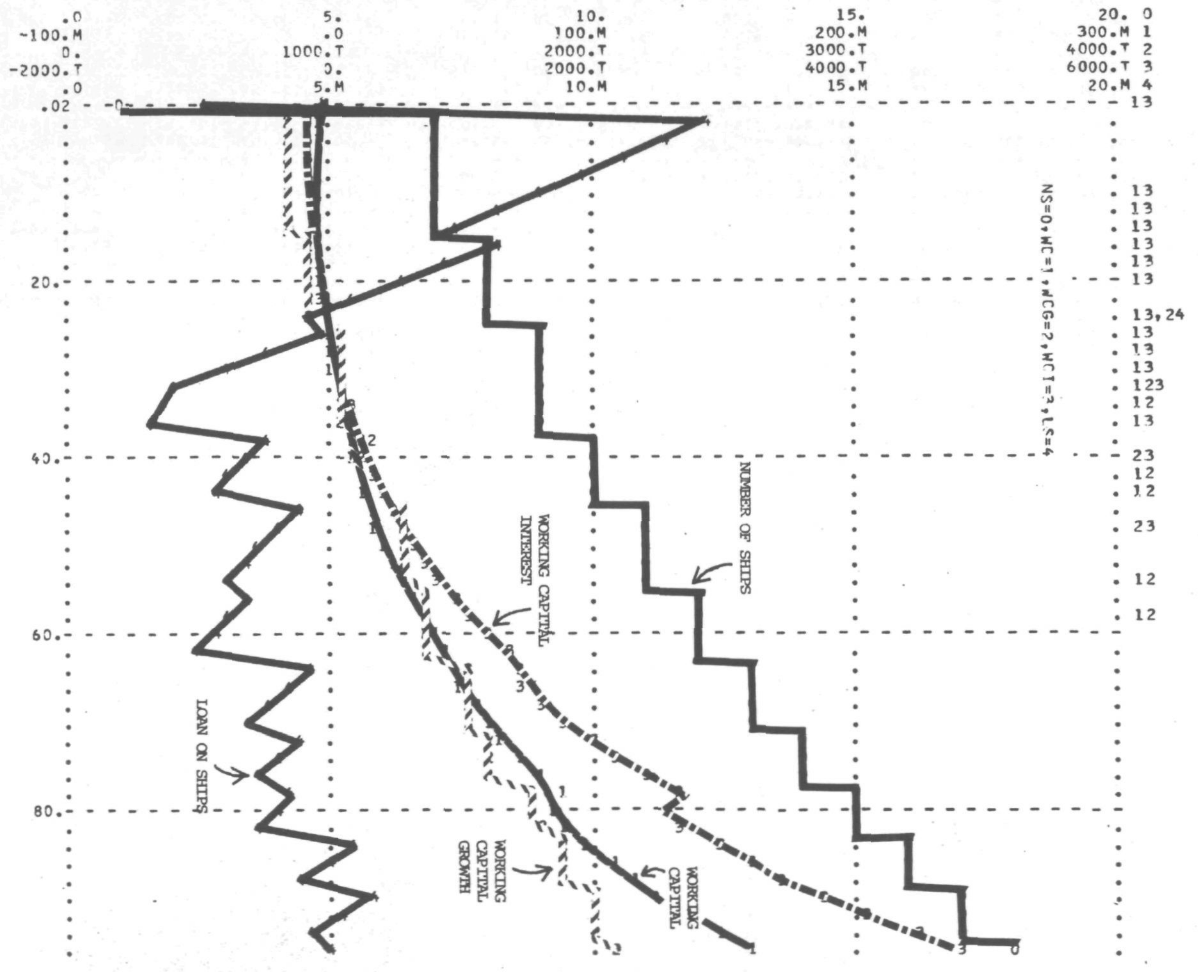
NOTE -3- SHADOW PRICED DISCOUNTED COSTS AND BENEFITS
L   DCBS.K=DCBS.J+DT*DCBRS.JK
N   DCBS=-SP*(1-LPPS)*PPS1-LPPS*PPS1
C   SP=1.3
R   DCBRS.KL=(WCCS.K/(EXP(TIME.K*LOGN(1+DR2))))
C   DR2=.04
A   WCCS.K=(WCGS.JK+WCI.JK-SP*((SDP.JK/DT)+(PRS.JK/DT)+LR.JK+LIP.JK))
R   WCGS.KL=CLIP(TNIS.K,0,TIME.K,DT)
A   TNIS.K=NSX.K*(((SP*(GRX.K*WITC.K-BX-PCX-.5*ACX.K-.7*CCX.K-SCCX.K-
X   .7*SCX.K)+(1-WITC.K)*GRX.K-.5*ACX.K-.3*CCX.K-.3*SCX.K)*OD)/RT)-
X   (SP*.9+.1)*(OCSX1.K+SWITCH(0,OCSX2.K,S3.K)+SWITCH(0,OCSX3.K,S5.K)+
X   SWITCH(0,OCSX4.K,S7.K)+SWITCH(0,OCSX5.K,S9.K)+
X   SWITCH(0,OCSX6.K,S11.K)+SWITCH(0,OCSX7.K,S13.K)+
X   SWITCH(0,OCSX8.K,S15.K)+SWITCH(0,OCSX9.K,S17.K)+
X   SWITCH(0,OCSX10.K,S19.K))+
X   NSY.K*(((SP*(GRY.K*WITC.K-BY-PCY-.5*ACY.K-.7*CCY.K-.7*SCY.K-SCCY.K)+
X   (1-WITC.K)*GRY.K-.5*ACY.K-.3*CCY.K-.3*SCY.K)*OD)/RT)-
X   (SP*.9+.1)*(SWITCH(0,OCSY1.K,S2.K)+SWITCH(0,OCSY2.K,S4.K)+
X   SWITCH(0,OCSY3.K,S6.K)+SWITCH(0,OCSY4.K,S8.K)+
X   SWITCH(0,OCSY5.K,S10.K)+SWITCH(0,OCSY6.K,S12.K)+
X   SWITCH(0,OCSY7.K,S14.K)+SWITCH(0,OCSY8.K,S16.K)+
X   SWITCH(0,OCSY9.K,S18.K)+SWITCH(0,OCSY10.K,S20.K))
NOTE -4- INCOME PLOUGHED BACK IN COUNTRY
L   IPBC.K=IPBC.J+DT*(IPBCI.JK-IPBCD.JK/DT)
N   IPBC=0
R   IPBCI.KL=CLIP(WCG.JK,0,WC.K,0)+AMC.K
R   IPBCD.KL=CLIP((SDP.JK+PRS.JK),0,WC.K,0)
NOTE  -5- EMPLOYMENT OF SHIPPING LINE
A   EMP.K=RA.K+OF.K+MAM.K
A   RA.K=NS.K*MSR
C   MSR=22
A   OF.K=NS.K*MSO
C   MSO=18
A   MAM.K=50+50*CLIP(((NS.K-6)/12),0,NS.K,6)
NOTE -6- TRANSPORT INDEPENDENCE INDICATOR
A   TII.K=(((NSX.K*2*.9*LCX+NSY.K*2*.9*LCY)*OD)/RT)/NEI1.K
NOTE -7- BOOK VALUE OF SHIPS
A   TBV.K=BV1.K+BV2.K+BV3.K+BV4.K+BV5.K+BV6.K+BV7.K+BV8.K+BV9.K+BV10.K+
X   BV11.K+BV12.K+BV13.K+BV14.K+BV15.K+BV16.K+BV17.K+BV18.K+BV19.K+
X   BV20.K
A   BV1.K=PPS1*S1.K/LTS1
A   BV2.K=PPS2*S2.K/LTS2
A   BV3.K=PPS3*S3.K/LTS3
A   BV4.K=PPS4*S4.K/LTS4
A   BV5.K=PPS5*S5.K/LTS5
A   BV6.K=PPS6*S6.K/LTS6
A   BV7.K=PPS7*S7.K/LTS7
A   BV8.K=PPS8*S8.K/LTS8
A   BV9.K=PPS9*S9.K/LTS9
A   BV10.K=PPS10*S10.K/LTS10
A   BV11.K=PPS11*S11.K/LTS11
A   BV12.K=PPS12*S12.K/LTS12
A   BV13.K=PPS13*S13.K/LTS13
A   BV14.K=PPS14*S14.K/LTS14
A   BV15.K=PPS15*S15.K/LTS15
A   BV16.K=PPS16*S16.K/LTS16
A   BV17.K=PPS17*S17.K/LTS17
A   BV18.K=PPS18*S18.K/LTS18
A   BV19.K=PPS19*S19.K/LTS19
A   BV20.K=PPS20*S20.K/LTS20
NOTE -8- NUMBER OF SAILINGS PER WEEK
A   NSPW.K=(NS.K*OD/RT)/13
SPEC   LENGTH=96/DT=.25/PRTPER=2/PLTPER=2
PRINT   NS,NSX,NSY,WC,WCG,WCI,SDP,PRS,LS,LR
PRINT   LIP,NCP,D,CCSL,NCCSL,TCCSL,CTCCSL,NEI1,TEI1
PRINT   DCB,DCBS,FEBT,EMP,IPBC,TBV,TII,NSPW
PLOT   NS/WC/WCG/WCI/LS
PLOT   DCB,DCBS/FEBT/IPBC
PLOT   EMP/TBV/TII/NSPW
RUN
```

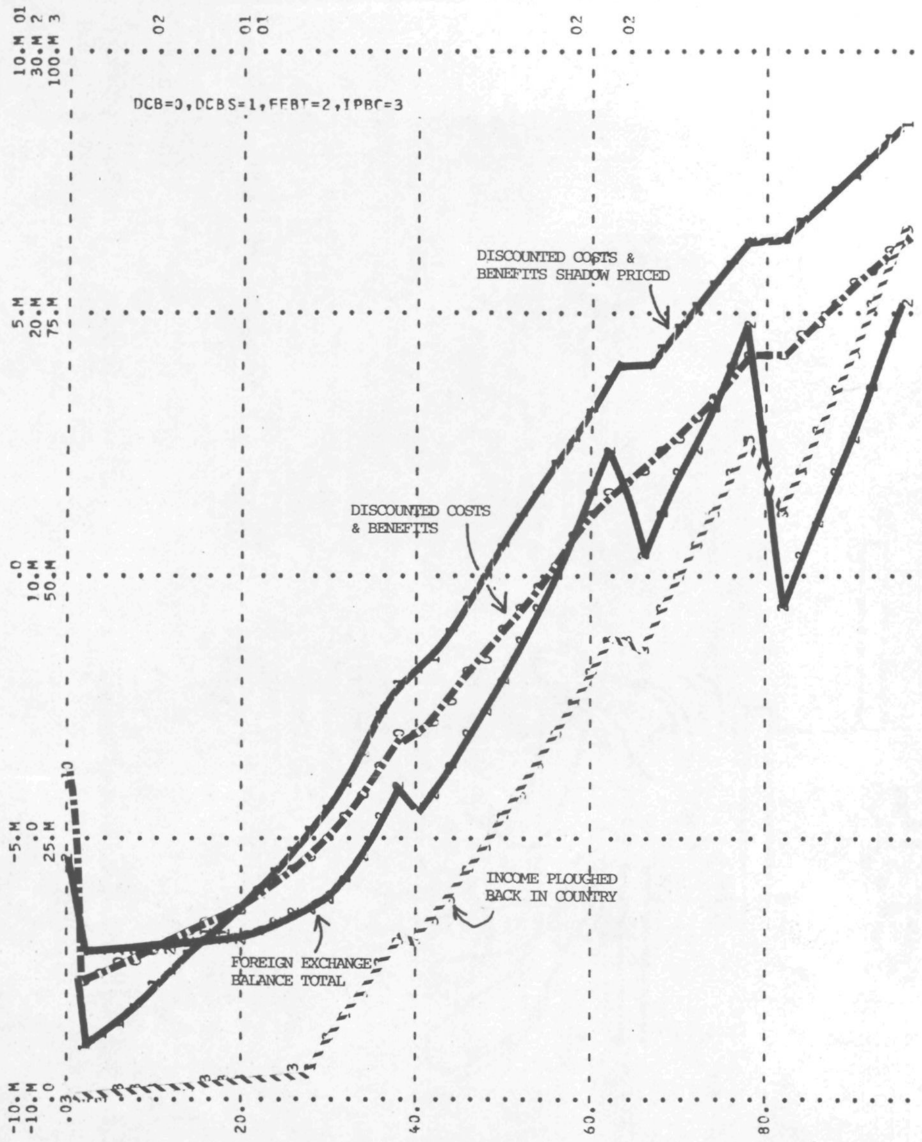
MODEL 15 - ENDOGENOUS FLEET EXPANSION 2

TIME	NS NCCSL	NSX TCCSL	NSY CTCCSL	WC NEI1	WCG TEI1	WCI DCB	SDP DCBS	PRS FEBT	LS EMP	LR IPBC	LIP TBV	NCP TII	D NSPW	CCSL
E+00	E+00	E+00	E+00	E+06	E+03	E+03	E+03	E+03	E+06	E+03	E+03	E+03	E+03	E+03
	E+03	E+03	E+03	E+03	E+03	E+03	E+03	E+06	E+00	E+06	E+06	E+00	E+00	
.0	1.000	1.0000	.0000	-.88	.0	.0	500.00	.0	2.625	82.03	52.50	73.22	61.593	16.61
	11.63	3.322	1.661	183.05	78.45	-3500.0	-3762.5	-.875	90.00	.000	3.500	.10208	.0570	
2.	7.000	4.0000	3.0000	-4.68	832.7	-140.5	.00	.0	12.246	398.44	244.92	74.70	.782	105.59
	73.92	21.119	10.559	186.74	80.03	-7703.2	-9094.7	-4.553	334.17	.192	16.675	.63613	.3993	
4.	7.000	4.0000	3.0000	-4.57	832.7	-137.1	.00	.0	11.449	398.44	228.98	76.20	2.289	105.59
	73.92	21.119	10.559	190.51	81.65	-7605.5	-8813.3	-4.547	334.17	.396	16.159	.62355	.3993	
6.	7.000	4.0000	3.0000	-4.42	832.7	-132.5	.00	.0	10.652	398.44	213.05	77.74	3.826	105.59
	73.92	21.119	10.559	194.35	83.29	-7482.6	-8512.6	-4.509	334.17	.599	15.644	.61122	.3993	
8.	7.000	4.0000	3.0000	-4.22	832.7	-126.6	.00	.0	9.855	398.44	197.11	79.31	5.395	105.59
	73.92	21.119	10.559	198.28	84.98	-7336.9	-8195.3	-4.438	334.17	.803	15.128	.59913	.3993	
10.	7.000	4.0000	3.0000	-3.98	832.7	-119.4	.00	.0	9.059	398.44	181.17	80.91	6.995	105.59
	73.92	21.119	10.559	202.28	86.69	-7170.8	-7863.8	-4.336	334.17	1.007	14.612	.58728	.3993	
12.	7.000	4.0000	3.0000	-3.69	832.7	-110.7	.00	.0	8.262	398.44	165.23	82.54	8.627	105.59
	73.92	21.119	10.559	206.36	88.44	-6986.4	-7520.2	-4.202	334.17	1.210	14.097	.57567	.3993	
14.	7.000	4.0000	3.0000	-3.35	832.7	-100.5	.00	.0	7.465	398.44	149.29	84.21	10.293	105.59
	73.92	21.119	10.559	210.52	90.22	-6785.7	-7166.5	-4.036	334.17	1.414	13.581	.56428	.3993	
16.	8.000	4.0000	4.0000	-2.96	933.3	-88.7	500.00	.0	8.168	398.44	163.36	85.91	2.856	118.64
	83.05	23.729	11.864	214.77	92.04	-6570.4	-6804.5	-3.838	378.33	1.618	15.066	.62149	.4563	
18.	8.000	4.0000	4.0000	-2.97	933.3	-89.2	.00	.0	7.277	445.31	145.54	87.64	4.589	118.64
	83.05	23.729	11.864	219.10	93.90	-6589.4	-6754.2	-4.085	378.33	1.837	14.487	.60919	.4563	
20.	8.000	4.0000	4.0000	-2.44	933.3	-73.1	.00	.0	6.387	445.31	127.73	89.41	6.357	118.64
	83.05	23.729	11.864	223.52	95.79	-6337.9	-6361.3	-3.828	378.33	2.056	13.909	.59715	.4563	
22.	8.000	4.0000	4.0000	-1.83	933.3	-54.9	.00	.0	5.496	445.31	109.92	91.21	8.161	118.64
	83.05	23.729	11.864	228.03	97.73	-6075.0	-5962.8	-3.534	378.33	2.276	13.331	.58534	.4563	
24.	8.000	4.0000	4.0000	-1.16	923.8	-34.7	.00	.0	4.605	445.31	92.11	93.05	10.001	118.64
	83.05	23.729	11.864	232.63	99.70	-5802.9	-5561.3	-3.210	378.33	2.495	12.753	.57376	.4563	
26.	9.000	5.0000	4.0000	-.44	1051.4	-13.1	375.00	.0	4.840	445.31	96.79	94.93	.252	135.25
	94.68	27.051	13.525	237.32	101.71	-5534.8	-5172.9	-2.879	422.50	2.714	13.675	.64115	.5134	
28.	9.000	5.0000	4.0000	.14	1051.4	4.2	.00	.0	3.879	480.47	77.57	96.84	2.167	135.25
	94.68	27.051	13.525	242.11	103.76	-5347.1	-4897.3	-2.781	422.50	3.212	13.022	.62847	.5134	
30.	9.000	5.0000	4.0000	1.18	1051.4	35.4	.00	.0	2.918	480.47	58.36	98.80	4.121	135.25
	94.68	27.051	13.525	247.00	105.86	-5016.5	-4443.7	-2.292	422.50	5.550	12.369	.61605	.5134	
32.	9.000	5.0000	4.0000	2.39	1051.4	71.8	.00	.0	2.077	292.97	41.54	100.79	6.114	135.25
	94.68	27.051	13.525	251.98	107.99	-4672.7	-3980.5	-1.738	422.50	7.888	11.716	.60386	.5134	
34.	9.000	5.0000	4.0000	4.28	1051.4	128.4	.00	.0	1.799	82.03	35.97	102.83	8.147	135.25
	94.68	27.051	13.525	257.06	110.17	-4173.3	-3323.3	-.608	422.50	10.226	11.062	.59192	.5134	
36.	9.000	5.0000	4.0000	6.46	1051.4	193.9	.00	.0	1.635	82.03	32.69	104.90	10.222	135.25
	94.68	27.051	13.525	262.25	112.39	-3621.8	-2608.0	.751	422.50	12.563	10.409	.58021	.5134	
38.	10.000	5.0000	5.0000	8.05	1152.0	241.5	.00	.0	3.703	152.34	74.06	107.02	3.203	148.30
	103.81	29.661	14.830	267.54	114.66	-3078.9	-1913.3	2.135	466.67	14.903	12.747	.62362	.5704	
40.	10.000	5.0000	5.0000	8.93	1122.0	267.8	.00	.0	3.398	152.34	67.97	109.18	5.362	148.30
	103.81	29.661	14.830	272.94	116.97	-3041.8	-1882.2	1.177	466.67	15.198	13.519	.61129	.5704	
42.	10.000	5.0000	5.0000	10.27	1111.0	308.2	.00	.0	3.094	152.34	61.87	111.38	7.564	148.30
	103.81	29.661	14.830	278.44	119.33	-2774.9	-1551.2	1.412	466.67	16.684	13.791	.59920	.5704	
44.	10.000	5.0000	5.0000	12.75	1111.0	382.6	.00	.0	2.789	152.34	55.78	113.62	9.811	148.30
	103.81	29.661	14.830	284.06	121.74	-2317.3	-977.8	2.651	466.67	19.156	13.062	.58735	.5704	
46.	11.000	6.0000	5.0000	15.40	1260.6	461.9	625.00	.0	4.359	152.34	87.18	115.92	.477	164.92
	115.44	32.983	16.492	289.79	124.20	-1866.0	-418.7	3.903	510.83	21.629	14.834	.64021	.6274	
48.	11.000	6.0000	5.0000	17.72	1260.6	531.6	.00	.0	3.984	164.06	79.68	118.26	2.815	164.92
	115.44	32.983	16.492	295.64	126.70	-1506.0	16.2	4.635	510.83	23.754	14.028	.62755	.6274	
50.	11.000	6.0000	5.0000	20.91	1260.6	627.2	.00	.0	3.656	164.06	73.12	120.64	5.201	164.92
	115.44	32.983	16.492	301.60	129.26	-1041.3	581.9	6.037	510.83	26.542	13.222	.61514	.6274	
52.	11.000	6.0000	5.0000	24.30	1260.6	729.0	.00	.0	3.328	164.06	66.56	123.08	7.635	164.92
	115.44	32.983	16.492	307.69	131.87	-583.4	1133.7	7.452	510.83	29.329	12.416	.60298	.6274	
54.	11.000	6.0000	5.0000	27.92	1260.6	837.6	.00	.0	3.000	164.06	60.00	125.56	10.118	164.92
	115.44	32.983	16.492	313.90	134.53	-132.3	1672.2	8.880	510.83	32.117	11.609	.59105	.6274	
56.	12.000	6.0000	6.0000	31.55	1351.7	946.6	.00	.0	3.410	187.50	68.20	128.09	3.516	177.97
	124.58	35.593	17.797	320.23	137.24	286.1	2164.0	10.100	555.00	34.681	11.791	.62521	.6845	
58.	12.000	6.0000	6.0000	35.79	1351.7	1073.7	.00	.0	3.079	152.34	61.58	130.68	6.100	177.97
	124.58	35.593	17.797	326.69	140.01	736.6	2694.2	11.632	555.00	37.666	10.934	.61285	.6845	
60.	12.000	6.0000	6.0000	40.34	1351.7	1210.1	.00	.0	2.774	152.34	55.48	133.31	8.737	177.97
	124.58	35.593	17.797	333.28	142.84	1184.7	3217.7	13.221	555.00	40.652	10.078	.60073	.6845	
62.	12.000	6.0000	6.0000	45.17	1351.7	1355.2	.00	.0	2.469	152.34	49.39	136.00	11.426	177.97
	124.58	35.593	17.797	340.01	145.72	1625.6	3728.7	14.823	555.00	43.637	9.222	.58885	.6845	
64.	13.000	7.0000	6.0000	47.44	1510.8	1423.1	.00	2500.0	4.667	234.38	93.33	138.75	2.543	194.58
	136.20	38.915	19.458	346.87	148.66	1819.3	3902.1	13.444	599.17	43.949	13.800	.63107	.7415	
66.	13.000	7.0000	6.0000	48.65	1521.8	1459.4	.00	.0	4.198	234.38	83.96	141.55	5.342	194.58
	136.20	38.915	19.458	353.86	151.66	1910.2	3938.5	10.875	599.17	43.284	16.856	.61859	.7415	
68.	13.000	7.0000	6.0000	54.12	1521.8	1623.7	.00	.0	3.729	234.38	74.58	144.40	8.198	194.58
	136.20	38.915	19.458	361.00	154.72	2304.5	4370.9	12.328	599.17	46.626	15.912	.60636	.7415	

MODEL 15 - ENDOGENOUS FLEET EXPANSION 2

TIME	NS	NSX	NSY	WC	WCG	WCI	SDP	PRS	LS	LR	LIP	NCP	D	CCSL
	NCCSL	TCCSL	CTCCSL	NEI1	TEI1	DCB	DCBS	FEBT	EMP	IPBC	TBV	TII	NSPW	
70.	13.000	7.0000	6.0000	59.98	1510.8	1799.5	.00	.0	3.313	164.06	66.26	147.31	11.111	194.58
	136.20	38.915	19.458	368.29	157.84	2693.6	4795.8	13.809	599.17	49.962	14.969	.59437	.7415	
72.	14.000	7.0000	7.0000	65.84	1611.4	1975.2	.00	.0	4.427	210.94	88.53	150.29	4.948	207.63
	145.34	41.525	20.763	375.72	161.02	3054.0	5183.0	14.942	643.33	52.891	15.986	.62169	.7986	
74.	14.000	7.0000	7.0000	72.60	1611.4	2177.9	.00	.0	4.005	210.94	80.09	153.32	7.980	207.63
	145.34	41.525	20.763	383.30	164.27	3438.6	5601.3	16.557	643.33	56.427	14.980	.60940	.7986	
76.	14.000	7.0000	7.0000	79.79	1611.4	2393.6	.00	.0	3.583	210.94	71.65	156.41	11.073	207.63
	145.34	41.525	20.763	391.03	167.58	3817.0	6011.2	18.189	643.33	59.963	13.973	.59735	.7986	
78.	15.000	8.0000	7.0000	87.18	1740.5	2615.5	.00	.0	4.286	187.50	85.72	159.57	2.602	224.24
	156.97	44.847	22.424	398.92	170.97	4175.2	6394.6	19.546	687.50	63.266	14.420	.63237	.8556	
80.	15.000	8.0000	7.0000	85.45	1770.5	2563.6	.00	.0	3.911	187.50	78.22	162.79	5.821	224.24
	156.97	44.847	22.424	406.97	174.41	4238.0	6394.7	14.411	687.50	60.086	23.339	.61987	.8556	
82.	15.000	8.0000	7.0000	89.15	1781.5	2674.4	.00	.0	3.536	187.50	70.72	166.07	9.106	224.24
	156.97	44.847	22.424	415.18	177.93	4261.0	6351.0	8.843	687.50	56.465	26.758	.60761	.8556	
84.	16.000	8.0000	8.0000	97.77	1882.1	2933.2	750.00	.0	5.411	187.50	108.22	169.42	3.321	237.29
	166.10	47.458	23.729	423.56	181.52	4592.7	6710.1	10.799	731.67	60.357	28.676	.63026	.9126	
86.	16.000	8.0000	8.0000	106.15	1882.1	3184.5	.00	.0	4.907	234.38	98.14	172.84	6.739	237.29
	166.10	47.458	23.729	432.10	185.19	4889.9	7024.3	11.981	731.67	63.690	27.520	.61779	.9126	
88.	16.000	8.0000	8.0000	115.88	1872.6	3476.3	.00	.0	4.438	234.38	88.76	176.33	10.226	237.29
	166.10	47.458	23.729	440.82	188.92	5209.6	7367.9	13.929	731.67	67.797	26.364	.60558	.9126	
90.	17.000	9.0000	8.0000	125.60	2011.2	3768.1	.00	.0	5.800	292.97	116.01	179.88	2.156	253.90
	177.73	50.780	25.390	449.71	192.73	5505.4	7680.4	15.291	775.83	71.326	27.678	.63515	.9697	
92.	17.000	9.0000	8.0000	136.64	2011.2	4099.3	.00	.0	5.215	292.97	104.29	183.51	5.786	253.90
	177.73	50.780	25.390	458.79	196.62	5815.5	8011.7	17.277	775.83	75.709	26.444	.62259	.9697	
94.	17.000	9.0000	8.0000	148.38	2001.7	4451.5	.00	.0	4.629	292.97	92.57	187.22	9.488	253.90
	177.73	50.780	25.390	468.04	200.59	6120.5	8336.5	19.286	775.83	80.091	25.210	.61028	.9697	
96.	18.000	9.0000	9.0000	159.74	2092.8	4792.2	.00	.0	4.945	234.38	98.90	190.99	4.130	266.95
	186.86	53.390	26.695	477.48	204.64	6392.6	8619.6	20.247	820.00	83.234	25.963	.62896	1.0267	

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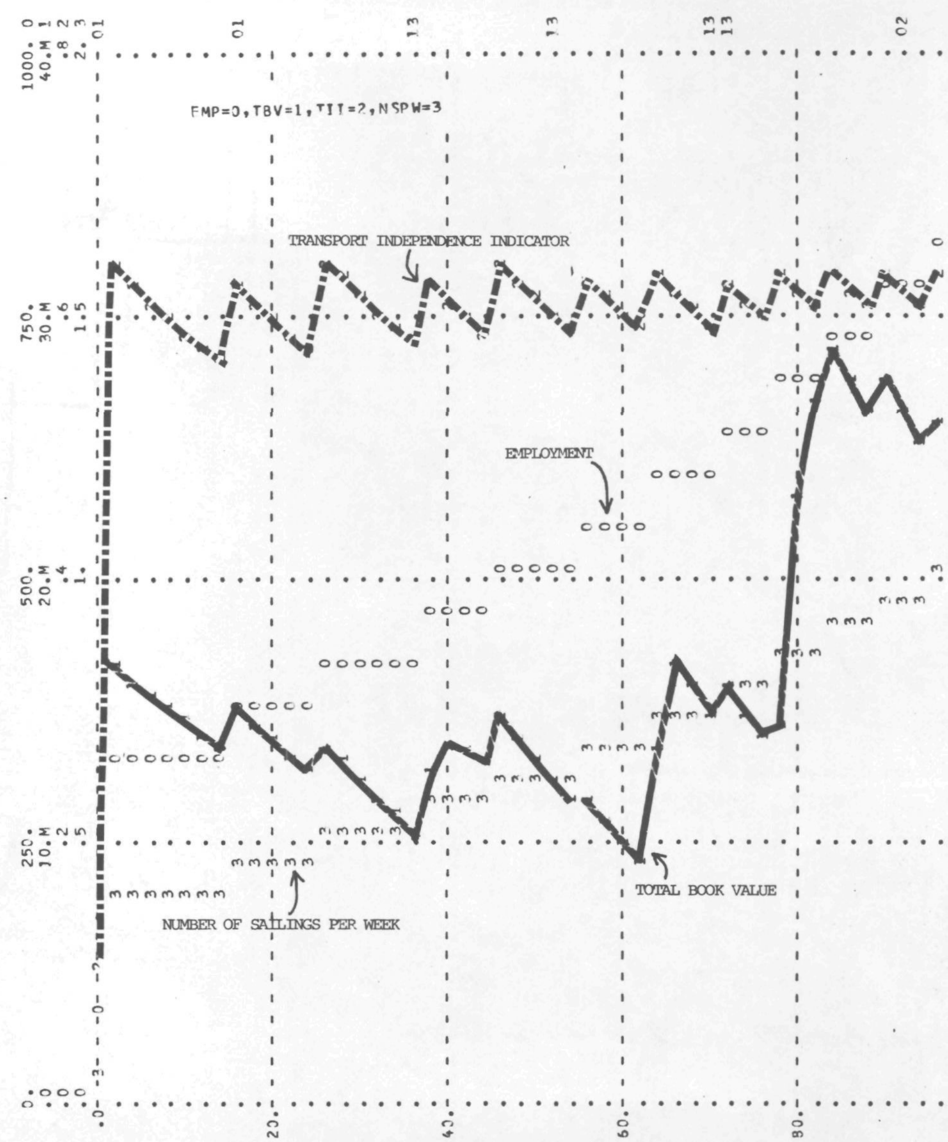
DISCOUNTED COSTS & BENEFITS SHADOW PRICED
DISCOUNTED COSTS & BENEFITS
INCOME PLOUGHED BACK IN COUNTRY
FOREIGN EXCHANGE BALANCE TOTAL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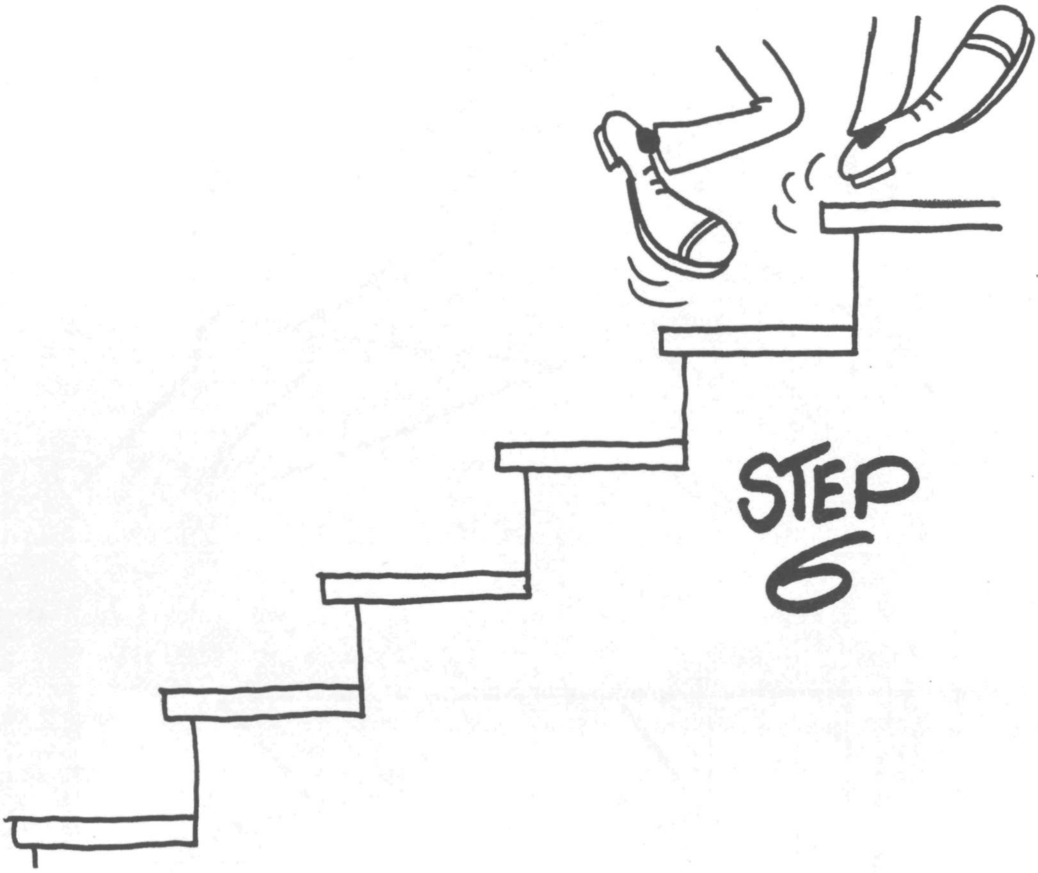
EMPLOYMENT
TOTAL BOOK VALUE
NUMBER OF SAILINGS PER WEEK


STEP
6

Chapter 8 - STEP 6: MODEL 16 - CONGESTION IN NATIONAL PORT

Paragraph 1.2 presented the causal-loop diagram of the simple port model. This causal diagram can also be translated into equations. The variables used in these equations have the following definitions:

EI export + import cargo flows through port (tons/year)
ACV average cargo per vessel (tons)
NC number of calls
VST vessel service time (days)
NG number of gang-shifts per vessel per full working day
TG tonnage handled per gang-shift (tons)
BO berth occupancy
NB number of berths
QT queueing time per vessel (days)
CVD cost of vessel per day (£)
QC queueing costs (£/year)

Equations

. number of calls $NC = \frac{EI}{ACV}$

. vessel service time $VST = \frac{ACV}{0.8 \times NG \times TG} + 0.5$

the cargo handling rates per full working day are multiplied by a factor 0.8 to take into account the loss of working time at weekends, on public holidays, and for other reasons such as bad weather; a 'non-working time' of 0.5 day is added to the VST in order to cover two periods from ship arrival on berth to the start of work, and from finish of work to ship departure.

. average berth occupancy $BO = \frac{NC \times VST}{NB \times 365}$ (days)

. queueing time per vessel $QT = \frac{(k + 1)}{2k} \times \frac{VST \times BO}{NB \times (1 - BO)}$

in a study on the national port,[16] where most of the data which is used in this model comes from, it is found that the arrival of ships in the port has a Poisson distribution, and that the service times of the ships has an Erlangian distribution; an Erlang number (k) has been found for the national port of 2.25, so that $(k + 1)/2k = 0.7222$; note that this Erlang number can vary quite widely without seriously affecting the ratio.

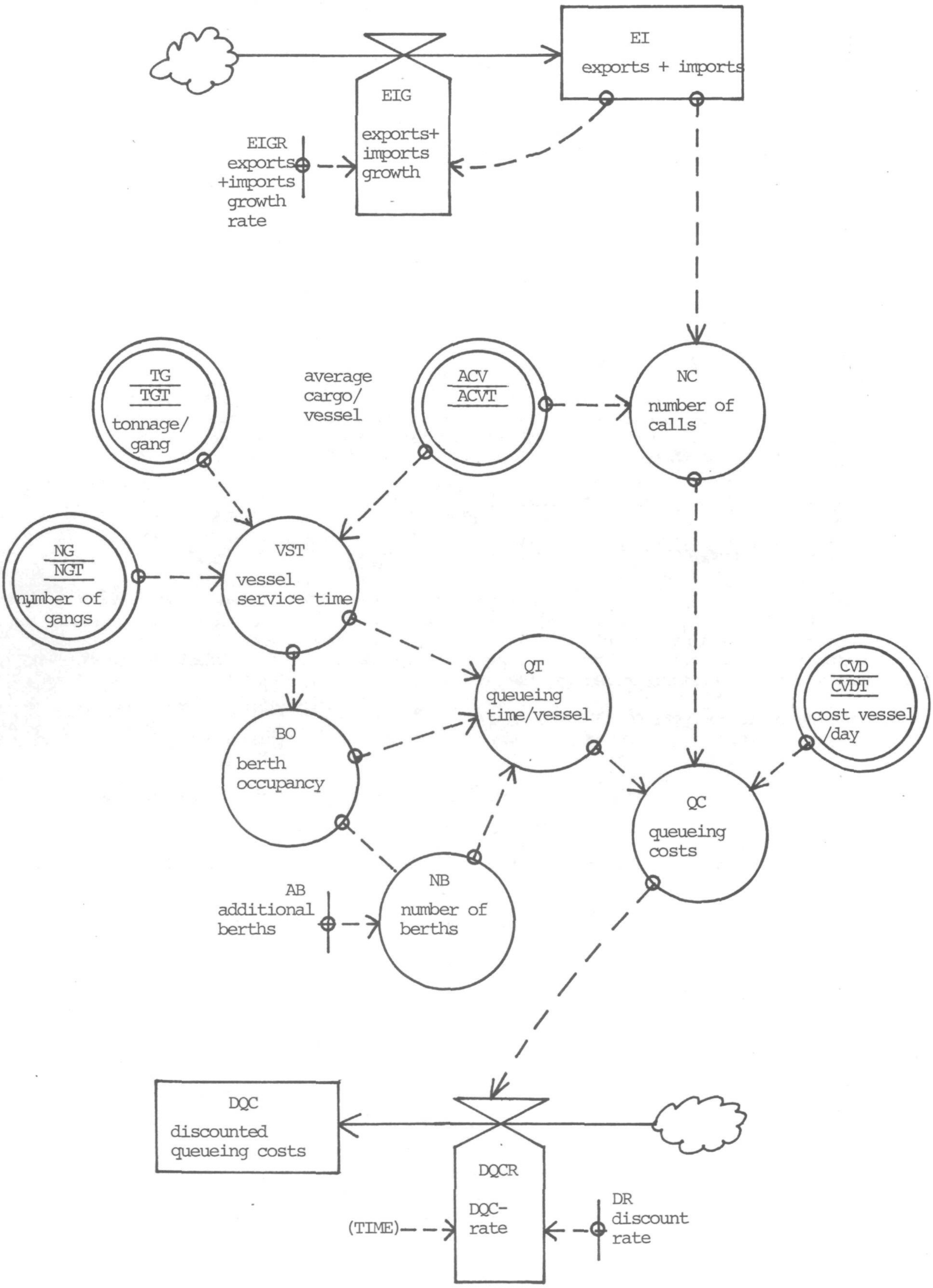
. queueing costs per year $QC = NC \times QT \times CVD$

The dynamo-flow diagram of the simple port model is presented on the following page.

. parameter values

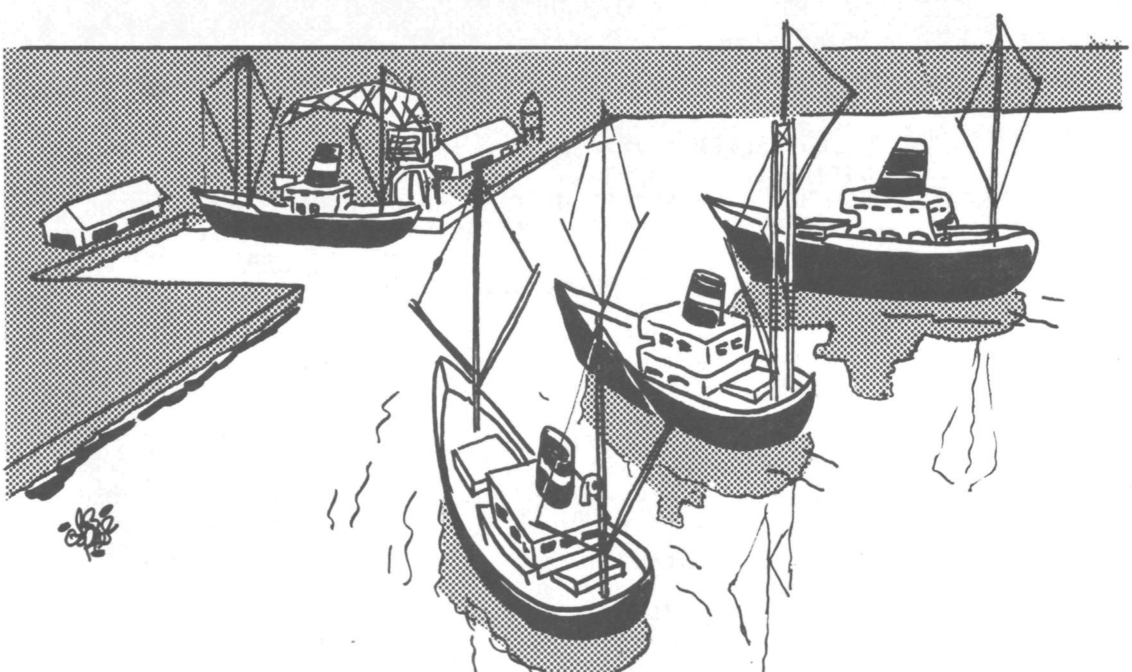
The unit of time in the calculation is the year. The time-horizon of the calculation is 1976 - 2000. The export and import general cargo flows (2.1 million tons in 1976) grow annually with 4 percent. The average cargo per vessel increases from 3800 tons in 1976 up to 5000 tons; the number of gangs per vessel increases from 12 to 13 and the tonnage per gang from 61.5 to 84. The cost of a vessel per day increases from £4000 to £4750.

The number of berths is 16, but this number may increase through the construction of additional berths (AB). The model calculates the queueing costs for 1,2,3 and 4 additional berths. The maritime planners can thus weight the cost of the additional berth construction against the savings in queueing costs. In order to make the queueing costs, which arise over the period 1976-2000, suitable for decision making in the present, they are discounted to the year 1976.


EI
exports + imports
EIG
exports+ imports growth
EIGR
exports +imports growth rate
TG
TGT
tonnage/ gang
average cargo/ vessel
ACV
ACVT
NC
number of calls
NG
NGT
number of gangs
VST
vessel service time
QT
queueing time/vessel
CVD
CVDT
cost vessel /day
BO
berth occupancy
QC
queueing costs
AB
additional berths
NB
number of berths
DQC
discounted queueing costs
DQCR
DQC- rate
(TIME)
DR
discount rate

. documentor listing

```
EI.K=EI.J+DT*EIG.JK
EI=2.1E6
    EI       - EXPORTS+IMPORTS THROUGH PORT   TONS/YEAR
    DT       - COMPUTATION INTERVAL   YEARS
    EIG      - EXPORTS+IMPORTS GROWTH   TONS/YEAR
EIG.KL=EIGR*EI.K
EIGR=.04
    EIG      - EXPORTS+IMPORTS GROWTH   TONS/YEAR
    EIGR     - EXPORTS+IMPORTS GROWTH RATE   %/YEAR
    EI       - EXPORTS+IMPORTS THROUGH PORT   TONS/YEAR
NC.K=EI.K/ACV.K
    NC       - NUMBER OF CALLS IN PORT
    EI       - EXPORTS+IMPORTS THROUGH PORT   TONS/YEAR
    ACV      - AVERAGE CARGO/VESSEL   TONS
ACV.K=TABLE(ACVT,TIME.K,1976,2000,6)
ACVT=3800/4200/4800/5000/5000
    ACV      - AVERAGE CARGO/VESSEL   TONS
    TABLE    - DYNAMO FUNCTION - SEE MANUAL
    ACVT     - AVERAGE CARGO/VESSEL TABLE
QC.K=NC.K*QT.K*CVD.K
    QC       - QUEUEING COSTS OF ALL SHIPS   $/YEAR
    NC       - NUMBER OF CALLS IN PORT
    QT       - QUEUEING TIME/VESSEL   DAYS
    CVD      - COST OF VESSEL/DAY IN PORT   $
QT.K=(.7222*VST.K*BO.K)/(NB.K*(1-BO.K))
    QT       - QUEUEING TIME/VESSEL   DAYS
    VST      - VESSEL SERVICE TIME   DAYS
    BO       - BERTH OCCUPANCY
    NB       - NUMBER OF BERTHS
VST.K=(ACV.K/(.8*NG.K*TG.K))+.5
    VST      - VESSEL SERVICE TIME   DAYS
    ACV      - AVERAGE CARGO/VESSEL   TONS
    NG       - NUMBER OF GANG-SHIFTS/SHIP/FULL WORKING DAY
    TG       - TONS/GANG
BO.K=(NC.K*VST.K)/(365*NB.K)
    BO       - BERTH OCCUPANCY
    NC       - NUMBER OF CALLS IN PORT
    VST      - VESSEL SERVICE TIME   DAYS
    NB       - NUMBER OF BERTHS
NB.K=16+AB
AB=1
    NB       - NUMBER OF BERTHS
    AB       - ADDITIONAL BERTHS
NG.K=TABLE(NGT,TIME.K,1976,2000,6)
NGT=12/12/13/13/13
    NG       - NUMBER OF GANG-SHIFTS/SHIP/FULL WORKING DAY
    TABLE    - DYNAMO FUNCTION - SEE MANUAL
    NGT      - NUMBER OF GANGS TABLE
TG.K=TABLE(TGT,TIME.K,1976,2000,6)
TGT=61.5/70/80/84/84
    TG       - TONS/GANG
    TABLE    - DYNAMO FUNCTION - SEE MANUAL
    TGT      - TONS/GANG TABLE
CVD.K=TABLE(CVDT,TIME.K,1976,2000,6)
CVDT=4000/4150/4400/4650/4750
    CVD      - COST OF VESSEL/DAY IN PORT   $
    TABLE    - DYNAMO FUNCTION - SEE MANUAL
    CVDT     - COST OF VESSEL /DAY IN PORT TABLE
DQC.K=DQC.J+DT*DQCR.JK
DQC=0
    DQC      - DISCOUNTED QUEUEING COSTS   $
    DT       - COMPUTATION INTERVAL   YEARS
    DQCR     - DISCOUNTED QUEUEING COSTS RATE   $/YEAR
DQCR.KL=QC.K/(EXP((TIME.K-1976)*LOGN(1+DR)))
DR=.12
    DQCR     - DISCOUNTED QUEUEING COSTS RATE   $/YEAR
    QC       - QUEUEING COSTS OF ALL SHIPS   $/YEAR
    EXP      - DYNAMO FUNCTION - SEE MANUAL
    DR       - DISCOUNT RATE
```

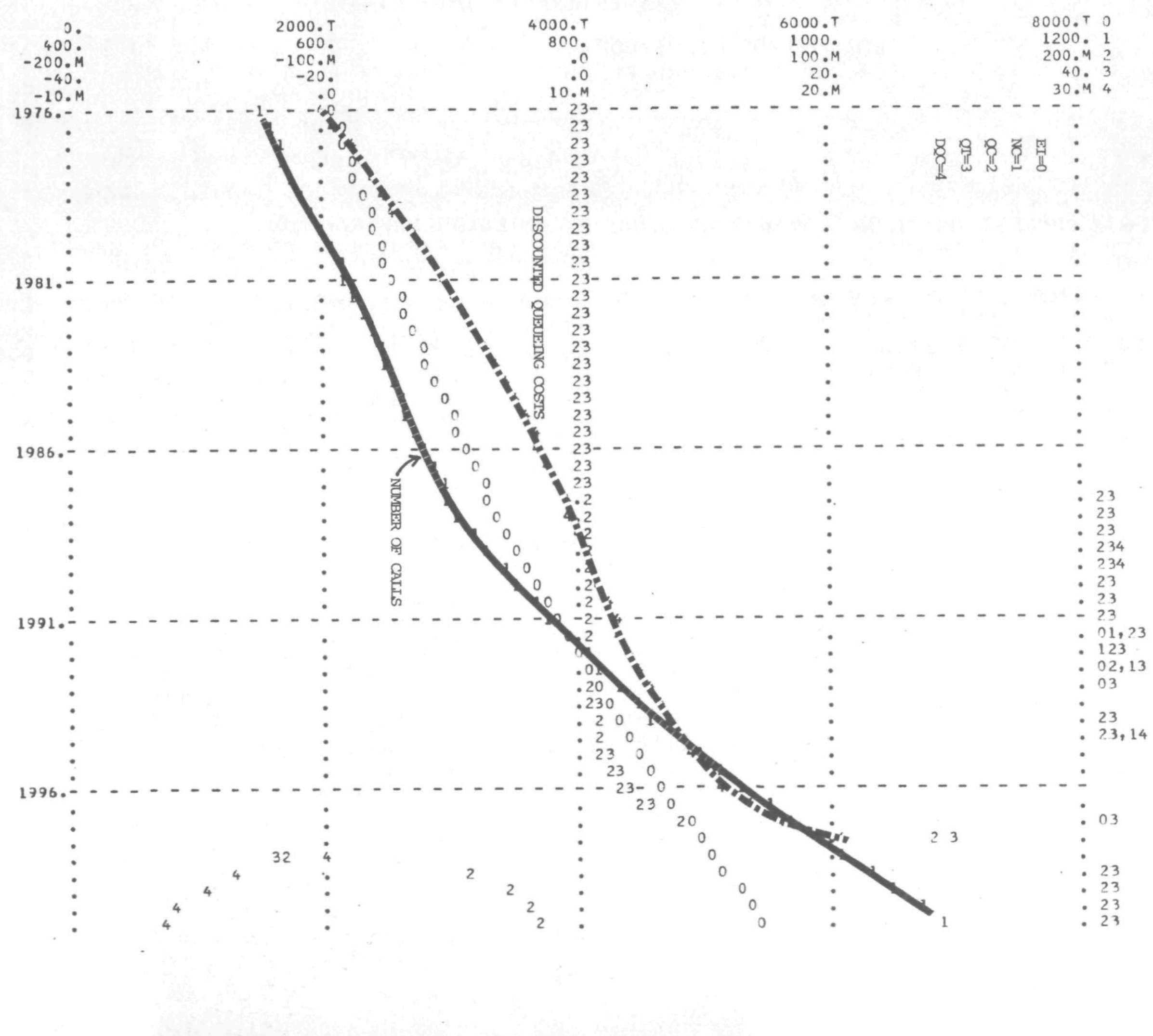


```
*   MODEL 16 - CONGESTION IN NATIONAL PORT
NOTE   EXPORTS+IMPORTS THROUGH PORT
L   EI.K=EI.J+DT*EIG.JK
N   EI=2.1E6
R   EIG.KL=EIGR*EI.K
C   EIGR=.04
NOTE   NUMBER OF CALLS IN PORT
A   NC.K=EI.K/ACV.K
A   ACV.K=TABLE(ACVT,TIME.K,1976,2000,6)
T   ACVT=3800/4200/4800/5000/5000
NOTE   QUEUEING COSTS IN PORT
A   QC.K=NC.K*QT.K*CVD.K
A   QT.K=(.7222*VST.K*BO.K)/(NB.K*(1-BO.K))
A   VST.K=(ACV.K/(.8*NG.K*TG.K))+.5
A   BO.K=(NC.K*VST.K)/(365*NB.K)
A   NB.K=16+AB
C   AB=1
A   NG.K=TABLE(NGT,TIME.K,1976,2000,6)
T   NGT=12/12/13/13/13
A   TG.K=TABLE(TGT,TIME.K,1976,2000,6)
T   TGT=61.5/70/80/84/84
A   CVD.K=TABLE(CVDT,TIME.K,1976,2000,6)
T   CVDT=4000/4150/4400/4650/4750
NOTE   DISCOUNTED QUEUEING COSTS
L   DQC.K=DQC.J+DT*DQCR.JK
N   DQC=0
R   DQCR.KL=QC.K/(EXP((TIME.K-1976)*LOGN(1+DR)))
C   DR=.12
SPEC   LENGTH=24/DT=.25/PRTPER=1/PLTPER=.5
N   TIME=1976
PRINT   EI,NC,ACV,QC,QT,VST,BO,NG,TG,CVD
PRINT   DQC
PLOT   EI/NC/QC/QT/DQC
RUN   1 ADDITIONAL BERTH
```

MODEL 16 - CONGESTION IN NATIONAL PORT 1 ADDITIONAL BERTH

TIME E+00	EI E+03	NC E+00	ACV E+00	QC E+06	QT E+00	VST E+00	BO E+00	NG E+00	TG E+00	CVD E+00	DQC E+06
1976.	2100.0	552.6	3800.0	1.05	.476	6.9363	.6178	12.000	61.500	4000.0	.000
1977.	2185.3	565.2	3866.7	1.13	.496	6.9018	.6286	12.000	62.917	4025.0	1.036
1978.	2274.0	578.1	3933.3	1.21	.519	6.8687	.6400	12.000	64.333	4050.0	2.028
1979.	2366.3	591.6	4000.0	1.31	.544	6.8371	.6518	12.000	65.750	4075.0	2.983
1980.	2462.4	605.5	4066.7	1.42	.572	6.8069	.6642	12.000	67.167	4100.0	3.904
1981.	2562.4	619.9	4133.3	1.54	.604	6.7778	.6772	12.000	68.583	4125.0	4.797
1982.	2666.4	634.9	4200.0	1.69	.640	6.7500	.6906	12.000	70.000	4150.0	5.664
1983.	2774.7	645.3	4300.0	1.73	.639	6.6644	.6930	12.167	71.667	4191.7	6.491
1984.	2887.4	656.2	4400.0	1.78	.640	6.5811	.6960	12.333	73.333	4233.3	7.249
1985.	3004.6	667.7	4500.0	1.83	.643	6.5000	.6994	12.500	75.000	4275.0	7.945
1986.	3126.6	679.7	4600.0	1.90	.647	6.4211	.7034	12.667	76.667	4316.7	8.587
1987.	3253.5	692.2	4700.0	1.97	.653	6.3442	.7078	12.833	78.333	4358.3	9.181
1988.	3385.6	705.3	4800.0	2.05	.660	6.2692	.7126	13.000	80.000	4400.0	9.732
1989.	3523.1	728.9	4833.3	2.40	.740	6.2613	.7355	13.000	80.667	4441.7	10.266
1990.	3666.2	753.3	4866.7	2.83	.838	6.2535	.7592	13.000	81.333	4483.3	10.825
1991.	3815.0	778.6	4900.0	3.39	.961	6.2458	.7837	13.000	82.000	4525.0	11.418
1992.	3969.9	804.7	4933.3	4.13	1.123	6.2382	.8090	13.000	82.667	4566.7	12.056
1993.	4131.1	831.8	4966.7	5.14	1.342	6.2308	.8352	13.000	83.333	4608.3	12.755
1994.	4298.9	859.8	5000.0	6.62	1.656	6.2234	.8623	13.000	84.000	4650.0	13.543
1995.	4473.4	894.7	5000.0	9.65	2.311	6.2234	.8973	13.000	84.000	4666.7	14.488
1996.	4655.0	931.0	5000.0	16.25	3.728	6.2234	.9338	13.000	84.000	4683.3	15.780
1997.	4844.0	968.8	5000.0	41.32	9.074	6.2234	.9717	13.000	84.000	4700.0	17.986
1998.	5040.7	1008.1	5000.0	-114.09	-23.994	6.2234	1.0111	13.000	84.000	4716.7	.027
1999.	5245.4	1049.1	5000.0	-26.46	-5.329	6.2234	1.0522	13.000	84.000	4733.3	-4.994
2000.	5458.4	1091.7	5000.0	-15.81	-3.050	6.2234	1.0949	13.000	84.000	4750.0	-6.523

	2 ADDITIONAL BERTHS				3 ADDITIONAL BERTHS				4 ADDITIONAL BERTHS			
TIME E+00	BO E+00	QT E+00	QC E+06	DQC E+06	BO E+00	QT E+00	QC E+06	DQC E+06	BO E+00	QT E+00	QC E+06	DQC E+06
1976.	.5834	.390	.86	.000	.55274	.326	.720	.000	.52510	.2769	.612	.000
1977.	.5937	.405	.92	.846	.56245	.337	.767	.707	.53432	.2860	.650	.600
1978.	.6044	.421	.99	1.654	.57261	.350	.819	1.379	.54398	.2959	.693	1.170
1979.	.6156	.439	1.06	2.428	.58323	.364	.877	2.021	.55407	.3068	.740	1.712
1980.	.6273	.460	1.14	3.171	.59432	.379	.941	2.635	.56460	.3187	.791	2.230
1981.	.6395	.482	1.23	3.887	.60588	.396	1.013	3.224	.57559	.3319	.849	2.725
1982.	.6523	.508	1.34	4.578	.61793	.415	1.093	3.791	.58703	.3465	.913	3.199
1983.	.6545	.507	1.37	5.234	.62010	.413	1.118	4.326	.58909	.3450	.933	3.646
1984.	.6573	.506	1.41	5.834	.62273	.413	1.147	4.816	.59159	.3442	.956	4.054
1985.	.6606	.508	1.45	6.385	.62580	.413	1.179	5.265	.59451	.3441	.982	4.428
1986.	.6643	.510	1.50	6.891	.62932	.414	1.216	5.677	.59785	.3447	1.011	4.771
1987.	.6684	.513	1.55	7.359	.63326	.416	1.256	6.057	.60160	.3459	1.044	5.087
1988.	.6731	.518	1.61	7.792	.63763	.419	1.301	6.408	.60575	.3478	1.079	5.378
1989.	.6947	.572	1.85	8.208	.65811	.458	1.483	6.744	.62520	.3771	1.221	5.656
1990.	.7170	.636	2.15	8.638	.67929	.503	1.700	7.086	.64532	.4109	1.388	5.938
1991.	.7402	.714	2.51	9.084	.70120	.557	1.963	7.438	.66614	.4500	1.585	6.224
1992.	.7641	.811	2.98	9.553	.72386	.622	2.284	7.802	.68767	.4960	1.823	6.516
1993.	.7888	.934	3.58	10.051	.74730	.700	2.685	8.181	.70994	.5507	2.111	6.817
1994.	.8144	1.096	4.28	10.589	.77155	.799	3.194	8.580	.73298	.6169	2.466	7.129
1995.	.8475	1.388	5.79	11.194	.80288	.964	4.023	9.014	.76274	.7224	3.016	7.460
1996.	.8819	1.865	8.13	11.923	.83548	1.201	5.238	9.507	.79371	.8646	3.770	7.824
1997.	.9177	2.785	12.68	12.870	.86941	1.575	7.171	10.090	.82594	1.0663	4.855	8.235
1998.	.9550	5.295	25.18	14.297	.90471	2.246	10.679	10.824	.85947	1.3744	6.536	8.715
1999.	.9937	39.660	196.94	17.789	.94144	3.803	18.885	11.858	.89437	1.9028	9.448	9.307
2000.	1.0341	-7.574	-39.27	12.728	.97967	11.398	59.102	13.790	.93068	3.0174	15.646	10.106



Chapter 9 - THE USE OF SIMULATION MODELS IN MARITIME PLANNING

9.1 POLICY ANALYSIS IN SHIPPING: THE NEED FOR A SYSTEM'S VIEW

Decision making in shipping is traditionally based more on intuition than on rational planning methods. Keywords in the expulsion of planning were the uncertainty and unpredictability of the shipping markets. However, in the mid-sixties many managers in the maritime industry felt that their mental models (intuition) were not adequate anymore to deal with the complexity of the present. This complexity had increased as a result of a number of factors:

. rapid expansion of seaborne trade flows
. structural changes in the composition of trade flows
. rapid technological change in ship types, ship size and cargo handling techniques
. huge increase in investments in ships, shipyards and ports
. a growing interest of non-traditional maritime countries for the shipping industry.

The managers requested,therefore, information on which they could base their planning. Thus, studies were commissioned with the intention to gain more understanding on the future demand for shipping services. In this framework forecasts were made of seaborne trade flows, demand for ship tonnage, and new-built tonnage. The structure of these forecasts was very simple: correlation and extrapolation. Although the forecasts offered useful insights in the factors which determine the long term development of shipping demand, they offered little help to the maritime decision maker with his day to day decisions, particularly investment decisions. For this purpose studies are needed into the dynamic phenomena of the freight markets, in particular the oil and dry-bulk markets, as fluctuations in these markets immediately influence the supply of new tonnage. In the early seventies a number of studies was published which attempt to explain the factors underlying the short term movements of freight rates. In these studies the tool of analysis is simulation models, as these models can deal with very complex time-related behaviour.

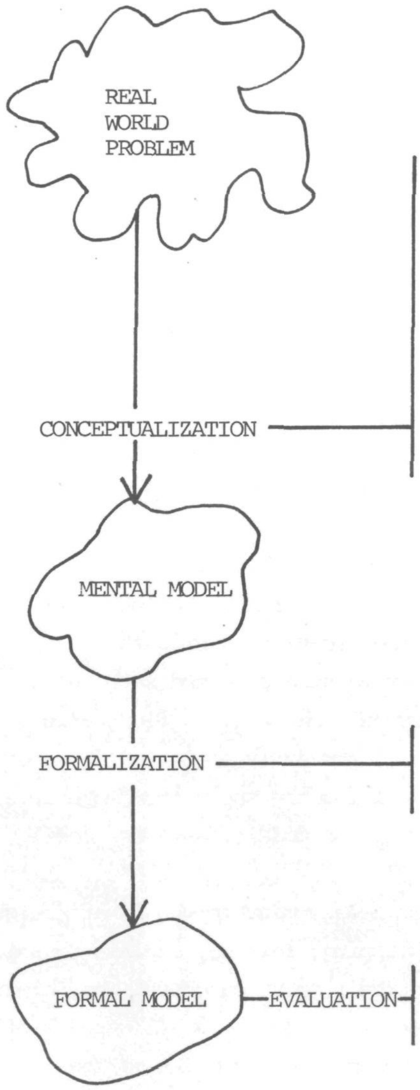
However, long term development in liner shipping and short term development in the liner freight rates have not been so spectacular as in liquid and dry-bulk shipping. This may explain to some extent why liner shipping has received relatively little attention from researchers. The Shipping Secretariat of UNCTAD signaled this lack and initiated considerable research in all aspects of liner shipping. In one of its publications 'The establishment or expansion of merchant marines in developing countries' it is attempted to formulate guidelines for evaluation of shipping investments. This publication provides the maritime planner in a developing country with a qualitative assessment of shipping and some quantitative methods to evaluate a shipping venture at the national level. However, seen from a system's point of view, the publication lacks a number of elements. This is illustrated with the help of a diagram which shows the different stages and steps in model building. (following page)

Looking at liner shipping as a system means that the maritime planner goes through all these stages and steps (which is an iterative process), and that he defines explicitely each activity. This is in itself one of the most important benefits of model building.

Chapter 1 dealt with the conceptualization and chapter 2 with the formalization of the liner shipping system. This chapter is confined to two activities of the evaluation step:

. parameter changes and model behaviour
. parameter selection in relation to national objective maximization.

The model building process[17)]



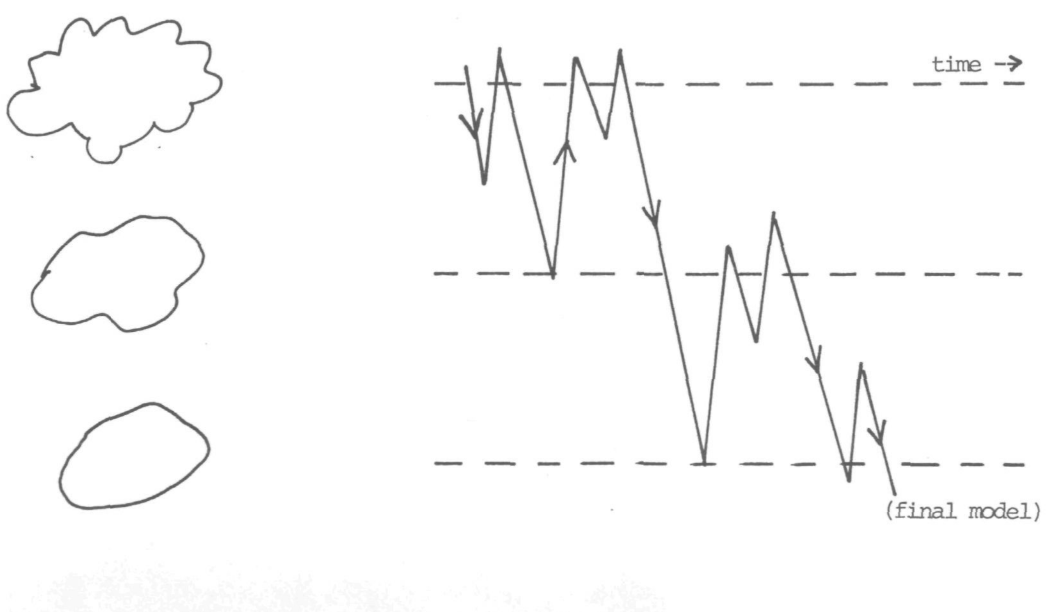
Conceptualization:
- familiarization with general problem area
- definition of the question to be addressed
- exploration of real-world behaviour and structure relevant to the question
- description of dynamic behaviour of interest
- development of organizing concepts
- definition of system boundary through verbal description of feedback loops
- representation of feedback loops in causal diagram form

Formalization:
- identification of system descriptors
- postulation of detailed model structure
- specification of a parametrization

Evaluation:
- simulation to evaluate model behaviour and test sensitivity to perturbations
- experimentation with different policies

(a representation of the mental model)

a typical time path of model building activities



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9.2 PARAMETER CHANGES AND MODEL BEHAVIOUR

For a maritime planner who prepares an evaluation of a national fleet project, it is very important to know the impact of a change in a parameter value on the overall results. If he has to calculate the impacts by hand, it will be virtually impossible for him to calculate a great number of impacts given the time-constraints. However, a computer can do this job in a matter of seconds. In this paragraph 18 model parameters are given different values and the impact on the model behaviour is studied. On this basis the parameters are classified into three groups, with a large, medium, and small impact respectively.

In order to decide whether a change in a parameter has a small or large impact, it is necessary to define the relative magnitude of the change and the impact. Arbitrarily the magnitude of the change is taken + or - 10% of the standard value of the parameter. The impact on the model behaviour is called: large, when the value of the decision criteria at the end of the calculation period changes much more than 10%; medium, when the decision criteria change just over 10%; small, when the decision criteria change much less than 10%.

The parameter changes are tested on two types of models in order to answer two kinds of questions:

- endogenous fleet expansion models 14 & 15; purpose: to determine the impact of the parameter on the development of the number of ships in the fleet;
- pre-determined fleet expansion models 8 & 9; purpose: to facilitate the comparison of the impacts in relation to parameter changes, as the basis (number of ships) of all comparisons is identical.

The parameters, their changes, the models tested, and the decision criteria for comparison, are presented in the table on the following page. The quantitative results of the some 160 runs which have been made, can be found in Appendix A. A qualitative assessment of the results follows hereafter.

A. Parameters with a LARGE impact.

1. freight rates (FR) - a 10% lower FR prohibits any fleet development; a higher FR improves more than proportionally the decision criteria DCB, DCBS, FEBT, IPBC.
2. load factor (LF) - a 10% lower LF prohibits any fleet development; a 10% higher LF has a large positive impact on the decision criteria, but the number of ships will slightly decrease as a result of the increased productivity of the ships.
3. voyage expenditures (VE) - a 10% higher VE has no substantial impact on the fleet development as such, but has a large negative impact on the decision criteria.
4. roundtrip time (RT) - a 10% increase in RT will increase the number of ships (as the productivity decreases), and has a large negative impact on the decision criteria.
5. operating cost (OC) - a 10% increase in OC has no substantial effect on the number of ships in the national fleet, but has a large impact on the decision criteria.
6. purchase price ship (PPS) - a 10% increase of PPS has no substantial effect on the number of ships, but has a large negative impact on the decision criteria.
7. incidence of transport cost (ITC) - a small decrease in the ITC has a large negative impact on the foreign exchange balance total, and consequently on the shadow priced discounted costs and benefits.
8. number of ships (NS) - if the size of the fleet is pre-determined, then the chosen number of ships has an impact on the decision criteria. A large fleet will have better values of the decision criteria in comparison with a small fleet, given the standard values of the parameters.

(9.) discount rate (DR) - a small increase in the DR has a large impact on the decision criteria. Note that this parameter is not a real model parameter.

TABLE

scenario	model tested	decision criteria of interest
I. Freight rates		
1. freight rate standard (100%)	14, 9	WC, NS, DCB, DCBS, FEBT, IPBC
2. fr = 90%		
3. fr = 80%		
4. fr = 110%		
5. fr = 120%		
II. Load factor		
1. load factor standard (100%)	14, 9	WC, NS, DCB, DCBS, FEBT, IPBC
2. lf = 90%		
3. lf = 110%		
1. load factor exports standard (100%)	9	DCB, DCBS, FEBT, IPBC
2. lfe = 90%		
3. lfe = 80%		
III. Voyage expenditures		
1. voyage expenditures standard (100%)	14, 9	WC, NS, DCB, DCBS, FEBT, IPBC
2. ve = 90%		
3. ve = 80%		
4. ve = 110%		
5. ve = 120%		
IV. Roundtrip time		
1. roundtrip time standard (100%)	14, 9	WC, NS, DCB, DCBS, FEBT, IPBC
2. rt = 90%		
3. rt = 80%		
4. rt = 110%		
5. rt = 120%		
V. Operating cost		
1. operating cost standard (100%)	14, 9	WC, NS, DCB, DCBS, FEBT, IPBC
2. oc = 90%		
3. oc = 80%		
4. oc = 110%		
5. oc = 120%		
VI. Administrative and management cost		
1. adm. & management cost standard (100%)	14, 9	WC, NS, DCB, DCBS, IPBC
2. amc = 90%		
3. amc = 50%		
4. amc = 110%		
5. amc = 150%		
VII. Purchase price ships		
1. purchase price ship standard (100%)	8	WC
2. pps = 90%	15	WC, NS
3. pps = 50%		
4. pps = 110%	9	DCB, DCBS, FEBT, IPBC
5. pps = 150%		
VIII. Lifetime ship		
1. lifetime ship standard	8	WC
2. lts = - 2 years	15	WC, NS
3. lts = - 5 years		
4. lts = + 2 years	9	DCB, DCBS, FEBT, IPBC
5. lts = + 5 years		
IX. Loan percentage price ship		
1. lpps standard = .75	15, 9	WC, NS, DCB, DCBS, FEBT, IPBC, WC
2. lpps = .65		
3. lpps = .5		
4. lpps = .85		
5. lpps = 1		
X. Loan interest rate		
1. loan interest rate standard = 2%/quarter	15, 9	WC, NS, WC, DCB, DCBS, FEBT, IPBC
2. lir = 1.5%		
3. lir = 1%		
4. lir = 2.5%		
5. lir = 3%		
XI. Loan repayment period		
1. repay period standard = 32 quarters	15, 9	WC, NS, WC, DCB, DCBS, FEBT, IPBC
2. rp = 28		
3. rp = 16		
4. rp = 36		
5. rp = 48		
XII. Local interest rate	14, 9	WC, NS, DCB, DCBS, FEBT, IPBC
1. interest rate = 2%/quarter		
2. ir = 1.5 %		
3. ir = 1%		
4. ir = 2.5%		
5. ir = 4%		
XIII. Cargo reservation goal		
1. crg = 40%	14, 15	WC, NS, DCB, DCBS, FEBT, IPBC
2. crg = 30%		
3. crg = 20%		
XIV. Working capital minimum		
1. wcm = -£10 M	14	WC, NS
2. wcm = -£5 M		
3. wcm = -£15 M		
XV. Percentage transfer and cross-trade		
1. ptct standard (100%)	14, 15	WC, NS, DCB, DCBS, FEBT, IPBC
2. ptct = 50%		
3. ptct = 0%		
XVI. Growth rate exports & imports		
1. gr standard = 4%/year	14, 15	WC, NS, DCB, DCBS, FEBT, IPBC
2. gr = 3%		
3. gr = 2%		
4. gr = 1%		
XVII. Shadow price foreign exchange		
1. sp = 1	9	DCBS
2. sp = 1.3 (standard)		
3. sp = 1.7		
4. sp = 2		
5. sp = 2.5		
XVIII. Incidence of transport cost		
1. itc = 1	9	DCBS, FEBT
2. itc = .7 (standard)		
3. itc = .5		

Note: the incidence of transport cost used in model 15 is 0.8, instead of the standard value 0.7

B. Parameters with a MEDIUM impact.

1. lifetime ship (LTS) - a small change in the lifetime of the ships has no substantial impact on the number of ships; the impact on the decision criteria depends to a large extent on the age-structure of the fleet. A decrease of the average lifetime of the ships will have a smaller impact on a well 'age-mixed' fleet than on a fleet with ships of approximately the same remaining lifetime.
In general, the impact on the decision criteria will be larger than the proportional change in the lifetime, and is therefore termed 'medium'.

2. loan percentage price ship (LPPS) - a small change in LPPS has a medium impact on the decision criteria DCB and DCBS, and a small impact on the FEBT and IPBC. Remarkable is the effect on the foreign exchange balance: a large LPPS diminishes the foreign exchange expenditures in the first years of operation, but the total balance at the end of the calculation period shows less difference.

A small change in LPPS can have a large impact on the expansion of the fleet; this depends on the capital which is available on the local capital market (working capital minimum, see C.)

3. loan interest rate (LIR) - an increase of the standard value of LIR with 10% has no effect on the number of ships, but has a medium negative impact on the decision criteria (especially the time-pattern of the foreign exchange balance total).

4. repay period (RP) - a small change in RP has a medium impact on DCB and DCBS, and a small impact on FEBT and IPBC. The RP has a large impact on the time-pattern of the foreign exchange expenditures.

5. cargo reservation goal (CRG) - a small change in CRG has a medium effect on the required number of ships and the decision criteria.

6. percentage transfer and cross-trade (PTCT) - a small change in the PTCT has a medium effect on the number of ships (a decrease in PTCT gives a decrease in NS), and a medium effect on the decision criteria DCB, DCBS and IPBC, but a large effect on the foreign exchange balance (a decrease of PTCT gives a decrease of FEBT).

7. shadow price foreign exchange (SP) - a small change in the SP has a medium effect on the shadow priced discounted costs and benefits.

C. Parameters with a SMALL impact.

1. administrative and management costs (AMC) - an increase of 10% in AMC has no effect on the number of ships, a small effect on the decision criteria DCB, DCBS and IPBC, and no impact on FEBT.

2. interest rate (IR) - a small change of IR has no impact on the number of ships and the decision criteria IPBC and FEBT. The impact on DCB and DCBS is small.

3. working capital minimum (WCM) - if the available local capital is small, then the fleet development may be constrained. As the purchase price of the ships are large amounts of money, which must be paid in one time, a small increase in the available local capital will have a small impact on the decision criteria.

4. growth rate exports & imports (GREI) - a small change in GREI has a medium effect on the number of ships and the decision criteria IPBC, and a small impact on the other decision criteria.

9.3 PARAMETER SELECTION IN RELATION TO NATIONAL OBJECTIVE MAXIMIZATION

On the basis of the information contained in the previous paragraph, it is possible to select the parameters which are of importance to the achievement of the national objectives as mentioned in chapter 3.

Objective 1 - contribution of national fleet to national income creation.
Those parameters must be selected which maximixe the discounted costs and benefits. Three cases can be distinguished:

a. discounted costs and benefits without constraints
b. discounted costs and benefits with constraint on the amount of capital that can be borrowed on the local capital market (WCM)
c. discounted costs and benefits with constraint on the amount of foreign exchange that can be used by the shipping line.

In the following tables the characters mean:
- \+ = as large as possible
- \- = as small as possible
- 1) = undecided, see remark
- . = not relevant

parameter	case a.	case b.	case c.
freight rate	+	+	+
load factor	+	+	+
voyage expenditures	-	-	-
roundtrip time	-	-	-
operating cost	-	-	-
adm. & management costs	-	-	-
purchase price ship	-	-	-
lifetime ship	+	+	+
loan percentage price ship	}	+	}
loan interest rate	} 1)	-	} 1)
loan repay period	}	+	}
interest rate	2)	-	2)
cargo reservation goal	+	3)	3)
working capital minimum	.	+	+
percentage transfer & cross-trade	+	-	+
growth rate exports & imports	+	3)	3)
shadow price foreign exchange	.	.	.
incidence of transport cost	.	.	+
number of ships	4)	4)	4)

1) a foreign loan on a ship, against a low interest rate, gives a leverage effect on the return of the shipping line's working capital. If this return is larger than the loan interest rate, a foreign loan becomes a means of improving the discounted costs and benefits.
However, a big loan percentage price ship (LPPS) and a long repay period (RP), bring along more loan interest payments, which are foreign exchange expenditures. For these reasons, no recipe can be formulated for the optimal values of LPPS, LIR and RP. Much will depend on the specific circumstances.

2) a low local interest rate limits in the early years of the shipping line the interest payments, which results in lower discounted costs. However, if the working capital becomes positive, the interest flow is reversed, which results in higher discounted benefits. The 'optimum' interest rate must be calculated in each specific case.

3) When the growth of the fleet is constrained by the available working capital and foreign exchange, all the available funds will be immediately used for the purchase and replacement of ships. This results in a negative working capital during many years, which increases the interest payments and consequently the discounted costs.
A small cargo reservation goal and/or growth of trade necessitates only occasionally the purchase of ships; the working capital can grow steadily and the discounted benefits with it.
The optimum cargo reservation goal and growth of trade, thus depend on the kind of capital constraints imposed by the financial position of the country.

4) the number of ships is not a parameter in the endogenous fleet expansion model, but a dependent variable. However, in the pre-determined fleet expansion models it is an important parameter.

Objective 2 - foreign exchange earnings of the national fleet.

Those parameters must be selected which maximize the foreign exchange balance total. Three cases are distinguished:

a. maximization of the foreign exchange balance total in the year 2000
b. minimization of the foreign exchange needs during the national fleet project life
c. maximization of the discounted costs and benefits with shadow priced foreign exchange.

parameter	case a.	case b.	case c.
freight rate	+	+	+
load factor	+	+	+
voyage expenditures	-	-	-
roundtrip time	-	-	-
operating cost	-	-	-
adm. & management costs	.	.	-
purchase price ship	-	-	-
lifetime ship	+	+	+
loan percentage price ship	-	1)	1)
loan interest rate	-	1)	1)
loan repay period	-	1)	1)
interest rate	.	.	2)
cargo reservation goal	5)	5)	5)
working capital minimum	-	5)	-
percentage transfer & cross-trade	+	5)	+
growth rate exports & imports	5)	5)	5)
shadow price foreign exchange	.	.	+
incidence of transport cost	+	+	+

5) The cargo reservation goal and /or growth rate of trade must be as large as possible, only in the case that the foreign exchange earnings exceed the foreign exchange expenditures. A large cargo reservation goal/growth rate of trade means a fast expansion of the number of ships in the fleet, which requires a lot of foreign exchange for the purchase of the ships over a short period of time. In order to limit the foreign exchange needs of the national shipping line, it is advisable to spread the purchase of the ships over time.
The working capital minimum can work as a constraint on the fleet development and therefore limit the foreign exchange needs.
A high interest rate on the local capital decreases the working capital in the initial years of the operation , and may thus constrain fleet development.

Objective 3 - employment creation (column a)

Objective 4 - influence on conference decisions (column b)

Objective 5 - avoidance of disruption of services during hostilities (column c)

Objective 6 - reduction of economic dependence (column d)

Objective 7 - promotion of exports (column e)

Objective 8 - economic integration (column f)

Objective 9 - stimulation of forward and backward linkages of the shipping industry (column g)

parameter	a	b	c	d[7]	e[8]	f	g
freight rate	.	.	.			.	.
load factor	.	.	.			.	.
voyage expenditures	.	.	.			.	.
roundtrip time	.	.	.			.	.
operating cost	6)	.	.			.	+
adm. & management costs	+	.	.			.	+
purchase price ship	.	.	.			.	9)
lifetime ship	.	.	.			.	.
loan percentage price ship	.	.	.			.	.
loan interest rate	.	.	.			.	.
loan repay period	.	.	.			.	.
interest rate	.	.	.			.	.
cargo reservation goal	+	+	+	+	+	+	+
working capital minimum	.	.	.			.	.
percentage transfer & cross-trade	+	+	+	+	+	+	+
growth rate exports & imports	+	+	.			+	+
shadow price foreign exchange	.	.	.		+	.	.
incidence of transport cost	.	.	.	+	+	.	.
number of ships	+	+	+	+	+	+	+

6) The crew of a ship can vary in number; if the shipping line wants to create employment, it can increase the crew, which will in turn increase the operating cost.

7) One indicator of economic dependence is the foreign exchange balance of the country; all the parameter changes as mentioned under objective 2 are in this respect relevant.

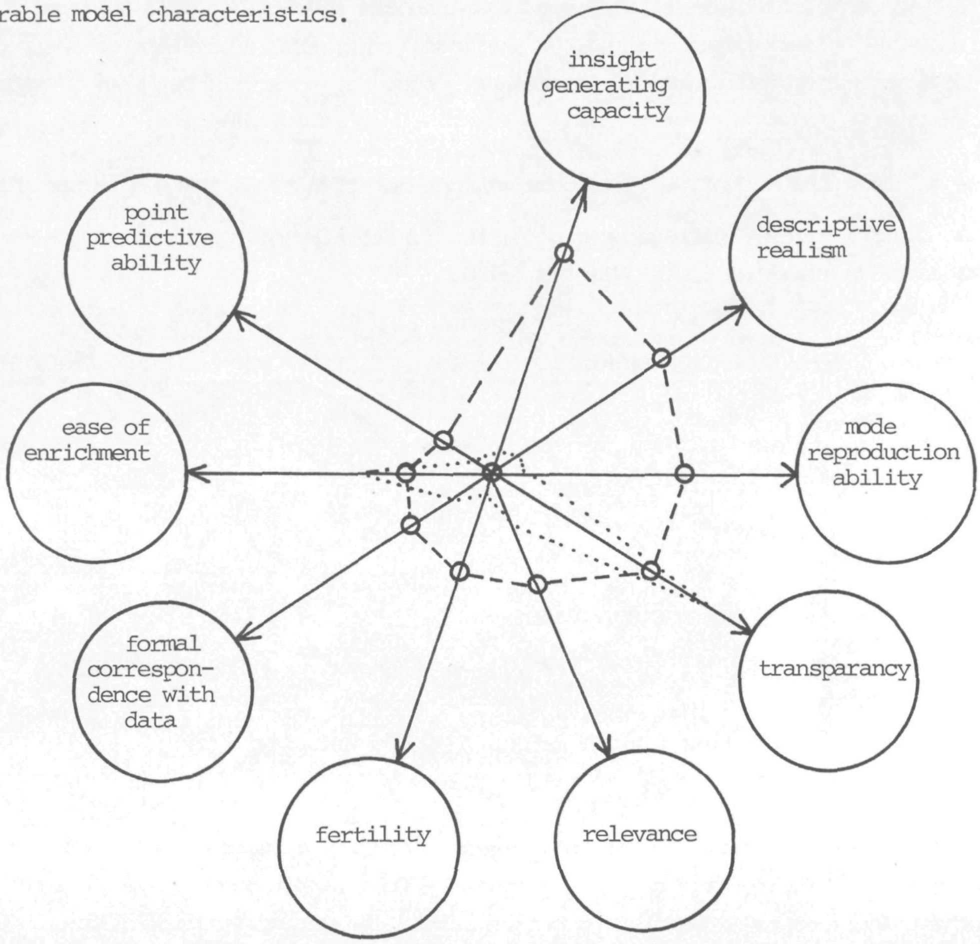
8) The promotion of exports is achieved by lowering the freight rate of exports; the loss in income must be compesated one way or the other, otherwise the company will go bankrupt. All the parameter changes that improve tne income position of the shipping line are in this respect relevant.

9) When a shipping line purchases 'cheap' second-hand ships, it is unlikely that a local shipbuilding industry will develop. If the shipping line intends to buy new ships, it may have a stimulating effect on such an industry. On the other hand, second-hand ships implicate more repairs than new ships, which may stimulate a local ship-repairing industry.

Chapter 10 - LIMITS OF THE SIMULATION MODELS

Before making a model of a system, the modeler should clarify the objectives he has in mind with the model. Only then a model can be evaluated properly. Jørgen Randers[18)] introduces in this respect the concept of the 'goal surface' of a model. This means that the modeler defines all his objectives with the model and puts relative weights on each of them. The figure below illustrates the procedure.

Some desirable model characteristics.



······ typical initial model
– – – goal surface of a finished model (according to one's paradigm)

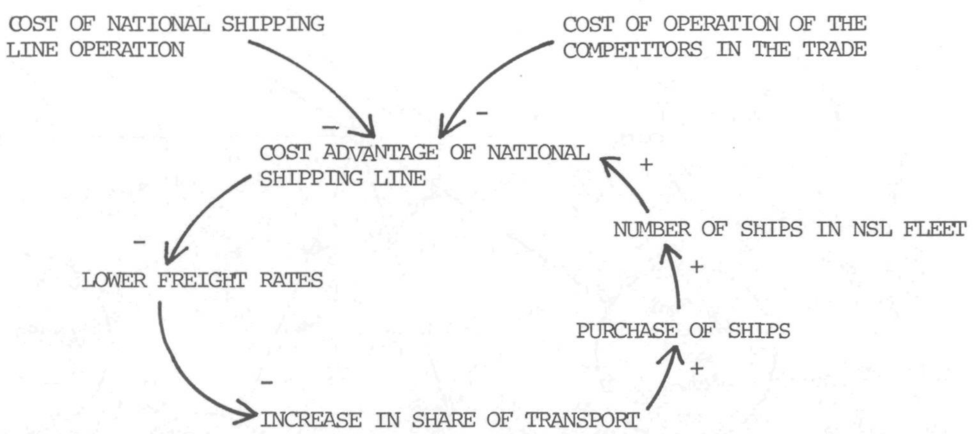
- insight generating capacity. Does the model increase real understanding about the system being modeled? Does it improve the mental models of the persons involved in making or assessing it?
- descriptive realism. Does the model elements and equations represent the real system in a form that corresponds closely to the way persons involved in the system perceive it? Can one easily identify in each parameter and element a perceivable or conceivable real-world equivalent?
- mode reproduction ability. Can the model reproduce all forms of dynamic behaviour that can be observed in the real system, under the same conditions that produce them in the real system?
- transparency. Is the model easily understandable even by a non-professional audience?
- relevance. Does the model address problems that are viewed as important by those involved in the real system?
- fertility. Does the model generate new ideas, new ways of looking at the problem, new experiments or policies that might not have been considered if the model had not been made?
- formal correspondence with data. Does the model incorporate real world observations as contained in standard data sources, and can it reproduce under historical conditions a reasonable statistical fit to historically-observed data?
- ease of enrichment. Can the model be altered to incorporate new findings or to test the effects of new policies that were not under consideration when the model was made? Can the model be adapted to represent systems related but not identical to the one originally represented? Can the model be updated without repeating all the work that went into creating it originally?
- point predictive ability. Can the model produce a precise prediction of a future event or of the future magnitude of important elements in the system?

In the INTRODUCTION it is stated that the purpose of simulation models of national fleet development is to generate insights into the system of liner shipping and to provide the maritime planners in developing countries with a tool for the evaluation of shipping projects. Defining the limits of the present models in the light of these objectives is difficult as there are no absolute criteria. The usefulness of the models can only be defined in comparison with the existing methods of evaluation. If the models generate more insights and calculate better the implications of fleet development scenario's in comparison with the existing approaches, then the model is 'good'. Howver, this does not mean that the model cannot be critisized. On any model criticism is possible on the model structure, the level of aggregation and the model parameters. These subjects will be briefly discussed.

a. model structure

The purpose of this paragraph is to show some examples of structural changes in the simulation models.

- A maritime planner has a different concept of the functioning of the fleet expansion mechanism. His mental model is illustrated in the diagram below.



  He believes that cargo reservation is not a means to acquire a share of the transport market, but that the national shipping line can only do this by free market competition with the other lines in the trade. In order to expand the number of ships, the national shipping line should be more competitive, which means, should offer lower freight rates. To be able to do so, the national shipping line should have a cost advantage over the competitors. The cost of ship operation and line management should thus be kept as low as possible. As some costs do not increase proportionally with an increase in the number of ships, each addition to the fleet influences the cost advantage in a positive way, etc.

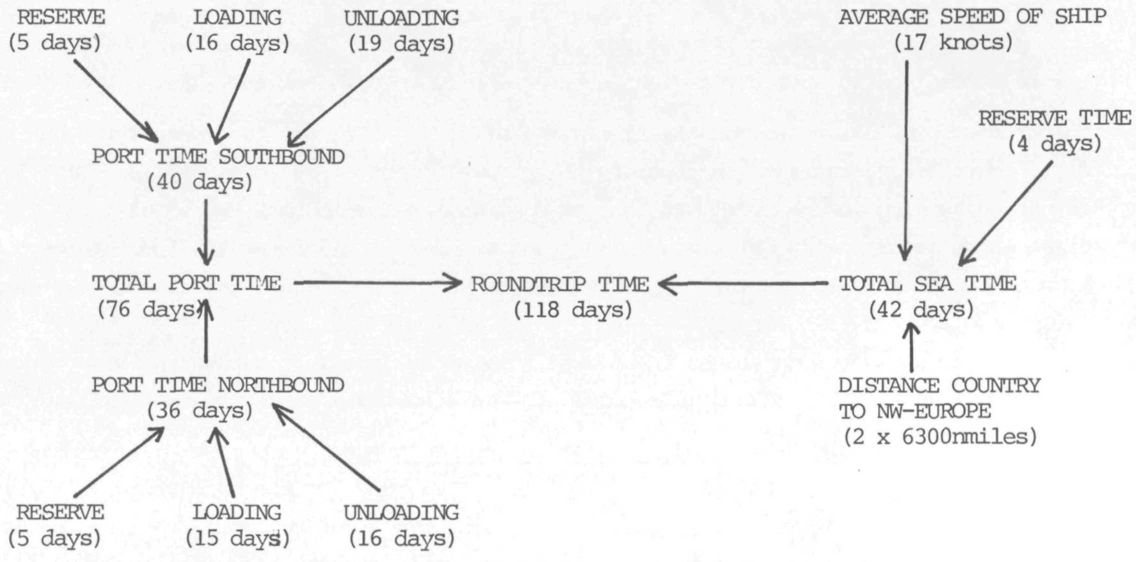
- Another maritime planner believes that the cargo reservation goal in his country is not static over time, but that it may be influenced by the actual performance of the shipping line, in terms of return on investment, foreign exchange balance effects, etc. Thus he will incorporate in his model causal influences from, for example, the levels 'working capital', 'discounted costs and benefits', 'foreign exchange balance total' to the cargo reservation goal (which also becomes a level). This is a structural change in the model.

- Yet another maritime planner does not like to buy ships, whether they are second-hand or brand new. He wants to charter them. A whole part of the model (ageing mechanism, loan sector) can thus be eliminated, as a fixed charter price is paid for each ship.

The three examples illustrate that other concepts can be used in the model. This does not limit the validity of the models. On the contrary, it enables the comparison of different concepts in model building of liner shipping.

b. aggregation

From a system's point of view one tries to grasp complex problems in their totality. The ensuing complexity, however, necessitates simplification. This is achieved by introducing general notions and properties, and by aggregation. For example, in the models the parameter 'roundtrip time' is used, which is an aggregation of a number of other parameters:



Another example of an aggregated parameter in the model is 'operating cost' of ship. This parameter can be disaggregated into the following components:

. oils and greases (excl. bunkers)	- £ 15,000
. general expenses: deck & hull	- £ 10,000
engine room	- £ 7,000
. repairs & renewals: deck & hull	- £ 8,000
engine room	- £ 37,000
. annual dry docking, spec. survey & classification society's requirements	- £ 35,000
. ropes, wires & deck tackle	- £ 2,000
. medical	- £ 3,000
. wages & other emoluments	- £ 115,000
. messing & victuals	- £ 24,000
. insurance (hull & equipment)	- £ 170,000
. miscellaneous	- £ 14,000
OPERATING COST	£ 440,000 /year

The aggregation of many parameters increases the transparency of the model and does not affect the the model behaviour. However, if the maritime planner is faced with decision makers who want to see detail in the model, he should not argue too long about the usefulness of this, but just do it.

b. parameters

In the models a great number of parameters remain constant over the calculation period. This will of course never happen in reality. But how to deal with this in a model? There is no solution to the problem, just as when using conventional evaluation methods. One possibility is to execute a number of runs with the models and determine the impact of a change in the parameter value on the overall performance of the model.

Another possibility comes from the continuous useof the models. The models are developed for pre-investment studies. However, as soon as the national shipping line is established and in operation, the data which is gathered can be fed into the model and the consequences calculated. On this basis the shipping line management and/or the government can change its fleet expansion policy or take measures in fields related to shipping.

Two more issues are relevant in relation to the limits of the simulation models: technological change in shipping, and the application of the models outside liner shipping.

Technological change.

The models have one serious limitation: they do not take technological change into account. Over the calculation period of the model (1976 - 2000) it is quite likely that:

. conventional general cargo ships are replaced by more modern ship types with different cost structures, speeds, etc.;
. completely new concepts of transport, like containerships, barge carriers, etc. are introduced;
. some general cargo commodities increase so much in volume that they are shipped in special carriers.

The problem with all these possibilities is that it is difficult to forecast whether and when they will occur. If one wants to incorporate these developments in a model, it is advisible not to try to put everything in one model. It is, for example, easier to make two models: one of a general cargo fleet which is gradually built down with the introduction of containerships, and another model of a container fleet which is built up in correspondence with the decrease in conventional general cargo ships.

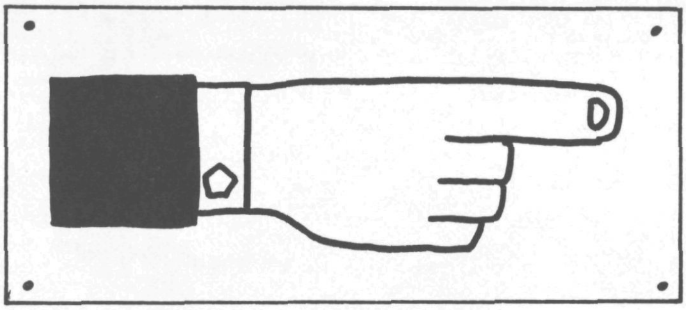
As the introduction of container transport is not very likely to happen in the future of many developing countries, such a double model has not been made.

Application of the simulation models outside liner shipping.

The general structure of the simulation models can be used for the evaluation of any longterm shipping project, whether it concerns dry-bulk, liquid-bulk or roll-on roll-off, as long as the ships provide regular services between fixed points. If the latter is not the case, for instance in tramp shipping, assumptions have to be made in respect of the 'average roundtrip time', the 'average freight rate', the 'average load factor', etc., as these parameters may vary widely from one trip to another.

Yet another approach might be to use the model 'the other way around'. This means that a number of assumptions regarding the purchase price of the ships, operating cost, voyage expenditures, etc. and the minimal required internal rate of return are put into the model. By iteration the corresponding minimum annual freight revenue requirements are calculated. If this figure is compared with the rates on the freight market and the productivity of the ship, one can arive at the conclusion whether or not to invest.

The application of the simulation models need not be restricted to shipping. It is very well possible to apply the models to the development plans of a national airline. Such an airline shows many similarities with a national liner shipping company.



Chapter 11- GUIDELINES FOR NATIONAL FLEET DEVELOPMENT STUDIES

The evaluation of national fleet development projects requires many different inputs. The following list is an attempt to formulate guidelines for the successful execution of such a study.

1. Study-team

- the establishment of a study-team is the first step in each study. It is very important that members of all the relevant ministries participate. Besides, if local or foreign experts join the team, their position must be clearly defined.

2. Definition of the role of the government in shipping

- a prerequisite for each investment evaluation study is the definition of the objectives against which the costs and benefits of the project must be measured. The team should thus explicitely define the national objectives of a national fleet.
- will the national shipping line be fully government-owned or will it become a mixed (with private local or foreign interests) company? A very important issue in this respect is: who carries the risk.
- survey the government instruments for assistence to shipping: subsidies, loan guaranties, cargo reservation, etc. Is the legal maritime regime appropriate to use these instruments?
- before making plans it should be clear to what extent local capital can be borrowed for the purchase of ships; likewise, the foreign exchange expenditures from the purchase and operation of the ships should be discussed with the Central Bank.

3. Trade route analysis

- review existing shipping services
- make analysis of national, transfer and cross-trade seaborne cargo as these determine the future size of the fleet
- make projections of trade flows
- select trades which have sufficient volume of cargo
- review marketing structure of national exports and imports (in relation to the implementation of a cargo reservation policy)
- study the development of freight rates
- study conference requirements
- study the adequacy of the national port and the inland transportation infrastructure, in relation to the projected trade volumes.

4. Ships

- survey the ship types and sizes which suit the selected trades
- determine the productivity of each ship and calculate the approximate required number of ships
- survey the price of ships, new buildings and second-hand ones
- survey the availability of ship financing from abroad and the loan terms
- survey the charter market
- survey technological development in ships and cargo handling techniques, and their implications for the future trade flows and replacement of ships.

5. Selection of trade routes, ships and financing mix

- in short, the definition of the system boundary of the fleet development study. This should be done in discussion with the heads of the relevant ministries.

6. Fleet development model

- make conceptual models and consequently formal models; make computer runs
- evaluate results and make, if necessary changes in models
- make a report and discuss the model results with the heads of the ministries
- make organizational structure of the shipping company

7. Establishment national shipping line
   - send final report to the cabinet and wait for a decision
   - if decision is positive, send official request to the financing agencies
   - if loan applications are approved, establish the national shipping line and start operation

8. Post evaluation
   - evaluate performance of the line with the help of the realized results and theoretical values as calculated by the model.

Chapter 12 - CONCLUSIONS

Liner shipping can be looked upon as a system. Through selection, abstraction and aggregation, the variables which constitute the system are formulated explicitely, as are the relations between them. The result of this process is a number of causal-loop diagrams, which together form the conceptual model of the liner shipping system.

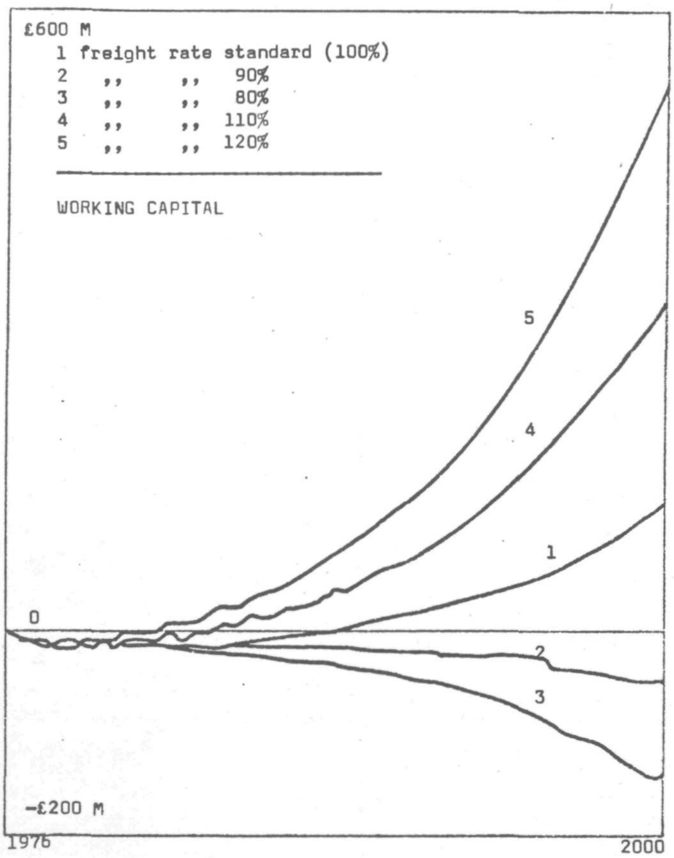
For economic evaluation purposes it is important to know the impact of a change in the system descriptors on the national objectives of the developing country. As these impacts can only be measured indirectly, a number of indicators is developed: discounted costs and benefits, foreign exchange balance, shadow priced discounted costs and benefits, income ploughed back in country, and some minor ones.

The data used in the models comes from a country in Africa. The conclusions reached in this study are thus conditional statements, which cannot always be generalized. Nevertheless, a number of parameters will have a large impact on the decision criteria in any fleet evaluation study. These are: freight rates, load factor, voyage expenditures, roundtrip time, operating cost, purchase price ship, number of ships, incidence of transport cost.

The structure of the models is flexible and allows application to any national fleet development project in any developing country. In order to avoid a lot of frustration and wasted time, the maritime planner should follow the guidelines for evaluation as formulated in the previous chapter.

APPENDIX A - PARAMETER CHANGES AND MODEL BEHAVIOUR

A. Working capital (model 14)



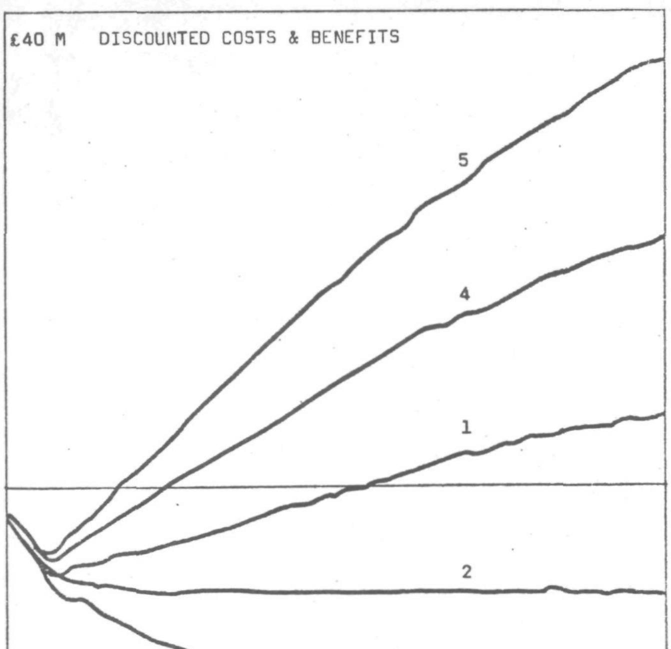
B. number of ships (model 14)

scenario: 1	number of ship in the year 2000:	16
2	,,	4
3	,,	4
4	,,	16
5	,,	16

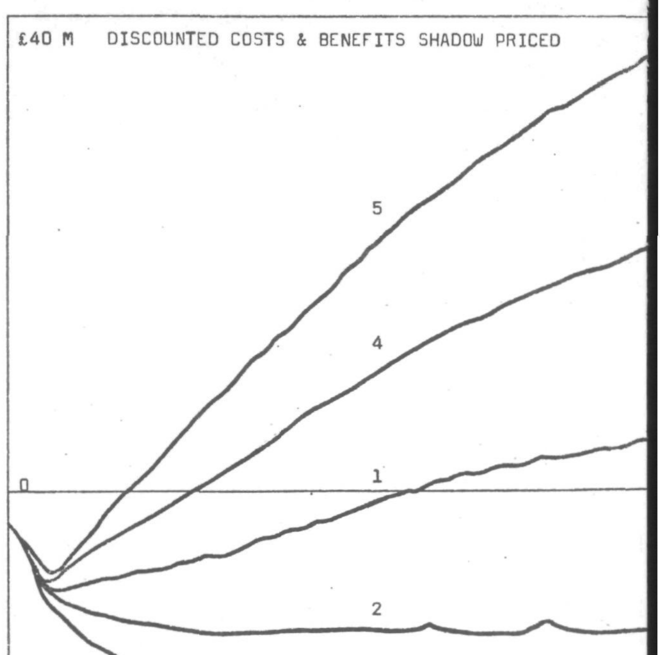
C.D.E.F.

DCB, DCBS, FEBT, IPBC (model 9)

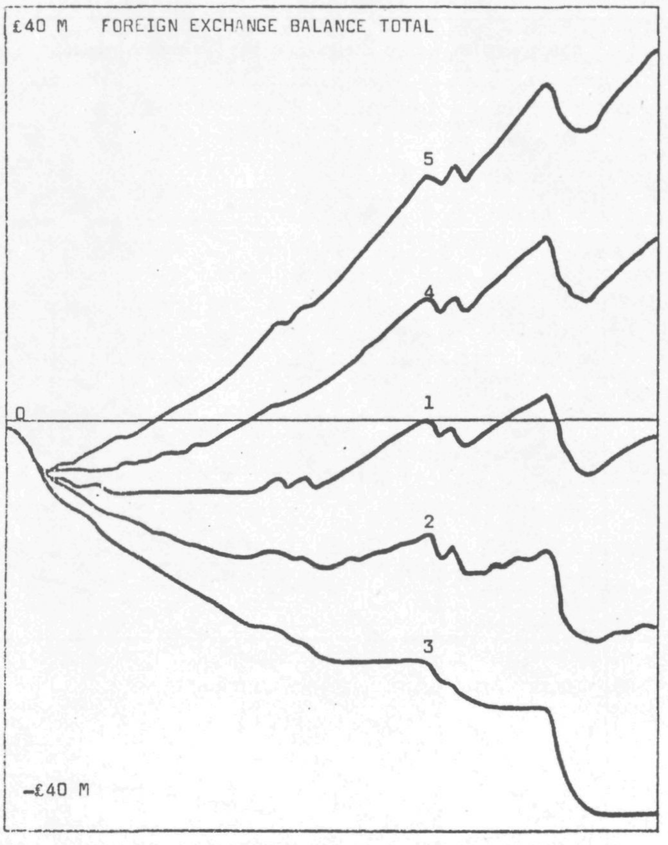
C.



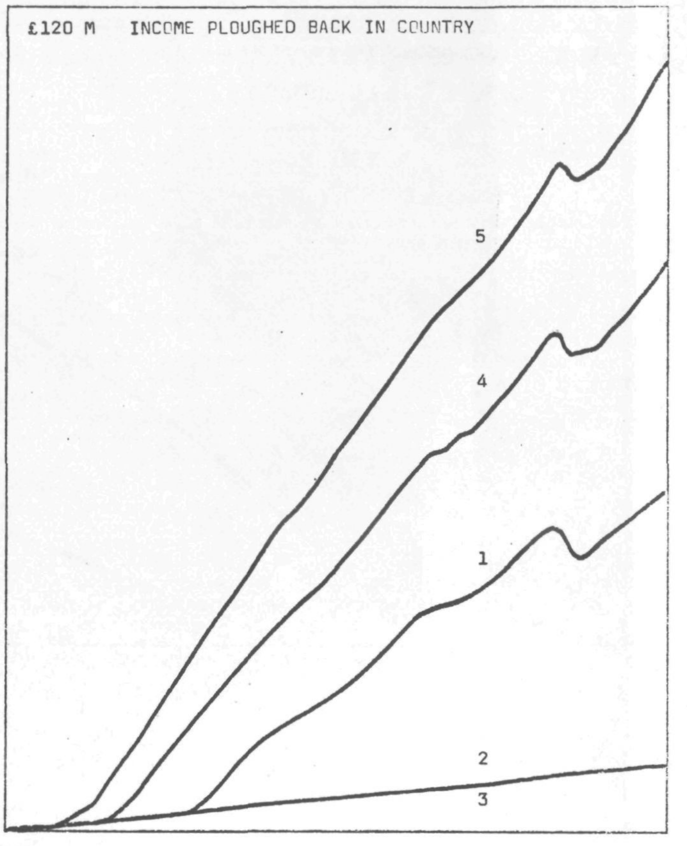
D.



E.

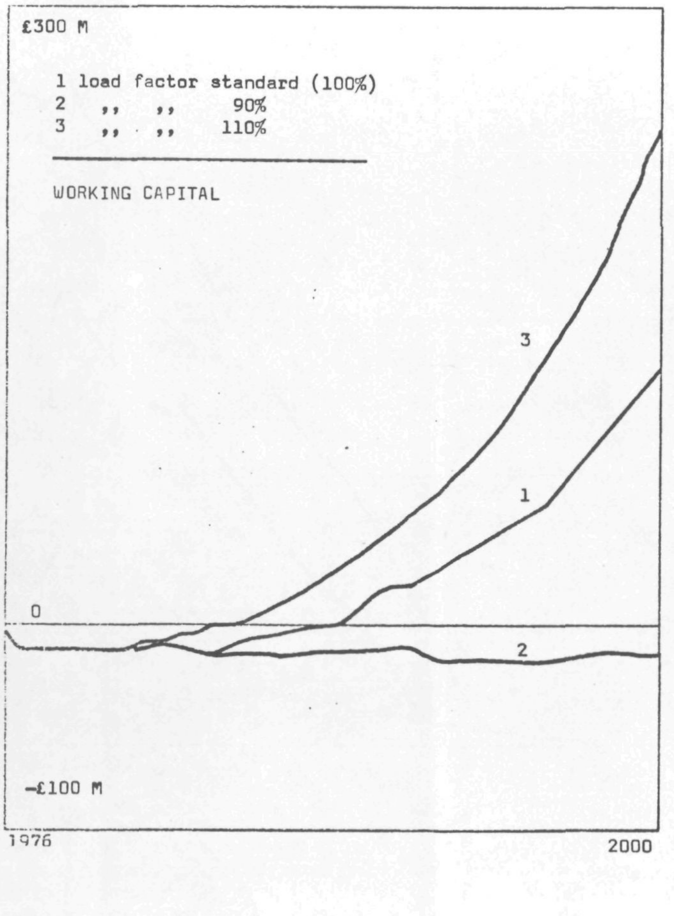


F.



II. LOAD FACTOR

A. Working capital (model 14)

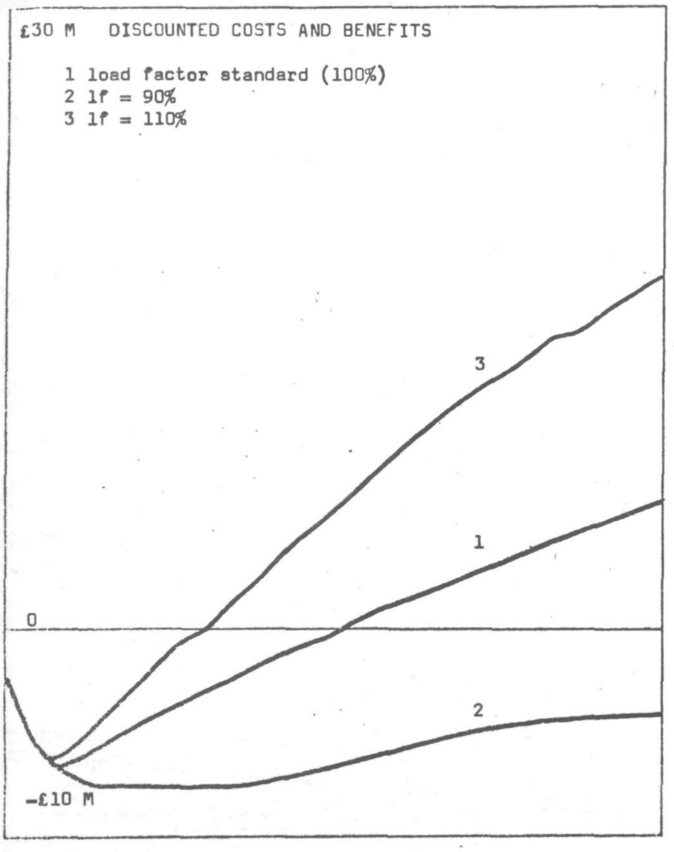


B. Number of ships (model 14)

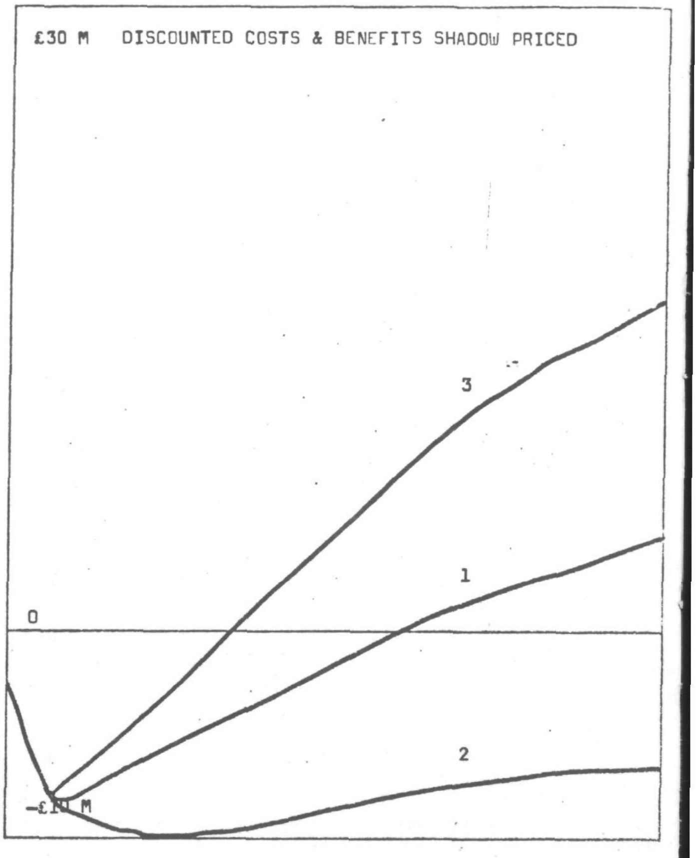
scenario: 1	number of ships in year 2000:	16
2		6
3		14

C.D.E.F. DCB, DCBS, FEBT, IPBC (model 9)

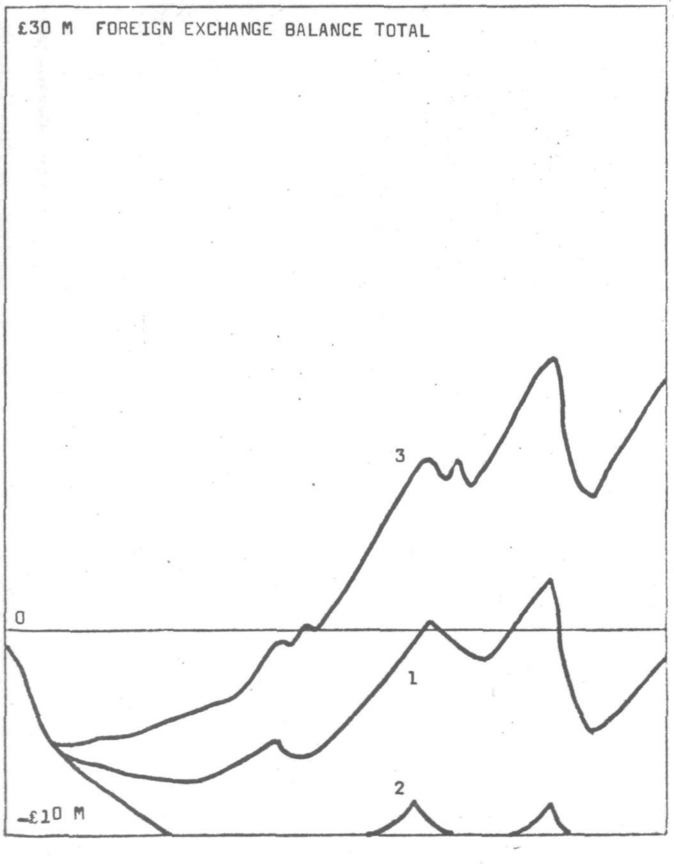
C.


£30 M DISCOUNTED COSTS AND BENEFITS
1 load factor standard (100%)
2 lf = 90%
3 lf = 110%
3
1
0
2
-£10 M

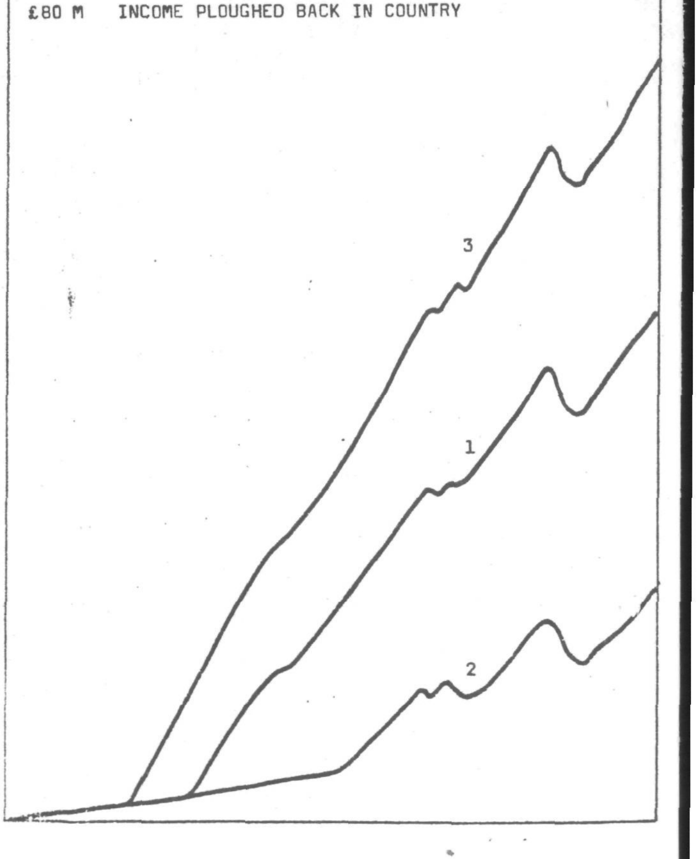
D.


£30 M DISCOUNTED COSTS & BENEFITS SHADOW PRICED
3
1
0
2

E.


£30 M FOREIGN EXCHANGE BALANCE TOTAL
3
0
1
2
-£10 M

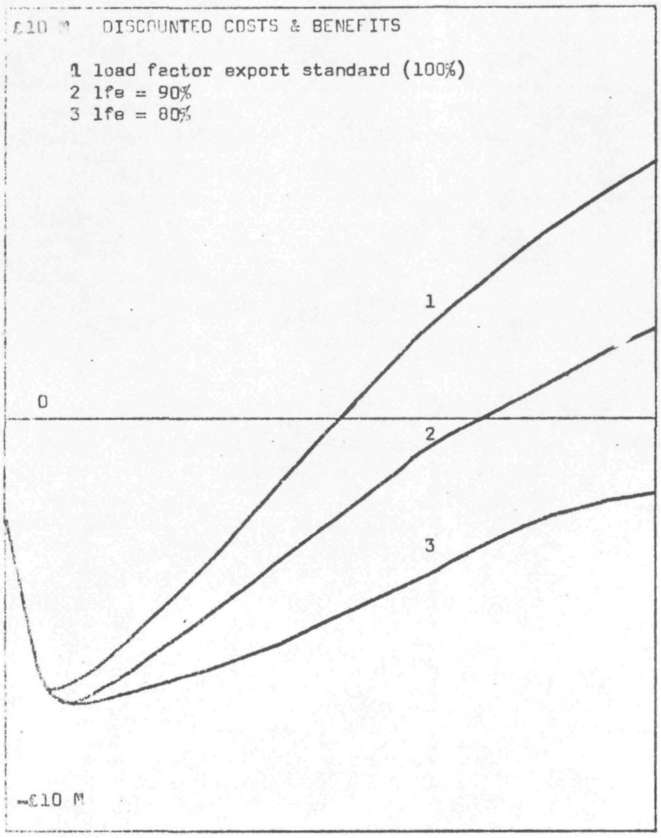
F.


£80 M INCOME PLOUGHED BACK IN COUNTRY
3
1
2

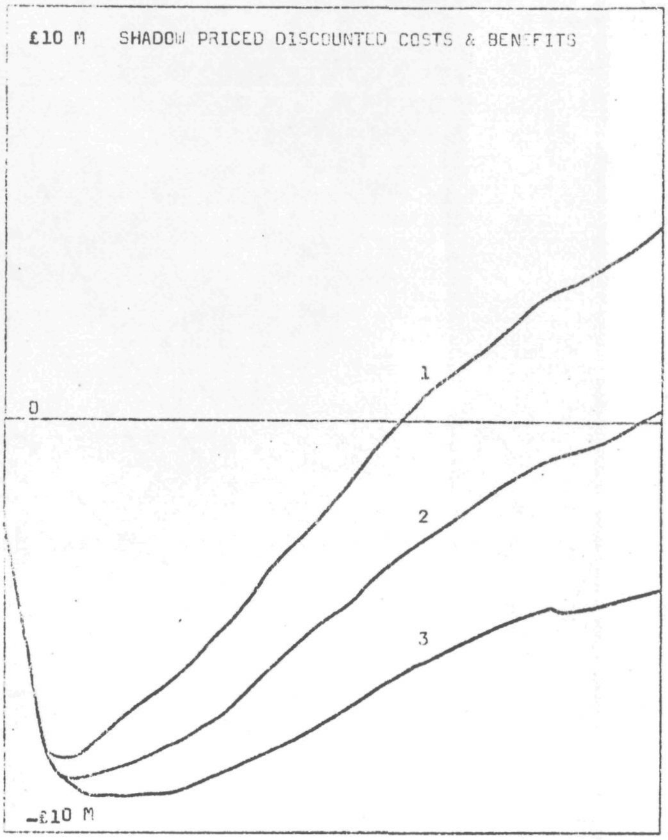
LOAD FACTOR EXPORTS (imbalance)

G.H.I.J. DCB, DCBS, FEBT, IPBC (model 9)

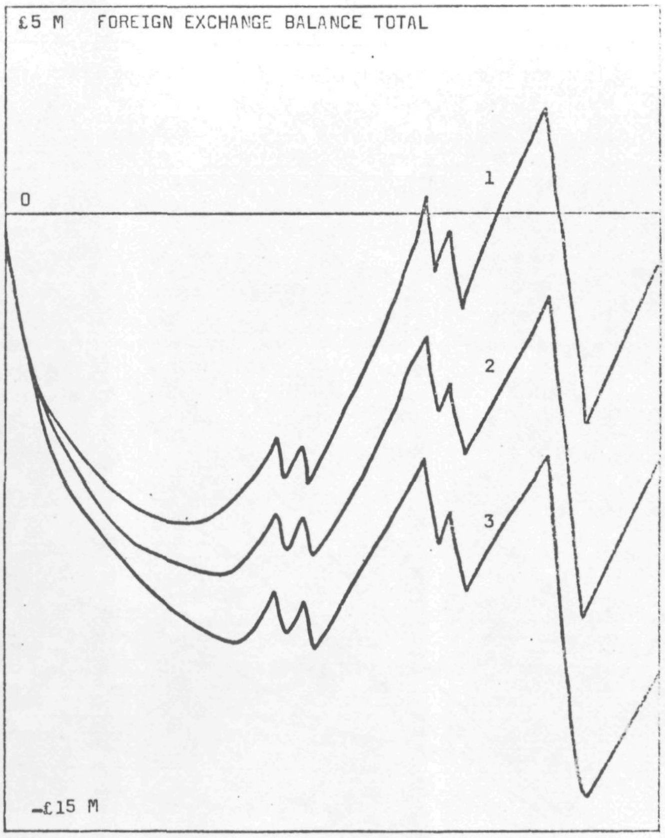
G.



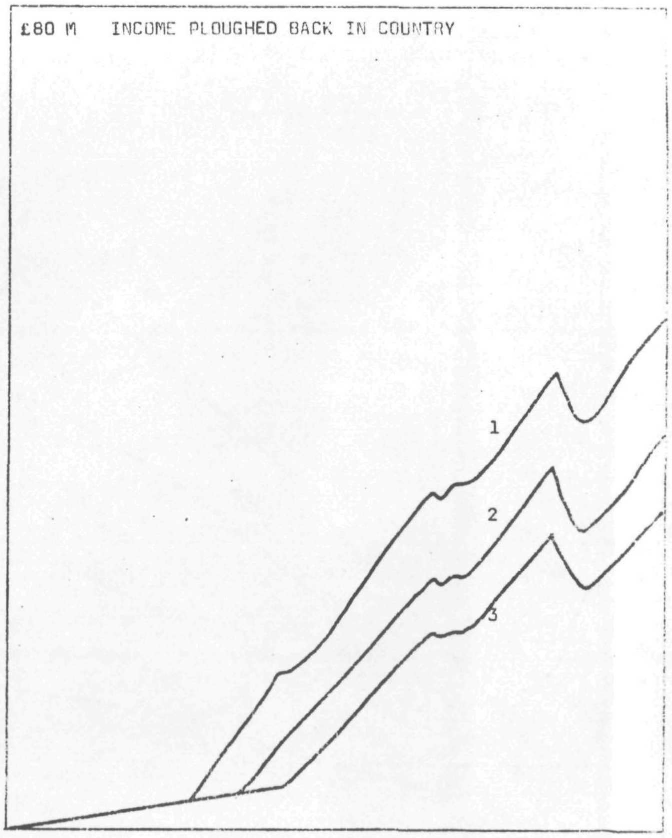
H.



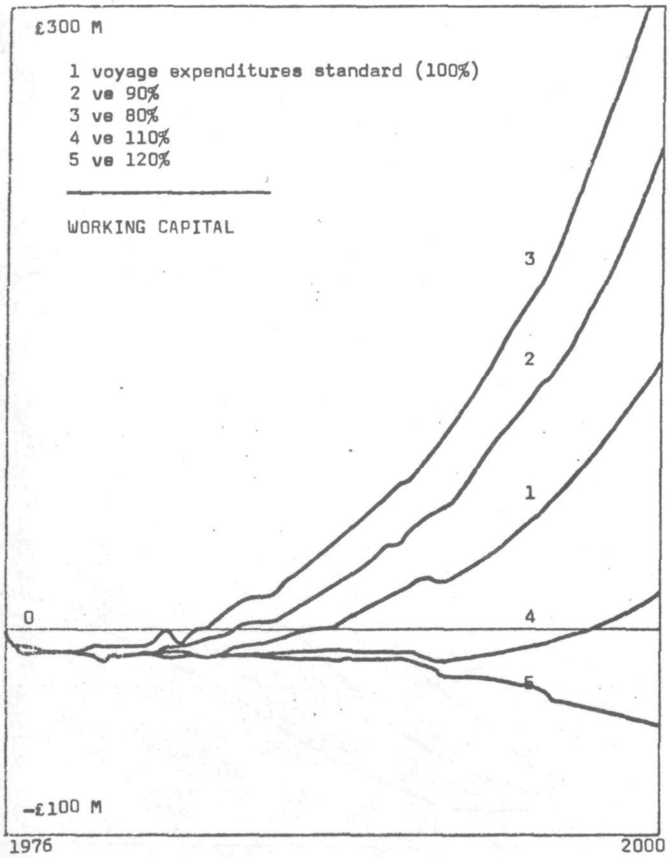
I.



J.



A. Working capital (model 14)

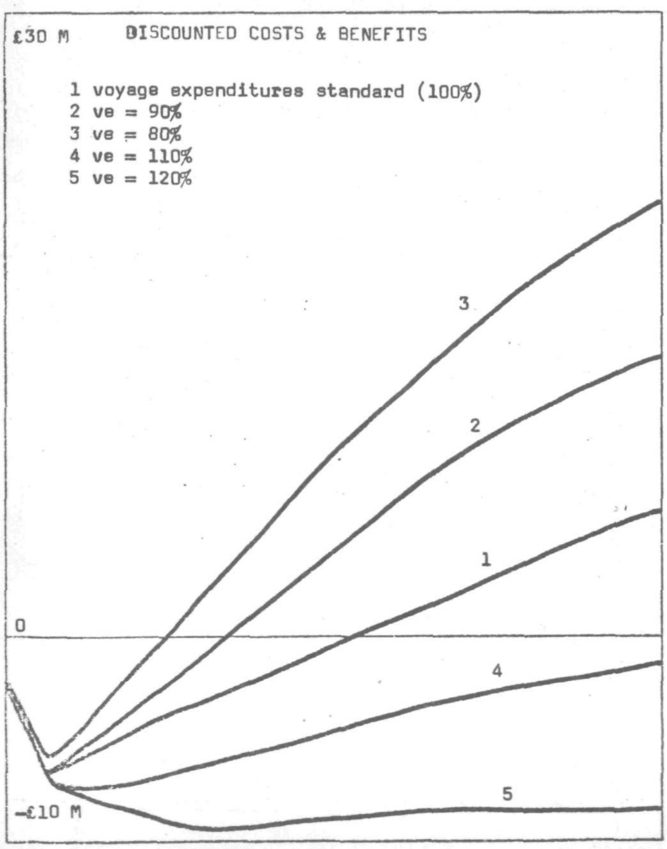


B. Number of ships (model 14)

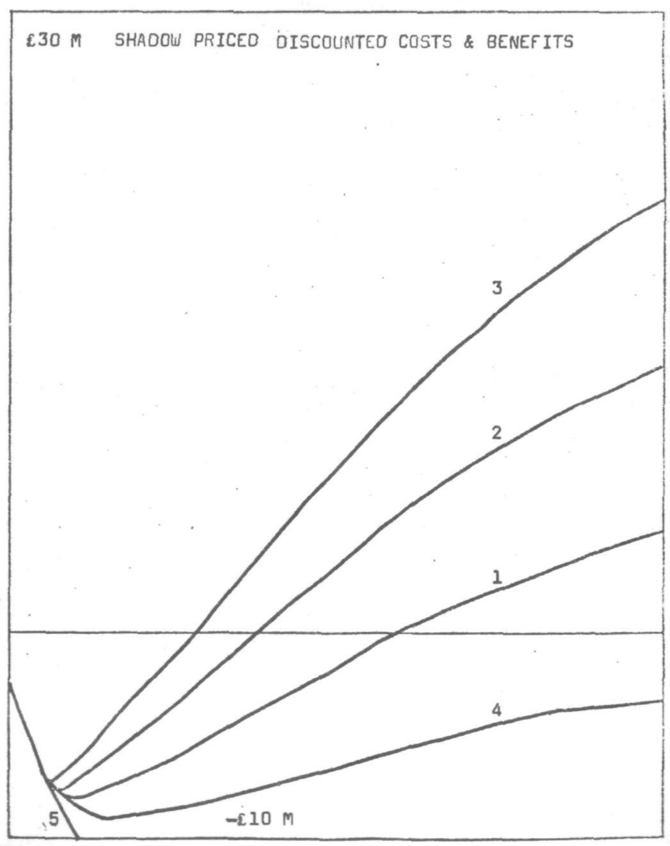
scenario: 1	number of ships in year 2000:	16
2		16
3		16
4		16
5		4

C.D.E.F. DCB, DCBS, FEBT, IPBC (model 9)

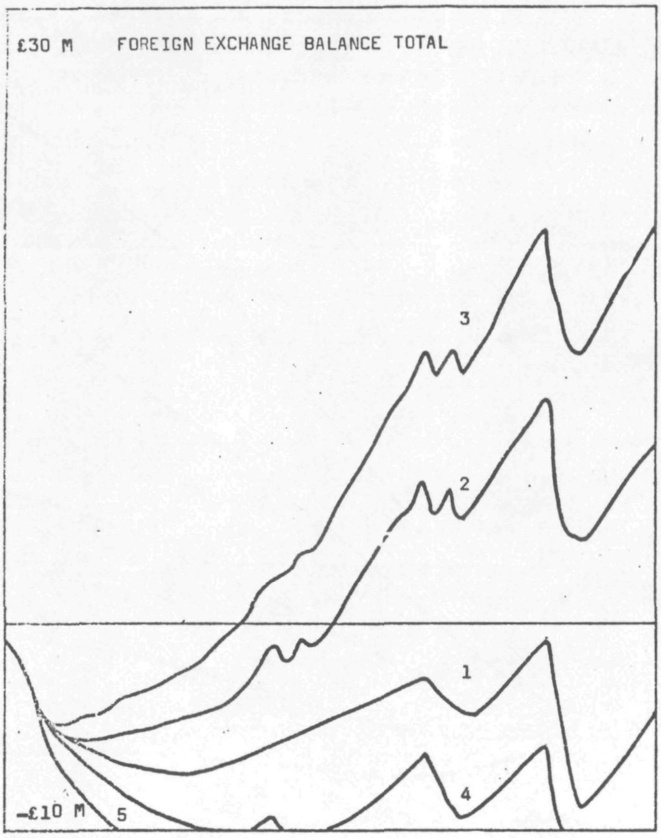
C.



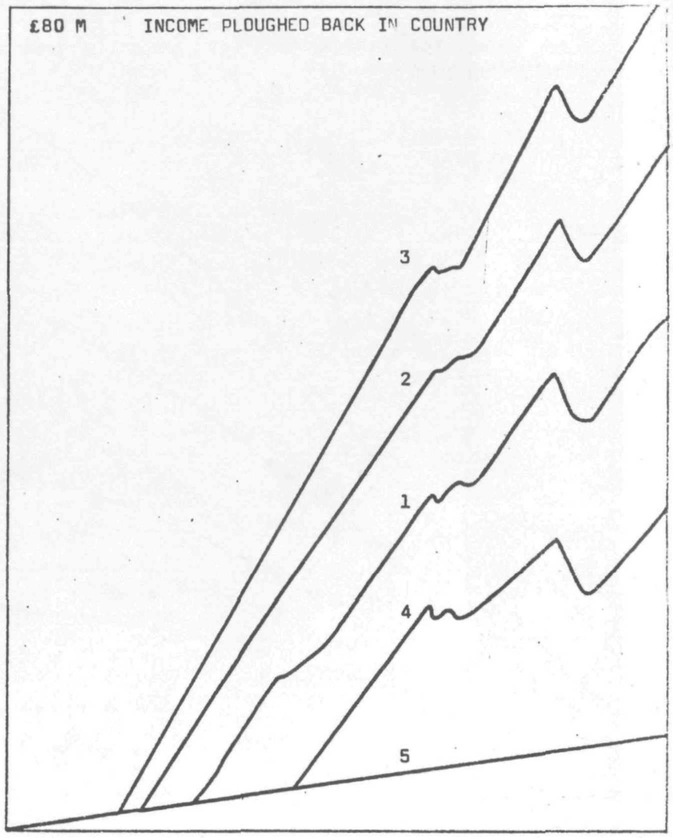
D.



E.

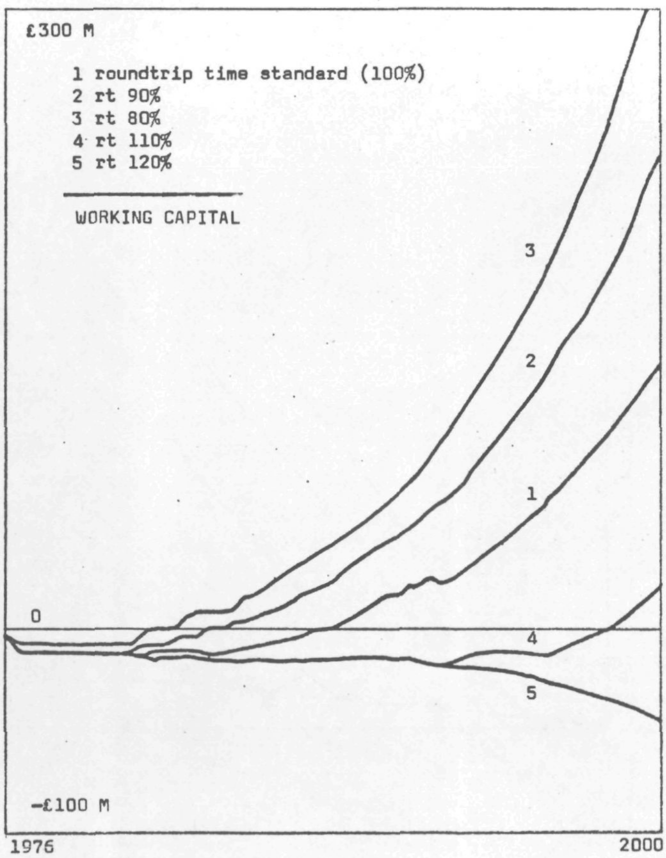


F.

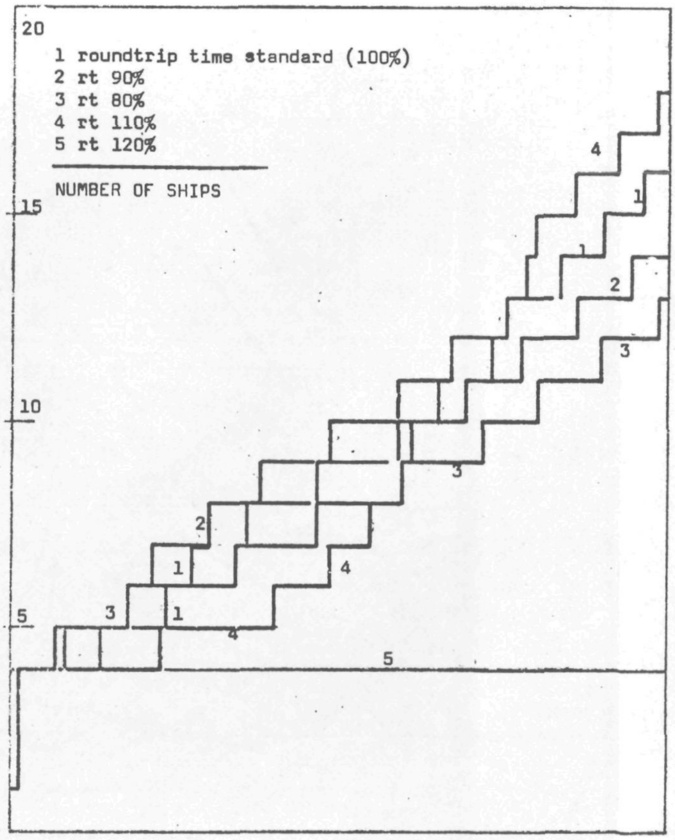


IV. ROUNDTRIP TIME

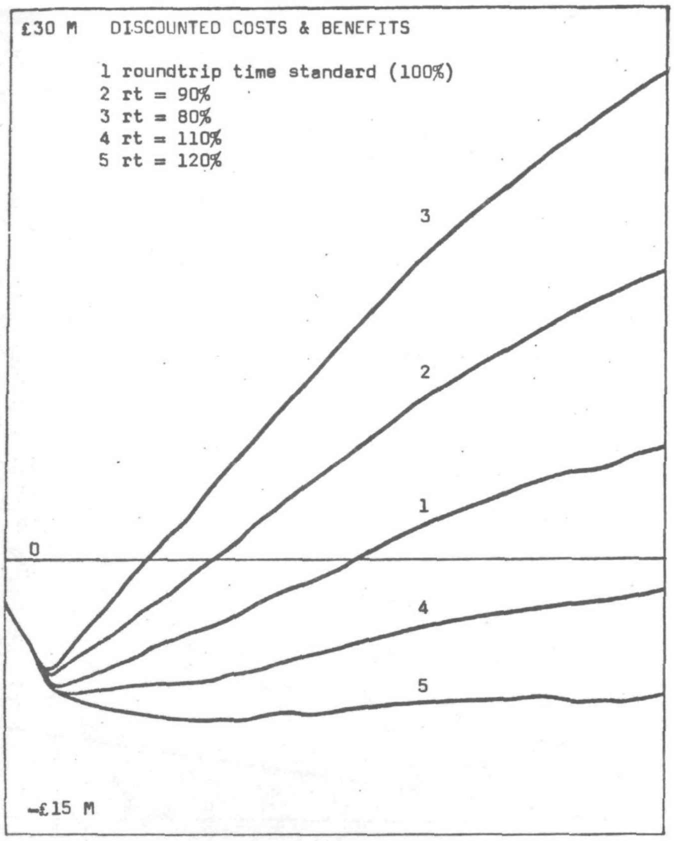
A. Working capital (model 14)



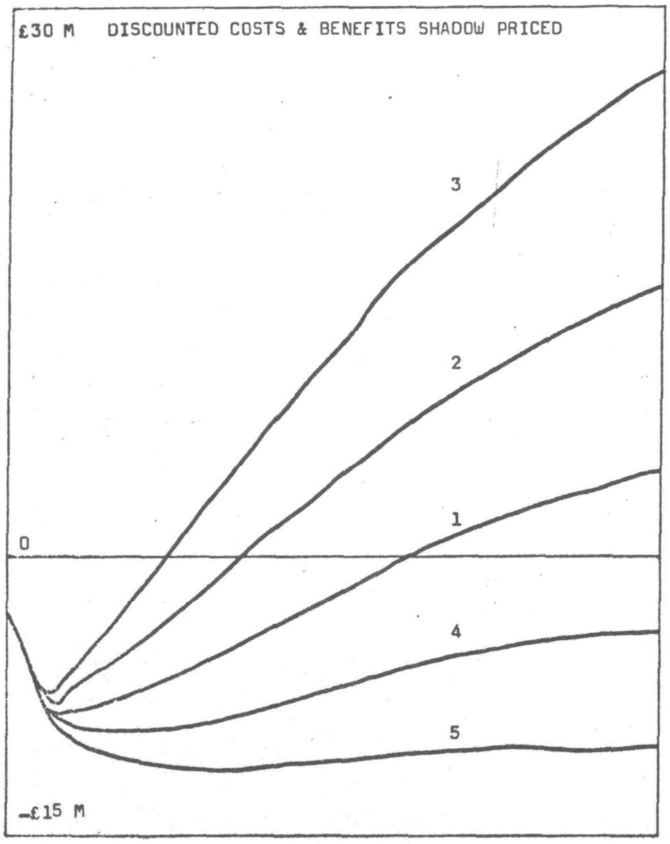
B.



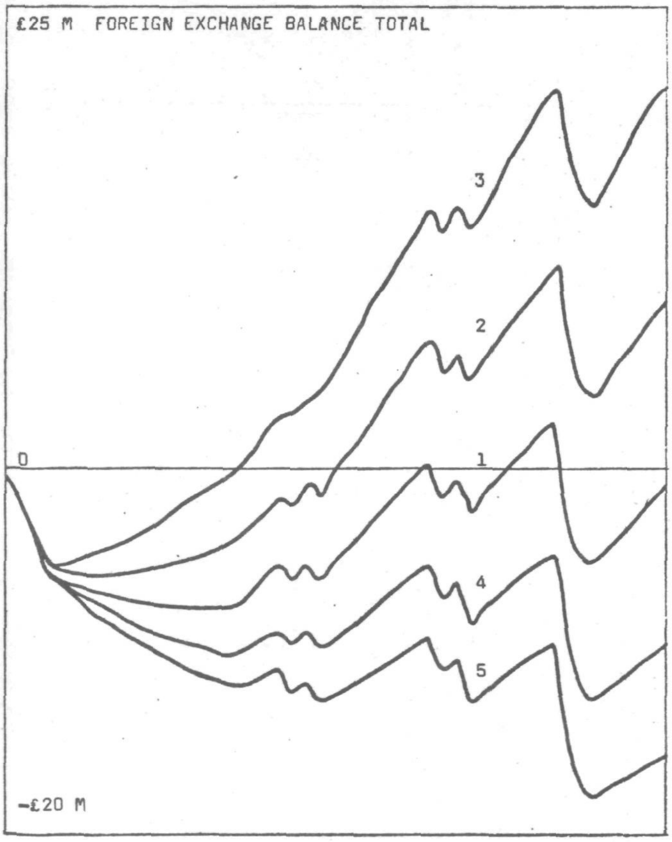
C.


£30 M DISCOUNTED COSTS & BENEFITS
1 roundtrip time standard (100%)
2 rt = 90%
3 rt = 80%
4 rt = 110%
5 rt = 120%
3
2
1
0
4
5
-£15 M

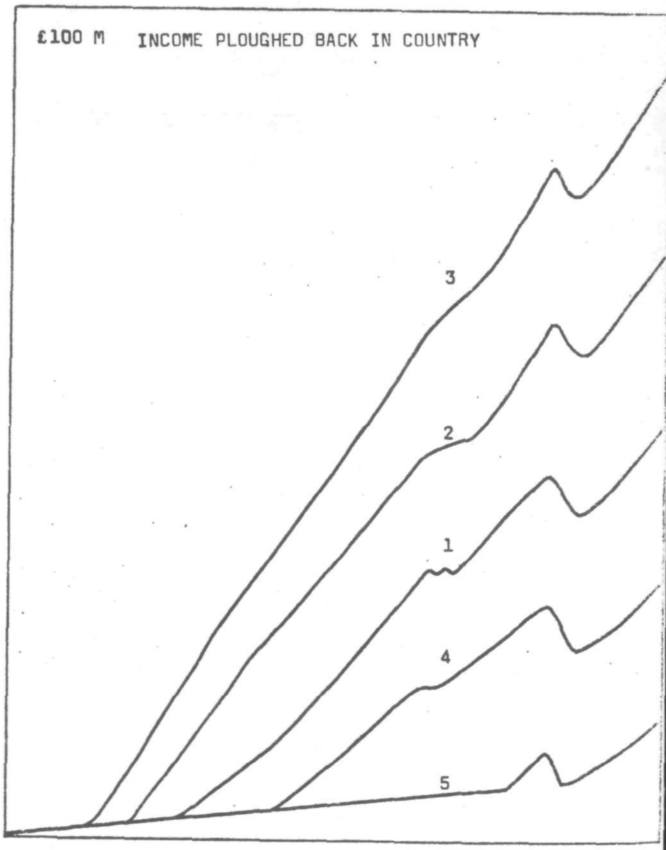
D.


£30 M DISCOUNTED COSTS & BENEFITS SHADOW PRICED
3
2
1
0
4
5
-£15 M

E.

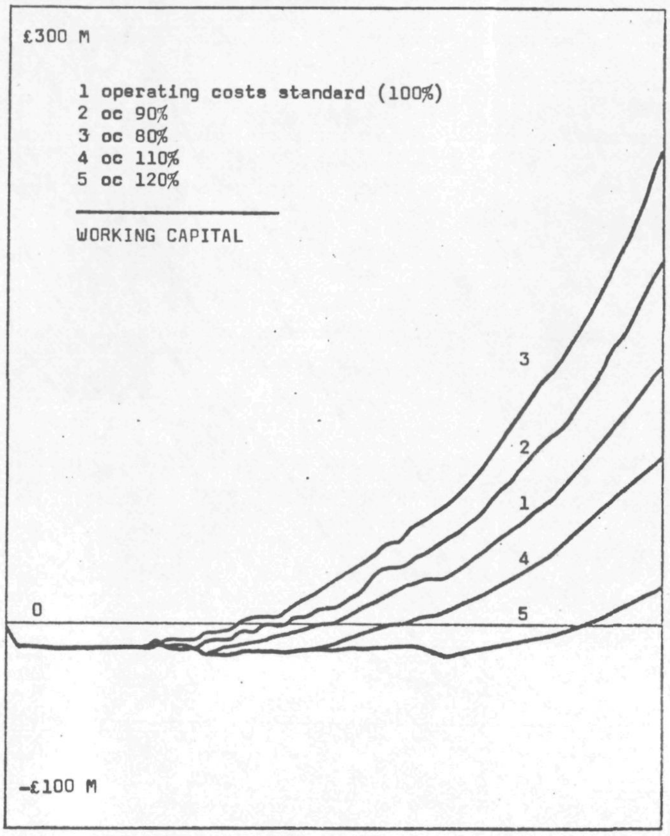

£25 M FOREIGN EXCHANGE BALANCE TOTAL
3
2
0
1
4
5
-£20 M

F.


£100 M INCOME PLOUGHED BACK IN COUNTRY
3
2
1
4
5

V. OPERATING COST

A. Working capital (model 14)

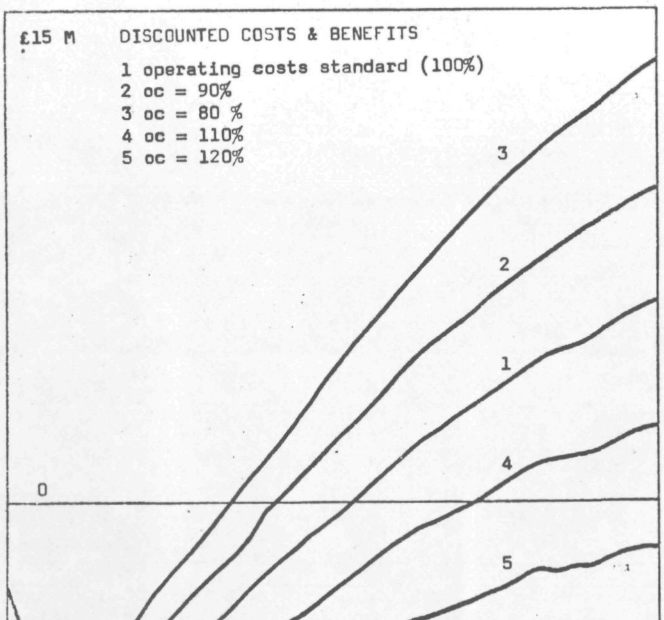


B. Number of ships (model 14)

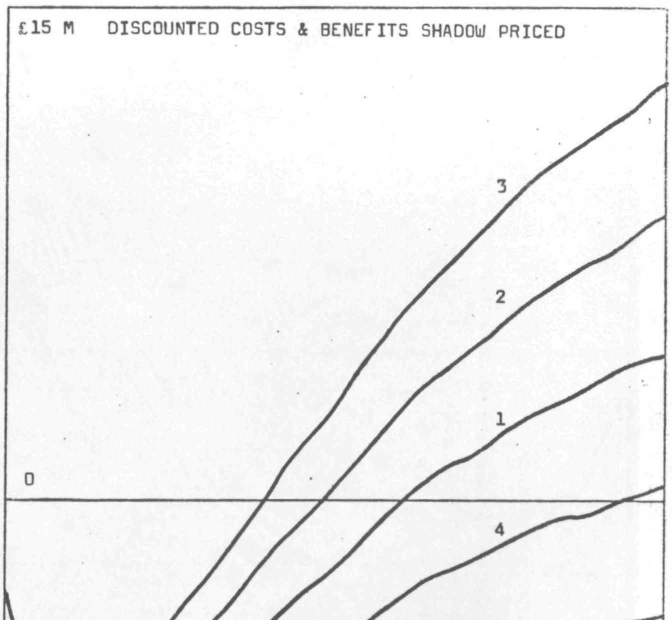
scenario: 1	number of ships in the year 2000:	16
2		16
3		16
4		16
5		16

C.D.E.F. DCB, DCBS, FEBT, IPBC (model 9)

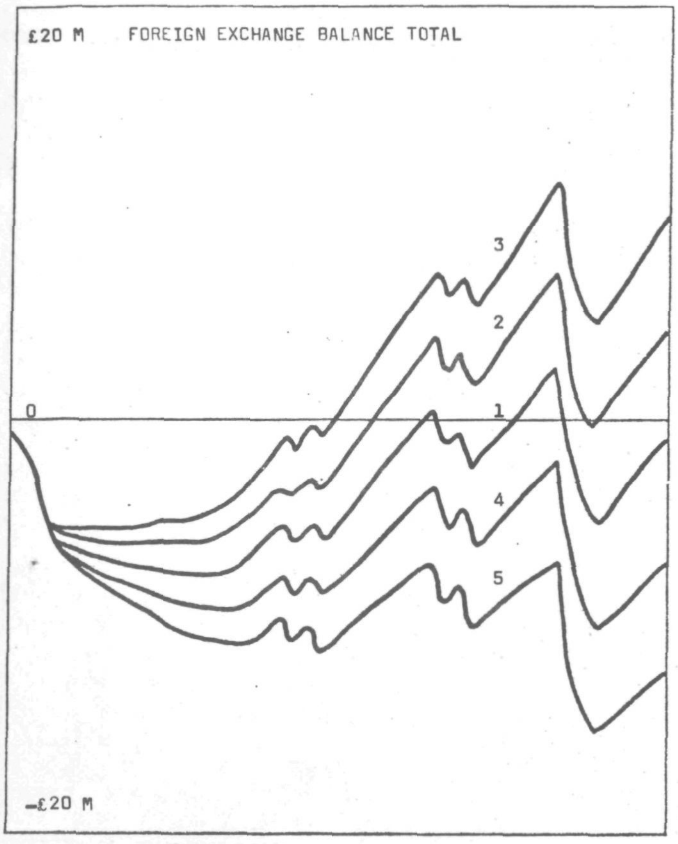
C.



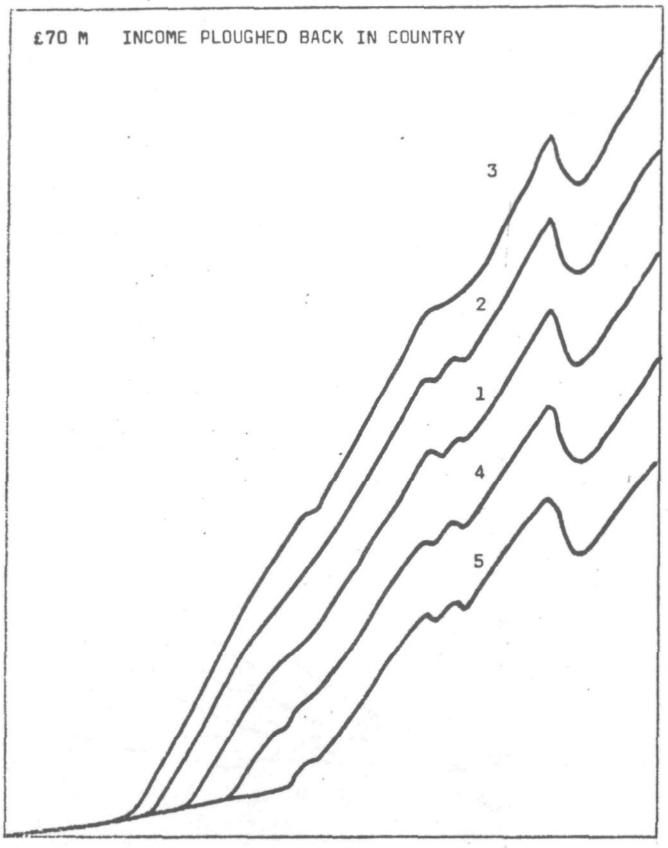
D.



E.

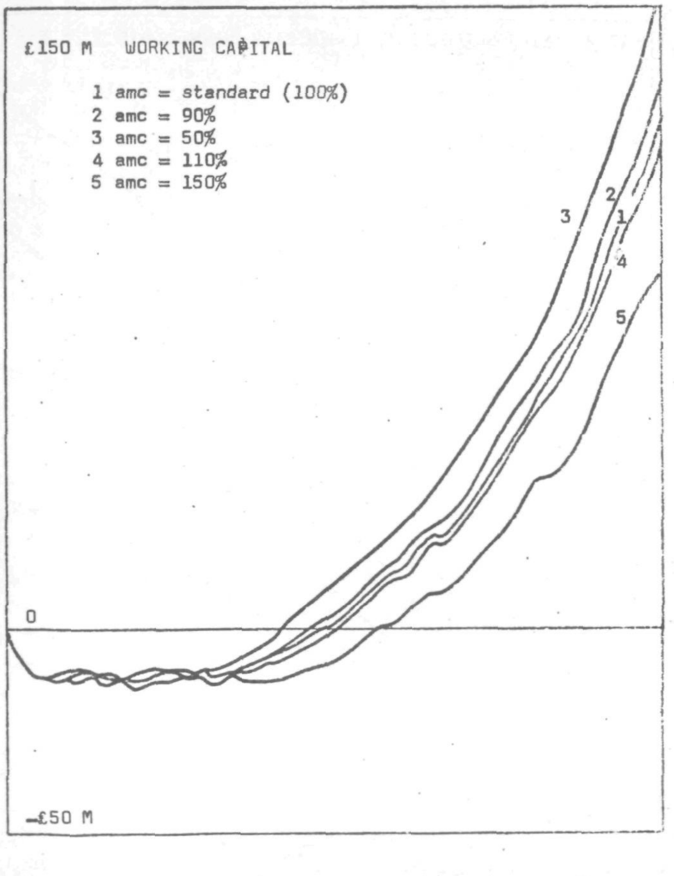


F.



VI. ADMINISTRATIVE AND MANAGEMENT COST

A. Working capital (model 14)



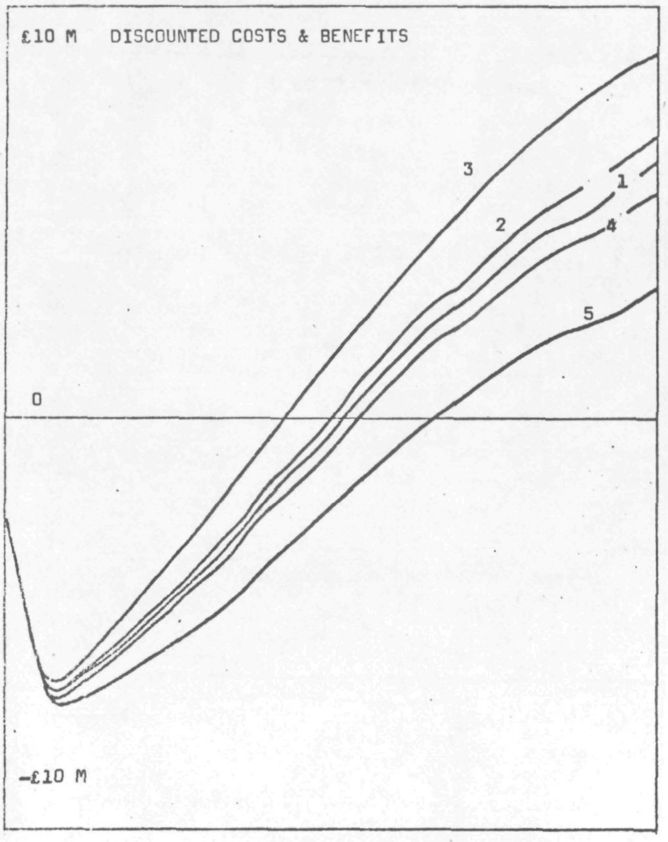
B. Number of ships (model 14)

scenario: 1	number of ships in year 2000:	16
2		16
3		16
4		16
5		16
6		16

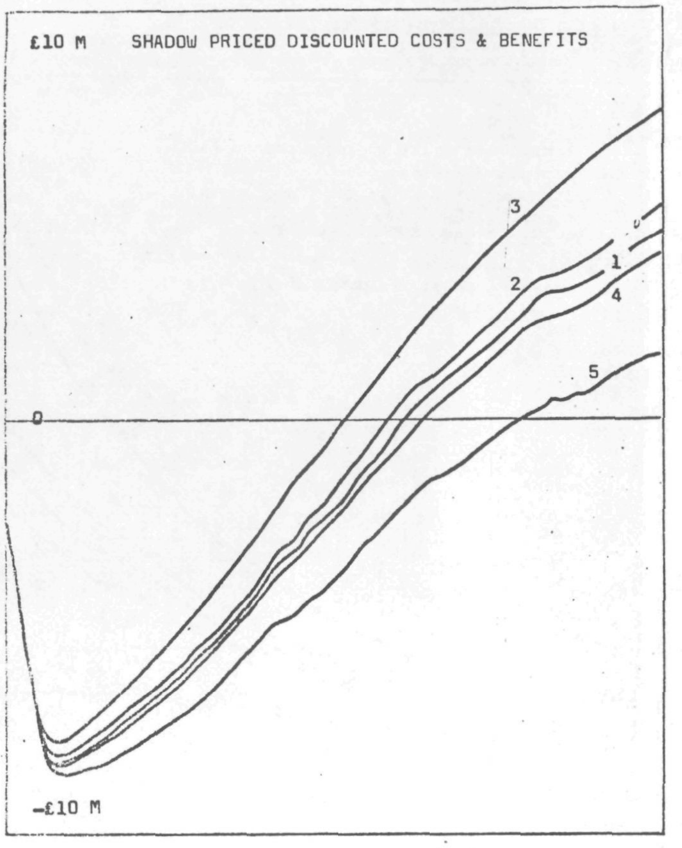
C.D.E. DCB, DCBS, IPBC (model 9)

(FEBT not affected by changes in adm.&management cost)

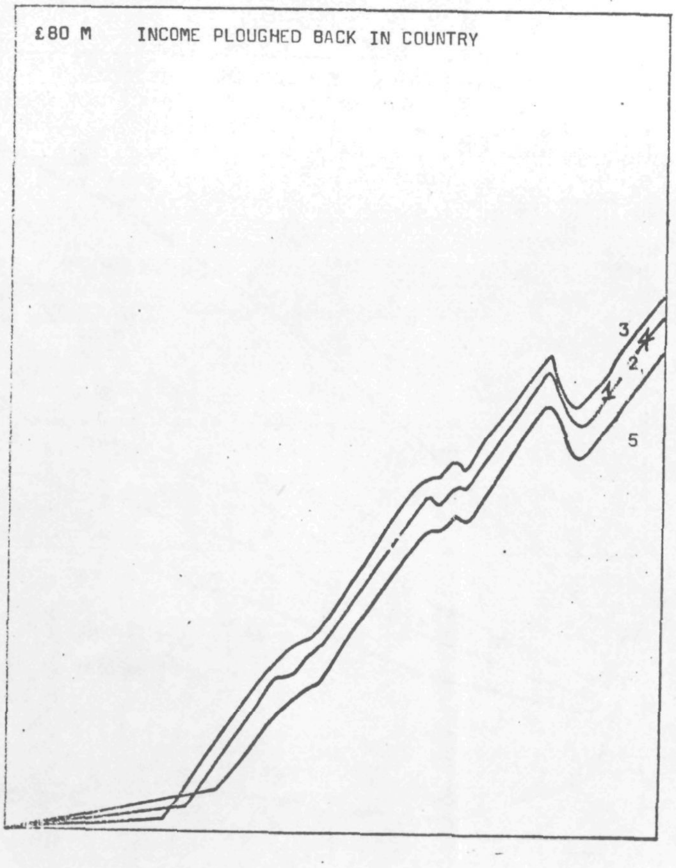
C.


£10 M DISCOUNTED COSTS & BENEFITS
3
1
2
4
5
0
-£10 M

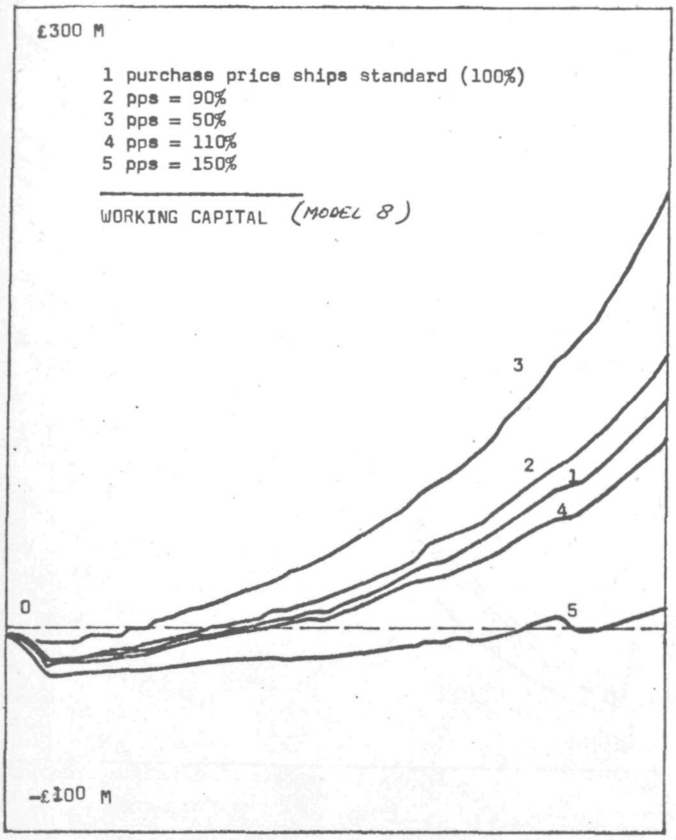
D.

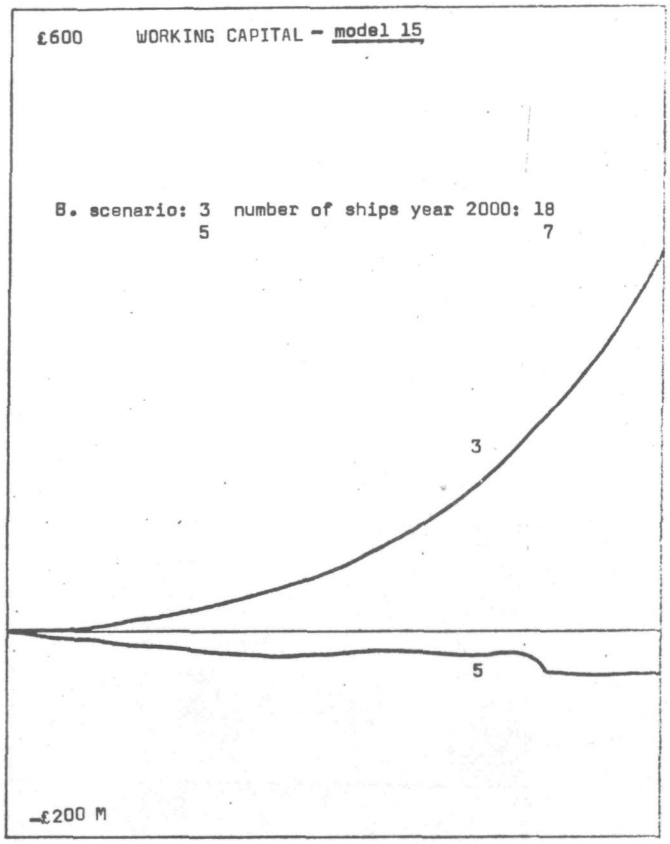

£10 M SHADOW PRICED DISCOUNTED COSTS & BENEFITS
3
1
2
4
5
0
-£10 M

E.

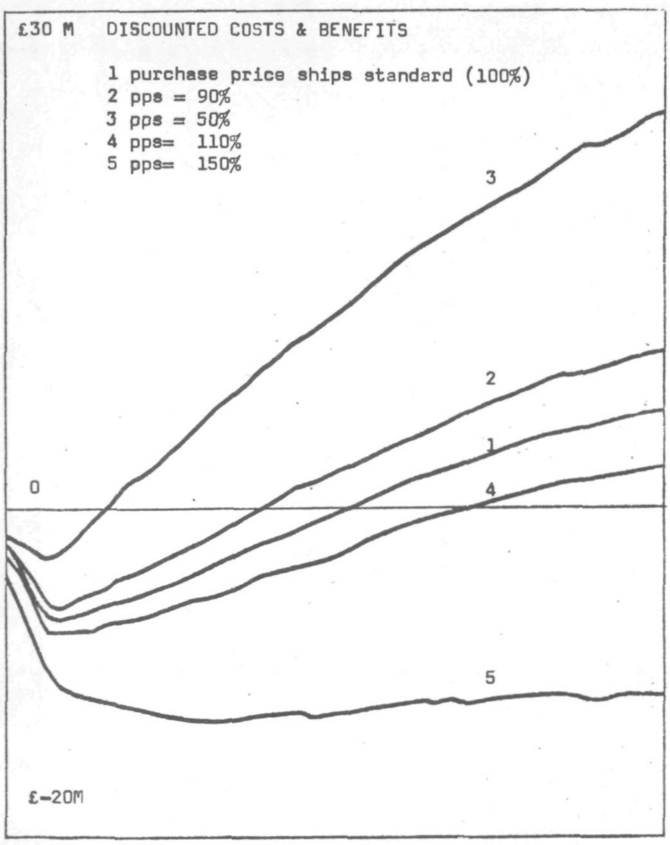

£80 M INCOME PLOUGHED BACK IN COUNTRY
3
2
5

A. Working capital (model 8 & 15)

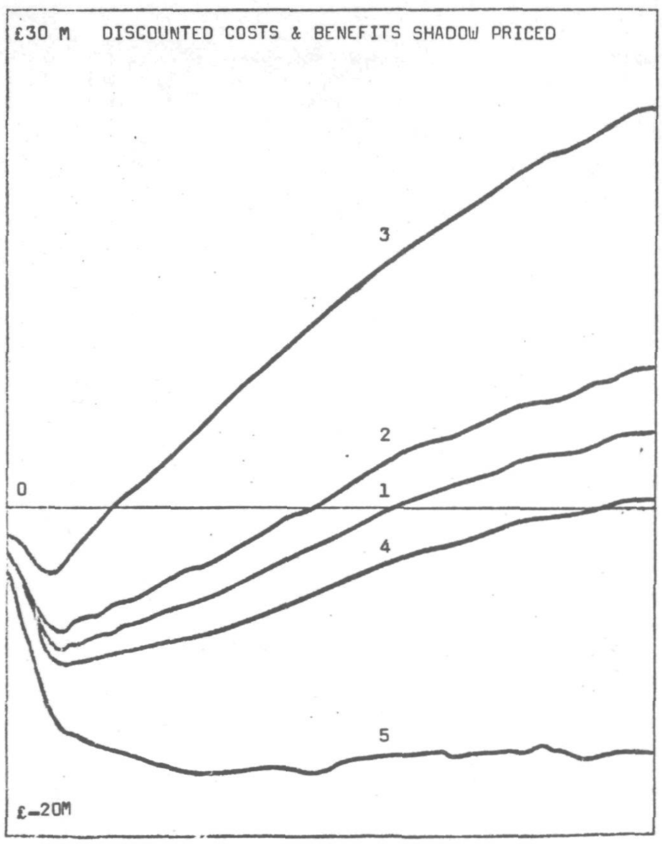




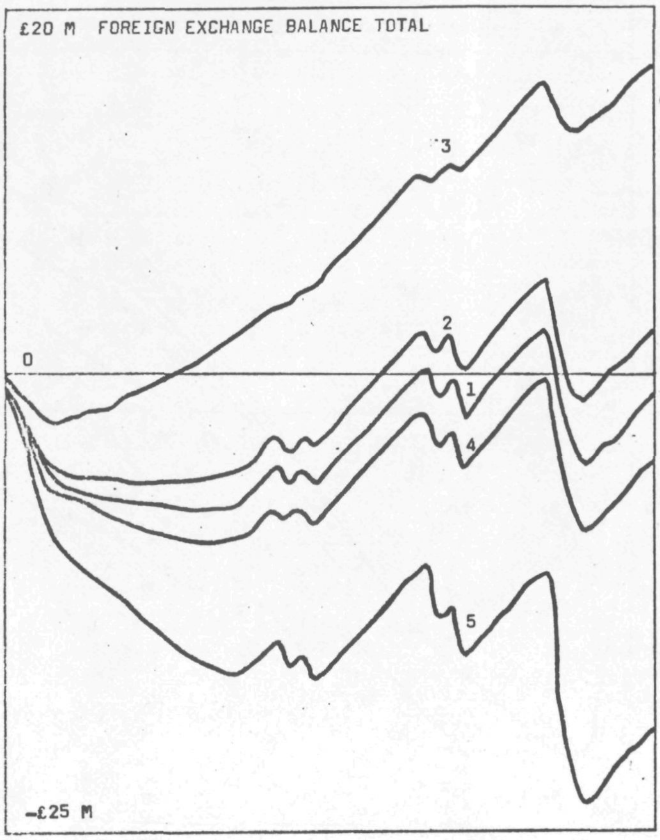
C.



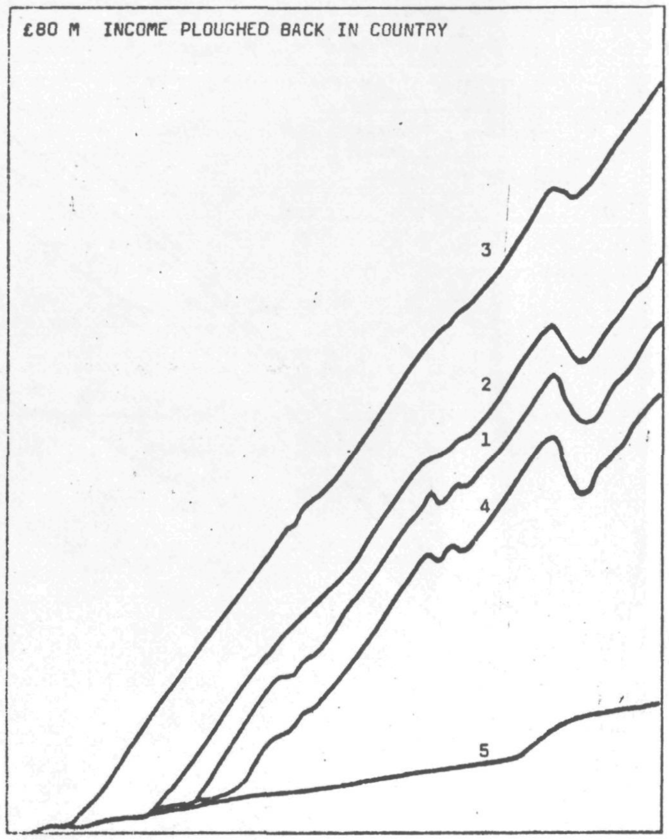
D.



E.

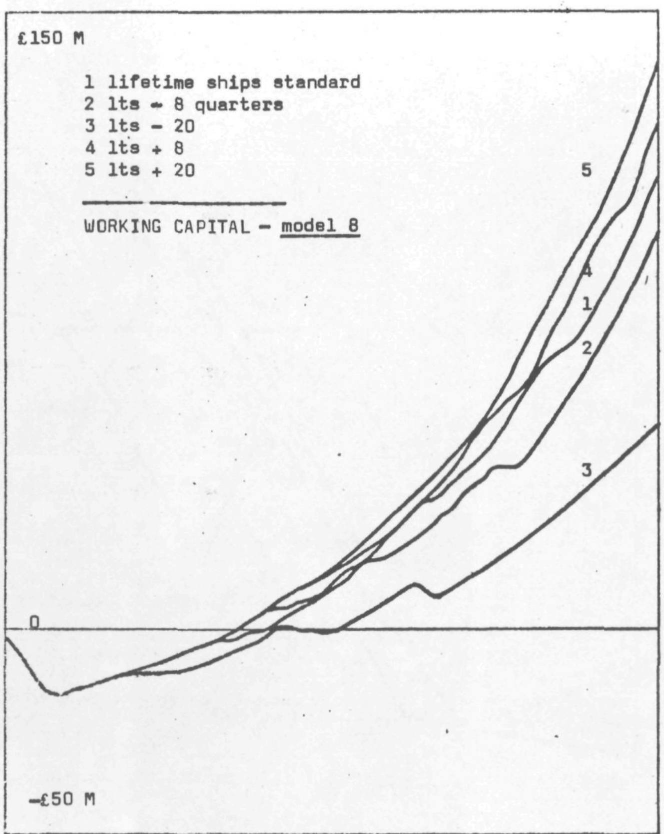


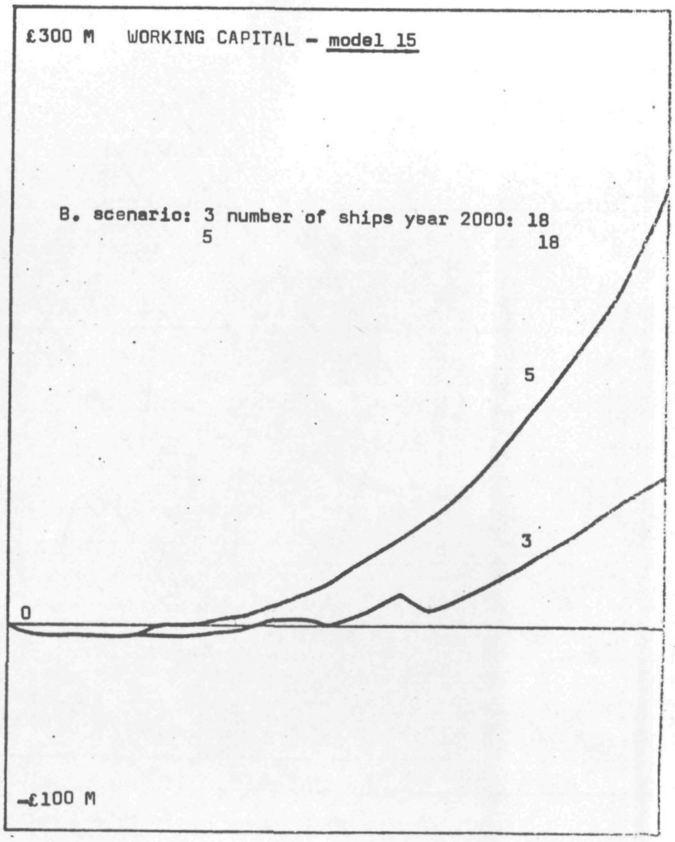
F.



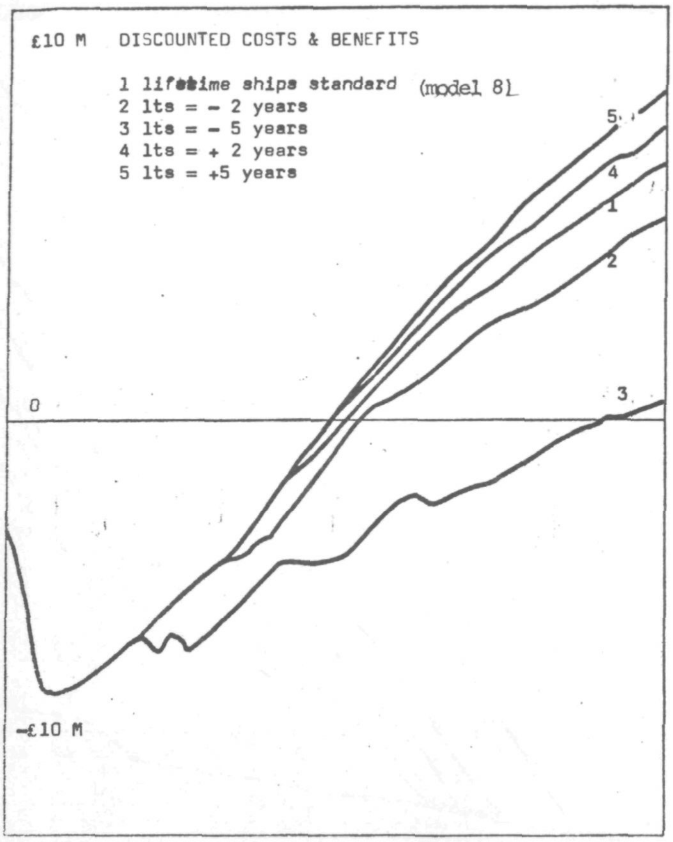
VIII. LIFETIME SHIP

A. Working capital (model 8 & 15)

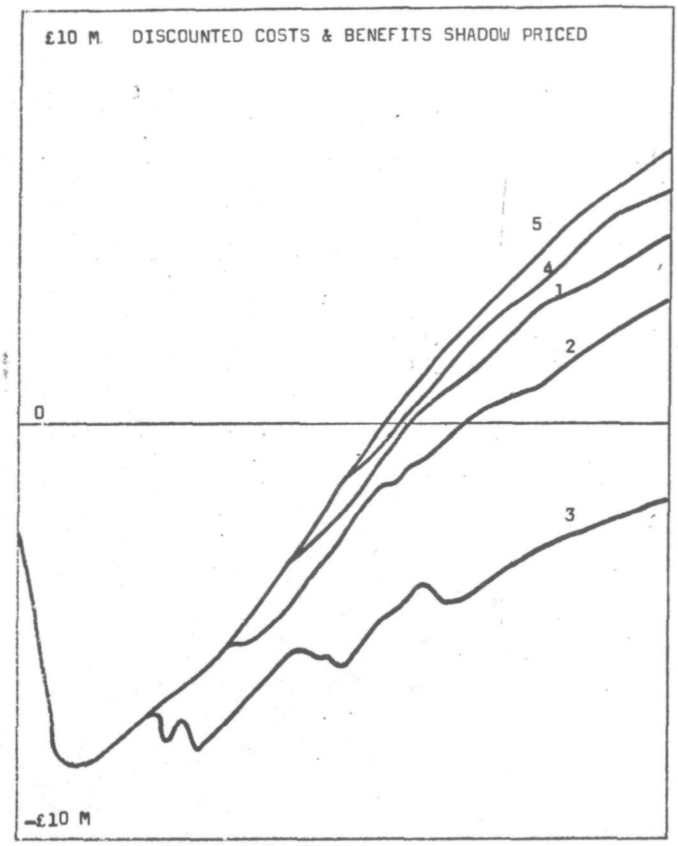




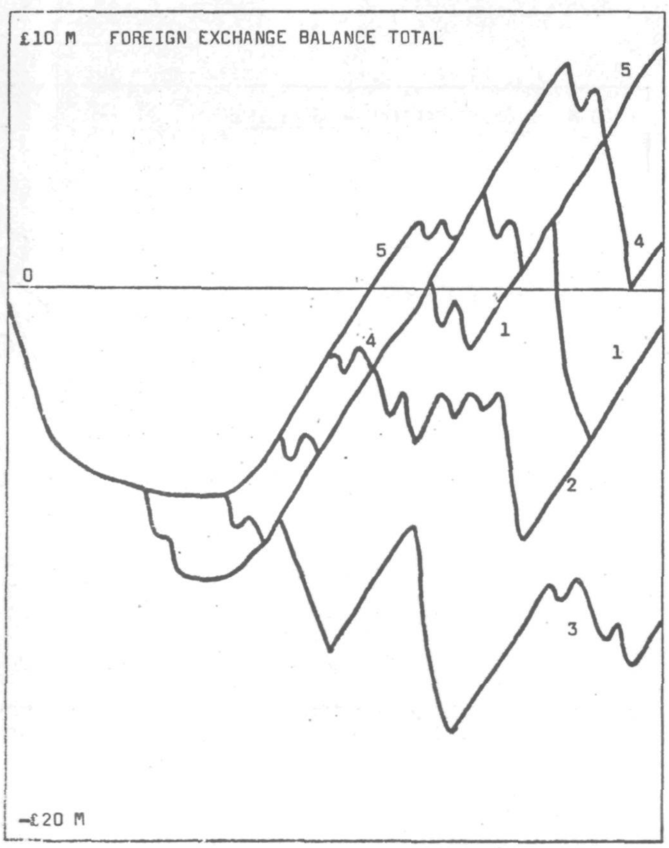
C.


£10 M DISCOUNTED COSTS & BENEFITS
1 lifetime ships standard (model 8)
2 lts = - 2 years
3 lts = - 5 years
4 lts = + 2 years
5 lts = +5 years
5
4
1
2
3
0
-£10 M

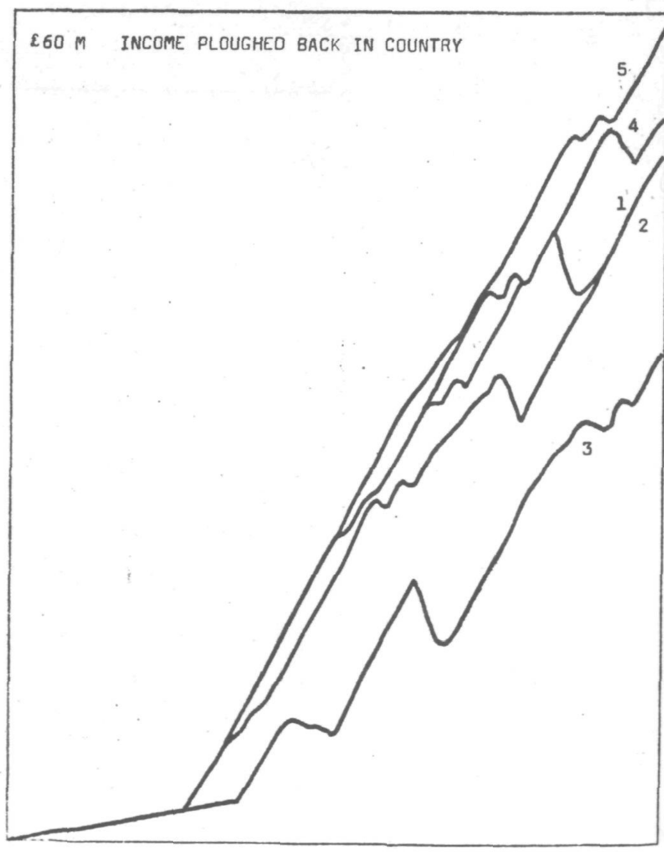
D.


£10 M DISCOUNTED COSTS & BENEFITS SHADOW PRICED
5
4
1
2
0
3
-£10 M

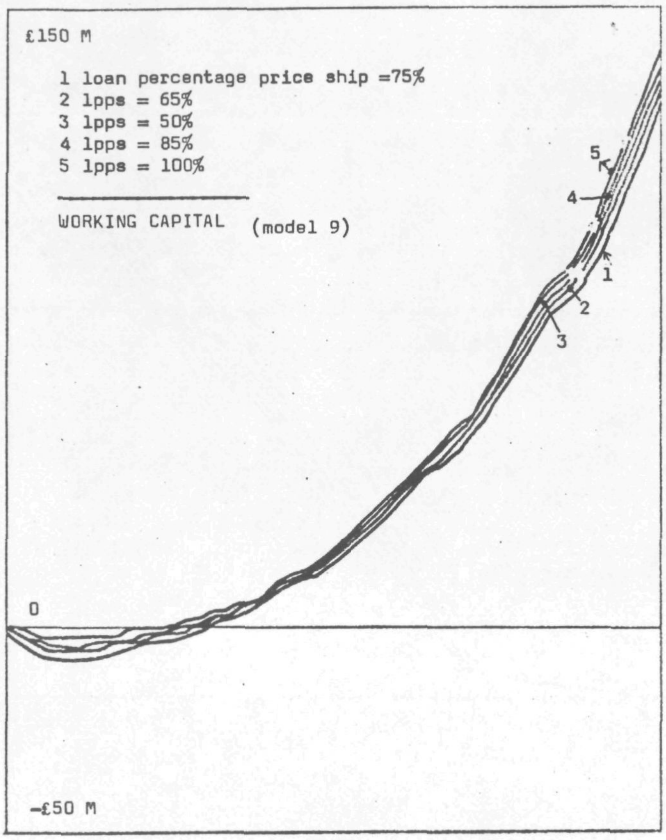
E.

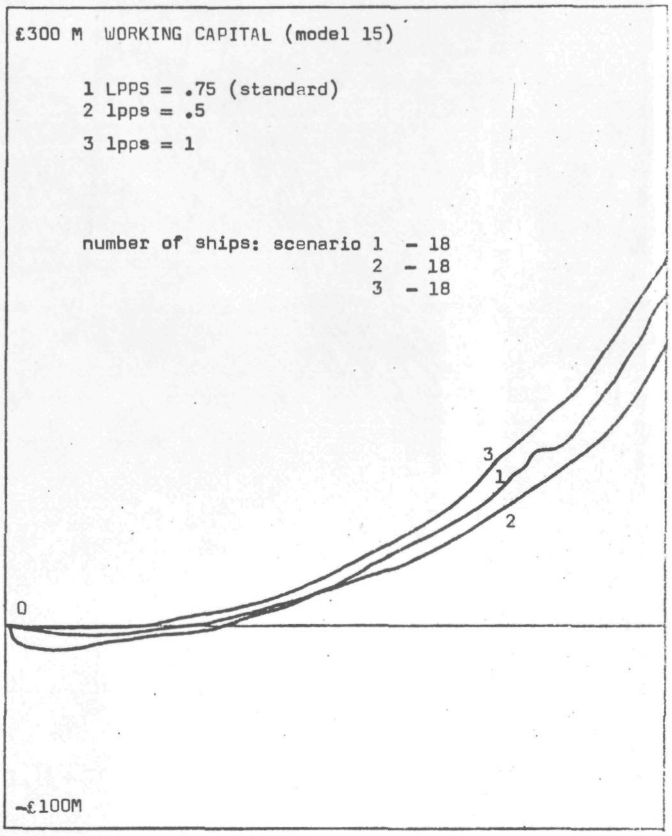

£10 M FOREIGN EXCHANGE BALANCE TOTAL
5
5
4
0
4
1
1
2
3
-£20 M

F.

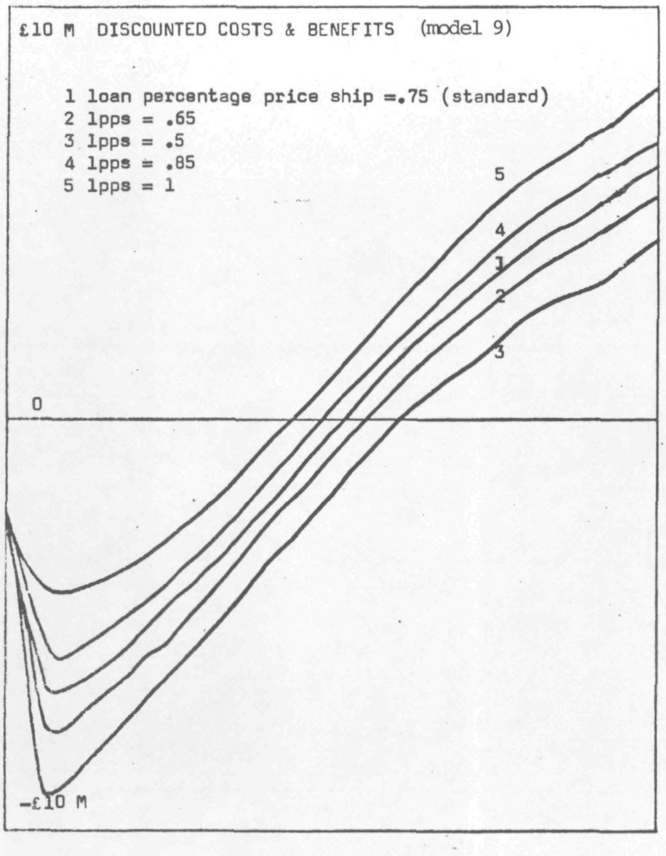

£60 M INCOME PLOUGHED BACK IN COUNTRY
5
4
1
2
3

A. Working capital (model 9 & 15)

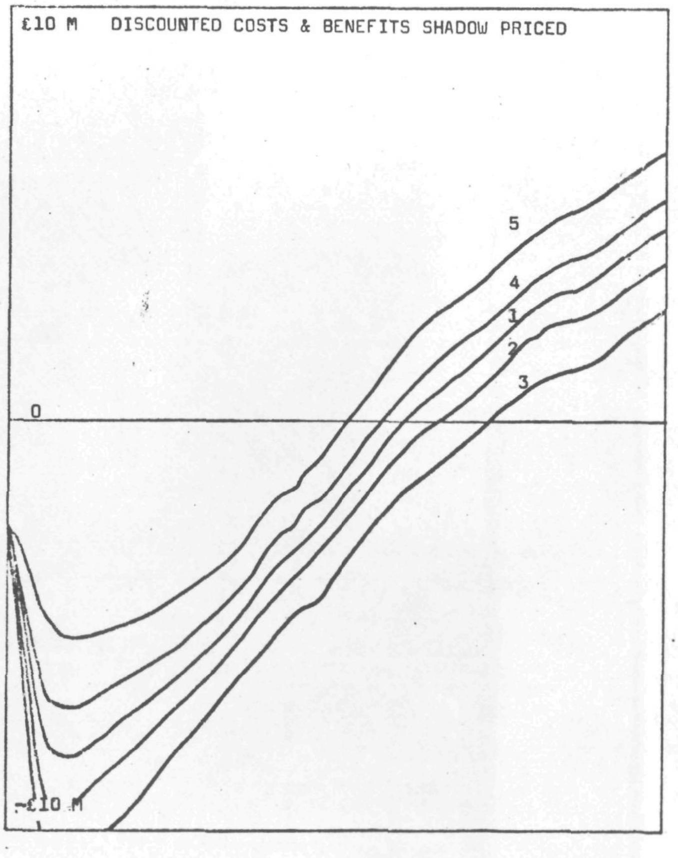




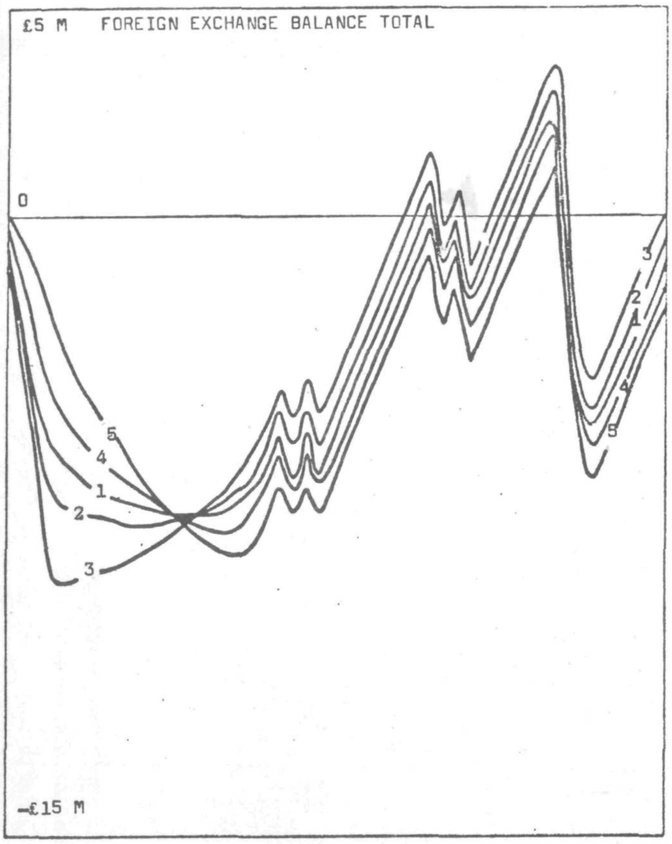
C.



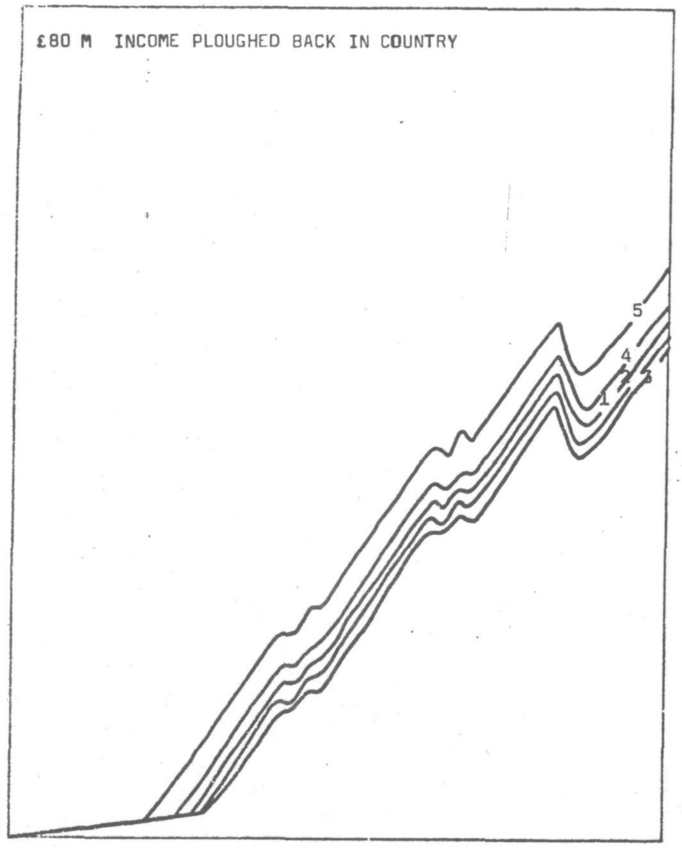
D.



E.

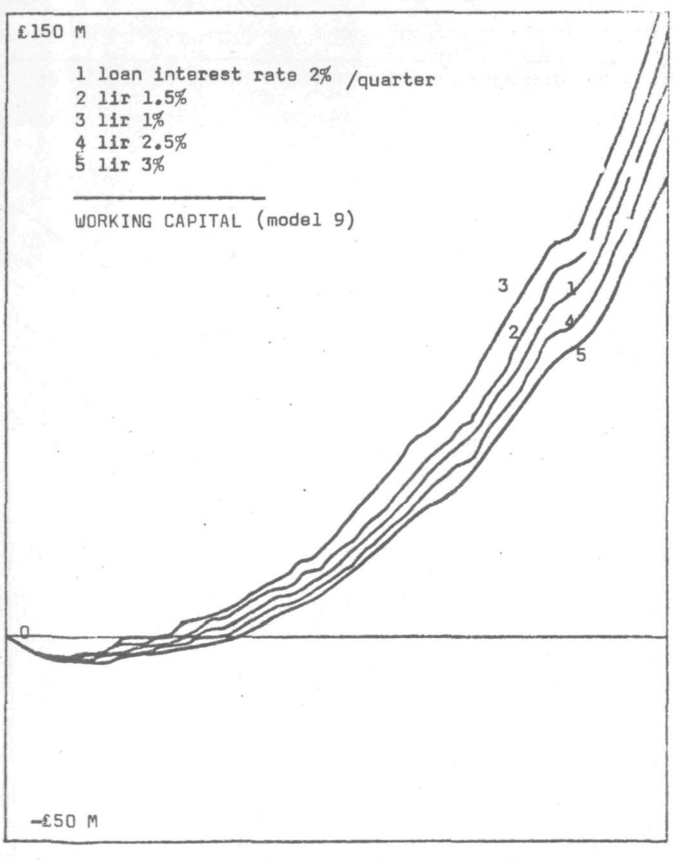


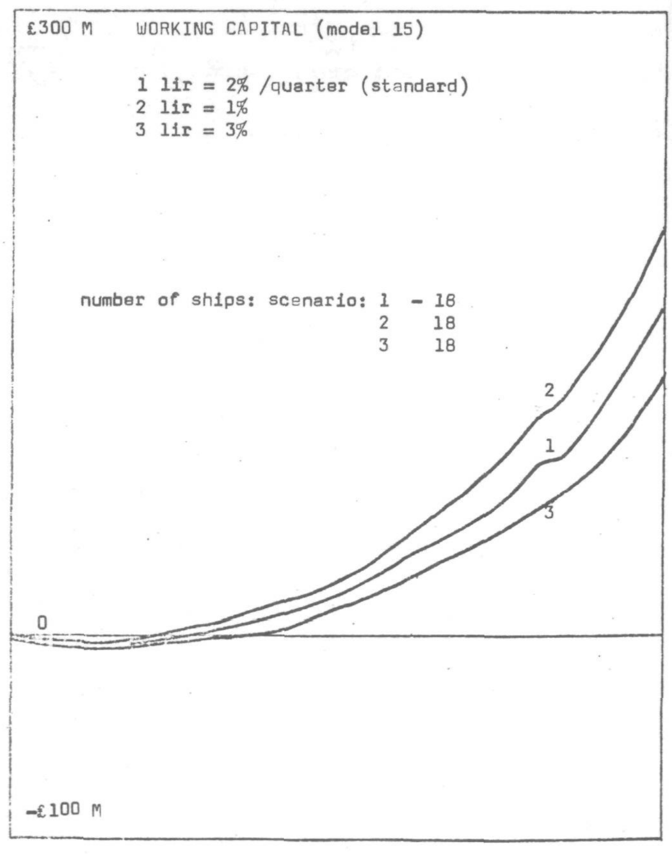
F.



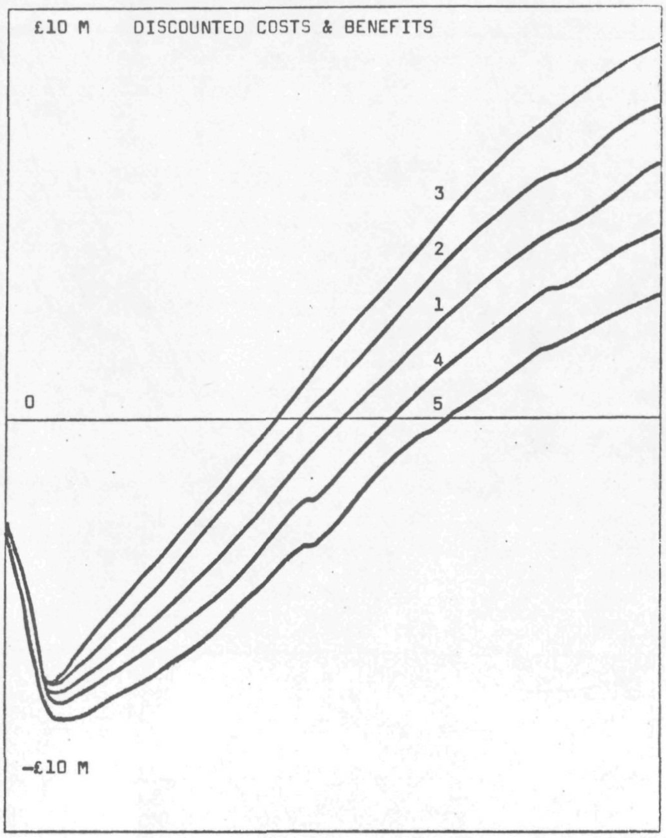
X. LOAN INTEREST RATE

A. Working capital (model 9 & 15)

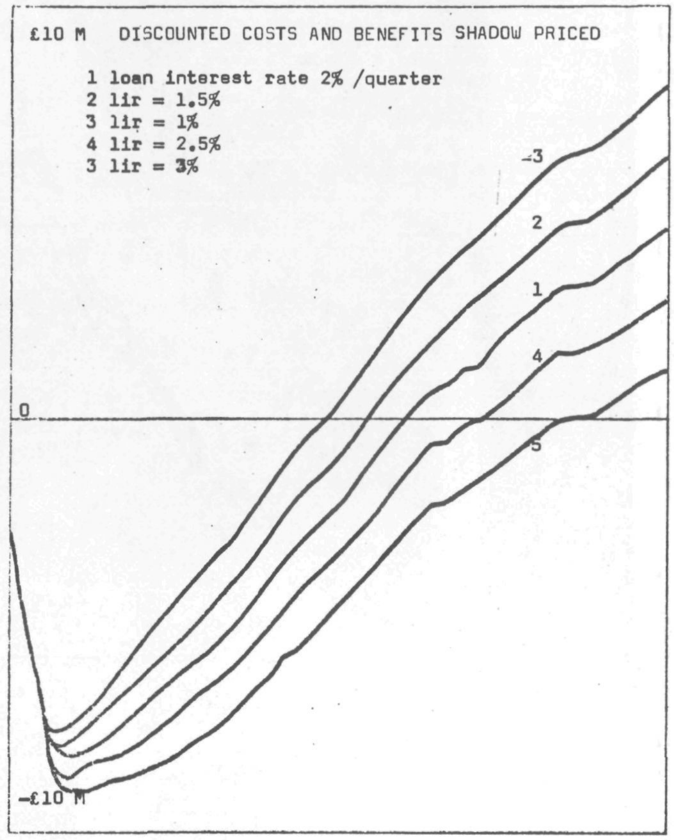


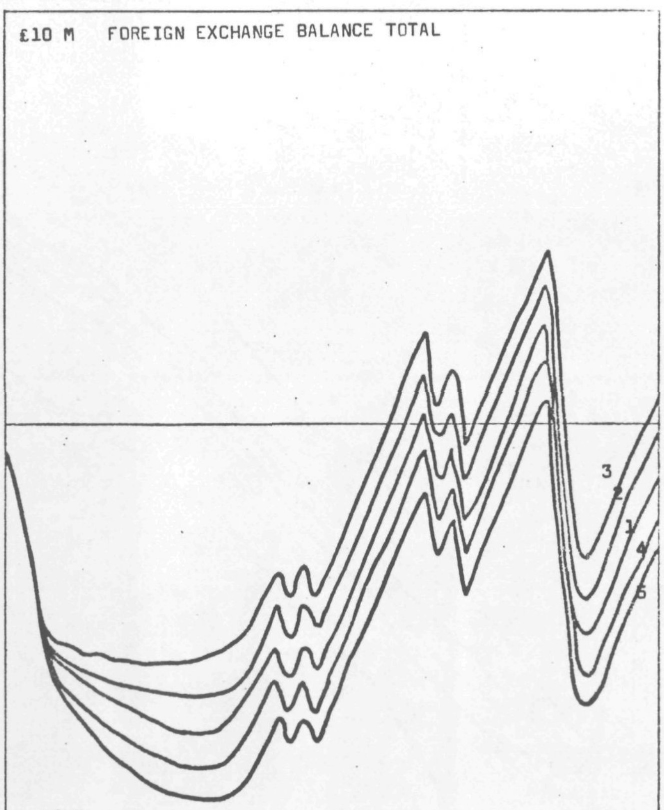


C.

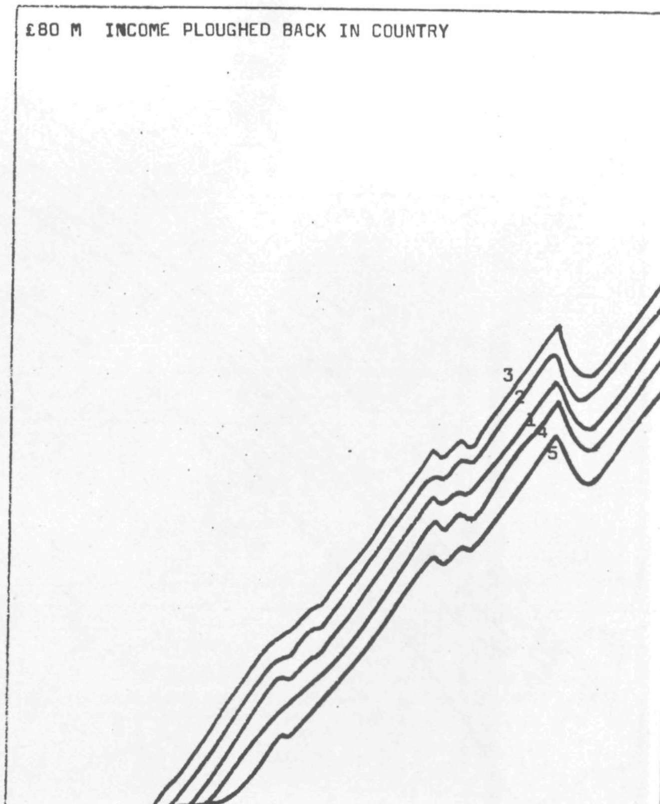

£10 M DISCOUNTED COSTS & BENEFITS
3
2
1
4
0
5
-£10 M

D.

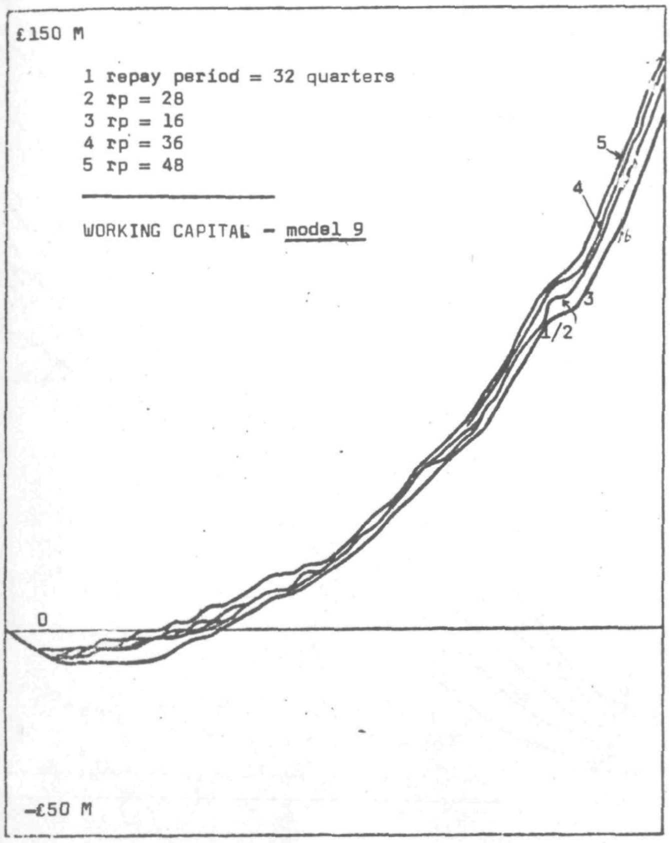

£10 M DISCOUNTED COSTS AND BENEFITS SHADOW PRICED
1 loan interest rate 2% /quarter
2 lir = 1.5%
3 lir = 1%
4 lir = 2.5%
3 lir = 3%
3
2
1
4
0
5
-£10 M

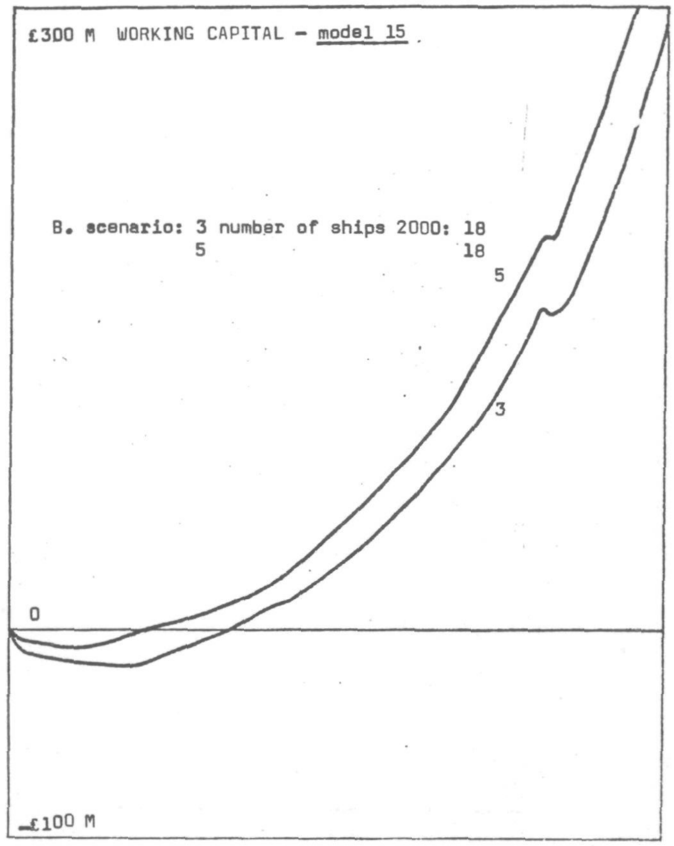

£10 M FOREIGN EXCHANGE BALANCE TOTAL
3
2
1
4
5
-£10 M

F.

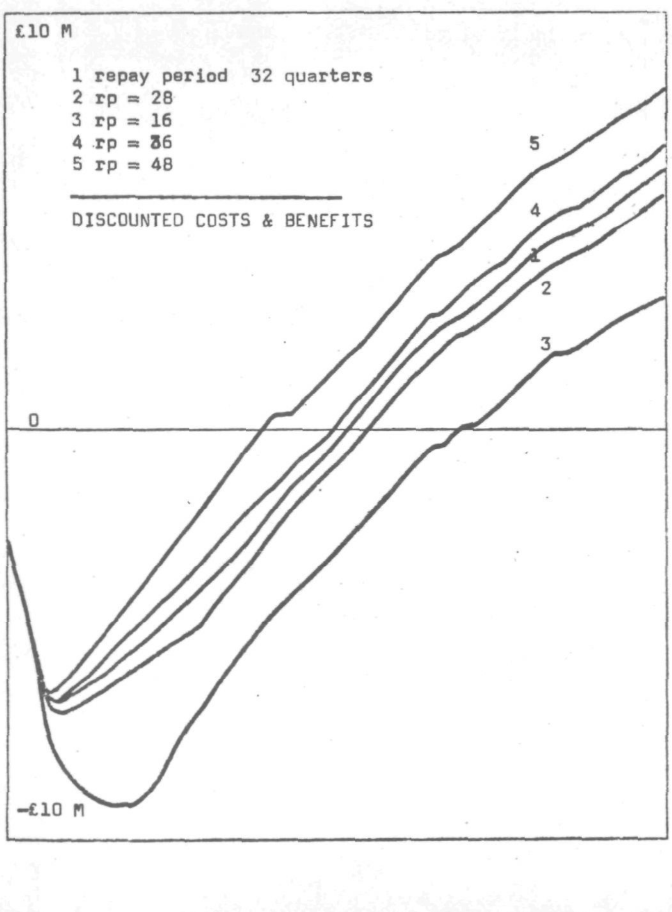

£80 M INCOME PLOUGHED BACK IN COUNTRY
3
2
1
4
5

A. Working capital (model 9 & 15)

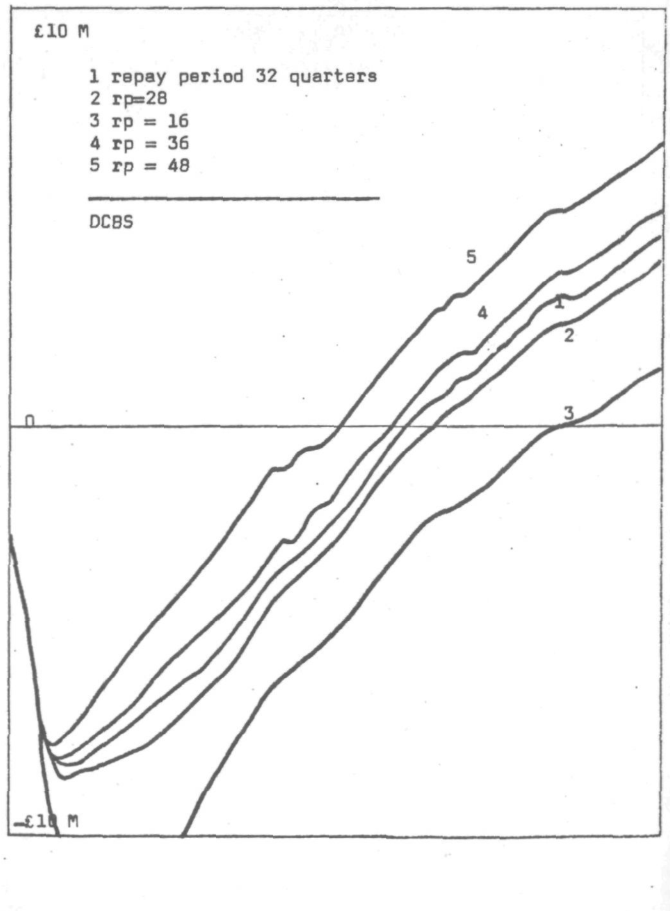




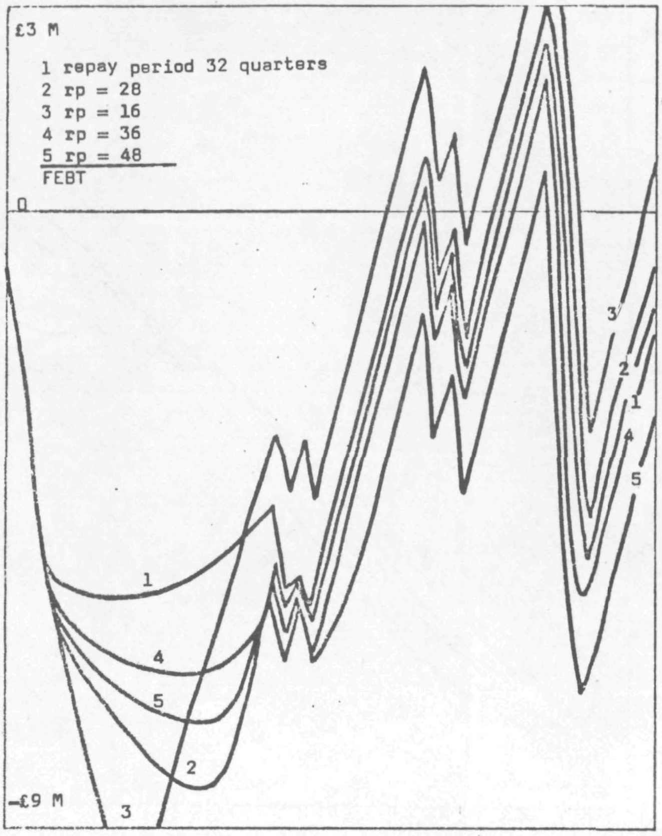
C.



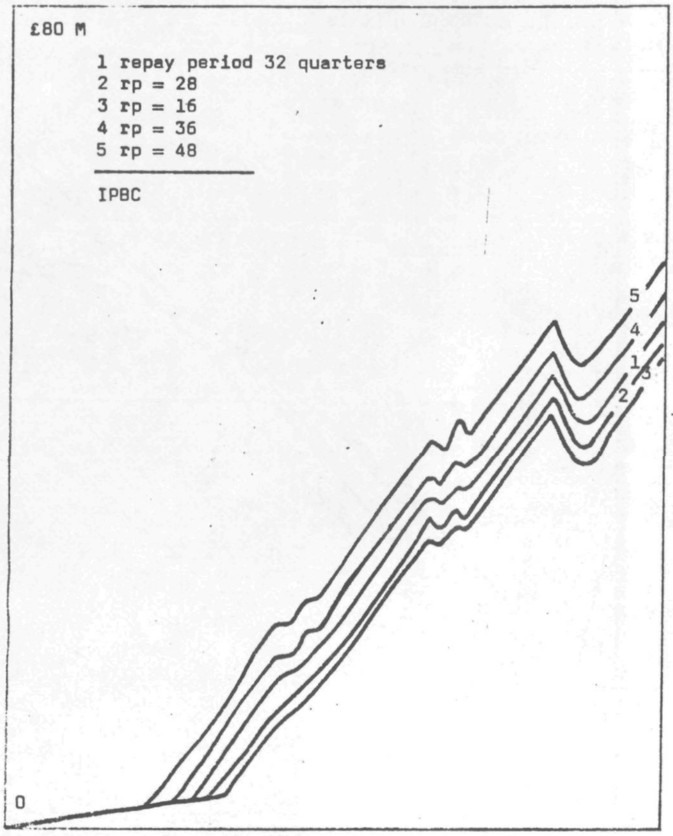
D.



E.

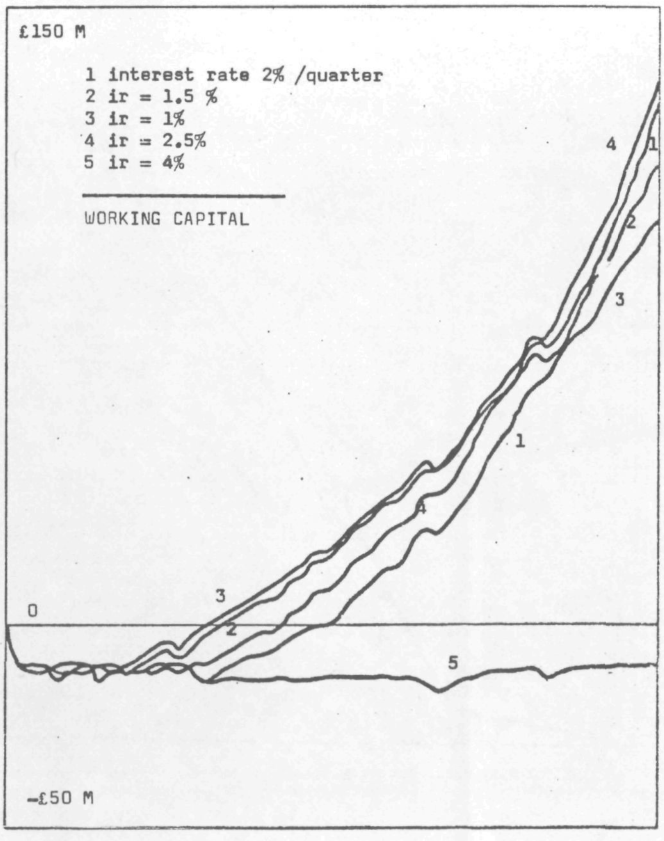


F.



XII. INTEREST RATE

A. Working capital (model 14)

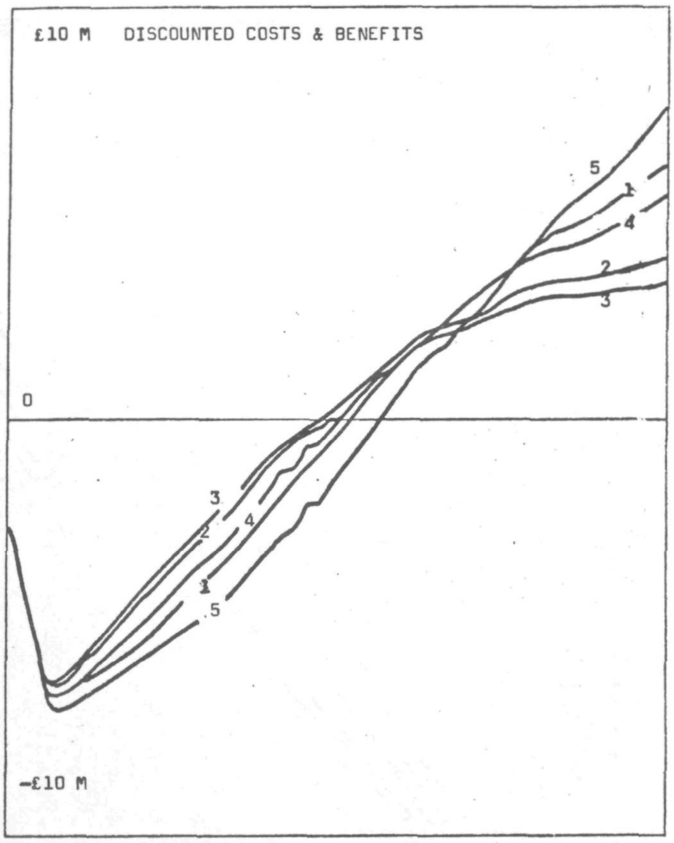


B. Number of ships (model 14)

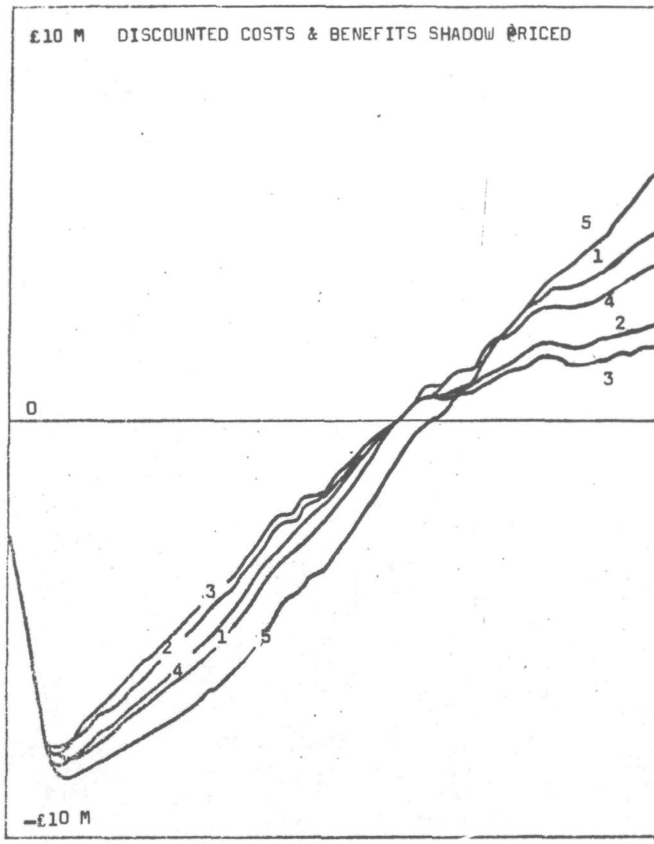
scenario: 1	number of ships in the year 2000:	16
2		16
3		16
4		16
5		16

C.D.E.F. DCB, DCBS, FEBT, IPBC (model 9)

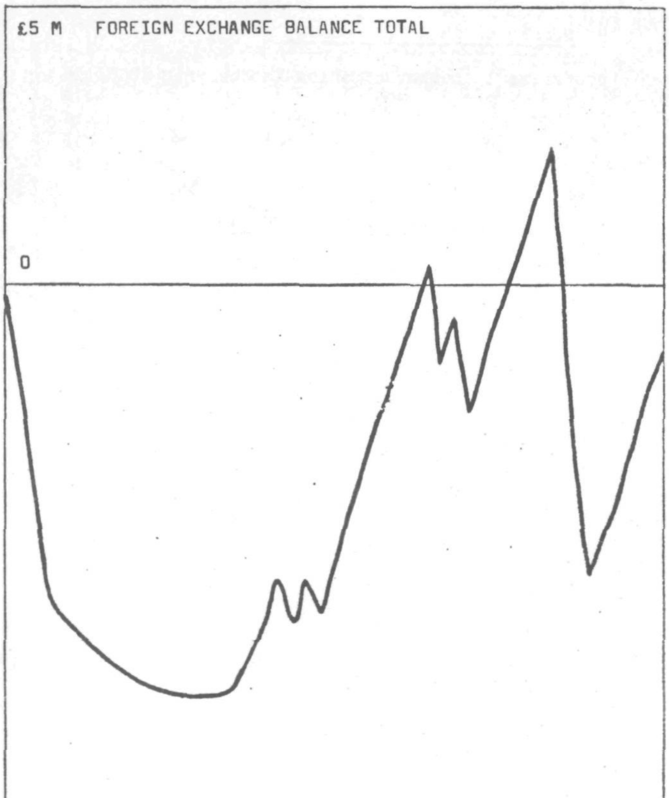
C.


£10 M DISCOUNTED COSTS & BENEFITS
5
1
4
2
3
0
3
2
4
1
5
-£10 M

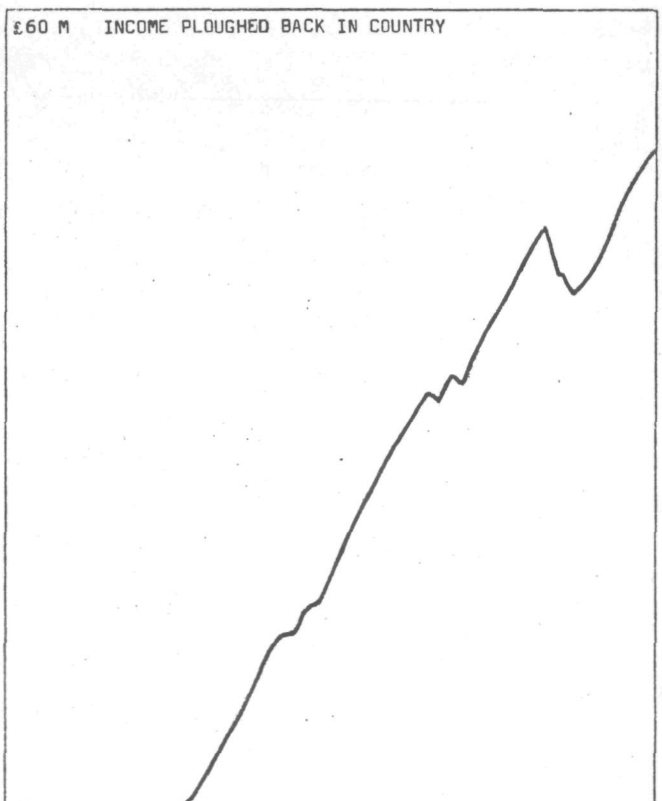
D.


£10 M DISCOUNTED COSTS & BENEFITS SHADOW PRICED
5
1
4
2
3
0
3
2
1
5
4
-£10 M

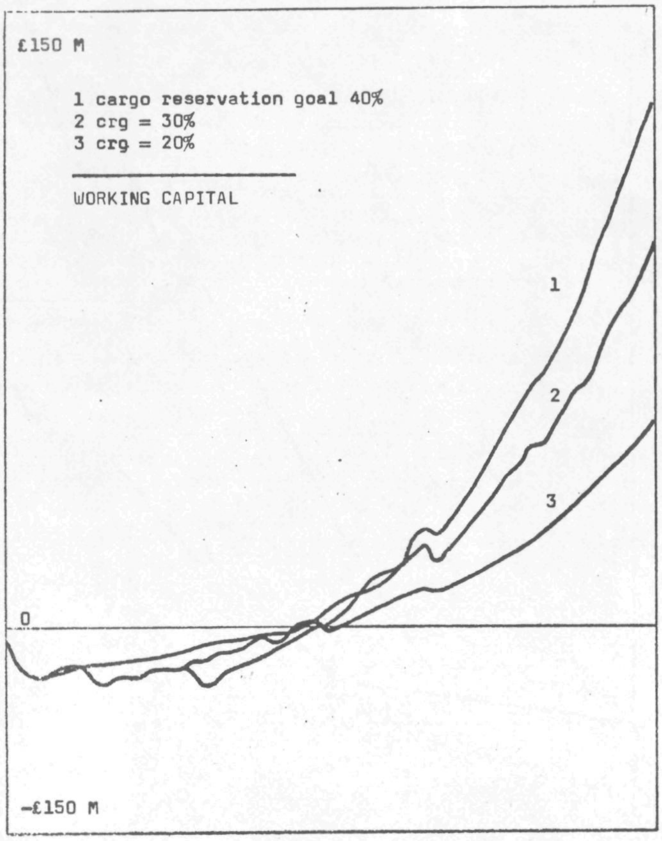
E.


£5 M FOREIGN EXCHANGE BALANCE TOTAL
0
-£10 M

F.


£60 M INCOME PLOUGHED BACK IN COUNTRY

A. Working capital (model 14)

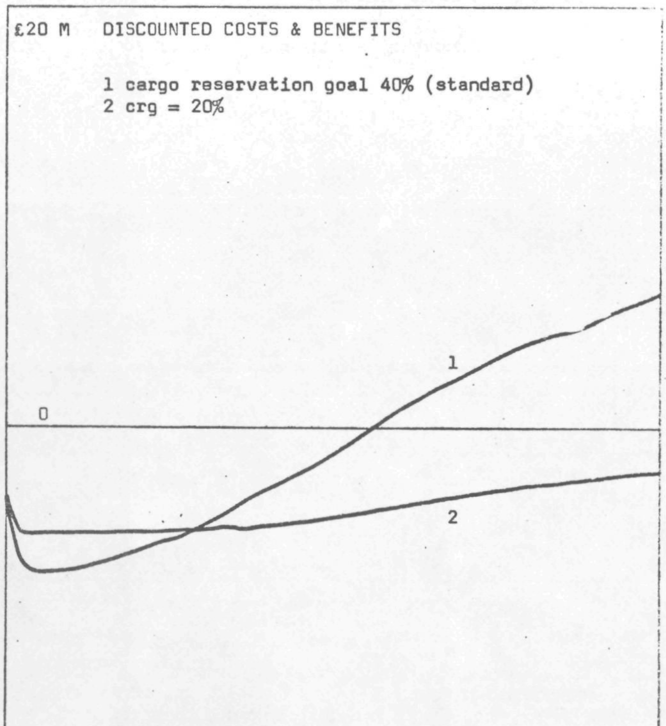


B. Number of ships (model 14)

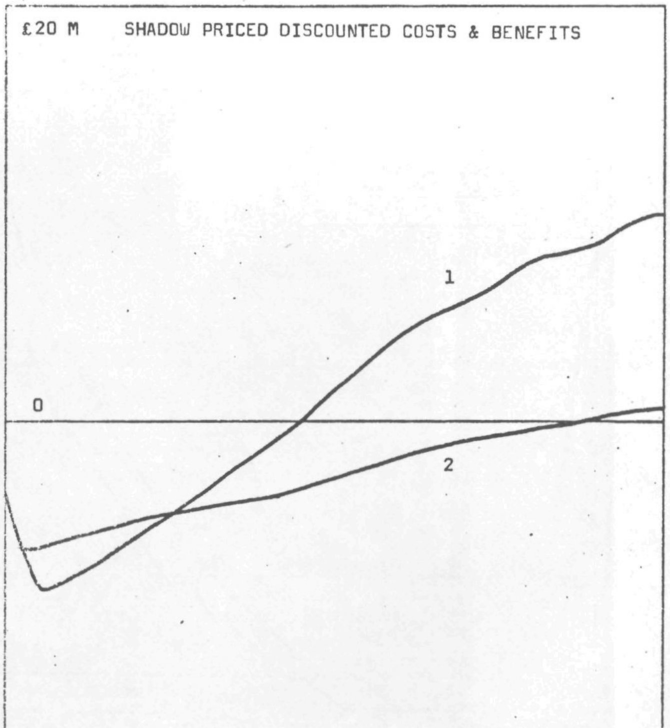
scenario: 1 number of ships in year 2000: 16
2 12
3 8

C.D.E.F. DCB, DCBS, FEBT, IPBC (model 15)

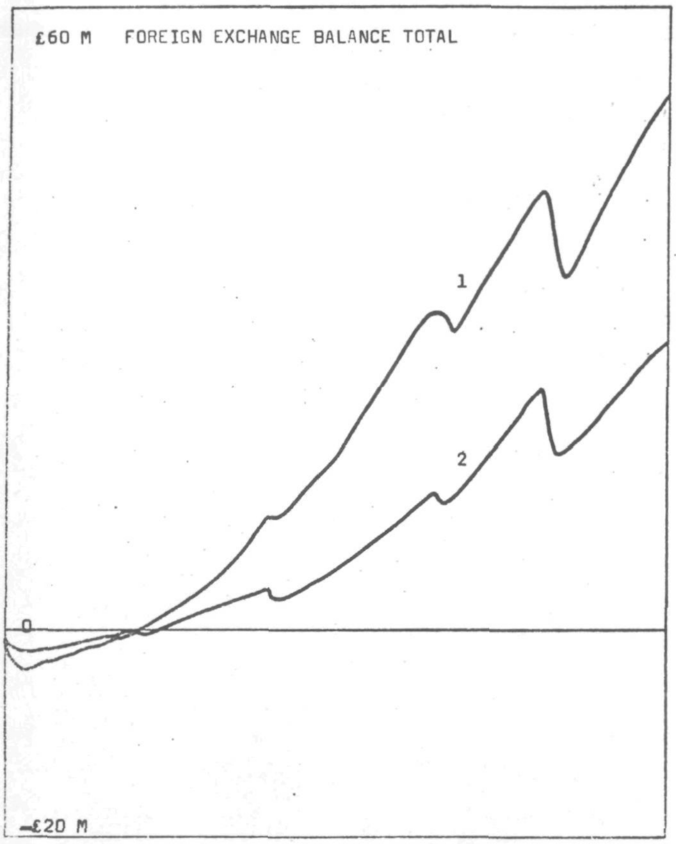
C.



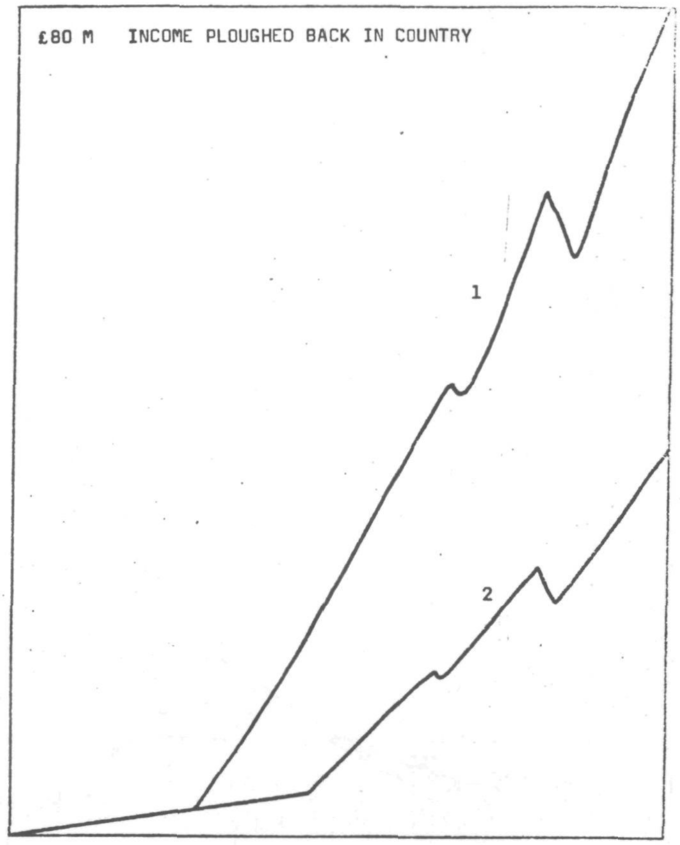
D.



E,

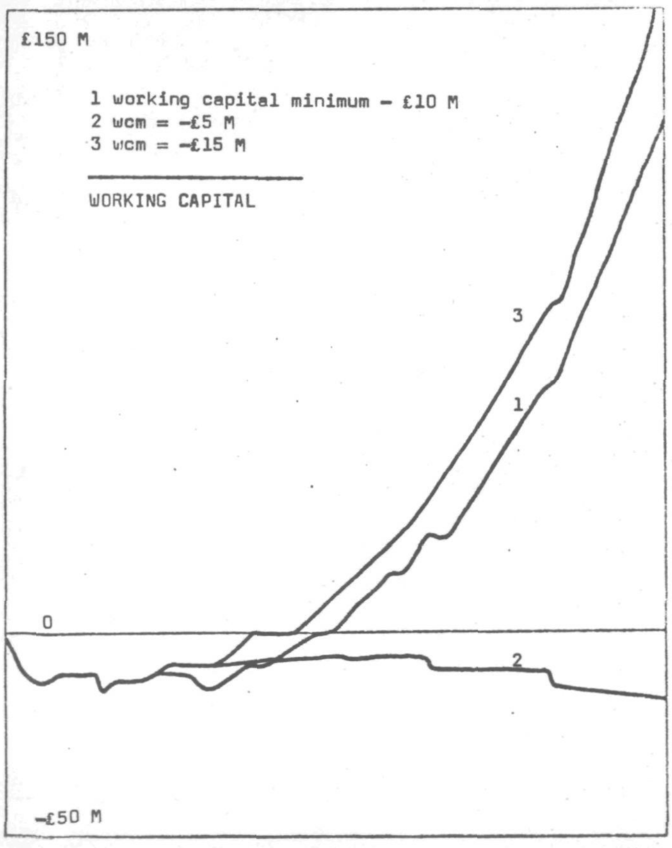


F.



XIV. WORKING CAPITAL MINIMUM

A. Working capital (model 14)

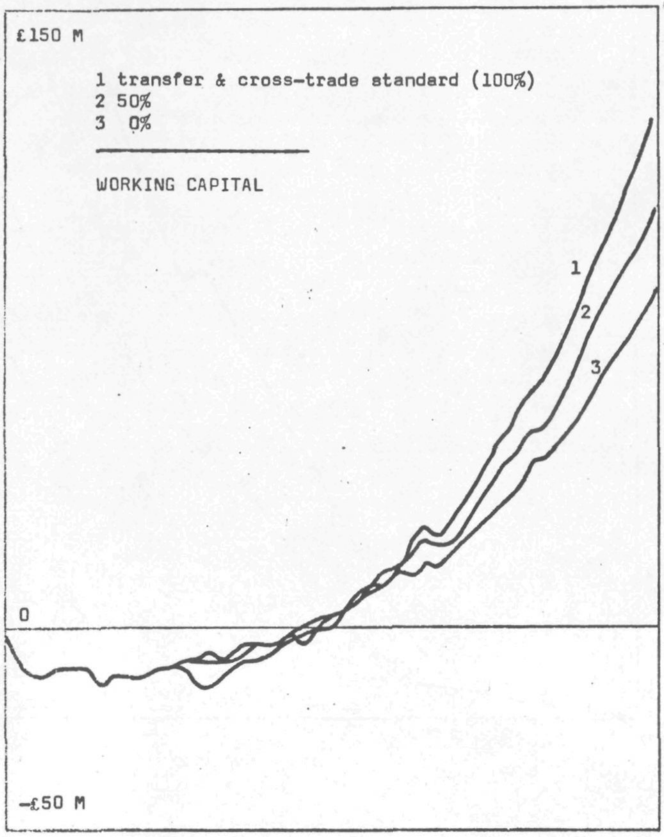


B. Number of ships (model 14)

scenario: 1 number of ships in year 2000: 16
2 2
3 16

XV. PERCENTAGE TRANSFER & CROSS-TRADE

A. Working capital (model 14)

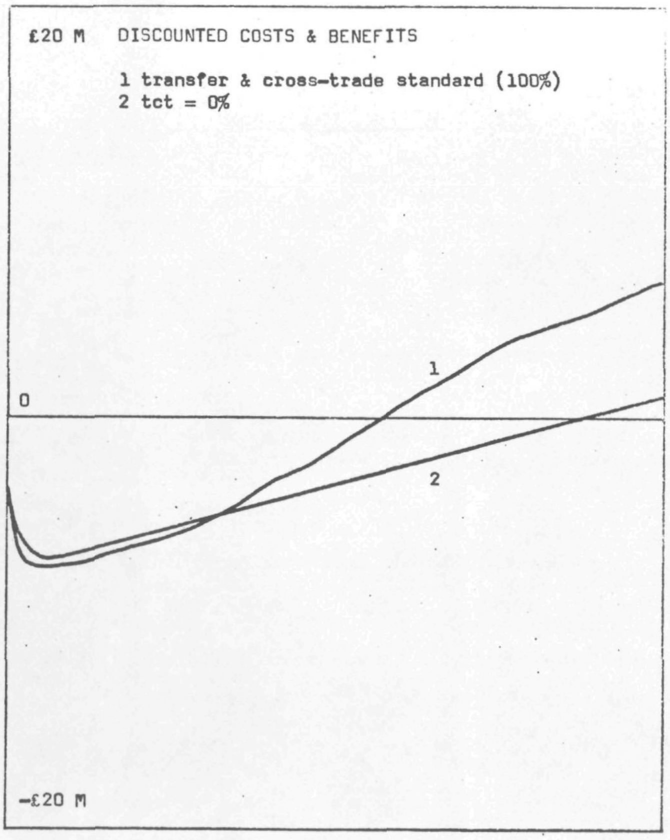


B. Number of ships (model 14)

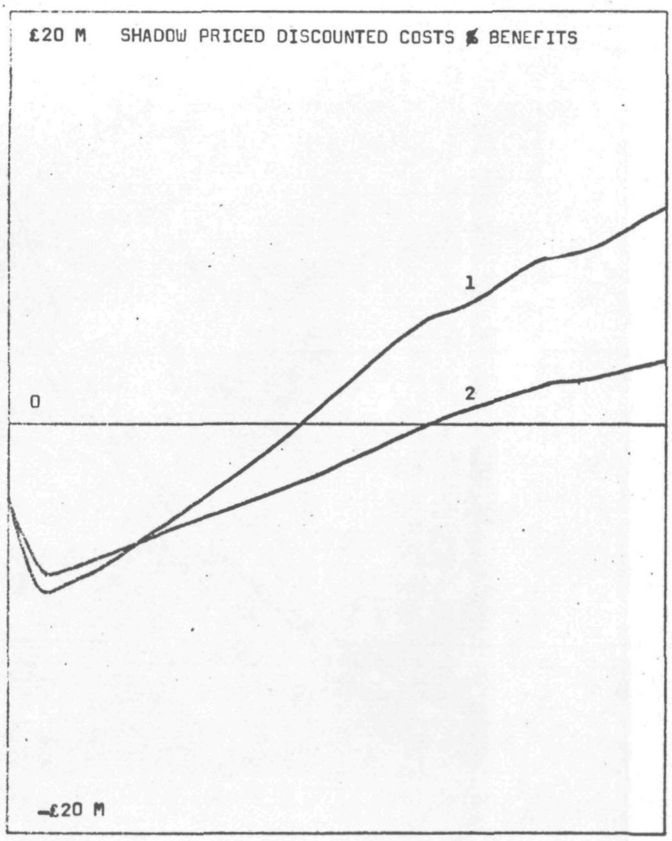
scenario: 1	number of ships in year 2000:	16
2		13
3		11

C.D.E.F. DCB, DCBS, FEBT, IPBC (model 15)

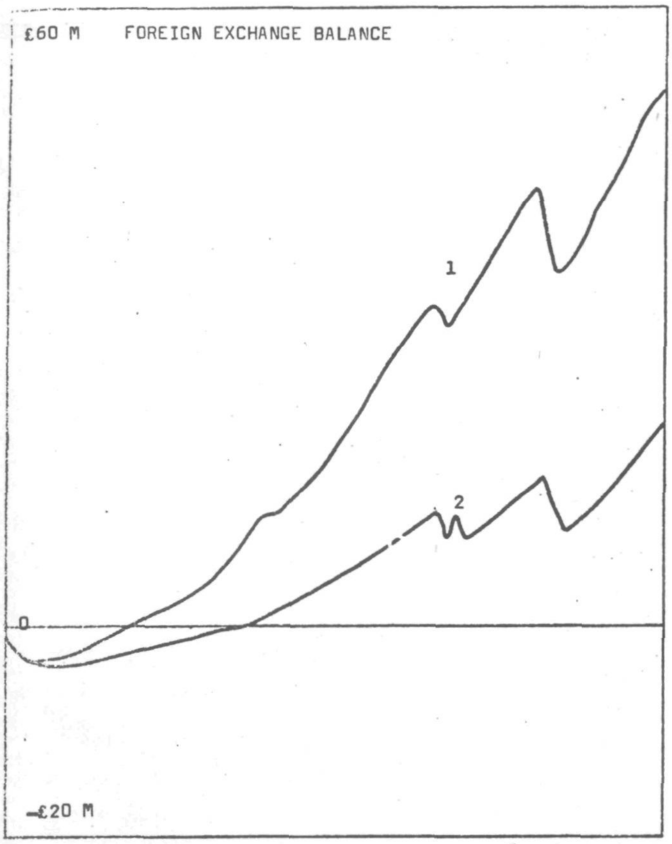
C.



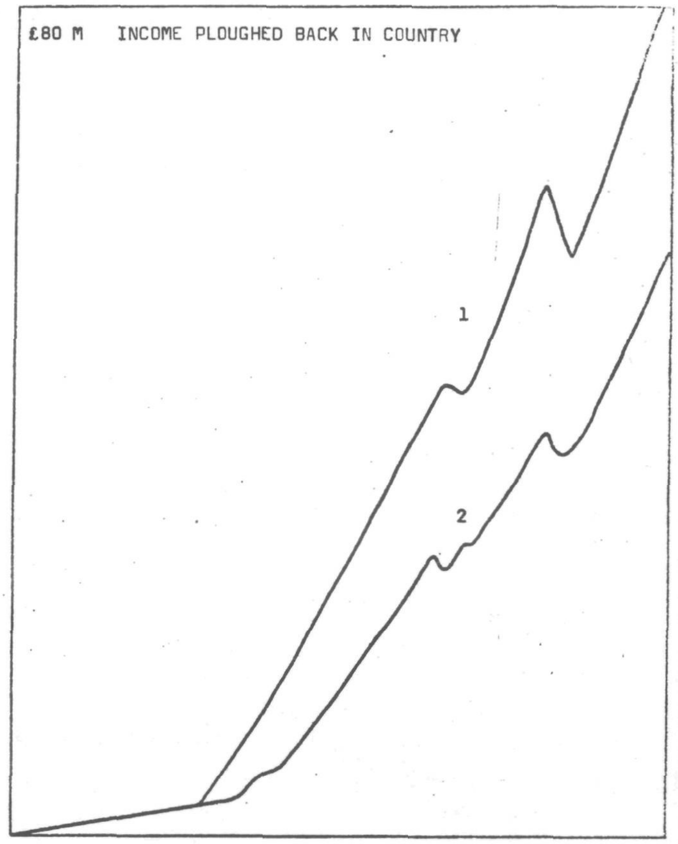
D.



E.

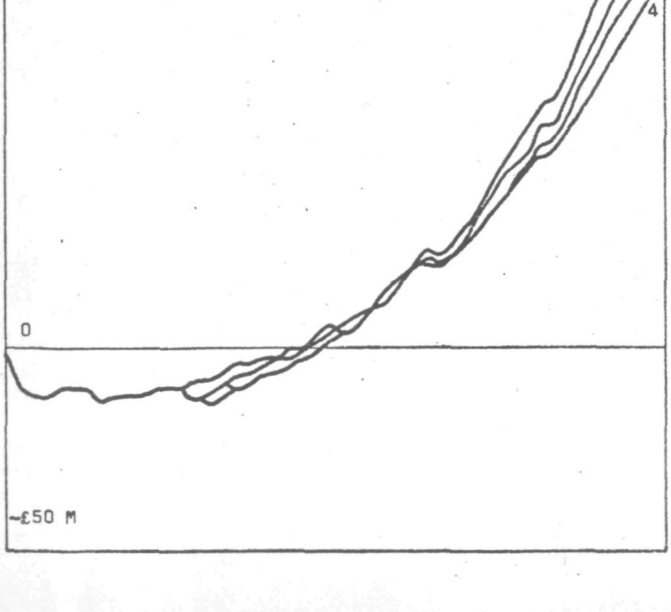


F.



XVI. GROWTH RATE EXPORTS & IMPORTS

A. Working capital (model 14)

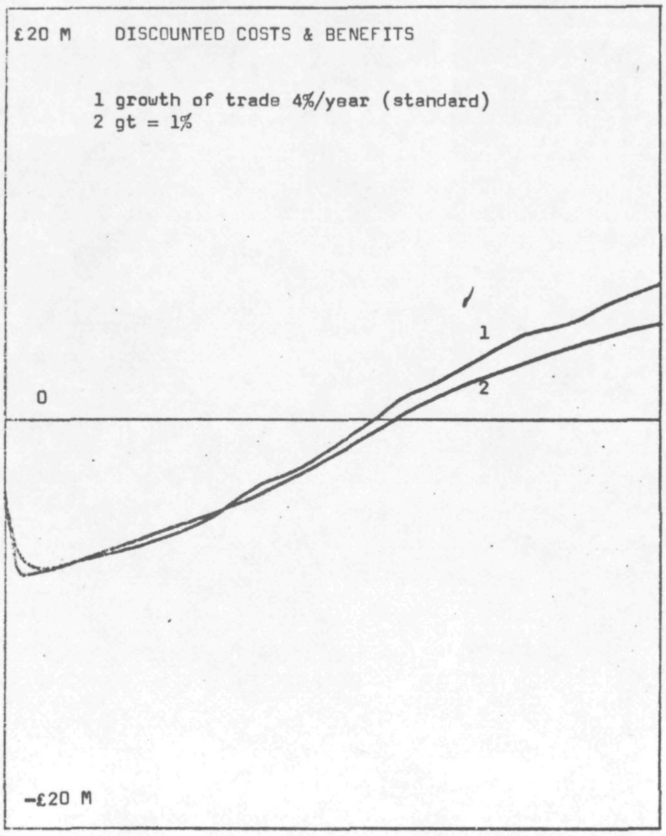


B. Number of ships (model 14)

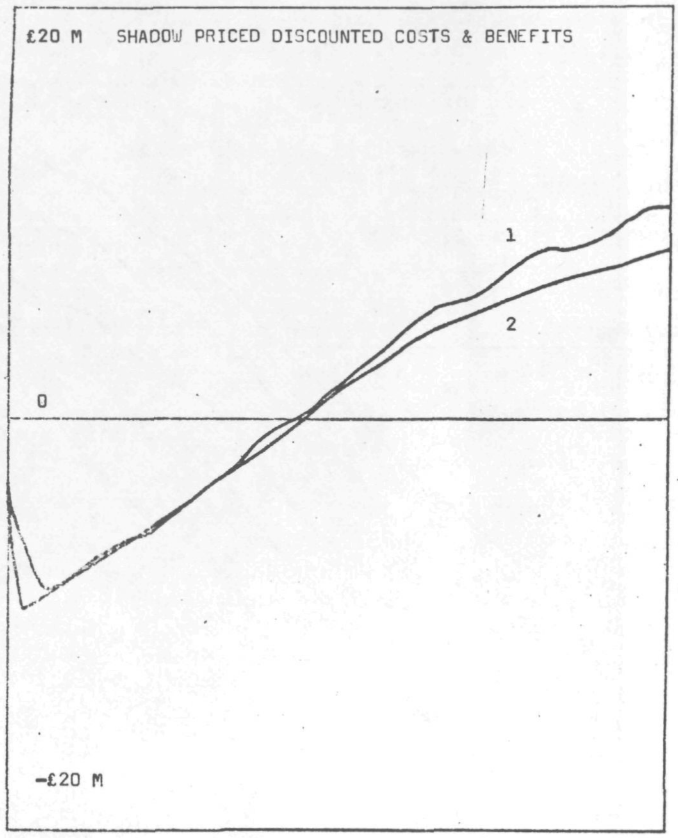
scenario: 1	number of ships in year 2000:	16
2		12
3		10
4		7

C.D.E.F. DCB, DCBS, FEBT, IPBC (model 15)

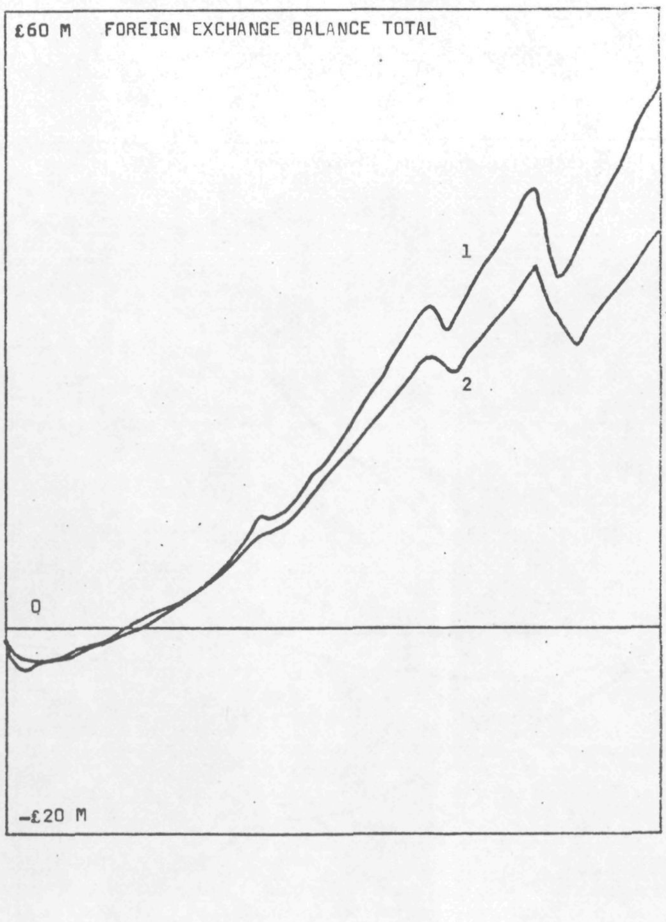
C.


£20 M
DISCOUNTED COSTS & BENEFITS
1 growth of trade 4%/year (standard)
2 gt = 1%
1
2
0
-£20 M

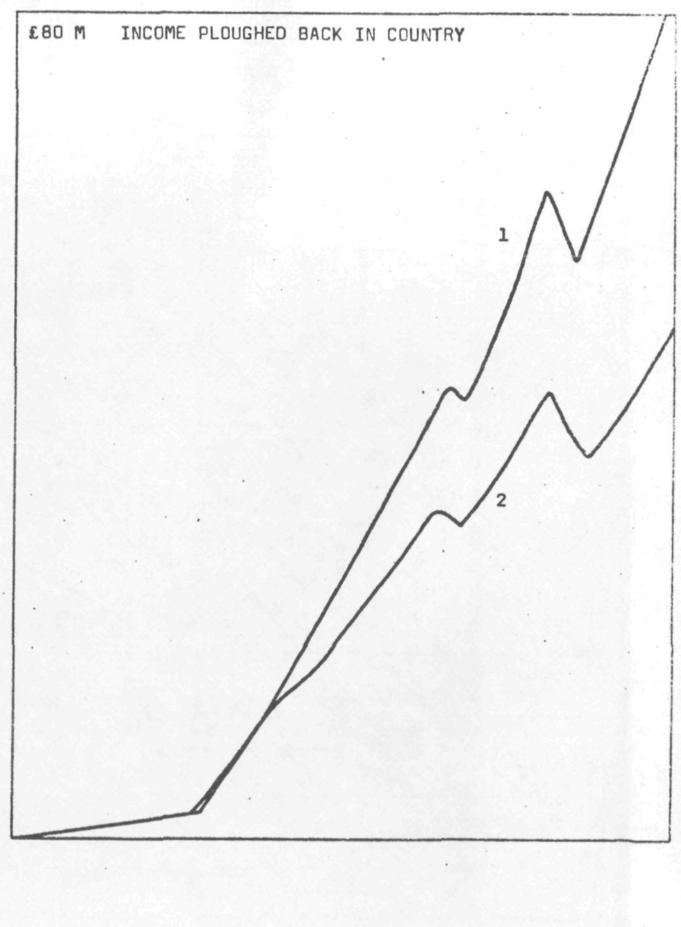
D.


£20 M
SHADOW PRICED DISCOUNTED COSTS & BENEFITS
1
2
0
-£20 M

E.

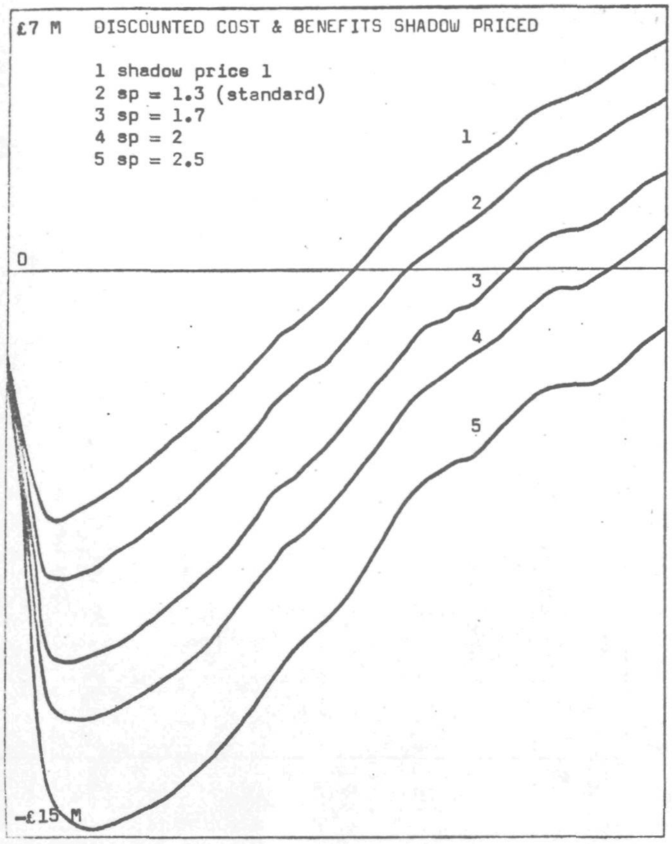

£60 M
FOREIGN EXCHANGE BALANCE TOTAL
1
2
0
-£20 M

F.

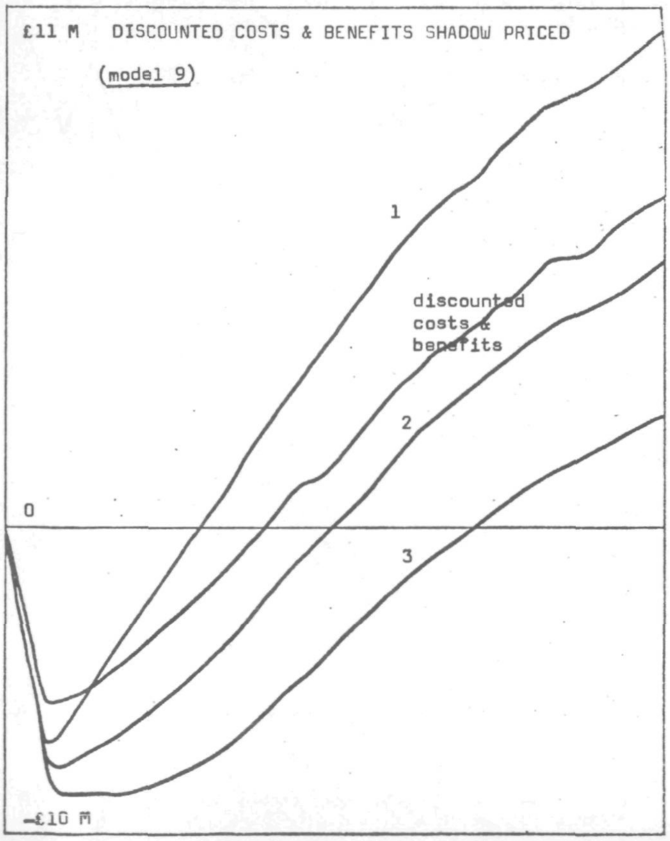

£80 M
INCOME PLOUGHED BACK IN COUNTRY
1
2

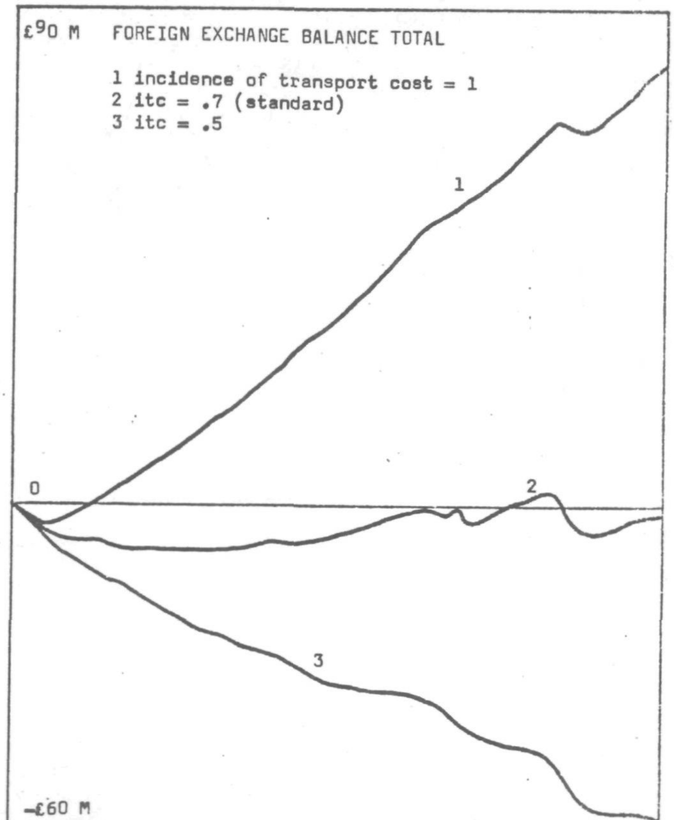
XVII. SHADOW PRICE FOREIGN EXCHANGE

A. Discounted costs & benefits shadow priced (model 9)



XVIII. INCIDENCE OF TRANSPORT COST





APPENDIX B - HOW TO READ DYNAMO-FLOW DIAGRAMS, EQUATIONS and GRAPHICAL OUTPUTS

source: Dennis L. Meadows et al.
Dynamics of growth in a finite world
Wright-Allen Press, Inc.
Cambridge, Massachusetts, 1974
Appendices C, D, E

A flow diagram is an illustration of the postulated relationships between the elements in a model system. It depicts the model assumptions with a degree of detail midway between the dynamically suggestive but incomplete causal-loop diagram and the detailed, precise DYNAMO equations. More complete information on DYNAMO flow diagrams, equations, and other conventions can be found in Forrester (1961, 1968) and Pugh (1970).

A DYNAMO flow diagram has seven main components (see Figure C-1):

Rectangles represent levels, for example, nonrenewable resources NR, industrial capital IC.

Valves represent rates, for example, nonrenewable resource usage rate NRUR, industrial capital depreciation rate ICDR.

Circles represent auxiliaries, for example, industrial output IO, per capita resource usage multiplier PCRUM. Table functions (see Appendix D) are indicated by overlining and underlining the DYNAMO variable name as in the auxiliary PCRUM.

Solid arrows represent material flows, for example, the solid arrow leaving nonrenewable resources NR represents the material flow of resources from a stock or inventory of resources. Dashed arrows represent flows of information, for example, information about the level of nonrenewable resources is used to determine the nonrenewable resource fraction remaining NRFR.

Input lines represent information inputs from constant parameters, for example, industrial capital-output ratio ICOR.

A double circle represents an exogenous, time-dependent input, for example, population POP. Since this input is determined in another sector of World3, it is exogenous to the nonrenewable resource sector as it is drawn in Figure C-1.

The "cloud" symbol represents a source or sink for various flows. A cloud effectively delimits the system boundary. After a flow enters a cloud it no longer affects the system. Similarly, what happens to a flow before it enters the system from a cloud is of no importance to the system.

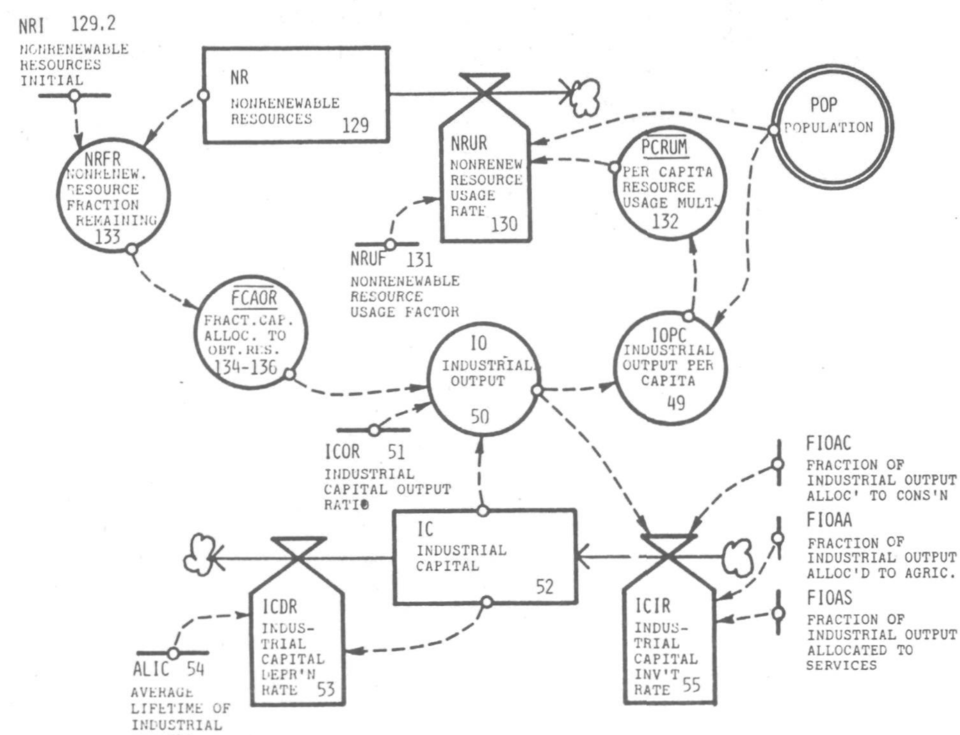


Figure C-1 Example of a DYNAMO flow diagram (nonrenewable resource sector)

A DYNAMO equation is written in the following form:

type *variable name = expression*

Type: a single letter designating the type of variable being defined:

L indicates a level equation
R indicates a rate equation
A indicates an auxiliary equation
N indicates an initial value
C indicates a constant
T indicates a table
S indicates a supplementary equation

Variable name: the specified abbreviation for the variable being defined by the equation. The name must be followed by the appropriate time subscript, depending on the type of variable it is. Levels and auxiliaries have the subscript .K; rates have the subscript .KL. Initial values, constants, and tables do not have time subscripts.
Expression: any algebraic expression. It may range from a simple number or single variable to a complicated combination of factors and terms involving functions, variables, and numerical values. The operations of addition, subtraction, multiplication, and division are indicated, respectively, by +, −, *, /. Multiplication and division are carried out before addition and subtraction. Expressions enclosed in parentheses are evaluated first, and the value is substituted for the parenthetical expression.

Level Equation

A level equation defines the present value of a level variable in terms of its value from the previous evaluation and its change in value in the intervening time, DT. A level equation represents a simple numerical integration. Numerical instabilities are avoided by taking DT to be a small fraction of the shortest time delay in the model.

The equation for nonrenewable resources NR (from Figure D-1) is an example of a level equation:

$$\text{L} \qquad \text{NR.K} = \text{NR.J} + (\text{DT})(-\text{NRUR.JK}),$$

where

NR.K = the value of NR at the present time K
NR.J = the value of NR at the previous time of evaluation J, DT time units before the present
DT = the length of the computation interval
NRUR.JK = the rate of change of NR over the interval DT

```
        RESTR

        *     NONRENEWABLE RESOURCE SECTOR WITH EXOGENOUS INPUTS
        NOTE
129     L     NR.K=NR.J+(DT)(-NRUR.JK)
        N     NR=NRI
        C     NRI=1E12
130     R     NRUR.KL=(POP.K)(PCRUM.K)(NRUF.K)
131     A     NRUF.K=CLIP(NRUF2,NRUF1,TIME.K,PYEAR)
        C     NRUF1=1
        C     NRUF2=1
132     A     PCRUM.K=TABHL(PCRUMT,IOPC.K,0,1600,200)
        T     PCRUMT=0/.85/2.6/4.4/5.4/6.2/6.8/7/7
133     A     NRFR.K=NR.K/NRI
134     A     FCAOR.K=CLIP(FCAOR2.K,FCAOR1.K,TIME.K,PYEAR)
135     A     FCAOR1.K=TABHL(FCAOR1T,NRFR.K,0,1,.1)
        T     FCAOR1T=1/.9/.7/.5/.2/.1/.05/.05/.05/.05/.05
136     A     FCAOR2.K=TABHL(FCAOR2T,NRFR.K,0,1,.1)
        T     FCAOR2T=1/.9/.7/.5/.2/.1/.05/.05/.05/.05/.05
        NOTE
        NOTE  EXOGENOUS INPUTS TO THE NONRENEWABLE RESOURCE SECTOR
        NOTE
        NOTE  POPULATION
        NOTE
        A     POP.K=CLIP(POP2,POP1.K,TIME.K,ZPGT)
        A     POP1.K=POPI*EXP(GC*(TIME.K-1900))
        C     POPI=1.65E9
        C     GC=.012
        C     POP2=4E9
        C     ZPGT=2500
```

```
NOTE
NOTE    INDUSTRIAL CAPITAL
NOTE
L       IC.K=IC.J+(DT)(ICIR.JK-ICDR.JK)
N       IC=ICI
C       ICI=2.1E11
R       ICIR.KL=(IO.K)(1-FIOAA-FIOAS-FIOAC)
C       FIOAA=.12
C       FIOAS=.12
C       FIOAC=.43
R       ICDR.KL=IC.K/ALIC
C       ALIC=14
NOTE
NOTE    INDUSTRIAL OUTPUT
NOTE
A       IO.K=(IC.K)(1-FCAOR.K)/ICOR
C       ICOR=3
A       IOPC.K=IO.K/POP.K
NOTE
NOTE    CONTROL CARDS
NOTE
N       TIME=1900
C       PYEAR=1975
SPEC    DT=1/PLTPER=5/LENGTH=2100
PLOT    NRFR=N,FCAOR=F(0,1)/IC=C(0,4E13)/
X       IO=O(0,1E13)/POP=P(0,1.6E10)
```

Figure D-1 Example of DYNAMO equations (nonrenewable resource sector equations)

In the simple numerical integration scheme used by DYNAMO, the rate of change is assumed to be constant during the small time interval DT.

Rate Equation

A rate equation describes how the rate of flow to or from a level changes, depending on other conditions in the system. The expression in the rate equation may contain constants, auxiliaries, and levels. The auxiliaries and levels used in rate equations are written in terms of their values at the present time, represented by the subscript .K. For example, in Figure D-1:

R NRUR.KL = (POP.K)(PCRUM.K) (NRUF.K).

In this example the rate, NRUR.KL, is defined as the product of a level, POP.K, and two auxiliaries, NRUF.K and PCRUM.K.

Auxiliary Equation

An auxiliary equation defines a component of a rate. Rates are separated algebraically into auxiliaries to clarify their structure. All auxiliary variables could be substituted back into rate equations, making them dependent exclusively on levels and constants. Auxiliaries are separated from rate equations only if they represent real-world quantities or concepts. The expression in an auxiliary equation can contain constants, functions (including table functions), levels, and other auxiliaries.

Initial-Value Equation

An initial-value equation defines the value of a level at the beginning of the simulated time period. The variable name in such an equation is the name of the level without subscripts. Its expression can be a number, the variable name of a constant, or a combination of other model variables specified without time subscripts.

Constant Equation

A constant equation defines the numerical value of a constant. The value must be given explicitly by the programmer.

Table Equation

A table equation lists the numerical values of a dependent variable as a function of an independent variable over a specified range. The independent variable and its range are specified in an auxiliary equation preceding the table, as in the following example:

A PCRUM.K = TABHL(PCRUMT,IOPC.K,0,1600,200)
T PCRUMT = 0/.85/2.6/4.4/5.4/6.2/6.8/7/7

The auxiliary equation defines a variable PCRUM as a table function of IOPC. It further specifies that the table PCRUMT gives the values of PCRUM for corresponding values of IOPC between 0 and 1600 units at intervals of 200 units. Since IOPC.K is the value of a continuously variable quantity, its values may not be exact multiples of 200. For values of IOPC.K between the specified points of the table, DYNAMO linearly interpolates the value of PCRUM.K. When IOPC.K is less than zero, DYNAMO uses the first value in the PCRUM table; when IOPC.K is greater than 1600, it uses the last value.

Supplementary Equation

A supplementary equation defines an auxiliary variable that is used only to produce output such as indices of interest to the user. Crude birth rate CBR is a supplementary variable. Supplementary variables cannot be used to compute the values of other variables.

Special Functions: CLIP

A NRUF.K = CLIP(NRUF2,NRUF1,TIME.K,PYEAR)

The CLIP function is one of several special functions available in DYNAMO. It is used to change the value of a variable, depending on the relative magnitude of two other variables. In the example given, NRUF has the value NRUF1 until TIME in the simulation run reaches PYEAR; then NRUF changes to NRUF2 and remains there for the duration of the run. Other special functions are described in Pugh (1970).

Specification Statement

The specification statement is identified by the letters SPEC. It contains information about the size of the time step DT, the time interval between plotted points PLTPER, and the time interval covered by a model run LENGTH.

SPEC DT = 1/PLTPER = 5/LENGTH = 2100

In the example, DT was chosen to be 1 time unit. In this model, the time unit is one year. DT can be set to any fraction or multiple of a year; it is usually set small enough to avoid computational instabilities, yet large enough to keep the computing time reasonably short.

The quantities to be plotted are defined by a PLOT statement (described next). PLTPER was set to 5 time units in the preceding example, so that only the values at every fifth time unit are actually plotted. The LENGTH specification can take two forms. The internal variable, TIME, can be initialized by the programmer, for example:

N TIME = 1900.

Here LENGTH = 2100 means that the run proceeds until TIME = 2100, that is, for 200 time units. If TIME is not explicitly initialized, the compiler supplies the initial value, TIME = 0, and the LENGTH specification then defines the number of time units for the run.

PLOT Statement

```
PLOT   NRFR = N,FCAOR = F(0,1)/IC = C(0,4E13)/
X      IO = O(0,1E13)/POP = P(0,1.6E10)
```

The variables whose values are to be plotted in graphical output are specified in a PLOT statement, which gives both the symbol used to plot the value of a variable and the range of values to be plotted. For example, NRFR = N means that NRFR is plotted with the symbol N. The range of NRFR is determined implicitly by the compiler so that all values of NRFR that occur in a run are included in the graph. The specification POP = P (0,1.6E10) means that POP is plotted on a scale from 0 to 1.6×10^{10}. Values of POP outside this range do not appear on the graphical output. An X in the first column of a card indicates that the contents of the card are to be considered an extension of the expression on the preceding card.

HOW TO READ A DYNAMO GRAPHICAL OUTPUT

Figure E-1 is an example of a typical DYNAMO output (from the nonrenewable resource sector). The first line on the left lists the symbols used for plotting each variable. For example, NRFR is the variable name for nonrenewable resource fraction remaining, in the DYNAMO program, and the symbol used for plotting NRFR is N.

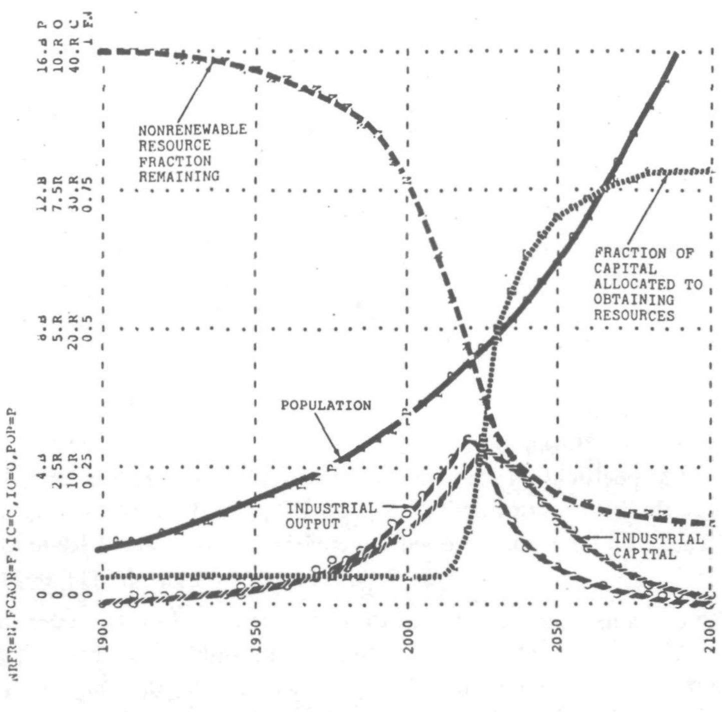


Figure E-1 Standard run for the nonrenewable resource sector

The remaining lines to the left of the graph give the scales for the plotted variables. The scales are divided into four equal parts by the compiler. Scientific notation is used and the power of ten employed as a scaling factor is indicated either with a standard exponential designation, for example 5 E+10 or with an alphabetic character (see Figure E-2). For example, the scale for IC, plotted as C in Figure E-1, has an upper value of 40.R, which is 40×10^{12} units. In the model run shown in Figure E-1, both the nonrenewable resource fraction remaining NRFR (plot symbol N) and the fraction of capital allocated to obtaining resources FCAOR (plot symbol F) are plotted on the same scale.

Letter	Multiply Plotted Value by	Letter	Multiply Plotted Value by
A	10^{-3}	N	10^{30}
B	10^{9}	P	10^{24}
C	10^{27}	Q	10^{15}
D	10^{33}	R	10^{12}
E	10^{-6}	S	10^{21}
F	10^{-9}	T	10^{3}
G	10^{-12}	U	10^{-24}
H	10^{-15}	V	10^{18}
J	10^{-18}	W	10^{-27}
K	$<10^{-30}$ (off scale)	X	1
L	10^{-21}	Y	10^{-30}
M	10^{6}	Z	$>10^{33}$ (off scale)

Figure E-2 Scaling letters used in DYNAMO

Time is plotted along the horizontal axis of the graph. The compiler attaches a "date" to the scale at every tenth plot period.

The series of letter groups that sometimes appear along the top of the graphical output indicate points at which two or more plot symbols overlap. The first letter is the one that is actually plotted in the output. The other letters identify the other variables whose plotted values intersect at that point. The intersections are purely geometric features of a given set of curves and scales; they are of no dynamic significance.

APPENDIX C - THE DEVELOPMENT OF THE WORLD MERCHANT FLEETS

Source: UNCTAD - Review of maritime transport 1975; TD/B/C.4/149, May 1976

Table 1 shows the distribution of world tonnage by groups of countries of registration.
Over the period 1965-1975 the tonnage of developing countries tripled, but their share declined from 7.3% to 5.6%.
Table 2 shows a break-down of the world tonnage by type of vessel and by groups of countries of registration. The developing countries own relatively more general cargo ships than any other vessel type.
The share of the developing countries in world tonnage is quite in contrast with their share in world seaborne trade. Table 3 shows the world seaborne trade by types of cargo and shares of groups of countries. In 1973, 63.7% of all goods loaded came from, and 17.3% of all goods unloaded went to developing countries.
Table 4 shows for a number of countries the approximate percent of the country's total seaborne foreign trade carried by national flag ships (source: U.S. Dept. of Commerce - Maritime subsidies; Gov. Printing Office, Washington D.C., 1971 + 1974)
Table 5 shows the merchant fleets by flag of registration, groups of countries and types of ships.

Table 1

Flags of registration in groups of countries b/	Tonnage and shares (in parenthesis)							Increase in tonnage (grt)		
	In grt (million)				In dwt (million)			Share of increase (%)		Index 1975 (1965 = 100)
	1965	1970	1974	1975	1970	1974	1975	1965-1975	1974-1975	
1. World total	146.8 (100.0)	217.9 (100.0)	306.1 (100.0)	336.9 (100.0)	326.1 (100.0)	486.9 (100.0)	546.3 (100.0)	100	100	229
2. Developed market-economy countries (excluding Southern Europe)	90.6 (61.7)	124.2 (57.0)	155.6 (50.8)	165.5 (49.1)	186.4 (57.2)	246.7 (50.7)	266.4	39.4	32.1	183
3. Open registry countries c/	22.1 (15.1)	40.9 (18.8)	74.5 (24.3)	88.4 (26.2)	70.3 (21.6)	133.5 (27.4)	161.9	34.9	45.1	400
4. Southern Europe (excluding Cyprus)	11.8 (8.0)	17.6 (8.1)	30.8 (10.1)	32.1 (9.6)	25.6 (7.8)	49.2 (10.1)	51.8	10.7	4.2	272
5. Total 2-4	124.5 (84.8)	182.7 (83.9)	260.9 (85.2)	286.0 (84.9)	282.3 (86.6)	429.4 (88.2)	480.1 (87.9)	85.0	81.4	230
6. Socialist countries of Eastern Europe and Asia	10.9 (7.4)	19.5 (8.9)	25.3 (8.3)	28.3d/ (8.4)	21.7 (6.6)	28.9 (6.0)	33.1d/ (6.1)	9.2	10.1	261
7. Developing countries	10.7 (7.3)	14.5 (6.7)	18.5 (6.0)	21.2 (6.3)	20.4 (6.3)	26.5 (5.4)	30.9 (5.6)	5.5	8.5	197
Total (excluding open registry countries)										
In Africa	0.6	0.8	1.5	1.8	1.1	2.0	2.5	0.6	0.1	300
In Asia	5.5	8.0	9.9	11.8	11.7	14.7	17.7	3.3	5.8	213
In Latin America and the Caribbean	4.6	5.7	7.0	7.5	7.6	9.7	10.6	1.5	1.6	163
In Oceania	-	-	0.1	0.1	0.0	0.1	0.1	-	-	-
8. Other - unallocated	0.7 (0.5)	1.2 (0.5)	1.4 (0.5)	1.4 (0.4)	1.7 (0.5)	2.1 (0.4)	2.2 (0.4)	0.4	-	200

Table 2

Country grouping	Year	All ships b/		Tankers	Ore and bulk c/ carriers, including combined carriers	General cargo d/	Container ships	Barge carrying vessels	Other ships
		Million grt	% of world total	Percentage share by vessel type					
1. World total	1965	146.8	100.0	37.1	11.1			51.8	
	1974	306.1	100.0	42.2	25.1	21.9	2.1	0.2	8.5
	1975	336.9	100.0	44.5	24.6	20.3	1.8	0.2	8.6
				Percentage share by groups of countries					
2. Developed market-economy countries (excluding southern Europe)	1965	90.6	61.8	62.9	69.0			64.6	
	1974	155.6	50.9	53.2	53.7	38.6	91.5	100.0	51.3
	1975	165.5	49.1	51.1	52.0	36.1	91.4	100.0	52.1
3. Southern Europe, excluding Cyprus	1965	11.8	8.0	4.9	6.2			9.3	
	1974	30.8	10.1	8.5	11.5	13.6	1.6	-	6.9
	1975	32.1	9.6	8.0	10.9	13.2	1.4	-	6.7
4. Open registry countries e/	1965	22.1	15.0	23.8	20.3			6.7	
	1974	74.5	24.3	30.9	27.1	18.2	4.5	-	4.9
	1975	88.4	26.2	32.9	28.7	19.6	5.0	-	5.7
5. Socialist countries of Eastern Europe and Asia	1965	10.9	7.4	4.5	1.3			9.5	
	1974	25.3	8.3	3.6	2.9	15.7	0.8	-	30.0
	1975	28.3	8.4	3.7	3.5	16.7	1.0	-	28.7
6. Developing countries (excluding open registry countries)	1965	10.7	7.3	3.8	3.2			9.2	
	1974	18.5	6.0	3.6	4.3	13.0	1.6	-	6.5
	1975	21.2	6.3	4.1	4.4	13.6	1.2	-	6.5
of which:									
in Africa	1965	0.6	0.4	0.1	-			0.5	
	1974	1.5	0.5	0.2	-	1.2	-	-	0.8
	1975	1.8	0.6	0.3	-	1.4	-	-	1.0
in Asia and Oceania	1965	5.5	3.8	0.7	2.9			5.4	
	1974	9.9	3.2	1.5	3.1	7.3	1.6	-	2.7
	1975	11.8	3.5	2.0	3.1	7.6	1.2	-	3.1
in Latin America and the Caribbean	1965	4.6	3.1	3.0	0.3			3.3	
	1974	6.6	2.3	1.9	1.2	4.5	-	-	3.0
	1975	7.5	2.2	1.8	1.2	4.6	-	-	2.5
Other - unallocated	1965	0.7	0.5	0.1	-			0.7	
	1974	1.4	0.4	0.2	0.5	0.9	-	-	0.4
	1975	1.4	0.4	0.2	0.5	0.9	-	-	0.3

World seaborne trade[a/] in 1965, 1972[b/], 1973 and 1974[c/] by types of cargo and shares of groups of countries [d/]

(Millions of tons and percentages of world total)

Country group	Year	Goods loaded				Goods unloaded			
		Petroleum		Dry cargo	Total all goods	Petroleum		Dry cargo	Total all goods
		crude	products			crude	products		
		(Trade in millions of tons)							
World total	1965	622	240	812	1 674	622	222	832	1 676
	1972	1 321	332	1 221	2 874	1 325	316	1 217	2 858
	1973	1 514	353	1 407	3 274	1 521	339	1 377	3 237
	1974	1 838		1 450	3 288	1 810		1 456	3 266
		(Percentage share of each category of goods in total)							
World total	1965	37.2	14.3	48.5	100.0	37.1	13.2	49.7	100.0
	1972	46.0	11.5	42.5	100.0	46.4	11.0	42.6	100.0
	1973	46.2	10.8	43.0	100.0	47.0	10.5	42.5	100.0
	1974	55.9		44.1	100.0	55.4		44.6	100.0
		(Percentage share of trade by groups of countries)							
Developed market-economy countries (excluding Southern Europe)	1965	0.1	23.0	53.5	28.6	76.4	77.0	72.3	74.5
	1972	2.0	28.5	59.1	29.3	76.0	78.4	73.3	75.1
	1973	2.1	27.7	60.5	29.9	75.3	79.5	73.5	75.0
Southern Europe	1965	-	0.3	2.4	1.2	2.5	2.0	4.2	3.2
	1972	-	1.7	2.5	1.3	4.1	3.1	4.3	4.1
	1973	-	2.1	2.4	1.3	5.0	2.2	4.0	4.3
Socialist countries of Eastern Europe and Asia	1965	4.6	8.9	8.2	6.9	0.4	1.0	5.9	3.2
	1972	3.1	8.5	7.5	5.6	1.8	0.9	5.7	3.4
	1973	2.9	8.6	6.6	5.1	2.1	0.9	5.5	3.4
Developing countries	1965	95.3	67.8	35.9	63.3	20.7	20.0	17.6	19.1
	1972	94.9	61.3	30.9	63.8	18.1	17.6	16.7	17.4
	1973	95.0	61.6	30.5	63.7	17.6	17.4	17.0	17.3
of which:									
In Africa	1965	16.0	1.7	10.6	11.3	2.5	5.1	4.1	3.7
	1972	19.7	3.3	8.5	13.1	1.7	3.4	3.7	2.7
	1973	18.0	3.1	8.0	12.1	1.6	3.2	3.6	2.6
In Asia	1965	58.4	23.3	9.2	30.0	5.5	8.5	9.0	7.6
	1972	66.0	25.7	9.0	37.1	7.7	7.7	8.6	8.1
	1973	68.5	21.3	9.1	37.9	7.0	8.1	9.1	8.0
In Latin America and the Caribbean	1965	20.9	42.8	15.4	21.6	12.7	6.0	4.3	7.7
	1972	9.2	32.2	12.8	13.3	8.6	5.8	4.2	6.4
	1973	8.5	36.9	12.8	13.4	8.9	5.4	4.1	6.5
In Oceania	1965	-	-	0.7	0.4	-	0.4	0.2	0.1
	1972	-	0.1	0.6	0.3	0.1	0.7	0.2	0.2
	1973		0.1	0.6	0.3	0.1	0.7	0.2	0.2

Table 4

country	% 1971	% 1974	country	% 1971	% 1974
Argentina	18	21	Italy	23	23
Australia	2	1	Japan	47	47
Belgium	5	5	Korea, South	24	24
Brazil	8	33	Kuwait	1	-
Canada	34	26	Mexico	15	15
Chile	28	33	Netherlands	7	5
Taiwan	37	40	Norway	43	37
Denmark	13	13	Pakistan	14	14
Finland	49	49	Philippines	22	22
France	38	32	Singapore	3	3
Germany (Fed.Rep.)	29	30	South Africa	23	26
Greece	40	48	Spain	37	37
India	21	20	Sweden	22	19
Indonesia	37	37	Thailand	1	5
Israel	50	50	Turkey	28	28
Uruguay	26	26	United Kingdom	35	34
Venezuela	10	10	United States	5	6

Table 5

Merchant fleets of the world by flag of registration a/, groups of countries and types of ships b/ in grt and dwt, as at 1 July 1975

(dwt figures are shown in parentheses)

	Total	Tankers	Bulk c/ carriers	General cargo d/	Container ships	Others
World total e/	336 929 974 (546 259 886)	149 794 351 (281 174 916)	82 742 772 (142 372 264)	68 555 540 ..	6 226 213 ..	29 611 098 ..
Developed market-economy countries						
Australia	1 205 248 (1 621 459)	263 152 (429 347)	434 737 (675 170)	230 750 ..	106 314 ..	170 295 ..
Austria	75 396 (144 978)	- -	22 712 (34 188)	49 355 ..	3 329 ..	- -
Belgium	1 358 425 (2 055 002)	367 069 (623 885)	546 889 (930 324)	301 739 ..	31 036 ..	111 692 ..
Bermuda	1 450 387 (2 557 302)	1 024 524 (1 874 437)	371 298 (609 592)	31 302 ..	- -	23 263 ..
Canada	988 726 (899 209)	237 388 (319 396)	81 021 (137 003)	264 905 ..	- -	405 412 ..
Denmark	4 478 112 (7 153 869)	2 161 291 (4 115 705)	552 206 918 857)	1 162 363 ..	178 694 ..	423 558 ..
Faeroe Islands	49 617 (28 267)	- -	- -	7 733 ..	- -	41 884 ..
Finland	2 001 618 (3 008 114)	1 139 779 (2 000 845)	153 257 (245 840)	485 757 ..	3 895 ..	218 930 ..
France	10 745.999 (18 134 518)	6 937 904 (13 137 135)	1 405 442 (2 403 643)	1 389 318 ..	138 770 ..	874 565 ..
Germany, Federal Republic of	8 516 567 (13 611 276)	2 724 643 5 133 196)	2 201 988 (3 776 351)	2 447 800 ..	637 809 ..	504 327 ..
Iceland	154 381 (128 669)	2 434 (3 756)	- -	58 998 ..	- -	92 949 ..
Ireland	210 389 (280 881)	5 688 (7 501)	148 319 (232 087)	15 685 ..	6 530 ..	34 167 ..
Italy	10 136 989 (15 602 898)	4 061 018 (7 214 005)	3 559 815 (6 123 297)	1 134 986 ..	97 077 ..	1 284 093 ..
Japan	39 739 598 (64 479 156)	17 519 924 (32 625 113)	12 401 382 (20 411 817)	4 912 288 ..	1 086 025 ..	3 819 979 ..
Monaco	14 588 (16 119)	10 590 (15 610)	- -	- -	- -	3 998 ..
Netherlands	5 679 413 (8 631 289)	2 637 318 (4 770 262)	508 096 (812 945)	1 829 751 ..	153 803 ..	550 445 ..
New Zealand	162 520 (174 248)	- -	- -	112 964 ..	- -	49 556 ..
Norway	26 153 682 (45 597 278)	13 386 687 (25 642 684)	9 214 941 (15 807 707)	1 866 604 ..	52 196 ..	1 633 254 ..
South Africa	565 575 (650 764)	27 355 (43 367)	56 873 (88 120)	301 273 ..	2 994 ..	177 080 ..
Sweden	7 486 196 (12 244 641)	3 033 080 (5 827 629)	2 775 365 (4 755 989)	1 099 649 ..	99 158 ..	478 944 ..
Switzerland	193 657 (293 727)	2 900 (2 901)	52 115 (83 055)	135 167 ..	- -	3 475 ..
United Kingdom	33 157 422 (53 421 663)	16 096 078 (29 871 486)	8 107 658 (13 903 826)	4 886 389 ..	1 346 559 ..	2 720 738 ..
United States (estimated active sea-going fleet)	10 931 002 (15 605 880)	4 966 972 (8 921 172)	405 323 (784 517)	2 000 079 ..	1 749 682 ..	1 808 946 ..
Sub-total: Developed market-economy countries	165 455 507 (266 341 207)	76 605 794 (142 579 432)	42 999 437 (72 734 328)	24 724 855 ..	5 693 871 ..	15 752 971 ..

	Total	Tankers	Bulk c/ carriers	General cargo d/	Container ships	Others
Southern Europe						
Gibraltar	28 850 (41 591)	- -	26 793 (38 667)	2 057 ..	- -	- -
Greece	22 527 156 (37 541 815)	8 295 415 (15 080 953)	7 172 185 (12 482 045)	6 302 826 ..	34 866 ..	721 864 ..
Malta	45 950 (62 966)	27 442 (44 242)	- -	12 523 ..	- -	5 985 ..
Portugal	1 209 701 (1 709 246)	516 122 (930 051)	73 204 (117 063)	391 189 ..	6 336 ..	222 850 ..
Spain	5 433 354 (8 280 883)	2 555 947 (4 589 291)	1 052 237 (1 821 684)	958 936 ..	32 489 ..	833 745 ..
Turkey	994 668 (1 365 050)	326 710 (541 307)	142 302 (222 378)	378 595 ..	- -	147 061 ..
Yugoslavia	1 873 482 (2 792 984)	250 481 (423 657)	539 313 (889 168)	1 023 422 ..	4 058 ..	56 208 ..
Sub-total: Southern Europe	32 113 161 (51 794 535)	11 972 117 (21 609 501)	9 006 034 (15 571 005)	9 069 548 ..	77 749 ..	1 987 713 ..
Open registry countries						
Cyprus	3 221 070 (4 779 729)	525 979 (831 832)	320 744 (490 852)	2 316 527 ..	2 490 ..	55 330 ..
Liberia	65 820 414 (126 053 631)	41 583 552 (83 441 459)	19 676 002 (36 117 087)	3 611 486 ..	226 407 ..	722 967 ..
Oman	3 159 (3 628)	- -	- -	1 462 ..	- -	1 697 ..
Panama	13 667 123 (22 161 517)	5 530 067 (10 281 717)	2 556 237 (4 071 158)	4 738 982 ..	26 557 ..	815 280 ..
Singapore	3 891 902 (6 215 400)	1 438 536 (2 578 453)	904 130 (1 511 024)	1 408 912 ..	54 655 ..	85 669 ..
Somalia	1 813 313 (2 703 403)	160 258 (260 672)	311 754 (483 223)	1 336 026 ..	- -	5 275 ..
Sub-total: Open registry countries	88 416 981 (161 917 308)	49 238 392 (97 394 133)	23 768 867 (42 673 344)	13 413 395 ..	310 109 ..	1 686 218 ..
Socialist countries of Eastern Europe and Asia						
Socialist countries of Eastern Europe						
Albania	57 368 (78 000)	- -	- -	57 068 ..	- -	300 ..
Bulgaria	937 458 (1 292 507)	299 567 (476 883)	212 237 (302 061)	291 619 ..	- -	134 035 ..
Czechoslovakia	116 148 (191 524)	- -	81 993 (131 112)	34 155 ..	- -	- -
German Democratic Republic	1 389 000 (1 854 090)	288 519 (517 204)	238 870 (368 561)	643 178 ..	- -	218 433 ..
Hungary	47 943 (66 931)	- -	- -	47 943 ..	- -	- -
Poland	2 817 129 (4 040 449)	301 492 (546 247)	1 025 888 (1 616 551)	1 144 909 ..	- -	344 840 ..
Romania	777 309 (1 145 041)	244 431 (431 548)	223 930 (329 400)	198 447 ..	- -	110 501 ..
Union of Soviet Socialist Republics	19 235 973 (20 106 839)	3 712 523 (5 499 294)	618 037 (953 607)	7 319 391 ..	61 112 ..	7 524 910 ..
Sub-total:	25 378 328 (28 775 381)	4 846 532 (7 471 176)	2 400 955 (3 701 292)	9 736 710 ..	61 112 ..	8 333 019 ..

	Total	Tankers	Bulk c/ carriers	General cargo d/	Container ships	Others
Socialist countries of Asia						
China	2 828 290 (4 246 637)	621 578 (1 039 796)	462 069 (779 786)	1 623 338 ..	- -	121 305 ..
Democratic People's Republic of Korea	81 782 (87 117)	21 734 (33 252)	- -	18 758 ..	- -	41 290 ..
Democratic Republic of Viet-Nam	12 011 (15 611)	- -	- -	8 463 ..	- -	3 548 ..
Sub-total:	2 922 083 (4 349 365)	643 312 (1 073 048)	462 069 (779 786)	1 650 559 ..	- -	166 143 ..
Sub-total: Socialist countries of Eastern Europe and Asia	28 300 411 (33 124 746)	5 489 844 (8 544 224)	2 863 024 (4 481 078)	11 387 269 ..	61 112 ..	8 499 162 ..
Developing countries and territories						
Africa						
Algeria	246 432 (299 600)	87 821 (135 710)	23 494 (34 314)	60 658 ..	- -	74 459 ..
Benin	656 (255)	- -	- -	- -	- -	656 ..
Congo	1 846 (275)	- -	- -	- -	- -	1 846 ..
Egypt	301 383 (387 001)	105 945 (165 897)	- -	158 180 ..	- -	37 258 ..
Ethiopia	24 953 (31 585)	2 051 (2 980)	- -	21 678 ..	- -	1 224 ..
Gabon	106 738 (186 178)	74 471 (141 158)	10 503 (15 537)	20 081 ..	- -	1 683 ..
Gambia	1 337 (1 065)	- -	- -	641 ..	- -	696 ..
Ghana	180 351 (202 894)	- -	- -	129 399 ..	- -	50 952 ..
Guinea	15 054 (19 738)	- -	10 764 (15 290)	3 280 ..	- -	1 010 ..
Ivory Coast	119 215 (174 028)	- -	- -	110 581 ..	- -	8 634 ..
Kenya	17 331 (24 617)	2 704 (4 329)	- -	8 579 ..	- -	6 048 ..
Libyan Arab Republic	241 725 (437 074)	221 448 (412 545)	- -	10 786 ..	- -	9 491 ..
Madgascar	44 273 (68 216)	11 043 (17 625)	- -	28 297 ..	- -	4 933 ..
Mauritania	1 681 (334)	- -	- -	- -	- -	1 681 ..
Mauritius	33 105 (45 126)	- -	- -	30 883 ..	- -	2 222 ..
Morocco	79 863 (97 025)	2 536 (4 015)	16 247 (25 000)	41 013 ..	- -	20 067 ..
Mozambique	149 (243)	- -	- -	- -	- -	149 ..
Nigeria	142 050 (188 026)	2 469 (3 443)	- -	125 151 ..	- -	14 430 ..
Senegal	23 261 (23 001)	3 876 (5 246)	- -	5 545 ..	- -	13 840 ..
Seychelles	1 901 (3 050)	1 595 (2 700)	- -	192 ..	- -	114 ..
Sierra Leone	17 209 (24 148)	11 920 (18 737)	- -	3 033 ..	- -	2 256 ..
Sudan	45 578 (59 529)	- -	- -	44 458 ..	- -	1 120 ..

	Total	Tankers	Bulk c/ carriers	General cargo d/	Container ships	Others
Tunisia	40 827 (57 565)	6 433 (9 600)	- -	21 740 ..	- -	12 654 ..
Uganda	5 510 (9 115)	- -	- -	5 510 ..	- -	- -
United Republic of Cameroon	3 199 (933)	- -	- -	- -	- -	3 199 ..
United Republic of Tanzania	33 449 (39 708)	239 (261)	- -	30 447 ..	- -	2 763 ..
Zaire	85 232 (137 445)	- -	- -	76 119 ..	- -	9 113 ..
Zambia	5 513 (9 110)	- -	- -	5 513 ..	- -	- -
Sub-total: Africa	1 819 821 (2 526 884)	534 551 (924 246)	61 008 (90 141)	941 764 ..	- -	282 498 ..
Asia						
Bahrain	3 670 (3 347)	433 (575)	- -	1 943 ..	- -	1 294 ..
Bangladesh	133 016 (180 898)	16 298 (24 657)	- -	98 671 ..	- -	18 047 ..
Burma	54 548 (72 211)	1 478 (1 709)	- -	44 720 ..	- -	8 350 ..
Brunei	283 (400)	- -	- -	283 ..	- -	- -
Cambodia	1 208 (1 537)	- -	- -	998 -	- -	210 -
Democratic Yemen	5 850 (7 479)	- -	- -	3 122 ..	- -	2 728 ..
Hong Kong	418 512 (594 196)	9 417 (14 365)	253 490 (434 380)	115 822 ..	- -	39 783 ..
India	3 869 187 (6 280 555)	657 209 (1 121 652)	1 637 108 (2 817 671)	1 424 808 ..	- -	150 062 ..
Indonesia	859 378 (1 057 751)	87 576 (128 244)	16 881 (24 100)	643 917 ..	- -	111 004 ..
Iran	479 718 (743 905)	180 558 (321 212)	- -	274 196 ..	- -	24 964 ..
Iraq	310 594 (475 034)	226 631 (391 013)	- -	47 743 ..	- -	36 220 ..
Israel	451 323 (604 863)	368 (642)	186 434 (279 744)	188 272 ..	58 281 ..	17 968 ..
Jordan	200 ..	- -	- -	- -	- -	200 ..
Kuwait	990 857 (1 671 659)	614 746 (1 164 250)	- -	331 770 ..	- -	44 341 ..
Lebanon	167 490 (248 750)	- -	- -	158 126 ..	- -	9 364 ..
Malaysia	358 795 (496 661)	25 363 (39 280)	183 850 (288 395)	130 968 ..	- -	18 614 ..
Maldives	95 154 (120 237)	- -	- -	95 154 ..	- -	- -
Qatar	1 389 (725)	200 (350)	- -	- -	- -	1 189 ..
Pakistan	479 358 (649 716)	15 863 (26 880)	11 950 (17 250)	414 417 ..	- -	37 128 ..
Philippines	879 043 (1 211 189)	216 667 (371 530)	60 325 (105 549)	543 066 -	- -	58 985 ..
Republic of Korea	1 623 532 (2 392 287)	646 415 (1 151 241)	227 703 (370 338)	456 664 ..	17 469 ..	275 281 ..
Republic of South Viet-Nam	57 615 (82 884)	5 330 (9 031)	- -	49 703 ..	- -	2 582 ..

	Total	Tankers	Bulk c/ carriers	General cargo d/	Container ships	Others
Saudi Arabia	180 246 (280 551)	118 927 (214 238)	– –	40 300 ..	– –	21 019 ..
Sri Lanka	80 862 (107 623)	19 839 (32 362)	– –	50 997 ..	– –	10 026 ..
Syrian Arab Republic	7 531 (11 242)	– –	– –	6 545 ..	– –	986 ..
Thailand	182 554 (277 128)	92 191 (161 231)	– –	75 932 ..	– –	14 431 ..
United Arab Emirates	50 638 (72 965)	15 118 (22 629)	– –	32 010 ..	– –	3 510 ..
Yemen	1 260 (1 850)	– –	– –	1 260 ..	– –	– –
Sub-total: Asia	11 743 811 (17 647 643)	2 950 627 (5 197 091)	2 577 741 (4 337 427)	5 231 407 ..	75 750 ..	908 286 ..
<u>Latin America</u>						
Argentina	1 447 165 (1 890 544)	546 246 (814 333)	158 423 (248 050)	623 462 ..	– –	119 034 ..
Bahamas	189 890 (280 068)	82 650 (132 726)	55 279 (86 146)	40 029 ..	– –	11 932 ..
Barbados	3 897 ..	– –	– –	– –	– –	3 897 ..
Belize	620 (800)	– –	– –	620 ..	– –	– –
Brazil	2 691 408 (4 293 105)	1 033 385 (1 838 012)	537 926 (988 742)	1 029 979 ..	– –	90 118 ..
Cayman Islands	49 320 (73 151)	1 492 (2 770)	– –	43 543 ..	– –	4 285 ..
Chile	386 322 (568 508)	85 007 (142 003)	80 381 (131 933)	197 443 ..	– –	23 491 ..
Colombia	208 507 (257 710)	4 784 (6 830)	– –	197 544 ..	– –	6 179 ..
Costa Rica	6 102 (5 835)	– –	– –	4 131 ..	– –	1 971 ..
Cuba	476 279 (628 582)	53 706 (80 718)	13 196 (22 670)	313 097 ..	– –	96 280 ..
Dominican Republic	9 920 (13 200)	674 (1 609)	– –	8 861 ..	– –	385 ..
Eduador	142 356 (187 156)	74 465 (115 610)	– –	60 704 ..	– –	7 187 ..
El Salvador	1 957 (3 260)	– –	– –	1 816 ..	– –	141 ..
Falkland Islands (Maldives)	7 931 (5 223)	– –	– –	537 –	– –	7 394 ..
Grenada	226 (340)	– –	– –	226 ..	– –	– –
Guatemala	9 584 (14 016)	– –	– –	9 334 ..	– –	250 ..
Guyana	16 828 (15 753)	943 (1 202)	– –	10 208 ..	– –	5 677 ..
Honduras	67 923 (76 514)	1 223 (1 703)	– –	63 197 ..	– –	3 503 ..
Jamaica	6 740 (6 064)	– –	– –	6 094 ..	– –	646 ..

	Total	Tankers	Bulk c/ carriers	General cargo d/	Container ships	Others
Mexico	574 857 (751 081)	305 519 (482 314)	32 105 (50 760)	120 765 ..	- -	116 468 ..
Montserrat	949 (1 320)	- -	- -	949 ..	- -	- -
Nicaragua	32 720 (45 156)	4 026 (6 107)	- -	26 609 ..	- -	2 085 ..
Paraguay	21 930 (23 619)	2 935 (4 114)	- -	15 566 ..	- -	3 429 ..
Peru	518 361 (617 070)	70 272 (105 377)	134 069 (216 249)	184 680 ..	- -	129 340 ..
St. Kitts-Nevis-Anguilla	405 (290)	- -	- -	149 ..	-	256 ..
St. Lucia	904 (1 140)	- -	- -	904 ..	- -	- -
St. Vincent	5 507 (7 698)	- -	- -	5 320 ..	- -	187 ..
Trinidad and Tobago	13 864 (9 519)	1 736 (2 000)	- -	6 425 ..	- -	5 703 ..
Turks and Caicos Islands	1 572 (2 160)	- -	- -	1 323 ..	- -	249 ..
Uruguay	130 998 (204 513)	92 757 (151 168)	- -	29 830 ..	- -	8 411 ..
Venezuela	515 661 (658 311)	307 882 (448 203)	- -	129 487 ..	- -	78 292 ..
Virgin Islands (United Kingdom)	2 420 (2 477)	- -	- -	1 410 ..	- -	1 010 ..
Sub-total: Latin America	7 543 123 (10 644 183)	2 669 702 (4 336 799)	1 011 379 (1 744 550)	3 134 242 ..	- -	727 800 ..
<u>Oceania</u>						
Fiji	7 674 (7 024)	254 (400)	- -	3 786 ..	- -	3 634 ..
Nauru	48 271 (61 889)	- -	19 564 (31 953)	28 707 ..	- -	- -
New Hebrides	4 916 (6 316)	- -	- -	4 916 ..	- -	- -
Gilbert Islands) Tuvalu)	1 518 (968)	- -	- -	1 518 ..	- -	- -
Papua New Guinea	14 550 (14 538)	783 (474)	- -	8 500 ..	- -	5 267 ..
Solomon Islands	629 (483)	- -	- -	629 ..	- -	- -
Tonga	9 644 (10 584)	- -	- -	6 827 ..	- -	2 817 ..
Sub-total: Oceania	87 202 (101 802)	1 037 (874)	19 564 (31 953)	54 883 ..	- -	11 718 ..
Sub-total: Developing countries and territories	21 136 342 (30 837 628)	6 150 587 (10 449 979)	3 669 692 (6 204 071)	9 312 593 ..	75 750 ..	1 927 720 ..
Other (unallocated)	1 449 957 (2 161 578)	332 287 (588 616)	435 718 (708 438)	598 177 ..	7 622 ..	76 153 ..

APPENDIX D - NOTES

1. Resolution 70 (III); UNCTAD paper TD(III)/Misc.3.GE.72-15177,p.121
   an overview of the UNCTAD (I, II, III) - activities in shipping gives the article (in dutch): André de Wilde - De UNCTAD-commissie voor zeetransport; in: UNCTAD-SCHRIFTEN 2 'De derde wereld en de zee'; Dienst voor de studie van vraagstukken van de derde wereld, Rijksuniversiteit te Gent, Fakulteit der Rechten, Korte Meir 11, 9000 Gent
2. some books on liner shipping:
   . Dieter Sartori; Einführung in die Reedereibetriebslehre; Deutscher Verkehrs-Verlag Gmbh, Hamburg, 1973
   . Lane C. Kendall; The business of shipping; Cornell Maritime Press Inc., Cambridge, Maryland,1973
   . P.M. Alderton; Sea transport; Thomas Reed Publication Ltd, 1973
   . Alan E. Branch; The elements of shipping; Chapman and Hall Ltd, 32nd edition, London, 1975
3. UNCTAD; Establishment or expansion of merchant marines in developing countries; E.69.II.D.1
4. for an overview of past and current system dynamics research activities see:
   System Dynamics Newsletter; System Dynamics Group, Alfred P. Sloan School of Management, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139
   Dynamo II users manual; Pugh-Roberts Associates Inc., Five Lee Street, Cambridge, Mass. 02139
5. Developing countries and shipping; Norwegian Shipping News no.17D/75
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SAMENVATTING

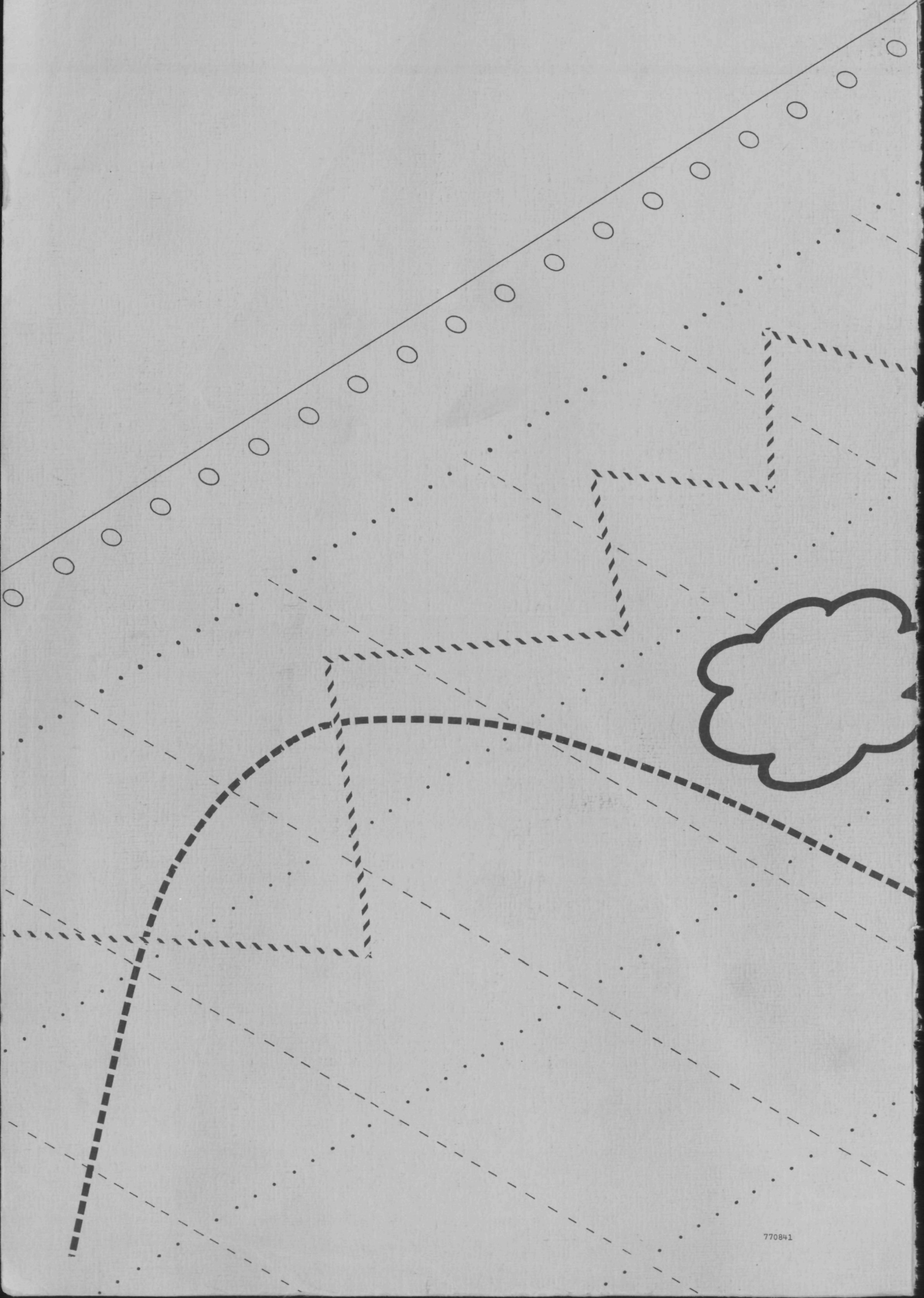
Vele ontwikkelingslanden wensen een koopvaardijvloot, in het bizonder een lijnvaartvloot op te bouwen. Een groot probleem is hierbij dat zij veelal niet de lange termijn konsekwenties op bedrijfs-ekonomisch en nationaal-ekonomisch nivo kunnen overzien van een dergelijk verlangen. De oorzaak hiervan ligt deels in het feit dat zij niet voldoende kennis van de scheepvaart hebben, maar zeker ook aan het gebrek aan metoden en technieken in de scheepvaartkunde.

Dit proefschrift bevat computer-simulatiemodellen waarmee de samenhang tussen de vele variabelen die in de lijnvaart en in een ontwikkelingsland een rol spelen duidelijk wordt, en waarmee tevens de konsekwenties van ieder vlootontwikkelingsplan op de doelstellingen van het ontwikkelingsland kunnen worden berekend. De opbouw van de modellen gebeurt in kleine stappen, zodat voor iedere maritieme planner een overzichtelijk beeld ontstaat.

De data welke gebruikt is in de modellen, is afkomstig uit studies van een ontwikkelingsland in Afrika.

Met behulp van de modellen is de gevoeligheid van de resultaten voor veranderingen in de afzonderlijke parameters doorgerekend. Op basis hiervan zijn parameters geselekteerd welke het belangrijkst zijn voor het maximaliseren van de nationale doelstellingen van het ontwikkelingsland.

Tot slot zijn richtlijnen geformuleerd voor het maken van vlootontwikkelingsstudies in ontwikkelings-landen.



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