APPENDICES

APPENDIX A

A COMPLETE DESCRIPTION OF THE SYSTEMS ANALYSIS

1. FORMULATION OF THE PROBLEM

1.1 First Statement of the Problem

In sponsoring the study, EASAMS' aim was to determine how the tools of systems engineering could be adapted to the design and improvement of the transport systems serving the Caribbean islands and those countries or parts of countries surrounding the Gulf of Mexico and the Caribbean Sea.

To define the problem in more detail some preliminary research was initiated.

1.2 Needs Research

Needs research aims to clarify the problem, redefining it where necessary, so that its scope can be presented in sufficient detail for a project team to be organised. In clarifying the problem, the author examined in turn, the requirements of:

- The study sponsors
- Any authority responsible for implementing the results of a transport study (EASAMS prospective clients).

1.2.1 The Sponsor's Needs

EASAMS' objective was to prove the company's ability to serve the needs of transport operators and investing authorities. In the first case, shipping lines could be assisted to plan their future fleet requirements over specific routes served. In the second, such authorities as the Ministry of Overseas Development, Development Banks and the government authorities of the respective islands could be advised on the optimum allocation of development funds to the transport sector. Thus, EASAMS' requirements would only be satisfied if those of the client were met.

1.2.2. The Clients Needs

There are three important conditions[1] which must be met if the preparation of a transport investment programme is to be worthwhile to a client :

- The region must be policy-oriented with regard to transportation (i.e. the machinery for implementing improvements to a transport system must be available to the appropriate transport authority).

- The policy makers must accept the view that planning is a continuous process

- Transport planning should be conducted in conjunction with regional economic planning[1]

To be of value, any investment policy for the transport sector of a region derived from a study must be capable of being

---

1. For a rigorous discussion of the above criteria, and the reasons for them, see Adler, A. H. Sector and Project Planning in Transportation , John Hopkins Press, 1967, Pages 6-8.

implemented. But the region originally selected for the study had no machinery for implementing transport investment proposals, either existing or in prospect. However, on May 1st, 1968, the Commonwealth Caribbean Free Trade Association, now familiarly called CARIFTA, was born with the signing of an agreement in Antigua on 30th April, 1968. The agreement was subsequently acceded to, and ratified by, the Governments of Jamaica, Guyana, Barbados, Trinidad and the associate territories of St. Kitts, Antigua, Montserrat, Dominica, St. Lucia, St. Vincent and Grenada.

Subsequently, the Institute of Social and Economic Research of the University of the West Indies, in a detailed report on CARIFTA, suggested that a Transport and Allied Services Commission should be formed among the member territories to support a Regional Commission for Economic Integration. Thus a region was identified with the prospect of receiving the machinery for implementing improvements to the transport system where transport planning might be conducted in conjunction with regional economic planning in the near future.

CARIFTA was formed to encourage the progressive development of the economies of the area by promoting the expansion and diversification of trade. A survey of the literature showed that these objectives would not be satisfied unless improvements to intra-regional shipping were made. The infrequency and unreliability of both scheduled and unscheduled transport services was regarded as a limiting factor, particularly to those industries seeking to establish a regular trade between the islands in perishable items. These difficulties are illustrated by three fundamental problems :

- The region's peculiar geography; a string of islands which, because of their small size, generate little transport revenue compared with the long and costly waiting times in harbour.
- Inadequate berthing facilities, creating congestion in ports,

which, for example, have sent up port charges per ton of cargo from $15 to $25 E.C. during 1970, and which, in turn, may increase freight rates.

- Seasonally fluctuating demand.

To enable some of these problems to be solved the study objectives were redefined.

1.3 A reformulation of the study objectives

With the agreement of the supervisory team the author decided that a methodology for deriving a time-phased transport investment programme for the shipping system serving CARIFTA should be developed.

This clearer picture of the scope of the problem enabled the author to organise the project, so that data collection could be carried out in parallel with other activities.

2. ORGANISATION OF THE PROJECT

2.1 Composition of the Systems Team

In December 1968, as an external student, the author was made responsible to Mr. D. J. Cashmore for the project in its entirety. Subsequently, part-time assistance was provided by :

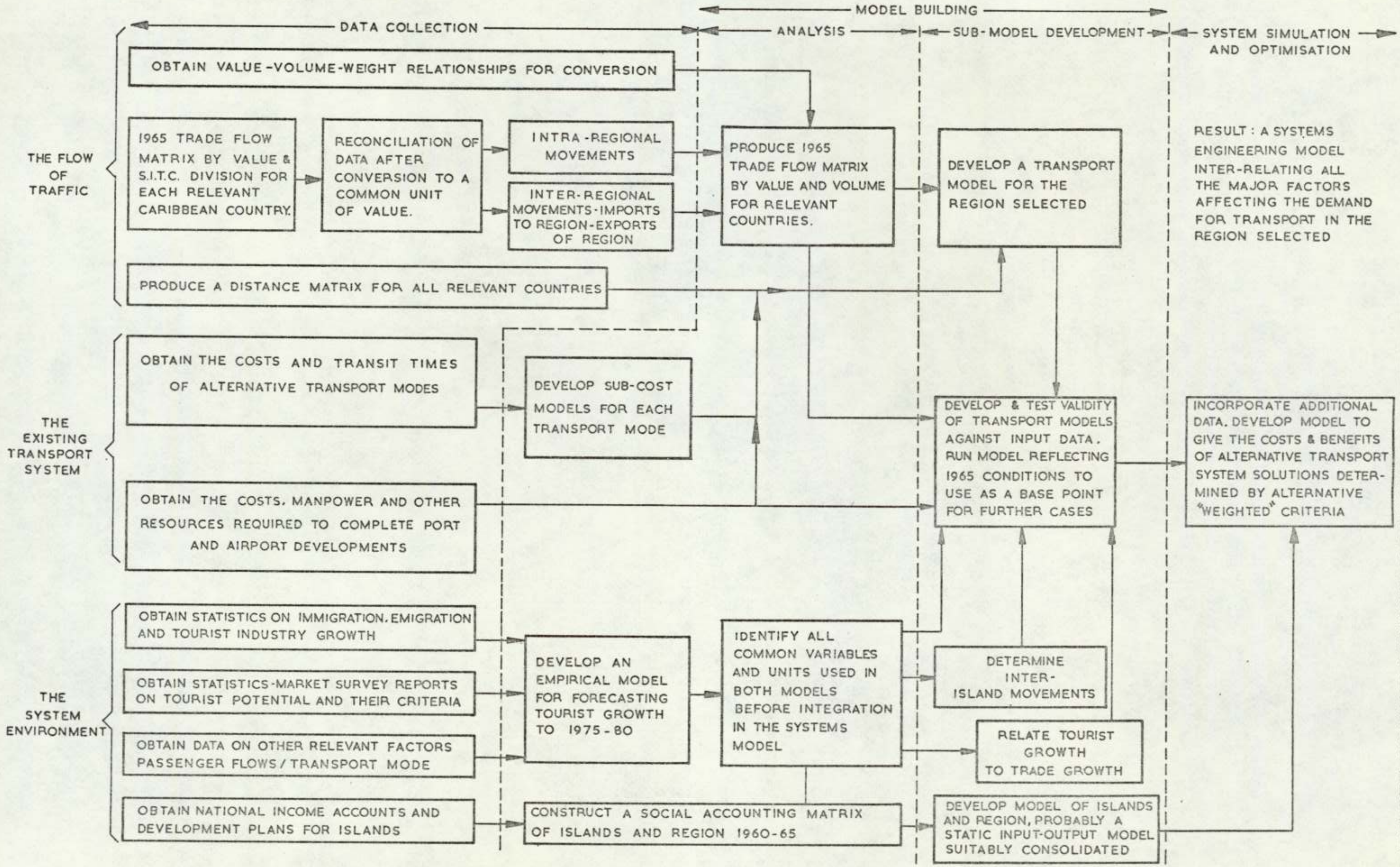
R. A. Friar, an operational research scientist (4 months)

J. R. Walker, a computer scientist (4 weeks)

2.2 Scheduling the Project

The project flow chart of fig A.1 was drawn up to initiate research and data collection activities. The data initially identified as relevant to defining the flow of traffic, the existing system, and its environment was categorized as follows :

- The collection of commodity flow statistics for 1965, the base year chosen for the study
- Cost data on the various forms of sea transport
- Information relating to the existing and potential movement of people
- Economic data on the relevant islands



PROJECT FLOW CHART

FIG. A1

Further data needs could not be identified until the system and its environment (the wider system) had been defined together with the overall economic criterion. The need to define both is that the form of the system is determined by the environment. "In fact the success of the design is measured by .... the degree of integration with the environment. Clearly - the better the environment is understood and evaluated, the more closely can the system be engineered" (Hall, 1960).

Hence, "one of the central objectives of the entire developmental sequence is to locate optimally two functional boundaries, or interfaces:

- The boundary setting off the universe of interest in a given problem

- The boundary between the system and the environment

This means gathering and analysing data to describe the operational situation, customer requirements, economic considerations, policy and possible system inputs and outputs", (Hall, 1960), in relation to the system and its environment.

A system is a set of objects with relationships between the objects and between the characteristics which each object exhibits. In this study objects are regarded as the sub-systems of a system.

In a system, the environment (or wider system) is the set of all objects outside the system, a change in the characteristics of which affect the system and whose characteristics are changed by the behaviour of the system.

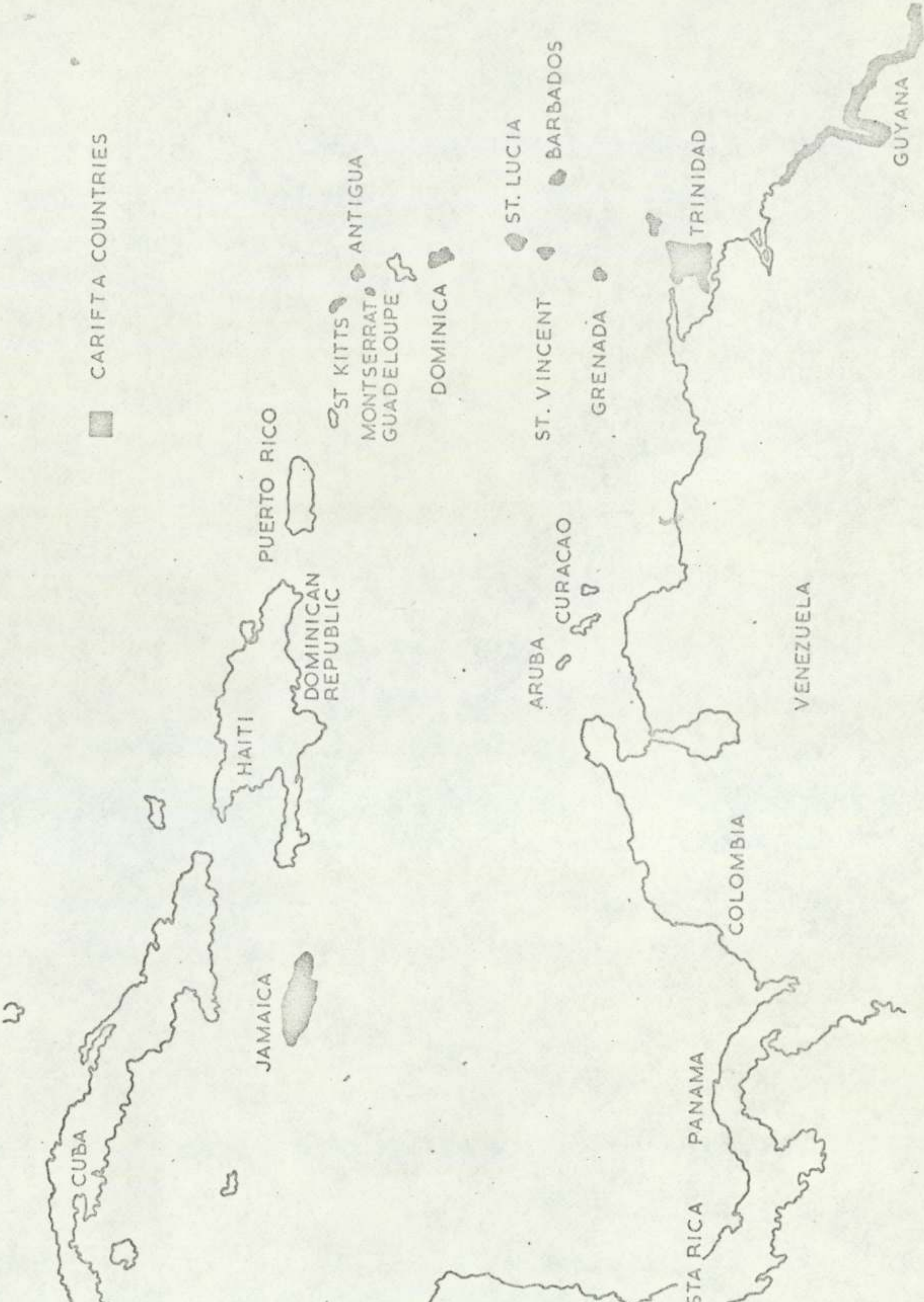
3 DEFINITION OF THE SYSTEM

3.1 The Approach Used to Define a System

To define the boundaries of a problem, the systems approach always requires that the system, the wider system and their objectives should be clearly formulated. Jenkins, (1969). In defining the system in precise terms it has to be broken down into its important sub-systems and the interactions between the latter identified. To do this, information is collected and analysed in respect of the operational and the financial situations and transport policy, the operational system and economic considerations.

3.2 The Operational Situation

The CARIFTA region, selected for this study, is illustrated in figure A.2. Within this region, inter-island transport is carried



CARIBBEAN FREE TRADE AREA

FigA·2

out by a regionally subsidised shipping service, consisting of two ships, the "Federal Maple" and the "Federal Palm", as well as the two cargo vessels of Booker Shipping, and a number of schooners. The "Federal Maple" and the "Federal Palm" sail regularly on fortnightly runs along the chain of islands from Trinidad to Jamaica. The "Booker Trojan" completes a 17-day journey from Guyana calling at Trinidad, Barbados, St. Lucia, St. Vincent and Grenada, while the "Talisman" visits Trinidad, Barbados, Dominica, Montserrat, St. Kitts, Antigua, Martinique, Cayenne and Paramaribo before returning to Guyana. The large number of schooner owners operate unscheduled services between the Leeward and Windward group of islands.

Competition between sea and air transport is very limited as ships' passengers generally belong to a lower income group than that of the flying public (who are largely tourists). In turn, ships carry nearly all the local passenger traffic previously carried by schooners.

All general cargo including oil - for which special shipping and terminal facilities are available - is carried almost entirely be sea. In spite of the existence of the highly subsidized shipping service, the schooners are able to offer competitive freights and better deliveries in nearly all inter-island trade. Over the past few years the fleet has been almost entirely mechanised and a number of locally built additions have been made to it. As a result, the schooners now carry as much inter-island trade as the regionally subsidized federal service.

3.3 The Financial Situation and Transport Policy

The financial situation of transport enterprises affect the extent to which particular facilities can be improved. For example, the timing and extent of port development will be influenced by such factors as the availability of manpower, equipment and capital. Similarly, government transport policy can restrict the categories of improvement that could be implemented.

Frequency of service between ports, freight charges, and routes used are separate policy variables which could be influenced by government or other legislation. The conference system, for example, prohibits a ship from charging anything other than the published conference freight rates.

For these reasons, a survey should, in practice, be carried out, which should include the financial situation of transport enterprises and the governments transport policies. (Adler, 1967) suggests further that the rationale on which policy decisions affecting the transport sector are taken should be reviewed. Such rationale should normally include :

- the rationality of the criteria used in deciding on new investments
- the relationship of tariffs to costs
- the adequacy of user charges
- the nature of the regulatory system

A study of the above will identify those factors which prevent :

- an efficient allocation of funds to transport compared to other sectors
- an optimum distribution of traffic among competing transport modes.

Criteria used in deciding on new investments should avoid such deficiencies as the use of low financial interest rates instead of the higher economic (opportunity) cost of capital and the failure to take into account alternative road transport when building a new railway line.

Rates and fares should reflect the costs of the principal categories of traffic handled - not only for the network as a whole but also by individual line. The survey should, therefore, identify tariffs above and below costs of major traffic categories, the resultant distortions in traffic and investments, and whether adequate freedom exists in fixing and adjusting tariffs.

Users of roads, ports and airports should be charged adequately for the cost of these services through fuel taxes, licence fees, tolls or other charges. If this is not done, "distortions between different transport modes will occur, accompanied by over-investment in transport as a whole, inefficient location of new industries, and an undue burden on the tax system and on public savings". (Adler, 1967).

Government policies on the regulation of trucking and bus services, including licensing, route and distance restrictions, limitations on rates and fares, and weight, and other controls may cause distortions in a country's transport system and can lead to a substantial waste of resources. Other policies that should be reviewed include :

- whether taxes, including import duties, are neutral among the various transport modes;
- whether the government discriminates in the availability and terms of financing among the modes;
- whether the government tries to allocate traffic directly to a specific mode;
- whether the government controls the production or imports of vehicles, spare parts, etc. in a way which discriminates against a particular mode; and
- whether the government imposes any special responsibility on a particular mode without adequate compensation.

Because governments can develop and administer their transport policies only when properly organized to do so, a transport survey must also review the institutional arrangements. It must ask whether a central transport organization exists at all, and if so, analyze the scope of its authority, i.e. whether it includes all modes and methods of coordination, whether it is properly staffed, and whether adequate statistics are available, so that policies can be established and applied intelligently.

The need to carry out such activities while, no doubt, very relevant to an actual study, were considered to be of less importance when considered in relation to the objectives of this study. To undertake the activities specified by Adler, (1967) was considered quite impossible unless full access to the government departments and other sources of information was obtained. It was therefore decided to ensure that essential elements of data should be incorporated in the methodology to be developed. In this way, the methodology will be applicable to transport investment planning, should a client sponsored study be undertaken.

3.4 The Operational System

3.4.1 Introduction

The broad boundaries of the intra-regional transport system can be defined by those territories forming the regions when the study was initiated. (See figure A.2).

Each island is both an exporter and importer of people, goods and services. Of these, the people and commodities (goods), can form both inter and intra-regional trade, and it is these that create a demand for transport in the form of air and shipping services.

For the purposes of this study, the physical facilities serving the needs of intra-regional trade (or rather the wider system) can be defined as the system, the behaviour of which is modified by changes in the characteristics of the wider system because of changes in the volume and composition of traffic flows.

3.4.2 Physical Facilities

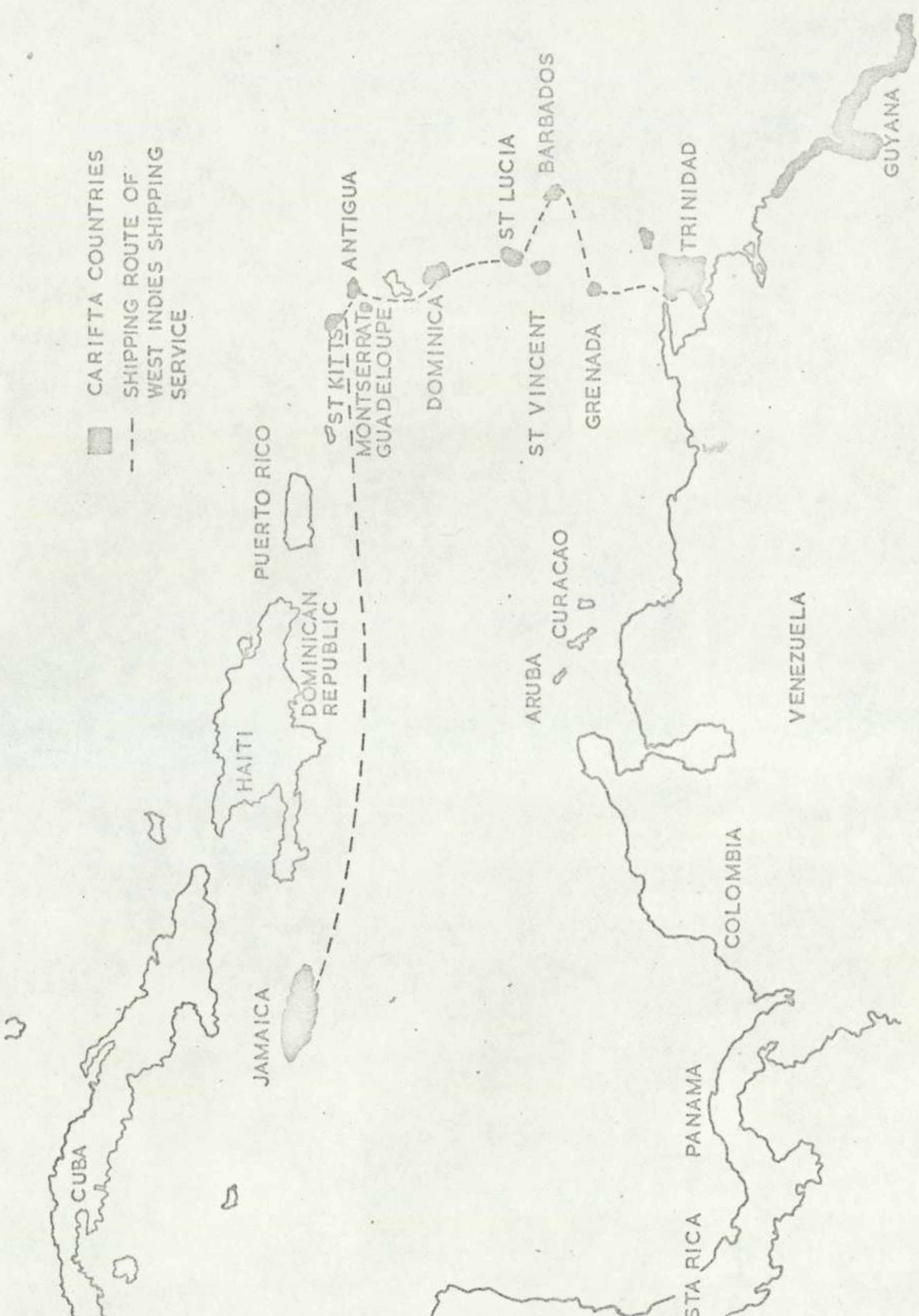
Introduction

The physical subsystems forming the system consist of the ships and the ports they visit. The Federal Maple and the Federal Palm will, it is assumed, come under the jurisdiction of the projected Transport and Allied Services Commission. At present, both these ships visit all the ports in the order shown in figure A.3, returning in the reverse order. Both ships are identical having gross tonnages of about 3200, speeds of 14 knots, accommodation for 50 cabin and 200 deck passengers (accommodated under cover and in dormitories), and 2000 cubic tons of total hold capacity, which with deductions made for the refrigeration area and broken storage could accommodate about 1500 cubic tons of dry cargo.[3]

In addition, the Windward and Leeward Islands, are served by a fleet of privately owned, schooners, sloops and motorised vessels.

---

3. For a full descriptive background to the development of the transport system within CARIFTA see O'Loughlin, C, Economic and Political Change in the Leeward & Windward Islands, Yale University Press, 1968, pages 155-165.



THE SHIPPING ROUTE USED

Fig A.3

The individual owners are forming consortia to combat the increasing traffic being carried by the Federal service.[4]

Booker-McConnell also run scheduled liner services, as described in section 3.2, the routes and ports chosen being published each year in the light of forecasts made in the previous year.

The ports within the region can be divided into two groups. The first group contains those ports with deepwater harbours while the second group use lighters which discharge or collect their cargo from the jetty and move it to and from ships anchored several hundred yards from the shore. In 1968, those ports within the two groups were as given below :

GROUP 1		GROUP 2	
PORT	TERRITORY	PORT	TERRITORY
KINGSTON	JAMAICA	BASSETERRE	ST. KITTS
ST. JOHNS	ANTIGUA	ROSEAU	DOMINICA
CASTRIES	ST. LUCIA	PLYMOUTH	MONTSERRAT
PORT OF SPAIN	TRINIDAD		
GEORGETOWN	GUYANA		
BRIDGETOWN	BARBADOS		
KINGSTOWN	ST. VINCENT		
ST. GEORGES	GRENADA		

4. A Regional Shipping Council, based in Jamaica, led by a Mr. Mohammed is understood to be considering such matters. The fact was reported at a meeting of the West India Committee in London on 26th September, 1969.

Descriptions of the current situation[5] showed that although lighterage facilities are available when required, port docking facilities are limited to specific types of ship. This view is confirmed by O'Loughlin, 1968, who states "if lack of shipping has been an important factor in retarding economic and social development, lack of good port facilities has been a determining factor in limiting shipping services." This is supported by Mr. Nicolson, of Booker McConnell, who told the author that both St. Kitts and Montserrat only have lighterage facilities for his 1000 ton coasters. Dominica has one jetty while the congestion in the port in Trinidad, due to the increase in trade, is increasing some ships turnround time to 5 days.

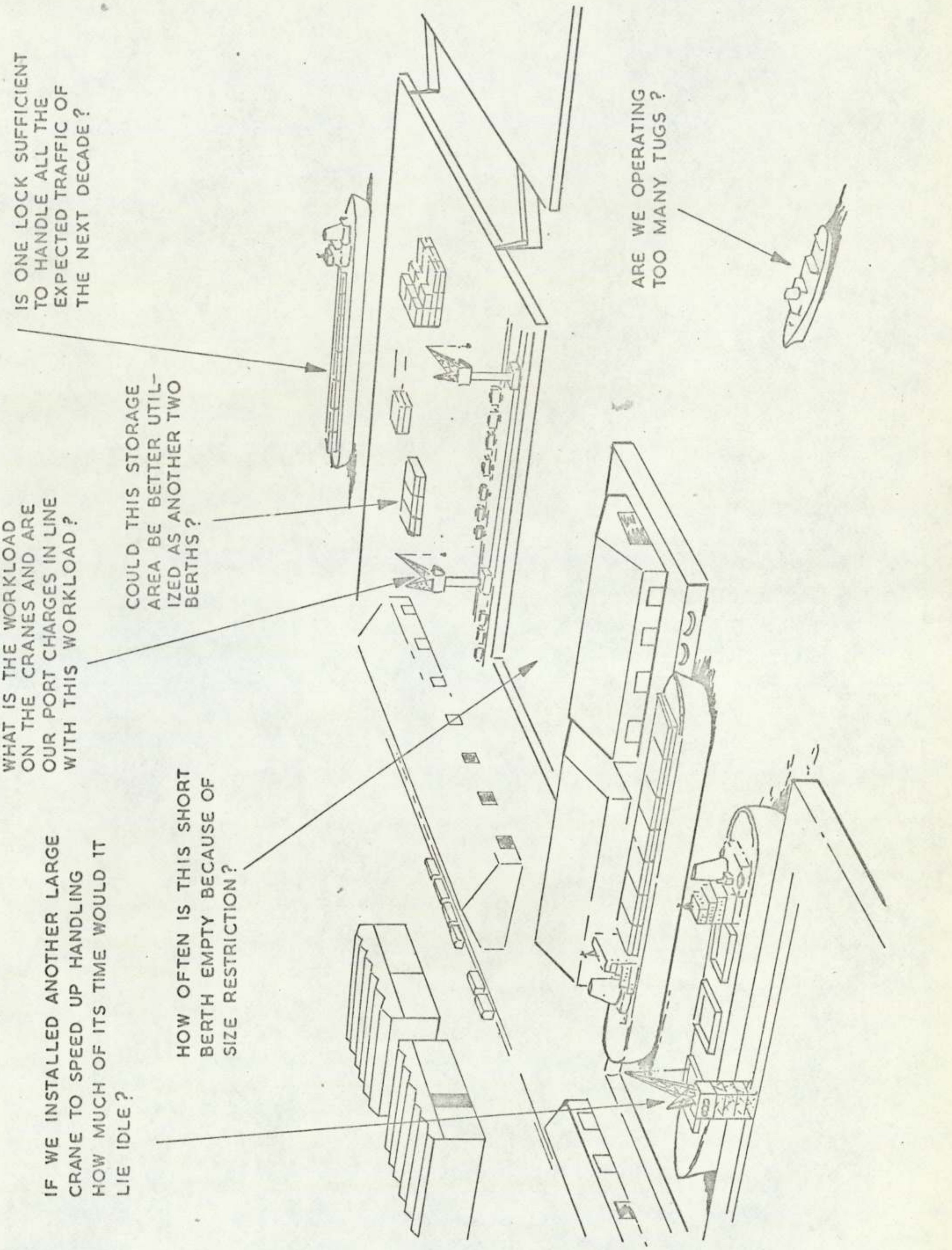
Recent unpublished studies by EASAMS suggest that the whole complex of port operations can be related to three main quantifiable factors :

- On-loading capacity
- Off-loading capacity and
- Ship docking capacity

Figure A.4 illustrates some of these factors, which, in port design studies, can be incorporated into a model of the port's capacity as defined above. In practice, these constraints may be used to pinpoint the areas for further detailed studies, should a particular port be identified during system design as inefficient

---

5. For a full description, see "Industrial Ports of the Caribbean", <u>Financial Times</u>, 27th August, 1969. Additional information can be found in Benn, Ports of the World, 1967.



A PORT COMPLEX

FigA-4

or inadequate.

3.4.3 The Volume and Composition of Traffic Flows

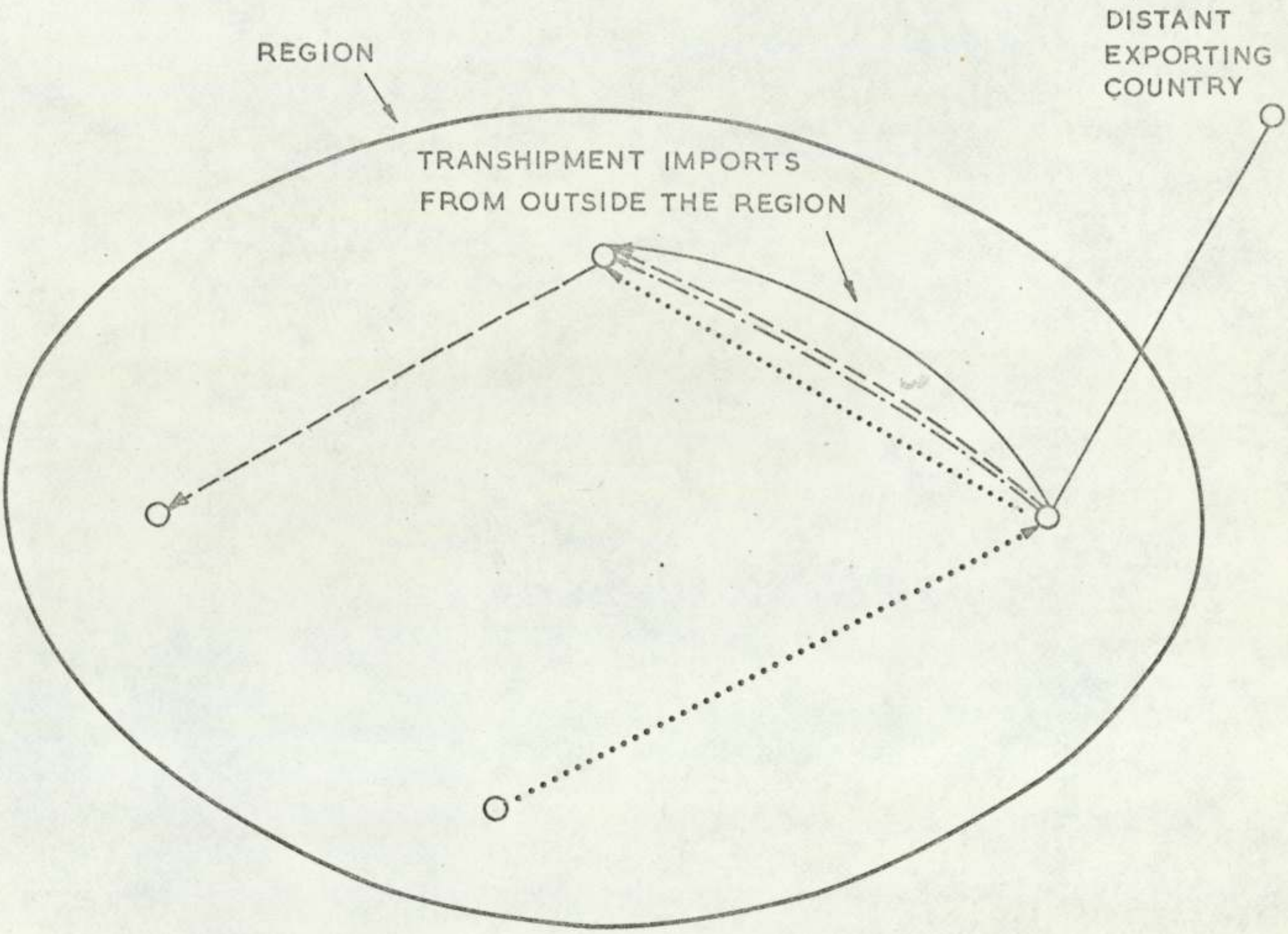
Before data collection was pursued in earnest, the data needs of the transport model, as yet unformulated had to be assessed. FigureA.5 shows that intra-regional commodity flows can comprise imports, exports, re-exports and goods for transhipment (i.e. the possible composition of the commodities carried over a shipping route). Thus, the need to collect such data in volume terms becomes important, because the volume of traffic affects the capacity of the transport system.

3.5 Economic Considerations

The main economic influence over each subsystem is the level of traffic. This can be classified in terms of the movement of tourists, local travellers and cargo, which determine the revenue derived by the transport system. To determine those factors which affect the cost of transport system operation all the inputs to and outputs from each sub-system were listed (influencing factors) so that this information could be reduced to workable proportions for subsequent analysis.[6]

---

6. For a full discussion of this approach, see Gregory, S.A., "Definitions and Methodologies," The Design Method, Butterworth, 1966, pages 24-30.



CATEGORY	
——	RE-EXPORTS OR TRANSHIPMENT GOODS DUE TO DISTANT COUNTRY.
......	RE-EXPORTS OR TRANSHIPMENT GOODS DUE TO INTRA-REGIONAL ISLAND.
—·—·	DOMESTIC EXPORTS.
– – –	EXPORTS DUE FOR TRANSHIPMENT.

COMPOSITION OF INTRA-REGIONAL COMMODITY MOVEMENTS

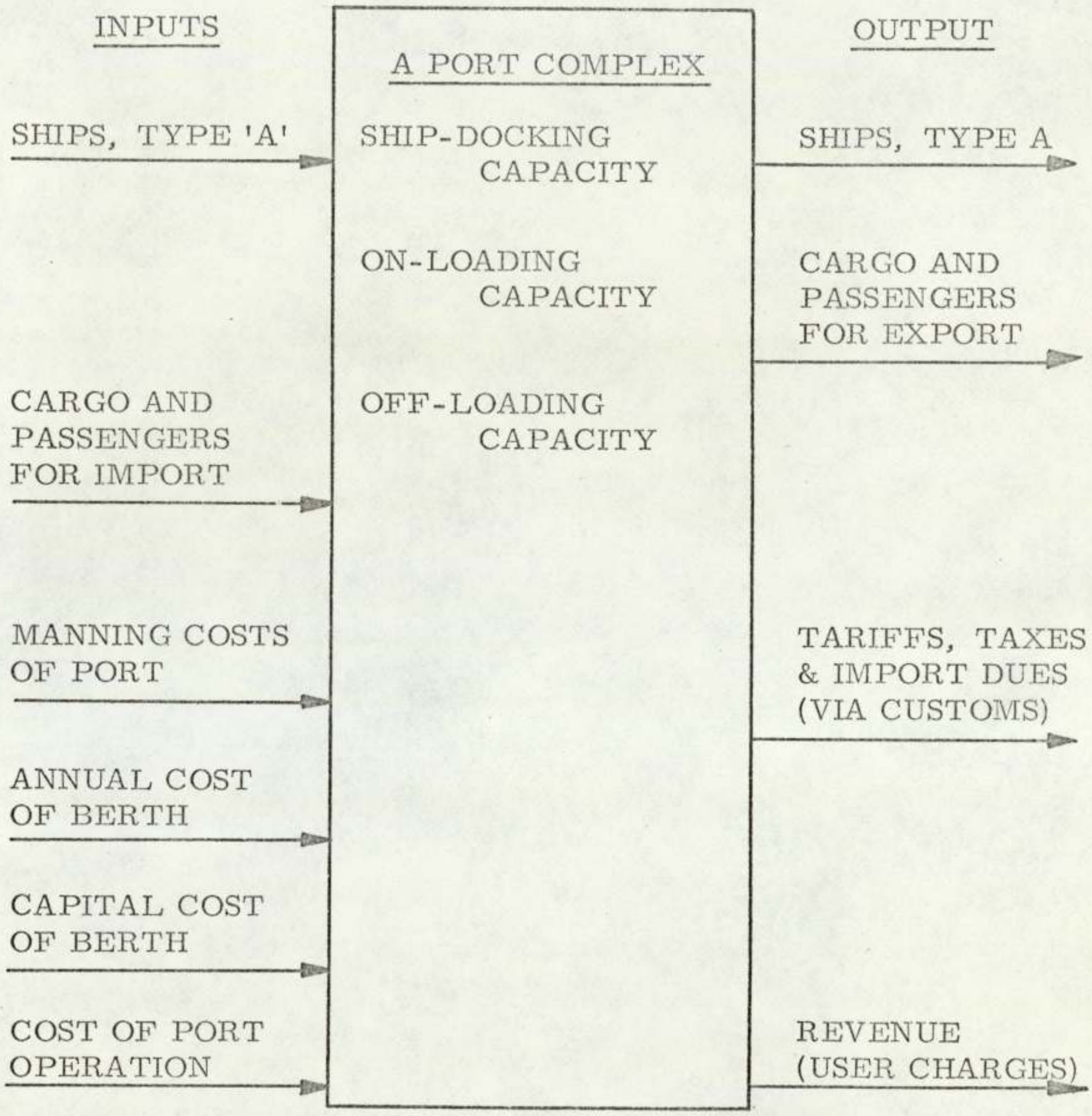
Fig.A·5

3.5.1 Port Costs

The cost of operating a port depends upon the cost of existing and future investments, the cost of maintenance and operation, and the revenue derived from it. The handling costs of a particular berth, for example, are determined by such factors as :

- Berth throughput
- Berth design and equipment
- Capital cost of berth
- Annual cost of berth
- Manning costs and other port charges

Sections 3.3 and 3.4 have identified a number of factors which could influence the operation of any of the ports within CARIFTA. An exhaustive listing of all the inputs and outputs to the subsystem, visualised as a black box was made. The inputs and outputs were then grouped according to whether they referred to the flow of information, materials, or money. The results of this exercise is illustrated in figure A.6 which lists factors relevant to the study.



Factors affecting port costs Fig. A.6

3.5.2 Shipping Costs

Recent studies undertaken by EASAMS suggest that the cost of operating a ship will be affected by the following:[7]

- Annual capital cost of ship
- Cost of hired equipment (X)
- Cost of stores and provisions (X)
- Administration costs (X)
- Repair costs (X)
- Number of journeys per annum
- Sailing distance
- Time in port
- Number of ports of call
- Number of ships
- Manning costs
- Cost of fuel per mile
- Cost of fuel in port
- Port charges, cost per call
- Cost of loading and discharge*

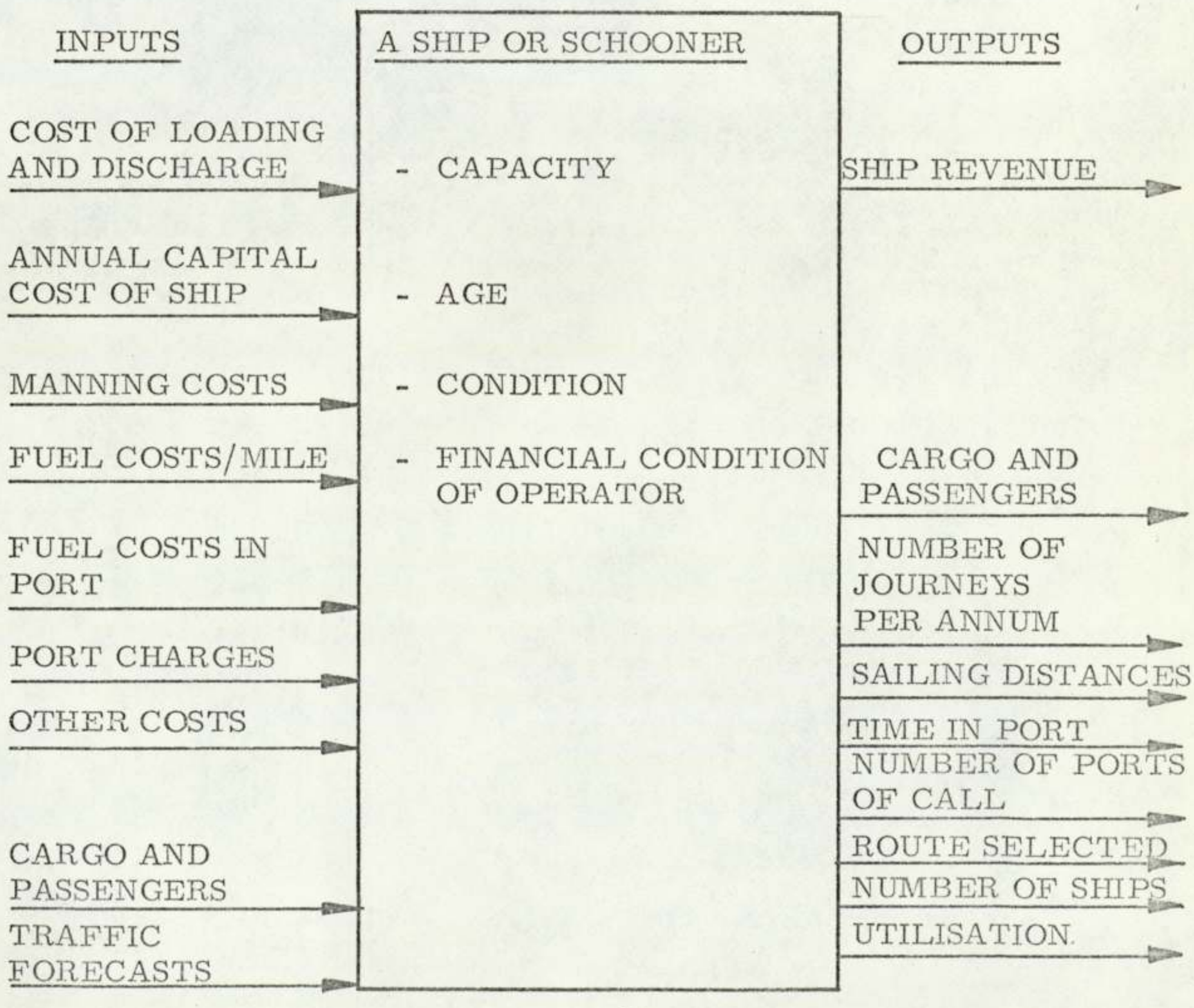
The last item* represented a significant part of the freight revenue of Booker-McConnell's liner service[8] (defined by the fact that it is a scheduled service with a published route which is faithfully followed).

---

7. Sources: EASAMS report to Autostrade, S.P.A. June 1968, edited by R.W. McLean, formerly of EASAMS.
8. - M.A. Nicolson of Booker-McConnell, Ltd.

Route changes are made after the annual freight forecast has been made. The cost elements marked by (X) could be regarded as a fixed cost and included within the annual capital cost of the ship.

A listing of all the inputs and outputs to the subsystem, visualised as a black box, was made. The inputs were then grouped according to whether they referred to the flow of money materials or information. The results of this exercise are illustrated in figure A.7 where factors of relevance are listed.



Factors affecting ship costs FIG. A.7

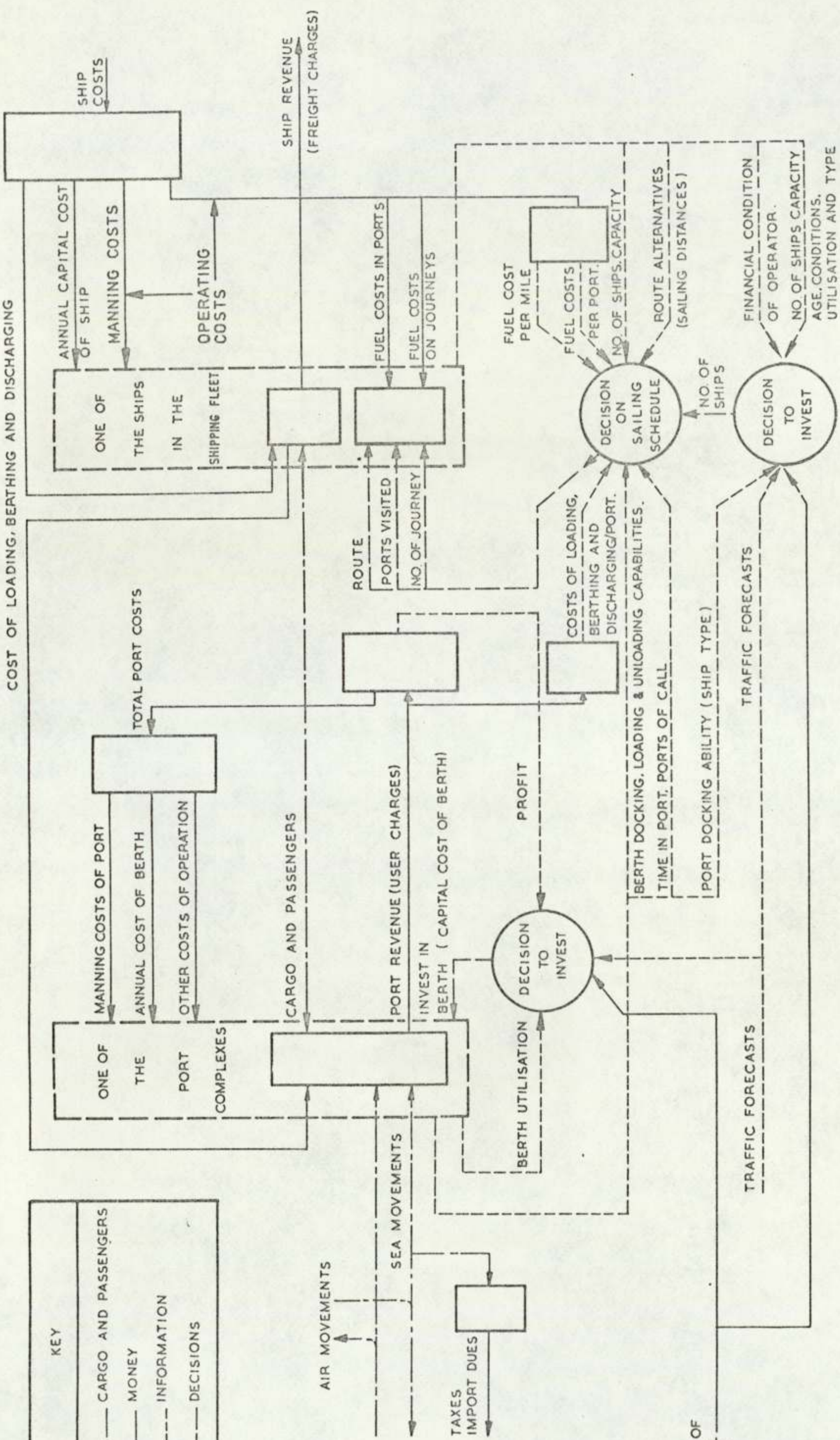
3.6 Subsystem Interaction

3.6.1 Introduction

The overall efficiency of the intra-regional transport system depends on the correct functioning of all its subsystems. This is because the subsystems have interacting tasks to perform. An example of a simple interaction is when an increase in the use of schooners causes a decrease in demand for passenger accommodation on the federal services. Because the performance of one subsystem interacts with the performance of other subsystems, on subsystem cannot be designed in isolation from the other subsystems.

To identify the boundary between the system and the environment, and the interaction between the subsystems, the following approach was used:

Data on the flows of cargo,passengers, money, resources and information between the sub-systems (the ships and the ports) enabled a flow block diagram of the transport system to be derived This is given in FigureA. 8 where the interaction between one of the ships in the fleet and one of the ports it serves is given. Each box in this diagram is a transfer function, and shows, for example, that ship costs are a function of the annual capital cost of the ship and operating costs. The circles identify decisions that have to be made and the categories of information that affect them. From this diagram the inputs to and outputs from the transport system and the decision circles were listed and are summarised as follows:



THE TRANSPORT SYSTEM-FLOW BLOCK DIAGRAM (SHIPPING).

Fig A8

- General and perishable commodities - Tourists and local travellers	Traffic flows	Factors
- Routes - Ports of call - Facilities (e.g. refrigeration, containers, LASH and roll-on/roll off) - Frequency of service	System characteristics	
- Freight and passenger revenue - Investment - Operating costs of system	Revenue and Expenditure	

These factors identified those parts of the environment that affect, and are affected by the transport system. The categories of traffic flow suggested the need to study the needs of the users of the transport system, intra-regional commodity transactions and tourism, and their relationship to the economy of each territory, because each economy is a generator of traffic. The system's characteristics suggested the need to study the organisational structure of the region, while the elements of revenue and expenditure identified the need to study the effect of transport investment on each island's economy. These suggested areas of study provided a start in identifying those parts of the environment that affect, and are affected by, changes in the transport system.

4. AN APPROACH TO DEFINE THE WIDER SYSTEM

To identify the wider system and define its bounds, it is necessary to consider those factors that might affect the design or operation of the transport system. A list of general applicability was used here to aid identification, under the headings: the needs of users of the transport system, the island's economies, organisation structure, the state of technology, economic conditions for new systems and human factors. The list of important factors to the transport system is the criteria for identifying what is relevant in the environment. In other words, a good idea of the requirements makes it easier to survey the environmental factors, and to classify them in order of importance.

4.1 The Needs of the Users of the Transport System

A number of references discussed the inadequacies of the existing transport system and served to identify the more important needs of the users. These may be summarised as the need for:

- Additional cargo space, particularly for the carriage of perishable commodities
-
- Suitable facilities for the movement of chilled and frozen food products
- Improved receiving and surface transportation
- Frequent scheduled shipping services to satisfy the demand for movement

The first requirement was suggested by a local correspondent[9] who stated that already "Jamaican exporters are having difficulty finding cargo space".

The existence of this constraint to further trade was also confirmed by the West Indies Chronicle (1968) which stated in a discussion on airline facilities: "cargo space is limited, and unless booked well in advance the chances are that orders cannot be filled to meet the requirements of importers, particularly those dealing in perishable commodities."

In supporting the second and third requirements, the (Tripartite Survey, 1966) stated that there is a need for "closer liaison between shippers and airline officials on the development of suitable packing and container materials for cargo of different types - including fresh chilled and frozen food products. Much improvement needs to take place in the provision of suitable receiving and surface transportation services as well." Further desirable characteristics are identified by the same reference, where it is stated "for larger firms contemplating export markets within the region or to overseas countries, there are many inconveniences to be faced with regard to the infrequency, unreliability and limited coverage provided by scheduled and unscheduled shipping services. This factor is particularly limiting to large industry location in the little islands of the region, even if such industry is contemplating exports only to the other islands of the area. Until improved services became operational, however, the type and frequency of inter-island shipping is such as to pose real difficulties for any marketing group seeking to establish a regular trade between the islands in perishable items." (Tripartite Survey, 1966).

---

[9] See the Financial Times, 12th December, 1968

To obtain a clearer picture of the transport need of the region an interaction matrix was constructed from figure A.8. Factors identified as relevant to the improvement of the transport system were listed so that the nature of each of the pairwise interactions affecting system improvement could be questioned.[10] The matrix concerned is illustrated in figure A.9. This matrix was used to derive a list of requirements to be met by the transport system.

At this stage, the requirements identified would be checked with the client to ensure that there has been a correct interpretation of the clients needs. In this case, some of the requirements were confirmed by surveying the more relevant literature. For example (O'Loughlin, C., 1968) suggested that

- "the present run of the Federal service is placing a greater burden on the smaller islands and depriving them of a more frequent service."

- "the inclusion of Guyana (whose trade with the islands is larger then Jamaica) would probably confer greater economies."

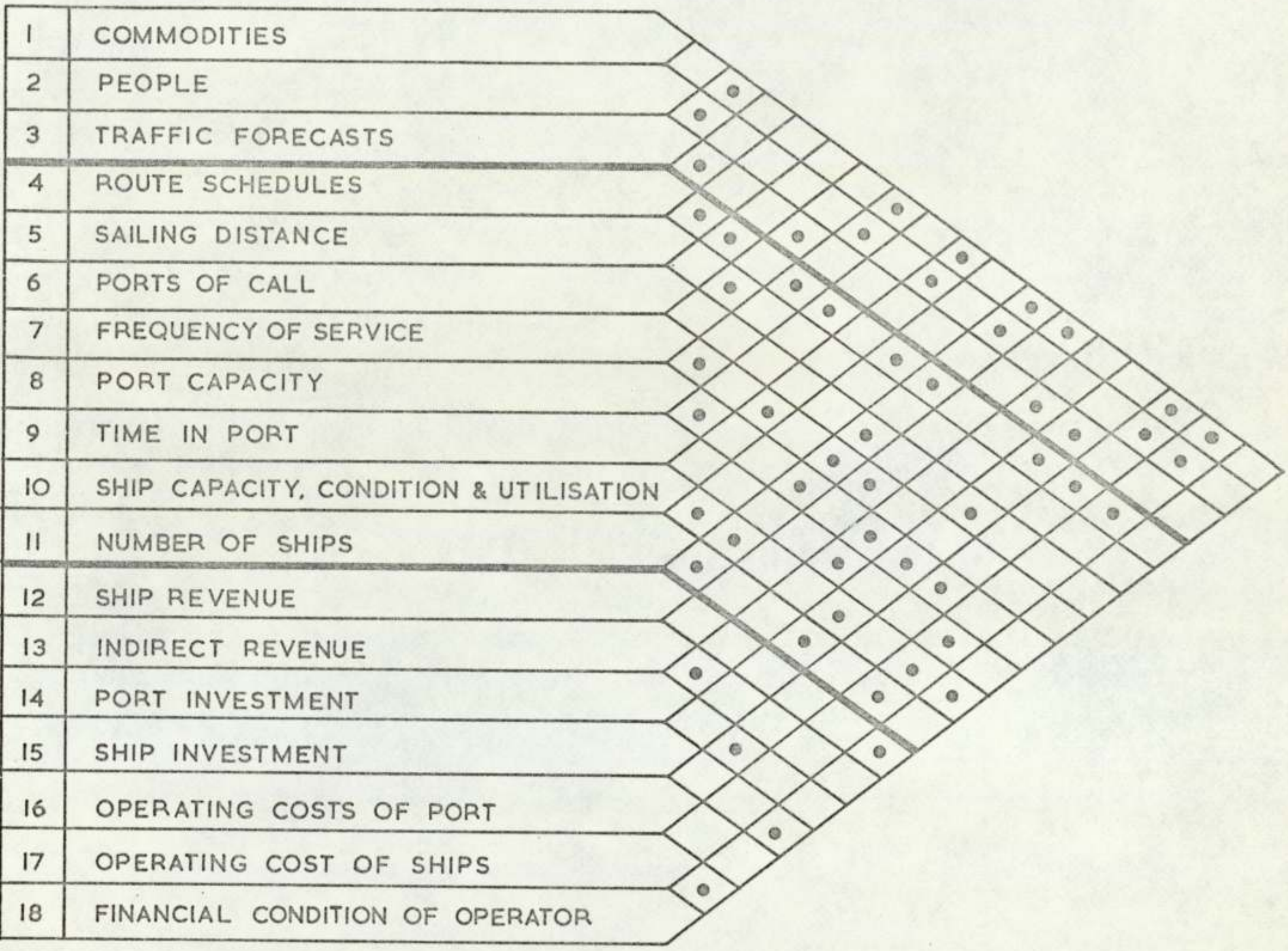
4.2 The Island's Economies

In this section a study of the relationship between the transport system and the island's economies identified the fact that income from exports and tourism have a major effect on an island's demand for imports when its income is a significant proportion of its industrial revenue.

---

[10] For a full description of this approach see Gregory, S. A. The design method, Butterworths', 1960.

See also Hall, A. D. A methodology for systems engineering. D. Van Nostrand Company Inc., Priceton, New Jersey, 1960.



INTERACTION MATRIX. FIGURE A. 9

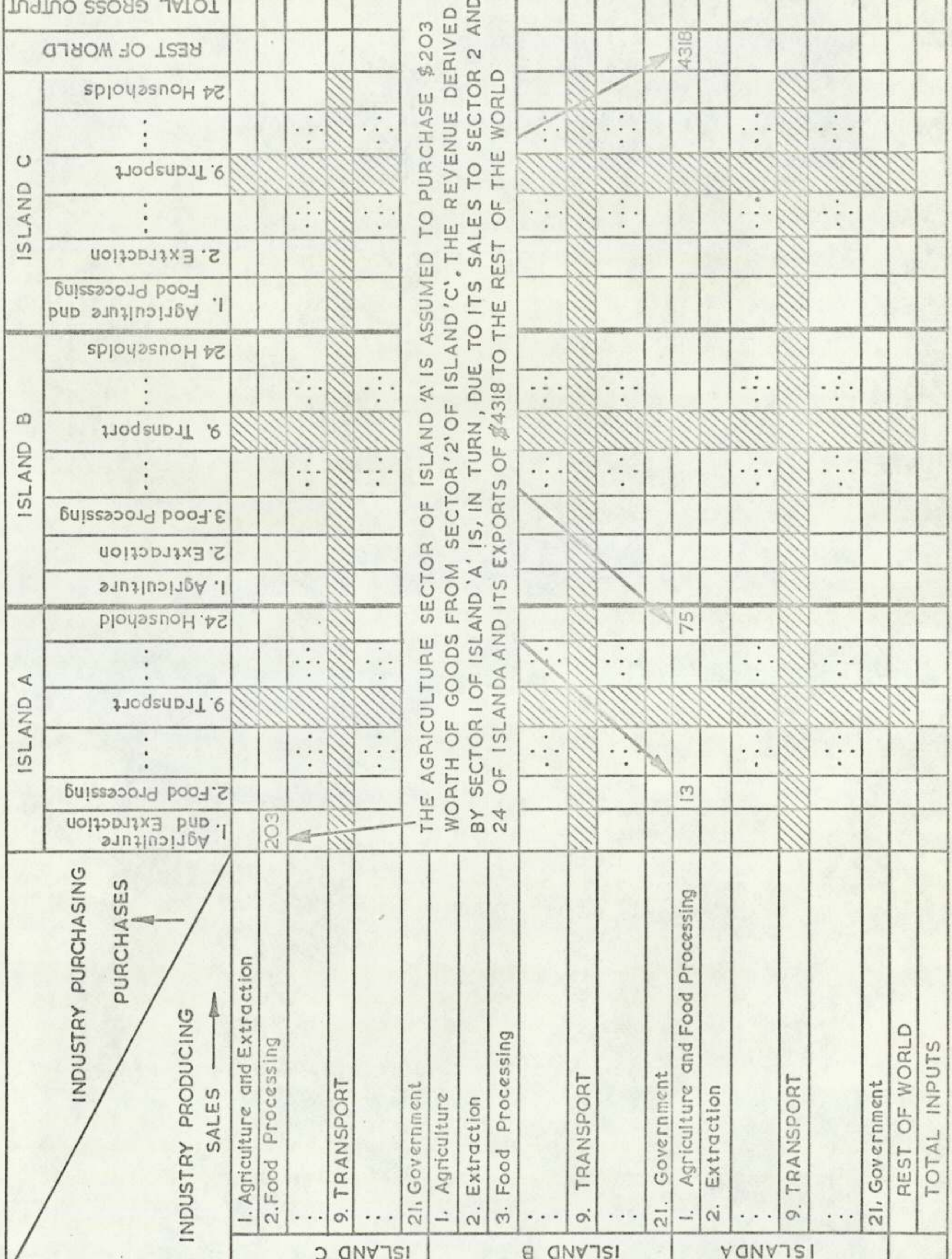
4.2.1 The Transport Sector

The transport sector of each island is linked to other sectors[11] within its own economy and to those of other islands. A change within one sector may have repercussions throughout the region Likewise, changes made to one mode of the transport system can affect all others by modifying prices, profits, choice of transport mode, cargo volumes, and so on.

Mathematical representations of these transactions have been developed, to illustrate not only the inter-industry relationships by region, but the inter-industrial and inter-regional relationships of a country, so that the effect of a change in one region's sector can be traced to, and through, the 'n' regions under consideration. The framework of such a representation, Isard, (1960), is illustrated in figure A. 10. For example, the sales of the agricultural sector of island A to each of its other sectors, as well as its sales to the sectors of other islands are identified. Similarly, both intra- and inter-island purchases by the agricultural sector from other sectors both within island A and from the other islands are identified. Transport is one of these sectors and in the Caribbean includes schooners, sloops, lighters and motor vessels. Thus, the relationship of the transport sector of an island to both its own economy and the economies of other islands can be illustrated by such a table. FigureA.10 also shows the inter-relationships between a hypthetical intra-regional transport system, and the economies of both the region and the rest of the world, where the demand for intra-regional transport is generated by those agricultural and industrial sectors of each island engaged in the intra-regional exchange of goods.

---

11 According to Tiebout, (1962) industries refer to aggregates of firms producing similar products. Sectors refer to the kinds of markets that the industries serve.



INTER-ISLAND INPUT-OUTPUT TRANSACTIONS

Fig. A·10

"The range of intra-West Indian trade is extremely narrow. Trinidad-Tobago and Guyana together have 76 per cent of the total trade. Only two commodities, petroleum and rice together account for 50 per cent of the trade. The remaining 50 per cent is taken by diverse commodities whose importance individually is negligible. Among these the main changes are the relatively large increases in the export of manufactured articles and chemicals from Jamaica and Trinidad-Tobago. These categories of commodities increased their share in inter-West Indian trade from 9 per cent in 1957 to 18 per cent in 1963. With the partial exception of Jamaica and Trinidad-Tobago the list of inter-West Indian exports has not altered from what is was a generation or more ago - oil seeds and nuts, margarines, vegetable oils and soaps, wood, rice," (Brewster and Thomas, 1967).

The pattern of specialisation which has become imprinted on the area is set out in table A.1 according to the divisions of the S. I. T. C. Each country's specialisation is determined by its predominant export commodity-group, that is, the group which accounts for more than one half of its exports to the Caribbean.

Food (Section 0)	Guyana
Beverages (Section 1)	Barbados
Crude Materials (Section 2)	Guyana, British Honduras
Fuels and lubricants (Section 3)	Trinidad-Tobago
Vegetable oils and fats (Section 4)	St. Lucia
Chemicals (Section 5)	Trinidad-Tobago, Jamaica
Manufactured foods by materials (Section 6)	Trinidad-Tobago, Jamaica
Machinery and transport equipment (Section 7)	Trinidad-Tobago
Miscellaneous manufactured articles (Section 8)	Trinidad-Tobago, Jamaica

THE PATTERN OF SPECIALIZATION IN EXPORTABLES
IN THE WEST INDIES, 1963

(1) Food (tree-crops, roots or vegetables)	Guyana, Monserrat, St. Kitts, Grenada
(2) Crude Materials (including copra)	British Honduras, Dominica, St. Vincent, St. Lucia
(3) Manufacturers (including chemicals)	Trinidad-Tobago, Jamaica, Antigua

TABLE A. 1

THE PATTERN OF SPECIALIZATION IN EXPORTABLES
TO THE WEST INDIES, 1963, ACCORDING TO THE
S. I. T. C.

The importance of the regions intra-regional transactions is illustrated in table A. 2. which shows that "although the size of inter-West Indian trade to its total volume or to its total domestic product is rather small" (Brewster & Thomas, 1967), the proportion of each island's income spent on intra-regional produce is significant. This is important because the continuance of this trading pattern may depend, not only on the characteristics of the regional transport system, but also on a number of other factors, political, social and geographical, which could have a considerable influence on the future demand for transport.

PROPORTION OF INCOME EXPENDED ON AND RECEIVED FROM INTER-WEST INDIAN TRADE
1963

	Proportion spent on West Indian Produce (%)	Proportion derived from Exports to the West Indies (%)
Trinidad-Tobago	1.09	3.45
Guyana	3.87	6.03
Barbados	8.37	2.68
Jamaica	1.66	0.36
Dominica	9.70	2.90
St. Vincent	9.53	5.04
St. Lucia	7.89	4.71
Grenada	11.61	0.62
St. Kitts-Nevis	11.32	0.83
Montserrat	14.91	3.48
Antigua	20.17	0.33
British Honduras	7.19	3.12

TABLE A.2

4.2.2 The Political and Social Environment

The aim of the Heads of the Governments of the Commonwealth Caribbean Countries, in establishing the Carribbean Free Trade Association was to obtain "an economically viable and secure future for the indigenous population of the region" (West India Committee, 1969) which was to be achieved through the immediate removal of customs duty on most of the items traded between the member territories. Certain products were placed on a reserved list and customs duties on these would be gradually phased out over a period of five years for the more developed territories and ten years for the less developed ones.[12]

---

12 See "Basic Provisions of the CARIFTA Agreement"," Department of Trade and Industry, Commercial Relations and Exports Division, London S. W. 1.

The feeling within the region is that the creation of a larger protected domestic market (CARIFTA) will offer opportunities for both industry and agriculture to expand. This will only be true if accompanied by a programme of import substitution[13] for Dr. Jefferson states, "the mere removal of customs duties will have only a marginal effect on trade and production with the region". He supports this by stating that only 6 per cent of the total trade of the Caribbean takes place between Caribbean countries themselves at present. In the case of Jamaica, the rest of the region accounts for only 5 per cent of Jamaica's exports and less than 2 per cent of that country's imports. This low level of trade, Jefferson considers, is due not so much to high tariff barriers as to the fact that the region produces relatively little which the territories can trade among themselves. (West Indies Chronicle, 1968). But the latter statement is only part of the truth for "it is also in part due to artificial impediments to trade within the region - to ignorance about trading possibilities; and to failure to exploit opportunities for diversifying the area's productive activities. The latter, in particular, has a growing importance now that it is becoming more and more evident that the size of the market in individual territories cannot permit the production of certain commodities on an economic scale". (Brewster & Thomas, 1967).

---

13 Import-substitution is interpreted to be a process of development which is initially geared to the regional market (which is protected by a common external trade policy) and which manifests itself in the growth and structural transformation of regional productive capacity.

In response to these views the CARIFTA Secretariat recently reported that they had delegated certain authorities to begin a number of studies on its behalf. Reports on these studies, and especially the study relating to the principle of seeking to establish more industries in the smaller territories and the feasibility of establishing certain regional industries, are to be presented shortly. (West India Committee, 1969).

This activity, the selection, location and timing of suitable agricultural industry is the responsibility of the island governments operating in conjunction with the Regional Commission for Economic Integration (Section 1.2)

Their decisions will have repercussions on the demand for transport. Income from exports and tourism also has an indirect but significant effect on the demand for transport, for these two sources form a significant part of each island's total income.

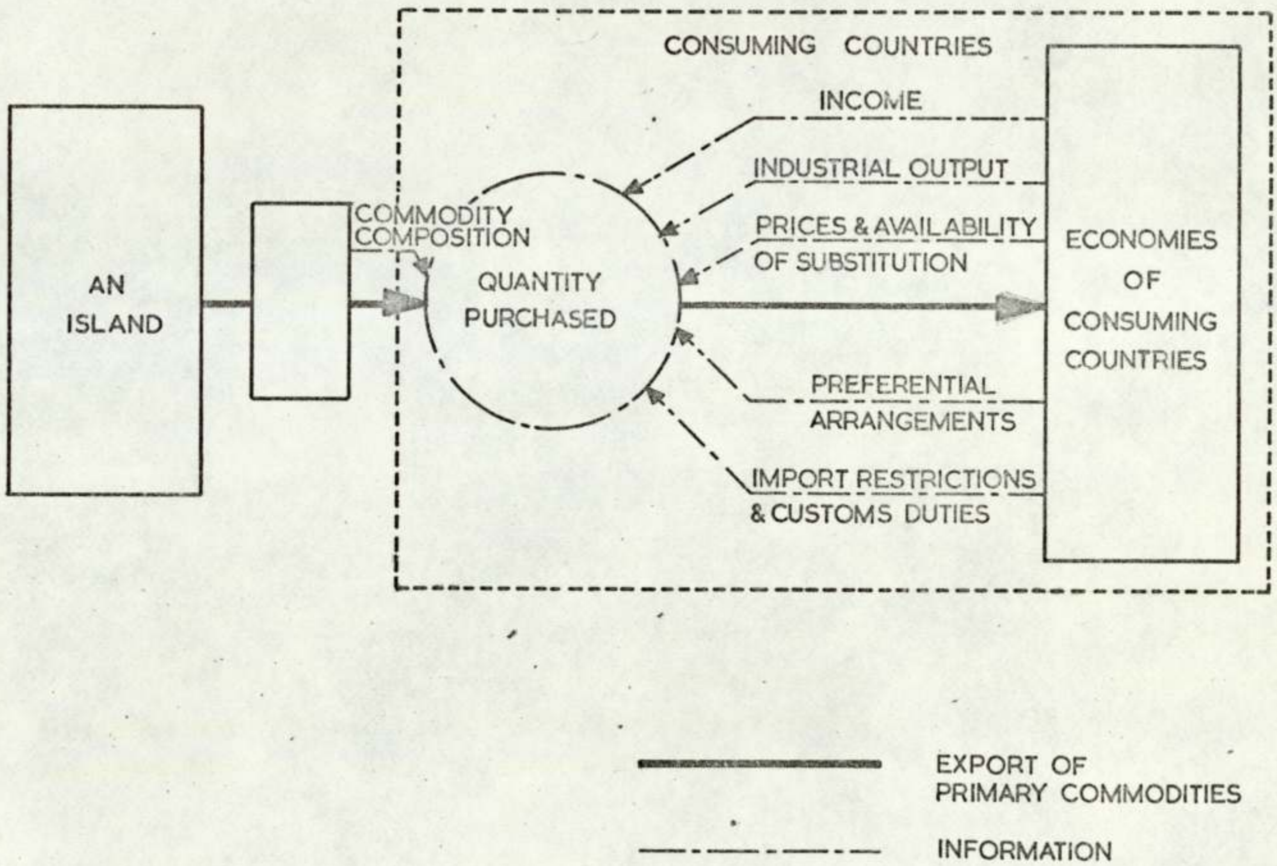
4.2.3 Exports

To estimate the income to be derived from the sales of future exports it is necessary to forecast both the volume of sales and the value for each year of interest. De Vries (1967), in a study of the growth of exports from developing countries in the period 1960-63 suggested that such growth was associated with the countries' shares in the markets of major commodities, its own development policies, as well as the basic variable of the consuming countries, e. g. income, output of industries utilizing the products of the developing countries, and prices (and availability) of substitutes for the imported materials. Demand was also found to be affected by "changes in preferential arrangements, import restrictions, and customs duties imposed by consuming countries. Considerable differences in the growth of exports were noted when the countries were grouped by their position in international trade, size of domestic market, and degree of price inflation. The commodity composition of exports was a further factor influencing the differences in export growth, as well as was the countries share in world markets for its major exports and the relative importance of major exports and of minor exports in its total exports. (De Vries, 1967).

The need to identify these factors does not appear to be necessary in the Caribbean case for Dudley Sears, the well known United Nations economist stated that " export income is comparatively stable - in terms of both price and volume from year to year." (Demas, 1965). (De Vries, 1967) also said that "the analysis of export growth should be supplemented by studies of the growth of earnings from services, especially tourism, which have become a major source of foreign exchange earnings for some developing countries." These factors are illustrated in the flow block diagram of figure A. 11.

4.2.4 Tourism

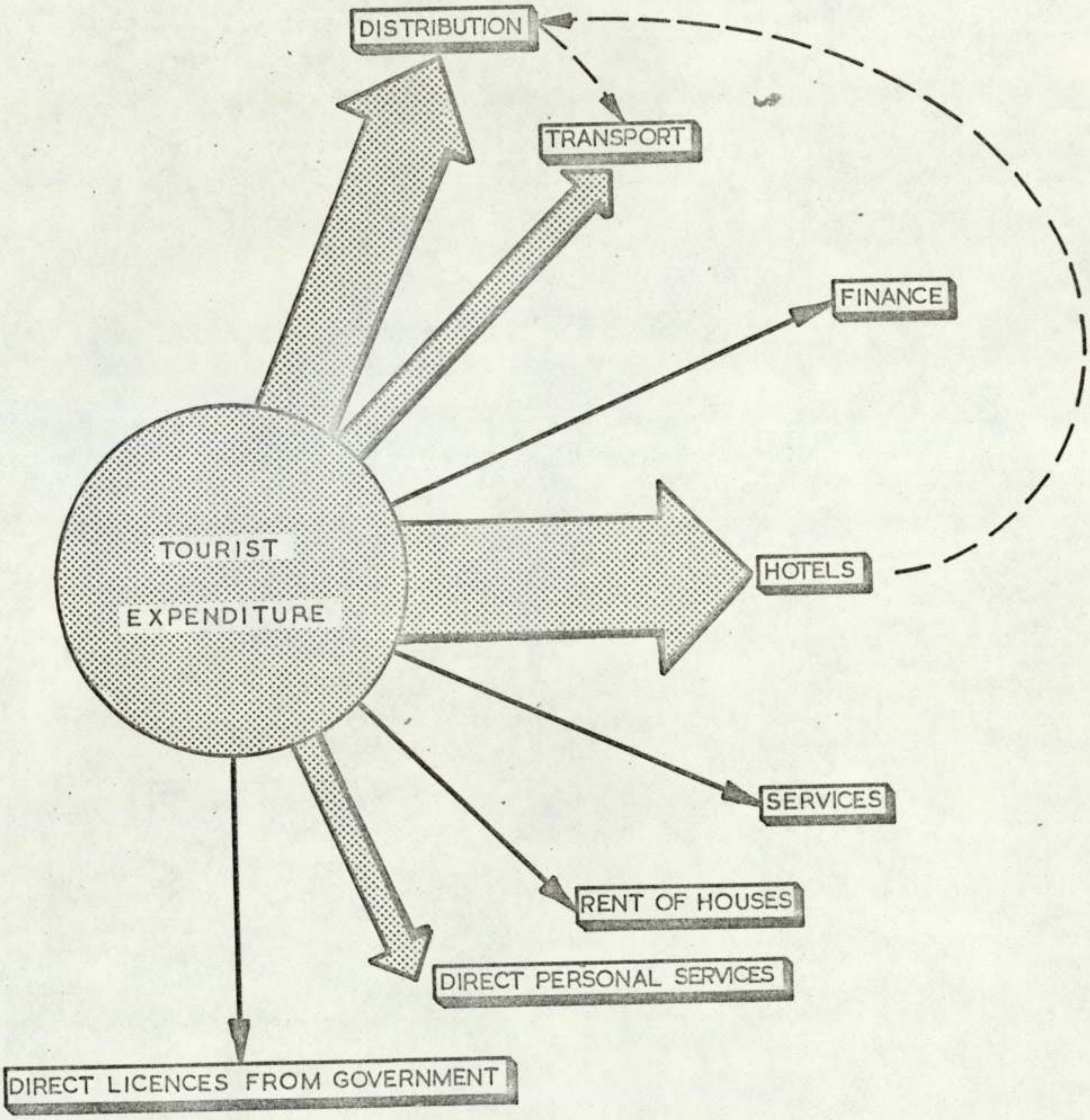
The (Tripartite Survey, 1966) remarked that " a very considerable additional demand for foodstuffs is generated (by the development of tourism)" which was illustrated by a study of the impact of tourist expenditure on the economy of Antigua. The estimated expenditure of tourists in Antigua in 1964 amounted to $ (W.I) 11, 069, 000 distributed as shown in figure A. 12 among the sectors which were its immediate recipients. "This represents, however, only the first stage of the impact of tourist expenditure. The hotels, for example, spent part of their reciepts on buying supplies from the Distribution sector, which in turn paid for services from the Transport sector, and all the sectors shown made payments to sectors not shown, for example to the Construction sector for maintenance work. Some of the receipts were spent on imports and some went to Government in indirect taxes". These inter-sectoral flows are illustrated in Table A. 3.



EXPORT DETERMINANTS

Fig.A.II

	($000)
DISTRIBUTION	3,050
TRANSPORT	900
FINANCE	276
HOTELS	5,450
SERVICES	225
RENT OF HOUSES	255
DIRECT PERSONAL SERVICES	890
DIRECT LICENCES FROM GOVERNMENT	23
TOURIST EXPENDITURE TOTAL	11,069



THE DISTIBUTION OF TOURIST EXPENDITURE
ANTIGUA – 1964

Fig A·12

ANTIGUA 1964

Purchases by: (All figures $'000/W.I.)

Sales and receipts by:	Export agriculture	Other agriculture construction and manufacturing	Sectors serving tourism *	Government current expenditure on goods and services	Consumption	Investment	Exports	Total sales
Export agriculture	-	104	250	-	-	-	4,873	5,227
Other agriculture, construction and manufacturing	795	59	3,246	235	1,145	8,141	194	13,815
Sectors serving tourism*	1,765	1,359	3,842	1,116	20,865	25	11,805	40,777
Government (mainly indirect taxes)	208	336	4,688	-	1,446	-	927	7,605
Imports	148	5,675	17,370	869	615	-	-	24,677
G.D.P. (factor cost)	2,311	6,282	10,632	5,213	-	-	890	25,328
TOTAL INPUTS:	5,227	13,815	40,028	7,433	24,071	8,166	18,689	118,178

* Distribution, transport, finance and insurance, hotels, services and entertainment, and house ownership.

THE INTER-SECTORAL TRANSACTIONS OF ANTIGUA

TABLE A.3

"From a knowledge of these inter-sectoral flows, the final destination of the $11,069,000 was traced as follows:

$4,441,000 (40,1 per cent) went to pay for imports;

$1,310,000 (11.8 per cent) went to the Government, mainly duplicated as indirect taxes, but some as payment for services rendered:

$5,318,000 (48.1 per cent) accrued in Antigua as income before direct taxes.

From knowledge of the extent to which each sector's sales were made to tourists, it is possible to estimate the extent to which income generated in each sector of the national product was due to tourism."[14] The results of these calculations are given in Table A.4.

TABLE A.4

The effect of tourist expenditure on the National Product

Sector	Income generated 1964 ($'000, W.I.		
	Due to tourism	Other	Total
Export agriculture	15	2,296	2,311
Other agriculture	202	963	1,165
Construction	338	4,096	4,434
Manufacturing	60	623	683
Distribution	749	3,101	3,850
Transport	474	552	1,026
Finance	369	767	1,136
Hotels	2,346)	125)	2,471)
Less losses	-711)	-38)	-749)
Services	386	837	1,223
Rent	200	1,475	1,675
Direct personal services to tourists	890	-	890
Government	-	5,213	5,213
G.D.P. (factor cost)	5,318	20,010	25,328
Remittances	-	940	940
Transfer to cover hotels' losses	749	-	749
Net interest	-	-	-47
G.N.P. (factor cost)	6,067	20,903	26,970

14 Income generated by the maintenance of hotels is included as due to tourism in the table though income generated by the building of hotels is not. The division of income between what is and is not tourism is based on the proportion of each sector's sales which is made to tourists, and on the assumption that its inputs can be divided in the same way.

The study concluded that "of every tourist dollar only about half passed directly into the income of Antigua residents, although 11 cents may have passed indirectly via government revenue and expenditure. The income generated was widely distributed, more than half of it accruing outside the hotel sector, and some sectors, especially transport, finance and services were quite heavily dependent on tourism as a source of income." (Tripartite Survey, 1966).

" To identify the impact likely to be made by a given increase in the level of tourist expenditure, the input-output structure of the Antiguan economy in 1964 was assumed to remain as it was in 1964." That is, "each sector spends the same proportion of its sales receipts on purchases from each other sector as it did in 1964." (Tripartite Survey, 1966). It was also assumed that:

- consumption of the products of the sectors remains the same proportion of G.D.P. as in 1964,
- government expenditure and exports (other than tourist expenditure remain unchanged,
- for the moment, that capital investment is not changed, not even in the tourist industry itself,
- receipts from tourists have been adjusted upwards by the amount necessary to eliminate the losses which were incurred in 1964,
- government receipts in the form of airport dues etc, rise in the same proportion as tourist expenditure.

" With these assumptions it was estimated that an increase of $10 million in tourist expenditure would generate the results given in Table A. 5.

TABLE A. 5

Increase in:	$'000
G.D.P (factor cost)	5, 850
indirect taxes, airport dues etc.	2, 880
G.D.P. (market prices)	8, 730
imports	7, 400
personal consumption	5, 400
exports of government services (airports etc)	730

THE EFFECT OF AN INCREASE IN TOURIST EXPENDITURE ON GDP

The study concluded that, " the substantial rise in imports amounting to almost 70 per cent of the foreign exchange receipts from increased tourist expenditure was due to:

- The high import element in the costs of the tourist industry
- The import contents of the other sectors which supply the tourist industry
- The import content of personal consumption, which is assumed to rise with income". (Tripartite Survey 1966).

If these islands " are to derive the maximum economic benefit from the growth of tourism, they should keep a close watch on the major imported items of consumption (and investment expenditure) in this industry and should consider whether they are all essential".[15] (I.U.O.T.O., 1966)

The Tripartite Survey (1966), in identifying the effect of the capital investment required to support such tourist expenditure estimated that "an expansion of $10 million in tourist expenditure would require a further 650 rooms, given existing occupancy rates, or an investment of $16-19 million over the six years 1964-70."

---

15. Measures designed to encourage the substitution of local products for imported goods may have a significant effect on the economy by creating further income for every unit of foreign tourist expenditure.

Measures designed to encourage the substitution of local products for imported goods may have a significant effect in increasing the tourism multiplier[16] and hence the overall benefit to tourism in the national economy. (I.U.O.T.O., 1966)

"The investment that would be required in the tourist industry outside the hotel sector (which include taxis, shops etc.) can only be guessed, but probably the capital-output ratio would not be as high. Altogether it was supposed that over the period 1964-70, a gross output from the construction industry of $27-30 million or $$4\frac{1}{2}$-5 million per annum on average, would provide the capital investment needed to sustain in 1970, a level of tourist expenditure $10 million above that of 1964."

When the effects of the above assumed expenditure in 1970 were "added to those of the increase of $10 million in tourist expenditure itself, taking account again of the multiplier effects on the output of other industries, on income and on consumption, the result could be the following," (Tripartite Survey, 1966) shown in Table A. 6

TABLE A. 6

Increase in:	($'000)
Exports	10,730
Investment	3,000
Consumption	7,350
Less increase in imports	9,770
Increase in G.D.P. (market prices)	11,310
Less indirect taxes	3,330
Increase in G.D.P. (factor cost)	7,980

THE COMBINED EFFECTS OF TOURIST EXPENDITURE

16. The "tourism multiplier" is the effect of one unit of foreign tourism expenditure in creating further incomes within the economy.

When account was taken in the study of a third round of expenditure, in which government spending was assumed to have risen by $2 million (W.I) it was found that the increase in imports exceeded the increase in exports. TableA.7 illustrates these results.

TABLE A.7

Increase in:	($'000)(W.J.)
exports	10,730
investment	3.000
consumption	9,380
government spending	2.000
Less Increase in imports	11,190
G.D.P. (market prices)	13,920
indirect taxes	3,730
G.D.P. (factor cost)	10,190

THE EFFECTS OF TOURIST AND GOVERNMENT EXPENDITURE

The additional $2 M of capital investment outside the tourist sector was assumed to include such things as housing and education. Such investment would be paid for by the extra revenue accruing to the Government, not only from indirect taxes and import dues as shown in TableA.6 but also from direct taxes on the incomes generated, which would allow a higher level of spending within a balanced budget. Such expenditure " will tend to move the balance of payment into deficit. This occurs not only because these expenditures themselves have an import content (and yield no exports), but because they have multiplier effect on income and consumption, which also have an import content and rather a high one." (Tripartite Survey, 1966)

The foregoing analysis of the impact of tourist expenditure on the economy of Antigua illustrates the fact that tourism makes itself felt in two ways:

- Through effects emanating from the original investment,
- Through repercussions throughout the economy once the original investment was completed and operative.

These major effects may be divided into two categories, the direct effects of

- Production
- Employment
- Balance of payments

and the indirect effects of

- Income
- Investment

These "original and subsequent effects of an investment in tourism can be shown to act on four main sectors of the economy, as follows:

- Domestic industry (goods and services)
- Households
- Government[17]
- Imports (goods and services)" (I. U. O. T. O., 1968)

The original investment in the tourism sector will make its effect on the economy through:

- The goods and services it requires from the business sector (including the extra investment required to produce this output)
- The extra imports in induces,
- The extra income it generates (both in the household and business sectors, particularly the building and allied trades).

---

17. The government sector in the classification refers to the taxation effect: where there are direct government investments in tourism these have the same effects as investments in the business sector.

while the subsequent repercussions on the economy occur because of:

- Import earnings
- Its earnings from domestic tourists
- Its consumption of goods and services from the business sector
- The income of the labour force it employs.

These repercussions of the initial investment also include such indirectly related effects as the expenditure by the tourists which the investment attracts on other sectors of the economy (the retail trade for example). These repercussions will occur whether the initital investment were a hotel or other form of tourism such as a marina." (I.U.O.T.O., 1968).

Tourist expenditure depends on many factors and may include the origin and holiday destination: the number of tourists who actually visit an island, their length of say, "their age, sex, family structure, income, occupation, educational background and relevant material possessions" (I.U.O.T.O., 1968)

The satisfaction of the demand depends upon each island, which must remove those factors which inhibit the expansion of the tourist industry. Journey time and comfort en route provide an indication of what is involved.

These considerations enabled the flow diagram of figure A.13 to be constructed which shows that tourist demand generates investment in tourism, which subsequently results in tourist expenditure. The repercussions of this expenditure on the economy include expenditure on imports and increases in the income of both the government and residents of the island, which results in further expenditure on imports. Thus, if tourist expenditure can be estimated, the resulting demand for imports maybe estimable

4.2.5 Geographical Factors

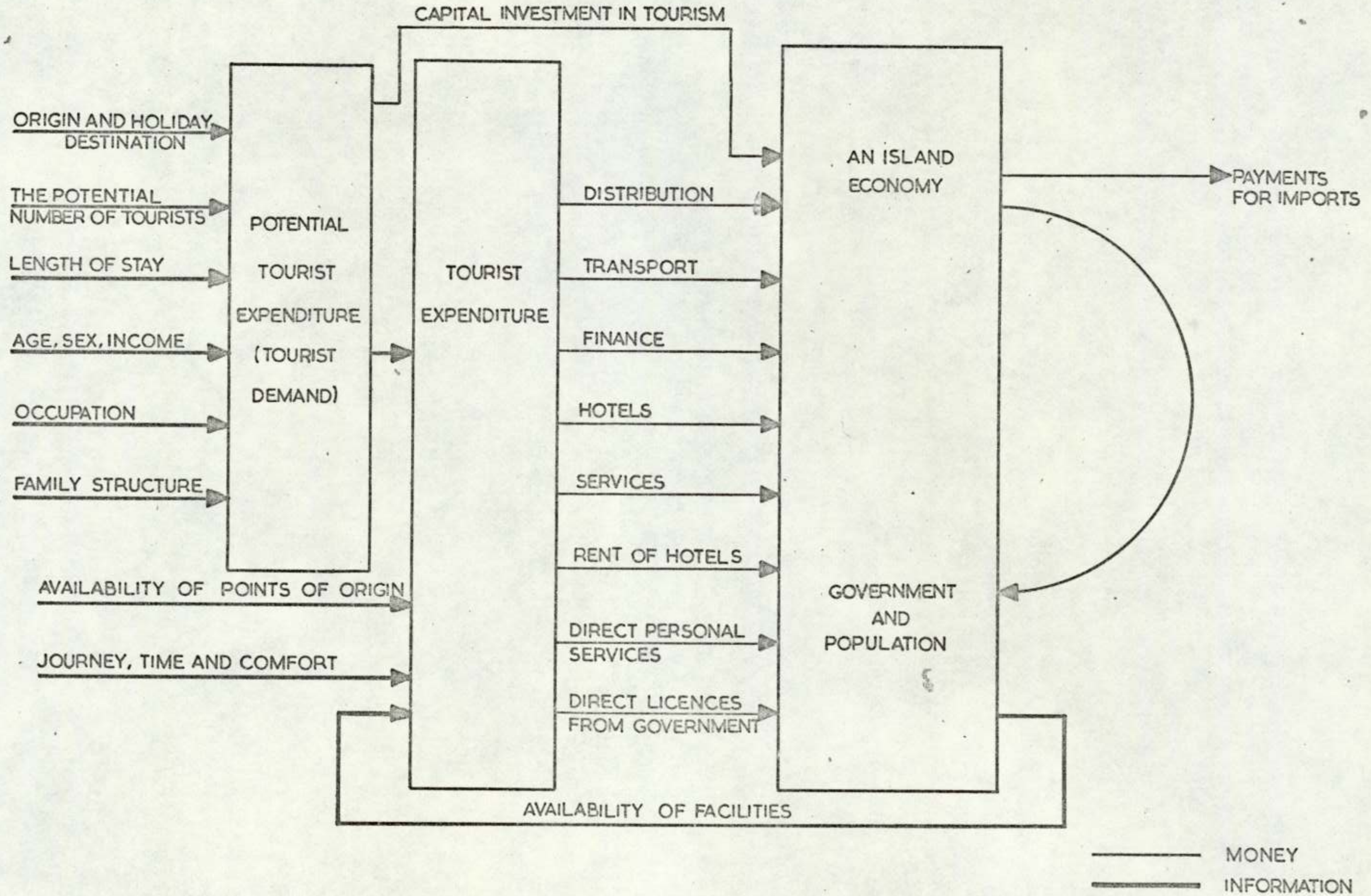
The formation of Carifta has created a widely dispersed market extending from Guyana, in a wide sweep to the Central American coast where Belize (British Honduras) is soon to become a member. This market extends over 2 million square miles, but its size in individual territories is severely limited as can be judged from the 1963 population estimates given in table A. 8.

Guyana	560, 406	St. Lucia	86, 108
Jamaica	1, 634, 102	St. Vincent	81, 720
Trinidad	794, 624	Dominica	60, 054
Barbados	242, 606	Antigua	53, 161
Grenada	90, 019	St. Kitts	38, 273
Montserrat	12, 538		

Source: The London Geographical Institute

The population of each territory. Table A. 8

The cost, adequacy and frequency of intra-regional transport will limit the market of an industry located in any one island. Perishable goods require rapid movement or refrigerated facilities when in transit between supplier and consumer, while the cost of movement must be minimal if consumer products exported over



THE IMPACT OF TOURISM ON AN ISLAND ECONOMY

Fig A.13

great distances are to remain competitive with sources outside the region. The need for transport can be understood by the existing distribution of production. Guyana, Montserrat, St. Kitts and Grenada specialise in the export of tree crops, roots or vegetables; Dominca, St. Vincent and St. Lucia in copra, while the major exports of Jamaica and Trinidad to the other islands are in manufactures and chemicals. Thus, the existing distribution of resources and production within CARIFTA is such as to demand some form of inter-island transportation.

4.3 Organisation Structure

A commonwealth Caribbean Regional Secretariat (popularly known as the CARIFTA Secretariat), was established by the governments of the region to be at their service to assist them to pursue their agreed policies of regional integration and co-operation. Specifically, the main functions of the Secretariat are:

- To service the conference of the heads of governments of the CARIFTA territories and any Committees appointed to it.

- To service the Council of Ministers established to negotiate and administer the Caribbean Free Trade Agreement.

- To initiate, arrange and undertake investigations into questions of economic co-operation relating to the region as a whole.

In a detailed report to the Secretariat, the Institute of Social and Economic Research of the University of the West Indies suggested that a Transport and Allied Services Commission should be formed among the member territories to support a Regional Commission for Economic Integration, which would operate within the Secretariat.

In developing the transport planning methodology described in this paper, it was assumed that this structure would become operative.

At present, the Secretariat functions in two broad divisions. Division I reviews development and reports on customs matters; deals with technical questions relating to day-to-day operation and functioning of the CARIFTA Agreement; facilitates the exchange of commercial information among Member Territories to enable traders and manufactureres to take full advantage of the opportunities created by the Agreement; and arranges and undertakes investigations into questions of economic co-operation relating to the region as a whole.

Division II concerns itself with the implementation of decisions of other aspects of the regional programme, namely: transport and communications, the Commonwealth Technical Assistance Programme co-ordination of efforts in external representation, and the regional development of tourism. At a meeting in London,[18] it was stated that the Regional Shipping Council would be included within the CARIFTA Secretariate with responsibility for intra-regional shipping. The development of port facilities would continue to remain a perogative of each island's government, which would make requests for external aid without recourse to the CARIFTA Secretariat.[19]

---

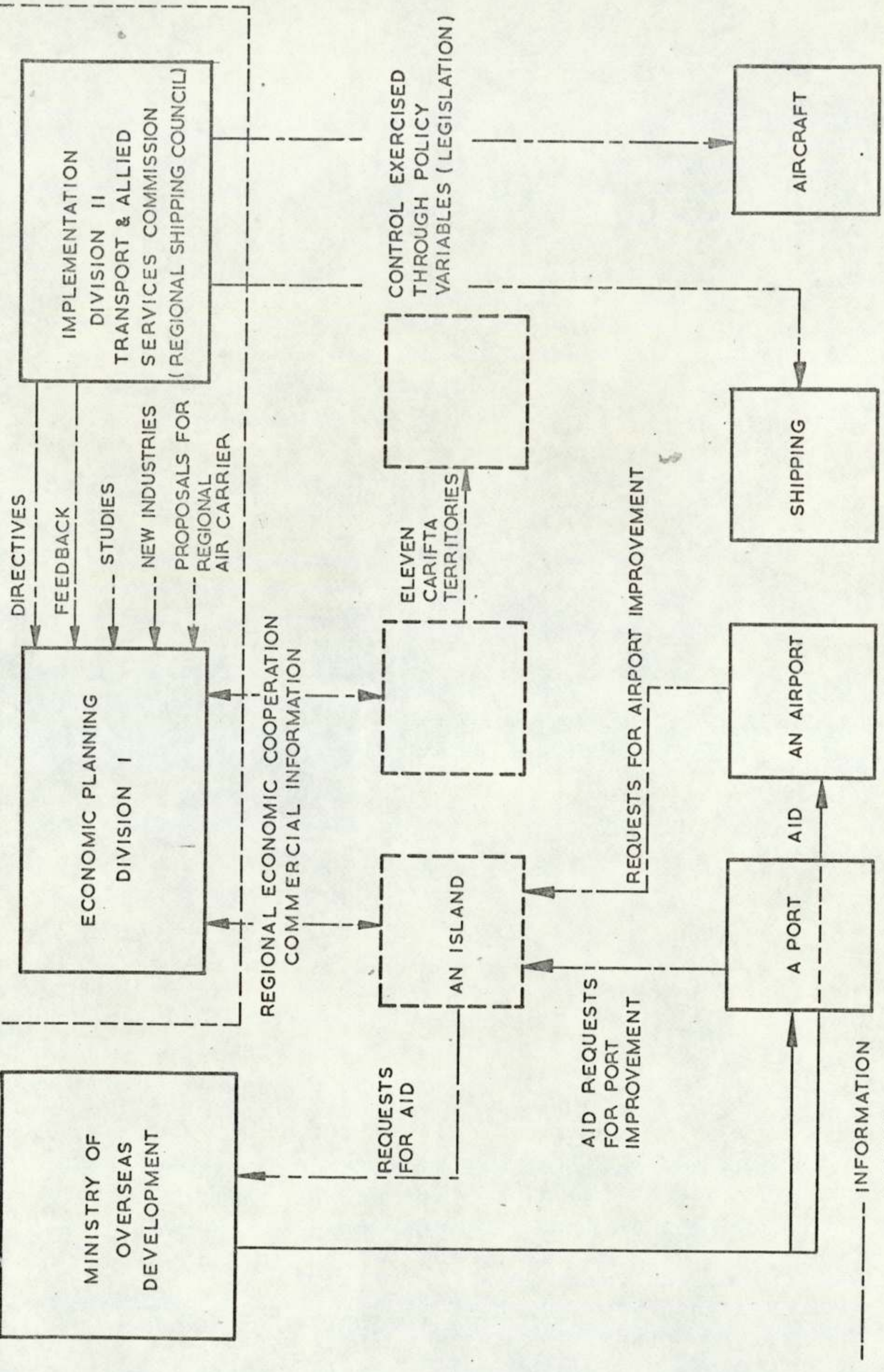
18. Lightbourne, R. C., West India Committee, London, 26th Sept, 1969.

19. Humphreys, P., Overseas Development Authority, 13th July, 1970.

Dr. Cracknell of the Ministry of Overseas Development suggested to the author that in time, the Ministry, in considering requests for aid (for port expansion) from individual islands, would have to take into account other competing port and airport developments to prevent over-investment within the region. Other sources of aid could include the Inter-American Development Bank and the Regional Development Bank,[20] the formation of which was recommended by the Tripartite Survey, (1966).

These references indicate the relationships between the authorities responsible for the continuing operation of the transport system. These relationships are displayed in Figure A. 14.

20. The envisaged functions of the Regional Development Bank are discussed in a report to the Caribbean Economic Development Coporation, San Juan, Puerto Rico, March, 1968.



ORGANISATION STRUCTURE

Fig.A·14

4.4 The State of Technology

Within the time scale of this study, the effect of new technology on improving the transport system could not be considered. Such developments as the LASH system (lighter aboard ship), container-ships and hovercraft could have a significant impact on intra-regional transport if they were to prove viable. Indeed, the Tripartite Survey (1966) states that "if a steady traffic between the islands builds up in the future in perishable food products, the performance and cost characteristics of the hovercraft should not be overlooked for specialised use, perhaps in combination with passenger movement". The views of the Tripartite Survey are about to be vindicated for it is understood that a hovercraft service may soon be inaugurated between St. Vincent and Grenada.[21]

---

21. Mr. M. A. Nicolson, the Booker Shipping Line, 12th Nov., 1970.

In the light of these developments, the author decided that the methodology to be developed must allow the effects of new technology, such as a hovercraft, to be evaluated compared with existing forms of transportation. Existing bounds on the transport system, identified in Section 3.4 were the depth of water at port approaches (which places constraints on ship size), the types of lighter used at certain ports and port docking, loading and unloading capacities. Other constraints such as the variability of sea and weather conditions would have to be identified in a practical study.

4.5 Economic Conditions for New Systems

The suitability of new forms of transport depends on their cost and performance compared to the existing system. No attempt was made at this stage to define acceptance criteria for new systems.

4.6 Human Factors

These can be of considerable importance, for proposed changes to a transport system must be acceptable to those who operate it. For example, the loading and unloading rates at a port are related to such factors as the hours worked, union practices and methods acceptable. Again, within the timescale of this study, these factors could not be identified because access to the appropriate people was impossible.

4.7 Definition of the Wider System

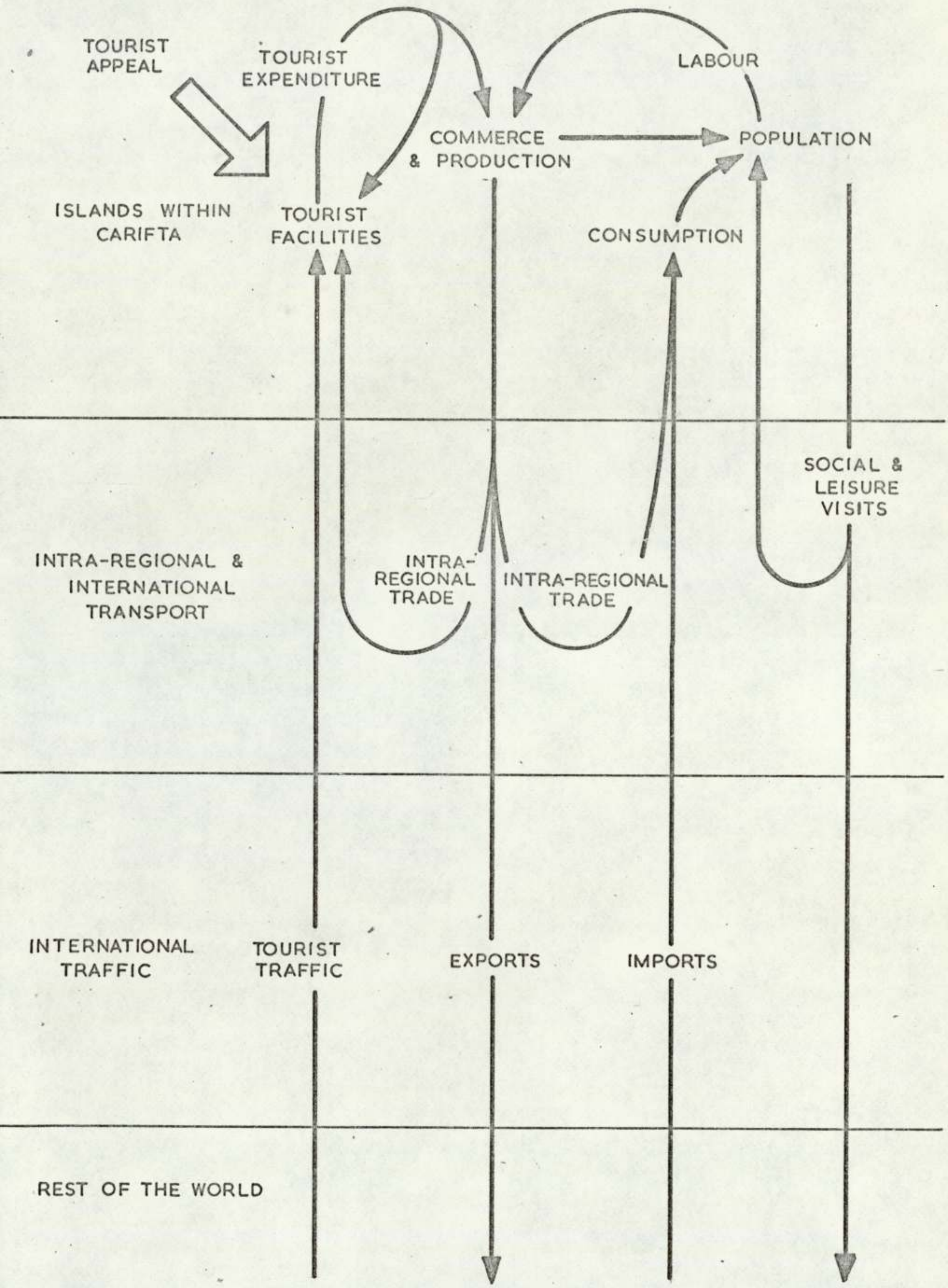
Sections 4.1 to 4.7 have identified some of those factors, both within the region and outside it, which generate demand for commodity and passenger movement. Figure A.15 assists in displaying the role played by the transport system in serving the wider system (the economies on those islands within CARIFTA).

It shows that tourist demand stimulates capital investment in tourist facilities in the CARIFTA islands. The subsequent provision of such facilities results in the movement of tourists between the source countries and the CARIFTA islands, over the transport routes linking them. These tourists spend money during their stay in the islands among such sectors of the economy as hotels and distribution. In turn, this expenditure generates a demand for imports which is due to the high import element in the costs of the tourist industry, is partly due to the import content of other sectors which supply the tourist industry, and is partly due to the import content of personal consumption, which is assumed to rise with income. This rise in the general level of income and consumption can call for capital investment by the government, from its own tourist derived income, in such areas as housing and education, which results in a further increase in imports. The demand for imports is also stimulated by revenues resulting from export sales to other islands within CARIFTA, as well as to the rest of the world. The level of imports, and in some cases exports, to and from any island is therefore dependent on:

- Its level of exports, which is dependent upon several factors, many of which cannot be influenced by those governments within the region
- The level of investment
- The availability of tourist facilities and
- The efficiency of the transport systems linking the island to its trading [22] partners

---

22. This word is used loosely here and is assumed to include "trade" in both passengers and commodities.



THE TRANSPORT SYSTEM
AS PART OF THE WIDER SYSTEM

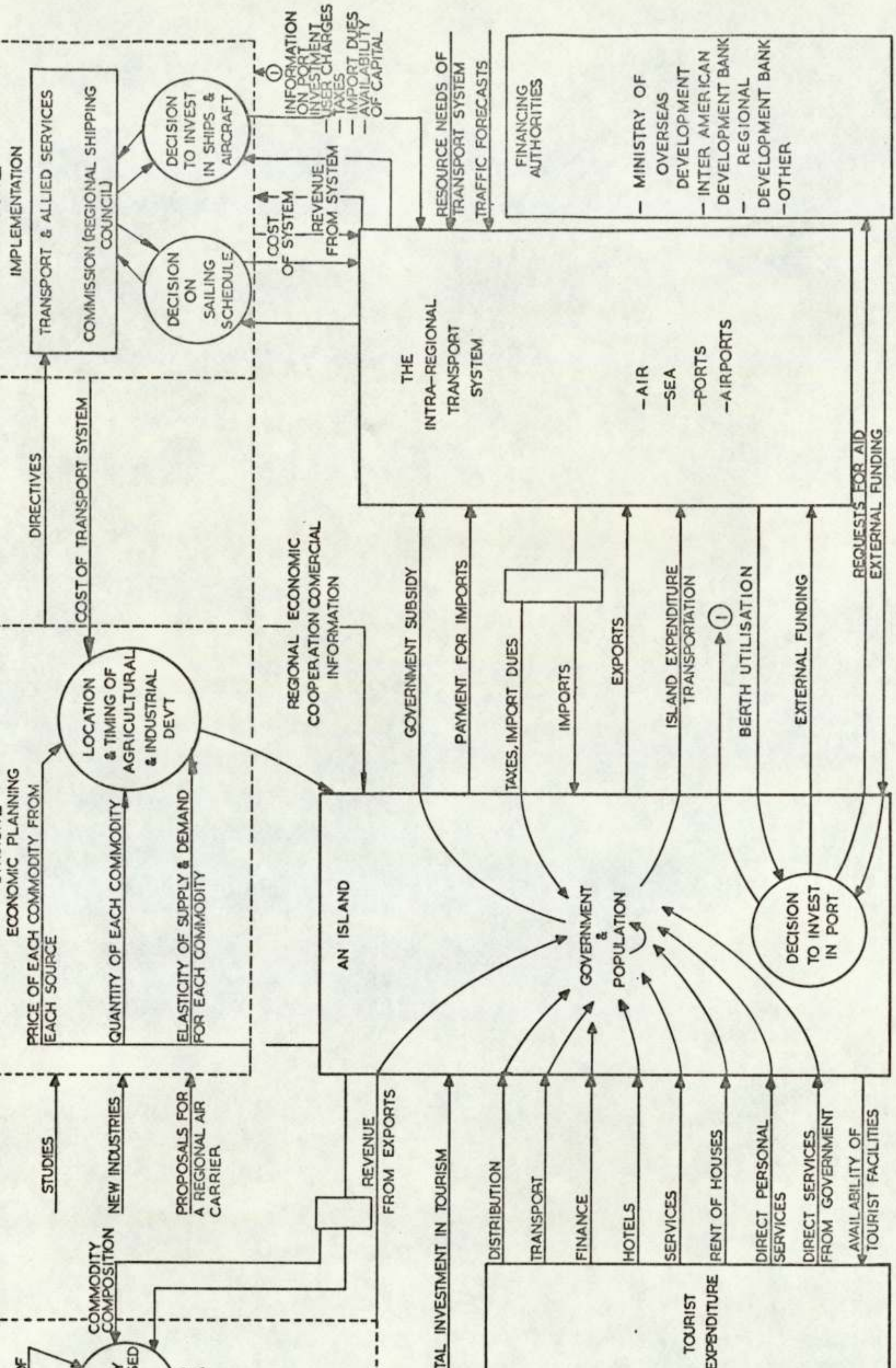
Fig A.15

The Carifta Secretariat, in conjunction with the region's economic planners, is assumed, from the foregoing discussion, to determine both the location and timing of industrial and agricultural investment within the region. For example, the expansion of beef production within CARIFTA will reduce, and perhaps completely eliminate, imports to the region from Australia and New Zealand.

Such activities could have significant implications on the transport system concerned. Thus, transport planning must be conducted in conjunction with the regional economic planners, if the objectives ofthe CARIFTA Secretariat are not to be limited by an inadequate transport system. It is also suggested, from this discussion,that transport planning can only be conducted if:

- Capital investment and tourist expenditure over time can be estimated accurately enough to determine the demand for imports of an economy in volume terms
- Export revenue can be estimated with sufficient accuracy to determine its effect on the demand for imports on the economy in volume terms
- The interaction between the transport system and the economies of the islands which it serves can be represented in quantifiable terms
- The location and timing of industrial and agricultural development can be defined in terms which will allow the volume of generated traffic to be estimated with sufficient accuracy.

The design of improvements to the transport system is divided between the CARIFTA Secretariat and the island government (fig.A .16).



THE SYSTEM AND WIDER SYSTEM Fig.A.16

- The Regional Transport Commission can only design improvements to the air and shipping subsystems of the transport system within the limits imposed by existing port and airport facilities, and the availability of resources for development (controlled by the funding agency). Instrument variables[23] include freight charges, routes served and service frequency.

- Island/Port authorities are limited to the provision of additional port facilities. Available instrument variables are user charges, taxes and import dues. and facility improvement which is governed by the availability of loan capital

Having defined the role of the Regional Transport Commission and the relationship between the transport system and the islands it serves, further definition of the wider system was left to section 3.2 (Forecasting).

5. Definition of the Objectives of the Wider System

As the transport system is a subsystem of the intra-regional economic system, it would be wrong to dissociate the objectives of the system being studied from those of the system of which it forms part. In fact, it is the objectives of the wider system which might be the crucial ones, since they determine the environment in

---

23. A port authority may exercise control over its port by changing port dues. As port dues influence the level of traffic through a port, and hence the operation of the port itself, the factor is described as an instrument variable.

which the transport system has to function. For example, a country such as Guyana may have mineral resources which it wants to develop for export. The necessary railway, mining and port investments are essentially a joint cost, which in combination justify the investment, but singly do not. A country's general strategy for economic development thus dictates the appropriate transport strategy, although the former must, of course, take into account transport costs as one of the relevant factors.

The objectives of Carifta are summarised in the opening paragraphs of the Agreement, (1968) which may be re-stated as follows :

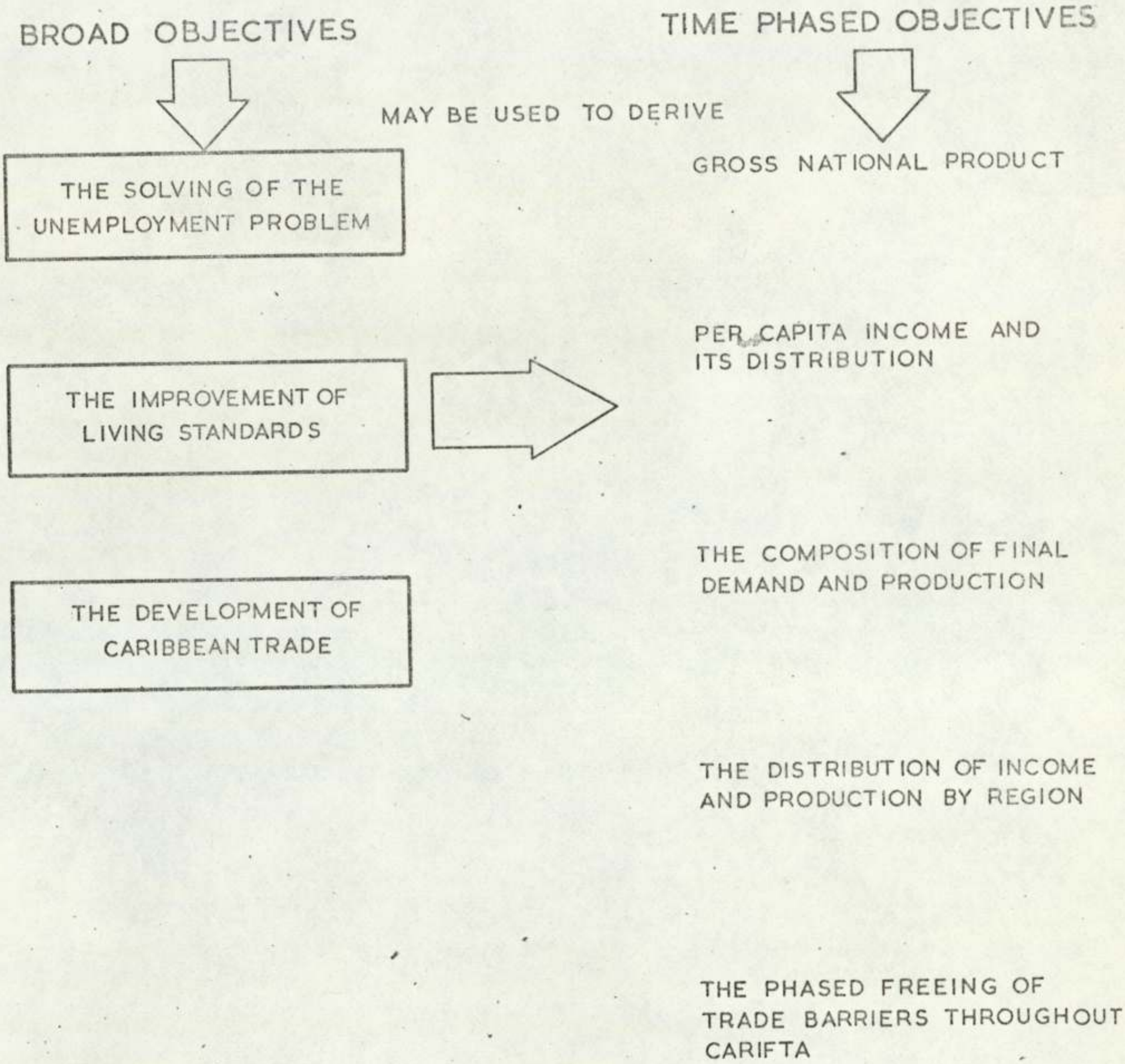
- To promote the expansion and diversification of trade in the area of the Association with a view to solving the unemployment problem
- To ensure that trade between Member Territories takes place in conditions of fair competition
- To encourage the progressive development of the economies of the area, to improve living standards
- To foster the harmonious development of Caribbean trade and its liberalisation by the removal of barriers to it

In general, these goals would encompass "a time spectrum for achieving such objectives as Gross National Product, per capita income and its distribution, the composition of final demand and production, and the distribution of income and production by region." (Fromm, 1965). The formulation of the objectives of the wider system is illustrated in figure A.17.

To achieve these objectives, a number of proposals have been made which include:

- The development of tourism as a leading growth sector
- Market research and development of new marketing channels within the area and outside
- Industrial and agricultural development, i.e. specialised planning and promotional efforts to encourage industrial location in the region

All these activities, it is assumed, will be programmed by a Regional Commission for Economic Integration (as proposed in a study conducted by the University of the West Indies) within which the proposed Transport and Allied Services commision would



THE OBJECTIVES OF THE WIDER SYSTEM

Fig A17

operate. Their long-term dynamic development plan would result in a broad programme of resource allocation, utilisation and production among islands over the forecasting period and would yield a near-optimal set of goods and services to meet the final demand.

The corresponding short term plan would identify the number of industry sectors and corresponding final demand categories giving greater regional detail. The regional planners would programme these short term plans to determine industrial capacities and outputs by island, to enable the transport planner to estimate the potential traffic volumes. The sub-systems of the wider system (the island economies) will define minimum and desired levels of growth within which the overall objectives of Carifta must be pursued.[24] This is because the degree of autonomy enjoyed by each island, and its political environment can significantly bias investment decisions.

6. Definition of the Objectives of the System

The objectives of the system are dictated by the objectives of the wider system, for if intra-regional trade is essential to the economic growth of the region, a transport system must be available to complete the required trade movements. Every physical system is accompanied by its own unique value system, which can generally be classified in terms of market, profit / cost, quality, performance,compatibility, flexibility, permanence,

---

24. This is because systems in the same level in a heirarchy of systems are normally in conflict. Thus, defining the objectives of the wider system is essential so that the objectives of the competing systems can be formulated in such a way that they contribute effectively to the objectives of the wider system instead of pulling in different directions (Jenkins, 1969).

simplicity and time objectives. Sections 2.5 and 2.4.1 were used to define the objectives of the intra-regional transport system as follows:

Profit-cost - To carry traffic at the lowest cost to the economy within the limitations of capital and other resources available to the transport sector.

Market - To satisfy the annual demand for transport. The implementation of an adequate pricing system would ensure that only demands which were economically desirable to the region would be placed on the transport system.

Quality - To attain a minimum standard of service in respect to the receiving and surface transportation of commodities.

Performance - To provide suitable facilities for the movement of chilled and frozen food products while maintaining existing facilities for the movement of general cargo.

Compatibility - The degree to which improvements or additions to the existing transport system had to be compatible, in terms of the equipment used, was not identified.

Flexibility - To provide a transport system which can easily be adjusted to carry cargo, the commodity composition of which will change rapidly over the next few years.

Permanence - To avoid technical obsolescence.

Simplicity - System improvements should be compatible with the technical competence of the labour available.

Time - To provide a sufficiently frequent scheduled service for all commodities, particularly perishables, between sources of supply and destination. Target dates for the introduction of specific categories of transport improvement could then be defined if users requirements could be forecasted.

7 Definition of the Overall Economic Criterion

7.1 System Objectives and Performance Criteria

Having defined the objectives of the system, it is important to combine these into a criterion which measures the efficiency with which the transport system can fulfil its objectives. A cursory examination of the derived design criteria shows that some of these objectives may be in conflict. For example, investment costs might be reduced at the expense of increasing both design and operating costs. In 1957, the Canadian Government chose to invest in two ships for the region, in preference to being involved in an unfair distribution of aid, as it would have been concentrated in islands where port and airport facilities were lacking. Now that some port improvements are even more urgent, these conflicting objectives must be resolved.

7.2 The Resolution of Competing Objectives

Before an overall economic criterion can be formulated, it is necessary to decide on the compromises which have to be achieved between the conflicting objectives of the transport system. To do this, the relative importance of each design criteria must be determined, so that appropriate weights, or constraints may be attached to each criterion.

7.2.1 General Considerations

The first objective, that of carrying traffic at the lowest cost to the regions economy conflicts with one for the wider system (to encourage the development of intra-regional trade). The present intra-regional shipping service is subsidised by the governments of the region by E.C. $ 700,000 per annum. However, "the regularity of the service has assisted in the development of regional trade and the improvement of communications between the West Indian peoples." C. O'Loughlin (1965) further states that "it must be agreed that the value of this type of service is partly non-economic, and its continuation is less justifiable if all West Indian countries feel that they have nothing particular to gain from the strengthening of the spirit of regional co-operation and cultural ties." Thus, the promotion of transport through Government subsidies might appear to be a legitimate goal, if the region's social and political integration cannot be pursued in any other way.

On the other hand, it can be argued that "subsidising transport is a practically inefficient method for achieving these goals, for several important reasons. First, the subsidy is in effect hidden and its amount is difficult to ascertain since allocating transport costs to specific users is a complex task, subject to wide margins of error and disagreement. Indeed, the fact that the subsidy is hidden is one of the reasons why this device is politically so attractive; it may also explain why so often no action is taken to change the subsidy. Second, the subsidy usually has to be financed by charging prices higher than costs for other transport services. For example, in the Soviet Union, profits on passenger services have helped to subsidise freight traffic. Third, transport subsidies tend, in effect, to support indiscriminately a multitude of diverse activities ranging from business functions, vacations, and social visits to religious pilgrimages; these hardly deserve equal government support and, if openly avowed, would rarely receive it. Fourth, using a particular transport mode for subsidization leads to distortions between modes; inadequate shipping user charges, for example, tend to shift traffic to shipping even though it might be more efficiently carried by air. Fifth, transport subsidies distort the location of new industries or population, and discourage existing industries from moving to more economic locations.

Sixth, passenger transport subsidization is frequently inconsistent with policies aiming at a more equal income distribution since the people who can afford to travel are usually in the middle and upper classes. Finally, it is sometimes argued that keeping transport prices low, regardless of costs, helps to reduce inflation in countries confronted with this problem. This may be valid in the short run for psychological reasons, but it merely increases government deficits, which are at least as inflationary as higher transport prices." (Adler, H., 1967)

Adler, H., (1967) further states that "instead of using the transport system as a subsidy device, it would be much more efficient to have the responsible government agencies finance the subsidy directly through their own budgets, either by supporting the ultimate objective directly or by buying the transport service at commercial rates. For example, if a country wants to promote the production of iron ore, direct payments to producers are more efficient than hidden transport subsidies. It is not surprising that many of these objectives look much less important to the interested government agencies when they have to finance and justify them directly in their own budgets than when they can impose the costs on others."

However, in the Caribbean, the retention of the shipping service is the method chosen to promote the region's social and political integration and, for the purposes of this study, is the method assumed to exist. For this reason, the overall objective is to carry traffic at the lowest cost to CARIFTA while satisfying th other objectives defined in section 6 (which are all constraints to system design).

7.2.2 The Relationship Between Conflicting Objectives

If the Carifta Secretariat is to carry out design improvements to the transport system it will first affect the allocation of investment funds among the islands within the region and secondly, and subsequently, the "efficiency," or operating cost of the transport system. In the first case, the island selected for the investment could benefit, while in the second case, all island governments would benefit if their contribution to the subsidy was reduced. As the autonomy of each island, in controlling investment decisions affecting itself, has to be recognised, it is clear that the Carifta Secretariat must allow each island to participate in the design process.

These separate objectives can only be combined into an overall economic criterion, if the importance of each to the investor[25], can be established. In discussing the formulation of such a criterion, the O.E.C.D. (1968) states "that the choice between projects in any sector should be made on the basis of the present discounted value of the benefits less costs in each year of the projects existence, provided sufficiently plausible estimates can be

---

25 The island governments

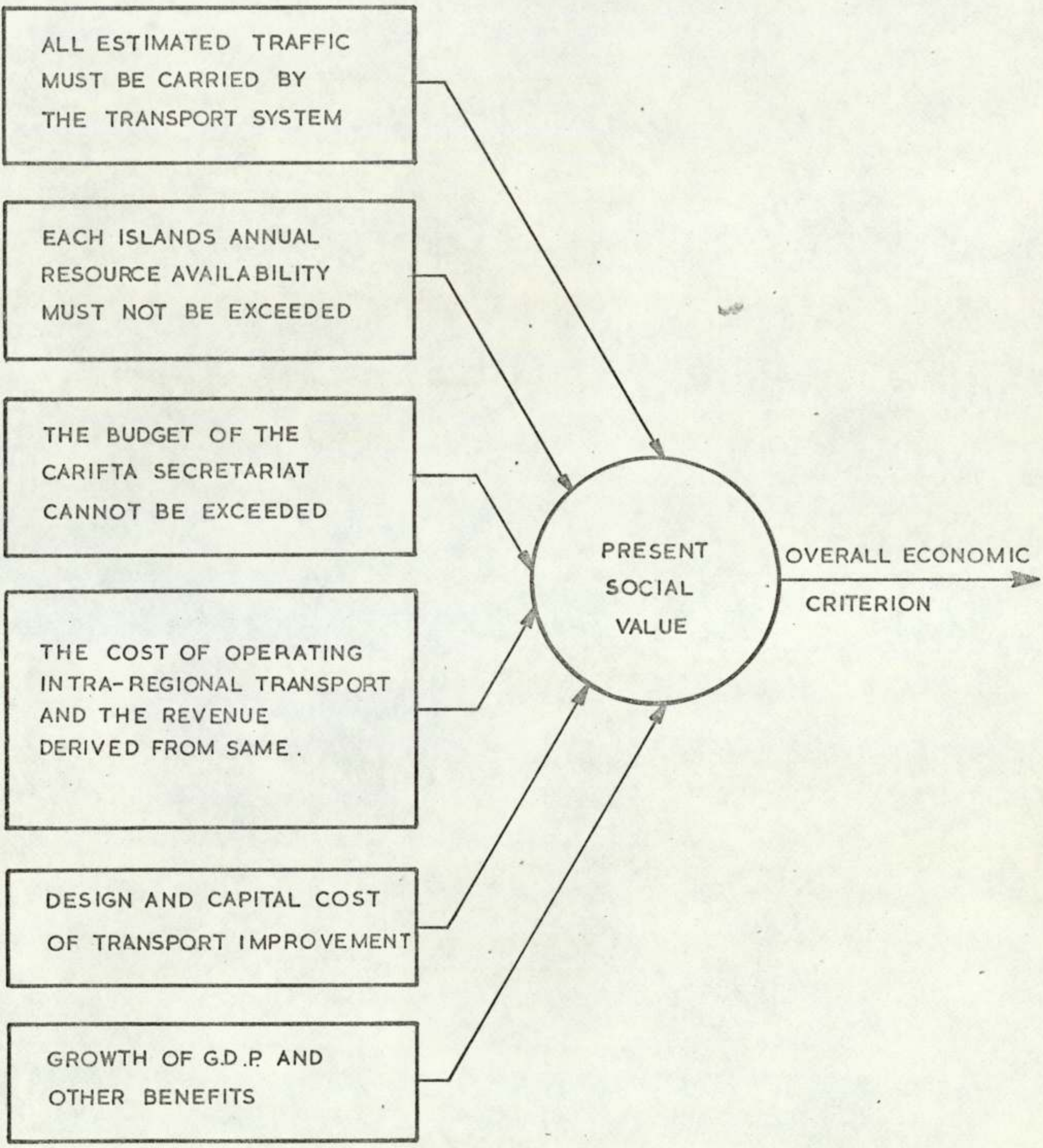
made of the benefits and costs. The selected cost-benefit criterion can be applied whenever the government makes industrial investments itself, or when it requires the private sector to submit projects before it decides to approve them." (O.E.C.D. 1968) The O.E.C.D. further explain that projects must be selected only if they have a positive present social value at the chosen rate of discount, where the rate of discount (the rate of interest by which future costs and benefits are discounted) is related to the balance of payments situation in the country.[26] The manual concludes with a scheme for the cost-benefit evaluation of an investment proposal, the primary aim of which is to calculate the cost of the quantities of inputs and outputs of the project which, it is assumed, have previously been estimated. The scheme suggests that external effects have to be estimated i.e. one has to estimate what kind of changes in the economy any particular project will lead to; The Carifta Secretariat would have to consider what these changes are worth to the region by, implicitly, comparing them with other changes that might have happened instead. This recommended approach to project evaluation was accordingly selected and resolves the problem of identifying the relative importance of each competing objective by stating that a proposed improvement to the transport system should only be undertaken if the present social value (PSV) of the improvement is positive. Clearly, the Carifta Secretariat would only accept the improvement which had the highest PSV from the alternatives proposed. Figure A.18 shows how the individual design criteria have been incorporated into an overall economic criterion which can be used to assess the value to Carifta of each transport system improvement.

The design constraints selected were :

- All estimated traffic must be moved by the transport system (The implementation of an adequate pricing system would

---

26. (O.E.C.D, 1968). See pages 88 to 100 where this point is explained as well as the methods of project evaluation.



DESIGN CRITERIA COMBINED

Fig. A·18

ensure that only demands which were economically desirable to the region would be placed on the transport system. (Governments could then subsidize those additional movements which, while desirable for social reasons, are not economic.)

- Each island's annual budget in terms of capital, manpower and equipment must not be exceeded in projects which directly concern its government, i.e. those projects over which it has jurisdiction.
- The resource budget of the Carifta Secretariat or other investing authorities cannot be exceeded.

The other criteria selected for inclusion in the calculation of the PSV of any selected transport system alternative were as illustrated in Figure A.18.

The other design criteria defined in Section 6 were regarded as constraints which any transport system improvement must satisfy.

8. Information and Data Collection

The earlier sections of this appendix have indicated the need for information about the existing transport system if regional planning for future needs is to be possible. The data needs identified in the flow block diagram of the transport system can be classified under the following headings :

- The volume and composition of commodity flows
- Physical facilities and their utilization
- The cost of transport and related tariffs
- Population movements
- The tourist industry
- Tourist movements

8.1 The Volume and Composition of Commodity Flows

The commodity flows of each island were collected for 1965 (the base year chosen for the study) from the various islands' Annual Trade Reports. In the Caribbean, the majority of their annual trade statistics do not contain summary totals. Thus, each inter-island flow in value and/or volume terms has to be obtained by summing all subcommodity statistics. Import, export and re-export statistics were collected for those islands within CARIFTA, in terms of both the value and volume of each commodity category quoted. From these, a table was constructed for 1965 for each of the eleven countries in the Caribbean, giving the value ($ BWI) and the volume (cubic feet) of imports and exports within the Caribbean according to certain commodity categories. The approach used is described in Appendix B where the different systems of recording trade statistics are also discussed.

The proportion of intra-regional traffic carried by the shipping service can be obtained by sampling the ships manifests and/or the master documents used by forwarding agents. Samples of these documents are also given in Appendix B.

Imports to the CARIFTA islands from outside the region in value terms are given in Appendix C together with the exports of the CARIFTA territories to the rest of the world. Only intra-regional volume flows were derived for the purposes of satisfying the aims of the study.

8.2 Physical Facilities and their Utilisation

The flow block diagram of the transport system (figure A.8) identifies those elements of data that would be obtained or derived in any client sponsored study. It can be seen that a port's facilities can be described in terms of its capacity for 'on-loading', 'off-loading' and ship-docking. In practice, such information would be estimated for the time period considered in a study. Committed investment plans could, for example, increase the on-loading capacity of a particular port in 2 years time. Information relating to the domestic shipping fleet concerning its capacity, age, and condition would also be obtained in a client sponsored study.

8.3 The Cost of Transport and Related Charges

8.3.1 Port Costs and Revenue

Those elements of data identified in the flow block diagram of the transport system (Figure A.8), are as follows :

Operating costs	-	the manning costs of a port
	-	the annual cost of each berth
	-	other costs of port operation
Investment costs	-	cost of investment in port facilities
Revenue	-	port charges for loading, berthing and discharging

8.3.2 Shipping Costs and Revenues

Those identified in figure A.8 were :

- The cost of loading, berthing and discharge
- The annual capital cost of a ship

- Manning costs
- Fuel costs per mile
- Fuel costs in port
- Port charges
- Investment costs
- Government subsidy
- Revenue derived from the carriage of cargo

Information on the landing, storage and delivery (L.S.D) charges[27] is given in table A.9.

Grenada	$	7.65	- per measurement-ton
St. Vincent	$	9.60	-
Barbados	$	6.30	-
St. Lucia	$	5.80	-
Dominica	$	9.50	-
Montserrat	$	12.00	-
Antigua	$	16.00	-
St. Kitts	$	13.50	-
Jamaica			Information not available
Trinidad			Information not available
Guyana			Information not available

Source : Alonzo, O.J., Shipping Manager, Port of Spain, Trinidad.

LANDING CHARGES, APRIL 1969

TABLE A.9

27. In the Caribbean the quoted freight rates only cover the cost of delivering cargo to a port. For each ton of cargo landed, an additional L.S.D. charge covering landing, lighterage, storage and delivery is levied by the port concerned.

Information relating to the cost per ton for cargo handling (loading/unloading) at some West Indian ports is given in table A.10.

TERRITORY	$ per ton
Antigua	27.22
Montserrat	20.86
Trinidad	15.91
Guyana	14.76
Dominica	13.10
St. Vincent	10.38
Barbados	9.56
St. Lucia	9.14

Source : Palmer, A., Booker Shipping (Barbados) Ltd.

AVERAGE CARGO HANDLING COSTS. TABLE A.10

These figures are an average of the cargo handling costs only and state the cost to the ship owner of loading or discharging cargoes at these ports. Other information listed in the flow block diagram of the transport system included sailing distance and journey time.

An intra-regional distance matrix was developed from an Admiralty chart of the area and is given in Appendix C, excerpts of which appear in table A.11.

10	7	11	2	3	4	5	6	8	9	Port Reference
1041	1075	1329	856	906	886	938	980	972	972	Jamaica (1)
	213	364	400	402	383	294	232	176	93	Trinidad (10)
		397	312	285	270	173	114	99	151	Barbados (7)
			702	669	646	550	478	464	412	Guyana (11)
				60	60	142	220	269	327	St. Kitts (2)
					40	119	198	252	317	Antigua (3)
						96	174	227	283	Montserrat (4)
							80	137	201	Dominica (5)
								66	129	St. Lucia (6)
									83	St. Vincent (8)
										Grenada (9)

Source: Admiralty Chart No. 762. 'West India Islands and Caribbean Sea'

INTER-PORT DISTANCE MATRIX TABLE 2.11

The actual journey times quoted by the present West Indies Shipping Service are given in Appendix D . Table D . 6.

These times were used to derive realistic journey times for all inter-port distances as tabulated below. (The ports do not operate at night.)

Thus:

If journey distance is < 240 miles, journey time = 1 day

If journey distance is > 240 and < 720 miles, " = 2 days

If journey distance is > 720 and < 1, 200 miles " = 3 days

If journey distance is > 1, 200 miles " = 4 days

These assumptions were used to derive the inter-port journey times illustrated in Table A.12.

10	7	11	2	3	4	5	6	8	9	PORT REFERENCE	
3	3	4	3	3	3	3	3	3	3	Jamaica	(1)
	1	2	2	2	2	2	1	1	1	Trinidad	(10)
		2	2	2	2	1	1	1	1	Barbados	(7)
			2	2	2	2	2	2	2	Guyana	(11)
				1	1	1	1	2	2	St. Kitts	(2)
					1	1	1	2	2	Antigua	(3)
						1	1	1	2	Montserrat	(4)
							1	1	1	Dominica	(5)
								1	1	St. Lucia	(6)
									1	St. Vincent	(8)
										Grenada	(9)

TABLE A.12

INTER-PORT JOURNEY TIMES (IN DAYS)

Partial information relating to shipping revenue was obtained in the form of the 1969 freight rates within the region.

The rates are quoted in Table A 13. They are taken from a common freight tariff, that is, the rates are the same from Jamaica to all islands southbound and from Trinidad to all islands northbound, and for all ports in between, the only difference being that there is a 5% surcharge on consignments originating from Kingston Jamaica, and Port of Spain, Trinidad.

Freight charges are normally based on cubic feet where 1 freight ton is equal to 40 cubic feet. Where particular commodities of high density exceed 1 freight ton so that the actual weight in tons exceeds this, the freight-rate is based on the actual weight of the commodity.

S.I.T.C.	COMMODITY	BASIC FREIGHT RATE
		West Indian Dollars[30]
01	Meat preserves	27.50 ton weight/ measurement
01	Meat, fresh - shipped refrigeration	86.00 ton weight
07	Tea, coffee	27.00 ton weight/ measurement (07 and 11)
11	Beverages	
121	Tobacco	
	Manufactured	37.00 ton weight/ measurement (121 and 122)
	unmanufactured	
122	cigarettes, cigars	
22	Oil seeds	21.00 ton weight
25	Woods, rough deals, etc.	38.00 per 1000 FBM
25	Cork	34.50 per ton weight/ measurement
55	Essential oils	0.16 per imp. gallon
54	Medicines	27.50 ton weight/ measurement
54	Medicines F.P. below 92°F	27.50 ton weight/ measurement
58/59	Plastics, resins (as a general guide)	27.50 ton weight/ measurement
62-64	Paper products as a general guide. Average	19.00 ton weight/ measurement
65	Textiles	41.00 ton weight/ measurement
69	Metal manufacturers (general guide)	29.00 ton average, alternatively 34.50 ton weight/ measurement (69 and 72)
72	Elec. machinery (general guide)	

Source : Furness Withy & Co.

---

30. 4.8 dollars W.I = £1 Sterling

INTRA-REGIONAL FREIGHT RATES TABLE A.13

TABLE A.14

MIGRATION, MODE OF TRAVEL 1964

	Antigua	Barbados	Dominica	Grenada	Montserrat	St. Kitts-Nevis-Anguilla	St. Lucia	St. Vincent
Arrivals:								
Sea	2,782	5,938	2,964	6,488	1,202	3,330	3,461	7,026
Air	49,224	76,145	5,208	13,618	4,630	12,591	12,330	8,589
Total	52,006	82,083	8,172	20,094	5,832	15,891	15,791	17,615
Departures:								
Sea	2,643	4,549	2,959	6,780	797	4,052	3,948	9,761
Air	55,740	78,085	5,196	13,842	4,969	12,613	12,311	9,030
Total	58,383	82,634	8,155	20,622	5,766	16,665	16,279	18,791
Temporary Halt:								
Sea	3,561	59,417	N.A.	N.A.	88	5,285	N.A.	N.A.
Air	114,897	84,550	N.A.	N.A.	3,384	12,290	N.A.	N.A.
Total	118,458	143,967	14,391[a]	10,436[a]	3,472	17,575	9,264[b]	4,212
Net migration	-6,377	-551	+17	-528	+66	-774	+468	-1,176

[a] Cruise passengers; [b] Cruise and intransit passengers (by sea);

8.4 Population Movements

Estimates of the population movements within the Caribbean and the mode of transport used were derived from the 1960 population census and figures of birth, deaths and net migration, supplied by the Statistics Departments of the various territories (Trinidad and Tobago Statistical Digest, 1966). Table A.14 shows that the volume of passenger traffic is heavily in favour of air travel in Barbados, St. Kitts, St. Lucia and Antigua. This is a reflection of the relatively better facilities for air travel in these territories and the greater availability and consequent importance of transport facilities by motor and sailing vessels in some of the other territories, especially in Grenada and St. Vincent in their traffic with Trinidad, and to a lesser extent with Barbados.

8.5 The Tourist Industry

8.5 The Growth of the Industry

Preliminary information on the industry and its characteristics was obtained from the Tripartite Survey, (1966). In 1965 the total of 170, 390 visitors to the islands included approximately 58, 000 West Indian visitors, that is, visitors from other British Commonwealth territories in the Caribbean area, including British Guiana. In 1961 the figure was about 33, 000, the increase in the number of visitors staying in hotels etc. between 1961 and 1965 is from about 66, 000 to about 141, 000. This is an increase of 21 per cent per annum. This is clearly a rapid rate of increase, though in absolute terms the increase was 75, 000 visitors over four years, or less than 20, 000 a year.

"The increase in the number of hotel beds between 1961 and 1965 was from 3, 480 to 6, 170, an increase over the four-year period of

77 per cent, or an annual rate of increase of 15 per cent. This discrepancy between the rate of increase of visitors and of hotel beds indicates that either occupancy rates have been rising or that average length of stay of visitors has been falling. In fact it seems that both trends have been taking place, neither particularly rapidly. However, trends in these important indicators of the state of the tourist industry can only be inferred. It is difficult enough in most islands to obtain some estimate of these figures for one year, but almost impossible to obtain a series over a number of years," (Tripartite Survey, 1966).

8.5.2 The Problem of Seasonality

In discussing this factor, the Tripartite Survey (1966) stated "tourism in the islands is highly seasonal, being heavily dependent on a short winter season from mid-December to mid-March. Grenada and St. Lucia have had some success in tackling this problem and have built up a sizeable summer trade. Barbados is spending a lot of money trying to do the same with some success, but Antigua has made practically no progress."

Occupancy rates in Antigua in 1963 by quarters were :

1st quarter - 56.9 per cent,
2nd quarter - 19.7 per cent,
3rd quarter - 19.7 per cent, and
4th quarter - 22.6 per cent

"In Barbados no information on occupancy rates for the whole hotel industry is available by quarters, but it is estimated that during the four month period January to April the average occupancy rate was 60 to 65 per cent in 1965, and for the rest of the year just over 30 per cent. In fact, in all the islands there is only one period of the year when all the hotels are effectively full to capacity, which is from the middle of December until the second half of March. The Christmas and New Year period shows a high occupancy rate and in Barbados occupancy rates are relatively high in July and August. The months of May, June, September, October and November all show disastrously low occupancy rates," (Tripartite Survey, 1966).

8.5.3 The Effect of Tourism on the Transport System

These findings have significant implications for the transport system. The seasonal fluctuation in tourist movements means under-utilization of the system at certain times of the year, while the rapid growth rate in tourist movements could have significant implications in terms of investment in new facilities (fixed installations, ports and airports; and moveable facilities, ships and aircraft).

Table A.15 illustrates recent changes in the travel modes used by passengers visiting the territories of Jamaica, Trinidad, Barbados and Guyana.

It can be seen that there are considerable differences from year to year between the territories in terms of the passenger arrivals by transport mode. If transport planning for future needs is to be possible, the existing flows of traffic between the islands and their countries of origin and destination must be determined.

8.6 Tourist Movements

To determine the movement of tourists within the Caribbean, reference must be made to the routes served and capacity offered. The I. C. A. O. (1968) provides the flow of passengers on all

TABLE A.15

	1961	1962	% Change	1963	% Change	1964	% Change
Jamaica							
total	284,612	276,390	-2.9	277,731	+0.5	303,743	+9.4
by air	192,676	202,136	+4.9	198,529	-1.8	226,358	+14.0
by sea	91,936	74,254	-19.2	79,202	+6.7	77,385	-2.3
temporary halts as % total	50.0	45.9	-	42.6	-	38.8	-
Trinidad and Tobago							
total	215,806	224,824	+4.2	221,650	-1.4	225,330	+1.7
by air	140,904	142,625	+1.2	152,160	+6.7	144,310	-5.2
by sea	74,902	82,199	+9.7	69,490	-15.5	81,020	+16.6
temporary halts as % of total	53.3	53.0	-	56.2	-	54.7	-
Barbados							
total	81,077	87,135	+7.5	96,466	+10.7	123,754	+28.3
by air	46,381	55,791	+20.3	62,369	+11.8	76,145	+22.1
by sea	34,696	31,344	-10.7	34,097	+8.8	47,609	+39.6
Cruise ship arrivals as % of total	33.2	28.3	-	28.2	-	33.7	-
British Guiana							
total	37,843	34,822	-7.8	30,015	-13.9	40,595	+35.3
by air	27,062	25,853	-14.5	21,816	-15.6	32,753	+50.1
by sea	10,781	8,969	-16.8	8,199	-8.6	7,842	-4.4
temporary halts as % of total	N.A.	N.A.	-	32.6%	-	43.5%	-

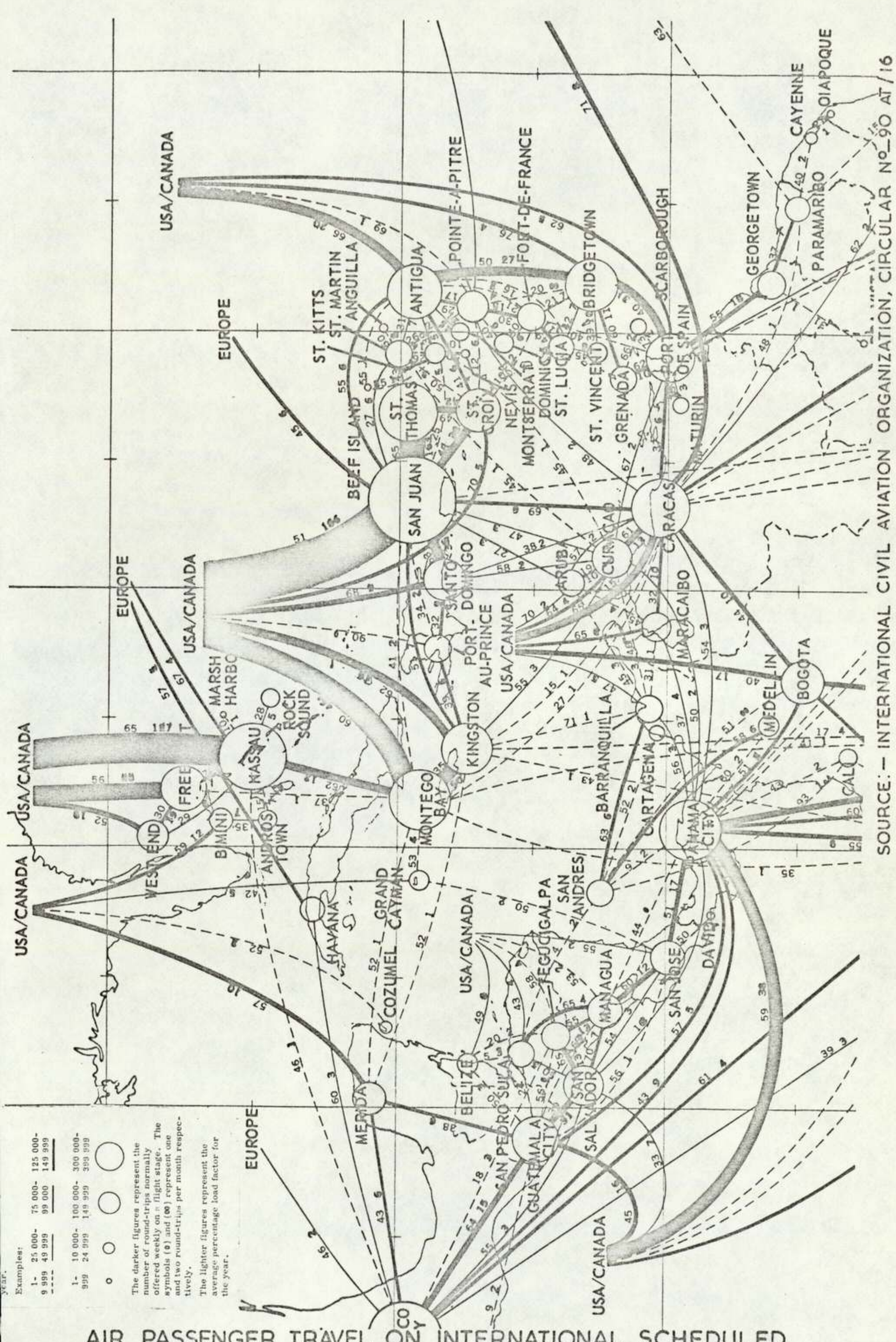
Source: De Castro, 1968

international non-stop flight stages, with one or both terminals in Latin America and provides a comprehensive view of the present state of international passenger traffic flow in the Caribbean. This view is provided in figure A.19. It can be seen that the traffic "has tended to concentrate on a few routes, on which simultaneously, flight frequencies, capacities and often load factors have increased." I.C.A.O. (1968) These major routes of course, illustrate the major sources of tourism.

In an attempt to cross check these figures, stated to be accurate within plus or minus 15%, Table 8 of appendix D was developed from a variety of sources of data and showed that an intra-regional matrix of passenger flows could not be completed. In fact, most of the sources of data consulted refer to the lack of information on this region. Many of the figures were found to be contradictory. This can be explained by the fact that some sources do not distinguish between visitors as defined by the East Caribbean Tourist Association[28] and other "visitors" or passengers entering a country, who will be going onto another destination and are therefore only in transit. If those in transit are counted at each stage of the journey, the figures for total visitors would far exceed the real numbers of tourists. In some cases the source did not define the word visitor. The West India Committee, in an attempt to provide a complete picture of the visitors to the Caribbean published some tourist statistics for the period 1965-1966 which was based on information supplied by the Tourist Boards and National Tourist Offices within the region. This is given in Appendix D, Table 7.

---

28. A visitor is a person who enters a territory, not normally being a resident of that territory for not less than 24 hours and not more than 6 months in the course of any 12 month period, for legitimate, non-immigrant purposes such as touring, business, sports, health, family reasons or study.



AIR PASSENGER TRAVEL ON INTERNATIONAL SCHEDULED SERVICES IN THE CARIBBEAN REGION (1966)

Fig A.19

APPENDIX B

THE VOLUME AND COMPOSITION OF COMMODITY FLOWS

1.0 The Sources of Data

The commodity flows of each island were collected for 1965 (the base year chosen for the study) from the various islands' Annual Trade Reports. An outline of the tables used to perform this arduous task is illustrated in Table B..1.

Trading Country - Trinidad

SITC[1] / Country	Imports (cif) 0 9	Total	Domestic Exports 0 9	Total Domestic Re-exports	Total Domestic Exports (f.o.b)	Total Re-Exports (f.o.b)
Totals	Commodity Totals	M			E	

Table B.1

Domestic exports and, where stated, re-exports, were collected in terms of their SITC division and country of origin or destination. Trade returns for the CARIFTA territories were obtained.

Statistics for the base year (1965) were not available for Montserrat, Dominica and Grenada, although a few statistics were collected from other sources.

---

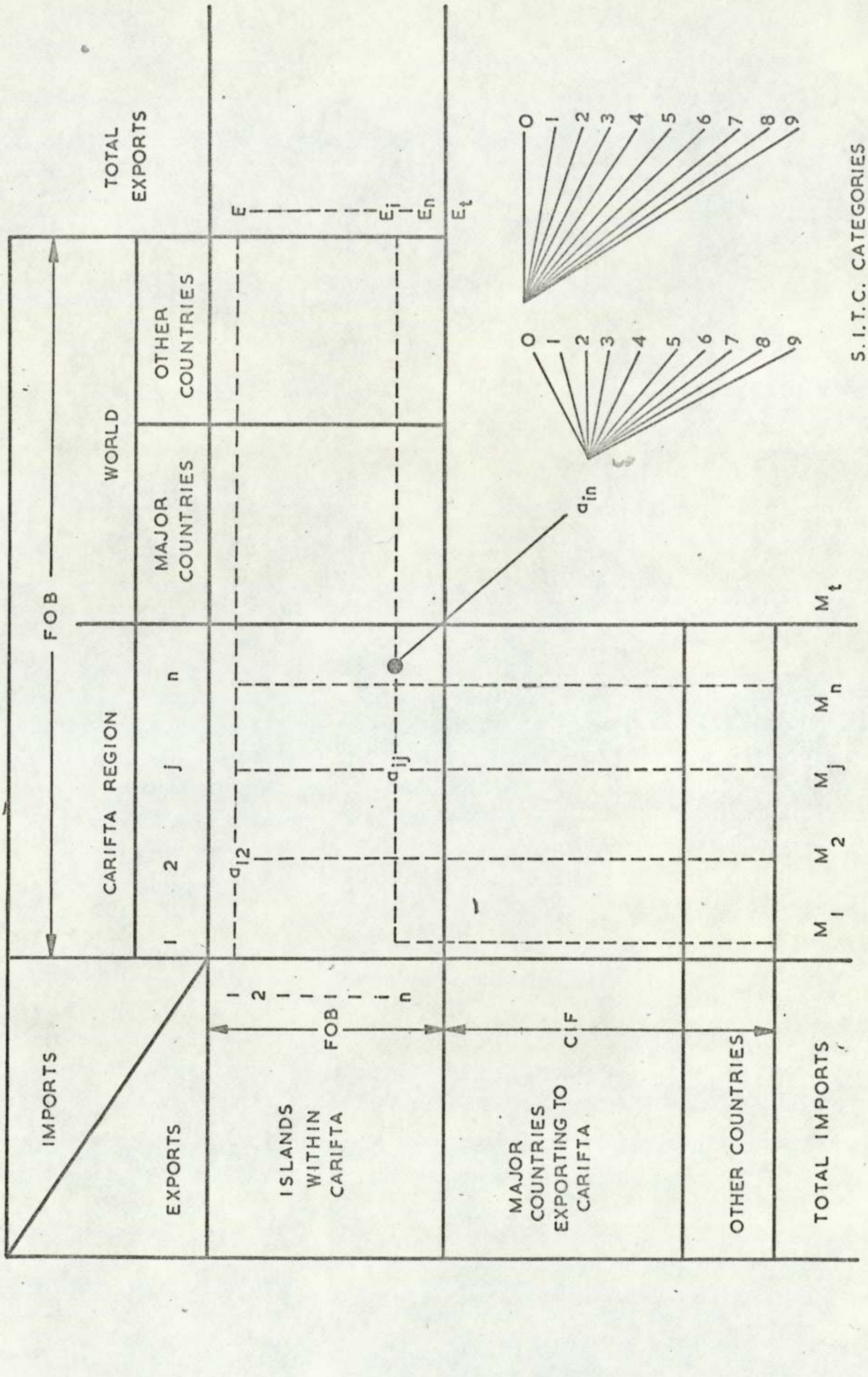
1. Standard International Trade Classification

2.0 The United Nations Annual Trade Statistics

The Derivation of Value and Volume Statistics for Commodity Flows

The collection of current statistics on the composition of commodity flows is a time consuming process, even if these flows are assumed to pass through one port. This can be explained in the trade flow matrix shown in Fig. B.1 . Each value of (a_{ij}) shown in this diagram, is the summation of ten categories of commodity movement. Each category is, in turn, the summation by value of a further ten sub-categories. These categories correspond to the Standard International Trade Classification (SITC) used in trade statistics. In the Caribbean, the majority of their annual trade statistics do not contain summary totals. Thus, each figure in this table in value and/or volume terms has to be obtained by summing all subcommodity statistics, either by country of origin where the values include the cost of freight and insurance (CIF), or by country of destination where the values are given as free on board (fob).

All member territories of CARIFTA use the Standard International Trade Classification (SITC) list issued by the United Nations Economic and Social Council adapted to meet their special requirements. In summary, this list divides the commodities into the following categories, given in Table B.2. The Annual Trade Statistics of each island give both value and volume figures against each sub-category.



A TRADE FLOW MATRIX

Fig.B.1

Table B.2

SITC Division*	Commodity Category
0	Food
1	Beverages & Tobacco
2	Crude Materials, Inedible, Excluding Fuels
3	Mineral Fuels, Lubricants, Related Materials
4	Animal and Vegetable Oils
5	Chemicals (Medicinal and Pharmaceutical Products etc.)
6	Manufactured Goods classified by materials
7	Machinery, Transport equipment
8	Miscellaneous Manufactured items
9	Other

* The Standard International Trade Classification

At this stage commodities 3 & 9 were excluded from further usage, being considered outside the scope of the study. Commodity '3' is largely petroleum; special ports, terminal facilities and ships being used for their movement. Commodity '9' consists of postal packets, other personal goods etc. and was regarded as negligible, in terms of volume.

Import, export and re-export statistics were collected for those islands within CARIFTA, in terms of both the value and volume of each sub-category of the SITC quoted. From these, a table was constructed for 1965 for each of the eleven countries in the Caribbean, giving the value ($ BW1) and the volume (cubic feet) of imports and exports within the Caribbean according to certain SITC categories.

Quantities had to be reduced to a common measurement (i.e. metric tons which are approximately equal to long tons[2]) so that figures for the volume occupied by each sub-category of the SITC could be derived.

Average figures of the volume occupied by each SITC commodity classification were obtained from a number of sources[3] .

These figures are shown in table B.3. As the sources were not in agreement an average figure was derived for each category used so that quantities of goods could be converted into volume terms.

An extract from one of these tables is given in Table B.4 which shows the exports from Jamaica to Guyana, using Jamaican statistical sources. Figures in the volume column are calculated from the annual trade report, which uses weight measurements. These tables were used to estimate the volume of intra-regional traffic using data based on import and export statistics.

Commodity categories 2-7 to 2-9 were omitted due to the lack of information on weight to volume conversion figures. Tables 1 and 2 of Appendix D illustrate the results.

---

2. 1 ton (20 cwt) $\equiv$ 1.016 metric tons.

3. - 'Storage, the Properties and Stowage of Cargoes', by Capt. R.E. Thomas.
   - 'A Handy Guide to Stowage', by G.P. Lewis
   - 'NEDC for Exports to Europe' (volume to weight ratios)
   - 'The Potential for Container Services Based on Physical Cargo Characteristics,' a report prepared by the University of Lancaster for the National Ports Council in December, 1967.

S.I.T.C.		NPC REPORT	LANCS.	THOMAS.	NEDC.	LEWIS.	AVERAGE OF SOURCES
		CUBIC FEET PER LONG TON					
01	MEAT & MEATPREPARATIONS	70	40/46	90	50	92	69
02	DAIRY PRODUCE	66	44	80	-	74	66
03	FISH & FISH PRODUCTS	60	46	76	100	60	68
046-048	CEREAL PREPS & MILLED	50	56	54	-	50	52
05	FRUITS, NUTS, VEGETABLES	85	50/100	60/100	100	50/92	82
062	SUGAR PREPARATIONS	54	94	50	-	56	64
071,072	COFFEE & COCOA	80	80	70	-	70	75
073	CHOCOLATE PREPARATIONS	70	80	70	60	90	74
074	TEA	80	80	70	60	100	78
075	SPICES	80	40	40	-	-	53
08	ANIMAL FEEDSTUFFS	76	-	-	-	-	76
09	MISC. FOOD PREPARATIONS	82	40	40	-	50	53
11	BEVERAGES	64	62	70	60	70	65
121	TOBACCO	112	-	102	60	126	100 (121 and 122)
122	TABACCO MANUFACTURES	100	-	-	-	-	
21	HIDES, SKINS UNDRESSED	102	40	120	100	100	93

S.I.T.C.		NPC REPORT	LANCS.	THOMAS.	NEDC.	LEWIS.	AVERAGE OF SOURCES
		CUBIC FEET PER LONG TON					
22	OIL SEEDS	74	-	-	-	-	74
23	CRUDE RUBBER & SYNTHETICS	72	-	68	-	70	70
25	WOOD, PULP & WASTE PAPER	64	-	56	-	76	65
26	TEXTILE FIBRES	104	70/80	100/150	100	110/70	109
41	ANIMAL OILS & FATS	50	40	40	-	50	} 47
43	ANIMAL & VEGETABLE FATS PROCESSED	50	-	-	-	-	
51	CHEMICALS	52	42	40	60	56	50
52	MINERAL TARS ETC.	50	-	-	-	-	50
53	DYEING & TANNING MATERIALS	52	-	-	-	-	52
54	MEDICINES	52	-	-	-	-	52
55	ESS. OILS, PERFUMES ETC.	52	40	40	-	50	45
56	CHEMICAL FERTILIZERS	54	40	-	-	-	47
58, 59	PLASTICS, RESINS ETC.	51	-	-	-	-	51
61	LEATHERS & FURS	102	30	86	100	140	92

Appendix B. (contd.)

	S.I.T.C.		NPC REPORT	LANCS.	THOMAS.	NEDC.	LEWIS.	AVERAGE OF SOURCES
			CUBIC FEET PER LONG TON					
	62-64	RUBBER, WOOD, PAPER PRODS.	67	68/112	68/90	100	70/100	83
	65	TEXTILES & YARNS	104	72	110	100	106	98
	661, 662	LIME, CEMENT, BRICKS	40	-	-	-	-	40
	663-666	OTHER MINERAL PRODUCTS	73	-	-	-	-	73
*	671, 2, 9	PIG IRON, CASTINGS ETC.	34	48	12	-	60	39
*	673-675	BARS & SHAPES	39	-	-	-	-	
*	677	WIRE	34	-	-	-	-	
*	678	TUBES & PIPES	48	30	-	-	56	
	68	NON-FERRCUS METALS	35	44	14	20	16	26
	69	MANUFACTURES OF METALS	52	68	40	-	40	50
*	711	NON-ELEC. POWER GEN.	100	-	-	-	-	120
*	712	AGRICULTURAL MACHINERY	160	-	-	-	-	
*	714-719	OTHER NON-ELEC. MACH.	100	86	120	100	-	
	72	ELECTRICAL MACHINERY	78	80	130	60	-	87
*	732	ROAD MOTOR VEHICLES PARTS	157	80	-	-	-	139
*	733	OTHER ROAD VEHICLES	160	-	-	-	-	
	8	MISC. MANUFACTURES	106	108	-	-	-	107

Appendix B (contd.)

* Freight rates are based on tonnage.
Freight rates for other commodities are based on volume.

TRADE FLOW - JAMAICA TO GUYANA

STATISTICS SOURCE		EXPORTS FROM JAMAICA	
COMMODITY		VALUE (£J)	VOLUME cu ft
01	Meat & Meat Preps	7	
02	Dairy Produce, eggs and honey	510	73
05	Fruits and Veg.	49112	4674
06	Sugar and Sugar Preps	2075	512
07	Coffee, Tea, Cocoa, etc.	27797	4340
08	Feeding stuff for animals	43	9
11	Beverages	200	15
12	Tobacco & Tobacco manu.	1067	125
41	Animal & Veg. oils	173	45
53	Dying, Tanning and colouring matl.	14504	4004
54	Medical & Pharm. products	7020	312
55	Essential oils & perfume	53205	7020
59	Starches, glues & other chem. mtls.	80	< 1
62-64	Rubber, wood & paper prods	7712	1743
65	Textile, yarn and fabric	25	1
66	Non-Metal mineral manu.	26065	162304
68	Base Metals	1172	60
69	Man. of metals	3004	258
71	Mach. other than elec.	931	12
72	Electrical mach.	312	9
73	Transport equip.	3550	910
81-89	Misc. Man. Prods.	13944	2130
TOTAL VOLUME*			4714

* MEASUREMENT TON TERMS
(40 cubic feet = 1 measurement ton)

Source: Annual Trade Report, Jamaica, 1965

TABLE B.4

3.0 The Reconciliation of Data

It is apparent from these tables that wide differences exist between flows estimated from import statistics and those based on export statistics. The differences must be explained if transport planning for future needs is to be performed. A more detailed examination of the basis of each islands statistics was therefore undertaken.

The basis of the islands statistics are defined by two systems of trade. Those used in the CARIFTA territories are listed below:

ISLAND	System of Trade
St. Kitts, Nevis & Anguilla	GENERAL SYSTEM
Antigua/Barbuda	GENERAL SYSTEM
Jamaica	GENERAL SYSTEM
Barbados	GENERAL SYSTEM
St. Vincent/Bequia	GENERAL SYSTEM
Grenada/Carriacou	SPECIAL SYSTEM
Dominica	SPECIAL SYSTEM
St. Lucia	SPECIAL SYSTEM
Trinidad & Tobago	SPECIAL SYSTEM
Guyana	SPECIAL SYSTEM

The following definitions apply to the two systems of trade:

Special and General System - Common Definitions

Period Covered

The figures of imports and exports represent the totals shown on all customs documents brought to account during the calendar year.

Valuation

Imports are valued c.i.f. and exports, including re-exports, f.o.b.

The c.i.f. valuation is the open market value of the goods at the time of importation, plus the cost of freight and insurance, and any other charges in respect of the preparation of the goods for shipment.

The f.o.b. value is the cost of the goods to the purchaser abroad, including all charges up to the point where the goods are put aboard the exporting ship or aircraft, but not including sea or air freight, or marine or air insurance. Trade discounts to the purchaser abroad are also excluded.

Countries and Areas

Imports are ascribed to the country of origin or country whence consigned, when origin cannot be clearly established. The country of origin is also defined to mean the country in which any final operation altered to any appreciable extent the character, composition and value of partly manufactured goods imported into the country.

Exports are ascribed to the country of final destination or country of consignment which may or may not be the country where the goods are eventually consumed.

Source

All published statistics are based upon the declaration of importers and exporters and are subject to verification by customs officials.

Special System - Definitions

a) Imports represent the total of all imports cleared by the customs for local economy, which excludes all imports remaining under the control of the customs authorities in the bonded warehouses.

b) Exports represent the total of all domestic produce and also re-exports of imported goods which have previously been entered into the local economy. Imported goods which are re-exported directly from the bonded warehouses, and transhipment are excluded.

Total exports are the products of domestic exports and re-exports.

Rounding of Figures

The figures shown in most of the tables are rounded off to the first figure after the decimal point. Addition of these rounded off figures may not always agree exactly with the rounded off totals shown in the tables.

Exclusions

The following are excluded from the Trade Report figures:

a) Ships/Aircraft, Stores/Bunkers supplied to locally registered craft.

b) Individual transactions below a value of $4. 50.

c) Gold coin and bullion issued coinage and issued bank notes.

d) Goods on loan as samples for exhibitions or study.

e) Personal and household effects.

f) Goods on lease such as cinematograph film.

Parcel Post

a) Parcel post imports valued at over $4.50 and less than $29.50 are not classified according to kind by SITC. and item No. (except in special cases and where the commodity can be identified for such classification) but tabulated under Item No. 911-01 - 'Postal Packages' not classified according to kind and showing country of origin.

b) Parcel post imports valued at $29.50 and over are classified according to kind by SITC Item No. and are tabulated with the other items of imports and therefore are identifiable as parcel post imports in the published trade statistics.

c) Exports by parcel post are not recorded or accounted for on customs warrants and therefore figures relating to these transactions are not always included in the trade statistics.

General System - Definitions

a) Imports relate to all goods (except transhipment goods) imported into the island, whether entered for home consumption or warehousing, or subsequently exported.

b) Exports relate to all goods, except transhipment goods, which leave the island. They comprise domestic exports and re-exports.

i) Domestic exports relate to the goods which are grown, produced, or wholly or partly manufactured in the island.

ii) Re-exports relate to goods which have been imported, and subsequently exported (other than transhipment goods).

Articles imported into the territory for repair are not valued on importation and only the cost of repairs (plus any other appropriate charges) are shown on re-exportation. Correspondingly, articles exported from the territory for repai r are not valued on exportation, and only costs of repairs (plus any appropriate charges) are shown on re-importation.

Exclusions

The following items are excluded from trade statistics:

a) Gold coin and bullion, issued coinage and issued bank notes.

b) Goods on lease e. g. (cinematographic films).

c) Exports by parcel post. (However, these are of negligible value).

d) Commercial travellers' samples, but the value of personal effects of travellers are included.

e) Imports and exports of less than six dollars in value.

f) Intransit goods.

Such is the basis of the statistical source on commodity flow within the CARIFTA territories.

Unfortunately these two systems of trade create data incompatibility. The following points are relevant:

- Both systems base statistics on customs documents bought to account in the period quoted in the annual trade report (calendar year).
- Imports are, where possible, re-allocated to their original sources even if a re-export from another island.
- Exports are ascribed to the country of final destination.
- Commodity classification SITC9 is not compatible with the two systems of trade.
- In the general system, imports include those for warehousing.
- In the special system, imports are mainly for domestic consumption, as imports remaining under the control of the customs authorities in the bonded warehouses are excluded.

Table B5 compares the two systems of trade and illustrates the compatibility between the trade statistics of each island when different systems of trade flow reporting are used. It is apparent that transhipment movements are excluded from both systems of trade, although section 3.4.3 shows that intra-regional commodity flows can comprise:

- Re-exports or transhipment goods due to distant country[4]
- Re-exports or transhipment goods due to an intra-regional island.

---

4. The only means of altering this activity would be through offering incentives to foreign shipping companies, e.g. subsidising port charges or improving port facilities, to reduce turn-round time. Even these moves might not have the desired effect if the shipping route is determined by factors outside CARIFTA, regardless of subsidy or other action.

- Domestic export
- Exports due for transhipment[5]

It is essential to have estimates of transhipment goods entering and leaving the region because these movements are created by the existing route structure outside the region. This structure may mean that only one or two ports can be used by some islands within the region to ship the major part of their exports to the outside world. Such transhipment movements will have a significant effect on the capacity requirements of an intra-regional transport system.

Such statistics can be collected by sampling appropriate waybill data. Fig.B .2 illustrates the 'Master Document' used by forwarding agents in the United Kingdom to initiate an export consignment. Cells to be completed include:

- Dock, wharf, station	- Local Vessel and port of loading
- Ocean vessel, aircraft, etc.	- Sea/Air port of loading
- Sea/air port of discharge	- Final destination

If documents used by forwarding agents in the Caribbean contain such information, then transhipment goods, and the link of the network over which they move could be identified by sampling such data. The United States Lines, Inc. use a short form bill of lading[6], containing spaces for the same information as quoted above.

---

5. The choice of entrepot for domestic exports to countries outside the region may be one forced upon the Regional Commission by the inter-regional shipping companies (e.g. their desire to call at one port only).

6. Held by R. G. Smith of EASAMS

TABLE B.5

(Actual trade flow between A & B) = Domestic exports + Re-exports + Exports of goods in bond				
System of trade	**Categories of trade**			**Error term**
Special System	(Exports of 'A' where 'A' uses the Special System) =	Domestic exports of Island A	+ Re-exports of Island A	+ Less goods in bonded warehouses
	(Imports to 'B' where 'B' uses the Special System) =	(Domestic exports of Island 'A')	+ 'A')	+ Less those re-exports assigned to their source of origin less goods due for storage in bonded ware-houses
General System	(Export of 'A' where 'A' uses the General System) =	(Domestic exports of Island 'A')	+ Re-exports including those for bonded warehouse	
	(Imports of 'B' where 'B' uses the General System) =	(Domestic exports of Island 'A')	(Re-exports of 'A' including those for bonded warehouse in Island 'B'	+ Less those re-exports assigned to country of origin

In using trade flow statistics the points given in Table B.6 may be noted.

TABLE B.6

System	Imports	Exports
Special	To local economy plus those for subsequent re-export, less (re-exports assigned to their source of origin and goods due for storage in a bonded warehouse)	Include both domestic and re-export categories excluding goods in bonded warehouses
General	To local economy plus those for subsequent re-export and storage in bonded warehouses. Less those re-exports assigned to country of origin.	Domestic exports plus re-exports and goods exported from bonded warehouses.

Appendix 7

Master Document

Exporter	J.L.C.D. Exports Ltd., 1, Victoria Street, LONDON S.W.1.
Air WB (or B/L) No.	
Exporter's Ref.	EX. 7454/6
Export Division	22
F/Agent's Ref.	AB.23459
C.D.6 No./N.A.	AA 323269
Consignee (if 'Order' state Notify Party)	ORDER - Notify Herrmann & Mayer Inc. P.O. Box 854 Indianapolis U.S.A.
Name & Address of Exporter's Bank in U.K.	General Export Bank of U.K. Ltd., Lime Street, LONDON E.C.3.
Forwarding Agent/Merchant	Atlas Forwarding Company Ltd., Tower Quay, LONDON E.C.3.
Export Licence No.	
Ship's Nationality	British
Country of Origin of Goods	
Country to which Goods Consigned	U.S.A.
Date of Clearance	1. 9. 65
Dock / Wharf / Station	3 Shed Albert Dk.
Terms of Delivery and Payment	C.I.F.
Local Vessel	
From (Local port of loading)	
CD6: Amount Due:	£ 17,250
Ocean vessel / Aircraft, etc.	M/V FERNIE
Sea / Air Port of Loading	London
Insured Value: (in words)	Seventeen thousand, five hundred and fifty
Currency:	£ Sterling
Figs:	£17,550
Sea / Air Port of Discharge	New York
Final Destination	Indianapolis
Freight payable at	Prepaid
Number of original Bs/L	3 (Three)

Marks & Numbers	Number and kind of packages: description of goods		Export List Code No.	Gross Weight T C Q L	Cube Ft. In.
a) H & M 2414 NEW YORK 95 - 99	5 crates Dairy machinery - Milking machines	a)	E.11.111	1- 8-3-12	28- 8
		b)	E.22.222	15-2- 9	30-10
b) H & M S.5376 NEW YORK 3621/3622/ 3627	3 cases Electric machinery - Switch gear 600 volts	c)	E.33.333	4-3-17	49-11
			Quantity	**Net Weight T C Q L**	**Value (£)**
c) H & M S.50763 NEW YORK 3127 - 3246	120 Fibre Board Cartons Domestic Radio Receivers (Transistor)	a)	-	1- 6-1-19	3,275
		b)	-	13-3- 7	12,590
		c)	120 sets 960 valves	4-1- 4	1,263

Particulars of any U.K. processing	
Invoice Price	£ 17,250
CD6: Total Value	- -
CD6: Date Payment Due or Consignment Permission Reference	One - half by 19. 12. 65, the balance by 19. 2. 66.

FREE DISPOSAL

(Certificates, Declarations,

Seals etc.,)

Number of Packages (in words): One hundred and twenty eight

Signature: J. Doe.

Date: 25. 8. 65.

20 mm. Margin for Machine Grip and Filing.

Fig. B .2

Thus, both import and export transhipment movements could be identified by sampling the appropriate forms. An alternative approach was suggested by Nicolson, M.A.[7] who informed the author that the transhipment cargo could easily be identified by sampling the ships 'manifest' where transhipment cargoes are identified by the name of the shipper. Apparently, some shippers are concerned only with intra-regional traffic; others are concerned only with transhipment traffic between Carifta and the rest of the world. An example of two ships manifests are illustrated in Fig. B.3 These show that the shipper can be identified, as well as the port of transhipment.

Now intra-regional transhipment movements originating and terminating within the region, are really a portion of the import-export movement of trade within the region, and have therefore, already been counted by the import/export statistics of the islands. It is therefore essential that transhipment flows are added to the flows between the origin or destination port and the port of transhipment while ensuring that flows are not double counted.

Table B.5shows that only the general system of trade provides error free statistics if export data only is used. When the intra-regional trade flow statistics were compared, large discrepancies between the import and export flows were identified as follows:

---

7. Interview with the author on 12th November 1970. at Booker McConnell head office. Mr. Nicolson is the chairman of the Booker Line.

FIRST SHIP'S MANIFEST (UNITED STATES LINE INC.).

MANIFEST OF CARGO LOADED IN LONDON
MANIFIESTO DE LA CARGA EMBARCADA EN LONDRES

ON BOARD THE SHIP / A BORDO DEL VAPOR } m.v./s.s. ______ NATIONALITY / DE NACIONALIDAD } ______

OF / DE } ______ N.R.T. / TONELADAS DE REGISTRO SAILED / SALIDO EL }

DESTINATION / CON DESTINO AL PUERTO DE } SHEET No. / FOLIO No. }

		Numero de Orden Del Conocimiento	Cargadores	Consignatorios	Marcas y Numeracion de los Bultos	Cantidad	Contenido	Peso Bruto	Observaciones	Peso Bruto	Medidas	Valor £
Sadle Code	Ship/Port Code	B/L No.	Shippers	Consignees	Marks and Numbers	Quantity	Description	Gross Wt. Kilos/Lbs.	Remarks Stowage	Gross Weight Tons Cwt. Qrs. Lbs.	Measurements Feet Ins.	Value £

SECOND SHIP'S MANIFEST (BOOKER McCONNELL)

B/L No.	SHIPPER	MARK	Nos	PKGS	DESCRIPTION OF GOODS	WEIGHT OF MEASUREMENT	CUBIC MEAS.	FREIGHT WEIGHT	BILL OF ENTRY	CONSIGNEE

SHIPS MANIFESTS

Fig. B.3.

INCONSISTENCIES IN IMPORT-EXPORT DATA

SITC	Trinidad[9] (f. o. b)	to St. Kitts (c. i. f)	Trinidad[9] (f. o. b)	to Antigua (c. i. f)
00	-	26	-	-
01	-	197	-	1668
02	6400	503	19400	2079
03		397		
04	18800	12139	1300	1129
05	40400	38800	88000	54484
06	500	12		
07	10200	2623	3300	11015
08	2200	3216	2400	237
09	91400	83585	50300	33480
11	72700	81668	9406	5245
12	-	1300	-	-
22			300	-
24	500	1349	2900	2680
26			3700	526
27			300	1248
29			700	305
41			22800	23980
51	3100	5986	5500	19982
52	-	91		
53	39400	45762	51000	56668
54	19300	16774	26200	24548
55	69200	70085	100700	77782
56	74700	91706	1400	
59	4600	3477	25200	15290
61	400	454	200	224
62 - 64	15500	8535	33400	14094
65	4400	4468	29800	10229
66	143100	183884	382200	278481
67		1920	9500	27066

TABLE B.7

contd. /...

TABLE B. 7 Contd.

SITC	Trinidad[9] (f.o.b)	to St. Kitts (c.i.f)	Trinidad[9] (f.o.b)	to Antigua (c.i.f)
68	21000	8077	23000	20124
69	58300	8759	82600	46168
71	11300	1146	49000	49062
72	3100	641	115900	5240
73	10900	605	6280	4190
81 - 89	251300[10]	217914	536300	418762

Trinidad ⟶ St. Kitts

Trinidad ⟶ Antigua

These comparisons are given in Table B 7. It can be seen that inconsistencies[8] exist in the following categories of data:

- Import total (c.i.f) is less than export total (f.o.b) although some of the individual categories are in agreement

- An import figure exists where no export figure exists

These errors are caused because customs documents brought to account in the export country do not coincide with the period used

---

8. In any study, under contract, a full investigation of the discrepancies would be undertaken if identified as significant.

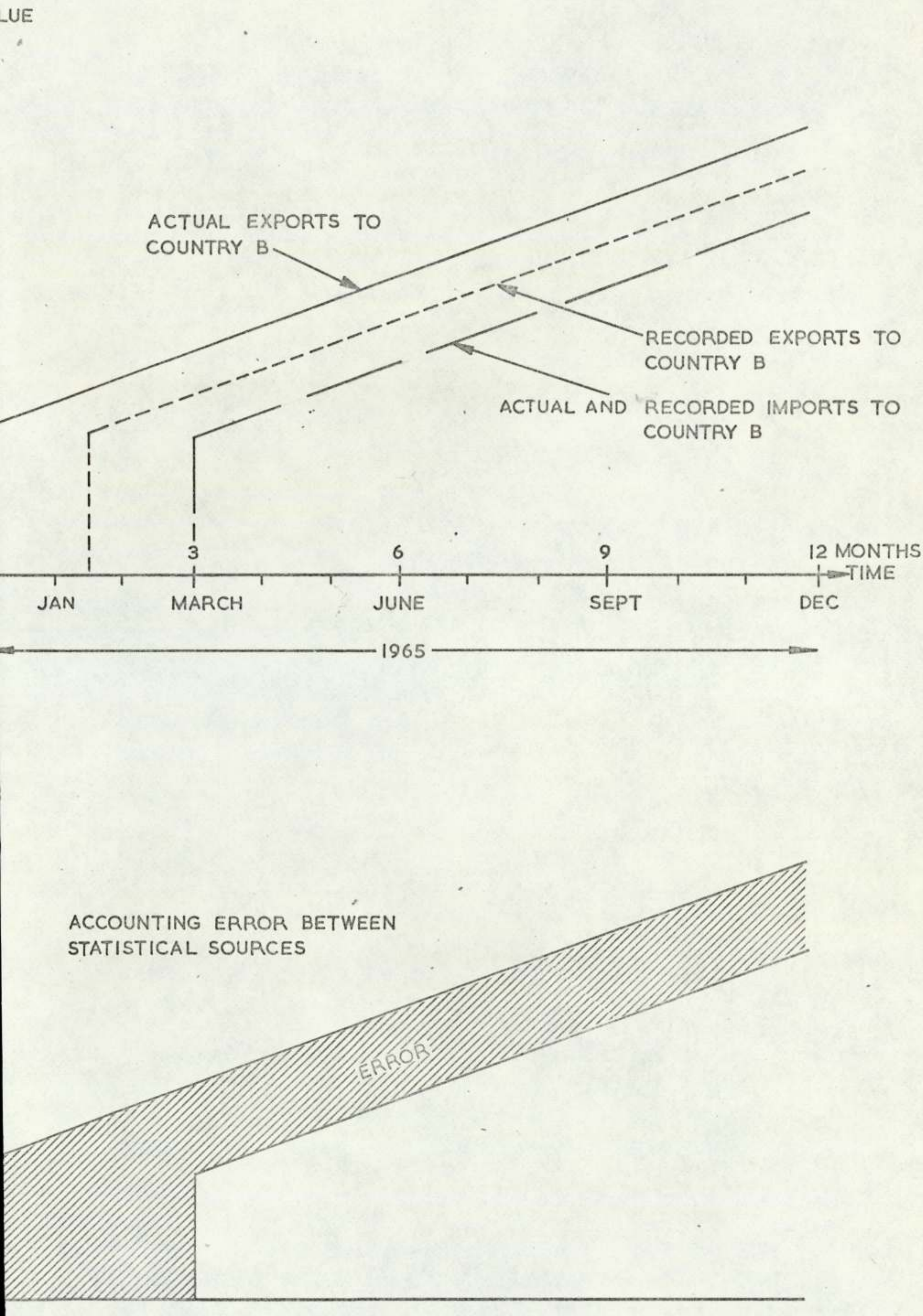
9. Exports and Re-exports. Values given in \$ W.I. (1 \$ W.I. = 0.5833 \$ U.S.)

10. Taken from the summary table in the 1965 annual trade report for Trinidad and Tobago, Series B due to an error identified by E.C. Emerson. All other figures in this table were derived by Miss Linda Job from the 1965 Annual Trade Reports of the islands concerned.

by the import country. Delays may occur for several reasons such as:

- The time lag between the submission of documentation of the consignment in the exporting country A and the importing country B; this can often be much longer than the time required for transfer of goods from A to B.
- A rapid trade growth is combined with an accounting period which differs, resulting in large errors. (Figure B.4).
- If trade is constant and existed in the year before the base year is considered, the accounting error becomes small.
- An importing country using the general system of trade might create a large discrepancy between imports c.i.f. and the corresponding f.o.b. figure obtained from the source country, because a high proportion of these imports may be for re-export.
- There are conceptional differences in the treatment of trade statistics - the differences between the special and general systems of compiling trade statistics, and the differences resulting from the application of the general system to exports by country A and to imports by country B.
- There are inaccuracies generated by such things as changes in the destination of cargoes and by the looseness of the SITC classification.
- Arbitrary values are applied to exports in certain countries; these goods are, of course, valued at market prices in the destination countries.

In practice, a detailed study by subcategories of the SITC trade flows per month between trading countries might become necessary to validate trade flow estimates for any transport model. Even this is difficult in under-developed countries, as illustrated in the following



ACCOUNTING ERROR

Fig. B.4.

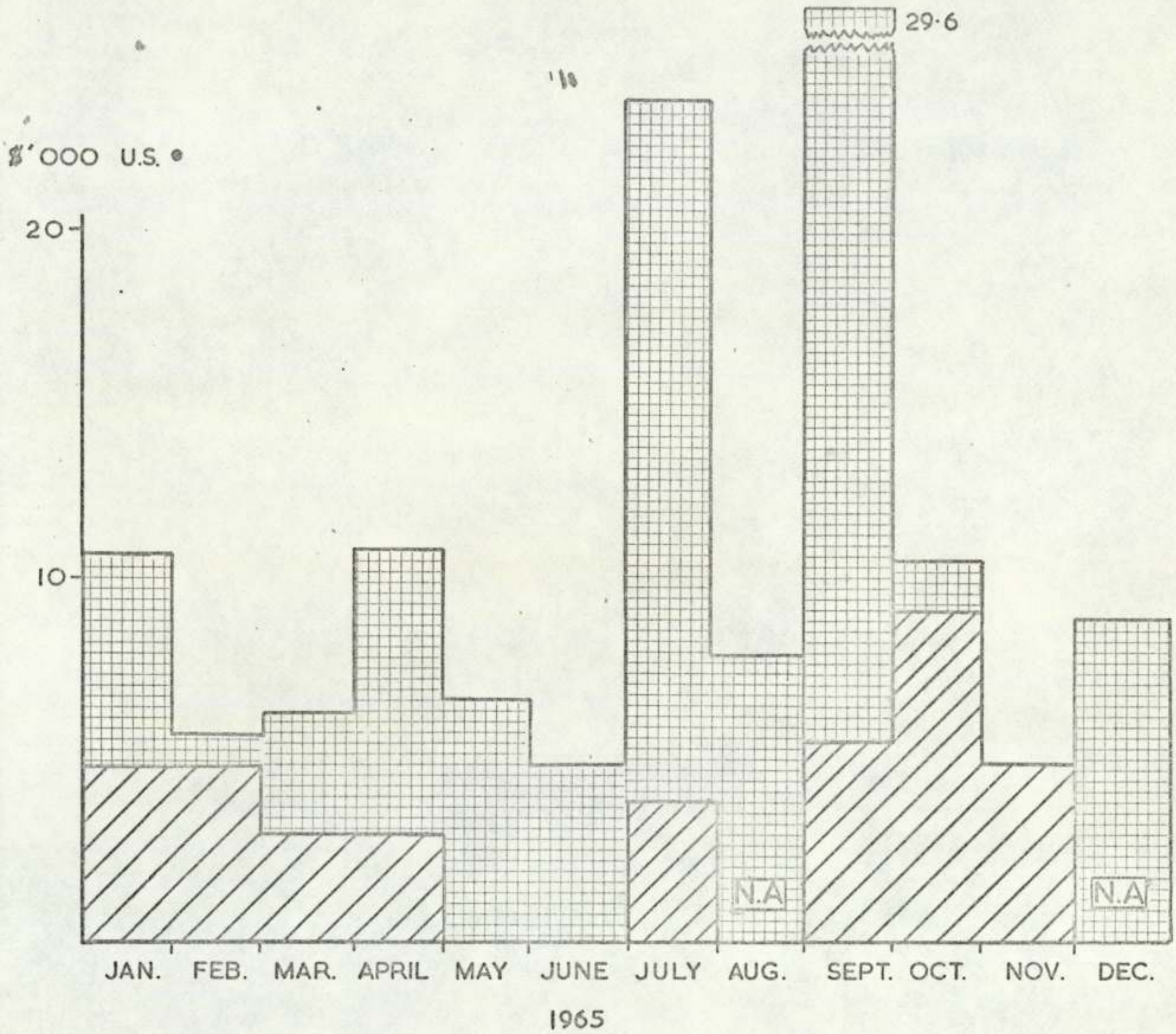
example.

An attempt was made to determine the accounting delay between exporting a commodity from Jamaica and its recorded arrival (statistically speaking) in Trinidad. The monthly returns for 1965 for both countries were examined and SITC 53 selected, being one of the few commodities being recorded in both the exporters monthly returns and the importers returns. The results are illustrated in Figure B.5. Jamaican exports for August and December 1965 were not available. These results fail to give an indication of accounting delay.

Morganstern, O (1953) discusses the disparity between import and export statistics listing such casual factors as diversion en route,* re-export,* time lag,* difficulties in recording value, differences in classification of commodities,* difference in valuation, the existence of multiple exchange rates and differences in quality. It is impossible, he states, "to separate actual errors in reporting from mere differences in emphasis and definition when sets of statistics are compared."

The conversion of statistics to a common unit, the United States dollar, though necessary, is one of the prime sources of trouble. When exchange control and multiple rates exist on either one or both sides of a trading pair of countries, the quoted figures are mostly meaningless since it is impossible to know at which rate which imports and which exports were computed, and for what reason."

The asterisked factors (*) were suggested during the period of analysis, and discussed in particular instances. Allen and Ely (1961) illustrate the difficulties of obtaining correct foreign trade statistics, but offer no method for the numerical estimation of the errors.



S.I.T.C. (53) DYEING, TANNING & COLOURING MATERIALS

EXPORTS TO TRINIDAD FROM JAMAICA.*

IMPORTS TO TRINIDAD FROM JAMAICA.

PERIOD	JANUARY TO JUNE	JANUARY TO NOVEMBER
TRINIDAD TOTAL*	15·2	38·4
JAMAICAN TOTAL	44·8	109·9

COMMODITY FLOWS COMPARED

Fig.B.5.

Some of the larger disparities, due in part to the inclusion of freight and insurance costs obtained in intra-regional trade, are tabulated in Table B.,8 being taken from the summary totals of commodities, considered (i.e. excluding SITC 3 & 9).

Trade Routes A to B	Imports (c.i.f) to B	Trade flow discrepancies		$\frac{(c.i.f - f.o.b)}{f.o.b}$ ** 100 %
		Exports (f.o.b.)	$\frac{c.i.f - f.o.b}{c.i.f.}$ x100 * %	
Trinidad-Jamaica	1767.5	1554.5	+12.1	+13.7
Jamaica-Antigua	221.8	262.8	-18.6	-15.7
Trinidad-St. Kitts	522.1	565.3	-8.3	-7.65
Trinidad-Antigua	709.5	967.7	-36.5	-26.7

TABLE B.8
(Values given in $'000 U.S.)

The reasons for such discrepancies, as already discussed, are difficult to determine. It is possible that invoices accompanying the commodities were not properly made out, or intentionally falsified. Often, important commodities are not followed or preceded by bills and invoices, which is why price estimation plays such a large role in statistical reporting. The country of final destination is not always stated at the country of origin, the first port of call being substituted.

Positive values may indicate that the first country understates its foreign trade statistics, or that the second country overstates its foreign trade. Negative values in the other cases suggest that the exporting country overstates its foreign trade, or that the importing country understates it. A further check was made to assess these points. Jamaican export trade to several other countries was compared to the other country's imports.

Export country	f.o.b.	Import country	c.i.f.	c.i.f. - f.o.b.
Jamaica	765.8	Trinidad	900.3	+
Jamaica	192.3*	St. Kitts	118.1	-
Jamaica	262.8*	Antigua (G)	221.8	-
Jamaica	137.7	St. Lucia	143.1	+
Jamaica	53.2	St. Vincent (G)	55.0	+

TABLE B.9

Source - Data Collected from 1965 Annual Trade Reports

Table B.9 suggests that Jamaican exports are possibly overstated in two instances,* or the importing countries are understated.

This discussion has assumed that all volume figures are correct. The large discrepancies identified for trade flow by value, and the many factors which create the errors also affect figures of trade flow by volume. It is well-known that the quantities of grain shipped undergo great changes because of destruction en route. There are also great differences in the reports of shipments of coal and other bulk transports, even when no transit is involved. These differences cannot be explained except as faults of the reporting of one or of both countries or because of different methods of attribution; differences in definition play a minor rôle with these types of standard and bulky commodities. Even when there are no doubts about exchange rates, there is the possibility that the invoices accompanying the commodities are not properly made out, are falsified, that values are hard to attribute to the right categories of commodities etc., all of which give rise to variations. Often the imported commodities are not followed or preceded by bills and invoices, which is why price estimation plays such a big role in this area.

However, further investigation of these points stopped to continue with the overall objectives of the study. The foregoing discussion suggested that, in a client sponsored study, the intra-regional commodity flows (as indicated by statistics based on the Annual Trade Reports of the island) should be compared with a sample of the flows derived from waybill data. The flow categories identified being :

- Re-exports or transhipment goods due to a distant country
- Re-exports or transhipment goods due to islands within CARIFTA
- Domestic exports
- Exports due for transhipment

Imports to the CARIFTA islands from outside the region in value terms are given in Appendix C together with the exports of the CARIFTA territories to the rest of the world. Only intra-regional volume flows were derived for the purposes of satisfying the aims of the study.

APPENDIX C

INTER-PORT DISTANCES

The distance between two countries has been measured as the shortest navigable distance between the main ports of the respective countries. Distances between the countries listed in the inter-port matrix have been taken from the Admiralty Chart of the North Atlantic for the East Coast of America and Canada,[1] the Admiralty Chart for Gulf Coast and northern countries of South America[2] supplemented by distance tables.[3]

This matrix was not extended to cover the whole world as originally intended, but was reduced to the CARIFTA countries because:-

- A transportation system extending beyond the CARIFTA countries sphere of influence would not be policy oriented with respect to transportation.
- Inter-island transportation requirements differ significantly from those of trans-oceanic services.

Sources: (1) No. 1400 February, 1967, U.S. Naval Oceanographic Office.

(2) Admiralty Chart, No. 762 West India Islands and Caribbean Sea

(3) Reeds New Marine Distance Tables

INTER-PORT DISTANCES

APPENDIX C

		PORT OF SPAIN, TRINIDAD	SCARBOROUGH, TOBAGO	ST. GEORGES, GRENADA	BRIDGETOWN, BARBADOS	KINGSTOWN, ST VINCENT	CASTRIES ST. LUCIA	FORT DE FRANCE, MARTINIQU	ROSEAN, DOMINICA	BASSETERRE, GUADELOUPE	POINT -A- PITRE	PLYMOUTH, MONTSERRAT	ST. JOHNS, ANTIGUA	BASSETERRE, ST. KITTS	ST. MARTIN	ST. CROIX U.S.VIRGINS	ST. JOHN U.S.VIRGINS
PORT OF SPAIN	TRINIDAD		79	93	213	176	232	261	294	336	351	383	402	400	471	482	515
SCARBOROUGH	TOBAGO			97	140	145	190	232	264	315	323	360	381	400	456	474	510
ST. GEORGES	GRENADA				151	83	129	168	201	243	258	283	317	327	378	391	420
BRIDGETOWN	BARBADOS					99	114	130	173	220	237	270	285	312	339	417	433
KINGSTOWN	ST. VINCENT						66	105	137	182	193	227	252	269	320	350	378
CASTRIES	ST. LUCIA							38	80	127	137	174	198	220	272	310	337
FORT DE FRANCE	MARTINIQUE								55	102	112	150	174	195	250	292	317
ROSEAU	DOMINICA									48	58	96	119	142	200	242	266
BASSETERRE	GUADELOUPE										32	49	73	94	152	200	223
POINT-A-PITRE	GUADELOUPE											76	102	129	187	233	254
PLYMOUTH	MONTSERRAT												40	60	97	160	174
ST. JOHNS	ANTIGUA													60	92	177	181
BASSETERRE	ST. KITTS														60	122	134
—	ST. MARTIN															98	94
ST. CROIX	U.S VIRGINS																37
ST. JOHNS	U.S. VIRGINS																
KINGSTOWN	JAMAICA																
GEORGETOWN	GUYANA																

INTER-PORT DISTANCES

Fig. C.1

INTER-PORT DISTANCES

APPENDIX C.

		ST. JUAN, PUERTO RICO	PONCE, PUERTO RICO	S. DOMINGO, DOM. REP.	PUERTO PLATA, DOM. REP.	CAP HAITIEN, HAITI	PORT-AU-PRINCE, HAITI	KINGSTON, JAMAICA	HAVANA, CUBA	CIENFUEGOS, CUBA	MANZANILLO	SANTIAGO, CUBA	BERMUDA, CUBA	NASSAU, BAHAMAS
PORT OF SPAIN	TRINIDAD	572	543	690	822	913	1064	1041	1478	1401	1201	1041	1350	1262
SCARBOROUGH	TOBAGO	570	551	715	830	921	1119	1094	1486	1454	1254	1096	1330	1260
ST. GEORGES	GRENADA	473	454	618	733	824	1013	972	1389	1332	1132	990	1257	1163
BRIDGETOWN	BARBADOS	500	504	682	783	874	1107	1075	1439	1435	1235	1084	1230	1190
KINGSTOWN	ST. VINCENT	440	431	598	710	801	1016	972	1366	1332	1132	993	1180	1130
CASTRIES	ST. LUCIA	400	404	582	683	774	1010	980	1354	1340	1140	977	1120	1090
FORT DE FRANCE	MARTINIQUE	374	389	574	668	759	1000	974	1339	1334	1134	977	1089	1064
ROSEAU	DOMINICA	334	345	578	674	715	967	938	1333	1298	1098	944	1056	1024
PASSETERRE	GUADELOUPE	177	310	494	589	680	936	915	1136	1275	1075	913	1020	867
POINT-A-PITRE	GUADELOUPE	327	337	520	616	707	966	947	1168	1307	1107	943	1020	1017
PLYMOUTH	MONTSERRAT	251	269	460	548	639	905	886	1036	1246	1046	882	967	941
ST. JOHNS	ANTIGUA	263	294	474	573	664	931	906	1076	1266	1066	908	950	953
BASSETERRE	ST. KITTS	212	235	418	574	605	869	856	1036	1216	1016	846	930	902
—	ST. MARTIN	177	212	405	491	582	857	838	996	1198	998	834	877	867
ST. CROIX	U.S. VIRGINS	93	114	303	393	484	753	729	890	1089	889	730	877	783
ST. JOHNS	U.S. VIRGINS	79	122	320	399	490	762	748	884	1108	908	739	830	769
KINGSTOWN	JAMAICA	674	615	429	451	360	293		743	400	272	185	1152	585
GEORGETOWN	GUYANA	864	835	1374	1653	1744	1386	1329	629	1689	1489	1363	1602	1612

INTER-PORT DISTANCES

Fig. C.2

INTER-PORT DISTANCES

APPENDIX C.

		PARAMARIBO, N. GUIANA	GEORGETOWN, GUYANA	LA GUIARA, VENEZUELA	MARACAIBO, VENEZUELA	ARUBA	CURACAO	BONAIRE	BARANQUILLA, COLOMBIA	P. UMON, COSTA RICA	EL BLÚFF, NICARAGUA	PT. CORTEZ, HONDURAS	BELIZE, BR. HONDURAS	VERACRUZ, MERICO	BOQUERON, CUBA
PORT OF SPAIN	TRINIDAD	530	364	329	818	523	457	417	836	1333	1348	1801	1680	2241	1011
SCARBOROUGH	TOBAGO	460	345	382	898	578	512	472	888	1388	1406	1844	1740	2294	1966
ST. GEORGES	GRENADA	542	412	319	760	497	431	396	807	1307	1322	1752	1660	2174	960
BRIDGETOWN	BARBADOS	530	397	468	910	614	564	532	941	1424	1439	1855	1800	2275	1054
KINGSTOWN	ST. VINCENT	573	464	315	790	513	463	431	833	1323	1338	1752	1702	2172	963
CASTRIES	ST. LUCIA	618	478	405	814	543	493	461	863	1353	1368	1770	1700	2180	947
FORT DE FRANCE	MARTINIQUE	650	510	428	818	547	497	465	867	1357	1372	1764	1704	2088	947
ROSEAU	DOMINICA	690	550	440	812	559	509	469	879	1369	1384	1708	1708	2138	914
BASSETERRE	GUADELOUPE	737	597	457	811	546	506	466	866	1356	1371	1705	1705	2115	883
POINT-A-PITRE	GUADELOUPE	745	605	478	833	565	531	491	885	1375	1390	1737	1737	2147	913
PLYMOUTH	MONTSERRAT	786	646	472	806	533	500	460	843	1343	1353	1706	1686	2086	852
ST. JOHNS	ANTIGUA	809	669	509	836	568	538	498	863	1378	1388	1726	1706	1206	878
BASSETERRE	ST. KITTS	842	702	466	800	535	505	465	845	1345	1345	1676	1656	2056	816
——	ST. MARTIN	902	762	505	813	555	530	490	833	1365	1365	1638	1638	2038	804
ST. CROIX	U.S. VIRGINS	843	703	442	724	463	443	403	728	1273	1263	1549	1529	1929	700
ST. JOHNS	U.S. VIRGINS	878	738	598	733	500	480	450	758	1310	1300	1568	1548	1948	739
KINGSTOWN	JAMAICA	1554		745	718	526	593	624	440	613	560	832	826	1200	185
GEORGETOWN	GUYANA	195		697	990	904	854	814	1113	1642	1429	2123	2095	2529	1333

INTER-PORT DISTANCES

Fig. C.3

INTER-PORT DISTANCES

APPENDIX C.

		AMERICA									CANADA						
		BOSTON	N. YORK	BALTIMORE	MIAMI	N. ORLEANS	HOUSTON	L. ANGELES	S. FRANCISCO	CHICAGO	HALIFAX	ST. JOHN	MONTREAL	QUEBEC	HAMILTON	P. ARTHUR	VANCOUVER
PORT OF SPAIN	TRINIDAD	1952	1932	1919	1496	2065	2350	4115	4464	4135	202	2046	2895	2756	3235	4105	5241
SCARBOROUGH	TOBAGO																
ST. GEORGES	GRENADA																
BRIDGETOWN	BARBADOS	1848	1829	1816	1561	2232	2384	4133	4522	4108	1907	1930	2868	2729	3208	4078	5360
KINGSTOWN	ST. VINCENT.																
CASTRIES	ST. LUCIA																
FORT DE FRANCE	MARTINIQUE	1734	1714	1713	1468	1926	2076				1693	1716	2654	2515	2990	3837	5290
ROSEAU	DOMINICA		1664														
BASSETERRE	GUADELOUPE		1618														
POINT-A-PITRE	GUADELOUPE	1670	1650	1649	1404	1862					1629	1652	2590	2457	2854	3701	
PLYMOUTH	MONTSERRAT		1564														
ST. JOHNS	ANTIGUA	1584	1572	1557	1296	1878	2084	4083	4422	3908	1642	1665	2603	2464	2943	3823	5260
BASSETERRE	ST. KITTS		1531														
—	ST. MARTIN		1491								1569	1592	2530	2391	2870	3750	
ST. CROIX	U.S. VIRGINS	1511	1491	1484	1223	1797											
ST. JOHNS	U.S. VIRGINS		1451														
KINGSTOWN	JAMACA	1502	1472	1404	746	1155	1309	3507	3873	3930	1744	1767	2690	2551	3030	3900	4633
GEORGETOWN	GUYANA	2268	2216	2226	1860	2376	2574	4471	4803	2569	2295	2318	3108	2969	3448	4318	5597

INTER-PORT DISTANCES

Fig. C .4

APPENDIX D

TRAFFIC FLOW DATA

- Tables 1 and 2 illustrate the estimated volume of inter-island commodity flows in 1965.[1]

- Table 3 illustrates the imports to each territory within CARIFTA from the rest of the world.

- Table 4 illustrates the exports from each territory within CARIFTA to the rest of the world.

- Table 5 provides data for certain components of the traffic flow on international flight stages of scheduled services to, from and within Latin America i.e. the number of airlines operating on each stage, the flight frequency, the passenger seats available, the revenue passengers carried and the passenger load factor. The data are classified by flight stages. The data shown under passenger seats available and "revenue passengers carried", represent approximate figures for a full year, being based on a two month sample.[2]

- Table 6 provides details of the 1968 shipping schedules of the West Indies Shipping Service .

- Table 7 provides estimates of the numbers of tourists visiting each island, and related data.

- Table 8 is a partially completed matrix of intra-regional passenger flows.

---

1. Assumptions made in deriving the eleven import-export tables for each island's trade are as follows : P.T.O.

---

2. This traffic flow data has been extracted from "The Development of International Air Passenger Travel, I.C.A.O., 1968, Appendix 13.
3. St. Vincent Statistical Digest, 1967

- Where a quantity was stated in gallons, there is no legal equivalent of the gallon in terms of cubic inches but the most up to data scientific determination gives 1 gallon = 277.42 cubic inches (1 cu. ft. = 1728 in inches, therefore 623 gallons = 1 cubic foot). When quantities were stated by number etc. it was assumed that :- 600 eggs = 1 cubic foot 32 light bulbs = 1 cubic foot, 93 dozen gramophone records = 218 lb, (therefore 1 dozen gramophone records = 2.34 lb.). 832 stems of bananas = 1 ton (approx)[3], approximately 8 pairs of shoes = 1 cubic foot (depends on size!), approximately 20 bottles = 1 cubic foot (depends on size).

- No conversion ratio is given for SITC commodity categories 2 - 7, 2 - 8 and 2 - 9 so that volume figures could not be derived.

- Category 8 includes a wide variety of commodities, e.g. furniture and fixtures, travel goods, printed matter etc. and it hardly seems feasible to group them together. Errors must obviously ari se and can only be reduced by increased commodity disaggregation, but the time-scale involved in performing such a task would be prohibitive. However, the average figure for this category has been used for the purposes of this study.

These figures are, of course, approximate, for further difficulties arise when a value is given for a particular commodity but no quantity is stated. Numerous reasons exist for not stating a quantity. It could be that the quantity is very small, e.g. jewellery or precious stones; or that it is impossible to give a quantity because of the variety of different articles included in the category - some are classified by weight, others not. In certain cases quantities were not stated by weight and therefore assumptions had to be made as to the volume these goods would occupy. Livestock are typical of such categories.

This approach is bound to result in estimating errors which could be significant. The significance of the errors in individual commodity flows can be determined from the transport model, so that the accuracy of particular flows could be improved.

	1	2	3	4	5	← PORT NOTATION USED IN 5 PORT PROBLEM						
IMPORTER / EXPORTER	JAMAICA	TRINIDAD X	BARBADOS O	GUYANA	ANTIGUA –	ST KITTS –	MONTSERRAT –	DOMINICIA O	ST LUCIA O	ST VINCENT X	GRENADA X	TOTAL
JAMAICA		3781·0	112·5	3156·2	163·2	419·2	263·3	N.A.	2703·5	47·6	179·5	10826·0
TRINIDAD	2800·9		6812·0	45264·5	6390·8	818·0	922·7	"	10503·9	12755·4	13431·2	93849·1
BARBADOS	10·2	2733·5		9486·5	1180·9	650·1	75·0	"	1555·0	987·2	1240·5	17918·9
GUYANA	19655·0		10353·9		1965·5	1653·6	23·4	"	2040·9	1631·2	474·9	47730·5
ANTIGUA		98·5	4·5				389·7	"	689·5	0·02	224·0	1416·0
ST. KITTS		31·1	8·0		9·8		5·7	"	13·6	843·8	3·0	897·2
MONTSERRAT			0·2		13·0			"		0·02		13·2
DOMINICIA	0·45	78·0	410·3	12·2	40·8		3·6			2·7	5·8	553·9
ST. LUCIA	0·05	859·5	1404·7	1040·0	36·1		17·7	"		0·07	67·3	3426·5
ST. VINCENT	4·15	6144 3	252·4		110·7		4·9	"	573 2		54·3	7144·0
GRENADA	1·0	1220·0	0·6	2·0	11·0			"	81·8	179·7		1483·1
TOTAL	22471·8	24878·0	19359·1	58959·4	4060·5	3540·9	1686·0	"	18161·4	16448·5	15680·5	

SOURCE. IMPORT STATISTICS, S.I.T.C. COMMODITIES 2-7 TO 2-9, 3 & 9 OMITTED

1965 VOLUME FLOWS WITHIN THE CARIBBEAN
(IN MEASUREMENT-TONS.)

TABLE D.1

	1	2	3	4	5	← PORT NOTATION USED IN 5 PORT PROBLEM						
IMPORTER / EXPORTER	JAMAICA	TRINIDAD X	BARBADOS O	GUYANA	ANTIGUA –	ST. KITTS –	MONTSERRAT –	DOMINICIA O	ST. LUCIA O	ST. VINCENT X	GRENADA X	TOTAL
JAMAICA		1406·5	436·3	4713·9	2766·1	2983·7	208·2	2046·8	2992·4	79·9	108·1	17601·9
TRINIDAD	26662·2		28339·8	58551·7	10414·6	9051·6		5489·2	10747·1	13962·4	12111·3	165429·9
BARBADOS	611·3	615·7		1466·1	849·5	596·5	60·1	881·3	1096·1	436·1	564·7	7177·4
GUYANA	15020·2	548901·2	12324·7		2471·7	16·5		2·5	199·9	4·2	217·6	579248·5
ANTIGUA	3·6	34·0	48·7	12·0		577·8	66·1	21·3	34·5	475·7	18·7	1292·4
ST. KITTS	4·7	2493·4	228·2	19·7								2746·0
MONTSERRAT		77·9	44·8		46·2	1·2		688·2	50·2	688·2		1596·7
DOMINICA	N.A.	N.A	N.A	N.A	N.A.	N.A.	N.A.		N.A.	N.A.	N.A.	N.A.
ST. LUCIA	0·05	1165·4	37086·3	738·7	27·3	35·4		2·8		0·35	45·1	39101·4
ST. VINCENT	91·2	8212·1	2511·1	493·9	130·7	8·9	28·1	249·8	1089·6		66·6	12881·95
GRENADA	0·07	432·0	229·8	2·5	11·5	3·3	4·5	9·1	90·9	107·6		891·9
TOTAL	42393·3	563338·2	71249·7	65998·5	16717·6	13274·9	367·0	9391·0	16300·7	15754·5	13132·1	

SOURCE. EXPORT STATISTICS. S.I.T.C. COMMODITIES 2–7 TO 2–9, 3 & 9 OMITTED.

1965 VOLUME FLOWS WITHIN THE CARIBBEAN
(IN MEASUREMENT – IN TONS)

TABLE D.2

IMPORTS TO THE CARIFTA ISLANDS FROM THE WORLD EXCLUDING SITC 3&9	JAMAICA	TRINIDAD	BARBADOS	GUYANA	ST. KITTS	ANTIGUA	MONTSERRAT	DOMINICA	ST. LUCIA	ST. VINCENT	GRENADA
CANADA	32420	24559	8067	67172	1446	2127	321	1053	1458	1049	1278
UNITED STATES	8800	79375	10098	19059	1310	4137	466	645	1553	896	2350
NETH W.I.	1058		16		23	11			48	235	
ARGENTINA	292	649	1180		52	60			43	36	32
COLUMBIA	53	61	56		0·4				0·3		0·2
VENEZUELA	23	1555	268			7			12	0·5	0·6
BELG./LUX.	3580	1649	286	847	48	98	12		51	25	
FRANCE	5730	2400	796	1059	63	100			134	84	
HOLLAND	4400	5497	1935	3939	394	584	40		1089	327	
BRITAIN	70500	75468	18783	27800	2285	6865	1032	1992	3975	2561	3418
W GERMANY	8840	4601	1504	2529	239	240	73		172	234	220
HONG KONG	2482	2927	598		79	112	22		159	100	185
JAPAN	9760	5240	1253	2580	71	109	23		306	107	252
AUSTRALIA	5590	5815	1596	1120	93	152	17		88	70	211
N. ZEALAND	5000	4964	1917		35	87	22		141	55	
ITALY	1860	1915	501	631	53	95			54	42	
NORWAY	1325	1523	424	343	19	21			27	26	37
SWEDEN	1748	962	148	248	24	47			34	40	41
SWITZERLAND	1598	646	152	188	20	27	20		20	9·8	
REST OF WORLD		13033	40961		601	873	196		877	465	
IMPORTS (WORLD) TOTAL	264000	241585	102354	148500	8160	17454	2850	10100	12421	8138	11100

STATISTICS FOR 1965 VALUES GIVEN IN $ '000 U.S.

URCE EASAMS SUMMARY OF INTRA REGIONAL TRADE FLOW STATISTICS WHICH WAS DERIVED FROM EACH ISLANDS ANNUAL TRADE REPORT

TABLE D .3

EXPORTS F.O.B. →		CANADA	UNITED STATES	NETHERLANDS	ARGENTINA	COLUMBIA	VENEZUELA	BELGIUM/LUXEMBOURG	FRANCE	NETHERLANDS	UNITED KINGDOM	WESTERN GERMANY	HONG KONG	JAPAN	AUSTRALIA	NEW ZEALAND	ITALY	NORWAY	SWEDEN	SWITZERLAND	REST OF THE WORLD		EXPORT TOTALS LESS S.I.T.C. 3&9
JAMAICIA	*	33447	80097	85	—	—	50	126	98	568	57627	2128	31	221	246	596	921	14972	3536	882	4438		202608
	•	61	1868	4.5	5.6	73	4.2	31	14	25	644	61	2.0	2.8	2.2	6.4	6.4	—	0.6	36	706		4007
TRINIDAD	*	5008	14215	210	41	8	483	71	51	2108	25237	1025	10	326	52	69	385	1	17	18	174.4		106884
	•	57	1428	63	50	17	335	1	3.2	16	762	14	0.4	6.4	1.5	11.4	2	1.2	4.0	1.2	517		4917
BARBADOS	*	2791	3666	11	0.3		4.4	12	0.3	58	15636	23	0.8		3.4	1.5	—	—	—	—	2665		27628
	•	156	194	99	—	0.1	3.1	—	—	0.6	142	3.9	0.4		—	6.4	0.1	0.2			100		3346
GUYANA	*	22202	17773	—	—	—	72	597	788	1543	23702	1417		587	4	6	569	4786	622		9167		95999
	•	55	302	—	—	—	—	—	—	7.2	244	2.9	—	1.4	6.7	3.1		0.7	0.9	0.4	341		1213
ST. KITTS	*	228	1.3	43	—						4113							—			38		4843
	•	0.3	—	30.1	—	—	—	—	—	—	2.6	—	—		—	—		—			15		248
ANTIGUA	*	9.4	5.4	—	—	—	—	—	—	—	1360	1.5	—	—	—	—	—	—	—	—	26		1442
	•	14.2	267	28	—	—	—	—	—	0.2	50	—	—		—	—	0.0	—			1335	950 PUERTO RICO	1853
MONTSERRAT	*										103										130		276
	•																						
DOMINICA	*																						
	•																						
ST. LUCIA	*	—	0.1	—	—	—	—	—	—	8	5428	1	—	4	—	—	—	—	—	—	61	230 COSTA RICA	6260
	•	0.1	5.7	0.2	—	—	—	—	0.1	—	12	0.5	—	—	—	—					57	31 MARTINIQUE	250
ST VINCENT	*	141	463						3.3	0.0	2078	5.8						—			38		3511
	•	2.6	37	0.1	—	—	—	—	—	0.1	14.6	—	—	—	—						5		224
GRENADA	*																						
	•																						

• RE-EXPORTS (F.O.B.)
* DOMESTIC EXPORTS (F.O.B.)

SOURCE OF DATA :—
ANNUL TRADE REPORTS OF EACH ISLAND FOR 1965
(SUMMARY TABLES SUB-DIVIDED INTO THE STANDARD INTERNATIONAL TRADE CLASSIFICATIONS ARE HELD BY EASAMS)

N.B. EXPORT TOTALS INCLUDE S.I.T.C. COMMODITIES 1, 2, 4, 5, 6, 7, & 8

INTER — REGIONAL TRADE FLOWS FOR 1965 $'000 US.

TABLE C4

TABLE D.4

APPENDIX D. 5 (continued)

TRAFFIC FLOW DATA 1956 and 1966

Scheduled Services - International Operations to, from and within Latin America by carriers registered in Latin America and other regions

STAGES OF SERVICE (non-stop flights between the following points)		NUMBER OF AIRLINES operating between these points		FLIGHT FREQUENCY (round-trips) per week		PASSENGER SEATS AVAILABLE (yearly total for both directions)		REVENUE PASSENGERS CARRIED (yearly total for both directions)		PASSENGER LOAD FACTOR %	
		1956	1966	1956	1966	1956	1966	1956	1966	1956	1966
ANGUILLA[1] (Leeward Islands-U. K.)	St. Martin	-	1	-	8	-	4 160	-	2 080	-	50
ANTIGUA (Leeward Island-U. K.)	Beef Island	-	1	-	1	-	520	-	286	-	55
	Bridgetown	1	4	1	27	2 856	316 102	1 974	157 152	69	50
	Fort de France	1	2	1	4	4 032	36 654	1 944	7 574	48	21
	Montserrat	-	1	-	21	-	36 400	-	16 380	-	45
	Pointe a Pitre	3	4	6	17	25 854	111 717	14 700	32 442	57	29
	Port of Spain[2]	1	-	1	-	7 008	-	2 246	-	33	-
	St. Croix	1	1	3	6	15 822	76 553	10 500	31 009	66	41
	St. Kitts	1	1	3	5	8 400	26 474	4 656	10 206	55	39
	St. Lucia	-	1	-	2	-	19 302	-	3 124	-	16
	St. Martin	1	2	2	7	4 692	51 684	3 270	15 973	70	31

APPENDIX D. 5 (continued)

STAGES OF SERVICE		NUMBER OF AIRLINES		WEEKLY FREQUENCY		SEATS AVAILABLE		PASSENGERS CARRIED		LOAD FACTOR	
		1956	1966	1956	1966	1956	1966	1956	1966	1956	1966
ANTIGUA (cont'd)	St. Juan	2	1	3	6	13 302	62 974	6 792	34 700	51	55
	USA/CANADA	-	4	-	20	-	241 089	-	160 128	-	66
					Total	81 966	979 469	46 182	468 974		
BRIDGETOWN (Barbados)	Antigua	1	4	1	27	2 856	316 102	1 974	157 152	69	50
	Caracas[2]	2	-	2	-	6 672	-	3 765	-	56	-
	Fort de France	2	2	3	7	5 740	69 418	986	14 452	17	21
	Grenada	1	1	2	11	5 880	51 660	4 104	31 234	70	60
	Pointe a Pitre	-	1	-	1/2	-	7 258	-	1 474	-	20
	Port of Spain	4	5	8	31	33 132	371 956	14 202	148 744	43	40
	St. Lucia	1	2	3	7	8 166	35 924	5 670	15 044	69	42
	St. Vincent	1	2	2	10	2 080	42 348	1 040	16 450	50	39
	San Juan[2]	1	-	3	-	12 096	-	7 938	-	66	-
	Scarborough[2]	1	-	1	-	2 676	-	948	-	35	-
	USA/CANADA	2	3	3	4	14 226	59 735	9 090	45 355	64	76
					Total	93 524	954 401	49 717	429 905		
DOMINICA (Windward Island-U.K.)	Fort de France	1	1	2	6	2 080	24 960	1 040	9 984	50	40
	Pointe a Pitre	-	1	-	6	-	24 960	-	9 984	-	40
					Total	2 080	49 920	1 040	19 968		

APPENDIX D. 5 (continued)

STAGES OF SERVICE		NUMBER OF AIRLINES		WEEKLY FREQUENCY		SEATS AVAILABLE		PASSENGERS CARRIED		LOAD FACTOR	
		1956	1966	1956	1966	1956	1966	1956	1966	1956	1966
GEORGETOWN	Boa Vista	1	1	1	1	1 680	2 824	180	870	11	31
(Guyana)	Paramaribo	2	3	2	7	9 780	73 063	5 328	27 330	54	37
	Port of Spain	3	5	2	18	9 752	128 987	3 654	71 077	37	55
					Total	21 212	204 874	9 162	99 217		
GRENADA	Bridgetown	1	1	2	11	5 880	51 660	4 104	31 234	70	60
(Windward	Port of Spain	1	1	2	10	4 506	50 514	3 264	31 424	72	62
Island-U.K.)	St. Vincent	1	-	1	-	1 040	-	572	-	55	-
	Scarborough	1	1	1	2	1 344	9 628	864	6 388	64	66
					Total	12 770	111 802	8 804	69 046		
KINGSTON	Aruba[6]	1	-	7	-	27 666	-	11 868	-	43	-
(Jamaica)	Barranquilla	2	1	11	1	48 972	9 375	18 666	6 622	38	71
	Camaguey[6]	1	-	6	-	24 396	-	10 302	-	42	-
	Caracas	1	1	2	1	7 248	14 093	3 252	2 155	45	15
	Caracao	1	1	1/4	3	672	33 088	306	18 258	46	55
	Guayaquil	-	1	-	1	-	9 198	-	3 982	-	43
	Havana[6]	1	-	3	-	12 168	-	7 188	-	59	-
	Lima	-	2	-	4	-	58 692	-	9 879	-	17
	Merida	-	1	-	1	-	7 280	-	3 785	-	52
	Montego Bay	4	5	18	50	75 840	585 306	33 018	206 354	44	35

APPENDIX D. 5 (continued)

STAGES OF SERVICE		NUMBER OF AIRLINES		WEEKLY FREQUENCY		SEATS AVAILABLE		PASSENGERS CARRIED		LOAD FACTOR	
		1956	1966	1956	1966	1956	1966	1956	1966	1956	1966
KINGSTON (cont'd)	Nassau[2]	1	-	1	-	4 800	-	1 560	-	33	-
	Panama[2]	1	-	3	-	16 200	-	4 212	-	26	-
	Port au Prince	1	1	8	6	41 766	75 991	24 822	29 925	59	39
	San Juan	1	2	1	7	2 766	78 353	1 680	39 715	61	51
	USA/CANADA	3	5	12	16	57 996	205 456	31 068	126 947	54	62
					Total	320 490	1 076 832	147 942	447 622		
MONTEGO BAY (Jamaica)	Barranquilla[6]	2	-	5	-	27 558	-	9 606	-	35	-
	Camaguey[6]	1	-	8	-	41 310	-	25 140	-	61	-
	Caracas	1	1	7	1	44 544	14 912	22 704	4 001	51	27
	Freeport	-	1	-	1	-	15 612	-	5 770	-	37
	Grand Cayman	1	2	1	4	3 360	16 508	1 872	8 782	56	53
	Guayaquil	-	1	-	1	-	7 358	-	2 570	-	35
	Havana[6]	1	-	8	-	46 848	-	32 586	-	70	-
	Kingston	4	5	18	50	75 840	585 306	33 018	206 354	44	35
	Lima	-	1	-	1	-	7 358	-	2 986	-	41
	Maracaibo[6]	1	-	2	-	9 152	-	5 216	-	57	-
	Merida	-	1	-	1	-	7 280	-	3 785	-	52
	Nassau	2	2	6	12	30 624	166 000	19 626	102 993	64	62
	Port au Prince[2]	1	-	2	-	11 142	-	5 688	-	51	-
	San Juan	1	1	1	2	4 176	19 883	132	8 228	3	41
	USA/CANADA	5	7	13	46	70 646	570 460	53 968	340 101	76	60
					Total	365 200	1 410 677	209 556	685 570		

APPENDIX D. 5 (continued)

STAGES OF SERVICE		NUMBER OF AIRLINES		WEEKLY FREQUENCY		SEATS AVAILABLE		PASSENGERS CARRIED		LOAD FACTOR	
		1956	1966	1956	1966	1956	1966	1956	1966	1956	1966
ST. MARTIN	Antigua	1	2	2	7	4 692	51 684	3 270	15 973	70	31
(Netherlands	Anguilla	-	1	-	8	-	4 160	-	2 080	-	50
Antilles)	Curacao	1	1	1	1	2 172	4 576	1 602	2 059	74	45
	Pointe a Pitre	-	1	-	2	-	12 020	-	3 151	-	26
	St. Croix	-	1	-	3	-	11 901	-	5 922	-	50
	St. Kitts	1	3	1	14	2 268	36 910	1 434	9 560	63	26
	St. Thomas	-	2	-	7	-	50 079	-	21 722	-	43
	San Juan	1	2	2	6	4 458	44 326	2 730	11 944	61	27
					Total	13 590	215 656	9 036	72 411		
ST. THOMAS	St. Croix	2	2	15	42	46 324	175 985	26 670	86 562	60	49
(Virgin Islands	St. Kitts[6]	1	-	2	-	4 668	-	2 610	-	56	-
- U.S.)	St. Martin	-	2	-	7	-	50 079	-	21 722	-	43
	San Juan	3	1	45	163	132 360	849 550	70 088	553 699	53	65
					Total	183 352	1 075 614	99 368	661 983		
ST. VINCENT	Bridgetown	1	2	2	10	2 080	42 348	1 040	16 450	50	39
(Windward	Grenada[6]	1	-	1	-	1 040	-	572	-	55	-
Islands-U.K.)	Port of Spain[6]	1	-	2	-	2 080	-	1 040	-	50	-
	St. Lucia	-	1	-	6	-	24 960	-	11 232	-	45
					Total	5 200	67 308	2 652	27 682		

APPENDIX D. 5 (continued)

STAGES OF SERVICE		NUMBER OF AIRLINES		WEEKLY FREQUENCY		SEATS AVAILABLE		PASSENGERS CARRIED		LOAD FACTOR	
		1956	1966	1956	1966	1956	1966	1956	1966	1956	1966
PORT OF SPAIN	Antigua[2]	1	-	1	-	7 008	-	2 346	-	33	-
(Trinidad &	Belem[2]	3	-	5	-	27 606	-	19 494	-	71	-
Tobago)	Brasilia	-	1	-	1/2	-	6 546	-	2 791	-	43
	Bridgetown	4	5	8	31	33 132	371 956	14 202	148 744	43	40
	Caracas	4	2	10	6	48 276	75 587	30 810	28 231	64	37
	Curacao	1	1	3	2	8 538	22 908	5 976	15 354	70	67
	Fort de France	2	1	5	1	21 078	6 240	7 908	2 496	38	40
	Georgetown	3	5	2	18	9 752	128 987	3 654	71 077	37	55
	Grenada	1	1	2	10	4 506	50 514	3 264	31 424	72	62
	Havana[6]	1	-	1	-	4 488	-	2 700	-	60	-
	Maturin	1	1	7	3	17 472	15 320	8 560	12 008	49	78
	Paramaribo[2]	1	-	2	-	4 122	-	2 784	-	68	-
	Rio de Janeiro	1	2	1	4	5 676	33 863	2 796	20 879	49	62
	St. Vincent[6]	1	-	2	-	2 080	-	1 040	-	50	-
	San Juan[2]	1	-	2	-	12 852	-	9 336	-	73	-
	Scarborough	1	1	1	2	2 568	8 998	1 686	6 540	66	73
	EUROPE	1	-	1	-	2 544	-	1 902	-	75	-
	USA/CANADA	-	2	-	5	-	41 378	-	25 521	-	62
					Total	211 698	762 297	118 458	365 065		

APPENDIX D. 5 (continued)

STAGES OF SERVICE		NUMBER OF AIRLINES		WEEKLY FREQUENCY		SEATS AVAILABLE		PASSENGERS CARRIED		LOAD FACTOR	
		1956	1966	1956	1966	1956	1966	1956	1966	1956	1966
ST. CROIX	Antigua	1	1	3	6	15 822	76 553	10 500	31 009	66	41
(Virgin Islands	Fort de France	-	1	-	2	-	23 493	-	2 370	-	10
- U.S.)	Pointe a Pitre	-	1	-	6	-	74 012	-	9 072	-	12
	St. Martin	-	1	-	3	-	11 901	-	5 922	-	50
	St. Thomas	2	2	15	42	46 324	175 985	26 670	86 562	60	49
	San Juan	1	2	2	38	12 564	248 049	8 184	119 102	65	48
	USA/CANADA	-	1	-	5	-	50 362	-	35 186	-	70
					Total	74 710	660 355	45 354	289 223		
ST. KITTS	Antigua	1	1	3	5	8 400	26 474	4 656	10 206	55	39
(Leeward	Beef Island	-	1	-	1	-	520	-	286	-	55
Island-U.K.)	Curacao	-	1	-	1	-	4 576	-	2 059	-	45
	Nevis	-	1	-	10	-	5 200	-	2 600	-	50
	Pointe a Pitre[6]	1	-	1	-	2 520	-	216	-	9	-
	St. Martin	1	3	1	14	2 268	36 910	1 434	9 560	63	26
	St. Thomas[6]	1	-	2	-	4 668	-	2 610	-	56	-
	San Juan	1	1	1	5	2 280	26 474	816	6 652	36	25
					Total	20 136	100 154	9 732	31 363		

APPENDIX D. 5 (continued)

STAGES OF SERVICE		NUMBER OF AIRLINES		WEEKLY FREQUENCY		SEATS AVAILABLE		PASSENGERS CARRIED		LOAD FACTOR	
		1956	1966	1956	1966	1956	1966	1956	1966	1956	1966
ST. LUCIA	Antigua	-	1	-	2	-	19 302	-	3 124	-	16
(Windward	Bridgetown	1	2	3	7	8 166	35 924	5 670	15 044	69	42
Islands-U.K.)	Fort de France	1	2	3	11	7 212	51 434	4 758	25 332	66	49
	Pointe a Pitre[2]	1	-	1	-	2 544	-	1 248	-	49	-
	St. Vincent	-	1	-	6	-	24 960	-	11 232	-	45
				Total		17 922	131 620	11 676	54 732		

TABLE D.6.

WEST INDIES SHIPPING SERVICE
JANUARY TO MAY 1968

NORTHBOUND SAILINGS

PORT CODE		10	9	8	7	6	5	4	3	2
		Trinidad	Grenada	St. Vincent	Barbados	St. Lucia	Dominica	Montserrat	Antigua	St. Kitts
"Federal Palm"	84N	Jan. 12	Jan. 13	Jan. 14	Jan. 15	Jan. 16	Jan. 17	Jan. 18	Jan. 19	Jan. 20
"Federal Maple"	89N	Jan. 26	Jan. 27	Jan. 28	Jan. 29	Jan. 30	Jan. 31	Feb. 1	Feb. 2	Feb. 3
"Federal Palm"	85N	Feb. 9	Feb. 10	Feb. 11	Feb. 12	Feb. 13	Feb. 14	Feb. 15	Feb. 16	Feb. 17
"Federal Maple"	90N	Feb. 23	Feb. 24	Feb. 25	Feb. 26	Feb. 27	Feb. 28	Feb. 29	Mar. 1	Mar. 2
"Federal Palm"	86N	Mar. 8	Mar. 9	Mar. 10	Mar. 11	Mar. 12	Mar. 13	Mar. 14	Mar. 15	Mar. 16
"Federal Maple"	91N	Mar. 22	Mar. 23	Mar. 24	Mar. 25	Mar. 26	Mar. 27	Mar. 28	Mar. 29	Mar. 30
"Federal Palm"	87N	Apr. 5	Apr. 6	Apr. 6	Apr. 7	Apr. 8	Apr. 9	Apr. 10	Apr. 11/12	Apr. 13
"Federal Maple"	92N	Apr. 19	Apr. 20	Apr. 21	Apr. 22	Apr. 23	Apr. 24	Apr. 25	Apr. 26	Apr. 27
"Federal Palm"	88N	May. 3	May 4	May 5	May 6	May 7	May 8	May 9	May 10	May 11

TABLE D. 6 (continued)

SOUTHBOUND SAILINGS

PORT CODE		1 Jamaica	2 St. Kitts	3 Antigua	4 Montserrat	5 Dominica	6 St. Lucia	7 Barbados	8 St. Vincent	9 Grenada
"Federal Maple"	88S	Jan. 12	Jan. 15	Jan. 16	Jan. 17	Jan. 18	Jan. 19	Jan. 20	Jan. 21	Jan. 21
"Federal Palm"	84S	Jan. 26	Jan. 29	Jan. 30	Jan. 31	Feb. 1	Feb. 2	Feb. 3	Feb. 4	Feb. 4
"Federal Maple"	89S	Feb. 9	Feb. 12	Feb. 13	Feb. 14	Feb. 15	Feb. 16	Feb. 17	Feb. 18	Feb. 18
"Federal Palm"	85S	Feb. 23	Feb. 26	Feb. 27	Feb. 28	Feb. 29	Mar. 1	Mar. 2	Mar. 3	Mar. 3
"Federal Maple"	90S	Mar. 8	Mar. 11	Mar. 12	Mar. 13	Mar. 14	Mar. 15	Mar. 16	Mar. 17	Mar. 17
"Federal Palm"	86S	Mar. 22	Mar. 25	Mar. 26	Mar. 27	Mar. 28	Mar. 29	Mar. 30	Mar. 31	Mar. 31
"Federal Maple"	91S	Apr. 5	Apr. 8	Apr. 9	Apr. 10	Apr. 11	Apr. 12	Apr. 13	Apr. 14	Apr. 15
"Federal Palm"	87S	Apr. 19	Apr. 22	Apr. 23	Apr. 24	Apr. 25	Apr. 26	Apr. 27	Apr. 28	Apr. 28
"Federal Maple"	92S	May 3	May 6	May 7	May 8	May 9	May 10	May 11	Apr. 12	Apr. 12
"Federal Palm"	88S	May 17	May 20	May 21	May 22	May 23	May 24	May 25	May 26	May 26

N.B. ALL SAILINGS ARE SUBJECT TO ALTERATION OR CANCELLATION WITH OR WITHOUT NOTICE

FURNESS, WITHY & COMPANY LIMITED
LONDON.

	ANTIGUA	BAHAMAS	BARBADOS	DOMINICA	GRENADA	JAMAICA	MONTS'RAT	ST. KITTS NEVIS ANGUILLA	ST. LUCIA	ST. VINCENT	TRINIDAD AND TOBAGO
TOTAL VISITORS	55,657 48,651	**822,317 **720,420	79,104 68,418	6,040 5,355	18,135 13,850	◇345,288 ◇300,258	7,314 7,412	6,586 7,116	14,512 12,908	6,716 —	64,910 57,920
ORIGIN: U.K.	3,460 2,706	10,269 10,703	8,304 6,673	218 465	3,509 2,607	+8,896 +5,775	277 234	160 359	1,794 1,457	676 —	2,540 2,220
EUROPE	365 —	— —	981 959	— —	— —	+4,619 +2,578	— —	— —	— —	— —	2,310 2,540
U.S.A.	28,863 23,611	282,456 185,070	23,837 19,811	1,357 970	6,357 4,240	+156,977 +123,809	2,874 1,955	2,225 2,060	3,957 2,860	1,714 —	12,420 10,970
CANADA	8,188 7,040	32,120 24,710	16,372 14,212	500 212	1,886 1,371	+22,309 +17,448	— —	315 358	1,365 1,065	413 —	3,010 2,120
OTHERS	14,781 15,294	17,566 17,210	29,610 26,763	3,996 3,708	6,383 5,632	+20,634 +11,138	4,163 5,223	3,886 4,339	7,396 7,526	3,913 —	44,630 40,070
ARRIVALS: BY SEA	1,418 2,577	•207,932 —	3,583 3,881	620 812	2,147 1,842	+1,760 +1,129	1,132 1,119	457 829	1,205 1,843	— —	5,280 5,120
BY AIR	54,239 46,074	•323,235 —	75,521 64,537	5,420 4,543	19,988 12,008	+208,870 +159,619	6,182 6,293	6,129 6,287	13,307 11,065	— —	59,630 52,800
OVERLAND											
CRUISE SHIP PASSENGERS	•15,911 •11,776	208,377 —	59,593 52,664	1,100 1,542	16,500 15,990	66,806 56,473	531 836	7,103 4,650	12,350 10,948	•9,390 —	— —
GRAND TOTAL	71,568 60,427	— —	138,697 121,082	7,140 6,897	34,635 29,840	412,094 356,731	7,845 8,248	13,689 11,766	26,862 23,856	16,106	— —
LONG STAY: VISITORS (3 NIGHTS & OVER)	19,928 —	— —	43,164 36,992	— —	— —	210,630 160,748	— —	— —	— —	— —	— —
SHORT STAY: VISITORS (UNDER 3 NIGHTS)	— —	— —	35,940 31,426	— —	— —	134,658 139,510	— —	— —	— —	— —	— —
ESTIMATED GROSS EXPENDITURE BY VISITORS	— —	£28,819,580	£5,833,333 £5,416,666	— —	£940,382 £674,424	£30,000,000 £23,200,000	— —	— —	£1,171,891 £472,222	— —	£5,000,000 £4,375,000

- INDICATES NO FIGURE RECEIVED.
* INCLUDES PASSENGERS ON THE FEDERAL SHIPPING SERVICE.
FIGURES ARE NOT COMPILED ON A COMPATIBLE BASIS.

◇ INCLUDES LONG & SHORT STAY VISITORS & ARMED FORCES ON LEAVE.
+ LONG STAY VISITORS ONLY.

SOURCE: WEST INDIES CHRONICLE: SEPTEMBER 1967.

• VISITORS TO NASSAU ONLY.
** INCLUDES BUSINESS VISITORS TO NASSAU & OUT-ISLANDS.

THE NUMBER OF VISITORS TO CARIFTA.

TABLE D.7.

TO \ FROM	ANTIGUA	BARBADOS	DOMINICA	GRENADA	JAMAICA	MONTSERRAT	ST. KITTS	ST. LUCIA	ST. VINCENT	GUYANA	TRINIDAD	FRENCH WEST INDIES	U.K.	U.S.A.	CANADA	EUROPE	SOUTH AMERICA	VENEZUELA	OTHER	TOTAL
ANTIGUA		←——— (10896) ———→									940•									54489•
BARBADOS	657×		580×	1079×	932×	100×	372×	2460×	1312×	3410×	5460×	972×	8303•	23827•	16372•	981•	233×	1717×	3515×	79104•
DOMINICA	←——— (2999) ———→										162•		218•	1356•	500•					5998•
GRENADA	←——— (5157) ———→										4150•		3509•	6357•	1886•			238−		18135•
JAMAICA	←	977	←——— (1825) ———→							1701	2240•	4159	9037•	172436•	23333•	4619•	3726−	964−		228141•
MONTSERRAT	←——— (4150) ———→										210•		277•	2874•	637•					8181•
ST. KITTS	←——— (3885) ———→										210•		160•	2225•	315•					7970•
ST. LUCIA	←——— (7256) ———→										590•		1794•	3957•	1365•					14512•
ST. VINCENT	←——— (4480) ———→										1240•		676•	1714•	413•					8960•
GUYANA	←——— (2624) ———→										5120•		1746•	3337•	765•					19244•
TRINIDAD	740+	4410+	270+	3680+	1550+	60+	210+	670+	620+	4400+		1440+	5230	21850*	7090*	2330+	1060+	6690+	4590+	67740+
FRENCH WEST INDIES											1440•									
UNITED KINGDOM											5160•									
UNITED STATES											22724•									
CANADA											7799•									
EUROPE											2330•									
SOUTH AMERICA											1070•									
VENEZUELA											7760•									
OTHER											4544•									
											73040•									
SUM. TOTAL.	54856	86179	5211	15645	264942	4473	9495	1163	9118*	22266										

× BARBADOS DIGEST OF STATISTICS, 1969
• WEST INDIES CHRONICAL, NOVEMBER 1968
+ TRINIDAD & TOBAGO INTERNATIONAL TRAVEL REPORT, 1966
* ST VINCENT DIGEST OF STATISTICS, 1967
− I.U.O.T.O. INTERNATIONAL TRAVEL REPORT ON JAMAICA & GRENADA, 1967

INTRA-REGIONAL PASSENGER TRAFFIC

TABLE.D.8.

APPENDIX E

THE ROUTE GENERATION ALGORITHM

This algorithm selects an optimal subset of routes from the set of all possible routes around 6 ports (at present). In order to make sure that the demand for transport is satisfied, the least cost route is selected for each possible grouping of ports and for 6 ports there are 57 different groupings or combinations given by the relationship

$$\text{No. of groupings} = ({}^6C_2 + {}^6C_3 + {}^6C_4 + {}^6C_5 + {}^6C_6)^2$$

---

1. This computer programme was developed and tested by R. A. Friar, formerly of EASAMS.

2. Now if there are a total of "N" ports then there will be (N - 1)! alternative shipping routes if :-

- All routes start and end at the same port and
- All other ports are visited once.

This second condition cannot be satisfied when ship capacity is limited. If only the first condition applies, then there will be the number of alternative routes given below where

n = number of ports in each port combination selected.

$$({}^N C_n) \left[(n-1)! + (n-2)! \; \ldots . \; 3! + 2! + 1! \right]^3 \text{ alternative routes.}$$

3. This is because

$${}^N C_n = \text{the number of combinations of "n" ports in an "N" port region}$$

$$= \frac{N!}{n!\,(N-n)!} = \text{the number of least-cost routes in an "N" port region}$$

$(n - 1)!$ = the number of alternative routes in a grouping of "n" ports.

This leads to a large number of alternative routings. Each of these routings may consist of routes visiting a different group of islands. This point is illustrated in Figure E.1.

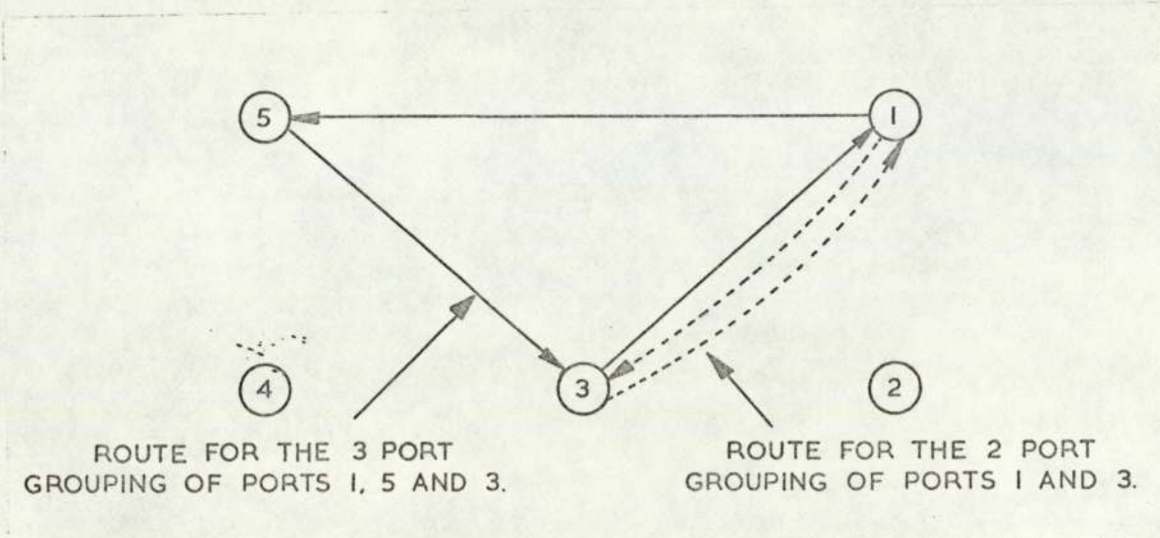


FIGURE E.1

From each of the alternative routings generated for each port grouping, the least cost route around all the ports of each combination can be chosen by using journey distance, time in port, and port and berthing cost data.

The algorithm is divided into 6 parts.

PART 1 reads in the data which consists of :-

- trade flows between ports
- time to travel between ports (for the ships envisaged)
- distance between ports (in nautical miles)
- parameters of the cost of ship operation
- upper bounds on the time for a ship to travel around the route and on the capacity of the ships.

PART 2 calculates every possible combination of ports and stores each in a 57 x 6 matrix, each row of which corresponds to a combination which has 6 elements as illustrated below.

Row 1	1	2	0	0	0	0
Row 2	1	3	0	0	0	0
•	•	•	•	•	•	•
•	•	•	•	•	•	•
•	•	•	•	•	•	•
Row 57	1	2	3	4	5	6

Each number corresponds to a port. For example port 1 represents the port of Kingston in Jamaica.

PART 3 considers each combination in turn i.e. row 1, row 2, etc. and generates all possible outward journeys. This is done by taking all the permutations of numbers in the row; the first number is not permuted with the rest of the numbers to ensure that routes will not be counted more than once. For example, route 1 2 1 is the same as 2 1 2. If the number of ports in the combination is "n", the number of routes will be (n - 1)!. These (n - 1)! permutations are assigned to a matrix consisting of (n - 1)! rows and 6 columns for subsequent use in Parts 4, 5 and 6.

PART 4 takes each outward route and then produces every possible way of calling at the ports on the return journey.

For example, consider Row 1 of the route matrix of Row 57 of the combination matrix.

i.e. 1 2 3 4 5 6

The first way is to go straight back from port 6 to port 1 without calling at any other port. This is illustrated as follows :-

1 2 3 4 5 6 1

The second way is as follows :-

1 2 3 4 5 6 5 1

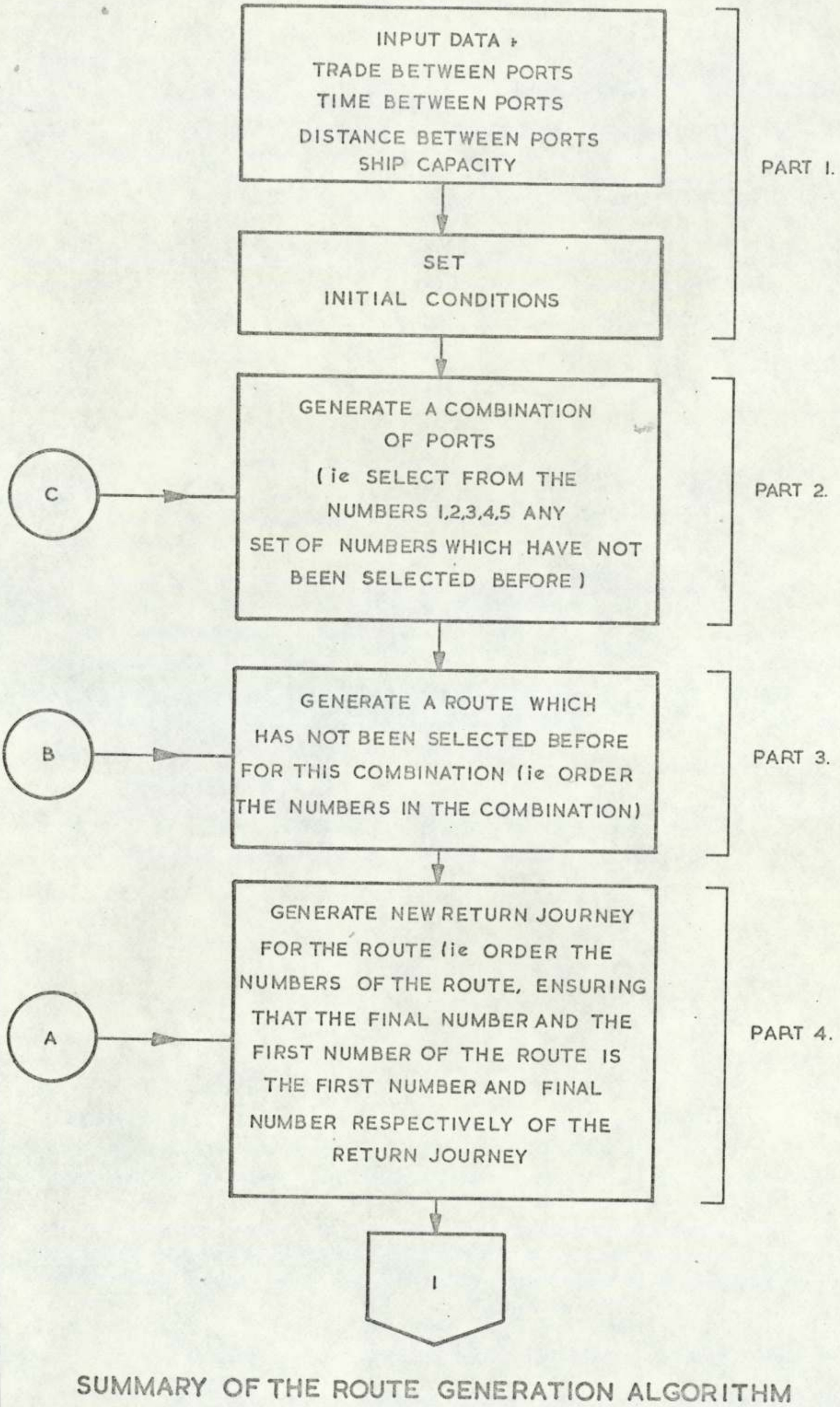
This route calls at port 5 on the return journey and so on.

PART 5 now calculates the time and distance of each route as obtained from Parts 2, 3, and 4. It also calculates the capacity needed to carry all the trade on one ship around the ports included in the route.

PART 6, using the time, distance and capacity figures obtained from Part 5, produces an annual cost for ship operation. (The cost is only approximate as the parameters used are not known exactly.) This cost is used to find the cheapest route for each port grouping by direct comparison with all the costs of the routes for that grouping. Thus a matrix consisting of 57 rows corresponding to the rows of the Part 2 matrix (combination matrix) will be produced. Each row is an optimum (least cost) route for the grouping of ports.

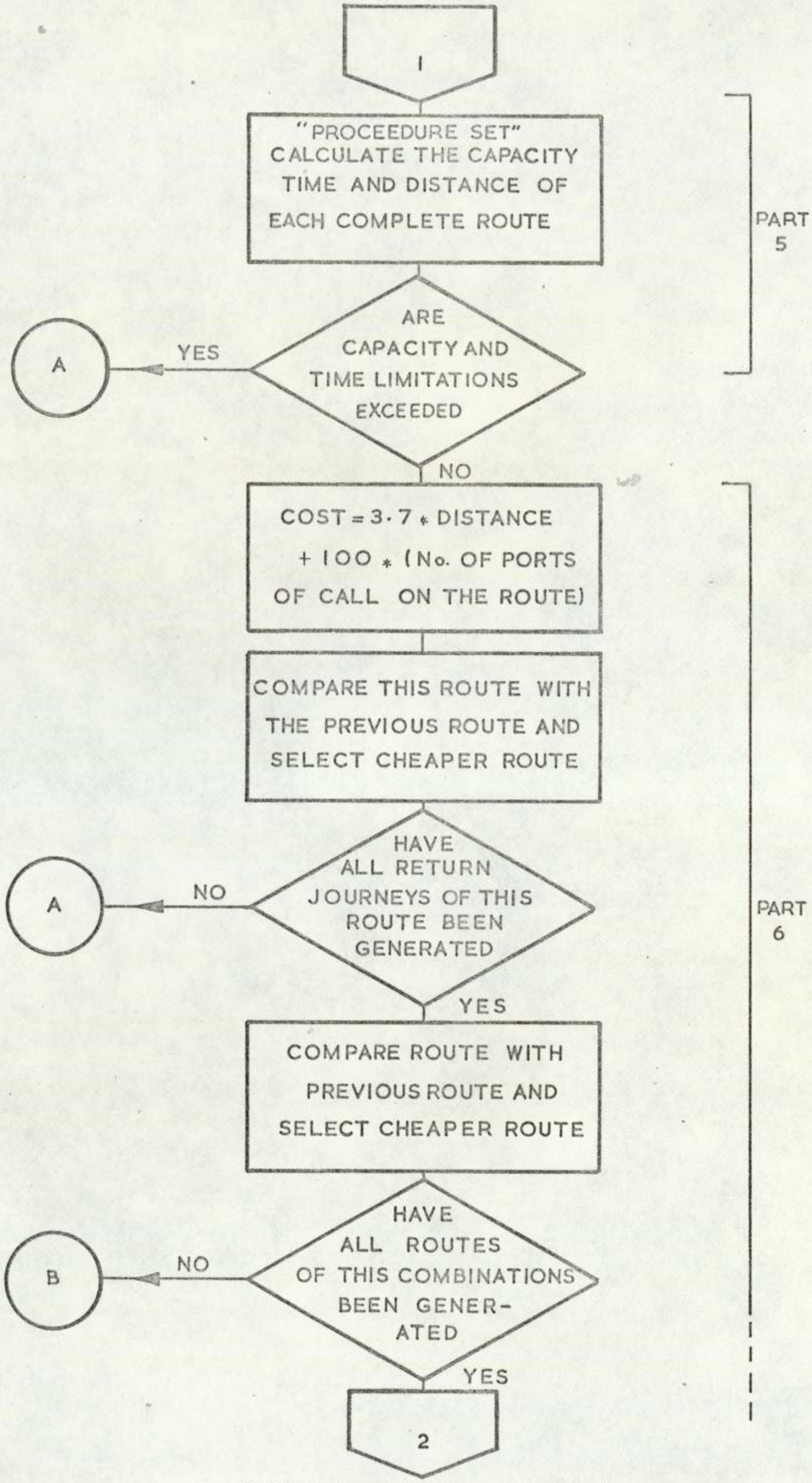
Each of these activities is illustrated in the summary flow chart of the route generation algorithm. (Figures E. 2 to E. 4).

It can be seen that this algorithm not only selects a route for each combination of "n" ports, but also selects its direction such that the volume of traffic over each arc of the network is minimised. Such a constraint ignores the interaction between 1 route and another. Further investigation of this point is required.



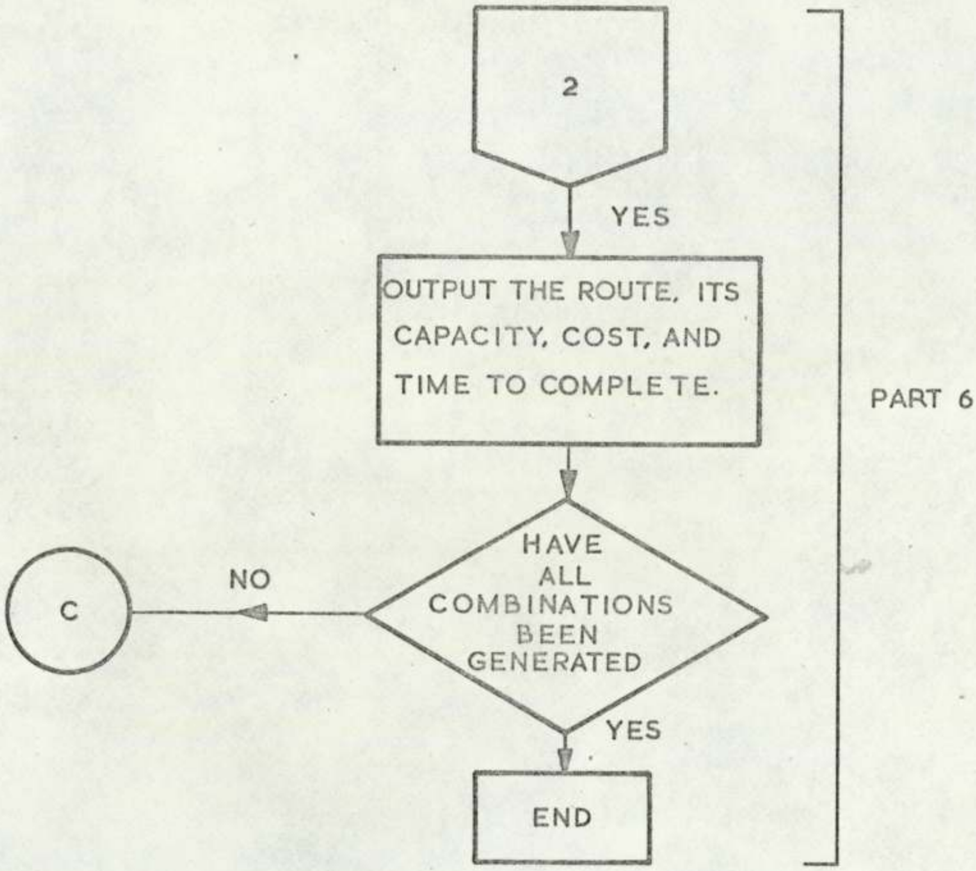
SUMMARY OF THE ROUTE GENERATION ALGORITHM

Fig. E.2



SUMMARY OF THE ROUTE GENERATION ALGORITHM CON'T

Fig E,3



SUMMARY OF THE ROUTE
GENERTION ALGORITHM CON'T

Fig E .4

APPENDIX F

THE LINEAR PROGRAMMING TRANSPORT MODEL

1.1 Introduction

In 1969, the Regional Shipping Council was charged with the co-ordination of the transportation activities of those islands forming the Caribbean Free Trade Association. Unfortunately, the tools required to enable the improvements to the transport system and their subsequent evaluation were not available. To determine such improvements, a mathematical model describing the regional transport system was formed to answer such questions as:-

- What pattern of shipping routes would permit the transport of intra-CARIFTA trade in 1975 and what additional port facilities would be necessary?
- How many additional ships will be required and what should be their capacity?
- What additional facilities will be required in each port?

Given the existing port facilities and shipping available, the model will determine simultaneously, the routes they should follow, the allocation of cargo to each route, and the number of journeys that should be completed over each route so as to carry out the transport requirements in the year selected, while minimising the cost of transport operation. Limitations considered include the docking capacity, and the loading and unloading rates at each port for each type of ship.

1.2 Notation

The following notation is used throughout this summary where the variables relate to one mode of transport (mode "m") unless otherwise stated.

$C_k^{(A)}$ = the tonnage capacity of the ship type A assumed to operate over route "k".

$NS_k^{(A)}$ = the number of ship-journeys completed over route "k" in one year by using ship type A.

$V_k^{(A)}$ = the cost per journey completed over route "k" by ship type (A).

T_k = journey time over route "k".

$P_j^{(A)}$ = the cargo-handling capacity, in tons, of destination port "j" over the time described by the model for ships of type (A).

$S_i^{(A)}$ = the ship-docking capacity at origin "i" over the time described by the model, in numbers of ships, for ship type A.

$S_j^{(A)}$ = the ship-docking capacity at destination "j" over the time described by the model, in numbers of ships, for ships of type A.

μ_{kA} = a factor, to indicate the possibility of ship-docking (vessel A at ports served by route "k").

a_{ijk} = the amount of cargo to be exported annually from port "i" to port "j" over route "k".

v_{ijk} = the revenue derived from shipping one ton of cargo from port "i" to port "j" over route "k".

N = the number of ports in the region.

a_{ij} = the total amount of cargo to be moved from port "i" to port "j" in one year.

SH = the number of ships available to the region.

CA+MX = the annual fixed cost of providing one ship and its supporting facilities in the region.

T_{ij} = the minimum service time in days between nodes "i" and "j" of the network.

TR_{ijk} = the volume of cargo transferred from route k of mode "m" to another mode for shipment over arc (i, j).

1.3 The Mathematical Model

A route generation algorithm was developed to select, from every possible route combination of the N ports forming the region, a subset of minimum cost routes satisfying journey time (distance) & capacity constraints.

A number of important assumptions are introduced to simplify the model. First, each shipping route is defined so as to permit a vessel operating over that route to make a round trip, that is, to return eventually to the port from which it originally sailed. Secondly, it is assumed that all vessels will operate within the CARIFTA region.

This linear programming model will select, from a subset of routes, that combination which will minimize the cost of transport operation while satisfying the demand for intra-regional transport.

1.4 The Constraints

It was considered that a number of conditions must be satisfied by any solution to the problem.

Firstly, the sum of the journeys between ports "i" and "j" of the network must not exceed a defined time interval. That is :-

$$\sum_{k \text{ all } (i,j)} NS_k \geq \frac{365}{T_{ij}} \quad \text{for all k serving arc (i, j)}$$

This constraint assumes that ship-journeys selected by the model can be equally spaced in time when subsequently scheduled.

Secondly, the shipping capacity of each route must be greater than, or equal to, the volume of shipments assigned to that route, for each directed arc (i, j), less those shipments that have been transferred for route k to another mode over the arc (i, j).

That is :-

$$\sum_{k.} C_k^{(A)} . NS_k^{(A)} \geq \sum a_{ij,k} - TR_{ijk} \quad \text{for each arc (i, j) served by route k.}$$

Thirdly, the sum of the cargoes allocated to each route of the network at port "i" when exporting to port "j" must equal the amount to be exported.

That is:-

$$\sum_{k \text{ all } (i,j)} a_{ijk} = a_{ij}$$

Fourthly, a solution will only be feasible if a solution results where the number of ships required are equal to, or less than, the number available.

That is:-

$$\sum_{\text{All } k} NS_k^{(A)} / NSMAX_k^{(A)} \leq SH^{(A)}$$

Fifthly, for cargo outbound from port "i" and inbound to port "j" the following constraints apply, where the cargo to be exported or imported on ship type A through the related facilities type A must be less than, or equal to, the maximum handling capacity of these facilities.

$$\sum_{\text{All } j,} a_{ij}^{(A)} \leq P_i^{(A)} \quad \text{and} \quad \sum_{\text{All } i,} a_{ij}^{(A)} \leq P_j^{(A)}$$

The value of these constraints will be determined by the time period represented by the model. Such constraints may be a function of working rules, crane capacity or any complex set of operations.

Sixthly, the docking-capacity of each port in terms of the numbers of ships handled over the time period envisaged, can be described by the constraints.

$$\sum_{j = 2} \mu_{kA} \cdot NS_k^{(A)} \leq S_1^{(A)} \qquad \text{(origin limit, port 1)}$$

$$\sum_{i=1}^{N} \mu_{kA} \cdot NS_k^{(A)} \leq S_2^{(A)} \qquad \text{(destination limit, port 2)}$$

The values of the μ factors may be unity for permissible sets $((A,_j)$ and $((A,_i)$ and infinity for excluded sets $(A,_j)$ and $(A,_i)$. It is clear that in the summations represented by:-

$$\sum \mu_{kA} \cdot NS_k^{(A)} \leq S_j^{(A)} \quad \text{and} \quad \sum \mu_{kA} \; NS_k^{(A)} \leq S_i^{(A)}$$

the $NS_k^{(A)}$ values will be forced to zero when $\mu_{kA} = \infty$ because the $S_i^{(A)}$ and $S_j^{(A)}$ are finite. Thus, in the general case the docking factors will force the variable $NS_k^{(A)}$ to be zero when the docking capacity does not exist.

1.5 The Objective Function

In this particular problem, the total cost to the carrier of transport provision could be described by the relationship

$$(CA + MX)SH. + \sum_{\text{All } k} NS_k . V_k)$$

where $CA+MX$ = the fixed cost element of transport provision (the cost of facilities ownership per ship).

V_k = the cost per complete journey over route "k"

Now the revenue derived from the transport system can depend upon the route the vessel follows. If freight rates differ between routes serving any two ports, shippers in the various islands will not be indifferent to the route the vessel follows. Hence, as the initial objective of the model is to maximize the profit from transport system operation while satisfying the demand for movement, the objective function can be written:-

$$\sum_{\text{All } i, j: \text{ all } k} a_{ijk} \cdot v_{ijk} - \left(SH.(CA+MX.) + \sum_{\text{All } k} NS_k \cdot V_k \right)$$

The above formulation subject to the constraints above, is now a linear programming problem which can be solved with existing computer packages.

1.6 The Model Applied

This form of the model can be applied to the design of any regional transport system while allowing a degree of autonomy to each transport authority.

Each island is considered to forward its views, to the Regional Shipping Council, on its transport investment plan over an "n" year period. Such a proposal would specify, for example, the new facilities in terms of the ship docking capacity at port "i" during the time period considered. Given these proposals and approximate estimates of intra-regional trade movements for each year considered, the model would then be used to derive a solution.

A sensitivity analysis of this solution results in an expression of the form:-

$$\Delta Z = \sum \left(\pi_i \cdot \Delta S_i + \pi'_i \cdot \Delta NJ_i + \pi''_i \cdot \Delta a_{ij} + \pi'''_i \cdot \Delta SH^{(A)} \right)$$

Hence, changes in the cost of transport provision resulting from changes in the constraint set, can be determined from the π_i or "simplex multipliers" related to each constraint.

Hence, an initial solution might result where the derived values of π_i, when passed to the island concerned, induce a revised transport investment proposal, subsequent revised proposals will, when incorporated in the transport model, result in a new and improved solution. This will minimise the cost of transport provision within the limits set by each

1.7 Application of the Model

The model can be applied as a corporate planning tool in a number of ways. A few applications are listed below.

- Additions to the fleet for estimated levels of trade can be determined in terms of both the numbers of journeys required, and the routes each ship should follow.
- Optimal route patterns can be determined for a company's shipping in future years given estimates of that year's intra-regional traffic.
- The need to invest in additional port facilities can be determined for forecasted increases in intra-regional traffic.
- The effect of modifying the number of vessels in a fleet can be determined by re-running the model for each selected number of vessels.
- The effect of trade flow forecasting errors on solutions of the model can also be derived from a sensitivity analysis.
- The effect of increasing trade flows on solutions of the model can also be determined.

1.8 The Validity of the Model

This linear programming model formulation theoretically admits a solution where a vessel can travel around one loop and also round another loop, but never takes the trip from one loop to the other. If warranted, subsequent runs with additional constraints to attach or destroy loops can be made. The model may also provide a solution where the number of journeys to be completed in a year over a particular route result in a non-integer number. Such a result should only be considered an approximation because the input data is really an estimate of the expected value of trade, not its actual value. The interpretation of such a solution is that the vessel should be scheduled to make approximately that number of journeys given by the solution.

A valuable by-product of the solution is the set of "simplex multipliers", or "shadow prices", which illustrate the rate of change of the objective function with respect to each variable in the constraint set. Thus, the value of investment in particular port and shipping facilities is indicated by their associated simplex multipliers, also the simplex multipliers related to each trade flow (a_{ij}) represent the cost associated with each additional ton of cargo to be carried over the (i, j) link.

APPENDIX G

1.0 AN APPROACH TO DATA COLLECTION[1]

Isard[2] states "....the value of flow studies is circumscribed by inadequate data. In the United States, for example, studies are handicapped by the almost complete absence of data on truck movements, by gaps in, and inadequate reporting and processing of, port-to-port water shipments over different routes, external and internal, and by insufficient data on rail and air traffic." The information exists, but is not in a summarized form. Isard gives examples of 1% samples where, for instance in a road transport survey, every hundredth waybill is used for the sample. However it is difficult to estimate the accuracy of the figures derived by this simple method, and a slightly more sophisticated sampling scheme should be adopted. In addition, even a 1% sample may involve a great deal of unnecessary work which may be avoided by the adoption of the following method.

1. Group commodities into N meaningful categories (e.g. by SITC classifications or by route.)

2. Derive an initial estimate of the breakdown of trade from a small, easily-handled sample, say, .01%. Let these values be e_1, e_2, e_3..... where e_i is the "expected" volume of trade in category i, calculated from the first sample.

3. Repeat the sampling procedure, again taking .01% of the data, and call the values obtained 0_1, 0_2, 0_3.... where 0_i is the "observed" volume of trade in category i, calculated from the second sample alone.

4. Calculate $\sum_{i=1}^{N}\left[\frac{(0_i - e_i)^2}{e_i}\right]$ and use a χ-squared statistical test with N-1 degrees of freedom, under the hypothesis that the first sample was representative of the total volume of trade.

5. Decide upon the statistical level of confidence required - e.g. 95% that both samples are representative of the total volume of trade, and use χ^2 - tables to accept or reject the hypothesis at that level.

---

1. This is due to J. Walker

2. Isard, W. Methods of Regional Analysis, MIT Press, 1960, pages 143, 144

6. If the hypothesis is rejected at that level, add the two samples together to obtain (in effect) a .02% sample, then take another .02% sample from the raw data. Using the values obtained in the first samples as new e_i, and those obtained from the latest sample as new 0_i repeat the procedure from para. 4, doubling the sample size each time until the required confidence level is reached.

This method ensures that data of the required accuracy is obtained with minimal data-collection. Furthermore the same calculation can be used to clarify the transport model at sensitive points, since we can put confidence limits around the input values e.g. we may have 95% confidence that a particular trade flow has a volume of 400 $\pm$ 5m.tons. However if the transport model tells us that this flow is critical at 402 (i.e. one investment plan holds if the flow is less than or equal to 402, otherwise a different plan has a higher social value) then we require to be more accurate and may use the above method to find, say, that we can have 87% confidence that the flow is 404 $\pm$ 1 and we select the second investment plan.

An example of this technique is given below, with a table of the χ^2 distribution for reference : as well as a normal distribution table.

Suppose we sample the flows entering a customs shed for exporting, and we divide the goods under 5 classifications A, B, C, D and E.

We obtain the following results on the first two days and proceed as shown in the table below :

	DAY 1 - e_i	DAY 2 - 0_i	$(0_i - e_i)^2 / e_i$	
A	300	325	$(325-300)^2/300 = 2.08$	
B	25	30	$(30-25)^2/25 = 1.00$	
C	1730	1760	$(1760-1730)^2/1730 = 0.52$	$\sum_i \frac{(0_i - e_i)^2}{e_i} = 7.91$
D	472	503	$(503-472)^2/472 = 2.04$	
E	75	62	$(62-75)^2/75 = 2.27$	

Referring to the χ^2 table we see that for N-1 = 4 degrees of freedom χ^2 will be 7.78 at the 10% level, which means that if two samples are supposedly representative of the same underlying situation we would expect their value of $\sum \frac{(0_i - e_i)^2}{e_i}$ to be less than 7.78 ninety per cent of the time. Therefore, a value of 7.91 is unlikely to support this supposition and we "reject it at the 10% level".

We now add up the first two days data and sample another two days :

DAYS 1 & 2	DAY 3	DAY 4	DAYS 3 & 4	(Col 4 - Col 1)^2/Col 1	
625	305	327	632	0.10	
55	25	28	53	0.07	$\sum \frac{(\text{COL4-COL1})^2}{\text{COL 1}} = 0.66$
3490	1724	1748	3472	0.09	
975	450	507	957	0.33	
137	65	75	140	0.07	

Referring again to the χ^2 table with 4 degrees of freedom we see that χ^2 is 0.711 at the 95% level, which means that unless the two samples (columns 1 and 4 in table 2) are representative of the underlying situation their value of $\sum \frac{(0_i - e_i)^2}{e_i}$ will be less than 0.711 only 5% of the time by chance.

Hence our value of 0.66 is highly indicative that these samples are in agreement with each other. Our best estimate of the true distribution is then to average over the 4 days and we estimate the daily traffic as

(625 + 632)/4 = 316 units of A

(55 + 53)/4 = 27 units of B.

(3490 + 3472)/4 = 1741 units of C

(975 + 957)/4 = 482 units of D

(137 + 140)/4 = 69 units of E

Percentage points of the χ^2-distribution; Required number of degrees of freedom is (NUMBER OF CLASSIFICATIONS - 1)

Degrees of freedom (v)	99	95	10	5	1	0.1
1	0.0^3157	0.00393	2.71	3.84	6.63	10.83
2	0.0201	0.103	4.61	5.99	9.21	13.81
3	0.115	0.352	6.25	7.81	11.34	16.27
4	0.297	0.711	7.78	9.49	13.28	18.47
5	0.554	1.15	9.24	11.07	15.09	20.52
6	0.872	1.64	10.64	12.59	16.81	22.46
7	1.24	2.17	12.02	14.07	18.48	24.32
8	1.65	2.73	13.36	15.51	20.09	26.12
9	2.09	3.33	14.68	16.92	21.67	27.88
10	2.56	3.94	15.99	18.31	23.21	29.59
11	3.05	4.57	17.28	19.68	24.73	31.26
12	3.57	5.23	18.55	21.03	16.22	32.91
14	4.66	6.57	21.06	32.68	29.14	36.12
16	5.81	7.96	23.54	26.30	32.00	39.25
18	7.01	9.39	25.99	28.87	34.81	42.31
20	8.26	10.85	28.41	31.41	37.57	45.31
22	9.54	12.34	30.81	33.92	40.29	48.27
24	10.86	13.85	33.20	36.42	42.98	51.18
26	12.20	15.38	35.56	38.89	45.64	54.05
28	13.56	16.93	37.92	41.34	48.28	56.89
30	14.95	18.49	40.26	43.77	50.89	59.70

We can now place confidence limits around our estimates by referring back to the original data and assuming Normally distributed flows.

For instance, the four days' samples of A were 300, 325, 305 and 327. Call these a_1, a_2, a_3, a_4 then calculate $\sqrt{\frac{1}{4}\sum_i (a_i - 316)^2} = 12.4$ which is the "standard deviation" of the samples around the mean of 316.

Referring to Normal distribution tables, 90% of samples will be within $\pm$ 1.64 standard deviations of the mean i.e. 316$\pm$ 1.64 x 12.4. Hence we are 90% confident that the correct figure lies between 295.7 and 336.3. Similarly 95% of samples will be within 1.96 standard deviations i.e. 316 $\pm$ 1.96 x 12.4 i.e. 291.7 and 340.3.

Normal Distribution Table :

If X is the mean and S the standard deviation, then values of x should lie within X $\pm$ mS with P% confidence according to the table below :

m	2.58	2.32	1.96	1.64	1.28	0.84	0.52	0.25	0.13	0.06	0.03	0.01
P	99	98	95	90	80	60	40	20	10	5	2	1

Linear Interpolation is sufficiently accurate for other values of P.

The standard deviation of "n" numbers a_i for i = 1, 2 ...n is given by :-

$$S = \sqrt{\frac{1}{n} \sum_i (a_i - X)^2}$$

where X = the mean of the a_i

APPENDIX H

THE REVISED SIMPLEX METHOD APPLIED

1.1 The Problem and its Solution

The two route, three port problem described in section 3.1.3.2 was formulated as a linear programming problem which, with the addition of non-negative slack and artificial variables may be solved by the two-phase method described in 1.2 of this appendix. This formulation of the problem is illustrated in table H.1.

So that calculations could subsequently be performed in an orderly fashion, the problem as defined in table H.1 was transferred to the initial tableau illustrated in table H.2. Only the infeasibility form of the objective function, defined by:-

$$W = x_{17} + x_{18} + \dots\dots\dots x_{22}$$

is presented in this table.

ROW NUMBER	BASIS	ARTIFICIAL VARIABLES	SIMPLEX MULTIPLIER	a'_{is} COEFFICIENT
1	b_1	1	π_1	a_{is}
2	b_2	1	π_2	a_{2s}
.	.	⋱	.	.
.	.		.	.
.	.		.	.
m	b_m	1	π_m	a_{ms}

TABLE H.2

A table of relative cost coefficients (d'_j for phase I and c'_j for phase II) was prepared and is shown in table H.3.

THE ORIGINAL PROBLEM

EQ.	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{20}	X_{21}	X_{22}		b_i
1	$a_{11}=0$	-1		1							1													0
2	-1		1		1			1				1												0
3	-1					1		1	1				1											0
4		-1					1							1										0
5	-1		1						1	1					1									0
6	1	1														1								S2
7			1	1													1							10
8					1													1						4
9						1	1												1					9
10								1												1				2
11									1												1			7
12										1												1		1
Z=	3	2	1	1	1	1	1	1	1	1							1	1	1	1	1	1		W
	NJ_1	NJ_2	a_{121}	a_{122}	a_{131}	a_{211}	a_{212}	a_{231}	a_{311}	a_{321}	SLACK VARIABLES						ARTIFICIAL VARIABLES							

TABLE H . 1

Relative Cost Coefficients

ITERATION	d'_1	d'_2		d'_n	d'_{n+1}	d'_{n+2}	----	d'_{n+m}	
0									
1									
.									
.									
.	c'_1	c'_2	----	c'_n					-Z
TERMINATION									

TABLE H.3

The tableau used for each iteration is as illustrated in table H.4.0 - H.4.11. The tableau records the basic variables, their values, the inverse of the basis, the values of π_i and a'_{is}. At the beginning of any iteration (k + 1), the tableau for iteration k is filled completely except for the last column. Using the π_i and a_{ij} recorded in table H.1 (in this case all equal to one) the c'_j or d'_j are computed from:-

$$c'_j = c_j + \sum_{i=1}^{m} \pi_i . a_{ij}$$

The results are entered in table G.4.0. By determining "s" in the usual way we can then complete the tableau for iteration k by filling in the last column with a'_{is} using:-

$$a'_{is} = \sum_{k=1}^{m} \beta_{ik} . a_{ks}$$

By forming ratios b'_i / a'_{is} the "r" can be determined as before and a box drawn around a'_{rs} the new pivot element. The results of these calculations become the tableau for iteration k + 1 except for the last column. The above procedure is now repeated in moving from the (k + 1) tableau to the (k + 2) tableau.

THE INVERSE OF THE BASIS

Row	Basis	Value	1	2	3	4	5	6	7	8	9	10	11	12	(hatched)	π_i	a'_{is}	
1	X 11	0	1													0	0	
2	X 12	0		1												0	0	
3	X 13	0			1											0	0	
4	X 14	0				1										0	0	
5	X 15	0					1									0	1	
6	X 16	S2						1								0	0	0
7	X 17	10							1							−1	0	
8	X 18	4								1						−1	0	
9	X 19	9									1					−1	0	
10	X 20	2										1				−1	0	
11	X 21	7											1			−1	0	
12	X 22	1												1		−1	1	

THE INITIAL TABLEAU. TABLE H. 4.0.

Row	Basis	Value	1	2	3	4	5	6	7	8	9	10	11	12	(hatched)	π_i	a'_{is}	
1	X 11	0	1													0	0	
2	X 12	0		1												0	1	
3	X 13	0			1											0	1	
4	X 14	0				1										0	0	
5	X 10	0					1									1	0	
6	X 16	S2						1								0	0	1
7	X 17	10							1							−1	0	
8	X 18	4								1						−1	0	
9	X 19	9									1					−1	0	
10	X 20	2										1				−1	1	
11	X 21	7											1			−1	0	
12	X 22	1												1		−1	0	

TABLE H. 4.1.

Row	Basis	Value	1	2	3	4	5	6	7	8	9	10	11	12	(hatched)	π_i	a'_{is}	
1	X 11	0	1													0	0	
2	X 12	0		1	−1											0	0	
3	X 18	0			1											1	−1	
4	X 14	0				1										0	0	
5	X 10	0					1									1	−1	
6	X 16	S2						1								0	1	2
7	X 17	10							1							−1	0	
8	X 18	4								1						−1	0	
9	X 19	9									1					−1	0	
10	X 20	2			−1							1				−1	1	
11	X 21	7											1			−1	0	
12	X 22	1					−1							1		−1	1	

TABLE H. 4. 2.

Row	Basis	Value	1	2	3	4	5	6	7	8	9	10	11	12	(hatched)	π_i	a'_{is}	
1	X 11	0	1													0	0	
2	X 12	0		1	−1											0	1	
3	X 8	1			1		−1							1		1	−1	
4	X 14	0				1										0	0	
5	X 10	1												1		−1	0	
6	X 16	S2-1					1	1						−1		0	1	3
7	X 17	10							1							−1	1	
8	X 18	4								1						−1	0	
9	X 19	9									1					−1	0	
10	X 20	1			−1		−1					1		−1		−1	1	
11	X 21	7											1			−1	0	
12	X 1	1					−1							1		1	−1	

TABLE H. 4. 3.

THE INVERSE OF THE BASIS

	BASIS	VALUE														π_i	a'_{is}	
1	X 11	0	1													0	0	
2	X 3	0		1	−1											2	−1	
3	X 8	1		1			−1							1		−1	−1	
4	X 14	0				1										0	0	
5	X 10	1												1		−1	0	
6	X 16	S2−1		−1	1		1	1						−1		0	2	4
7	X 17	10		−1	1				1							−1	1	
8	X 18	4								1						−1	0	
9	X 19	9									1					−1	0	
10	X 20	1		−1			1					1		−1		−1	1	
11	X 21	7											1			−1	1	
12	X 1	1		1	−1		−1							1		1	−2	

TABLE H.4.4.

	BASIS	VALUE														π_i	a'_{is}	
1	X 11	0	1													0	0	
2	X 3	1			−1		1					1		−1		−1	−1	
3	X 8	2										1				−1	0	
4	X 14	0				1										0	0	
5	X 10	1												1		2	0	
6	X 16	S2−3		1	1		−1	1				−2		1		0	1	5
7	X 17	9			1		−1		1			−1		1		−1	1	
8	X 18	4								1						−1	0	
9	X 19	9									1					−1	1	
10	X 9	1		−1			1					1		−1		2	0	
11	X 21	6		1			−1					−1	1	1		−1	0	
12	X 1	3		−1	−1		1					2		−1		−2	−1	

TABLE H. 4.5.

	BASIS	VALUE														π_i	a'_{is}	
1	X 11	0	1													0	0	
2	X 3	10			−1		1				1	1		−1		−1	0	
3	X 8	2														−1	0	
4	X 14	0				1										0	0	
5	X 10	1												1		2	0	
6	X 16	S2-12		1	1		−1	1			−1	−2		1		0	1	6
7	X 17	0			1		−1		1		−1	−1		1		−1	0	
8	X 18	4 .								1						−1	1	
9	X 6	9									1					1	0	
10	X 9	1		−1			1					1		−1		2	−1	
11	X 21	6		1			−1					−1	1	1		−1	1	
12	X 1	12		−1	−1		1				1	2		−1		−2	−1	

TABLE H. 4.6.

	BASIS	VALUE														π_i	a'_{is}	
1	X 11	0	1													0	1	
2	X 3	10			−1		1				1	1		−1		−1	0	
3	X 8	2										1				−1	0	
4	X 14	0				1										0	0	
5	X 10	1												1		2	0	
6	X 16	S2-16		1	1		−1	1		−1	−1	−2		1		0	0	7
7	X 17	0			1		−1		1		−1	−1		1		−1	1	
8	X 5	4								1						1	0	
9	X 6	9									1					1	0	
10	X 9	5		−1			1			1		1		−1		2	0	
11	X 21	2		1			−1			−1		−1	1	1		−1	0	
12	X 1	16		−1	−1		1			1	1	2		−1		−2	0	

TABLE H. 4.7.

	BASIS	VALUE	THE INVERSE OF THE BASIS													π_i	a'_{is}	
1	X 11	0	1		−1		1		−1		1	1		−1		0	0	
2	X 3	10			−1		1				1	1		−1		−1	0	
3	X 8	2										1				0	0	
4	X 14	0				1										0	0	
5	X 10	1												1		1	0	
6	X 16	S2-16		1	1		−1	1		−1	−1	−2		1		0	1	8
7	X 4	0			1		−1		1		−1	−1		1		0	0	
8	X 5	4								1						1	0	
9	X 6	9									1					0	0	
10	X 9	5		−1			1			1		1		−1		1	−1	
11	X 21	2		1			−1			−1		−1	1	1		−1	1	
12	X 22	16		−1	−1		1			1	1	2		−1		−1	−1	

TABLE H.4.8.

	BASIS	VALUE														π_i	a'_{is}	
1	X 11	0	1		−1		1		−1		1	1		−1		0	1	
2	X 3	10			−1		1				1	1		−1		0	1	
3	X 8	2										1				+3	0	
4	X 14	0				1										0	1	
5	X 10	1												1		0	0	
6	X 16	S2-18			1			1			−1	−1	−1			0	−1	9
7	X 4	0			1		−1		1		−1	−1		1		−1	−1	
8	X 5	4								1						−1	0	
9	X 6	9									1					−4	1	
10	X 9	7											1			−4	0	
11	X 12	2		1			−1			−1		−1	1	1		−4	0	
12	X 1	18			−1						1	1	1			−1	1	

TABLE H.4.9

PHASE II

	BASIS	VALUE														π_i	a'_{is}	
1	X 11	0	1		−1	−1	1		−1		1	1		−1		0	0	
2	X 3	10			−1	−1	1				1	1		−1		0	1	
3	X 8.	2										1				3	0	
4	X 7	0				1										3	−1	
5	X 10	1												1		0	0	
6	X 16	S2 18			1	1		1			−1	−1	−1			0	0	10
7	X 4	0			1	1	−1		1		−1	−1		1		−1	−1	
8	X 5	4								1						−1	0	
9	X 6	9				−1					1					−4	1	
10	X 9	7											1			−4	0	
11	X 12	2		1			−1			−1		−1	1	1		−4	0	
12	X 1	18			−1	−1					1	1	1			−1	1	

TABLE H.4.10.

	BASIS	VALUE														π_i	b_i	
1	X 11	0	1		−1	−1	1		−1		1	1		−1		0	0	
2	X 3	1			−1		1					1		−1		0	0	
3	X 8	2										1				3	0	
4	X 7	9									1					2	0	
5	X 10	1												1		0	0	
6	X 16	S2-18			1	1		1			−1	−1	−1			0	52	11
7	X 4	9			1		−1		1			−1		1		−1	a_{12}	
8	X 5	4								1						−1	a_{13}	
9	X 2	9				−1					1					−3	a_{21}	
10	X 9	7											1			−4	a_{23}	
11	X 12	2		1			−1			−1		−1	1	1		−4	a_{31}	
12	X 1	9			−1							1	1			−1	a_{32}	

TABLE H.4.11.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	-W
I	D'_1 ------------ RELATIVE COST COEFFICIENTS ------------ D'_{15}															PHASE I	1	1	1	1	1	1	6
0	0	0	-1	-1	-1	-1	-1	-1	-1	-1					R								6
1	-1	0	0	-1	-1	-1	-1	-1	0	S			R		1								6
2	-2	0	0	-1	-1	0	-1	S	1				1		1							R	6
3	S	0	-2	-1	-1	0	-1		-1			R	1		-1							0	5
4		0	S	-1	1	-2	-1		-3			2	-1		-1					R		+2	5
5		0		-1	-2	-2	-1		S			-1	-1		2				R	3		-1	4
6		0		-1	-2	S	1					-1	-1		2			R	2	3		-1	3
7		0		-1	S		1					-1	-1		2		R	2	2	3		-1	2
8		0		S			0					-1	0		1		1	2	1	2	R	0	1
	C'_1 ------ RELATIVE COST COEFFICIENTS ------------											S	-------- C'_{16}										0
	3_{18}	2	1_{10}	1_{0}	1_{4}	1_{9}	1	1_{2}	1_{7}	1_{1}						PHASE II							-Z
9		2					-3						3	R	0								87
10		-1				R	S						3	3	0								87
11		S				1							3	2	0								78

NO NEGATIVE C'_j REMAINING–SOLUTION THEREFORE OPTIMAL

TABLE H:4:12.

APPENDIX I

A 5 PORT, 24 ROUTE TRANSPORT PROBLEM

1.0 Introduction

The route generation algorithm of appendix E and a linear programming transport model were applied to the problem of selecting an optimal combinatio of shipping routes[1] to serve 5 ports in the Caribbean. Antigua, Barbados and Trinidad were assumed to act as transhipment ports for the Windward and Leeward group of islands. These three islands' ports were assumed to handle the trade of the other islands in the following way.

TRANSHIPMENT PORT	ISLANDS SERVED
ANTIGUA	ST. KITTS, MONTSERRAT
BARBADOS	DOMINICA, ST. LUCIA
TRINIDAD	ST. VINCENT, GRENADA

TABLE I .1

In turn these three islands were assumed to trade with each other and with Jamaica and Guyana; a total of 5 ports in all.

2.0 The Route Generation Algorithm Applied

The route generation algorithm described in appendix E was used to select a subset of routes from which the optimal pattern of routes would be chosen. Inputs to the algorithm were as follows:-

- Artificial trade flows between the five ports of Jamaica, Antigua, Barbados, Trinidad and Guyana.
- The travel time between these five ports.
- The distance between these ports in nautical miles
- The parameters of the cost of ship operation
- Upper limits on journey time and ship capacity

---

1. A route involves a ship calling at each port in a combination of "n" ports.

The data used is as follows:-

THE TRADE FLOW MATRIX						
PORTS		1	2	3	4	5
JAMAICA	1	0	4008	4862	3156	865
TRINIDAD	2	2806	0	23972	45760	8266
BARBADOS	3	11	5974	0	10539	2039
GUYANA	4	19655	201360	12397	0	3642
ANTIGUA	5	7	1201	1475	31	0

TABLE I .2

THE TRAVEL TIME MATRIX						
PORTS		1	2	3	4	5
JAMAICA	1	0	3	3	4	3
TRINIDAD	2	3	0	1	2	2
BARBADOS	3	3	1	0	2	2
GUYANA	4	2	2	2	0	2
ANTIGUA	5	2	2	2	2	0

TABLE I .3

THE DISTANCE MATRIX						
PORTS		1	2	3	4	5
JAMAICA	1	0	1041	1075	1329	906
TRINIDAD	2		0	213	364	402
BARBADOS	3			0	397	285
GUYANA	4				0	669
ANTIGUA	5					0

TABLE I .4

2. Solution 2B used this data. For authors reference only.

The cost per mile of ship operation = £3.7[3]

The cost per port of call = £100[4]

The maximum loop journey time = 15 days[5]

The maximum ship capacity = 6400 m-tons[6]

---

3. The operating cost per mile = fuel cost/ mile + manning cost/ mile

= 1.5 + 2.2

where the manning cost per mile was calculated as follows :-

$$\frac{\text{The annual manning cost per ship}}{\text{The average annual completed ship mileage}}$$

4. An assumed figure based on the data presented in section 2.8

5. If one ship operated over a route serving two ports (i, j) then the maximum loop journey time must be 15 days if a ship is required to call at each port every 15 days. If two ships existed and only one operated over any one route, then again the above constraint would be required.

6. As each of the two Government supported ships has a cargo capacity of 3,200 measurement tons then the most capacity that the two ships could provide in one movement over link (i, j) would be 6,400 tons.

This data was used to derive the cost of ship operation per loop. That is :-

The cost per ship per loop = $3.7\, d_k + 100\, (j + rr - 2)$[7] where

d_k = distance over route "k"

j = the number of ports in the route combination

rr = the number of ports of call on the return journey to the starting port.

7. Due to R. A. Friar, formerly of EASAMS.
This figure was calculated from the equation CS' = CS + manning cost/ mile = £1.5 + £2.2 = 3.7. The figure for CS was taken from the list of typical values given in section 8 of the appendix.

Using this data, the following subset of routes were selected by the algorithm

ROUTES	NOTATION	MAX. TONNAGE CARRIED [8]	COST/LOOP [9] PER TON ASSUMING A SHIP OF 3,200 TONS	JOURNEY TIME	$NS_{MAX.}$	COST/LOOP BASED ON DISTANCE
121	NS_1	73.20	2.50	6.0	54.75	7903.2
131	NS_2	88.80	2.58	6.0	54.75	8156.0
141	NS_3	478.70	3.17	8.0	41.06	9134.4
151	NS_4	15.40	2.19	6.0	54.75	6904.8
232	NS_5	145.90	0.59	2.0	164.30	1775.2
242	NS_6	2451.90	0.94	4.0	82.13	2892.0
252	NS_7	100.65	1.02	4.0	82.13	3173.6
343	NS_8	150.95	1.01	4.0	82.13	3138.4
353	NS_9	24.83	0.75	4.0	82.13	2309.6
454	NS_{10}	4.43	1.64	4.0	82.13	5151.2
1231	NS_{11}	674.20	2.85	7.0	46.93	8916.8
1241	NS_{12}	5713.00	3.32	9.0	36.50	10414.4
1251	NS_{13}	290.20	2.87	8.0	41.06	8990.4
1341	NS_{14}	559.30	3.40	9.0	36.50	10664.0

TABLE I.5

ROUTES	NOTATION	MAX. TONNAGE* CARRIED	COST/LOOP PER TON ASSUMING A SHIP OF 3,200 TONS	JOURNEY TIME	REQUIRED $NS_{MAX.}$	COST/LOOP BASED ON DISTANCE
1351	NS_{15}	174.90	2.78	8.0	41.06	10364.0
1451	NS_{16}	571.60	3.51	9.0	36.50	1044.8
2342	NS_{17}	3064.80	1.28	5.0	65.70	3902.4
2352	NS_{18}	513.10	1.20	5.0	65.70	3630.4
2452	NS_{19}	3835.40	1.81	6.0	54.80	5608.0
3453	NS_{20}	270.30	1.72	6.0	54.80	5287.6
12351	NS_{21}	1156.90	3.05	9.0	36.50	9447.2
14351	NS_{22}	1326.00	3.59	11.0	29.86	11194.4
24352	NS_{23}	6035.50	1.89	8.0	41.06	5757.6
153421 X	NS_{24}			12.0	38.5 but NSMAX=30/yr	11474.1

TABLE .. .5 continued

8 This is the maximum tonnage carried by a ship per journey over any one link over the stated route assuming that no other ship operates over that route and that the ship concerned completes NS_{MAX} journeys per year. For example, over route 121, the larger movement is 4008 m.tons. Hence 4008/NS equals 73.2 tons which are carried over link 1,2.

9 Differences occur due to different distances between ports

X This route was added by hand, but exceeds the NSMAX constraints.

A linear programming transport model was applied to the selection of a number of routes from those identified by the algorithm.[11] The resulting linear programme, as formulated, is given in 3.0 below, and incorporates limitations on the number of ships, the port handling capacities, and on the frequency of journeys between each pair of nodes in the network. The variables used are as defined below.

V_k = the cost per journey over route "k".

NS_k = the number of journeys completed over route "k" in one year.

v_{ijk} = the revenue derived from shipping one ton of cargo from port "i" to port "j" over route "k".

a_{ijk} = the amount of cargo to be exported annually from port "i" to port "j" over route "k".

C = the tonnage capacity of the ship assumed to operate over any route selected.

a_{ij} = the summation of trade flows a_{ijk} moving between nodes "i" and "j".

S_i = the ship-docking capacity at origin "i" over the time described by the model, in numbers of ships.

SH = the number of ships available to the region.

T_{ij} = The minimum service time in days between nodes "i" and "j" of the network[12]

---

11. Theoretically, the number of port combinations which should be selected by the route generation algorithm should equal $\sum_n ({}^N C_n)$ where N = the total number of ports in the region = 5 in this cas n = the number of ports in a group of ports = 2, 3, ...N. That is 10 routes containing two ports, 10 routes containing three ports 5 routes containing 4 ports and 1 route containing 5 ports. The algorithm in fact only output 10 routes containing two ports, 10 routes contain 3 ports and 3 routes containing 4 ports before it was stopped.

12. This constraint ensures that for each arc (i, j) the sum of the journeys serving that arc must be greater than or equal to 22 journeys per year.

3.0 The linear programming transport model

$$\text{MINIMISE } \sum V_k . NS_k + \sum v_{ijk} . a_{ijk}$$

Subject to:

Arc 1.2

$$\begin{cases} C.NS_1 \geqslant a_{121} \\ C.NS_{11} \geqslant a_{1211} + a_{1311} + a_{3211} \\ C.NS_{12} \geqslant a_{1212} + a_{1412} + a_{4212} \\ C.NS_{13} \geqslant a_{1213} + a_{1513} + a_{5213} \\ C.NS_{21} \geqslant a_{1221} + a_{1321} + a_{1521} + a_{3221} + a_{5221} + a_{5321} \\ C.NS_{24} \geqslant a_{1224} \end{cases}$$

Arc 2.1

$$\begin{cases} C.NS_1 \geqslant a_{211} \\ C.NS_{24} \geqslant a_{2124} + a_{2324} + a_{2424} + a_{2524} + a_{3124} + a_{3524} + \\ \quad a_{4124} + a_{4324} + a_{4524} + a_{5124} \end{cases}$$

Arc 1.3

$$\begin{cases} C.NS_2 \geqslant a_{132} \\ C.NS_{14} \geqslant a_{1314} + a_{1414} + a_{4314} \end{cases}$$

Arc 3.1

$$C.NS_{11} \geqslant a_{2111} + a_{3211}$$

Arc 1.4

$$\begin{cases} C.NS_3 \geqslant a_{143} \\ C.NS_{16} \geqslant a_{1416} + a_{1516} \\ C.NS_{22} \geqslant a_{1322} + a_{1422} + a_{1522} + a_{3422} + a_{5322} + a_{5422} \end{cases}$$

Arc 4.1

$$\begin{cases} C.NS_3 \geqslant a_{413} \\ C.NS_{12} \geqslant a_{2112} + a_{3112} + a_{4112} + a_{4212} + a_{4312} \\ C.NS_{14} \geqslant a_{4114} \end{cases}$$

Arc 1.5

$$\begin{cases} C.NS_4 \geqslant a_{154} \\ C.NS_{13} \geqslant a_{1313} + a_{1513} \\ C.NS_{24} \geqslant a_{1224} + a_{1324} + a_{1424} + a_{1524} + a_{2324} + a_{2424} + \\ \quad a_{2524} + a_{3524} + a_{4324} + a_{4524} \end{cases}$$

Arc 5.1
$$\left[\begin{aligned} C.NS_{13} &\geq a_{2113} + a_{5213} \\ C.NS_{15} &\geq a_{5115} \\ C.NS_{16} &\geq a_{4116} + a_{5116} \\ C.NS_{22} &\geq a_{3422} + a_{4122} + a_{5322} \end{aligned}\right.$$

Arc 2.3
$$\left[\begin{aligned} C.NS_{5} &\geq a_{235} \\ C.NS_{11} &\geq a_{1311} + a_{2111} + a_{2311} \\ C.NS_{17} &\geq a_{2317} + a_{2417} + a_{4317} \\ C.NS_{18} &\geq a_{2318} + a_{2518} + a_{5318} \\ C.NS_{21} &\geq a_{2121} + a_{2321} + a_{2521} \end{aligned}\right.$$

Arc 3.2
$$C.NS_{5} \geq a_{325}$$

Arc 2.4
$$\left[\begin{aligned} C.NS_{6} &\geq a_{246} \\ C.NS_{12} &\geq a_{1412} + a_{2112} + a_{2412} \\ C.NS_{19} &\geq a_{2419} + a_{2519} + a_{5419} \\ C.NS_{23} &\geq a_{2323} + a_{2423} + a_{2523} + a_{3423} + a_{5323} \end{aligned}\right.$$

Arc 4.2
$$\left[\begin{aligned} C.NS_{6} &\geq a_{426} \\ C.NS_{17} &\geq a_{3217} + a_{4217} + a_{4317} \\ C.NS_{24} &\geq a_{1224} + a_{3124} + a_{3224} + a_{3524} + a_{4124} + a_{4224} + \\ &\quad a_{4324} + a_{4524} + a_{5124} + a_{5224} \end{aligned}\right.$$

Arc 2.5
$$\left[\begin{aligned} C.NS_{7} &\geq a_{257} \\ C.NS_{13} &\geq a_{2113} + a_{2513} + a_{1513} \end{aligned}\right.$$

Arc 5.2
$$\left[\begin{aligned} C.NS_{7} &\geq a_{527} \\ C.NS_{18} &\geq a_{3218} + a_{5218} + a_{5318} \\ C.NS_{19} &\geq a_{4219} + a_{5219} \\ C.NS_{23} &\geq a_{3223} + a_{3423} + a_{4223} + a_{5223} + a_{5323} \end{aligned}\right.$$

Arc 3.4
$$\begin{cases} C.NS_8 \geq a_{348} \\ C.NS_{14} \geq a_{1414} + a_{3414} \\ C.NS_{17} \geq a_{2417} + a_{3217} + a_{3417} \\ C.NS_{20} \geq a_{3420} + a_{3520} \\ C.NS_{24} \geq a_{1224} + a_{1424} + a_{2424} + a_{3124} + a_{3224} + a_{3424} + \\ \quad a_{3524} + a_{5124} + a_{5224} + a_{5424} \end{cases}$$

Arc 4.3
$$\begin{cases} C.NS_8 \geq a_{438} \\ C.NS_{22} \geq a_{1322} + a_{1522} + a_{4122} + a_{4322} + a_{4522} + a_{5322} \\ C.NS_{23} \geq a_{2323} + a_{2523} + a_{4223} + a_{4323} + a_{4523} + a_{5323} \end{cases}$$

Arc 3.5
$$\begin{cases} C.NS_9 \geq a_{259} + a_{329} + a_{359} \\ C.NS_{15} \geq a_{3515} \\ C.NS_{18} \geq a_{2518} + a_{3218} + a_{3518} \\ C.NS_{21} \geq a_{1521} + a_{2121} + a_{2521} + a_{3221} + a_{3521} \\ C.NS_{22} \geq a_{1522} + a_{3422} + a_{3522} + a_{4122} + a_{4522} \\ C.NS_{23} \geq a_{2523} + a_{3223} + a_{3423} + a_{3523} + a_{4223} + a_{4523} \end{cases}$$

Arc 5.3
$$\begin{cases} C.NS_9 \geq a_{539} \\ C.NS_{15} \geq a_{1315} + a_{5315} \\ C.NS_{20} \geq a_{5320} \\ C.NS_{24} \geq a_{1224} + a_{1324} + a_{1424} + a_{2324} + a_{2424} + a_{4324} + \\ \quad a_{5124} + a_{5224} + a_{5324} + a_{5424} \end{cases}$$

Arc 4.5
$$\begin{cases} C.NS_{10} \geq a_{4510} \\ C.NS_{16} \geq a_{1516} + a_{3516} + a_{4516} \\ C.NS_{19} \geq a_{3519} + a_{4319} + a_{4519} + a_{2519} + a_{4219} \end{cases}$$

Arc 5.4 $\quad C.NS_{24} \geq a_{5424}$

$$a_{121} + a_{1211} + a_{1212} + a_{1213} + a_{1221} + a_{1224} = a_{12}$$

$$a_{132} + a_{1311} + a_{1313} + a_{1314} + a_{1315} + a_{1321} + a_{1322} + a_{1324} = a_{13}$$

$$a_{143} + a_{1412} + a_{1414} + a_{1416} + a_{1422} + a_{1424} = a_{14}$$

$$a_{154} + a_{1513} + a_{1516} + a_{1521} + a_{1522} + a_{1524} = a_{15}$$

$$a_{211} + a_{2111} + a_{2112} + a_{2113} + a_{2121} + a_{2124} = a_{21}$$

$$a_{235} + a_{2311} + a_{2317} + a_{2318} + a_{2321} + a_{2323} + a_{2324} = a_{23}$$

$$a_{246} + a_{2412} + a_{2417} + a_{2419} + a_{2423} + a_{2424} = a_{24}$$

$$a_{257} + a_{259} + a_{2513} + a_{2518} + a_{2519} + a_{2521} + a_{2523} + a_{2524} = a_{25}$$

$$+ a_{3112} + a_{3124} = a_{31}$$ [13]

$$a_{325} + a_{329} + a_{3211} + a_{3217} + a_{3218} + a_{3221} + a_{3223} + a_{3224} = a_{32}$$

$$a_{348} + a_{3414} + a_{3417} + a_{3420} + a_{3422} + a_{3423} + a_{3424} = a_{34}$$

$$a_{359} + a_{3515} + a_{3516} + a_{3518} + a_{3519} + a_{3520} + a_{3521} + a_{3522} + a_{3523} + a_{3524} = a_{35}$$

$$a_{413} + a_{4113} + a_{4114} + a_{4116} + a_{4122} + a_{4124} = a_{41}$$

$$a_{426} + a_{4212} + a_{4217} + a_{4219} + a_{4223} + a_{4224} = a_{42}$$

$$a_{438} + a_{4312} + a_{4314} + a_{4317} + a_{4319} + a_{4322} + a_{4323} + a_{4324} = a_{43}$$

$$a_{4510} + a_{4516} + a_{4519} + a_{4522} + a_{4523} + a_{4524} = a_{45}$$

$$+ a_{5124} = a_{51}$$ [13]

$$a_{527} + a_{5213} + a_{5218} + a_{5219} + a_{5221} + a_{5223} + a_{5224} = a_{52}$$

$$a_{539} + a_{5315} + a_{5318} + a_{5320} + a_{5321} + a_{5322} + a_{5323} + a_{5324} = a_{53}$$

13. Other routes incorrectly omitted

$$+ a_{5419} + a_{5422} + a_{5424} = a_{54}^{14}$$

$$NS_1 + NS_2 + NS_3 + NS_4 + NS_{11} + NS_{12} + NS_{13} + NS_{14} + NS_{15} + NS_{16} + NS_{21} + NS_{22} + NS_{23} \leqslant S_1$$

$$NS_1 + NS_5 + NS_6 + NS_7 + NS_{11} + NS_{12} + NS_{13} + NS_{17} + NS_{18} + NS_{19} + NS_{21} + NS_{23} + NS_{24} \leqslant S_2$$

$$NS_2 + NS_5 + NS_8 + NS_9 + NS_{11} + NS_{14} + NS_{15} + NS_{17} + NS_{18} + NS_{21} + NS_{22} + NS_{23} + NS_{24} \leqslant S_3$$

$$NS_3 + NS_6 + NS_8 + NS_{10} + NS_{12} + NS_{14} + NS_{16} + NS_{17} + NS_{19} + NS_{20} + NS_{22} + NS_{23} + NS_{24} \leqslant S_4$$

$$NS_4 + NS_7 + NS_9 + NS_{10} + NS_{13} + NS_{15} + NS_{16} + NS_{18} + NS_{19} + NS_{20} + NS_{21} + NS_{22} + NS_{23} + NS_{24} \leqslant S_5$$

$$0.018\,(NS_1 + NS_2 + NS_4 + NS_{19} + NS_{20}) + 0.024\,(NS_3 + NS_{13} + NS_{15} + NS_{23}) + 0.006\,NS_5 + 0.012\,(NS_6 + NS_7 + NS_8 + NS_9 + NS_{10}) + 0.021\,NS_{11} + 0.027\,(NS_{12} + NS_{14} + NS_{16} + NS_{21}) + 0.015\,(NS_{17} + NS_{18}) + + 0.033\,NS_{22} + 0.038\,NS_{24} \leqslant SH$$

$$NS_1 + NS_{11} + NS_{12} + NS_{13} + NS_{21} + NS_{24} \geqslant 365/T_{12}$$
$$NS_2 + NS_{11} + NS_{12} + NS_{13} + NS_{15} + NS_{21} + NS_{22} + NS_{24} \geqslant 365/T_{13}$$
$$NS_3 + NS_{12} + NS_{14} + NS_{16} + NS_{22} + NS_{24} \geqslant 365/T_{14}$$
$$NS_4 + NS_{13} + NS_{16} + NS_{21} + NS_{22} + NS_{24} \geqslant 365/T_{15}$$
$$NS_1 + NS_{11} + NS_{12} + NS_{13} + NS_{21} + NS_{24} \geqslant 365/T_{21}$$
$$NS_5 + NS_{11} + NS_{17} + NS_{18} + NS_{21} + NS_{23} + NS_{24} \geqslant 365/T_{23}$$
$$NS_6 + NS_{12} + NS_{17} + NS_{19} + NS_{23} + NS_{24} \geqslant 365/T_{24}$$
$$NS_7 + NS_9 + NS_{13} + NS_{18} + NS_{19} + NS_{21} + NS_{23} + NS_{24} \geqslant 365/T_{25}$$
$$NS_{12} + NS_{24} \geqslant 365/T_{31}$$
$$NS_5 + NS_9 + NS_{11} + NS_{17} + NS_{18} + NS_{21} + NS_{23} + NS_{24} \geqslant 365/T_{32}$$
$$NS_8 + NS_{14} + NS_{17} + NS_{20} + NS_{22} + NS_{23} + NS_{24} \geqslant 365/T_{34}$$
$$NS_9 + NS_{15} + NS_{16} + NS_{18} + NS_{19} + NS_{20} \quad NS_{21} + NS_{22} + NS_{23} + NS_{24} \geqslant 365/T_{35}$$
$$NS_{12} + NS_{13} + NS_{14} + NS_{16} + NS_{22} + NS_{24} \geqslant 365/T_{41}$$
$$NS_6 + NS_{12} + NS_{17} + NS_{19} + NS_{23} + NS_{24} \geqslant 365/T_{42}$$

---

14. Other routes incorrectly omitted

$$NS_8 + NS_{12} + NS_{14} + NS_{17} + NS_{19} + NS_{22} + NS_{23} + NS_{24} \geqslant 365/T_{43}$$

$$NS_{10} + NS_{16} + NS_{19} + NS_{22} + NS_{23} + NS_{24} \geqslant 365/T_{45}$$

$$NS_{24} \geqslant 365/T_{51}$$

$$NS_7 + NS_{13} + NS_{18} + NS_{19} + NS_{21} + NS_{23} + NS_{24} \geqslant 365/T_{52}$$

$$NS_9 + NS_{15} + NS_{18} + NS_{20} + NS_{21} + NS_{22} + NS_{23} + NS_{24} \geqslant 365/T_{53}$$

$$NS_{19} + NS_{22} + NS_{24} \geqslant 365/T_{54}$$

4.0 The Results

The routes selected by the model are given in table I.6.

Route Number	Route	Value	NSMAX*
NS_5	232	4.4	164.3
NS_6	242	181.8	82.1
NS_8	343	0.2	82.1
NS_9	353	8.5	82.1
NS_{12}	1241	1.1	36.5
NS_{13}	1251	3.0	41.1
NS_{14}	1341	14.2	36.5
NS_{15}	1351	0.01	Ignored
NS_{16}	1451	4.4	36.5
NS_{17}	2342	20.0	65.7
NS_{18}	2352	1.2	65.7
NS_{19}	2452	0.03	} Ignored
NS_{24}	153421	0.03	}

*NSMAX = Days available in year/Loop journey time in days

TABLE I.6 (Solution 2B)

These results may leave the reader with grave doubts about its value. In particular, the following points may have been noted, which could either make the interpretation of results difficult, or cast doubts on the transport system improvements generated by the model.

- The number of routes selected by the model exceed the number of ships.
- The problem size becomes enormous as the number of ports and therefore, the number of routes increase.
- The constraint values applied to port handling capacity only accounted for intra-regional movements of shipping.

- The use of the model is limited.

Each of these points was considered in turn.

4.1 The Ship Quantity - Route Assignment Problem

Now the proportion of a year occupied by a ship completing NS_k journeys over route k is given by :-

$$\left(\frac{NS_k}{NSMAX_k} \right)$$

Hence, one ship may complete any number of journeys over any combination of routes as long as the sum of the $NS_k / NSMAX_k$ (for all k) is less than or equal to unity. That is :-

$$\sum NS_k / NSMAX_k \quad \leq \quad 1 \quad \text{for all routes "k"}$$

A ship cannot journey between one loop and another if the value of the objective function is to remain valid, although ships could change loops at those ports which are common to two loops. Unfortunately, routes which include more than two ports cause problems because, when jumping from a 3 port route to a 2 port route, the ship concerned will still contain cargo for the third port of the original route. Thus the solution is far from satisfactory.[15]

Where a very few ships exist with a region, a mixed linear-integer programming approach might be adopted so that the number of routes chosen equal the number of ships available. The existing linear programming transport model can be modified in the following way.

The objective function is described by the equation :-

$$\left[\sum a_{ijk} . v_{ijk} \quad - \sum NS_k . V_k \right] \qquad \text{(for all routes "k")}$$

The first term concerns the allocation of cargo movements (a_{ijk}) between nodes "i" and "j" to those routes "k" which pass through both nodes. The first term is not considered here. Now any solution to the programme must satisfy the conditions that no more than SH routes can be chosen where SH equals the number of ships. That is :-

---

15. If the region contained a large number of ships of lower capacity, route selection using the linear programme as defined could be acceptable, for there could then be more ships than loops in a solution of the model.

$$Z = -\sum_{i} [V_k . NS_k \, \delta_k] \quad + \text{(The first term)}$$

$$\sum_{i} \delta_i \leq SH \qquad \text{where each } \delta_i \text{ equals 0 or 1}$$

The above equations can be re-formulated in the following way

$$- V_k . NS_k \qquad + \quad v_{ijk} . a_{ijk}$$

$$C.NS_k - P_k . \delta_k \leq 0$$

$$\sum \delta_k \leq SH$$

where P_k = the maximum value that $C.NJ_k$ can take

δ_k = 0 or 1

When δ_k = 1 the value of $C_k.NS_k$ can be any value up to P_k.

That is $C.NS_k \leqslant P_k$.

When δ_k = 0 the value of $C_k.NS_k$ can only be zero since the constraint applies. While a programme is available to handle the problem as formulated here, it was not used due to the high cost of such a run. Such a run may subsequently be applied should a suitable contract be forthcoming.

The resulting linear programming model was intended as a planning model[16] rather than as an operating model. Thus, the model does not produce a sequence of voyage assignments for each ship; it does produce the number of voyages to be made by each ship in a given time period. Hence, the results indicate basic strategy and could provide inputs to a vessel scheduling model.

---

16. The study objective was to develop a methodology for deriving a time staged transport investment programme.

The size of the linear programming problem can be described in terms of the number of rows forming the set of constraints and the number of variables.

The maximum number of rows associated with each constraint type can be calculated from the expression :-

$$3N(N-1) + SH + 2N = 3N^2 - N + SH$$

the formulation of which is given in table H. 7.

CONSTRAINT	MAXIMUM NUMBER OF CONSTRAINTS
$\sum\limits_{k \text{ all } (i,j)} NS_k \geq \frac{365}{T_{ij}}$	$= N(N-1)$ links
$C_k \cdot NS_k \geq a_{ijk}$	$= N(N-1)$ arcs
$\sum\limits_{k \text{ all } (i,j)} a_{ijk} = a_{ij}$	$= N(N-1)$ arcs
$NS_k^{(A)} / NS_{kmax} \leq SH^{(A)}$	$= SH^{(A)}$ ships
$\sum a_{ij}^{(A)} \leq P_i^{(A)}$	$=$ N ports
$\mu_{kA} \; NS_k^{(A)} \leq S_i^{(A)}$	$=$ N ports
TOTAL MAXIMUM NUMBER OF ROWS $(3N^2 - N + SH)$	

TABLE I.7

The number of variables is determined by the form of the objective function which is given as :-

$$\sum_{\text{All } i,j \text{ all } k} [a_{ijk} \cdot v_{ijk}] \quad - \quad \left[(CA+MX).SH + \sum_{\text{All } k.} NS_k \cdot V_k \right]$$

In general, the algorithm will identify

$$\sum_{n=2}^{N} {}^{N}C_n \qquad \text{groups of ports}$$

and for each group will select a minimum cost route satisfying journey time (distance) and capacity constraints. That is :-

$$NS_k \leq \sum_{n=2}^{N} {}^{N}C_n$$

To each route "k" with n ports can be allocated the flows (a_{ijk}), the number of assignments being equal to n(n-1). Hence, the number of variables can be given by the expression :-

$$\sum_{n=2}^{N} {}^{N}C_n \left[1 + \sum_{n=2}^{N} n(n-1) \right] \qquad \text{where}$$

N = the total number of ports in the region.

In a 5 port region there would therefore be routes and allocations as derived from table I.8.

n	$2({}^{N}C_n)$	n(n-1)	${}^{N}C_n \left[n(n-1) \right]$
2	10	2	20
3	10	6	60
4	5	12	60
5	1	20	20
TOTAL ROUTES 26		TOTAL ALLOCATIONS 160	

TABLE I.8

In the light of these results, further discussions were held with the Booker Shipping Line which revealed that each year's shipping routes and related schedules are selected by "seat of the pants" methods, the following factors being uppermost in the minds of the decision makers :-

- The cost of ship operation over alternative routes
- The estimated traffic for the coming year
- Their estimated share of this traffic
- Ship capacity
- The time spent in each port
- The nature of the traffic (e.g. perishable commodities)
- The home port of the ships*
- The time at which the ship must be in the home port* (a factor governed by those who man the ships).

The effect of the asterisked factors, which were not included in the route generation algorithm, is to further reduce the number from which an optimal pattern of routes can subsequently be selected. The following additional constraints would apply :-

- the number of port groups must be limited to those groups which include the home port of the ships.
- the journey time of the ship must be limited to 6 days if 1 day in every 7 is to be spent in port. Alternatively, two journeys of either 5 & 1; 4 & 2; or 3 & 3 days could be contemplated if adequate ship capacity was available. Similar considerations apply to longer periods of absence from the home port.

These constraints have a significant effect on the size of the problem. This is because there are now only :-

$$\sum_{n=1}^{N} \sum_{\substack{h=1 \\ n-h < N-H}}^{n} {}^{H}C_{h} \left({}^{(N-H)}C_{n-h} \right)$$ [17]

groups of ports in any region containing H home ports where

n = the number of ports in a group of ports

N = the total number of ports in the region

H = the number of home ports

h = the number of home ports in the group of "n" ports.

As there will be a minimum cost route associated with each group of ports then the maximum number of variables is as given in table I.9 for the case with one home port in a region containing 5 ports. (H = h = 1, N = 5)

n	2 (Groups of Ports with one Home Port)	n(n-1)	ALLOCATIONS
2	4	2	8
3	6	6	36
4	4	12	48
5	1	20	20
TOTAL ROUTES	15	TOTAL ALLOCATIONS	112

TABLE I.9

17. A proof of this expression is given in appendix I.

$^{H}C_{h}$ is the number of ways of choosing h home ports from H home ports.

$^{N-H}C_{n-h}$ is the number of ways of choosing (n-h) non-home ports from a total of (N-H) non-home ports.

These results are verified by the output obtained from the route generation algorithm which is given in table I.5. When journey time constraints are introduced, only 7 routes out of a maximum possible number of 15 are left when port 2 is selected as a home port in the 5 port problem. Four of the 7 routes consist of 2 port routes while the other 3 routes contained 3 ports. This reduces the number of variables in the 5 port problem from 244 to 66 as illustrated in table I 10.

ONE HOME PORT IS ASSUMED				
n	2 x Groups of "n" Ports		ALLOCATIONS	
	Without Constraint	With Constraint		
2	8	8	16	16
3	12	6	72	36
4	8	0	96	0
5	2	0	40	0
TOTALS	30*	14+	224*	52+

TABLE I.10

* Total Variables without Time Constraints = 254

+ Total Number of Variables with Constraints = 66

Within Carifta the West Indies Shipping Service operate two ships[18] based on Trinidad; the Booker Line has two ships[19] based on Georgetown, Guyana while the schooner operators are understood to operate largely out of Barbados and Antigua. The existing Regional Shipping Commission[20] is only responsible for the first activity.

Hence there would be one home port from which the Federal ships would serve eleven ports. The total number of rows associated with such a problem equals 354 from the equation :

$3N(N-1) + SH + 2N$ where $N = 11$ and $SH = 2$

---

18. "The Federal Maple" and "The Federal Palm".
19. "The Booker Trojan" and "The Booker Talisman".
20. The Transport & Allied Services Commission is expected to replace this body according to a statement made by Mr. Lightbourne, Minister of Trade & Industry in Jamaica at a meeting of the West India Committee in London on 26th September 1969.

The total number of variables equals 34303 - derived in table I.11.

n	n(n-1)	$2\left[{}^{10}C_{n-1}\right]$	TOTAL ALLOCATIONS
2	2	10	20
3	6	45	270
4	12	120	1440
5	20	210	4200
6	30	252	7560
7	42	210	8820
8	56	120	6720
9	72	45	3240
10	90	10	900
11	110	1	110
		1023	33280

TABLE I.11

While these numbers are within the limitations of the Ophelie linear programming package (used with a CDC6600), table H.10 suggests that the number could well be nearer 10,000 when the asterisked constraints are considered.

4.3 A Reconsideration of the Port Constraints

The use of these constraints is intended to identify those ports that affect the efficiency of the transport system and those that do not. Thus, more detailed models (United Nations, 1969) may be built to describe the operations of ports concerned, should this be necessary. Where the ports included in the transport model accept large numbers of ships from outside the region which use the same berths as intra-regional shipping the problem of defining a port's handling capacity could be difficult. Such a figure could only be determined after consultation with the port authority concerned to identify the priorities attached to different categories of shipping. For example, in the port of Casablanca (United Nations, 1969) the following rules are applied :

First priority : passenger and tourist ships

Second priority : ships carrying citrus and vegetable exports, and liner ships

Third priority : other ships

The main point to make here is that such constraints have been used to describe port capacities.[21] In the Caribbean, some ports are used for both inter and intra-regional shipping. The affected material balance equations are as given below :-

$$\sum a_{ij}^{(A)} \leq \sum P_i^{(A)} \qquad \text{and} \sum a_{ij}^{(A)} \leq \sum P_j^{(A)}$$

$$\sum \mu_{kA} \,.\, NS_k \leq S_i^{(A)} \qquad \text{and} \sum \mu_{kA} \; NS_k^{(A)} \leq S_j^{(A)}$$

Now $P_i^{(A)}$ = the cargo handling capacity, in tons, of the origin port "i" in the time period described by the model.

$P_j^{(A)}$ = the cargo handling capacity, in tons, of the destination port "j" in the time period described by the model.

$S_i^{(A)}$ = the ship-docking capacity, in number of ships of type A, of the origin port "i" over the time period described by the model.

$S_j^{(A)}$ = the ship-docking capacity, in numbers of ships of type A, of destination port "j", over the time period described by the model.

Extensions to the intra-regional transport model could be made to incorporate the use of the region's ports by ships from outside the region, in the following way.

Now an island imports a total volume of goods given by :-

$\sum a_{ijk} + \sum a_{ijk}'$ where the first term refers to those imports purchased from intra-regional sources and the second term refers to those imports purchased from countries outside the region.

Where P_i[22] can be defined in terms related to specific ships where :-

---

21. See Whiton, J. C., Some constraints on linear programming models", Naval Logistics Research Quarterly, Date, Vol. No., Page. The work referred to in this article was undertaken at the Research Analysis Corporation, McLean, Virginia.

22. Sub-division of P_i will almost certainly be required for cargo handling facilities are related to the following general categories of cargo : dry bulk, liquid, general and containerised cargo. (Appendix B).

$P_i^{(A)}$ is related to ship type A

$P_i^{(B)}$ is related to ship type B, which might operate outside the region, then the constraint equations become :-

$$\sum_{\text{All } i} a_{ijk} \leqslant P_j^{(A)} \quad \text{and} \quad \sum_{\text{All } i} a_{ijk'} \leqslant P_j^{(B)}$$

or where A $\equiv$ B then

$$\sum a_{ijk} + \sum a_{ijk'} \leq P_j^{(A)}$$

The port-docking capacities for particular ship types are similarly affected. That is, they become

$$\sum \mu_{kA} \cdot NS_k^{(A)} \leqslant S_i^{(A)} \quad \text{and} \quad \sum \mu_{kB} \cdot NS_k^{(B)} \leqslant S_j^{(B)}$$

where $\sum NS_k^{(A)}$ refer to the number of visits made by intra-regional shipping, as determined by the transport model, and $NS_k^{(B)}$ refer to the exogenously estimated number of visits made by ships to the j^{th} port in the time period considered.

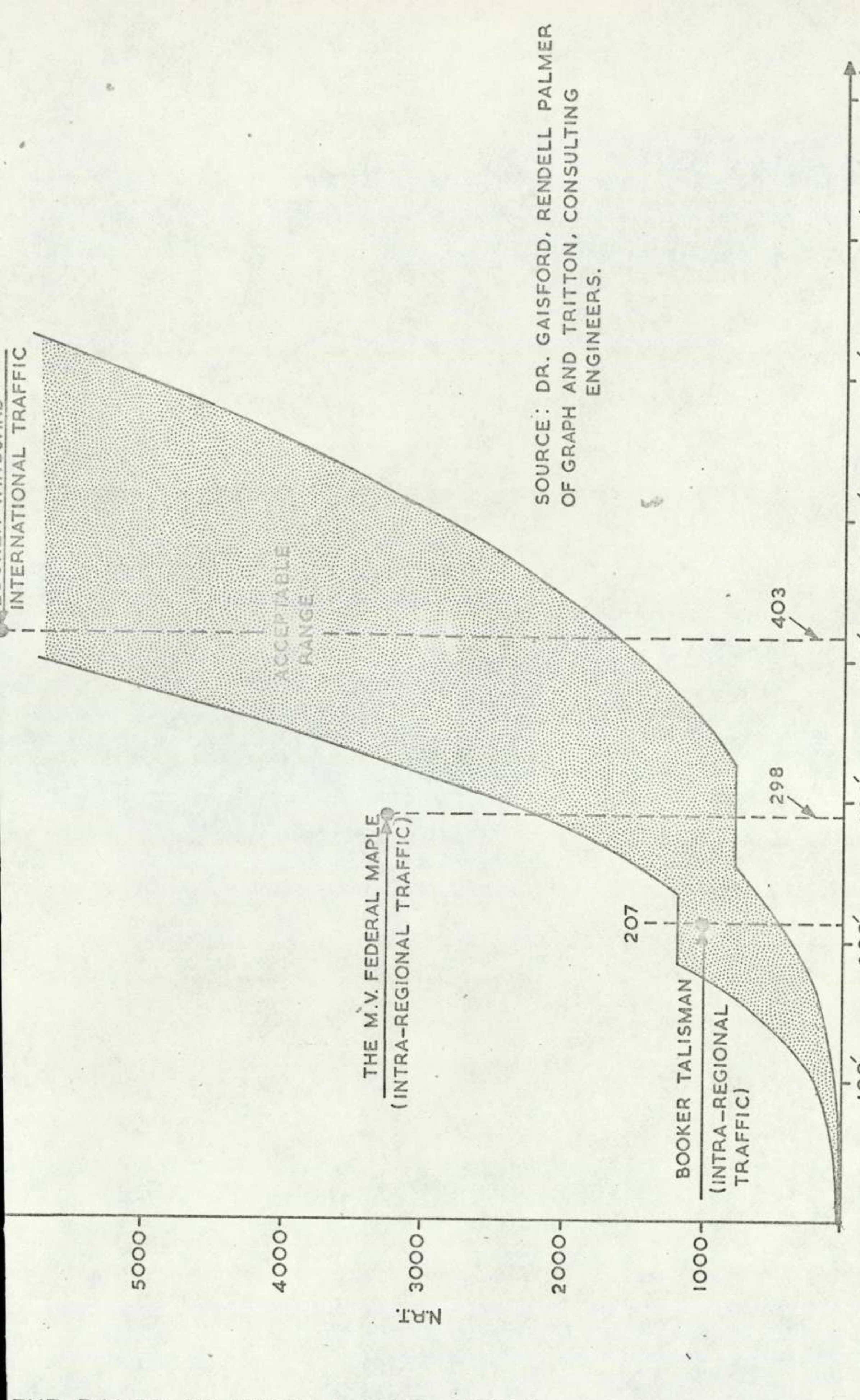
These port constraints, while they may prove adequate in describing some ports, may be inadequate for others. Dr. Gainford (1971) has suggested that port docking capacity is related to ship length, not numbers of ships (although they are inter-related). Figure I.1 illustrates ship length as a function of tonnage and suggests that the length of ships serving ports only within CARIFTA varies between 207' and 298' while those ports serving intra-regional and transshipment traffic may receive vessels varying in length from 207' to 403'. Thus, port constraints may be modified as follows :-

$$NS_k^{(A)} \cdot K^{(A)} \leqslant L_i$$

where

$NS_k . K$ = the length of quay required by vessel (A) in one year when using route k.

L_i = the length of quay available to vessels in one year.



THE RANGE OF VALUES OVER WHICH THE RATIO OF LENGTH TO N.R.T. IS ACCEPTED WITHOUT FURTHER EXAMINATION

Fig. I .I.

Other uses of the model can be envisaged, some of which are summarised below.

- If the existing transport system is incapable of carrying the demand for movement, but the ships must, for policy reasons, maintain their existing routes, then the model could be used to determine both the ship capacity and the routes to be followed by tne new ship(s) to minimise the cost of transport provision and operation while satisfying the demand for movement.

- The model could be run for different seasons of the year to identify the number of vessels that will be needed for the season, at which date to withdraw vessels and the route structure to be followed.

- Changing water levels resulting from dredging or other port improvements can appreciably alter a ships capacity in certain ports. Appropriate changes in the $S_i^{(A)}$ values will simulate such changes. Tides, however, are of negligible importance in the Caribbean.

- A by-product of the linear programming solution is the set of simplex multipliers for the rows.[25] These give the rate of change of the objective function with respect to each of the right-hand-side values. Thus, they represent :-

    - the change in the cost of transport operation per ship-journey completed over arc (i, j).
    - the marginal cost of unit transport capacity provided. (Second, third and fourth constraints.)
    - the marginal cost of handling additional units of cargo (fifth constraint)
    - the marginal cost of docking capacity at a port per ship-journey. (Sixth constraint.)

  Thus, these shadow-prices are particularly useful for pricing.

---

25. See section 1.2 of appendix F, where each row category is defined in the order in which they are discussed above.

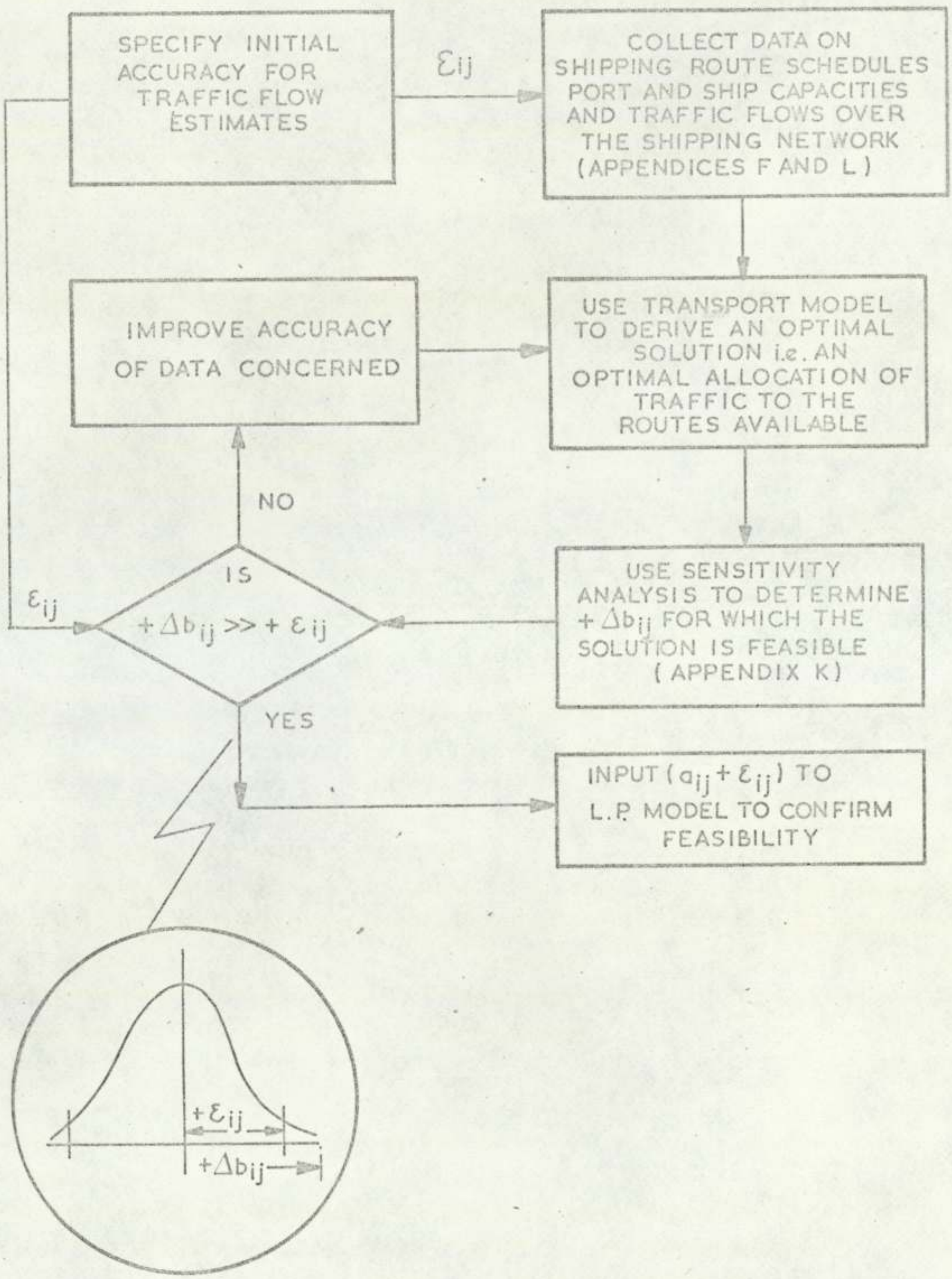
- Another by-product of the model is the set of relative cost coefficients assigned to each of the non-basic variables in the problem. Some of these refer to the routes not in the solution, and hence they indicate the desirability of each such route. This is useful in suggesting alternatives to the optimal solution.

- Finally, the model may be used for data collection purposes. Data on the shipping system may be input to the transport model in terms of the routes, ship and port capacities; the number of ship-journeys per year would be set at the number which occur in practice. As the system is known to be feasible, then if a feasible solution results when estimates of traffic handled are input to the model, the estimates must be reasonable approximations. The approach is illustrated in figure I.2.

The result of such a sensitivity analysis, conducted on a solution[26] to the 5 port 24 route problem is given in table I.12.

---

26. Solution X2; for author's reference only.



DATA COLLECTION ACTIVITIES

Fig. I.2.

Trade Flow	Value	Acceptable Limits	Acceptable Variation
a_{12}	4008	0 to 5969	- 100% + 48%
a_{13}	5200	0 to 13710	- 100% + 164%
a_{14}	3400	0 to 3642	- 100% + 7%
a_{15}	865	0 to 10023	- 100% + 1058%
a_{21}	3200	2639 to 3570	- 20% + 11.6%
a_{23}	29000	28169 to 29370	- 2.8% + 1.26%
a_{24}	45760	831 to 177204	- 98% + 287%
a_{25}	8600	7769 to 8970	- 9.7% + 4.3%
a_{31}	11	0 to 381	- 100% + 3370%
a_{32}	5974	0 to 17400	- 100% + 192%
a_{34}	10539	0 to 23026	- 100% + 119%
a_{35}	0	0 to 370	- 100% + ∞
a_{41}	19655	18824 to 20025	- 4.2% + 1.88%
a_{42}	201360	69916 to 205088	- 65% + 2.36%
a_{43}	14000	13169 to 14370	- 6% + 2.64%
a_{45}	3642	3400 to 4473	- 6.6% + 23%
a_{51}	7	0 to 377	- 100% + 5300%
a_{52}	1201	830 to 9431	- 31% + 685%
a_{53}	1475	0 to 9985	- 100% + 580%
a_{54}	31	0 to 8541	- 100% + 27500%

Sensitivity Analysis, Table 1.12

If the accuracy of the data initially collected was ± 10%, then either the accuracy of those flows which upset the optimality of the solution should be improved, or the effect of errors ± 10% on the solution should be investigated.

APPENDIX J

The selection of groups of ports which contain a home port.[1]

The CARIFTA region contains a number of islands. Each island has a port which is served by one or more ships. These ships use predetermined routes which always include their home port. To determine all the possible routes which might be used, means firstly, identifying all the possible groups of ports which include one or more home ports. The approach is as follows :

Let n = the number of ports in a group of ports

N = the total number of ports in the region

H = the maximum number of home ports

h = the number of home ports selected for inclusion in the group of "n" ports.

1. If $n = 1$ there are only ${}^{H}C_{1}$ ways of choosing n from H home ports.

2. If $n = 2$ either one or two home ports can be chosen for inclusion in the 2 port group. If $h = 2$ there are ${}^{H}C_{2}$ combinations of two home ports when both ports must be home ports.

If $h = 1$ (there being ${}^{H}C_{1}$ ways of choosing one home port from H home ports) then a non-home-port must be chosen to go with it, otherwise the h - 2 case would recur. The number of ways of choosing a non-home port is ${}^{N-H}C_{1}$. Therefore, the total number of two port groups with one home port is $\left({}^{H}C_{1}\right).\left({}^{N-H}C_{1}\right)$.

The total number of two port groups which include all combinations of one and two home ports is therefore equal to $({}^{H}C_{1}.\left[{}^{N-H}C_{1}\right] + {}^{H}C_{2})$.

3. If $n = 3$ one, two or three home ports can be selected for inclusion in the $n = 3$ port group.

If only one home port ($h = 1$) is to be included in the three port group then $n-1 = 2$ others must be chosen to make up the number. That is, one home port can be chosen in ${}^{H}C_{1}$ ways; the two others in ${}^{N-H}C_{2}$ ways.

---

1. This appendix was written by J. Walker and the author.

If two home ports are chosen (h = 2) then one other (n-2 = 1) must be chosen to make up the number. That is, two home ports can be chosen in ${}^{H}C_2$ ways; the other one in ${}^{N-H}C_1$ ways.

If three home ports are chosen (h = 3) then as (n-3) = 0 no others need to be chosen to make up the n = 3 ports. That is, three home ports can be selected in ${}^{H}C_3$ ways.

The total number of 3 port groups which incorporate all the combinations of one, two and/or three home ports is equal to:-

$${}^{H}C_1 . {}^{N-H}C_2 + {}^{H}C_2 \, {}^{N-H}C_1 + {}^{H}C_3$$

K. In general, if n = K then 1, 2, 3 .... K home ports can be chosen, where $K \leq H$ must obviously apply.

If only one home port must be chosen: i. e. one home port can be chosen in ${}^{H}C_1$ ways; (K-1) others in ${}^{N-H}C_{K-1}$ ways.

If only two home ports are to be chosen then (K-2) other ports must be chosen; i. e. two home ports can be chosen in ${}^{H}C_2$ ways, (K-2) others in ${}^{N-H}C_{K-2}$ ways.

If K home ports are to be chosen, then no others have to be chosen; i. e. K home ports can be selected in ${}^{H}C_K$ ways. Therefore, the total number of port groups with n = K ports equals:-

$$\left[\left({}^{H}C_1\right) . {}^{N-H}C_{K-1} + \left({}^{H}C_2\right) {}^{N-H}C_{K-2} + \left({}^{H}C_3\right) . {}^{N-H}C_{K-3} . \ldots\ldots + {}^{H}C_K \right] \quad *$$

This expression holds if home ports that exist are chosen i. e. $h \leq n \leq H$ and that no more than N-H others are chosen i. e. $n-h \leq N-H$

The above series * automatically truncates itself at both ends. If n>H then zero terms will occur at the right hand tail of the expression because ${}^{H}C_K$ is zero for K>H. If n-h > N-H then zeros occur at the left hand tail. If n>H and n-h>N-H then there will be zero terms at both ends of the expression. Hence the expression:-

$$\left[\sum_{\substack{k=1 \\ n-h \leq N-H}}^{n} {}^{H}C_h . {}^{N-H}C_{n-h} \right]$$

can be used to determine the number of groups of "n" ports which include "h" home ports. If the groups of ports obtained for n=1, 2...N ports are summed, then the answer will state the maximum number of groups of n=1, 2...N ports which include all combinations of h=1, 2......H home ports.

APPENDIX K

1. An Application of Parametric Linear Programming

The data given in Appendix I was used to apply the parametric approach to transport investment planning as described in section 3.2.2.2. The initial values of trade assumed to flow between each node in the 5 port region assumed are given below.

PORTS	1	2	3	4	5
1	-	4008	4862 + θ.250	3156 + θ170	865
2	2806	-	23972 + θ1500	45760	8266 + θ430
3	11	5974	-	10539	0
4	19655	201360	12397 + θ630	-	3642
5	7	1201	1475	31	-

INTER-ISLAND TRADE FLOWS. Table K.1

For simplicity, only a few flows were assumed to increase over time. It can be seen from the above that the general flow equation is :-

$$a_{ij}(\theta) = a_{ij} + (0.05\ a_{ij})\theta = a_{ij}(1 + \theta)$$

The values of $(0.05\ a_{ij})$ given in the above table are approximate and no particular significance should be attached to this fact.

The ship docking and shipping capacities used in deriving a solution to the programme were :-

CONSTRAINT	NOTATION	VALUE[1]
Ship docking capacity, port 1	S_1	30
Ship docking capacity, port 2	S_2	240
Ship docking capacity, port 3	S_3	70
Ship docking capacity, port 4	S_4	240
Ship docking capacity, port 5	S_5	30
Number of Ships within Carifta	SH	4
Journey frequency	$365/T_{ij}$	22

Transport System Constraints. Table K. 2

For purposes of illustration, the changes to the optimal basis as θ increased with the data describing the existing transport system were as listed below.

THETA	Z	VARIABLE IN	VARIABLE OUT
0	1.32356	-	-
0.3014	1.32611	ARC3523 = 58*	NS_3 = 90
"	"	a_{4324} = 163	a_{2523} = 214
1.2410	1.33705	a_{4314} = 168	a_{1224} = 142
1.3777	1.33865	a_{4319} = 259	NS_1 = 88
1.4235	1.33924	NS_3 = 115	ARC1416* = 14
1.8469	1.33488	ARC5219 = 43*	NS_{18} = 130
2.1445	1.34985	a_{2523} = 214	a_{4324} = 163
"	"	a_{2519} = 210	ARC3523* = 58
3.0801	1.3655	LIMIT OF FEASIBILITY	
* SLACK VARIABLES			

Basis Changes. Table K. 3

1. This base year case assumes that no investment in port or shipping has been made.

The meaning of the incoming and outgoing variables is explained in table K.4.

VARIABLE	MEANING
a_{4324}	That part of a_{43} assigned to route NS_{24}.
NS_3	Route 3, number of ship-journeys.
S_3	The docking capacity of Port 3.

Table K.4

These results are illustrated in figure K.1. With $\theta = 1.432$, it can be seen that a change in the transport network becomes a necessity, if the envisaged trade flows are to be moved within the time period considered by the transport system. Before such a change, a reallocation becomes necessary if the demand for movement is to be satisfied at minimum cost. Thus, the reaction of shippers to a re-routing of their commodities will need to be determined to identify whether the re-allocation identified by the model will take place, or whether an alternative transport mode would be selected. If mode changing takes place when the frequency of service drops below some determined level of service such an activity could be replicated through the iteration of the inter-related models.

As previously stated a change in route structure occurs as θ increases. These changes are given in table K.5.

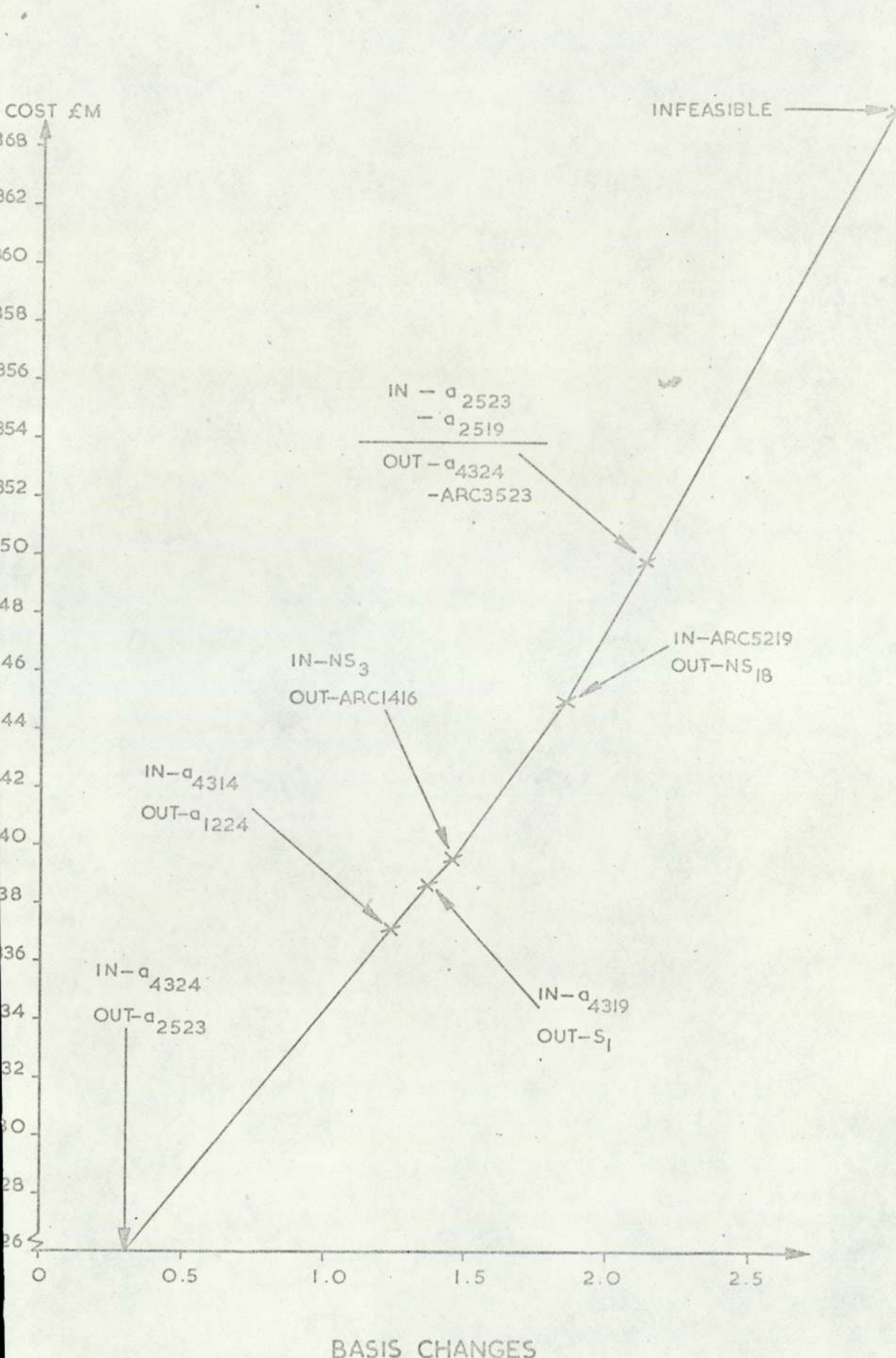

COST £M
INFEASIBLE
IN – a 2523
– a 2519
OUT – a 4324
-ARC3523
IN-ARC5219
OUT-NS 18
IN-NS 3
OUT-ARC1416
IN-a 4314
OUT-a 1224
IN-a 4324
OUT-a 2523
IN-a 4319
OUT-S 1
0
0.5
1.0
1.5
2.0
2.5
BASIS CHANGES

Fig.K.1.

NOTATION	θ = 0	INCREASE IN	θ = 3.08
ROUTE	INITIAL	TRADE FLOW from θ = 0 to 3.08	FINAL
NS_3	-		0.28
NS_5	5.97		5.97
NS_6	173.43		163.39
NS_8	14.0		14.31
NS_9	3.16		0
NS_{12}	1.47		4.01
NS_{14}	0		0.07
NS_{16}	3.64		3.64
NS_{17}	23.03		27.64
NS_{18}	1.2		-
NS_{19}	0		4.36
NS_{24}	22.0		22.0
a_{121}	0		0
a_{1212}	1473		4008
a_{1213}	0	0	0
a_{1221}	0		0
a_{1226}	2535		-
a_{1324}	5200	770	5870
a_{143}	0		282
a_{1416}	3400	523.6	3642
a_{1524}	865	0	865

Basis Changes. Table K.5

ROUTE	INITIAL		FINAL
a_{211}	0		0
a_{2111}	0	0	0
a_{2124}	3200		3200
a_{235}	5974		5974
a_{2317}	23026		27646
a_{2318}	0	4620	0
a_{2321}	0		0
a_{246}	44287		40191
a_{2412}	1473	0	4008
a_{2419}	0		1561
a_{259}	3157		0
a_{2513}	0		0
a_{2518}	1201		0
a_{2519}	-	1324.4	2797
a_{2523}	0		0
a_{2524}	4242		7127
a_{3124}	11	0	11
a_{325}	5974	0	5974
a_{3424}	10539	0	10539
a_{3523}	0	0	0
a_{413}	0		281.6
a_{4112}	1473	0	4008
a_{4114}	0		68.4
a_{4116}	3642		3642

4.5 (continued))

ROUTE	INITIAL		FINAL
a_{4122}	0		0
a_{4124}	14540		11655
a_{426}	173427		163387
a_{4217}	23026	0	27646
a_{4224}	4907		10327
a_{438}	14000		14311.5
a_{4319}	-	1940.4	1560.6
a_{4323}	0		0
a_{4516}	3642	0	3642
a_{5115}	0		0
a_{5124}	7	0	7
a_{527}	0		0
a_{5218}	1201		0
a_{5219}	0		1201
a_{5324}	1475	0	1475
a_{5424}	31	0	31

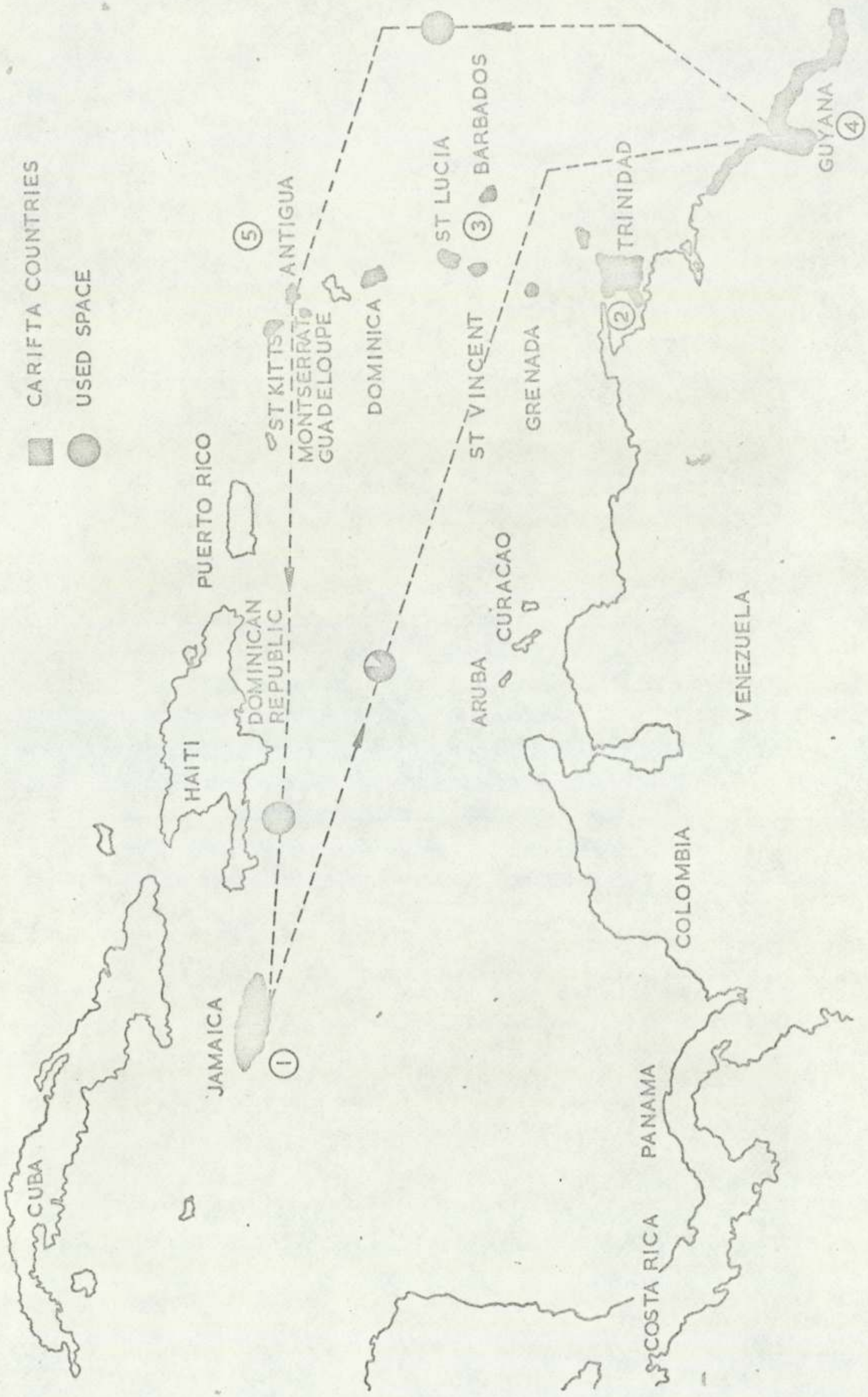
Basis Changes. Table K.5 (continued)

Table K.5 shows that route changes rarely occur but that re-allocation of cargo occurs frequently in maintaining optimality. As θ increases, the route structure increases incrementally. In practice, the solution values of the route structure selected by a shipping authority would be those which would satisfy the demand for transport at the end of the year. For example, if in the above case[2], θ = 1.424 at the end of year 1 and θ = 3.08 at the end of year 2, the although for example, NS19 changes from θ at year 1 to 4.36 at year 2, the shipping authority would publish their shipping service over route NS19 as 4.36 journeys. In practice, a much higher integer value would be quoted. Where changes of the optimal basis occur when the value of θ is equivalent to the mid-year forecast of intra-regional trade, either the routing pattern would be changed if, with the maximum values of trade forecast in that year, the system was still feasible, or the system corresponding to the optimal basis in the second year would be chosen.

The route network at the start of the period (θ equal to zero) is shown in figureK.2. Route 16, which is 1451 has a small amount of slack on arc 14. As trade flows a_{13}, a_{14}, a_{23}, a_{25}, and a_{43} are assumed to increase over time, clearly trade flow a_{14} will affect route 16. As a_{14} increases the slack on arc 14 is reduced to zero as shown in figureK.3. Once a_{14} increases beyond the point at which zero slack occurred, a new route 141, (defined as route 3) enters the network of routes and carried any further increase in the a_{14} trade flow. The return journey on this route (over arc 4.1) is also fully utilised (that is, the ship plying over route 141 is fully utilised over arcs 1,4 and 4,1) as part of the trade flow a_{41} is transferred to it from route 24, which visits all the ports within the defined region. The introduction of route 3 occurs because the marginal cost of its introduction is less than the cost of maintaining the allocation of trade to route 16, where extra journeys would be required over this route if the demand for trade is to be satisfied. In fact, if this re-allocation did not occur, slacks on arcs 4,5 and 5,1 could result.

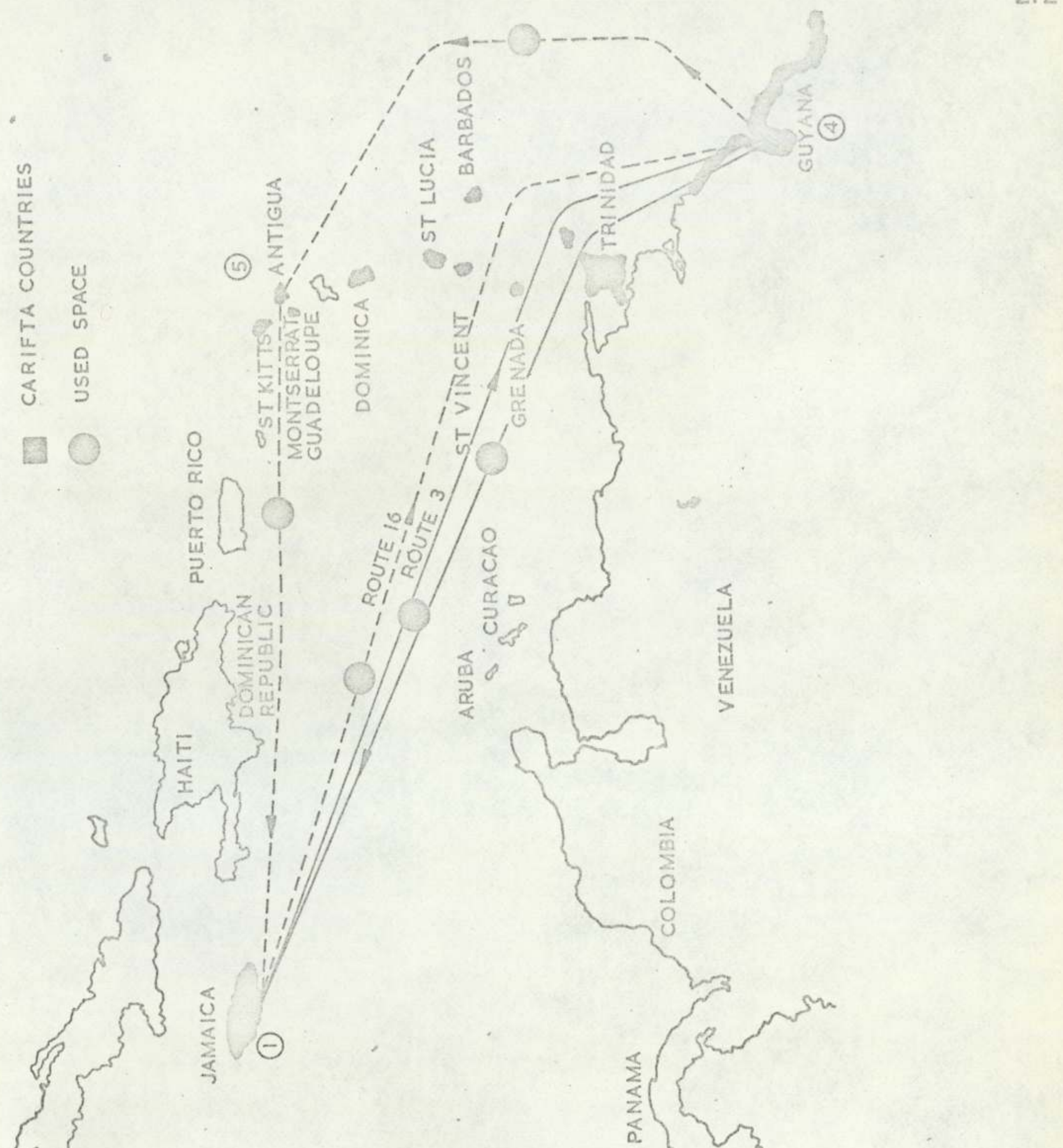
---

2. In this case, the value of θ is the number of years since the start of the period.



SHIPPING ROUTE 16-YEAR O (NO INVESTMENT)

Fig. K. 2.



INTRA-CARIFTA SHIPPING ROUTES–YEAR 3 (NO INVESTMENT)
(ONLY ROUTE 3 AND ROUTE 16 ARE SHOWN)

Fig.K.3.

In addition to running case 1 as described above, other cases were run where a variety of port improvements were postulated. These alternatives are given in table K.6.

Constraint	Notation	Case	Alternative Cases		
		1	2	3	4
Ship docking capacity	ΔS_1	$S_1 = 30$	-	+ 10	+ 10
" " "	ΔS_2	$S_2 = 240$	-	-	-
" " "	ΔS_3	$S_3 = 70$	+ 10	+ 10	-
" " "	ΔS_4	$S_4 = 240$	-	-	-
" " "	ΔS_5	$S_5 = 30$	-	-	+ 10

Alternative Improvements. Table K.6.

The results for each alternative are as given in tables K.7 to K.9.

THETA	Z	Variable In	Variable Out
0	1.32356	-	-
1.424	1.3356	NS_3	ARC 1416
4.996	1.3674	ARC 3523	S_3(SLACK)
"	"	a_{4324}	a_{2523}
5.284	1.3709	a_{4319}	S_1(SLACK)
5.488	1.3736	a_{2523}	a_{4324}
"	"	a_{2519}	ARC 3523
5.753	1.377	ARC 5219	NS_{18}
5.797	1.378	-	-

Results for Case 2. Table K.7

THETA	Z	Variable In	Variable Out
0	1.32356	-	-
1.4235	1.3356	a_{2519}	ARC 1416
"	"	a_{143}	a_{4519}
4.996	1.3674	a_{4322}	S_3 SLACK
"	"	a_{4319}	a_{4522}
"	"	a_{4324}	a_{2519}
5.4121	1.3724	NS_{14}	a_{1224}
7.948	1.403	a_{1315}	ARC 1524
"	"	a_{1313}	ARC 5315
"	"	a_{132}	ARC 1513
"	"	ARC 5113	ARC 132
"		SLACK TIME 54	S_3 SLACK
8.375	1.4088	a_{3223}	NS_{18}
"	"	NS_{13}	ARC 3523
9.659	1.4284	ARC 5219	S_1 SLACK
10.163	1.437	ARC 5223	a_{5223}
10.88	1.453	a_{2324}	NS_9
"	"	a_{2519}	a_{4324}
10.893	1.453	-	-

Results for Case 3. Table K.8

THETA	Z	Variable In	Variable Out
0	1.3188	-	-
0.14453	1.3202	a_{4112}	a_{2518}
1.42235	1.33474	a_{3516}	ARC 1416
"	"	a_{2518}	NS_{18}
"	"	a_{413}	a_{3518}
1.7305	1.338	a_{4114}	a_{1224}
3.365	1.357	a_{2521}	ARC 348
"	"	a_{2524}	a_{2121}
4.817	1.3797	a_{1315}	ARC 1524
		a_{1313}	ARC 5315
		a_{154}	ARC 1513
		a_{132}	ARC 154
		ARC 5223	ARC 132
		ARC 257	a_{5223}
		ARC 5219	a_{527}
8.889	1.444	a_{2121}	a_{2521}
		ARC 132	a_{132}
		ARC 5315	a_{1315}
		ARC 1524	a_{259}
9.330	1.4507	a_{3518}	S_5 SLACK
		a_{2311}	ARC 3111
		a_{3211}	a_{2518}
		a_{3221}	a_{2111}
		a_{2324}	a_{2121}
9.622	1.4567	a_{2519}	a_{4324}
10.893	1.4825	-	-

Results for Case 4. Table K.9

FORECASTING METHODS AND SUPPORTING DATA

1. Introduction

There are several methods of forecasting trade flows between regions. The objective of these methods is "to show, in a quantifiable manner, the structural relationships between regions, so that the effect of an autonomous shock may be traced to, and through, the "n" regions under consideration"(Tiebout, 1968).

The original approach due to Isard, (1953) was developed to illustrate, not only the inter-industry relationships by region, but the inter-industrial and inter-regional relationships of a country. The framework of such a multi-regional model was discussed in section 4.2. of Appendix L.

"The transactions table of such a model shows, not only the sales of a given industry to all other industries in the region, but also the sales of that industry to all other industries in the other regions of the system" (Miernyk, 1967).

The conceptual framework of an open, static input-output model is given by Leontief, (1953). The accounting balance equation is given as:

$$X_i - \sum_{j=1}^{n} X_{ij} = Y_i \quad \text{where}$$

X_i = the total output of the i^{th} industry

X_{ij} = the demand by sector "j" for part of the output of the i^{th} sector

Y_i = the final demand for the output of the i^{th} sector

The structural equations are given by the production coefficients for each industry or sector

$$X_{ij} = a_{ij} \cdot X_j \qquad \text{for } i = 1,2 \ldots m;\ j = 1,2 \ldots\ldots m$$

where a_{ij} is the production coefficient indicating the amount of industry "i" needed to produce a unit of the output of industry "j".

These two equations yield:

$$X_i = \sum_{j=1}^{n} a_{ij} X_j + Y_i \quad \text{for } i = 1,2 \ldots\ldots m.$$

This system of equations may be solved for X if a bill of final demands $Y_1, Y_2 \ldots\ldots\ldots Y_m$ is known, from the equation:

$$X = (I - a)^{-1} Y \quad \text{where I is the unit matrix and } a \equiv \left[a_{ij}\right] \quad \text{for all } i, j.$$

Subsequent refinements have been made which add another dimension to national input-output models; namely, the regions are identified. The X_i become ${}_pX_i$ which represents the total output X of industry "i" in region p. The delivery of this output ${}_pX_i$ to all sectors and all regions can be described by the relationship:

$$ {}_pX_i - \sum_q \sum_j {}_{pq}X_{ij} = \sum_q {}_{pq}Y_i \quad \text{for } p, q = 1,2 \ldots n \text{ regions}; \quad i, j = 1,2 \ldots m \text{ sectors}$$

where ${}_{pq}X_{ij}$ = the delivery from industry "i" in region p to industry "j" in region q.

${}_pX_i$ = the total output of the commodity produced by industry "i" in region p

${}_{pq}Y_i$ = the final demand for industry "i" in region "q" met from region "p".

Assuming constant production coefficients, then the coefficient for a specific cell, say sector j, may be expressed as:

$$_{pq}a_{ij} = \frac{_{pq}X_{ij}}{_{q}X_{j}} = \frac{\text{the delivery of "i" in region "p" to "j" in region "q"}}{\text{the output of "j" in region "q"}}$$

Substituting technical input coefficients into the balance relation, the $_{p}X_{i}$ may be solved for the whole system of regions and industries (or sectors) from the equation

$$\left[{_{p}X_{i}} - \sum_{q=1}^{n} \sum_{j=1}^{m} {_{pq}a_{ij}} \left({_{q}X_{j}} \right) = \sum_{q} {_{pq}Y_{i}} \right]^{*}$$

The solution of equations for the required output of each industry in each region in terms of the bill of goods is determined from the inverse in the normal way.

In this form of model, the relationships for the production coefficients "$_{pq}a_{ij}$" assume that an industry in one region can be different from the same industry in another region. An alternative approach is to replace the coefficients for each industry in each region by two types of coefficients, one relating inputs to outputs, the other concerning regional coefficients.

Firstly, each region is assumed to have a separate input coefficient:

$$ {}_{q}a_{ij} = \frac{{}_{q}X_{ij}}{{}_{q}X_{j}} \quad \text{where} $$

${}_{q}X_{ij}$ = the input to the j^{th} industry in region "q" from the i^{th} industries in all regions

${}_{q}X_{j}$ = the output of the j^{th} industry in region "q"

Secondly, the regional coefficients define the proportion of the inputs of the i^{th} industry received by region "q" from region "p". That is:

$$ {}_{pq}t_{i} = \frac{{}_{pq}X_{i}}{{}_{q}R_{i}} \quad \text{where} $$

${}_{pq}X_{i}$ = the inputs to all industries in region "q" from industry "i" in region "p"

${}_{q}R_{i}$ = the total inputs from the type "i" industries imported by region "q" from all the regions

As ${}_{q}a_{ij}$ equals the inputs from the i^{th} industries in all regions to the j^{th} industry in region "q" per unit of output of the j^{th} industry in region q then of this ${}_{q}a_{ij}$, $({}_{q}a_{ij} \cdot {}_{pq}t_{i})$ units will be coming from region "p".

Once the values of ${}_{q}a_{ij}$ and ${}_{pq}t_{i}$ have been calculated, then the values of $({}_{q}a_{ij} \cdot {}_{pq}t_{i})$ may be input to the balance relations given below:

$$\left({}_{p}X_{i} - \sum_{q} \sum_{j} \left[{}_{q}a_{ij} \cdot {}_{pq}t_{i} \right] {}_{q}X_{j} = \sum_{q} {}_{pq}Y_{i} \right)^{1} \quad ; \text{ all } i, p.$$

A solution of the levels of regional outputs immediately follows.

Although there are a variety of input-output models they can be broadly classified into "pure" inter-regional models, "balanced" inter-regional models and "gravity" models.

2. Pure Inter-Regional Models

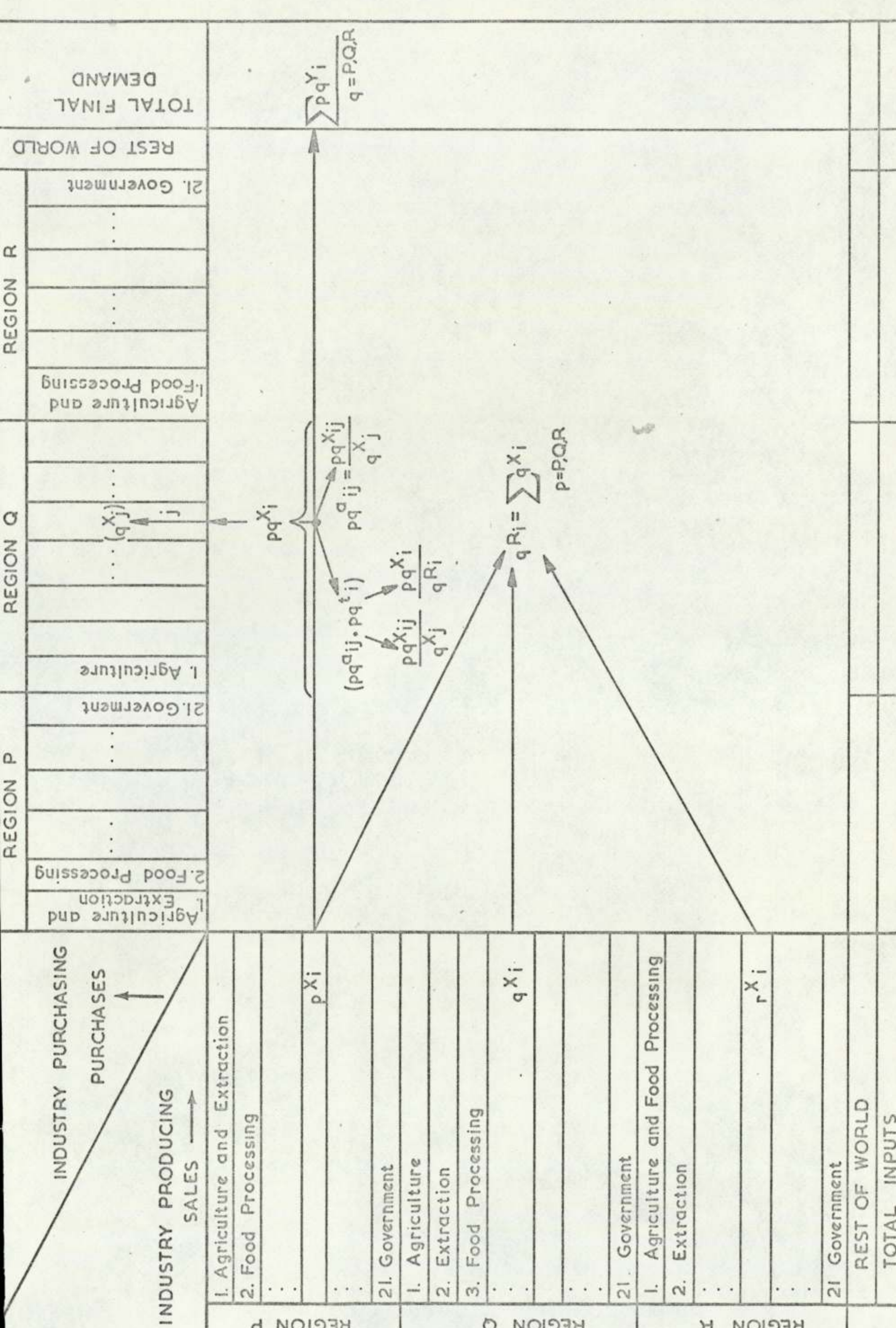
The pure inter-regional model has been particularly useful for determining national implication of regional projections for it is implemented "by aggregating a number of regional tables"(Miernyk, 1967).

"The transactions table of such a model shows, not only the sales of a given industry to all other industries in the region, but also the sales of that industry to all other industries in the other regions in the system"(Miernyk, 1967). Figure L.1 illustrates the format of a "pure" inter-regional transaction table. If the appropriate data could be acquired for such a model, "it would show how changes in final demand for the products of one region generate impulses that are transmitted to other regions" (Miernyk, 1967).

An example of a pure inter-regional model was developed by Isard and consists of a series of six input-output tables, one for

---

1. The description of this model is based on that given by Ghosh, A., Planning, Programming and Input - Output Models, Cambridge University Press, 1968, pages 116 and 117.



A PURE INTER-REGIONAL TRANSACTIONS TABLE.

Fig. L.1

each of the sub-basins of the Colorado River Basin[2] . "In this analysis, a separate regional input-output table was constructed for each of the six sub-basins. The sub-basin tables are linked together through import rows and export columns. That is, instead of the single import row and export column found in a national table, each of the sub-basin tables has two import rows and two export columns. One import row, in each of the sub-basin tables shows imports from other sub-basins in the Colorado River Basin and the remaining rows show imports from the "rest of the world". Similarly, there is a column showing exports from each sub-basin to all other sub-basins and a second column for exports outside the Colorado River Basin. Through this linkage it is possible to show how an exogenous change (a change in final demand) in any one sub-basin will affect the level of activity in other sub-basins. Although it is rather an awkward term, this is actually an inter-sub-regional model since it is primarily concerned with intra-regional interdependence. After the six tables had been constructed independently, the import rows and export columns were reconciled to make the six sub-basin tables internally consistent"(Miernyk, 1967).

Where imports and exports account for a substantial proportion of total transactions in an input-output model of a region, two basic model forms may be used. "For simplicity, these will be referred to as the "dog-leg" and "square" models. The square model is identical with the national input-output table of the kind illustrated in Figure L.2 ,While it might contain two or more important rows and a corresponding number of export columns, both imports and exports are highly aggregated in this type of system. In the dog-leg

---

2. This model was used by Professors W.H. Miernyk, B. Udis and Dr. Clyde Steward as the basis of a comprehensive study of economic growth in the Colorado River Basin conducted for the United States Public Health Service of the U.S. Department of Health. (Miernyk, 1967).

INDUSTRY PURCHASING (OUTPUTS) / (INPUTS) INDUSTRY PRODUCING	(1) A	(2) B	(3) C	(4) D	(5) E	(6) F	(7) GROSS INVENTORY ACCUMULATION	(8) EXPORTS TO FOREIGN COUNTRIES	(9) GOVERMENT PURCHASES	(10) GROSS PRIVATE CAPITAL FORMATION	(11) HOUSEHOLDS	(12) TOTAL GROSS OUTPUT
(1) INDUSTRY A	PROCESSING $\sum_{j=1}^{n} a_{ij} \ (x_j)$ SECTORS						FINAL DEMAND (Y)					X
(2) INDUSTRY B												
(3) INDUSTRY C												
(4) INDUSTRY D												
(5) INDUSTRY E												
(6) INDUSTRY F												
(7) GROSS INVENTORY DEPLETION (–)	PAYMENTS SECTORS											
(8) IMPORTS												
(9) PAYMENTS TO GOVERNMENT												
(10) DEPRECIATION ALLOWANCES												
(11) HOUSEHOLD												
(12) TOTAL GROSS OUTLAY												

A NATIONAL INPUT—OUTPUT TABLE

Fig L2

model, imports and exports are disaggregated by industry and sector. The basic transactions table of the region being analysed is set in the upper left-hand corner. This part of the table is similar to a national table except that it does not include any import row and an export column. Instead there is an export "table" appended to the right of the transactions table, and a similar import "table" appended below the transactions table. Such a table shows the inter-industry transactions within the region and also the detailed inter-industry transactions between this region and another region or "the rest of the world"(Miernyk, 1967).

"This type of transactions table is particularly useful for making a structural analysis. It shows in detail the sources of demand for goods and services produced in the region under study, and it shows in similar industrial detail where imports come from and the destination of exports. If one wishes to go beyond a detailed description of structural inter-relationships, however, not all of the detail in the dog-leg table can be employed. The only part of the table which is inverted to obtain a table of direct and indirect requirements per dollar of final demand is the processing or endogenous sector of the basic region's transactions table, and in practice the final demand columns are combined into a single final demand vector for analytical purposes. When this stage of the analysis is reached, the export and import "tables" are collapsed into a single row and a single column". (Miernyk, 1967).

3. Balanced Inter-Regional Models

3.1 An Outline of this Type of Model

"A balanced regional model is constructed by disaggregating a national input-output table into its component regions"(Miernyk, 1967) and is therefore particularly useful for determining regional implications of national projections. This type of model explicitly recognises for a given nation, an hierarchy of regions and commodities. "National commodities are those commodities whose production and consumption balance only within the nation as a whole. Regional commodities of the first order are those whose production and consumption balance within the nation as well as within each first order region. Regional commodities of the second order are those whose production and consumption balance, not only within the nation and each region of the first order, but also within each region of the second order"(Isard, 1960). By definition, no regional commodity is subject to inter-regional trade. Thus the balance equations for the economy as a whole are:

$$X_n = \sum_{l} a_{nl} \cdot X_l + \sum_{n} a_{nn} \cdot X_n + Y_n \quad \text{(National)}$$

$$X_l = \sum_{l} a_{ll} \cdot X_l + \sum_{n} a_{ln} \cdot X_n + Y_l \quad \text{(Regional First Order)*}$$

$$\text{Therefore } {}_pX_l = \sum a_{ll} \cdot {}_pX_l + \sum a_{ln} \cdot {}_pX_n + {}_pY_l \quad \text{(Second Order)}$$

since, for locally balanced commodities equation * holds for each region where the vectors are defined as follows :-

X_l = the total output of the regional commodities

Y_n = the final demand for national commodities

Y_l = the final demand for regional commodities

${}_pX_l$ = the production of X_l in region "p"

${}_pX_n$ = the production of X_n in region "p"

a = the input-output coefficients

Given the final demand items for the nation as a whole, the outputs of industries producing national commodities are determined from a set of inverse matrices as described below.

Data on the existing geographic distribution of current production can be used to determine that portion of X_n to be produced in each region. That is:

$_pX_n = {_pC_n} \cdot X_n$ where

X_n = the output of the national industries

$_pC_n$ = that amount of X_n produced in region "p" per unit of X_n

To produce these outputs of national industries in each region (equal to $_pX_n$), inputs of both regional and local commodities are required. The level of output from the regional and local industries required to satisfy the production level $_pX_n$ as well as the level of final demand at regional and local level can be determined by substituting the derived values of X_n and $_pX_n$ into the equations:

$$X_1 = \sum_1 a_{11} \cdot X_1 + \sum_n a_{1n} \cdot X_n + Y_1$$

$$_pX_1 = \sum_1 a_{11} \cdot {_pX_1} + \sum_n a_{1n} \cdot {_pX_n} + {_pY_1}$$

Mathematically, $_pX_n = {_pC_n} \cdot X_n = {_pC_n}\left[\sum_1 a_{n1} \cdot X_1 + \sum_n a_{nn} \cdot X_n + Y_n\right]$

$$\therefore \quad {_pX_1} = \sum_1 a_{11} \cdot {_pX_1} + \sum_n a_{1n} \left[{_pC_n}\left\{\sum_1 a_{n1} \cdot X_1 + \sum_n a_{nn} \cdot X_n + Y_n\right\}\right] + {_pY_1}$$

Therefore, if final demand for local commodities is known in each region, and if final demand for national commodities is known for all regions together and can be sub-divided by region, then a trading pattern as well as an output pattern will emerge. Because it is assumed that a given industry has the same cost structure in each region, national input coefficients can be used as regional coefficients. In this model it is also assumed that industries in the different regions which produce a commodity which is subject to inter-regional trade, contribute to that commodity in fixed proportions.

The trading pattern which emerges from this model shows each regions vector of imports and each region's vector of exports, but it does not show either the source of the imports or the destination of the exports. In other words, the regions are not connected directly but only indirectly through the economy as a whole. Also it can be seen that this model allows:

- variable relative regional outputs, but no trade in locally balanced goods and,
- variable trading patterns but fixed relative regional outputs for goods entering into regional trade.

In these approaches a set of pure trading coefficients for regional flows has been assumed constant. There is no valid reason for assuming that inputs which are substitutes must come from one area in preference to another. In Section 3.2.4.2 it was suggested that if a commodity is produced in many regions purchases by other regions will be determined by a number of factors. The supplies from different regions are always potential substitutes and sources of supply may be changed if these conditions change. Secondly, there is no reason to anticipate that as final demand changes, all regions will expand or contract outputs of any national industry in fixed proportion, as implied by the use of invariant allocating coefficients. To overcome the problems of substitution an interesting variation of an inter-regional model has been developed by Moses, (1960). He has blended inter-regional input-output analysis and a linear programming technique to make an empirical study of regional comparative advantage in the United States. In this study, trading patterns as well as regional outputs and requirements of all goods are determined while allowing for the introduction of alternative production techniques and substitution (between regions) into input-output analysis.

This differs from the normal transportation study, where the supply (availabilities) and demands (import requirements) at each node of a network are specified, as well as the cost of node to node transportation.

3.2 The Data Needs of the Model

A two region closed economy is assumed, where each region is engaged with the other "in the production and distribution of three homogenous commodities: food, fuel and clothing." "The assumption of homogeneity means that a given food from one region is a perfect technical substitute for the same good from another region. This being the case, economic rather than technical considerations will determine the regional flow of goods"(Moses, 1960). The fourth and fifth sectors of each region's input-output table consist of transport (a single transport medium is assumed) and the household or final demand sector while labour is treated as the only primary factor of production.

Regional final demands by sector, regional capacities and the inter-industry transactions table for each region must be known for the model to be applied where:

Y_i^r = the final demand for the output of sector "i" by region "r"

K_i^r = the maximum amount of sector 'i' which can be produced in region 'r' per unit of time

For example, K_4^1 represents the maximum amount of freight can be handled by the transport industry (sector 4) of the first region per unit of time. Finally:

L^r = the maximum amount of labour which the final demand sector region "r" is able to supply

"The L's do not carry subscripts because the model assumes that within each region labour is homogenous and perfectly mobile." (Moses, 1960). The inter-industry transaction table for each region is assumed to list "the inputs required to produce a unit of each good in each region and to transport it to itself and the other regions" (Moses, 1960). In this case, each inter-regional input-output table has a number of transport columns, the precise number being equal to the number of regions multiplied by the number of producing sectors. The transport row is omitted from these regional matrices. Thus, the inter-industry,transaction table uses the headings shown in Figure L.3 which illustrates the technological coefficient matrix for one region. In abbreviated form, this matrix can be written $(A^1 | V^1)$.

Region "p"

Sales \ Purchases	Food	Fuel	Clothing	THE TRANSPORT SECTOR					
				Intra-regional flows			Inter-regional flows		
				Food	Fuel	Clothing	Food	Fuel	Clothing
Food (1)	a^1_{11}	a^1_{12}	a^1_{13}	${}_1V^{11}_1$	${}_1V^{11}_2$	${}_1V^{11}_3$	${}_1V^{12}_1$	${}_1V^{12}_2$	${}_1V^{12}_3$
Fuel (2)	a^1_{21}	a^1_{22}	a^1_{23}	${}_2V^{11}_1$	${}_2V^{11}_2$	${}_2V^{11}_3$	${}_2V^{12}_1$	${}_2V^{12}_2$	${}_2V^{12}_3$
Clothing (3)	a^1_{31}	a^1_{32}	a^1_{33}	${}_3V^{11}_1$	${}_3V^{11}_2$	${}_3V^{11}_3$	${}_3V^{12}_1$	${}_3V^{12}_2$	${}_3V^{12}_3$

TECHNOLOGICAL COEFFICIENT MATRIX

FIGURE L.3

The coefficients can be defined as follows:

a^p_{ij} = the amount of sector 'i' that is required to produce a unit of 'j' in region 'p'

${}_iv^{pq}_j$ = the amount of sector 'i' required to transport a unit of sector 'j' from region 'p' to region 'q'

The reason for sub-dividing the transport sector into several columns is that "the transport industry's requirements may differ for hauling given weights of different goods. Input requirements may also differ for hauling a given weight of a given commodity between different pairs of regions. Since changes in the composition of trade, by commodity and/or by region, may take place from period to period multiple transportation columns allow us to take into account the effect of these changes on all regional outputs" (Moses, 1960).

The reason for the omission of the transport row in each matrix is that transportation service, interpreted as ton-miles, need not be included as an input, for "the effect on output of variations in the quantities of physical inputs is taken into account in the parameters of the production function. Variations in the distance these physical inputs travel will not affect the output of an industry ... his reasoning also appears valid for a linear production function. Output of any industry still depends on the quantities of the various inputs employed rather than on the distances they are transported." (Moses, 1960).

By omitting the transport row, Moses allows substitution of products between sources, i.e. "they can still substitute spatially by using more of a given input from some regions and less from others. The derived transportation coefficient would be stable only if the inter-regional trading pattern of every good was frozen" (Moses, 1960).

"Trading patterns, and expenditure on transportation are determined within the model, rather than assumed at the outset". In so doing, the rigidity of a coefficient "which purported to reflect the expenditure on transportation by an industry in a region per unit of that "industry's output" is avoided" (Moses, 1960).

3.3 The Variables to be Determined

The model was designed to determine inter-regional and intra-regional shipments, as well as regional outputs where:

S_i^{pq} = the shipment of the products of sector 'i' between region 'p' and region 'q'

x_i^p = the output of sector 'i' in region 'p' which consists of the direct and indirect requirements necessary to satisfy the given regional final demands

By ignoring the inventory problem, Moses was able to state that the sum of all shipments of a good by a region is its output of that good. That is:

$$x_i^p = S_i^{pp} + \sum_q S_i^{pq} \qquad \text{for } p, q = 1, 2 \ldots. m \text{ and } i = 1, 2 \ldots. n$$

where the output of sector 'i' is equal to its shipments to itself plus its exports to region 'q'. "Since national outputs are the sum of regional outputs, the former are also derived as a by-product of the model. Total transportation costs can be determined by multiplying total shipments of each good by the relevant per unit shipping costs" (Moses, 1960).

3.4 Substitution and Cost Minimisation

By allowing substitution of products between sources and by assuming the homogeneity of commodities traded between regions, the "firms or households in each region can adjust their purchasing pattern to minimise costs". A linear programming problem was derived from these considerations such that, for the case discussed:

$$Z = \sum_{i=1}^{3} \sum_{p=1}^{2} \sum_{q=1}^{2} (a^{p}_{4i} + {}_4v_i^{pq}) S_i^{pq} \quad \text{where:}$$

a_{ij}^{p} = the amount of sector 'i' that is required to produce a unit of 'j' in region 'p'

${}_iv_j^{pq}$ = the amount of sector 'i' required to transport a unit of sector 'j' from region 'p' to region 'q'

S_i^{pq} = the units of sector 'i' shipped between region p and region q

That is, the total labour required directly and indirectly in production and transportation, in regions 1 and 2 to satisfy regional final demands must be minimised.

Thus, in the above expression, the a's are labour inputs in production, the v's are labour inputs in transportation and the S_i variables, when summed by region, determine the output by sector 'i'. For example, the second term is $S_1^{12} (a^1_{41} + {}_4V_1^{12})$..... which states the amount of labour required to produce and transport S_1^{12} units of sector 1 from region 1 to region 2.

3.5 The Constraints

For each sector of each region the final demand is equal to the output of that sector, x_1^1, plus imports m_1^1, minus exports e_1^1 minus the intermediate demand n_1^1, thus, in this example:

$$Y_1^1 = x_1^1 + m_1^1 - (e_1^1 + n_1^1)$$

Now x_1^1 can be expressed entirely in terms of shipments. Thus,

$$x_1^1 = s_1^{11} + s_1^{12}$$

$$e_1^1 = s_1^{12}$$

$$m_1^1 = s_1^{21}$$

$$n_1^1 = (a_{11}^1 + {}_1v_1^{11})\, s_1^{11} + (a_{11}^1 + {}_1v_1^{12})\, s_1^{12}$$

$$+ (a_{12}^1 + {}_1v_2^{11})\, s_2^{11} + (a_{12}^1 + {}_1v_2^{12})\, s_2^{12}$$

$$+ (a_{13}^1 + {}_1v_3^{11})\, s_3^{11} + (a_{13} + {}_1v_3^{12})\, s_3^{12}.$$

"Here, the first three terms represent the quantity of food which region 1 must grow in order to produce and transport stipulated quantities of food, fuel and clothing to itself. The latter three terms represent the quantity of food which region 1 must grow in order to produce and transport the three goods to region 2"(Moses, 1960).

Capacity restraints are introduced for each industry in each region such that "total shipments (output) by each industry in each region must be less than, or equal to, the maximum rate of output.

For example,

$$s_3^{11} + s_3^{12} \leqslant K_3^1$$

states that the shipments of clothing by region 1 must be less than, or equal to the capacity of region 1's clothing industry" (Moses, 1960).

Capacity restraints are also introduced for the transport of each region but, as Moses states, "a realistic statement of the transport capacities and restraints would greatly complicate the system. Such a statement would include terminal, car, and line-haul capacities. Further complications would arise because different commodities may require different kinds of transport, particularly vehicle capacity".

For these reasons, Moses employed a set of weight coefficients, (w) for each commodity, where

w = the pounds per base year dollar's worth of each good

"Thus, the weight (capacity) constraint of the transport industry in region 1 is

$$w_1^1 (S_1^{11} + S_1^{12}) + w_2^1 (S_2^{11} + S_2^{12}) + w_3^1 (S_3^{11} + S_3^{12}) \leqslant K_4^1$$

Finally, labour constraints were introduced to state that "the total labour required to produce and transport all goods in each region must be less than, or equal to, the maximum quantity of labour which households can provide per period. This formulation assumes intra-regional factor mobility - both geographic and industrial - but rules out inter-regional factor movements within the production period. This difficulty would not arise in period-to-period applications of the model" (Moses, 1960).

This constraint states that the amount of labour required in region 1 to produce an amount of commodity (2) (equal to S_2^{11}), and transport it to households and other economic sectors in region 1 must be less than, or equal to the labour available in region 1. That is:

$$L^1 \leq a_{52}^1 S_2^{11} + {}_5v_2^{11} S_2^{11}$$

To remove the inequalities, two slack variables have been added such that, for example:

$$w_1^1(S_1^{11} + S_1^{12}) + w_2^1 (S_2^{11} + S_2^{12}) + w_3^1 (S_3^{11} + S_3^{12}) + \alpha_4^1 = K_4^1$$

and

$$a_{52}^1 S_2^{11} + {}_5v_2^{11} \cdot S_2^{11} + \beta^1 = L^1$$

where the α's stand for idle capacities of the producing and transport industries and the β's stand for unemployed labour. "Use of these slack variables permits the model to consider as candidates for optimality all those solutions in which one or more industries is under-utilised". (Moses, 1960).

Thus, this model assumes a closed economy that is divided into p = 1, 2 ... r open regions, where each region is engaged in the production and distribution of 1, 2 ... m homogenous goods and services.

4. Gravity Models

This model was developed by Leontief, (1963) for the purpose of determining regional flows and has been described as a gravity model in the sense that the structure of the model is not unlike the usual gravity models of the physical sciences. The gravity model may be defined as follows:

$$\frac{{}_{n}R_{i} \cdot {}_{mn}X_{i}}{\sum_{m} {}_{m}X_{i}} \cdot {}_{mn}Q_{i} = {}_{n}R_{i} \left(\frac{{}_{m}X_{i}}{X_{i}}\right) \cdot \text{(A CONSTANT)}$$

where ${}_{mn}X_{i}$ = the input from region m to region n of commodity "i"

${}_{n}R_{i}$ = the total commodity of type "i" imported to region "n" from all regions

${}_{m}X_{i}$ = the output of commodity "i" in region "m"

X_{i} = the output of commodity "i" in the nation $\left(\sum_{m} {}_{m}X_{i}\right)$

${}_{mn}Q_{i}$ = a constant, estimated from data with respect to a base year

"This Leontief gravity model tries to explain regional flows by considering the attraction of a volume of demand at a point and the sales push of a volume of supply from a given centre. All other forces are estimated through a coefficient evaluated from one set of observed values of the system. The coefficient thus may include the effect of distance, cost and other factors. The basic limitation, once more of the model is that it does not allow regional substitution", Ghosh, (1968).

5. Model Limitations

Most of the input-output models reviewed assume the validity of constant production coefficients. Such usage assumes that the production functions for various industries are assumed to be uniform throughout the whole country. Isard, (1960) mentions the following factors which question the use of constant production coefficients in the types of study referred to in this section:

These are:

- "Economies of scale, which are present in most industries"
- "Localisation economies - external economies, which accrue when like plants agglomerate at one place"
- "Urbanisation economies - external economies, which derive when unlike plants agglomerate at one locality"
- "Price changes - where relative price changes induce substitutions among inputs, such as scrap iron for pig iron, in the production of steel ingots"
- "Limitations of data"
- "Technological advance"

Two problems generated by data limitations concern:

- the distortion of production coefficients computed from inadequate transactions tables
- variations in "industry-mix" and "product-mix" from region to region

The former problem arises "when transaction tables are distorted by capital transactions inextricably mixed with current transactions"(Miernyk, 1960). The latter problem arises from the fact that "most transactions tables are constructed on an establishment or industry basis, rather than on a product basis". (Miernyk, 1960). This problem is minimised if a table of national coefficients is available in great detail and if the distribution of industries within each region is available in similar detail. Sadly, such information is rarely available, even in the United States. In discussing this point Miernyk, (1960) states "even the most detailed table published by the U.S. Department of Labour in its 1947 national input-output study - a table which contained 192 rows and columns - was not entirely sufficient for this purpose".

The problem generated by technological advances in particular industries, is that the coefficients derived in the base year only reflect the technological structure of the industry in that year. Where the technological structure of an industry is changing, coefficients should really be changed in concept, so that the future pattern of production can be adequately reflected.

As a result Tiebout, (1968) states that production coefficients have been divided into three categories:

- "Average coefficients as determined operationally, by the last Census of Manufacturers"
- "Best coefficients, which represent the coefficients of the newest of "planning board" plants in the industry"
- "The worst coefficients which represent the coefficients of the marginal firm"

In discussing these points Tiebout, (1968) states

"Which coefficient one chooses depends on the assumed capacity of the industry and which firms bear the impact of demand changes. If demand is assumed to increase, best coefficients will apply if the industry was previously operating at capacity, for added capacity will have to come from new plants. If the industry is assumed to be operating at less than capacity, worst coefficients could be the ones to use".

Another serious pitfall of regional coefficients is that they "not only specify the amount of needed inputs per unit of output, but each source is assumed to be a constant proportion of total output, i.e. trading patterns are assumed to be stable, "(Tiebout, 1968) for all levels of output. The case for stable trading coefficients presents an interesting paradox. Moses, (1955) is quite explicit that "even for short run predictions, the following conditions should be satisfied:

- There is excess capacity in the transport network between every pair of regions
- Each industry in each region has excess capacity
- There is a pool of unemployed labour for each region"

These assumptions are necessary to justify constant costs which, Moses feels, are needed to justify stable trading patterns.

6 The Input-Output Model

6.1 The Sectors Defined

The industrial classification of the sectors of the 1962 input-output table of Dominica is as follows :-

A - Banana industry

B - Export agriculture

C - Domestic agriculture

D - Construction & engineering

E - Manufacturing

F - Distribution

G - Transport

H - Finance and insurance

I - Services

J - Rent of dwellings

K - Earnings and investment

L - Households

M - Profit appropriation

N - Government

O - Rest of the World

Now the inclusion of a sector in final demand implies that "any functional relationship between that sector's input and output - is being disregarded" in the context of the input-output analysis. United Nations, (1966). Conversely, those sectors designated as processing sectors imply that there is a linear physical relationship between the input and output of that sector. Each of the above sectors will be considered as candidates for final demand in relation to the above comments.

Rest of the World. The exports of Dominica, (largely bananas) are probably better explained in terms of political factors[4].

Government. This is nearly always considered as part of final demand for many of the factors affecting this sector are politically motivated, and "items of government expenditure are most truly innocent of any dependent

---

4. Approximately "96% of the total Jamaican & Windward Islands production of bananas is sold in the U.K. market, where a preference of £ 7.5 per ton is received. The U.K. imposes quota restrictions on the entry of bananas which is at present 4,000 tons p.a." The West Indies Committee, (1970).

relation with other variables in the input-output system" United Nations, (1966).

Profit Appropriation. This sector "receives gross profit - that is before tax, savings, and depreciation are taken out - and then allocates this total between government (corporate tax), households (distributed profit), savings and investment (corporate savings), and the rest of the world (overseas profit, dividends, etc.)". O'Loughlin (1971). Clearly this sector will only form one of the primary inputs to final demand because there is no physical relationship between its inputs and outputs, it merely overcomes the need to divide industries into corporate and non-corporate sectors.

Households. To assign households to final demand means that the relationship between consumption (sector output) and employment (output) is ignored. "There are clear grounds for relating, via constant coefficients, a large fraction of household output (income) to the levels of output of other sectors". Isard, (1960). This latter approach has the following general weaknesses:

- "Household expenditures form such an enormous proportion of the total value of transactions, that a small error in the estimate of an input coefficient for that sector might introduce a large error in estimates of output.
- The assumption of simple proportionality between household income and expenditure on individual items is implausible. A linear relation can be introduced within the theoretical framework of the model, but usually the empirical estimation of the parameters of such a relation is costly.
- With households included within the matrix, the input-output system logically leads to the conclusion that if investment, export, and government expenditures were reduced to zero, all output would cease in each sector of the economy.
- Empirical applications, estimating the consequences for a national economy of changes in components of final demand, including the income-multiplier effect obtained through including households

within the matrix, have usually yielded numerical solutions which seriously over-estimate the actual consequences". United Nations, (1960).

In the input-output analysis of small regions, the employment-consumption relation cannot always be ignored.[5] In such cases it is desirable "to take account of the employment-consumption relation and thus to include households within the matrix". United Nations, (1966). But if "this increase in earnings is spent on imported consumer goods, although the economy is correspondingly better off, there is no multiplier effect within the economy like that occurring if a proportion of the new income was spent internally". O'Loughlin, (1971). These arguments, when considered in the context of the economy of Dominica, suggest that the household sector should remain part of final demand.

Savings & Investment. This sector shows, "on the receipts side and on the expenditure side the totals of fixed capital formation (to construction and engineering) and stock changes from the various sectors". O'Loughlin, (1966). "While an increase in capital utilization reflected in depreciation may very well lead to future investment, that investment will be primarily composed of capital goods obtained from future, not current production". United Nations, (1966). For this reason, this sector should also form part of final demand, which leaves sectors A-J to represent the industrial or "processing" sectors.

"Such a convention explicitly recognises that an operational input-output model at the present time can only be a static one. It cannot explain :-

- the process by which investment decisions are made by firms, households, government, and thence
- the level of capital formation and the corresponding input requirements". Isard, (1960).

Thus, the input-output model will contain the specified final demand sectors whose levels of operations and requirements are not to be determined by the model.

---

5. For example, the output of the services sector is indirectly dependent upon the regions exports through the income and expenditure of local residents.

The processing sectors.

Information on each sector drawn from Bartell, (1965) was supplemented by O'Loughlin, (1966) and enabled the compilation of the following information.

Export Agriculture. This includes banana, copra, cocoa and lime production as well as the limited production of pickles, condiments and sauces, fruit and vegetables, and unrefined coconut oil.

Domestic agriculture. This sector produces sugar (for the local rum distilleries), vanilla, fruit and vegetables, livestock and fish. Bartell, (1965).

Construction and engineering. This sector includes the "building of modern homes....and....commercial construction such as new banking and supermarket buildings...and the expansion and modernisation of electric power and lime processing industries". Bartell, (1965). The sector also includes "engineering and maintenance of motor vehicles and other equipment and maintenance of private buildings" O'Loughlin, (1966). "All capital formation, whether public or private is included...The figure of Gross Domestic Capital Formation is shown as a receipt in this account, being paid by the Savings and Investment sector" O'Loughlin, (1966).

Manufacturing. "Processing of limes is the principal export manufacturing activity in this sector, while handmade straw products "account for about ten per cent of the total value added in manufacturing and constitutes the only other significant manufactured export product" Bartell, (1965). The production of essential oils (lime and bay oil) is part of the lime processing industry.

The generation of electricity, and the manufacture of cigarettes from mostly home grown tobacco are important activities but rum processing, baking, and the bottling of soft drinks are also mentioned by Bartell, (1965) but leather working, dressmaking, pottery, cabinet and furniture, aerated drinks, brewery, distillery, confectionery, synthetic liquors, gasolene products, fertilisers, cannery and handicrafts are mentioned by O'Loughlin, (1966) as a small part of this sector in the Leeward and Windward Islands.

Distribution. "This sector includes retail and wholesale distribution, importing, commission agencies, travel agencies, gasolene and liquor sales, higgling, huckstering and stevedoring". O'Loughlin, (1966). The C.I.F. value of the imports is normally shown "as purchased by Distribution from the Rest of the World, and the total of import duties as payments by Distribution to Government".

Finance. This sector includes banks, insurance, hire purchase companies and estate agents. Payments made by this sector to the Rest of the World will consist of financial transfers.

Transport. This sector includes road transport and schooners, sloops, lighters and motor vessels for the movement of passengers and goods, but fishing vessels are excluded.

Services. This sector includes the professions and those in domestic service. Those engaged in the telephone and education services (run by the Government sector) are excluded. Payments made by this sector to the Rest of the World are generally for administrative and professional service provided by foreign nationals.

Rent of dwellings. This sector accounts for the gross rent paid by households, rent paid by government to owners of private dwellings, and rent paid by tourists who rent dwellings for short periods of time.

An examination of the principal imports to Dominica during 1961-64 (table L4) suggested that a significant proportion were destined for the processing sectors of the economy. Such imports are therefore related to the level of output of each sector. For this reason, only the hybrid input-output model and the model of method four[6] were applicable, if the aggregation error associated with method 3 was to be overcome. The total import and export statistics of Dominica are given in table L.5

6. These methods are discussed in Chapter 3.2.5 of the main report.

ITEMS	CATEGORY	$'000 (W.I.) 1961	1962	1963	1964
Machinery	Intermediate	682.0	951.8	698.1	832.1
Textiles	Inter/Consumer	740.2	794.2	674.9	772.4
Flour, wheat	Consumer	502.6	609.8	692.3	725.4
Manures	Other	364.0	431.2	684.6	1208.2
Metals & other manufactures	Consumer	598.7	719.3	617.7	757.8
Butter, Milk & Cheese	Consumer	288.5	412.2	646.9	469.5
Sugar	Consumer	438.7	510.9	570.3	727.3
Fish & Fish Preparations	Consumer	312.8	344.6	412.3	495.6
Meat & Meat Preparations	Consumer	421.6	567.8	549.9	643.3
Transport equipment	Finished	661.1	622.3	545.3	907.4
Footwear	Consumer	221.5	353.4	307.3	379.8
Oils not edible	Intermediate	429.8	306.5	348.9	398.3
Oils, edible	Consumer	78.3	216.6	209.1	223.3
Liquor	Consumer	359.5	360.0	298.4	408.2
Soap	Consumer	152.9	167.5	183.2	203.0
Rice	Consumer	779.0	136.4	135.4	166.9
Tobacco	Consumer	128.3	79.3	106.8	99.9
Animal Feed	Intermediate	82.6	140.0	109.0	142.8
Margarine	Consumer	98.6	120.9	156.5	137.9
Cement	Intermediate	119.6	228.9	149.6	145.5
Wood and Lumber	Intermediate/ Consumer	183.6	347.5	269.6	471.1
Other Imports	-	2995.3	4882.3	3625.4	4715.8
TOTAL IMPORTS		10639.4	12798.4	11991.5	15041.5

Source: Annual Statistical Digest No. 3
for Dominica, 1969, Table 60

Principal Items of Imports, 1961-1964

Table L.4

1962 TRADE STATISTICS FOR DOMINICA TABLE L.5

	IMPORTS	EXPORTS
0. FOOD AND LIVE ANIMALS	3530802	
00. Live animals (excluding zoo animals, dogs and cats)	6690	-
01. Meat and meat preparations	563702	-
02. Dairy products and eggs	412205	428
03. Fish (not of British taking) and fish preparations	347511	-
04. Cereals and cereal preparations	887272	27
05. Fruit and vegetables	224657	6383796
06. Sugar, sugar preparations and honey	599049	-
07. Coffee, tea, cocoa, spices and manufactures thereof	91366	144737
08. Feeding stuff for animals and food wastes	140011	
09. Miscellaneous food preparations	258339	10961
1. BEVERAGES AND TOBACCO	439096	-
11. Beverages	359784	-
12. Tobacco and tobacco manufactures	79312	-
2. CRUDE MATERIALS, INEDIBLE, EXCEPT FUELS	391879	
21. Hides, skins and fur skins, undressed	-	
22. Oil seeds, oil nuts and oil kernels	-	430490
23. Crude rubber (including synthetic and reclaimed)	2874	-
24. Wood, lumber and cork	347548	500
25. Pulp and waste paper	678	-
26. Textile fibres (not manufactured into yarn, thread or fabrics) and their waste; old clothing and other textile articles; rags	2396	-
27. Crude fertilisers and crude minerals (excluding coal, petroleum and precious stones)	32537	-
28. Metalliferous ores and metal scrap	-	3683
29. Crude animal and vegetable materials, not elsewhere specified	5846	2802
3. MINERAL FUELS, LUBRICANTS AND RELATED MATERIALS	351272	-
31. Coal, coke and briquettes	-	-
32. Petroleum and petroleum products	349556	-
33. Gas, natural and manufactured	1716	-

1962 TRADE STATISTICS FOR DOMINICA (cont.)

	IMPORTS	EXPORTS
4. ANIMAL AND VEGETABLE OILS AND FATS	219698	11859
41. Animal oils and fats	219698	11859
42. Fixed vegetable oils and fats	-	-
43. Animal and vegetable oils and fats, processed, and waxes of animal or vegetable origin	-	-
5. CHEMICALS	1334520	
51. Chemical elements and compounds	39588	-
52. Mineral tar and crude chemicals from coal, petroleum and natural gas	1200	-
53. Dyeing, tanning and colouring materials	96878	-
54. Medicinal and pharmaceutical products	222274	-
55. Essential oils and perfume materials; toilet, polishing and cleansing preparations	302795	481750
56. Fertilisers, manufactured	431174	-
57. Explosives and pyrotechnic products	-	-
58. Plastic materials, regenerated cellulose and artificial resins	-	-
59. Chemical materials and products, not elsewhere specified	240611	-
6. MANUFACTURED GOODS CLASSIFIED CHIEFLY BY MATERIAL	1684078	
61. Leather, leather manufactures, not elsewhere specified, and dressed fur skins	5641	-
62. Rubber manufactures, not elsewhere specified	220898	-
63. Wood and cork manufactures (excluding furniture)	167405	-
64. Paper, paperboard and manufactures thereof	531541	-
65. Textile yarn, fabrics, made-up articles and related products	709153	
66. Non-metallic mineral manufactures, not elsewhere specified	318772	-
67. Iron and steel	19623	-
68. Non-ferrous metals	269252	-
69. Manufactures of metal	450793	
7. MACHINERY AND TRANSPORT EQUIPMENT	1883271	
71. Machinery, other than electric	951750	-
72. Electrical machinery, apparatus and appliances	309212	-
73. Transport equipment	622309	226

1962 TRADE STATISTICS FOR DOMINICA (cont.)

	IMPORTS	EXPORTS
8. MISCELLANEOUS MANUFACTURED ARTICLES	1711255	
81. Sanitary, plumbing, heating and lighting fixtures and fittings	80322	-
82. Furniture	149240	698
83. Travel goods, handbags and similar articles	41045	614
84. Clothing, knitted or crocheted articles including elastic or rubberised fabric and articles of fur	530732	1943
85. Footwear, gaiters and the like	353418	83
86. Professional, scientific and controlling instruments; photographic and optical goods, watches and clocks	78379	-
89. Miscellaneous manufactured articles, not elsewhere specified	478109	1461
9. COMMODITIES AND TRANSACTIONS NOT CLASSIFIED ACCORDING TO KIND	114787	49031
VALUES ARE GIVEN IN WEST INDIAN DOLLARS	$ CIF	$ FOB
SOURCE. DERIVED FROM ANNUAL TRADE REPORTS FOR 1961 AND 1963.		

The input-output coefficients.

The input-output tables constructed from the sector accounts of Dominica[7] for the years 1961-63 are illustrated in tables L.6-L.8. From these a table of input coefficients were developed to show the amount of inputs required from each industry to produce one dollar's worth of the output of a given industry. These coefficients were calculated as follows:- Gross output was adjusted by subtracting inventory depletion during the period covered by the table to obtain adjusted gross output. As gross outlays in the processing sector are identical with gross output in this sector, adjusted gross outputs can be computed by subtracting the entries in row K from the entries in row P. The technical coefficients were then derived by dividing each entry in each industry's column by the adjusted gross output for that industry less imports to it. The results of this exercise are illustrated in table L.9

This table shows that even large errors in the coefficients would have little effect on industrial output, whichis the prime determinant of the level of imports. For this reason, no attempt was made to determine trends in the coefficients. To understand such trends a knowledge of the underlying changes in the economy are required. Such knowledge is difficult to acquire without a visit to Dominica. However, sensitivity analysis could be used to calculate the effect on X_i of changes in the coefficients.

The inverse of the domestic production coefficient is given in table L.10 for the years 1962-63 where the differences in the inverse, resulting from the changes in the input-output coefficients referred to above can be seen.

Imports - Volume/Value Ratios

The main imports to the export agriculture, manufacturing and distribution sectors were selected to examine the stability of the volume/value ratio over time. The imports selected are given in table L.11

---

7. See Bartell, E, National Income Statistics, Dominica, 1961-64, Statistical Series No. 2, University of the West Indies, 1965.

Receipts \ Expenditure 1961	Banana Industry	Other Export Agriculture	Domestic Agriculture	Construction & Engineering	Manufacturing	Distribution	Transport	Finance & Insurance	Services	Rent of Dwellings	Savings & Investment	Households	Profit Appropriation	Government	Rest of the World	Total Gross Output
Banana Industry		11.5				36.5					15.8	73.0			4637.8	4774.6
Other Export Agriculture					539.1	264.0					3.1	24.3			823.9	1654.4
Domestic Agriculture					60.0	898.5						2899.1				3857.6
Construction & Engineering	12.0	5.0	9.5		74.0	35.2	164.1	10.5	10.9	500.7	4041.7	127.4		40.0		5031.0
Manufacturing						1427.7						159.0		42.0	1550.5	3179.2
Distribution	81.0	12.5	137.4	1330.2	197.9		492.7	15.0	23.6		168.6	11643.1		563.4	26.4	14691.8
Transport	716.6	111.0	109.3	49.2	35.5	157.6						216.6		37.3	103.5	1536.6
Finance & Insurance	136.8	35.8	8.9	17.4		97.6	61.3			75.0		209.5				642.3
Services	294.4	4.0		3.0	5.0	41.4	13.0			11.0		937.4		14.3	106.7	1430.2
Rent of Dwellings												2913.5				2913.5
Savings & Investment (Depreciation)	51.1				1.0							2463.4		2436.7	467.2	5419.4
Households	755.7	340.3	2483.3	1411.7	1072.1	683.6	200.0	349.1	596.8				9991.0	3537.6	1565.8	22987.0
Profit Appropriation	1936.8	860.4	1101.7	403.2	414.6	1823.9	422.6	152.1	578.6	2276.9					132.3	10103.1
Government	149.0	73.4	5.0	143.2	345.6	1633.1	195.9	5.0	8.5	49.9		714.4			4024.5	7347.5
Rest of the World	641.2	200.5	2.5	1673.1	434.4	7592.7		97.6	211.8		1190.2	606.3	112.1	676.2		13438.6
Total Gross Outlays	4774.6	1654.4	3857.6	5031.0	3179.2	14691.8	1536.6	642.3	1430.2	2913.5	5419.4	22987.0	10103.1	7347.5	13438.6	
ADJUSTED GROSS OUTPUT	4723.5	1654.4	3857.6	5031.0	3178.2	14691.8	1536.6	642.3	1430.2	2913.5	5419.4	20523.6	10103.1	4910.8	12971.4	

1961 INPUT-OUTPUT TABLE, DOMINUCA

TABLE L6

Receipts \ Expenditure 1962	Banana Industry	Other Export Agriculture	Domestic Agriculture	Construction & Engineering	Manufacturing	Distribution	Transport	Finance & Insurance	Services	Rent of Dwellings	Savings & Investment	Households	Profit Appropriation	Government	Rest of the World	Total Gross Output
Banana Industry		13.0				37.5						75.0			4317.5	4443.0
Other Export Agriculture					585.5	286.5					26.3	22.6			898.2	1819.1
Domestic Agriculture					61.0	937.2						2975.8				3974.0
Construction & Engineering	15.4	5.4	9.5		83.4	34.5	198.7	11.8	11.3	604.9	4756.8	144.3		42.0		5918.0
Manufacturing						1626.3					50.8	167.4		45.1	1701.6	3591.2
Distribution	83.3	14.7	183.4	1535.6	204.9		525.6	8.0	32.8		241.8	11573.0		569.3	32.5	15004.9
Transport	681.0	105.1	113.9	51.4	37.3	192.0						244.0		41.5	114.5	1580.7
Finance & Insurance	121.0	28.2	7.1	24.9		132.2	74.2			80.0		266.9				734.6
Services	287.2	4.5		3.5	5.3	41.3	13.5			11.4		961.8		14.2	109.3	1452.0
Rent of Dwellings												3483.2				3483.2
Savings & Investment (Depreciation)	85.3											836.6		1379.8	2873.5	5175.2
Households	989.5	367.1	2525.1	1487.3	1205.5	807.5	228.0	408.2	608.3				8420.7	3480.4	1515.9	22043.5
Profit Appropriation	1310.9	950.8	1125.0	431.5	610.4	147.8	334.1	142.4	584.1	2729.8					127.9	8494.7
Government	147.6	85.5	6.7	274.7	377.0	1792.4	220.1	5.1	8.5	57.1	99.5	938.6			2437.8	6450.6
Rest of the World	721.7	244.8	3.3	2109.1	420.9	8969.7		145.6	207.0			354.3	74.0	878.3		14128.7
Total Gross Outlays	4443.0	1819.1	3974.0	5918.0	3591.2	15004.9	1580.7	734.6	1452.0	3483.2	5175.2	22043.5	8494.7	6450.6	14128.7	
ADJUSTED GROSS OUTPUT	4357.7	1819.1	3974.0	5918.0	3591.2	15004.9	1580.7	734.6	1452.0	3483.2						

TABLE L7

Receipt \ Expenditure 1963	Banana Industry	Other Export Agriculture	Domestic Agriculture	Construction & Engineering	Manufacturing	Distribution	Transport	Finance & Insurance	Services	Rent of Dwellings	Savings & Investment	Households	Profit Appropriation	Government	Rest of the World	Total Gross Output
Banana Industry		30.5				38.5					875.0	76.9			4738.9	5749.8
Other Export Agriculture					611.8	310.8						23.0			981.1	1926.7
Domestic Agriculture					82.3	990.6						2992.0				4064.9
Construction & Engineering	19.7	5.7	10.6		81.1	35.0	202.9	12.0	11.4	646.3	3512.0	147.1		45.0		4728.8
Manufacturing						1753.9						178.1		49.1	1283.6	3264.7
Distribution	78.5	16.0	128.0	1410.3	207.6		555.5	8.5	24.5			12460.7		607.5	28.8	15525.9
Transport	806.5	130.0	119.6	40.3	38.1	180.0						252.0		42.0	108.8	1717.3
Finance & Insurance	119.7	22.2	6.0	24.4		132.1	77.7			78.0		270.6				730.7
Services	287.0	5.0		3.4	6.0	44.7	14.5			12.0		984.0		14.4	93.6	1464.7
Rent of Dwellings												3713.4				3713.4
Savings & Investment (Depreciation)	86.1				62.4	180.0						1049.2		980.9	2072.5	4431.1
Households	1053.5	394.1	2531.7	1337.7	1089.5	830.8	252.5	416.8	620.9				9697.3	3829.9	1269.5	23324.2
Profit Appropriation	2153.4	1090.2	1258.8	574.1	197.0	433.3	400.2	124.9	589.4	2911.0					130.0	9862.3
Government	159.7	107.7	5.8	170.1	399.4	1855.5	228.5	5.2	8.6	66.1	54.1	904.8			2474.9	6440.4
Rest of the World	985.6	125.3	4.4	1168.5	489.5	8740.7		148.8	209.9			272.4	165.0	871.6		13181.7
Total Gross Outlays	5749.8	1926.7	4064.9	4728.8	3264.7	15525.9	1717.3	730.7	1464.7	3713.4	4431.1	23324.2	9862.3	6440.4	13181.7	
ADJUSTED GROSS OUTPUT	4874.8	1926.7	4064.9	4728.8	3202.3	15345.9	1717.3	730.7	1464.7	3713.4						

1963 - INPUT - OUTPUT TABLE, DOMINICA

TABLE L.8

		A	B	C	D	E	F	G	H	I	J
A	1961 1962 1963		.00792 .00826 .01692				.00515 .00597 .00583				
B	1961 ↓ 1963					.1960 .1850 .2205	.0372 .0455 .0471				
C	1961 ↓ 1963					.02182 .01938 .02972	.1268 .1491 .1508				
D	1961 ↓ 1963	.00294 .00414 .00506	.00344 .00344 .00316	.00247 .00240 .00261		.0269 .0262 .0292	.00496 .00549 .00530	.1071 .1257 .1181	.0193 .0210 .0206	.00896 .00907 .00909	.1720 .1738 .1741
E	1961 ↓ 1963						.2050 .2582 .2655				
F	1961 ↓ 1963	.01987 .0228 .0202	.00861 .00935 .00889	.0357 .0462 .0316	.3963 .4025 .3960	.0720 .0649 .0746		.322 .332 .324	.0276 .0136 .0147	.0194 .0264 .0196	
G	1961 ↓ 1963	.1756 .1862 .2076	.0765 .0669 .0722	.0284 .0286 .0294	.01469 .01352 .01132	.0129 .0118 .0137	.0222 .0305 .0272				
H	1961 ↓ 1963	.0335 .0332 .0308	.0246 .0179 .0126	.00232 .00179 .00148	.00519 .00652 .00685		.01378 .0210 .0200	.040 .047 .045			.0258 .0230 .0211
I	1961 ↓ 1963	.0722 .0784 .0739	.00275 .00286 .00278		.00895 .00919 .00955	.001821 .001673 .002161	.0058 .0066 .0067	.0085 .0085 .0085			.00378 .00328 .00323
J	1961 ↓ 1963										

INPUT-OUTPUT COEFFICIENTS FOR DOMINICA

TABLE L.9

SECTORS		A	B	C	D	E	F	G	H	I	J
Banana Industry	(A)	1.0007 (1.0008)	.0086 (.0172)	.0004 (.0003)	.0029 (.0032)	.0022 (.0045)	.0071 (.0080)	.0027 (.0030)	.0002 (.0002)	.0002 (.0002)	.0005 (.0006)
Other Export Agr.	(B)	.0097 (.0113)	1.004 (1.004)	.0057 (.0049)	.0400 (.0445)	.1937 (.2318)	.0980 (.1111)	.0377 (.0414)	.0022 (.0025)	.0030 (.0026)	.0070 (.0078)
Domestic Agriculture	(C)	.0161 (.0171)	.0061 (.0065)	1.009 (1.007)	.0661 (.0668)	.0337 (.0466)	.1620 (.1668)	.0623 (.0622)	.0036 (.0038)	.0049 (.0039)	.0116 (.0117)
Construction and Engineering	(D)	.0312 (.0333)	.0133 (.0134)	.0073 (.0071)	1.0102 (1.0099)	.0320 (.0360)	.0203 (.0207)	.1348 (.1270)	.0215 (.0211)	.0097 (.0096)	.1761 (.1762)
Manufacturing	(E)	.0269 (.0285)	.0103 (.0109)	.0158 (.0122)	.1107 (.1118)	1.0240 (1.0283)	.2713 (.2791)	.1044 (.1040)	.0060 (.0064)	.0082 (.0065)	.0194 (.0196)
Distribution	(F)	.1043 (.1072)	.0398 (.0411)	.0612 (.0459)	.4289 (.4212)	.0928 (.1066)	1.0509 (1.0513)	.4042 (.3917)	.0233 (.0241)	.0316 (.0244)	.0752 (.0739)
Transport	(G)	.1914 (.2128)	.0704 (.0777)	.0315 (.0315)	.0331 (.0303)	.0297 (.0364)	.0480 (.0472)	1.0202 (1.0189)	.0013 (.0013)	.0016 (.0012)	.0058 (.0053)
Finance and Insurance	(H)	.0448 (.0429)	.0225 (.0176)	.0047 (.0039)	.0181 (.0175)	.0072 (.0072)	.0267 (.0252)	.0582 (.0553)	1.0007 (1.0007)	.0009 (.0007)	.0262 (.0242)
Services	(I)	.0811 (.0769)	.0046 (.0052)	.0008 (.0007)	.0129 (.0133)	.0036 (.0046)	.0088 (.0091)	.0131 (.0131)	.0004 (.0004)	1.0004 (1.0003)	.0056 (.0056)
Rent of Dwellings	(J)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)

The figures in brackets represent the inverse coefficients derived from the 1963 input-output table.

INVERSE COEFFICIENT MATRIX (DOMINICA, 1962)

TABLE L.10

Commodities	Unit	Quantity 1959	1960	1961	1962	1963	Value (c.i.f.) 1959	1960	1961	1962	1963
							$'000	$'000	$'000	$'000	$'000
Banana Industry & Other Export Agriculture											
Fertilizers	ton	2,899	2,468	2,869	3,220	5,372	407	320	364	431	684
Animal Oils & Fats**	'000 gal.	1,167	868	1,286	1,222	1,505	362	280	430	351+	330+
Construction & Engineering											
Transport Equipment	-	-	-	-	-	-	532	573	661	622	545
Machinery	-	-	-	-	-	-	1,137	759	682	952	698
Manufacturing											
Sugar and sugar preparations*	'000 lb.	4,989	4,906	4,824	4,630	4,956	504	531	503	511	607
Distribution											
Food, Drink and Tobacco											
Butter, Cheese & Milk	'000 lb.	421	491	571	769	872	213	237	289	412	413
Butter substitutes	'000 lb.	222	231	223	270	345	97	101	99	121	157
Fish and fish preparations	'000 lb.	853	1,000	854	930	1,112	303	358	313	345	415
Flour, wheaten	'000 lb.	6,717	5,525	5,907	6,662	6,915	553	495	503	610	692
Rice	'000 lb.	769	844	779	1,110	1,042	91	100	93	136	135
Liquor	'000 gal.	63	70	87	80	66	271	305	359	360	298
Meat and meat preparations	'000 lb.	435	672	719	1,046	1,105	249	322	422	568	538
Oils, edible	'000 gal.	77	72	78	69	70	217	200	238	232	208
Tobacco	'000 lb.	101	132	156	73	117	100	112	128	79	106
Manufactured Articles											
Textiles	-	-	-	-	-	-	593	660	740	794	679
Soap	'000 lb.	556	616	513	605	595	144	157	153	181	183
Metals and their manufactures	-	-	-	-	-	-	606	753	599	719	618
Footwear	'000 pr.	97	135	104	146	137	220	283	222	353	307

+ Disagrees with Summary Tables derived from 1962 Annual Trade Report.

* Approximately one fifth of these should be allocated to the Distribution Sector. See Figure 83 -(Sector Imports, 1962).

** Includes Competing Imports

Source. Annual Trade Report for Dominica, 1968, Page 22.

MAIN IMPORTS TO DOMINICA

TABLE L.II

COMMODITY	cu.ft./Ton	Weight '000 lb.	Volume cu. ft.
Animal Oils & Fats	47	1,222	25,600
Fertilizer	47	3,220	67,800
Sugar	84	4,830	181,200
Butter, Cheese & Milk	66	769	22,610
Butter Substitutes	66	270	7,950
Fish & Fish Preparations	68	930	28,200
Flour, Wheaten	52	6,662	154,600
Rice	52	1,110	25,800
Liquor	+	80,000 gall.	12,900
Meat & Meat Preparations	69	1,046	32,200
Oils, Edible	+	69,000 gall.	11,100
Tobacco	100	73	3,260
Textiles	109	**	***
Soap	45	605	12,140
Metal & Manufactures	50	**	***
Footwear	0.25/pair*	146,000 prs.	36,000*

+ 6.23 gallons/cu.ft.   * Authors Estimate

** Figures can be derived from the Annual Trade Statistics & Appendix B

*** Weight figures were not given in table R.9

1962 IMPORTS TO AGRICULTURE, MANUFACTURING & DISTRIBUTION

TABLE L.12

The major imports to each sector are shown in table L.13, from which the stability of the import ratio (D_c)[8] and volume/value ratio (B_c) can be gauged.

---

8. For convenience, the weight/value relationship is given in the majority of cases. Weight/volume relationships are constant (Appendix B).

YEARS	1961	1962	1963
Imports to Export Agriculture+ (Excluding Competing Imports)	N.A.	637	672
Animal Oils & Fats (Based on Annual Trade Report)- Non-Competing & Competing	N.A.	16.2 203.5	9.0 202.5
Proportion of SectorImports	-	2.54 ↓	1.34 ↓
Competing import coefficient		0.314	**
Weight/Value Ratio (Competing & Non-Competing)	2.99	3.49	4.56
Fertilizer	364	431	684
Proportion of Sector Imports	-	0.572	0.672
Weight (tons)/Value Ratio	7.89	7.46	7.85
Imports to Manufacturing $'000+	434.4	420.9	489.5
Unrefined Beet & Sugar Cane*	N.A.	356.8	420.6
Proportion of SectorImports	N.A.	0.848	0.861
Weight '000 lbs.*	N.A.	3,564	3,675
Weight/Value Ratio	N.A.	10.0	8.64
Weight/Value Ratio (from Table R9)	9.6	9.4	8.2
* From 1962 Annual Trade Report			
Imports to Distribution+	7449.9*	8680.1	8602.9
Butter, Cheese & Milk	289	412	413
Proportion of SectorImports	0.0388	0.0475	0.0481
Weight/Value Ratio	1.98	1.87	2.11
Butter Substitutes	99	121	157
Proportion of SectorImports	0.0133	0.0139	0.0182
Weight/Value Ratio	2.03	2.23	2.20
Fish & Fish Preparations	313	345	415
Proportion of SectorImports	0.0420	0.0398	0.0482
Weight/Value Ratio	2.72	2.70	2.68

** A figure for 1963 was not calculated because table 45 suggested an error in the sector accounts for that year.

WEIGHT/VALUE RATIOS TABLE LJ3

YEARS	1961	1962	1963
Flour	503	610	692
Proportion of Sector Imports	0.0675	0.0715	0.0805
Weight/ Value Ratio	11.76	10.93	10.0
Rice	93	136	135
Proportion of Sector Imports	0.0125	0.0157	0.0157
Weight/ Value Ratio	8.38	8.16	7.72
Meat & Meat Preparations	422	568	538
Proportion of Sector Imports	0.0565	0.0655	0.0625
Weight/ Value Ratio	1.70	1.84	2.05
Footwear	128	79	106
Proportion of Sector Imports	0.0172	0.0091	0.0123
Volume(prs)/ Value Ratio	0.468	0.414	0.446

+ Derived from Sector Accounts   * Competing Imports assumed to equal 144.8

WEIGHT-VALUE RATIOS   Table . L13

APPENDIX M

A TRANSPORT MODEL FOR CARIFTA

1. The constraints[1]

Firstly, the sum of the journeys between ports "i" and "j" of the network of shipping routes must not exceed 14 days. That is :-

For arc (i, j) $\sum_{k} NS_k \geq 26$ (365/14 DAYS = 26)

Secondly, the shipping capacity of each route must be greater than, or equal to, the shipments assigned to that route, over each directed arc (i, j). That is

$C_a \cdot NS_k \geq a_{ijkc}$ for cargo, and

$C_p \cdot NS_k \geq a_{ijkp}$ for passengers

where C_a = the cargo capacity of the ship (in freight-tons)

C_p = the passenger capacity of the ship

a_{ijkp} = the number of passengers to be moved on route "k" over arc (i, j).

Thirdly, the sum of the cargoes and passengers allocated to each route of the network at port "i" when exporting to port "j" must equal the amount to be exported. That is :-

$\sum_{k,j} a_{ijk} = a_{ij}$ and $\sum_{k,j} P_{ijk} = P_{ij}$ for routes 'k' serving (i, j)

Fourthly, the number of ships required must be less than, or equal to, the number available. That is :-

$\sum_{k} NS_k / NSMAX_k$ for k = 1, 2

where $NSMAX_k$ = 365/Journey time for round trip.

---

1. All variables are as defined in appendix , unless otherwise stated.

For both routes, the journey times were derived as follows :-

Journey time for route 1 = 2 (3 + 8(1)) = 22 days

" " " route 2 = (3 + 2 [7(1)] + 3) = 20 days

the journey times over each arc, including in-port time, being taken from table 22 of section 2.8.

Fifthly, the number of ship-journeys completed over any one route in carrying passengers must equal the number completed in carrying cargo. This is because cargo and passenger accommodation is provided on each of the two ships available.

2. The objective function

The revenue derived from the cargo and passengers carried, less the cost of carrying them should be maximised. That is :

$$\sum_{i,j,k} a_{ijk} \cdot v_{ijk} + \sum_{i,j,k} p_{ijk} \cdot v'_{ijk} - \left[\sum_{k} V_k \cdot NS_k + SH(CA+MX) \right]$$

where a_{ijk} = the amount of cargo to be exported annually from port "i" to port "j" over route "k"

v_{ijk} = the revenue derived from shipping one ton of cargo from port "i" to port "j" over route "k".

p_{ijk} = the number of passengers to be exported annually from port "i" to port "j" over route "k".

v_{ijk}' = the revenue derived from moving one passenger from port "i" to port "j" over route "k".

Other variables are as described in appendix N.

3. The data

The data derived relates to the revenue/ton, the capacity of the ships (C_a and C_p), the total flows of cargo and passengers (a_{ij} and p_{ij}), the cost per route (V_k), the number of ships available to the region (SH) and the maximum number of journeys that can be completed by one ship over any one defined route, and the fixed costs of shipping (SH $\left[CA + MX \right]$)

3.1 Revenue

The revenue per ton of cargo was derived as follows :-

$$v_{ijk} = 31.28 - 12.75\,(1 + 0.05)$$
$$= 17.89 \text{ \$ W.I. per freight-ton for } i, j = 1, 2 \ldots 10 \text{ \& } k = 1, 2$$

where 31.28 = the charge levied on the shipper

12.75 = the freight-handling cost

0.05(12.75) = the cost of commissions.

The revenue per passenger was derived as follows :-

$$v'_{ij} = 0.8\left(14.5(1-0.08)\right) + 0.2\left(P_{ij}\,(1 - 0.3)\right)$$

where 0.8 = the proportion of passengers carried on deck[2]

0.08 = commission and expenses

0.2 = the proportion of passengers carried in cabins[2]

14.5 = the average revenue per deck passenger per journey

v'_{ij} = the revenue per cabin passenger moved from the i^{th} port to the j^{th} port

0.3 = the proportion of cabin passenger revenue lost on victualling.

TableM.1 illustrates the results of these calculations

---

2. Accommodation exists for 200 deck passengers and 50 cabin passengers.

Exports \ Imports	Jam.	St.K.	Ant.	Mont.	Dom.	St.Luc.	Bar.	St.V.	Gren.	Trin.
Jamaica (1)	-	24.3	31.9	40.0	41.4	42.8	51.1	56	61.0	66.0
St. Kitts (2)	24.3	-	17.0	21.9	27.2	31.8	36.5	41.5	46.2	51.0
Antigua (3)	31.9	17.0	-	17.0	21.9	27.2	31.8	36.5	41.5	46.2
Montserrat (4)	40.0	21.9	17.0	-	17.0	21.9	27.2	31.8	36.5	41.5
Dominica (5)	41.4	27.2	21.9	17.0	-	17.0	21.9	27.2	31.8	36.5
St. Lucia (6)	42.8	31.8	27.2	21.9	17.0	-	17.0	21.9	27.2	31.8
Barbados (7)	51.1	36.5	31.8	27.2	21.9	17.0	-	17.0	21.9	27.2
St. Vincent (8)	56	41.5	36.5	31.8	27.2	21.9	17.0	-	17.0	21.9
Grenada (9)	61.0	46.2	41.5	36.5	31.8	27.2	21.9	17.0	-	17.0
Trinidad (X)	66.0	51.0	46.2	41.5	36.5	31.8	27.2	21.9	17.0	-

Source : Furness, Witby & Co. Ltd. (Nov. 1967)

The revenue per passenger (v'_{ij}). Table M.1

3.2 Ship capacity

The capacity of the ship can be expressed in terms of (C_a), the hold capacity in freight-tons and (C_p), the passenger capacity.

C_a = 1450 freight-tons[3]

C_p = 250 passengers[3] (50 cabin & 200 deck passengers)

3.3 Cargo & passenger movements

Tables M.2 and M.3 provide the estimates derived from ship returns.[3]

3. Source : I.S.E.R., (1964).

Exports \ Imports	Jam.	St.K.	Ant.	Mont.	Dom.	St.Luc.	Bar.	St.V.	Gren.	Trin.
Jamaica 1	-	2333	2203	836	1192	1307	3205	62	290	2912
St. Kitts 2	48	-	180	133	24	9	142	13	5	19
Antigua 3	112	96	-	66	33	13	146	5	20	156
Montserrat 4	5	6	12	-	3	2	18	1	1	47
Dominica 5	34	64	88	1	-	24	88	9	25	55
St. Lucia 6	60	23	8	12	10	-	63	5	12	51
Barbados 7	664	592	1088	1073	350	208	-	316	362	97
St. Vincent 8	44	50	101	82	50	15	35	-	35	29
Grenada 9	12	3	25	6	13	31	51	35	-	21
Trinidad X	3234	2768	4345	716	1901	1204	1438	543	730	-

1963 CARGO MOVEMENT (Freight-Tons) TABLE M.2

Exports \ Imports	Jam.	St.K.	Ant.	Mont.	Dom.	St.Luc.	Bar.	St.V.	Gren.	Trin.
Jamaica 1	-	219	83	14	54	56	208	63	47	598
St. Kitts 2	225	-	66	110	87	34	65	13	11	105
Antigua 3	96	92	-	207	316	236	155	20	29	298
Montserrat 4	13	84	201	-	42	8	35	2	10	39
Dominica 5	61	75	436	45	-	77	517	49	51	148
St. Lucia 6	63	35	335	5	86	-	1022	172	39	210
Barbados 7	192	89	142	22	385	1243	-	675	198	544
St. Vincent 8	68	7	18	2	39	116	600	-	226	1490
Grenada 9	61	12	56	13	59	54	230	201	-	4001
Trinidad X	589	108	244	9	122	256	601	1490	3271	-

1963 PASSENGER MOVEMENT (Passengers) TABLE M.3

3.4 The cost per journey over each route

These costs were derived from the equations

$$V_k = \left(\text{Bunkering cost/route + agency fees + port charges} \right)$$

V_1 = 305[4] + 340[4] + 1328 = 1973 \$ W.I.

V_2 = 305 + 340 + 1250 = 1890 \$ W.I.

Port charges per call (\$) are as follows, but exclude pilotage, towage and wharfage charges.

Jamaica (35), St. Kitts (10), Antigua (19), Montserrat (14), Dominica (15-5), St. Lucia (152), St. Vincent (160), Barbados (140), Grenada (15.5), and Trinidad (205).

3.5 The number of ships and journey frequency

Only 2 ships were available to the region, the number of journeys that could possibly be completed by these two ships being :-

$$NS_1/NSMAX_1 + NS_2/NSMAX_2 \leq SH$$

Now $NSMAX_k = 365/20 \simeq 18$ for $k = 1,2$ because journey time equals 20 days.

Hence $0.055\ NS_1 + 0.055\ NS_2 \leq 2$.

(In fact, $NSMAX_k = 13$ because each round journey takes 28 days, each ship spending 3-4 days alternatively in Jamaica and Trinidad over each weekend.)

3.6 The fixed costs of ship provision

These are given in terms of each ship in table M.4.

---

4. Derived from I.S.E.R. (1964), page 34.

TABLE M.4

COST ELEMENTS	YEAR 1963	
	M.V. Maple	M.V. Palm
Steward wages	$ 46,000	$ 47,000
Crew wages, subsistence	104,000	117,000
Officers salaries	77,000	74,000
Officers gratuities	16,000	14,000
Uniforms	1,000	2,000
Travelling	9,000	4,000
Victualling crew	48,000	50,000
Insurance	41,000	38,000
Unrecoverable insurance claims	5,000	5,000
Running repairs	12,000	21,000
Dry dock	21,000	22,000
Deck & engine stores	9,000	24,000
Radio maintenance	10,000	12,000
Laundry	5,000	6,000
TOTAL	$404,000	$438,000

4.0 The Linear Program

The Constraints

4.1 Journey frequency

NS1C + NS2C $\geqslant$ 26 $\equiv$ TIME 12C.

4.2 Shipping capacity

ARC 121C 1450.NS1C = A121C + A131C + A141C + A151C + A161C + A171C + A181C + A191C + A1X1C + S121

ARC 122C 1450.NS2C = A122C + A162C + A172C + A152C + A132C + A142C + A362C + A372C + A352C + A182C + A192C + A1X2C + A382C + A392C + A3X2C + A482C + A492C + A4X2C + A462C + A472C + A452C + A432C + A562C + A572C + A582C + A592C + A5X2C + S122C

ARC 241C 1450.NS1C = A241C + A231C + A251C + A261C + A271C + A281C + A291C + A2X1C + A141C + A131C + A151C + A161C + A171C + A181C + A191C + A1X1C + S241C

ARC 431C 1450.NS1C = A431C + A451C + A461C + A471C + A481C + A491C + A4X1C + A231C + A251C + A261C + A271C + A281C + A291C + A2X1C + A131C + A151C + A161C + A171C + A181C + A191C + A1X1C + S431C

ARC 351C 1450.NS1C = A351C + A361C + A371C + A381C + A391C + A3X1C + A451C + A461C + A471C + A481C + A491C + A4X1C + A251C + A261C + A271C + A281C + A291C + A2X1C + A151C + A161C + A171C + A181C + A191C + A1X1C + S351C

ARC 561C 1450.NS1C = A561C + A571C + A581C + A591C + A5X1C + A361C + A371C + A381C + A391C + A3X1C + A461C + A471C + A481C + A491C + A4X1C + A261C + A271C + A281C + A291C + A2X1C + A161C + A171C + A181C + A191C + A1X1C + S561C

ARC 671C   1450.NS1C = A671C + A681C + A691C + A6X1C + A571C + A581C + A591C + A5X1C + A471C + A481C + A491C + A4X1C + A371C + A382C + A391C + A3X1C + A271C + A281C + A291C + A2X1C + A171C + A181C + A191C + A1X1C + S671C

ARC 672C   1450.NS2C = A672C + A572C + A472C + A372C + A272C + A172C + A682C + A582C + A482C + A382C + A282C + A182C + A692C + A592C + A492C + A392C + A292C + A192C + A6X2C + A5X2C + A482C + A3X2C + A2X2C + A1X2C + A132C + A142C + A152C + A232C + A242C + A252C + A432C + A452C + A352C + S672C

ARC 781C   1450.NS1C = A181C + A281C + A381C + A481C + A581C + A681C + A781C + A191C + A291C + A391C + A491C + A591C + A691C + A791C + A1X1C + A2X1C + A3X1C + A4X1C + A5X1C + A6X1C + A7X1C + S781C

ARC 782C   1450.NS2C = A182C + A282C + A382C + A482C + A582C + A682C + A782C + A192C + A292C + A392C + A492C + A592C + A692C + A792C + A1X2C + A2X2C + A3X2C + A4X2C + A5X2C + A6X2C + A7X2C + A132C + A232C + A142C + A242C + A152C + A252C + A432C + A452C + A352C + S782C

ARC 891C   1450.NS1C = A191C + A291C + A391C + A491C + A591C + A691C + A791C + A891C + A1X1C + A2X1C + A3X1C + A4X1C + A5X1C + A6X1C + A7X1C + A8X1C + S891C

ARC 892C   1450.NS2C = A892C + A792C + A692C + A592C + A492C + A392C + A292C + A192C + A8X2C + A132C + A7X2C + A6X2C + A5X2C + A4X2C + A3X2C + A2X2C + A1X2C + A142C + A152C + A232C + A242C + A252C + A432C + A452C + A352C + S892C

ARC 9X1C   1450.NS1C = A9X1C + A8X1C + A781C + A6X1C + A5X1C + A4X1C + A3X1C + A2X1C + A1X1C + S9X1C

ARC 9X2C   1450.NS2C = A9X2C + A8X2C + A7X2C + A6X2C + A5X2C + A4X2C + A3X2C + A2X2C + A1X2C + A132C + A142C + A152C + A232C + A242C + A252C + A432C + A452C + A352C + S9X2C

ARC 262C 1450.NS2C = A132C + A142C + A152C + A162C + A172C + A182C + A192C + A1X2C + A232C + A242C + A252C + A262C + A272C + A282C + A292C + A2X2C + A432C + A452C + A462C + A472C + A482C + A492C + A4X2C + A352C + A362C + A372C + A382C + A392C + A3X2C + A572C + A582C + A592C + A5X2C + S262C

ARC X91C 1450.NS1C = AX91C + AX81C + AX71C + AX61C + AX51C + AX41C + AX31C + AX21C + AX11C + SX91C

ARC X92C 1450.NS2C = AX82C + AX72C + AX62C + AX52C + AX42C + AX32C + AX22C + AX12C + AX92C + A352C + A432C + A452C + A242C + A252C + A132C + A142C + A152C + SX92C+ A232

ARC 981C 1450.NS1C = AX81C + AX71C + AX61C + AX51C + AX41C + AX31C + AX21C + AX11C + A981C + S981C + A971C + A961C + A951C + A941C + A931C + A921C + A911C

ARC 982C 1450.NS2C = AX82C + AX72C + AX62C + AX52C + AX42C + AX32C + AX22C + AX12C + A982C + A972C + A962C + A952C + A942C + A932C + A922C + A912C + A132C + A142C + A152C + A232C + A242C + A252C + A432C + A452C + A352C + S982C

ARC 871C 1450.NS1C = AX71C + AX61C + AX51C + AX41C + AX31C + AX21C + AX11C + A971C + A961C + A951C + A941C + A931C + A921C + A911C + A871C + A861C + A851C + A841C + A831C + A821C + A811C + S871C

ARC 872C 1450.NS2C = AX72C + A X62C + AX52C + AX42C + AX32C + AX22C + AX12C + A972C + A962C + A952C + A942C + A932C + A922C + A912C + A872C + A862C + A852C + A842C + A832C + A822C + A812C + A132C + A142C + A152C + A232C + A242C + A252C + A432C + A452C + A352C + S872C

ARC 761C 1450.NS1C = AX61C + AX51C + AX41C + AX31C + AX21C + AX11C + A961C + A951C + A941C + A931C + A921C + A911C + A861C + A851C + A841C + A831C + A821C + A811C + A761C + A751C + A741C + A731C + A721C + A711C + S761C

ARC 762C 1450.NS2C = AX62C + AX52C + AX42C + AX32C + AX22C + AX12C + A962C + A952C + A942C + A932C + A922C + A912C + A862C + A852C + A842C + A832C + A822C + A812C + A762C + A752C + A742C + A732C + A722C + A712C + A132C + A142C + A152C + A232C + A242C + A252C + A432C + A452C + A352C + S762C

ARC 651C   1450.NS1C = AX51C + AX41C + AX31C + AX21C + AX11C + A951C + A941C + A931C + A921C + A911C + A851C + A841C + A831C + A821C + A811C + A751C + A741C + A731C + A721C + A711C + A651C + A641C + A631C + A621C + A611C + S651C

ARC 652C   1450.NS2C = AX52C + AX42C + AX32C + AX22C + AX12C + A952C + A942C + A932C + A922C + A912C + A852C + A842C + A832C + A822C + A812C + A752C + A742C + A732C + A722C + A712C + A652C + A642C + A632C + A622C + A612C + A132C + A232C + A142C + A242C + A152C + A252C + A432C + A452C + A352C + S652 C

ARC 531C   1450.NS1C = A531C + A631C + A731C + A831C + A931C + AX31C + A541C + A641C + A741C + A841C + A941C + AX41C + A521C + A621C + A721C + A821C + A921C + AX21C + A511C + A611C + A711C + A811C + A911C + AX11C + S531C

ARC 532C   1450.NS2C = A532C + A562C + A572C + A582C + A592C + A5X2C + A512C + A522C + A542C + A642C + A632C + A622C + A612C + A742C + A732C + A722C + A712C + A842C + A832C + A822C + A812C + A942C + A932C + A922C + A912C + AX42C + AX32C + AX22C + AX12C + A132C + A142C + A232C + A242C + A432C + S532C

ARC 341C   1450.NS1C = A341C + A541C + A641C + A741C + A841C + A941C + AX41C + A321C + AX11C + A521C + A621C + A721C + A821C + A921C + AX21C + A311C + A511C + A611C + A711C + A811C + A911C + S341C

ARC 342C   1450.NS2C = A312C + A322C + A342C + A352C + A362C + A372C + A382C + A392C + A3X2C + A512C + A522C + A542C + A562C + A572C + A582C + A592C + A5X2C + A612C + A622C + A642C + A712C + A722C + A742C + A812C + A822C + A842C + A912C + A922C + A942C + AX12C + AX22C + AX42C + A142C + A242C + S342C

ARC 421C   1450.NS1C = A311C + A411C + A511C + A611C + A711C + A811C + A911C + AX11C + A321C + A421C + A521C + A621C + A721C + A821C + A921C + AX21C + S421C

ARC 422C   1450.NS2C = A412C + A422C + A432C + A452C + A462C + A472C + A482C + A492C + A4X2C + A312C + A322C + A352C + A362C + A372C + A382C + A392C + A3X2C + A512C + A522C + A562C + A572C + A582C + A592C + A5X2C + A612C + A622C + A712C + A722C + A812C + A822C + A912C + A922C + AX12C + AX22C + S422C

ARC 211C 1450. NS1C = A211C + A311C + A411C + A511C + A611C + A711C + A811C + A911C + AX11C + S211C

ARC 212C 1450.NS2C = A212C + A312C + A352C + A362C + A372C + A382C + A392C + A3X2C + A412C + A432C + A452C + A462C + A472C + A482C + A492C + A4X2C + A512C + A562C + A572C + A582C + A592C + A5X2C + A612C + A712C + A812C + A912C + AX12C + S212C

The above equations are repeated by replacing 1450 with 250 & "C" with "P".

4.3 The Trade Flow Equations

A121C + A122C = 2333 = A12C A121P + A122P = 219 = A12P

A131C + A132C = 2203 = A13C A131P + A132P = 83 = A13P

AX91C + AX92C = 730 = AX9C AX91P + AX92P = 3271 = AX9P

The values of AIJC and AIJP were taken from table S.2 and table S.3

4.4 Ship Availability

$0.055\ NS1C + 0.055\ NS2C \leqslant 2 \equiv SHIPNUMC$ $0.055NS1P + 0.055NS2P \leqslant 2 \equiv SHIPNUMP$

4.5 Ship-Journeys

NS1C - NS1P = 0

NS2C - NS2P = 0

4.6 The Objective Function

$$\text{MAXIMIZE} - 1973(\text{NS1C} + \text{NS1P}) - 1890(\text{NS2C} + \text{NS2P}) + 17.9 \sum_{\text{ALL I,J,K,I} \neq \text{J}} \text{AIJKC} + \Big[24.3(\text{A121P} + \text{A122P}) + 31.9(\text{A131P} + \text{A132P}) + \ldots\ 17.0(\text{AX91P} + \text{AX92P})\Big].$$

The AIJKP coefficients are given in TableL.1.

5.0 The results obtained from the transport model

Variable Name	Value	Variable Name	Value
COST	£209,068	S342C	25286.5
NS1C }	2.132	S421C	3085.3
NS1P }		S422C	28122.5
NS2C }	25.208	S211C	3091.3
NS2P }		S212C	31670.5
S121C	3091.3	S121P	382.0
S122C	21553.5	S122P	3437.0
S241C	3082.3	S211P	533.0
S431C	3082.3	S212P	3240.0
S351C	3082.3	S241P	119.0
S561C	3082.3	S262P	3428.0
S671C	3091.3	S341P	533.0
S672C	24691.5	S342P	2851.0
S781C	3091.3	S351P	34.0
S782C	27472.5	S421P	449.0
S891C	3056.3	S422P	3047.0
S892C	27854.5	S531P	533.0
S9X1C	3091.3	S532P	2753.0
S9X2C	31460.5	S561P	533.0
S262C	23370.5	S651P	533.0
SX91C	380.3	S652P	3541.0
SX92C	17767.5	S671P	533.0
S981C	1075.3	S672P	2948.0
S982C	17626.5	S761P	533.0
S871C	1653.3	S762P	2396.0
S872C	17249.5	S781P	533.0
S761C	3091.3	S782P	2981.0
S762C	13360.5	S871P	533.0
S651C	3091.3	S872P	3038.0
S652C	14705.5	S891P	533.0
S531C	3091.3	S892P	2259.0
S532C	17893.5	S981P	533.0
S341C	3091.3	S982P	2197.0
		SX91P	145.0

The results Table L.5

These results provide a non-integer solution, where two ships are allocated to two routes NS_1 and NS_2 but one ship is only required to complete 2.13 journeys over route 1 before transferring to the second route for the rest of the year. This is unrealistic. An integer solution would allocate both ships to route 2 to produce the cheapest solution. The utilisation of each ship over each arc can be derived from the results given in table L.5. The annual capacity provided between any two ports (i, j) is equal to :-

1450 NS_k for cargo

250 NS_k for passengers.

The unused capacity between any two ports (i, j) over route "k" is equal to :-

S_{ijkc} for cargo

S_{ijkp} for passengers

The results given in table L5 are illustrated in figures L.1 and L.2.

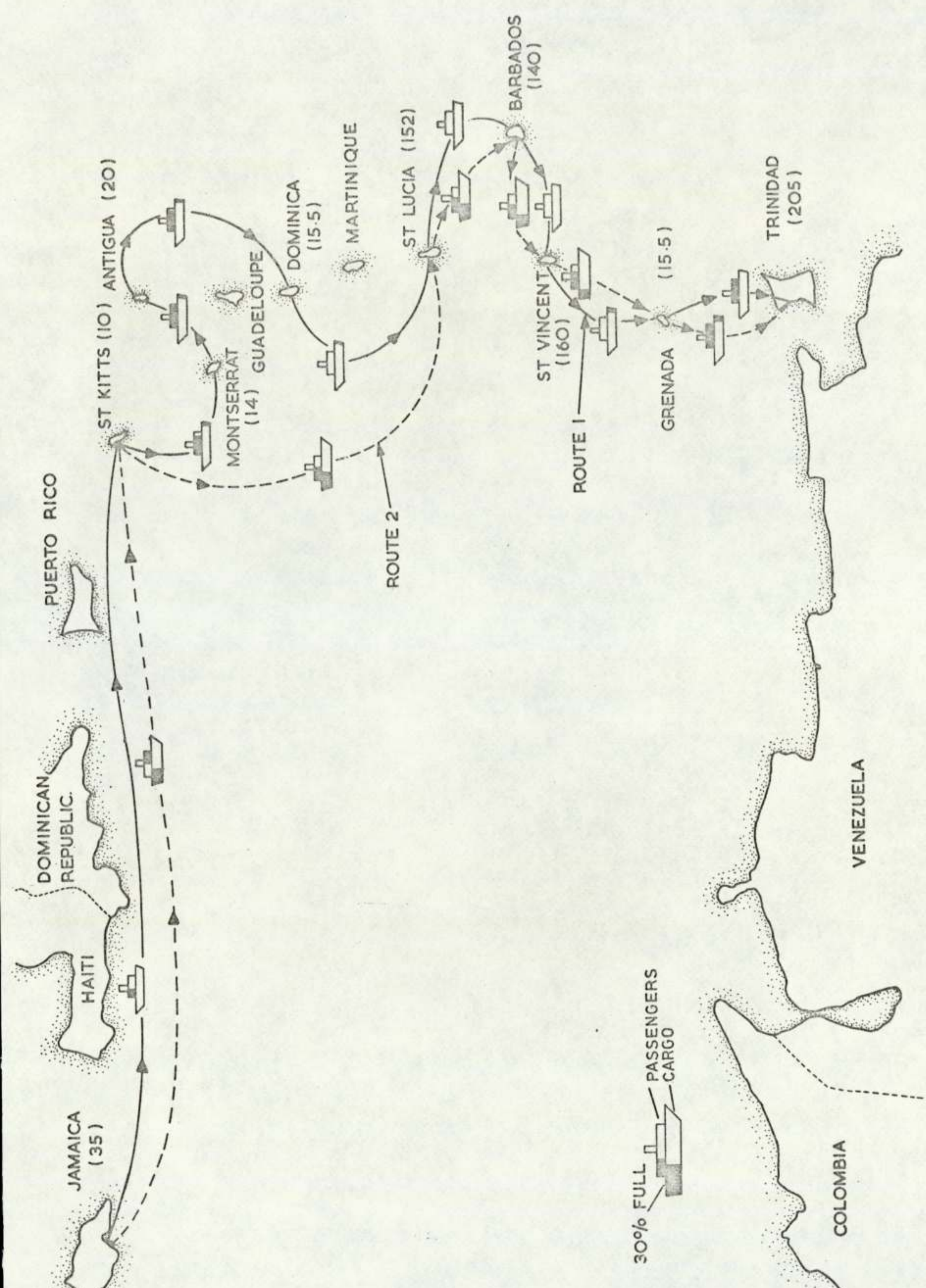
6.0 Other calculations

6.1 The annual costs of ship operation

The fixed annual cost of operating two ships was derived from table S.4. The variable costs were derived from the equation $NS_k V_k''$ where V_k'' is the cost per journey. It comprises those cost elements listed below.

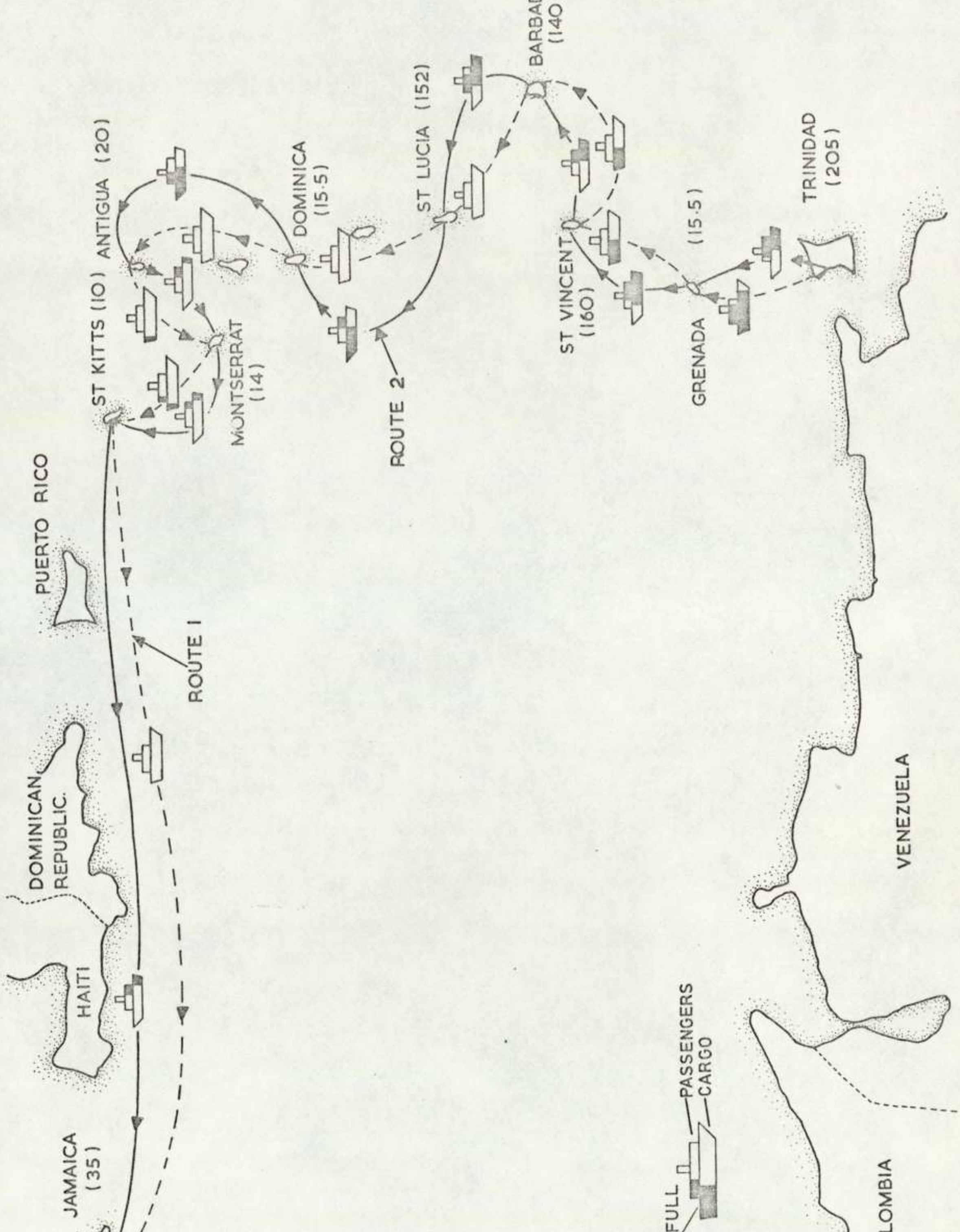
- Cost per ship-journey (i.e. the bunkering costs, agency fees and ports costs associated with the journey over route "k").
- (Number of passenger ports)x(ferry costs per port)
- (Number of passenger and cargo ports)x(pilotage, wharfage & related fees.)

Thus, the costs of each alternative route schedule (illustrated in figure L.3) was derived as shown in table L.6.



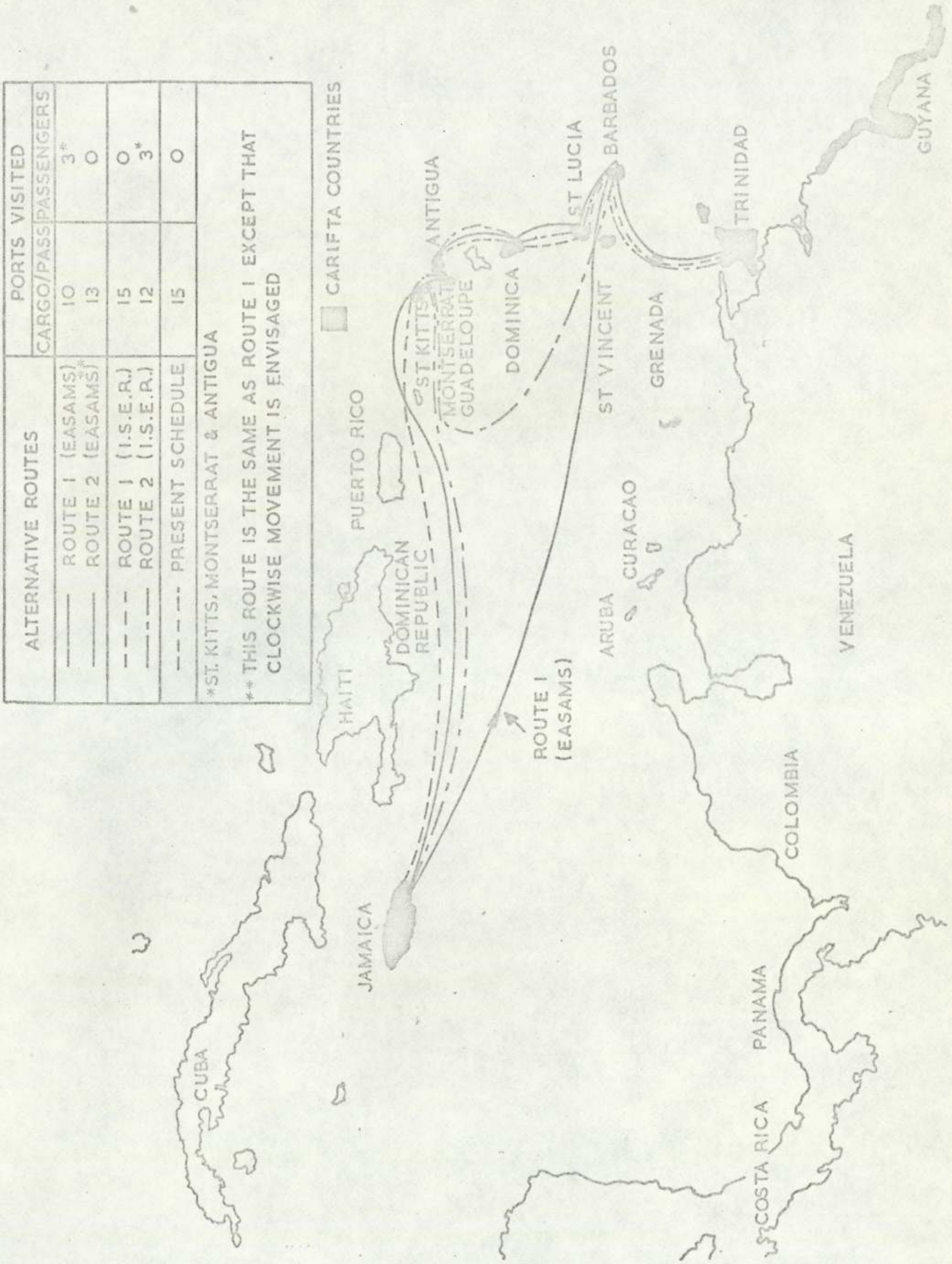
SOLUTION DERIVED BY THE TRANSPORT MODEL
(SOUTHBOUND JOURNEYS)

Fig.M.I.



SOLUTION DERIVED BY THE TRANSPORT MODEL
(NORTHBOUND JOURNEYS)

FigM.2.



ROUTE SCHEDULES COMPARED

Fig.M·3

Route Schedules[1]		Ports Visited		Passenger	Port Costs	
		Cargo & Passengers	Passengers Only	Ports	Cargo/ Pass.	Pass.
Present (Both ships)		15	0	St. Kitts		
EASAMS	Ship 1	13	0	Antigua	$435[2]	$50[3]
	Ship 2	10	3			
I.S.E.R.	Ship 1	15	0	Montserrat		
	Ship 2	12	3			

1. In all cases, there were 14 journeys per route.
2. Pilotage, wharfage & towage dues.
(Only the figures for Trinidad could be obtained.)
3. Given by I.S.E.R., (1964).

Alternative Route Schedules TableM. 6

The cost per ship-journey for each defined route was calculated in relation to the ports visited. The resulting total cost of each alternative was then derived.

Alternative		Cost Per Ship-Journey	Total Costs ($)	
Present		8483 $ W.I.	2(14)(8483) = $237,500	
I.S.E.R.	Route 1	8483	14(8483)	233,200
	Route 2	7260	14(7260)	
EASAMS	Route 1	6262	14(6262)	191,200
	Route 2	7412	14(7412)	

The "Variable Costs" of alternative schedules. TableM. 7

6.2 Passenger Freight Rates

A general equation was derived as follows

$$FR_{ijk} = \left[\frac{CT'_k . D_{ij}}{Kc \sum_{\text{All } i,j} (D_{ij} . a_{ijc})} + \frac{(V_k + V_{kc}')}{C_{kc}} \right]^{5}$$

where FR_{ijk} = the freight rate per unit carried (a measurement-ton of cargo or one passenger) from port 'i' to port 'j' over route "k".

CT'_k = the cost of providing the ton-miles and/or passenger-miles per year

K_c = a constant, equal to $(1 - K_p)$ where $1/K_c$ is the proportion of CT_k attributable to cargo (c) transport provision.

D_{ij} = the journey distance between port "i" and port "j".

a_{ijc} = the measurement-tons of cargo moved annually between ports "i" and "j".

a_{ijp} = the number of passengers moved annually between ports "i" and "j".

V_k = the cost incurred in completing one ship-journey over route "k".

V_k' = the pilotage, berthing and wharfage costs incurred in completing route "k". (This cost is only incurred when a ship has to visit a port to collect or deposit cargo.)

C_{kc} = the annual cargo capacity of the ship operating over route "k".

The term CT_k/K_c represents the cost of providing $\sum_{\text{All } i,j} a_{ijc} . D_{ij}$ ton-miles of capacity over route "k" per year. The proportion of capacity used by

---

5. To calculate passenger freight-rates, substitute the subscript "c" for subscript "p".

cargo when moved from port "i" to "j" being $D_{ij} / \sum_{\text{All } ij} a_{ijc} . D_{ij}$.

The second term is the cost of transport provision (the shadow-price) which is obtained as a by-product of solving the transport problem. Thus, freight rates are related to the routes served, for if these are changed the number of ships required (and hence CT_k) would also change.

The passenger fares from Antigua to other ports were derived as follows :-

$$CT_k = (CA + MX) + NS_k . (V_k + V'_{kc})$$
$$= (404,000 + 438,000) + 28\left(1973 + 435(15)\right)$$
$$= 842,000 + 237,500$$

$1/Kc$ = 0.5 (Chosen arbitrarily)[6]

$\sum_{\text{All } i,j,c} D_{ij} . a_{ijc}$ = 24,172,324 from table M.2 and the inter-port distance matrix given in appendix G.

$\sum_{\text{All } i,j,p} D_{ij} . a_{ijp}$ = 5,856,401 from table M.3 and the inter-port distance matrix given in appendix G.

V_k / C_{kp} = 1973/250 = \$7.9

The resulting passenger fares derived from these figures are given in table M.8

---

6. If the primary purpose of the shipping route schedules, as agreed by the signatories, is to carry inter-island cargo (passenger business being incidental to the operation of the service) then $1/K_c$ would be unity.

Table M.8

Ports Served		Freight Rates $ (W.I.)		
Antigua to :-		Existing	Calculated[2]	Calculated[1]
Jamaica	(906)[3]	31.9	518.0	831.0
St. Kitts	(60)	17.0	31.1	50.0
Montserrat	(40)	17.0	20.6	33.5
Dominica	(109)	21.9	56.6	91.0
St. Lucia	(198)	27.2	102.2	165.0
Barbados	(285)	31.8	150.2	242.5
St. Vincent	(252)	36.5	131.6	211.0
Grenada	(317)	41.5	164.2	265.0
Trinidad	(402)	46.2	210.0	347.0[4]

1. Based on the total cost of transport operation and provision.
2. Based on (1) less the proportion paid by the subsidy.
3. Inter-port distances are given in brackets.
4. $V_k / C_{kp} \simeq 8$ $(W.I.), the only link over which the marginal cost is applied.

The lower freight rate was obtained by multiplying the figures in the third column by 0.621 (the proportion of the cost recovered from freight and passenger revenue).

APPENDIX N

IMPLEMENTATION AND OPERATION[1]

Although these two stages are outside the scope of the present study, the author felt that the report would be incomplete if omitted completely. No systems study is worthwhile unless it leads to positive action and results in the recommended system being properly implemented. After completing the activities illustrated in figure N.1 which are described in the body of the report, five important activities must be undertaken to conclude a systems study. These are :

Documentation and sanction approval
Construction
Initial operation
Retrospective appraisal
Improved operation

1. Documentation and sanction approval.

Normally a report or prospectus is prepared which provides :-

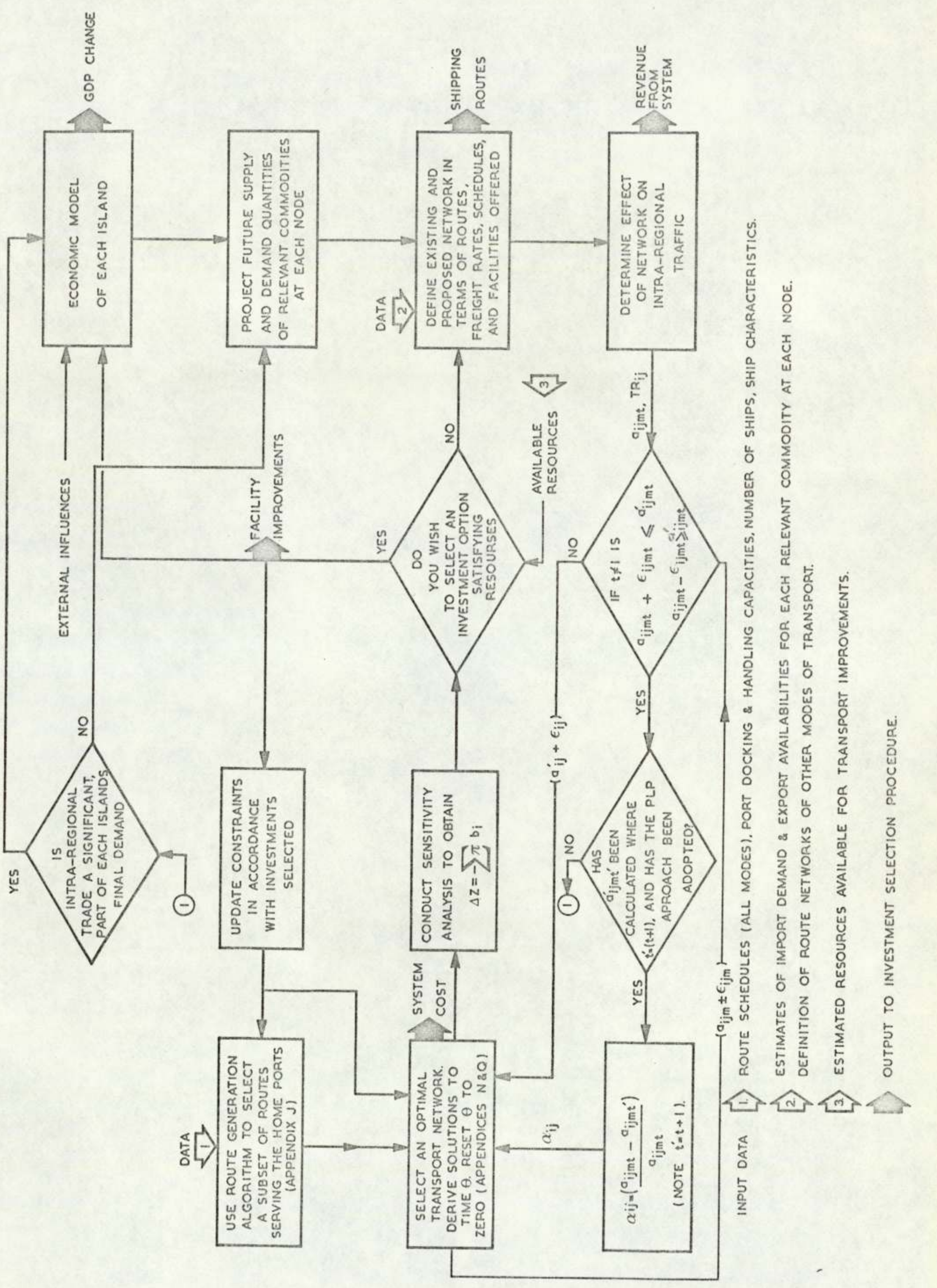
- a brief history of the problem and the reasons why a solution (or improvement) is desirable at this time.
- a summary of the main conclusions and benefits of the study
- a summary of the recommendations, including an overall figure for the savings and the cost of implementing them.

In more detail, this prospectus will provide :

- A description of the overall economic criterion, and a justification for it.
- A complete specification of the requirements, including detailed data illustrating the demand for the system.
- Environmental factors which have an influence on the design of the system (physical, economic and social). These factors should be ranked, the system inputs and outputs derived from these factors being listed, classified and described.

---

1. The description that follows is largely based on(Jenkins, 1969)and (Hall, 1960)



THE DESIGN CYCLE

Fig N.I.

- A list of features wanted in the new system
- A list of constraints and tolerances
- A description of the system plan. This should include :-
  - An introductory functional description of the proposed system that will satisfy the requirements, meet the objectives, and match the environment, explaining how the system is to operate on its inputs to produce the wanted outputs.
  - Supporting technical and theoretical texts which are necessary to understand the basic principles of the proposed system.
  - A complete description of the new system and its planned evolution over time, illustrating detailed objectives and requirements. Block diagrams, pictures of system models, and references to schematic drawings are normally brought in here.
- An estimate of system cost, savings, profit, or other primary measure of evaluating system alternatives.
- A discussion of alternative systems, why they were not chosen, and their preference ordering.
- An estimate of development resources in time, number, and kinds of manpower, facilities and staff support. The most desirable build-up and decay of these resources should also be estimated.
- A schedule giving estimated dates for various stages of development, production, trials, and deliveries. Various techniques may be used to designate the sequence of critical activities so that the whole system can be constructed in working by its scheduled completion date.

2. Construction

Once a decision has been made to implement the system improvement, EASAMS, in conjunction with the Carifta Secretariat and island/port authorities would discuss the method of project control to be adopted. Full co-operation may not be possible with all developers but an indication of progress (as it affects the master plan) would probably still be possible. Full co-ordination of priority projects should be possible if a condition of the financiers approval to the developers was their agreement to co-operate as required.

Once agreement had been reached with the Secretariat and islands on the projects and the nature and extent of the progress reporting system, the necessary control system would be implemented.

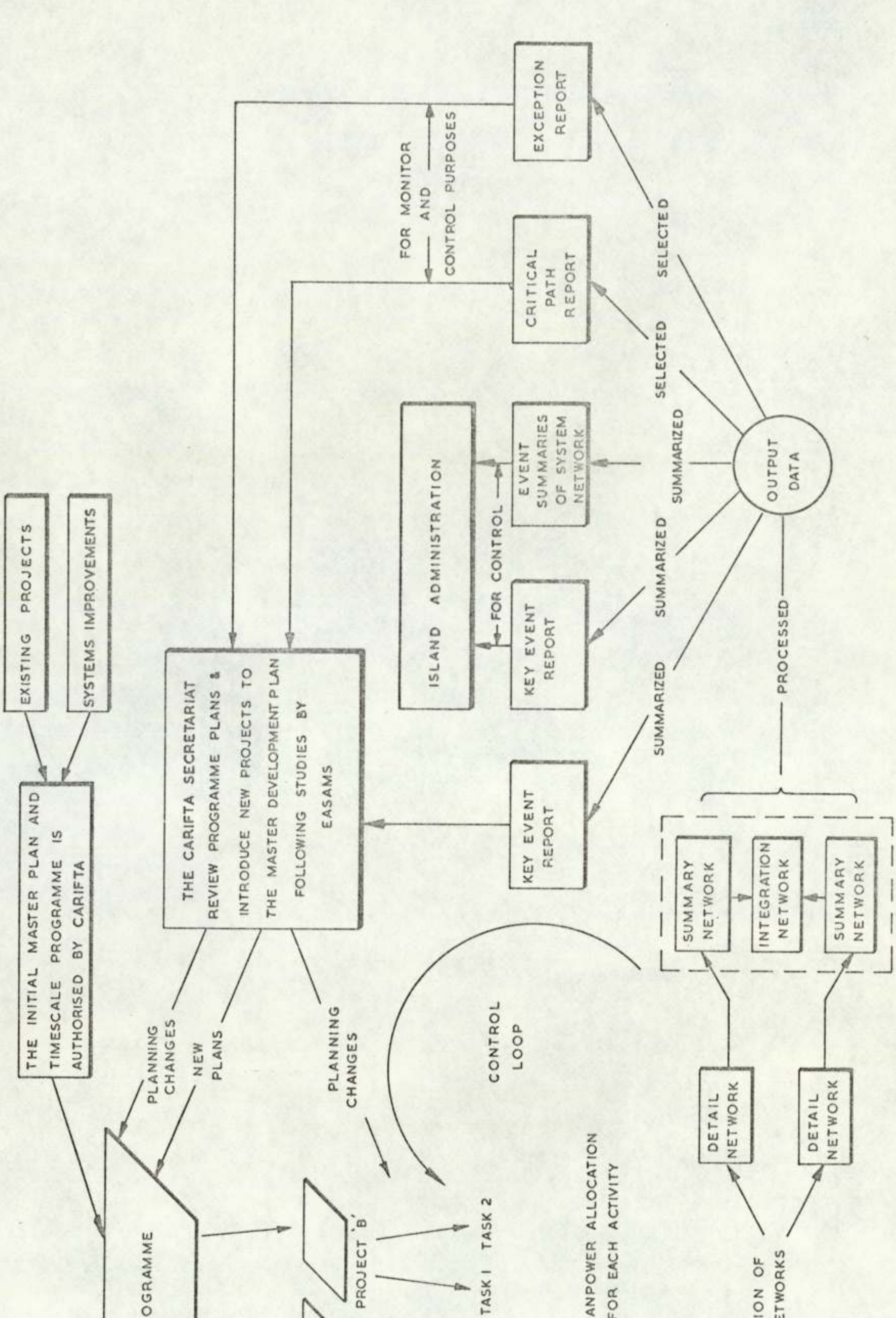
An outline of a basic system and its up-dating cycle is illustrated in figure N.2.

The initial programme plans established form the starting point of the whole cycle. The programme would indicate the timescales to completion of each project, the effect of one project on the other having been considered in relation to the whole programme. This programme is then broken down into projects, and tasks within each project so that compatible time, cost and resource requirements can be established for each activity. Detail networks (work plans) are prepared for each task required to complete the projects and programme originally defined. The detail networks established for the programmes can then be periodically processed to provide progress reports on the programme as the work proceeds. The Carifta Secretariat and island/port authorities would review such progress periodically while introducing planning changes or new plans to the system. Detail networks would be up-dating from information fed via the island/port authorities to the Carifta Secretariat.

The system provides means for numerous and diverse elements of the plan to be brought together and integrated into one large programme. It will handle in addition to time scheduling, the means for allocation of resources and costs. The system will provide information by simulating proposed decisions and their effect on the overall programme, to aid objective decision making by the Carifta Secretariat.

The important features of this approach are:

- The three elements of planning, time, resources and costs are integrated. (Only key events or selected reports are fed to the Secretariat while project and task reports are fed to the port authorities.
- The programme recognises the need for more than one level of



THE PROGRESS REPORTING SYSTEM.

Fig.N.2.

management reporting, i.e. the islands and the Carifta Secretariat.

3. Initial operation

Effective liaison between the systems team and the users of the system is essential if the full benefits of the systems study are to be realised. As one of the users of the operational system is normally involved as a member of the systems team, liaison should not be too difficult. If adequate communication between the systems team and the users is maintained, any defects or misunderstandings can be quickly resolved.

4. Retrospective appraisal of the project

If, after a sufficiently long period, the system is shown to be working according to plan, the original systems thinking will have been vindicated. On the other hand, the retrospective appraisal may show that :

- the original systems study has overlooked certain factors, or
- the system has had to operate in an environment which is different from that for which it was designed.

5. Improved operation

Improved operation of the system will only be needed :-

- if the retrospective appraisal of the system shows that actual performance is falling short of plan, or
- in certain cases, because certain parameters can only be optimised when operational experience has been obtained.

The system can then be "tuned" to its environment, which will lead to improved operation. If the retrospective appraisal shows that re-optimisation is necessary, the systems engineering work at the design stage may have to be re-examined. In normal cases, this should not be necessary, for the earlier sensitivity analyses should have eliminated such a possibility.