TRANSPORTATION AND REGIONAL INTEGRATION IN THE CARIBBEAN

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ABSTRACT

This dissertation presents for the Caribbean a normative theory of interisland transport which combines premises drawn from Caribbean experience with the notion of distance to arrive at a view of the way in which transportation might have influenced the development of a regional economy. It seeks to show how the introduction of new forms of transportation would affect the relationship of individual islands to the region, and their chances of becoming centres of economic activity for the region as a whole.

The developments in interisland shipping in the Caribbean since 1954 are then interpreted in the light of the ideas presented and an attempt is made to trace the relationship between transportation development and inequalities of trade up to 1970. The year 1955 saw the beginning of a regional shipping service for which island governments were fully responsible, and is therefore considered the point at which regional transportation policy could begin to be held accountable for later developments. To estimate the likely effects of changes in transportation arrangements, Markov chain estimates of the outcome in the absence of change were made. Comparisons with the actual changes in trade allowed a judgment of the relationship between interisland transportation and regional inequality. The findings indicated that initial endowment accounted for far less, and transportation change for more of the subsequent inequalities of trade than has been accepted in the past.

SOMMAIRE

La présente thèse propose une théorie normative de transports interinsulaires pour les Caraïbes. Des prémisses tirées de l'expérience caraïbe ont été associées au facteur distance afin d'établir la façon dont les transports auraient pu agir sur le développement d'une économie régionale. Notre théorie vise à démontrer de quelle manière l'introduction de nouveaux moyens de transport modifierait les rapports d'une île particulière avec la région et les possibilités que l'île pourrait avoir de devenir le centre économique de la région entière.

L'évolution du commerce maritime aux Caraïbes de 1954 à 1970 est interprétée selon cette conception et on cherche à expliquer le lien entre le développement des transports et le déséquilibre des échanges. L'année 1955 a vu la mise sur pied d'un service maritime régional dirigé par les gouvernements insulaires eux-memes: c'est à cette date que la politique régionale des transports peut être considérée comme responsable de certains développements. Pour déterminer les effets possibles des modifications au réseau de transports maritimes, on a formulé les probabilités en termes de chaînes de Markov. Des comparaisons établies entre ces hypothèses et les transformations réelles du commerce maritime nous ont permis de juger des rapports entre les transports interinsulaires et les inégalités régionales. On conclut, contrairement à la pensée contemporaine, que le déséquilibre des échanges ressort moins des conditions naturelles favorables que des changements dans la structure des transports.

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He had tried before to get a better picture,
to see the bigger light....

Austin Clarke, The Bigger Light, p. 187

INTRODUCTION

The efforts to pursue some form of economic integration in the Commonwealth Caribbean in the post-war period have brought to the fore the problem of distance and isolation. In particular, fundamental questions have been raised about the location of facilities and, more recently, industries; about the nature of interisland transport, and about the widening gap between the units of the region. Despite these long-standing problems and the volume of literature which has been published on the question of integration, there is as yet no explicit treatment of the effects of distance on any of these problems in the Caribbean.

The process of integration is, in the broadest sense, a reorganisation of space, a re-ordering of the effects of distance, or, as Janelle has shown, a changing of place utilities by means of innovations in transport.[1] In the interisland context of the Caribbean, therefore, any attempt at integration should be based on a thorough understanding of the characteristics of distance inherent in the system which the process of economic integration is geared to transform. The central proposition here is that economic integration of the Caribbean implies a spatial integration which, we shall argue, will derive its logic from the manner in which transport innovations and structures are used to change the utilities of places in the system. In attempting to explore the effects of distance on the pattern of location, to specify the appropriate structural properties of the inter-island shipping network, and the tendencies towards regional equality or inequality, this thesis makes its contribution to the literature on Caribbean economic development.

In terms of conventional transportation geography, this is an attempt to explore the way in which transport can be used to achieve the goals of society. It, therefore, is a study which responds to the question--for what purpose transport? In a recent survey of transportation geography,[2] Elliot Hurst noted two tendencies in published work. First, there has been a relative sophistication of the technical analysis of transportation structures, principally through the use of graph theory in network analysis, linear programming, and its extensions. Secondly, there has been extensive treatment of the functional aspect of transport and its association with economic development. The major limitation he noted was the absence of research aimed at exploring the notion of purpose in transport development. The purpose of individual transport networks, or how societies harness transport to achieve national goals represent, in his view, the points of departure for significant new research in the geography of transportation. The absence of techniques to deal with the question of purpose could hardly be surprising, since this requires a study of <u>policy</u> over the long term and does not offer the degree of precision befitting the sophisticated analysis which techniques developed for the analysis of "problems" in the short term make possible. In exploring the relationship between interisland transport and the regional goals of the Caribbean, this thesis offers some insight into these problems for a particular society in the post-war period. It deals entirely with the long-term effects of policy, for the short-term problems of interisland transport i.e. level of freight rates, etc. have received attention from official bodies in the Caribbean. In this way a contribution is made to that knowledge which is necessary for the formulation of a more general theory of transport and society so lacking at the present time.

Organisation of the thesis

The present thesis asks not how does society resolve a transport problem, but rather how does transport serve to resolve problems of society--in this case, regional integration and inequality. To deal with equality and inequality raises the problem of justice, which is a normative question. Like other discussions of justice, this thesis presents a normative theory--one of interisland transport. But normative theory is by definition unverifiable, in that it outlines only what ought to exist. Its use as an interpretive device can be justified to the extent that its premises can be shown to be relevant. Chapter One of this thesis therefore examines developments in the Caribbean so as to derive meaningful premises for a theory of interisland transport, and to specify the economy to which the theory refers. Now any theory of transport embodies, implicitly or explicitly, a theory of location. Hence the normative theory presented in Chapter Two of this thesis is a theory of interisland transport and location, but the propositions on location are dependent on those about transport. By inverting some of the normative arguments, an attempt is made to derive the degree of choice associated with some of the rigid theoretical propositions, for, as Harvey points out, "particular theories or models are not in themselves status quo, revolutionary or counter-revolutionary, but only assume a status by virtue of the kind of analytical framework they provide."[3]

In Part Two the primary data on interisland shipping are analysed and interpreted in the light of the theory presented. The year 1954 is important as it represents the end of the old system and the beginnings of regional government activity in interisland transport. The network existing in 1954 is reconstructed as a base from which to discuss the changes that followed. The main stages of government activity and network change since 1954 are then outlined and traced up to 1970, as are certain aspects of the location of activity. These form the basis of the discussion in Chapter Six of the patterns of flow and the tendencies towards inequality which have emerged since 1954. This pattern is then compared with patterns derived from a Markov chain analysis, in which the matrix of the transport network of 1954 is used to generate probability matrices whose limiting vectors describe the tendencies inherent in the transport network before the changes after 1954. The transition probabilities are derived from this matrix in a number of ways and the limiting distributions are compared with the actual distribution of trade. From these, an assessment is made of the likely effect of the changes in transport on the inequalities of inter-regional trade.

LITERATURE REVIEW

Caribbean Shipping: 1945-71

Moyne Commissioners 1945.--Although political and economic integration have been a central concern of politicians and academics in the Caribbean over the last twenty years, the study of transport has only recently commanded any attention. The Moyne Commissioners reported in 1945 on the state of interisland transport and made recommendations.[4]

Caribbean Commission, 1950-56.--Little action on shipping seems to have followed the Commissioners' Report. But the Caribbean Commission attempted an inventory of resources available to Caribbean traders in the early 50's. Two publications emerged: one, a summary of problems in interisland transport which highlighted the situation, and the other the results of all available information.[5] This survey represents the best data for the early 50's and, while much pertinent information is missing, seems unlikely to be surpassed. Its reliability is considered the best that can be expected for the early 50's, the more so because of its source. At that time, the Caribbean Commission was engaged in a series of surveys of various aspects of the economies of the region.

Further light is thrown on the network of the 50's by Doran in an article published in 1964.[6] He examined registries in the Leewards for 1957 and his data give some details for 1956, mainly for registrations and tonnages, coupled with flow diagrams for December 1956.

The Federal Period 1956-62.--The attempt to establish a federation highlighted the problem of interisland transport. Canada's gift to the "new nation" of two ships made it possible for a scheduled service to be attempted. Out of this came a study of freight rates which attempted to outline a reasonable freight rate structure.[7] Little had been attempted in this field before, inasmuch as there had been no regional service for which each government had a contribution to make and a commitment for service.

An even more general survey of transport in the region is D.A. Smith's Ph. D. thesis of 1959.[8] Here the intention was to compare the role of transportation in the Eastern Caribbean with Hawaii; hence the level of generality. The most interesting result was the recognition of the importance of the incidence of political authority. A single authority in Hawaii was able to implement a regional air transport system as the integrating link, while many decision makers in the Caribbean were unable to establish an integrated system, either by air or sea. The truth of this is still with us today.

Federation to Carifta 1962-71.--The renewed attempts at regional integration in the 1960's which culminated in the Carifta agreement once again highlighted the paucity of information on interisland shipping. The Economic Commission for Latin America provided assistance and a survey report on small vessels was published in 1970.[9] This was very much the same sort of report as that of the Caribbean Commission in 1954 and was an attempt to take inventory of the facilities available. Most of the data was for the year 1968. Of interest is an article by Adams on maritime activity in the Grenadines.[10]

Two papers of a different nature appear in the literature. The first is an outline study of a systems approach to transport which seeks to use a linear programming model to produce a system of flows between and from the islands which minimises costs for the system, and at the same time to predict where and when port improvements are necessary. No results are published for any test of the model but the project was unfinished at that time (1971).[11] The second is a paper by McDonald which recommends the use of linear programming as a means of solving the transportation problems of the Caribbean and outlines what a linear program should look like.[12] The Caribbean office of the Economic Commission for Latin America and the Carifta Secretariat have, since 1970, conducted a number of studies on shipping in the Caribbean. These are unpublished and have been restricted to circulation in government circles.[13]

Caribbean Economy

Regional.--The publication of regional studies has reflected the current thrust of the regional interest. The early federal attempts gave rise to studies of the political approach to regionalism. These effects at political integration are well chronicled in Sir John Mordecai's study of the Federal Negotiations,[14] while Springer provides an assessment of the Federal venture.[15] Earlier background studies by Lowenthal and Cumper described the economy and resources of the region and provide a good underpinning to the works of Mordecai.[16] In the sixties the work of Demas, Best, and

Brewster and Thomas provided a central focus for much of the work on economic integration,[17] while Segal and Preiswerk deal with the politics of regionalism in the sixties.[18]

Island.--Much attention has been given to the larger islands by academics. The Jamaican economy has been described in standard economic terms by Palmer and Jefferson, Trinidad by Seers and Havelock Brewster, Barbados by Bonnett, Bethel and Armstrong, Daniel and Francis.[19] The smaller islands have been described in the same way by O'Loughlin, while Bryden has provided a good description of the structural changes in the Leewards and Windwards of the 1960's.[20] The approach to the economy through the study of firms has antecedents in economics in Steindl and Wedervang, and in geography in the recent work of Collins and Auty.[21] Brewster and Brown have aptly summarised the achievements and shortcomings of economic theory in the Caribbean, while Brewster has demonstrated the shortcomings of policy in another article.[22]

NOTES

1. D.G. Janelle, "Spatial Reorganisation: a Model and a Concept," A.A.A.G., June 1969, pp. 348-364.

2. M.E. Elliot Hurst, "Transportation and the Societal Framework," E.G., April 1973, pp. 163-180.

3. D. Harvey, Social Justice and the City, (London: Edward Arnold, 1973) p. 194.

4. West India Royal Commission Report, (London: HMSO, 1945).

5. The works referred to are C.J. Burgess, "Problems of Intra-Caribbean Transportation," Monthly Bulletin, Caribbean Commission, February 1954, pp. 152-154, and "Caribbean-owned Shipping Facilities in Relation to Intra-Caribbean Trade" published with "Extra-Caribbean Shipping Facilities available to the Countries served by the Caribbean Commission" in Caribbean Economic Review, vol. 4, December 1954, pp. 101-168.

6. E.B. Doran, "Commercial Sail in the Leeward Islands," American Neptune, vol. 24, no. 2, April 1964, pp. 95-108.

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8. D.A. Smith, A Geographic Analysis of Inter-Island Transportation in the Lesser Antilles and Hawaiian Islands, (Ph. D. thesis, University of Michigan, 1959).

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11. E.C. Emerson, "A Systems Study of Caribbean Transport," Journal of Systems Engineering, December 1971, pp. 81-93.

12. V.R. McDonald, "Transportation: An Infrastructural Variable in Caribbean Economic Development," Paper presented at the 6th West Indies Agricultural Economics Conference, Georgetown, 1971.

13. See for instance:

    (1) ECLA, Analysis of Steps for Reorganisation of the West Indies Shipping Service, (Port of Spain, September 1971).
    (2) ____, Caribbean Basin Transportation File, (Port of Spain, 1970).
    (3) Commonwealth Caribbean Regional Secretariat, West Indies Shipping Corporation: Some Considerations of its Efficiency, (Georgetown, September 1971).

14. Sir J. Mordecai, The West Indies: The Federal Negotiations, (London: George Allen and Unwin, 1968).

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17. W. Demas, The Economics of Development in Small Countries, (Montreal: CDAS, 1965); L. Best and K. Levitt, Export-propelled Industrialisation in the Caribbean, (Montreal: CDAS, 1969); H. Brewster and C.Y. Thomas, The Dynamics of West Indian Economic Integration, (Mona: ISER, 1967).

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19. R. Palmer, The Jamaican Economy, (New York: Praeger, 1968); O. Jefferson, The Postwar Economic Development of Jamaica, (Mona: ISER, 1972); D. Seers, "A Step towards a Political Economy of Development: Trinidad and Tobago," SES, September 1969, pp. 217-253; H. Brewster, Wages Policy in an Underdeveloped Economy, (Mona: ISER, 1972); R. Bonnett, "National Income and National Accounts of Barbados," SES, 1954, pp. 213-260; J. Bethel, A National Accounts Study of Barbados, (Mona: ISER, 1960); W. Armstrong, S. Daniel and A. Francis, "A Structural Analysis of the Barbados Economy, 1968," SES, 1974, pp. 493-520.

20. C. O'Loughlin, Economic and Political Change in the Leeward and Windward Islands, (New Haven: Yale University Press, 1968); J. Bryden, Tourism and Development in the Caribbean, (London: Cambridge University Press, 1974).

21. J. Steindl, Random Processes and the Growth of Firms, (New York: Hafner, 1965); F. Wedervang, Development of a Population of Firms, (Oslo: Norwegian Research Council, 1965); L. Collins, "Industrial Size Distributions and Stochastic Processes," Progress in Geography, no. 5, (London: Arnold, 1973); R.M. Auty, "Factory Size and Plant Vintage," E.G., April 1975, pp. 150-163.

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PART I

TRANSPORTATION AND LOCATION

...where definition often fails to illuminate the essence of what it defines.

George Lamming, Cannon Shot and Glass Beads, p. 11

CHAPTER ONE

PRELIMINARIES

Caribbean Integration and Interisland Transport

The idea of integration has a long and varied history in the Commonwealth Caribbean. In the twentieth century its early manifestations are clearest in the conference summoned at Barbados in 1929. At this conference, many of the issues which have plagued subsequent efforts at integration were raised, none more so than the problem of distance and its attendant isolation. The issue was raised squarely in the discussion of the possible location of some future university of the West Indies:

> Today steamship communication has for all practical purposes brought England nearer to Trinidad than is Bermuda. Students from Trinidad would find it as difficult, if not more so, to attend a university in Jamaica than in England, and that circumstance constitutes one of the drawbacks to the suggestion that has been put forward if Jamaica is to be centre for the establishment of the West Indian University.[1]

These were the remarks of a Trinidad delegate. Others put it differently, but they all had the same thought in mind. Quite early in the efforts at integration, the peculiar problems of fragmentation arose. Communication with the outside world was far easier than communication between islands. Secondly, that fact was critical for the location of any facility designed to benefit the entire region. Specifically, Jamaica seemed one of the least promising locations for any such facilities. The implication was that such facilities should be located in territories other than Jamaica. The conference did not draw the corollary that separate facilities might be located in Jamaica as a result of this isolation. We shall see later the importance of this oversight with respect to industrial development.

The "celebrated riots" of the late thirties brought the standard Royal Commission of Enquiry, but the outbreak of war delayed both the publication of its report, and the changes which were to follow. In their hearings, the Moyne Commissioners were confronted with the problems of isolation. In particular, the difficulties of the smaller Windward and Leeward islands drew attention to the transport problem. They noted that communications with the metropoles were good but observed:

> It is the lack of adequate means for the transport of produce between the smaller islands which most urgently demands attention.[2]

For, they concluded

> There can be no doubt that if trade in agricultural produce between the Lesser Antilles is to be encouraged and developed, a regular service must be provided.[3]

The Commissioners noted the poor state of communications, and the inequality between the Windward and Leeward Islands as opposed to Jamaica, Barbados, Trinidad and Guyana. They proposed a shipping service by at least two vessels of about 650 tons gross, with a cargo capacity of 400 tons. As oil was available at Trinidad, the ships would be powered by deisel engines. The cost was estimated at £50,000 per ship with costs of maintaining the service set at £60,000 per year.[4] Clearly expenditure of that order was not possible from island sources, given the depressed state of the economies, nor was the service expected to pay its way in the early stages. Yet the Commissioners concluded

> the need for improvement of communications between the islands was so great that the question of expense of the order we have mentioned ought not to be allowed to prevent the execution of measures which, in our view, may be expected to bring substantial benefits to the trading community, and to help the work of the administration.[5]

Any improvement in communications would be welcome, but if the smaller islands were to benefit, a service with ships of a particular capacity would have to be introduced. If a subsidy was necessary for this purpose, then it should be paid. We shall see that the relationship between the type of service proposed and the needs of the smaller islands came to be overlooked in later days. The possible effects on inequality were never considered.

The thrust towards integration gained such impetus after the war that by 1947 the Secretary of State for the Colonies summoned a conference in Montego Bay in order "to arrive at collective views for consideration by the individual governments."[6] This conference marked the high point of Caribbean unanimity and emotional fervour.[7] The delegates must have read the Moyne Commissioners report. They, too, saw that an interisland shipping service was a necessity. Resolution number 3, adopted at the conference, ran as follows:

> That this conference believes that the provision of adequate intercolonial and external shipping services and other communications is essential if progress is to be made towards federation, and recommend that in the meantime, and until a federal authority exists, a British Caribbean Shipping Committee should be set up.[8]

Out of this, in 1953, came an agreement signed by all the Commonwealth Caribbean governments to run a subsidised shipping service from Jamaica to Guyana calling at all islands en route. This, then, was the first attempt, and the network which resulted will be described in Chapter Four. From the outset it was agreed that a subsidy would be necessary. Until ships could be purchased, vessels of 750 and 1,200 gross tons would be chartered. Unfortunately no suitable offers could be found and the vessel eventually chartered was the "Wing San" of 3,000 gross tons! Such a size was far in excess of what the Commissioners had recommended and of what the Shipping Committee had intended. Though the island governments bore the first $600,000 of the subsidy, the operating costs exceeded this by

$400,000 in a single year. After operating from January 20, 1955 to the end of 1957, the "West Indian" was returned to the Far East. Thus ended the first attempt at an interisland service.

In a second attempt to fill the breach, two ships of 1,200 gross tons, the "Oluf Sven" and the "Herman Langreder", were chartered. They were run at near full capacity and the subsidy was accordingly small. But their sailings were irregular and this combined with the absence of berthed passenger accommodation led to an assessment by the travelling public as "little better than the schooners."[9] These ships seemed to be handling the cargo trade reasonably well but were inadequate for passenger needs, as were the schooners. The Moyne Commissioners had recommended that passenger transport be left to the airlines, but this, too, seems to have been overlooked. This period of experiment had drawn attention to the problem of costs. Thereafter cost was to remain a central problem.

The ferment of the Montego Bay conference passed. Throughout discussions, as Fertig has shown, distance in relation to services was a constant source of friction and rivalry.[10] The location of the Federal Capital was a case in point.[11] When Canada offered a "gift to the new nation" of $10 million, there was the proviso that it be spent on projects which would provide employment for Canadians. Each island wanted to benefit from the gift and eventually an agreement was reached to "purchase" two ships for an interisland service.

The ships commissioned were of 3,200 gross tons in size, and had both cabin and deck accommodation. Like the earlier service, they were required to call at each island. The earlier lessons on the size of vessels and the separation of passenger and cargo transport were once again ignored. The ships were delivered in August and September of 1961, but, by then, the political federation was already in shambles. Jamaica had just voted to leave, Trinidad followed suit, and the Federation itself was dissolved by January 1962. There was an agreement to continue the service for two years, with a planned subsidy of $900,000. The ships were too large for the trade as it then was and by 1964, Trinidad put forward the view that the ships were expensive status symbols and should be scrapped. The Leewards and Windwards, in a separate survey, found that cargo had doubled since 1959 and that the subsidy was stabilising at about $700,000--rather less than that predicted; that costs should be viewed against the returns, and the fact that private enterprise had been discouraged from attempting any such service.

The demise of the Federation in 1962 was followed by efforts to form a smaller group, but the issue was resolved in 1965 when Barbados decided to seek independence alone. By 1966 Barbados and Guyana had joined Trinidad and Jamaica as independent nations while the remaining territories became states in association with Great Britain by 1968. However with respect to the Caribbean nations they are independent. The groups which eventually signed the Caribbean Free Trade Agreement in 1968 were independent with respect to each other and were thus equal partners.

The CARIFTA Agreement marked a departure from previous attempts at integration. Here the emphasis was on issues primarily economic[12] initially the liberalisation of trade and attempts to organise the maximum regional supply of regional demands. Of particular importance was the recognition that the Leewards and Windwards should be given certain privileges if they were to gain from the agreement. The "less developed" countries, in the CARIFTA terminology, were allowed to retain tariffs at higher levels for longer periods. Implicit in all this was the acceptance of a reduction of regional inequality as one of the goals of integration. By 1973, the "less developed" countries were claiming explicitly that little benefit had accrued to them and were unwilling to enter the new Caribbean Common Market and Community Agreement unless specific demands on the location of industry could be met. These apparently were not, for the "more developed countries" signed the Community agreement alone early in July 1973. The issue of special tariffs had transformed itself into the question of the location of industry.

Throughout this period from 1965 to 1973, the West Indies Shipping Company maintained the two Federal Boats on a service much like before. The ships called at each island from Jamaica to Trinidad, and after 1971, to Guyana. The Carifta agreement merely endorsed a resolution "to endeavour to maintain and improve regional carriers to facilitate the movement of goods and services within the region."[13] Since then the Carifta Secretariat in cooperation with the Caribbean Office of the Economic Council for Latin America has been trying to ensure adequate services. There is now a proposal to establish an extra-regional service to the metropoles, stemming largely out of irritation with the ever-increasing rise in freight rates unilaterally imposed by the conference lines.[14]

In brief, the long approach to integration saw certain problems emerge repeatedly. First among them was the problem of distance. Distance was central to the question of participation in and benefit from the integration process. From 1929 to 1973 distance in relation to facilities was broadened into distance and the location of industry. Secondly, trade and interaction between the units was expected to increase and, more and more, regional supplies were expected to satisfy regional demands. The general prosperity would be increased. Thirdly, integration was to be allowed to reduce the wide gap between the more developed and faster developing territories on the one hand, and the less developed on the other. Interisland transport was accepted as critical for the success of these goals, but adequate shipping was all that was ever promised. Moreover interisland shipping was a costly business, and such costs had to be kept to a minimum. Each island had to participate in the shipping. There was little explicit discussion of the shipping requirements of these separate goals, seemingly because the importance of each appeared at different times.

In the planning stage, distance with respect to location of any activity seemed paramount; in the operating stage, costs became the central concern, while in the reflective period, the question of inequalities emerged. There seemed little recognition that the transport network appropriate for the trade as it was might prohibit the reduction of inequalities by restricting trade to certain channels. Nor did it seem to be understood that, with the network as it was maintained, costs might be unnecessarily high, and participation in facilities might not be as high as possible. What was necessary was a theoretical framework in which the effects of distance on patterns of location in the fragmented economy under the constraints of distance (costs) minimisation were clearly brought to light. Secondly, in view of the desire for maximum participation, we need to know the range of choice associated with those patterns of location and the kind of transport networks appropriate to these choices. Thirdly, we need to show how the transport pattern has affected regional inequality. In this way, it becomes possible to ensure that the short run "problem" solutions are consistent with long run "policy" prescriptions. And it is these questions which will be the concern of this thesis. Transportation, however, operates within the framework of an economy. The following sections explore the nature of Caribbean economy in a general way.

APPROACHES TO THE CARIBBEAN ECONOMY

The "size" view

The spirited attempts at regional cooperation in the 1940's rested in the belief that the small size of the economies posed a problem for their development which regional aggregation would alleviate. This was the basis of the political federation but the idea later received wide support from the economists. In what has come to be considered a classic for the Caribbean, Demas made a clear statement of what can be called the "size" view of the economy.[15] The fundamental proposition of this view is that singly or collectively the territories of the Caribbean are small and should be analysed as such. Regional grouping enlarges the individually small markets, reaching new thresholds for activities which would not be feasible in the fragmented market. Regional resources would be pooled to achieve such objectives. Much more than this is set out in Demas' early work, but it opened the debate on economic integration to such an extent that all governments after 1965 were openly proclaiming support for this view, even if slow in taking action. Indeed there followed a series of studies on the possibilities of integration in various sectors, to which reference will be made later.

The "plantation economy" view

The failure of the units to achieve notable success in economic cooperation up to 1965 and the dismal experience of the federation gave credence to the second important approach to the Caribbean economy. Here the fundamental proposition is that the structure of production is the basic constraint on development and that this structure was determined by the plantation. This is the view whose strongest proponent is Lloyd Best.[16] The plantation economy is export oriented with a traditional sector supplying exports in response to metropolitan demand, and a residentiary sector arising out of the wages fund established after the emancipation of the slaves. To these in time may be added a new mineral sector, a new Manufacturing sector or a Tourist sector. In essence, it represents a peculiar kind of staple economy or, formally, a multiplier model of an economy. According to Best and Levitt,[17] the sectors are allocated as follows:

1. Traditional exports include agricultural staples and other agriculture even though production units are different. Orientation to metropolitan demand is the central characteristic.
2. Mineral exports are allocated to the Traditional sector since apart from the technology, all else is similar.
3. Manufacturing and Tourism are kept in the New sector even though their behaviour resembles traditional exports. This is to highlight the traditional nature of current policy.[18]

The responses to external demand are governed by the internal production functions which, in the specific case of the Caribbean, inhibit the development of backward and forward linkages which are the expected results of a staple economy.[19] One of the principal reasons for this is the capital specificity of the export staples in the Caribbean.[20] Sugar manufacturing equipment cannot be switched to vegetable processing nor can banana boats be readily switched to general carriers. In essence therefore changes in resource allocation must be made via exports, i.e. the staple is exported and the desired inputs procured abroad either as final demand (direct consumption) or as intermediate goods for further processing. Hence the paradoxical result that attempts to broaden the production base require expansion of the staple.[21] The survival of the staple is thus guaranteed.

Metropolitan Dependence

The third approach is a variant of the above but focusses on the metropolitan dominance of the economies as opposed to the internal production functions. Metropolitan dominance, and its modern version the multinational corporation, control extensive sectors of the economy. Hence the direction and pace of development are not determined by those in the Caribbean but by the metropoles, in response to metropolitan needs. What has to be done, therefore, according to this view, is to extend the area of decision making in the Caribbean so as to be able to induce the backward and forward linkages which the present structures obstruct. In the Caribbean, the results so far have been a series of proposals for 51% ownership in the corporations' branches which operate in the Caribbean--the Guyana takeover of complete ownership of the Alcan subsidiary being a notable exception.[22] But 51% ownership of resources did not automatically confer 51% of the decision making, as is being discovered.[23]

Limitation for Interisland Analysis

These, then, are the three central elements of current approaches to Caribbean economy. Emphases vary but most views embrace some or all of these. There can be no dispute of the validity of these propositions as they apply to individual units. What is open to question is whether these propositions govern the relationships between the units of the region. The plantation and metropolitan dominance views are applicable only in the limited and negative sense that the greater the former, the lesser the residual for interisland relationships. The size view, with its attendant policy of regional aggregation, is more important but also has to be divided into regional cooperation for action towards the metropoles i.e.

rationalisation of sugar or banana production, and regional aggregation for balancing of domestic supply and demand.

Whereas Demas attempted to make the general case for regional integration, Brewster and Thomas tried to show clearly those sectors which could most readily be integrated.[24] They showed that it was possible to organise motor vehicle, pulp and paper, fish processing and even steel manufactures in an integrated Caribbean market. This was an important advance. But a major omission was the failure to tackle the problem of the location of any such activities. For given the island realm of the Caribbean, if all demands for a given commodity are to be satisfied, a manufacturing plant must be located in one or other of the territories. The distribution of such benefits are held to be of importance for the acceptance of integration by the politicians.[25] Moreover, given the fragmentation of resources and markets, transport costs both in product collection and distribution would play a part in the solution. More important, however, is the organisation of interisland transport, for even if transport costs are small in proportion to total costs, an integrated island economy cannot function without an appropriate transport network. Hence it is imperative that both the location of industry and the appropriate transport networks be specified. Neither of these appeared in the Dynamics, as it is referred to. Hence the difficulty in its acceptance, despite its great work. A clear conception of the interisland economy seems lacking in the literature, and one such conception will now be presented.

AN INTERISLAND ECONOMY

The Open Dual Economy

Openness and dualism are basic features of the economies of the Caribbean. The former manifests itself in a high import coefficient and a structure of production dominated by one or more export commodities, while the latter is exemplified by the existence within the same unit of what Best calls the Traditional and New sectors. The concomitant of openness is a large overseas trade, while dualism perpetuates a scarcity of links between the sectors of the economy. Trade, then, is of great significance for growth in the open dual economy.

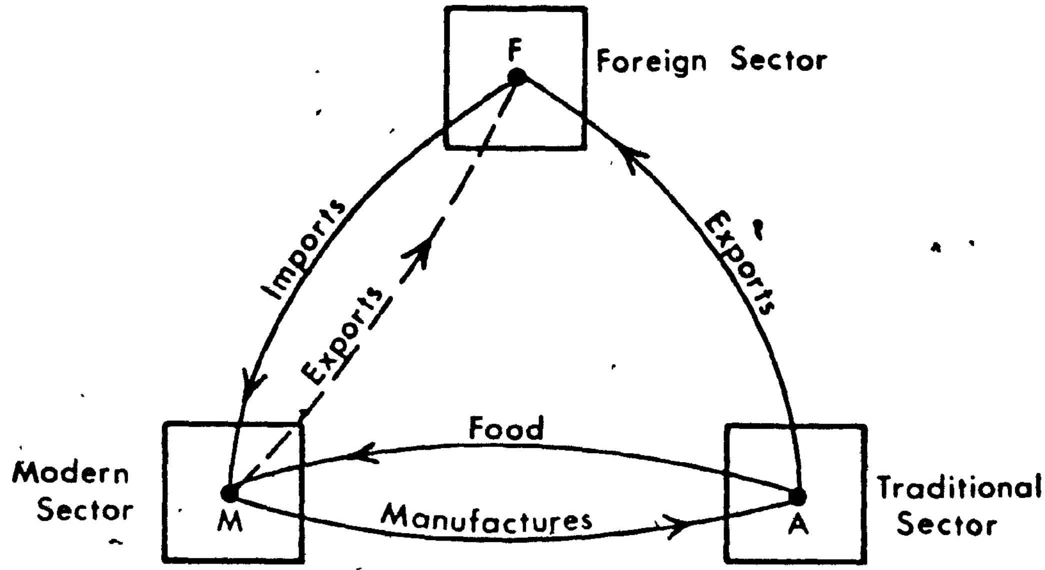
The Structure of Flows in the Open Dual Economy

Following Hicks and McNicoll,[26] we may distinguish three sectors in such economies; traditional, modern and foreign. The foreign sector is the market for the exports and is a direct acknowledgement of openness. Such a flow structure can be represented by a digraph in which the links represent flows, and the nodes the sectors of the economy. By reversing the direction of the links, the money flows or payments can be plotted as a graph.

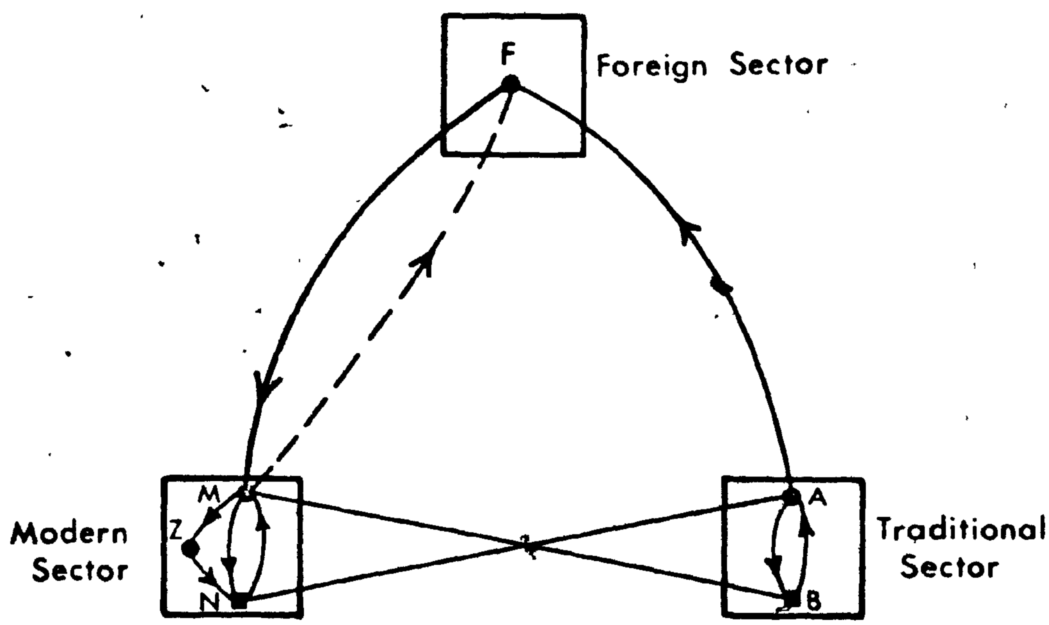
The basic pattern shown in Figure 1.1 identifies exports from the traditional sector (AF) being converted in the foreign sector into imports for the modern sector (FM) at a rate determined by the capacity to import, and the exchange of output between the domestic sectors: food into the modern sector (AM) and manufactures into the traditional sector. Part of the modern output may be exported, as MF suggests, but this is unlikely.

SECTORAL REPRESENTATION OF ECONOMY

1.1 Flows in Open Dual Economy [a]



1.2 Flows in Open Dual Economy [b]



● Production
■ Consumption

The traditional sector, by exporting its surplus, generated the foreign exchange necessary for payment for imports of capital goods.

Elaborating further in Figure 1.2, we may distinguish between the production and consumption elements of the domestic economy: A and M being the production elements with B and N the consumption elements of the traditional and modern sectors. We may enter Z as the finance and government sector. The flows to the foreign sector remain unchanged, but now the flows between the domestic sectors are directed from the production elements of one to the consumption elements of the other (AN and MB). In addition, AB represents the flow of food to households while BA shows the labour input to agriculture. Analagous flows exist in the modern sector (MN and NM).

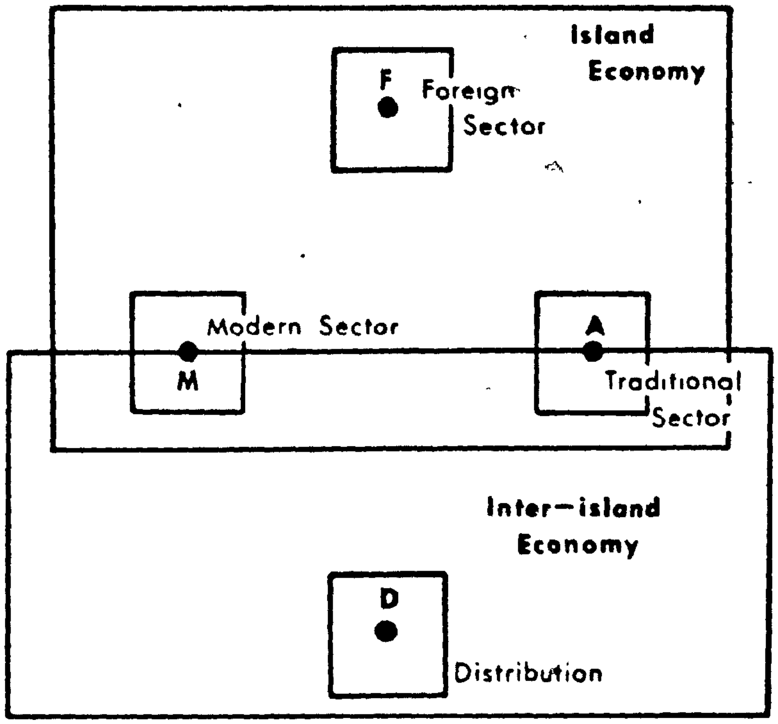
Such a flow structure is an appropriate basis for description of individual Caribbean territories but has to be modified in an interisland economy to take account of the spatial incidence of the sectors. The mineral sector is confined to Jamaica, Trinidad and Guyana; the manufacturing sector is developed only in Jamaica, Trinidad and recently in Guyana and Barbados. However, the main contention is that the interisland economy should exclude the foreign sector and be restricted to what has been called the domestic economy. In the spirit of the metropolitan dominance view, we agree that the sectors dominated by the metropoles behave more as a part of the centre than as part of Caribbean economy. With the plantation economy view, we accept that the capital specificity of the plantation structure forces the change in resource allocation to be made via exports. The interisland economy thus defined consists of those flows between sectors in the domestic economy, and those flows which take place between the segmented parts of the various sectors. What would this mean in terms of transportation?

Towards a Transport Economy

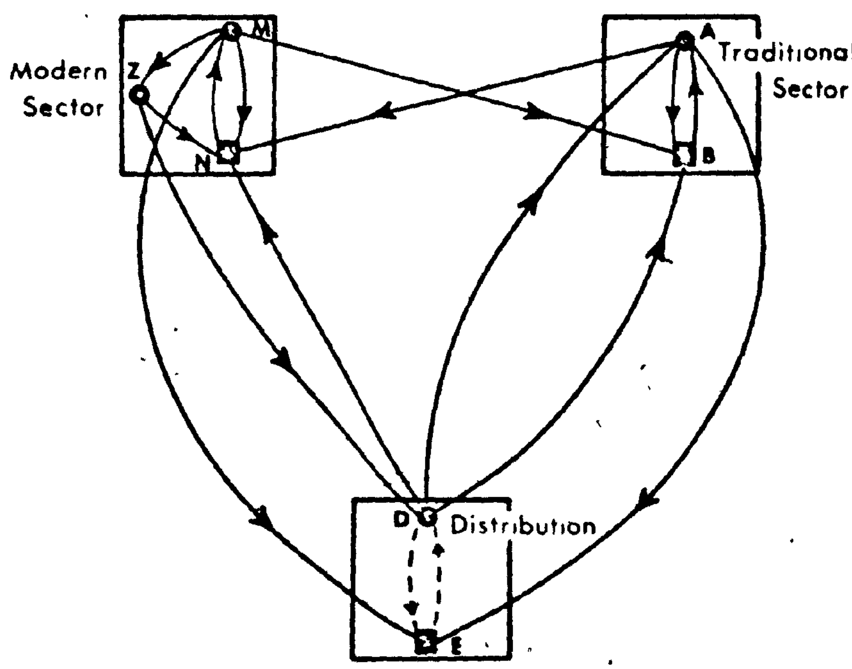
It is precisely because the sectors are fragmented that we propose that for an interisland economy the foreign sector be replaced by a distribution sector with production and consumption ends D and E as in Figure 1.3. If traditional exports pass between parts of the region, as say sugar does from Trinidad to St. Vincent, flows such as DA arise. Sale of Jamaican manufactures to the other islands give rise to DM, since exports require a medium for distribution. The extent to which the distributive sector is serviced by say Trinidad petroleum, or repairs are made in dock, or bunkers procured in any island, gives ME flows. Likewise the supply of food to ships' crews gives AE flows. It may be objected that exclusion of the foreign sector is an unwarranted assumption, since the receipts from this are channelled into the modern sector and the government sector. But in this way they would enter the regional economy; if they are dissipated abroad, then it is fair to exclude them. The flow structure highlights those areas in which decision making in the Caribbean is strongest and also points to those areas in which structural changes have been slowly emerging. Finally it brings to the fore the distributive sector without which schemes for regional aggregation, à la Demas, cannot succeed. The contours of such an interisland economy can best be explored through the flows which bind the units together. The contention is that regional flows should be seen not so much as residuals from the external orientation of the economies but as building blocks of an interisland economy. No judgment is made of the possibility of extending the regional economy to cover the total economy, i.e. that all flows should be between regional units, though it is a theoretical long run possibility. Furthermore, the present small size of the regional economy is urgent reason for seeking to extend it. The

SECTORAL REPRESENTATION OF ECONOMY

1.3[a] Island Economy and Inter-island Economy



1.3[b] Flows in Inter-island Economy



rmw

interisland economy, then, is a transport economy, with its distance bias, the contours of which will now be explored.

TRANSPORT AND THE INTERISLAND ECONOMY

The Fragmented Economy

The Commonwealth Caribbean is an island realm and the incorporation of mainland territories does not alter this fact. The islands have never been so closely linked as to constitute "that bracelet of islands which curves in a great arc from Trinidad in the southeast to Cuba and Jamaica in the northwest."[27] Indeed it is the absence of strong transport links which has plagued the development of integration. The arrangement of the units of the study area may be described by the following matrix of distances between ports (in miles).

	1	2	3	4	5	6	7	8	9	10	11	Σd_{ij}
1 Jamaica	x	970	1030	1000	1090	1130	1250	1130	1130	1190	1400	11320
2 St Kitts		x	62	50	170	275	378	300	380	500	700	3785
3 Antigua			x	36	114	225	321	280	360	470	682	3580
4 Montserrat				x	125	220	325	260	330	440	643	3429
5 Dominica					x	100	200	150	230	340	560	3079
6 St Lucia						x	121	46	140	250	486	2993
7 Barbados							x	116	160	213	400	3484
8 St Vincent								x	80	190	440	2993
9 Grenada									x	110	400	3320
10 Trinidad										x	374	4077
11 Guyana											x	6085

$$\Sigma \Sigma d_{ij} = \frac{48145}{2} = 24{,}072 \text{ miles}$$

The island units can be defined as nodes in the system, numbered as in Figure 1.4, and connected by links of varying length. Such an arrangement represents a maximally connected system since each node has a direct connection to every other node. Total link length is 24,072 miles and average link length is 438 miles. For each node we may define a minimum aggregate distance (MAD)

$$MAD = \Sigma d_{ij}$$

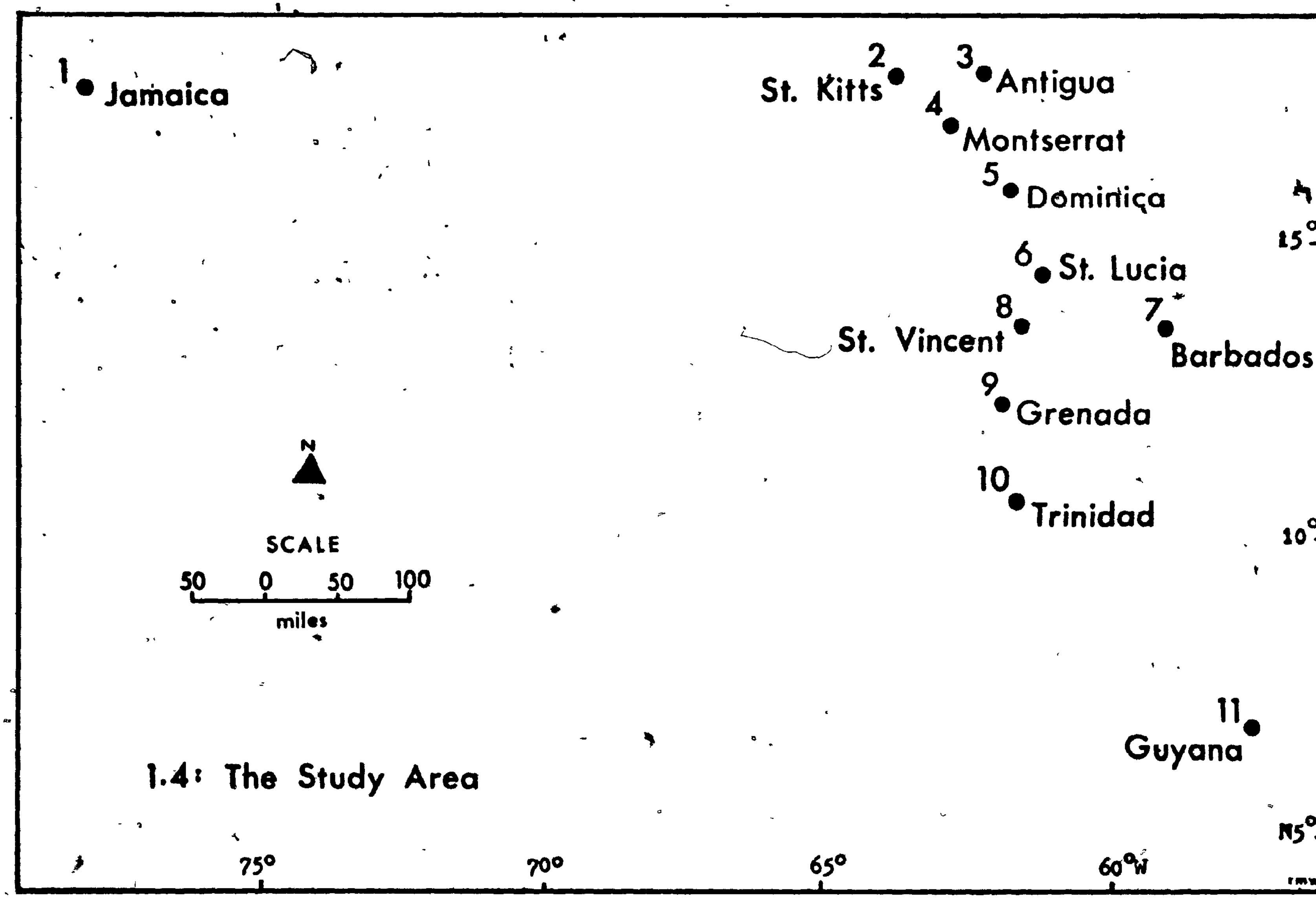
where d = distance in miles from Matrix 1, and

i, j = nodes in the system

which measures its relationship to the region as a whole. The larger MAD is, the more distant a node is from the others.

Centrality

The system may now be decomposed in order to explore the notion of centrality. Table 1.5 shows average link length for successive reductions of the system. At each stage the node with the highest value for average link length is omitted. As we reduce the system, average link length decreases from 438 to 200 miles. Yet if we define centrality as the minimization of MAD for each unit, then there is little change in rank order of centrality between the nodes even after three reductions. In short, as we omit first Jamaica, then Guyana, then Trinidad from our calculations (A, B and C in Table 1.5), St. Lucia, St. Vincent and Dominica remain the most central locations with Montserrat and Grenada next in line. Jamaica Guyana, Trinidad and Barbados have been called the more developed countries (MDC) in regional parlance. In this thesis they constitute the peripheral territories, while the more central nodes, as here measured, are the less developed territories. We shall later be concerned with the degree of



1.4: The Study Area

inequality between these two groups of territories. It is important to note here that while Jamaica, Trinidad, Guyana and Barbados may be considered the "centres" of the region, with respect to the fundamental geographic factor of distance they are peripheral to the region. And this distinction remains critical for any analysis of regional transportation.

TABLE 1.5

Changes in Centrality

	A		B		C		D	
	MAD/n-1	Rank	MAD/n-1	Rank	MAD/n-1	Rank	MAD/n-1	Rank
J	1132	11						
K	378	8	312	8	252	8	216	6
A	359	7	285	7	234	7	200	5
M	342	5	270	5	223	4	192	4
D	307	3	220	3	179	3	179	3
L	299	1	207	1	172	1	161	1
B	348	6	275	6	229	6	231	7
V	299	1	207	1	177	2	176	2
G	332	4	250	4	224	5	240	8
T	408	9	318	9	314	9		
Gy	608	10	524	10				
	n=11		n=10		n=9		n=8	
Average Link Length	438		284		224		200	

Transport in the Fragmented Economy

If, as we have argued, the fragmented interisland economy derives its organisation from the distribution sector, then it is necessary to understand the bases of this sector to explore the growth of the interisland economy. There are three technical possibilities for overcoming fragmentation: (1) bridge or tunnel--a land extension, (2) an airline network, (3) a shipping network. As yet neither bridge nor tunnel has been proposed for the Caribbean and can safely be ruled out. The development of a passenger airline network in the Caribbean has been chronicled by Rees[28] who shows that by 1950, St. Vincent, Dominica and Montserrat, of the units of our study, still had no air service. It was not till 1953 that service reached the first two units and 1956 for the latter. These were small 8-seater planes, and even at the present, the less developed countries of the region are served from the more developed by aircraft of lesser technical capacity. We might say that the capacity to engage in air transport varies inversely with the degree of centrality as defined earlier. It means, too, that air cargo is of greater importance for carriage of goods to extra-regional than for regional destinations.

TABLE 1.6

Cargo Tonnage Handled[29]

	SEA	AIR	AIR AS % OF SEA
BARBADOS			
1966	262,806	2,210	0.75
1967	272,843	2,528	0.9
1968	277,658	2,884	1.04
1969	303,678	4,144	1.4
TRINIDAD			
1966	38,916,500	4,704	0.01
1967	38,294,000	3,985	0.01
1968	40,718,100	-	-
1969	42,109,000	6,643	0.02
JAMAICA			
1966	2,645,000	9,161	0.33
1967	2,714,000	10,100	0.36

The relative importance of air transport for the carriage of goods can be judged from Table 1.6. By 1969, not more than 2% of total tonnage of goods leaving any unit travelled by air and in 1970, air cargo accounted for no more than 5% of total commodity tonnage in the Caribbean region.[30] Whatever the importance of air transport for passengers, or for certain highly perishable or valuable commodities, it is clear that the fundamental flows in the interisland economy rest with the shipping network and subsequent analysis will be confined to this transport mode.

The capacity along a route is determined in the first instance by the type of ship. In the Caribbean three types of vessel have been used. Sailing vessels--schooners and sloops--with a cargo capacity of about 50 tons and average speed of 5 mph, would be useful on short routes or for durable products which could withstand lengthy journeys. Motor vessels, larger, with capacities of about 325 tons and speeds of 10 mph, could ply longer routes, and carry less durable cargo. The third type of vessel is the well known steam or motor ship of 7,000 to 10,000 tons in the 1950's, with a speed of about 15 mph, and refrigerated capacity. Such a ship was, broadly speaking, open to any type of cargo.[31] On a route a voyage could be expected every two months, or six per year.

NOTES

1. Remarks of Mr. Gaston Johnson at the First West Indies Conference, Barbados, January-February 1929, (London: H.M.S.O. 1929).

2. West Indies Royal Commission Report, (London: H.M.S.O. 1945) p. 339.

3. WIRC, p. 340.

4. WIRC, p. 340.

5. WIRC, p. 340.

6. F.R. Augier and S.C. Gordon, Sources of West Indian History, (London: Longmans, Green and Company, 1962) p. 289.

7. Hugh Springer, "Federation in the Caribbean: An attempt that failed," International Organisation, vol. 21, no. 4, 1967, pp. 758-75.

8. Augier and Gordon, p. 293.

9. C. O'Loughlin, Economic and Political Change in the Leeward and Windward Islands, (New Haven: Yale University Press, 1968) p. 157.

10. N.R. Fertig, The Closer Union Movement in the BWI (unpublished Ph. D. Thesis, University of Southern California, 1958) p. 132.

11. See further, D. Lowenthal, "The West Indies chooses a Capital," Geographical Review, vol. 48, 1958, pp. 336-64.

12. We ignore for simplicity the fact that economic agreements involve certain restrictions on sovereignty and can hardly be said to be non-political.

13. Caribbean Free Trade Agreement: Text of Principal Agreement (Bridgetown: Government Printing Office, 1968).

14. Witness the long debate about freight rates in the banana industry early in 1971, and the battle between Elders and Fyffes and the Jamaica government during the period November 1970-January 1971.

15. W. Demas, The Economics of Development in Small Countries (Montreal: CDAS, 1965).

16. L. Best and K. Levitt, Export-propelled Growth and Industrialisation in the Caribbean, 4 vols., (Montreal: CDAS, 1969) or see L. Best, "Outlines of a Model of Pure Plantation Economy," SES, vol. 18, no. 1, 1968.

17. Best and Levitt, vol. 1, pp. 27-31.

18. The similarity of behaviour of the tourist industry in Hawaii has recently been demonstrated by B. Renard, "The Influence of Tourism on the Production Structure of Island Economies," Review of Regional Studies, vol. 2, no. 3, 1972, pp. 41-56.

19. See the arguments of Melville Watkins, C.J. Ec.Pol. Sci. Vol. XXIX, May 1963, or K. Levitt, Silent Surrender, (Toronto: McMillan, 1970).

20. See further the arguments of G. Beckford, Persistent Poverty, (London: Oxford University Press, 1972) pp. 161-64.

21. This is the dilemma that engulfed Cuba up to 1968, when the early drive to industrialisation seemed to fail.

22. See in particular the attempts to obtain 51% ownership of Cable & Wireless (West Indies) Ltd in Jamaica, the Trinidad petroleum deal, and the many solutions with respect to banks.

23. See the extensive discussion in C.Y. Thomas, "Meaningful Participation: the Fraud of It," Ratoon, Occasional Paper, no. 1, 1971.

24. H. Brewster and C.Y. Thomas, The Dynamics of West Indian Economic Integration, (Mona: ISER, 1967).

25. Steve De Castro, "Caribbean Economic Integration and the West Indians," New World Quarterly, vol. 5, no. 3, 1970, pp. 27-35.

26. G. Hicks and G. McNicoll, Trade and Growth in the Philippines, (Ithaca: Cornell University Press, 1972) Chapter I.

27. A. Adamson, Sugar without Slaves, (New Haven: Yale University Press, 1972) p. 3.

28. P.W. Rees, Air Transport in the Lesser Antilles, (Berkeley, 1964).

29. Compiled from: Annual Abstract of Statistics, 1967-1970, Jamaica, Trinidad, Barbados.

30. ECLA, Caribbean Basin Transportation File, (Port of Spain, 1970) p. 5.

31. These vessels are described fully in E.H.M. Blenman, Interisland Shipping in the Eastern Caribbean, (unpublished M.A. Thesis, University of Calgary, 1970).

CHAPTER TWO

A THEORY OF INTERISLAND TRANSPORT

The preceding elements may now be drawn together to form a set of assumptions which will inform the development of ideas about the nature of interisland transport. Here the transport expectations from Chapter One will be translated into premises.

Major Premises

1. All demands for any given commodity in the region must be satisfied.

The region constitutes a number of units separated by water and of varying economic size. The adoption of regional integration as a strategy of economic development, and the rationalisation of certain economic activities on the grounds that the total market reaches an economic threshold are justifications for the assumption that all demands must be satisfied. This is of importance, too, because of the oft-repeated dictum that interisland transport is bad because interisland trade is small. Central to any such concepts is the idea of economies of scale. This premise reflects the desire for maximum participation.

2. At any given time the capacity to transport is limited to a certain distance.

This notion allows the systematic evaluation of the influence of transport on the growth of an interisland economy. It makes possible the notion of the "null" economy, where there is no interaction between the separated units, and the meaning of change due to technological innovations can be investigated.

3. Transport costs should be minimized.

It has been shown that concern for the high cost of transport, per se, rather than the utility of interisland transport has dominated the discussions in the last twenty years. The result has been the adoption of a linear programming approach.

Minor Premises

1. That the size of the individual demands is a secondary attribute.

As long as the total demand meets the threshold, its size distribution among the units is not of primary importance. This is so because of the next minor premise.

2. Transport costs are proportional to distance and are independent of flow values.

3. That a shipping region exists in which direct journeys are the least cost routes.

This assumption seems justified as there would be no reason to call at ports on route unless cargo was to be discharged and this would certainly involve extra cost and time. These last two minor premises retain the relative locational advantages of the various islands.

TRANSPORT AND LOCATION

The Least-cost Route

The units of an interisland region are bound by transport links which have been shown to be those of a capacitated shipping network. In the case of land networks, journeys may be made by indirect means through some intermediate point without much increase in the penalty over the direct journey. For example, a journey from A to C may be directed via B to avoid the congestion on the direct route AC even if there is no necessity to stop at B for business reasons. By sea, however, this is not the case and a direct journey is always the least costly in distance or time. In the analysis of shipping networks, therefore, the least-cost routes are direct.

The Principle of Maximum Distance

The development of an interisland economy depends on the ability to overcome distance. In the limiting case, if the ability is zero, then there is no economy; the maximum limit is set by the distance between those points separated by the greatest distance. The extent of the interisland economy at any time is related to the maximum distance which can be bridged by the transport means available. The development of the economy is then conditioned by the nature and speed of innovation in transport. In view of the suggestion above, the changes in the shipping network and the introduction of new types of ships of greater technical capacity, i.e. either size or range, would extend the interisland economy. In the limiting case of zero transport capacity, each unit will have to be served by itself for all requirements, but as the capacity to overcome distance increases, there is then a reduction in the number of supply locations required to serve the entire region, as some units fall within the range of another location, satisfying the principle of the maximum distance.

The Linear Program

The relationship between the required number of supply locations and maximum distance can be resolved by means of a distance/locations curve, which shows for each distance the number of locations required to serve the entire region. The construction of this curve requires the solution of a linear program of the following form:

$$\text{define } X_j = \begin{cases} 1, & \text{if } j \text{ is a chosen location} \\ 0, & \text{otherwise.} \end{cases}$$

Given a set of direct distances between each location, minimize

$$Z = \sum_{j=1}^{n} X_j,$$

subject to the constraint of some maximum distance, S. Since there is need for at least 1 location, there is the non-zero constraint

$$\sum_{j \in N_i} X_j \geq 1$$

for all nodes, i, where N_i = set of nodes within the maximum distance, S, of node i. Formally $N_i = \{ j \mid d_{ji} \geq S \}$, where d_{ji} = distance from j to i. Solving this linear program gives the minimum number of locations necessary such that each and every node is within the specified maximum distance, S, of at least one of the chosen supply locations.

Graphical Solution

Toregas and Revelle have recently proposed a graphical solution to this type of linear program which has certain attractive properties.[1] It is simple; it reduces large problems to successively smaller ones which are then simple to resolve, and it allows the exploration of other aspects, particularly the degree of choice involved, while maintaining the clarity of the exposition.

The Method[2].--Given a matrix of direct distances between the units, and setting the maximum distance, S, at say 225 miles, it is possible to describe, for each node, all others which fall within the prescribed distance, or all those which could supply it. These are the demand surfaces of the nodes. Some of these demand surfaces dominate others in that the enforcement of that demand ensures the satisfaction of those dominated. The presentation and graphical solution make this clear.

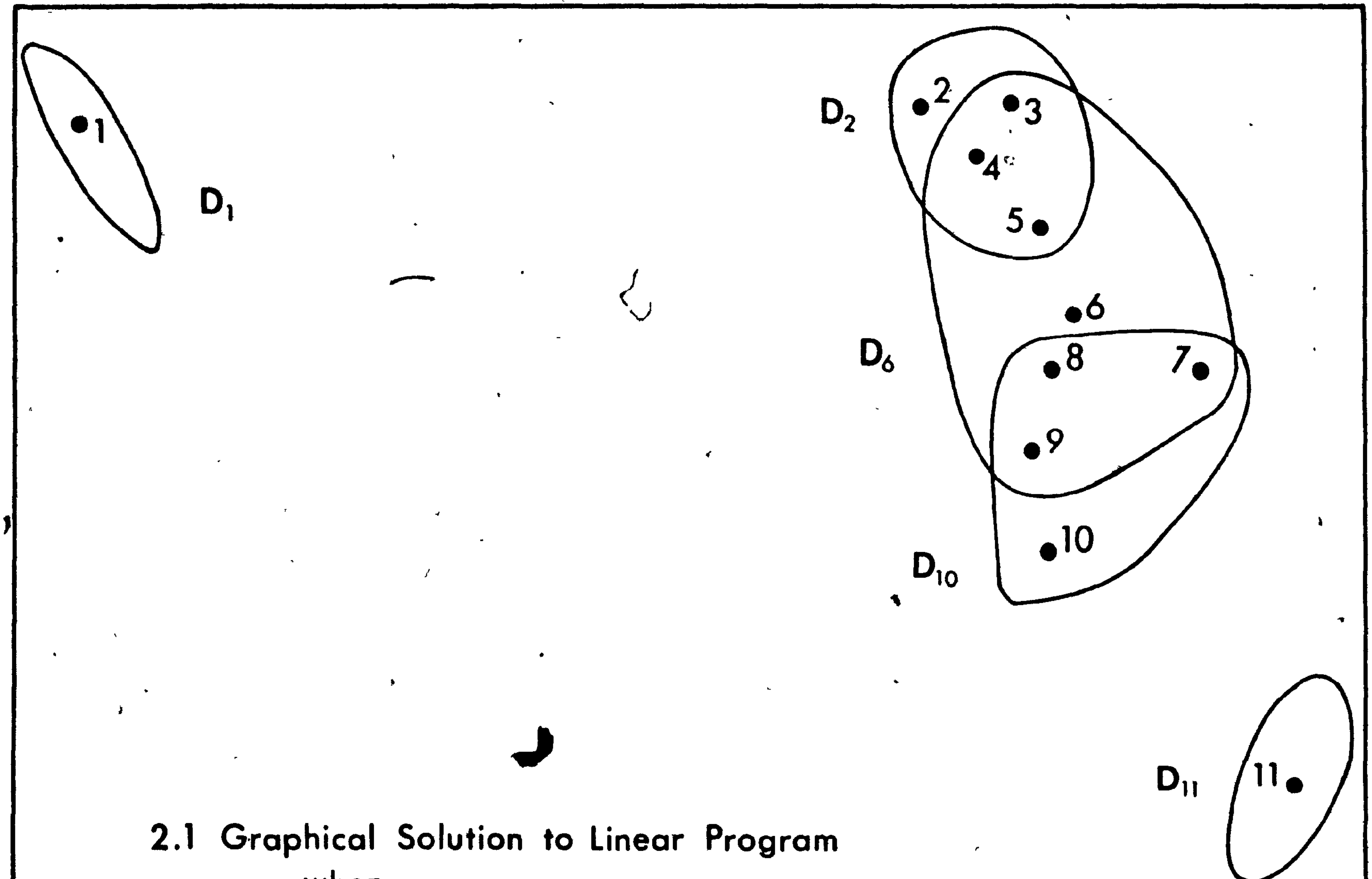
S = 225 miles

Node		Demand Surfaces	Dominant Demand
1	=	(1)	D_1 = (1)
2	=	(2,3,4,5)	
3	=	(2,3,4,5,6)	D_2 = (2,3,4,5)
4	=	(2,3,4,5,6)	
5	=	(2,3,4,5,6,7,8)	
6	=	(3,4,5,6,7,8,9)	D_6 = (3,4,5,6,7,8,9)
7	=	(5,6,7,8,9,10)	
8	=	(5,6,7,8,9,10)	
9	=	(6,7,8,9,10)	D_{10} = (7,8,9,10)
10	=	(7,8,9,10)	
11	=	(11)	D_{11} = (11)

These dominant demand surfaces are then drawn on the graph as in Figure 2.1. The second step is to consider the question from the supply side to ascertain which of the nodes have the greatest power to supply these dominant demands. The least powerful supply nodes can then be eliminated.

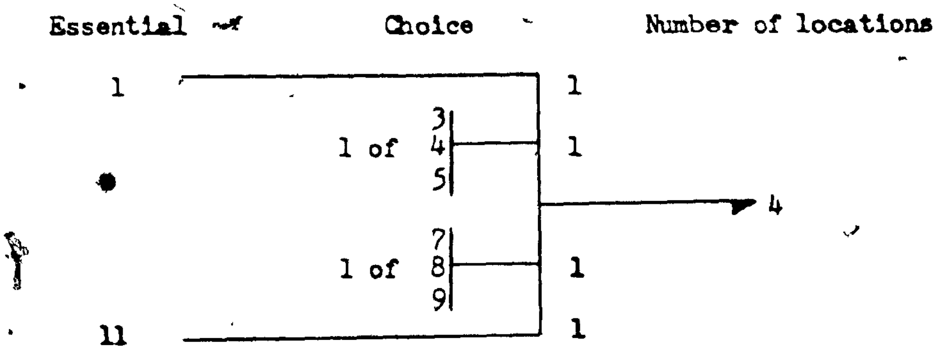
Supply Point	Covers	
1	D_1	
2	D_2	Supply points 3, 4 and 5 dominate 2. Eliminate 2, but retain 3, 4 and 5.
3	$D_2 + D_6$	
4	$D_2 + D_6$	
5	$D_2 + D_6$	
6	D_6	
7	$D_6 + D_{10}$	Points 7, 8 and 9 can supply both D_6 and D_{10} whereas 6 can supply only D_6, and 10 supplies D_{10} only. Eliminate 6 and 10, but retain 7, 8 and 9.
8	$D_6 + D_{10}$	
9	$D_6 + D_{10}$	
10	D_{10}	
11	D_{11}	

Note that there is only one point which can supply node 1 and one for node 11. Such points are essential to the solution and must be retained to cover demand surfaces 1 and 11. Three points are available to cover demand D_2, i.e. nodes 3, 4 and 5, and they also cover demand D_6. Likewise three points cover D_{10} and also cover D_6. Hence we can choose any one of the points which cover $D_2 + D_6$ in addition to any one of those covering $D_6 + D_{10}$. Our final solu-



2.1 Graphical Solution to Linear Program
when
S = 225 miles

tion requires 4 locations and can be summarised as follows:



The Analysis

This solution of the linear program was employed for the study region with the maximum distance, S, varying from 1,400 miles--the absolute maximum for the region--to 35, the maximum distance which requires individual locations, i.e. the condition of no transport. The results for specified values of S are given in Appendix A and are described here according to certain values of S.

1,400 At this maximum distance, a single location is all that is necessary and we are indifferent as to which of the 11 units is chosen.

1,200 A single location still serves, but there is a restriction to a choice between nodes 2, 3, 4, 5, 6, 8, 9 and 10.

1,100 One location required. Choice between 2, 3, 4 and 5.

970 One location required. Node 2 alone satisfies the maximum distance constraint.

If, therefore, a single facility is all that is possible, then transport distance can be minimized when node 2 is chosen. Every other choice is a sub-optional transport choice.

500 Two locations are now required--one of which is essential, node 1, while there is for the second a choice between nodes 6, 7, 8,9,10.

438 When the maximum distance is set at the average link length of the region (438 miles), two locations are required. Node 1 is essential and the choice is restricted to nodes 7 or 9.

400 Solution as for S = 438.

380 Three locations required, one of which, 1, is essential. The choice for the second is between 5, 6, 7 and 8, and for the third between 10 and 11.

350 Three locations. Nodes 1, 11 essential, with a choice of 5, 6 or 8 for the third.

300 Three locations. Nodes 1 and 11 essential; 6 or 8 for the third.

284 At S = 284, the average link length of the region without node 1, three locations are required but no choice exists. The solution is satisfied by nodes 1, 6 and 11 only.

225 The solution has already been described. Four locations are required of which nodes 1 and 11 are essential. Choice for the third is between 3, 4 and 5, with a choice of 7, 8 or 9 for the fourth.

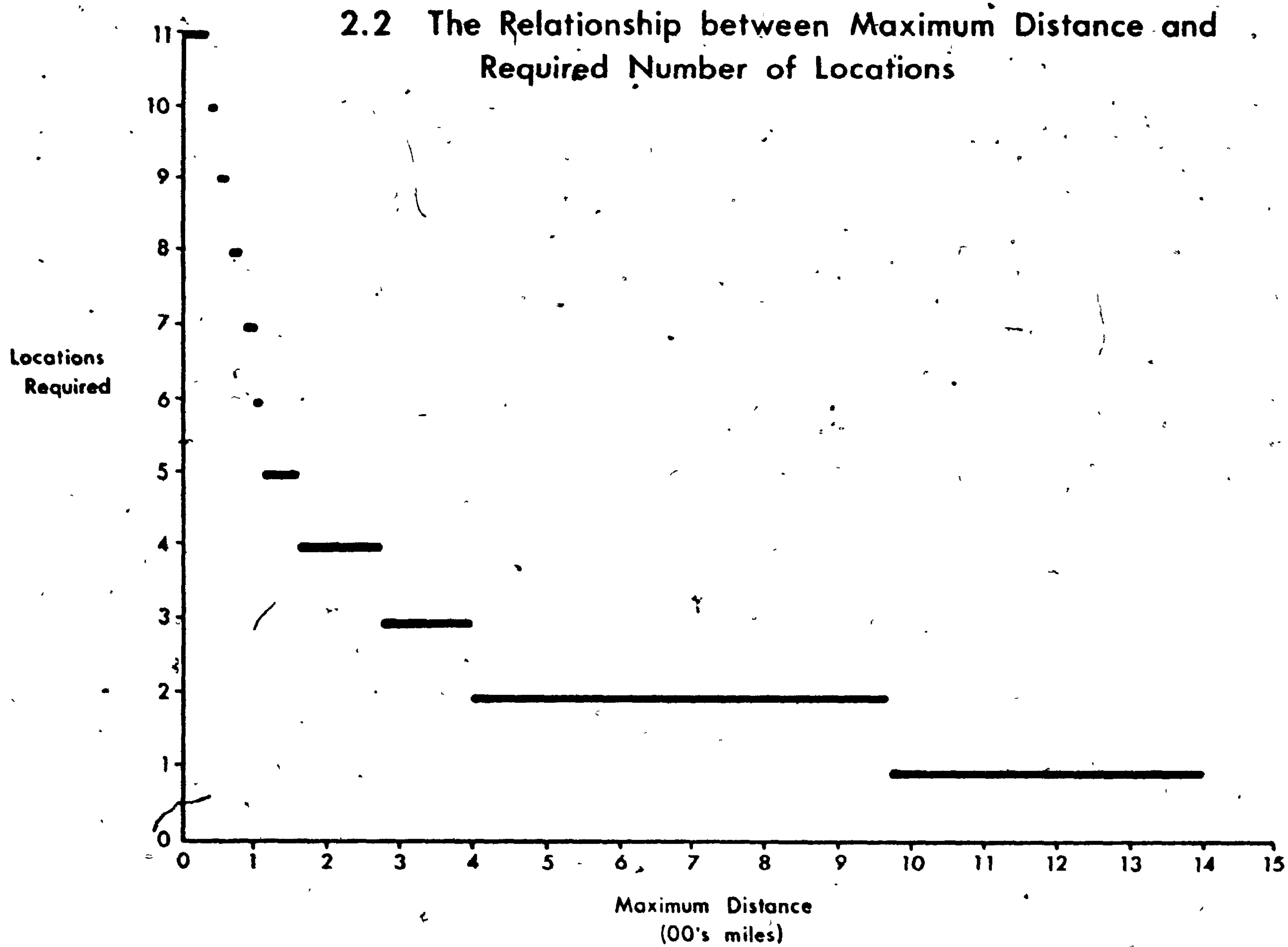
The demand surfaces for distances less than 225 are shown in Appendix A to a maximum distance of 110 miles, when 6 locations are required. With S values lower than this, the solutions are complex and are not shown.

INTERPRETATION OF RESULTS

Distance

The results of such an analysis can be drawn together in a curve which plots the relationship between the number of locations required and maximum distance for all those distances which exist in the region. Such a curve is shown in Figure 2.2. From this, it is possible to read off the required

2.2 The Relationship between Maximum Distance and Required Number of Locations



number of locations for any distance. Beginning with the case of no transport capacity, it is possible to describe the way in which an increase in the maximum distance capability reduces the number of locations required. Small increases in capability to 110 miles reduce the required locations from 11 to 5. Thereafter the speed of reductions slackens. To reduce to 2 locations it is necessary to increase the maximum distance to 400 miles. For one location, a minimum distance of 970 miles must be entertained.

Time

The same curve may be used to define the time relationships of the system. Since transport must be performed at a rate determined by the means of transport, all that is needed is a conversion rate to produce equivalent distance. From then on, the curve can be used directly. For the Caribbean region in the period 1950-1970 three types of vessels have been in use, with different average speeds. For the transoceanic liners of the cargo trade, the Harrison Line ships are typical. Hyde, the business historian of the line, estimates the maximum speed at 14 knots per hour.[3] This can be estimated at 15 miles per hour, and is reasonable for ships of the trade. The Federal Boats were also of this speed. For the motor vessels of smaller size which were introduced in the 1950's, Burgess has estimated their speed at 10 miles per hour.[4] Estimates for the schooners are 5 - 8 mph for those with auxiliary engines.[5] Doran has provided the most thorough testing for Tortola boats and gives an average speed of 5 mph.[6] This will be the value assigned to schooners in the Eastern Caribbean.

Using these values as conversion factors, it is possible to read off from the curve the number of locations required such that the maximum travel time is 24 hours by schooner, motor vessel or Federal Boat. For example, for each node to be within 24 hours travel time by schooner requires the number of locations appropriate to a maximum distance of 120(24 x 5) miles, or 5. For motor vessels at 10 mph, this is equivalent to a distance of 240 miles, requiring only 4 locations, while use of the Federal Boats requires only 3 locations since the 24 hour distance is 360 miles. The relationship between time, speed and number of locations required is shown in Figure 2.3.

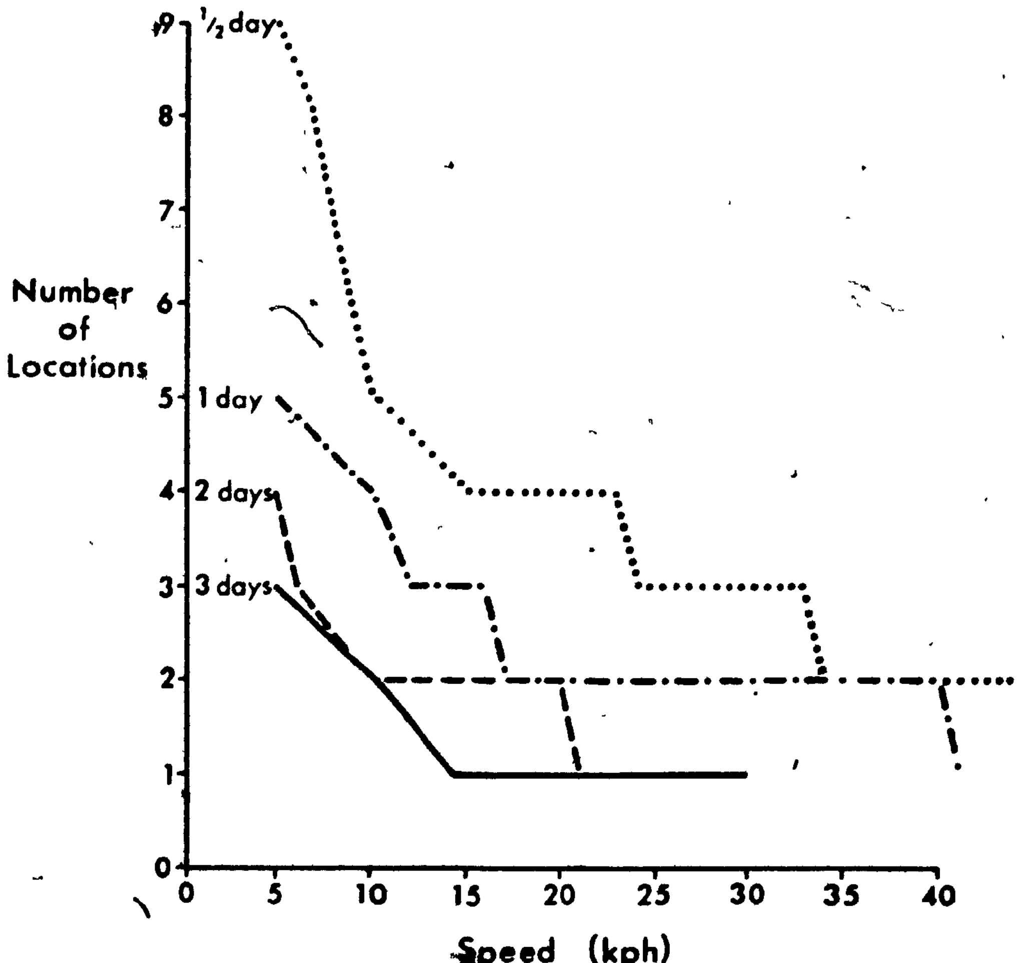
Maximum Distance as "best estimates"

Another property of the maximum distance approach is its utility as a best estimate. In the absence of complete information on the links in the network which are actually employed, the longest link known to be used can be taken as an estimate of the capacity to transport, on the assumption that all lesser links are possible. Used in this way the maximum distance becomes a most favourable estimate. This is what is meant by a "best estimate".

Effects of Innovations

The preceding can be combined to give an indication of the effects of an innovation in transport on the organisation of activity in the region. A positive or negative change in the capacity to transport has implications for the supply of the nodes in the system. If a new means of propulsion increases the average speed of a ship, the possible reduction in the number of locations can be judged. Conversely, if a particular location becomes inoperative, it is possible to determine the new maximum distance which must be crossed for all demands to be supplied. The locations curve has a utility which will be explored further in the following sections.

2.3 Supply Time, Speed + Number of Locations



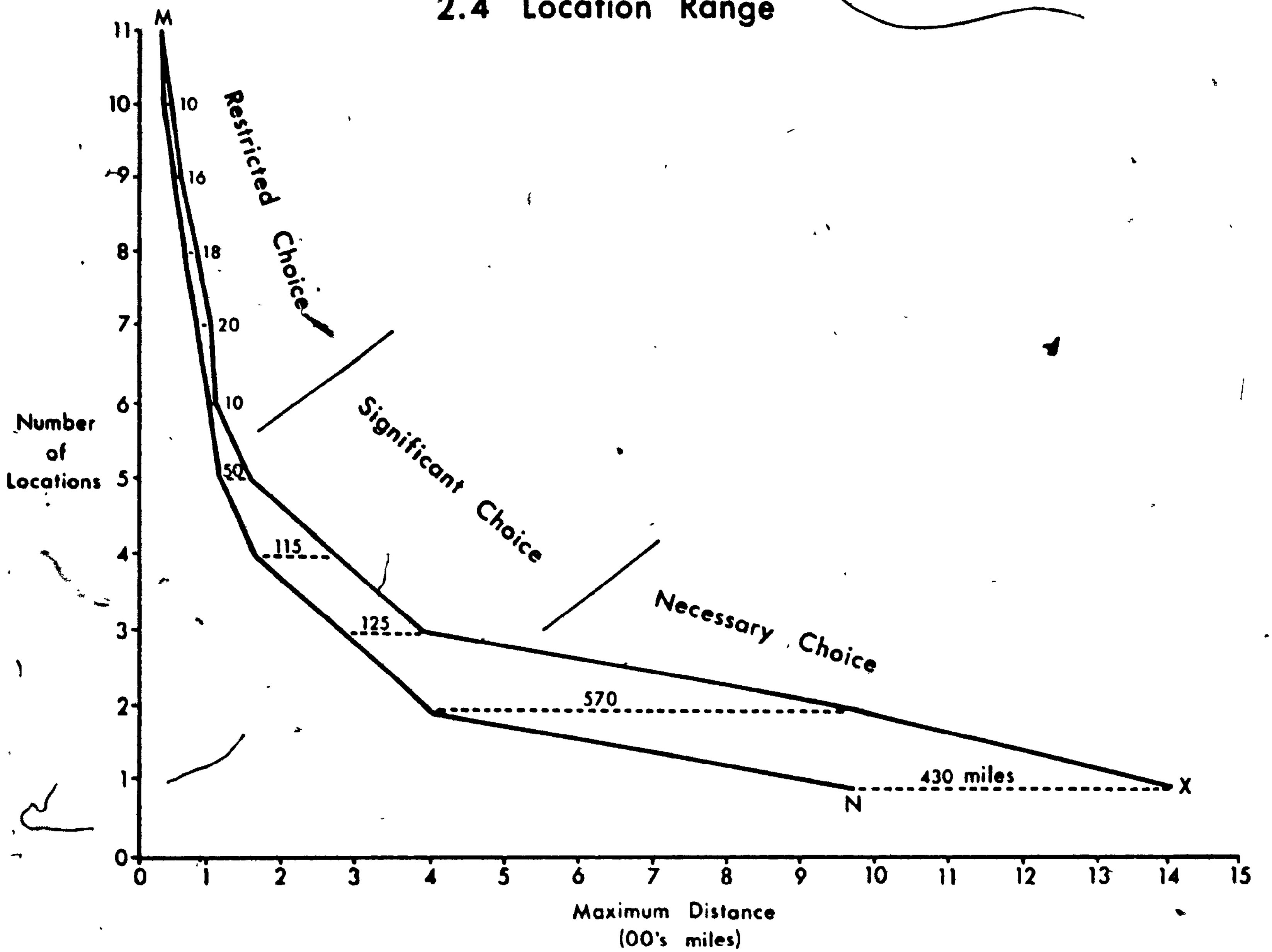
rmw

CHOICE IN LOCATION

Location Range

The locations curve shows a range of distances over which the number of locations required to serve the entire region does not vary. This distance, or location range, varies inversely with the number of locations i.e. the greater the number of locations the smaller the location range. When ten locations are required the location range is a mere 10 miles; for nine it is 16 miles; for eight, 18 miles; for seven, 20 miles; and for six, 10 miles again. In reducing the number of locations to 6, the average location range is 15 miles. Below these values however there is a progressive increase in the location range. When five is the required number of locations, the range expands to 50 miles or more than three times the average of the preceding values. Reducing to four locations gives a range of 115 miles; and to three, one of 125 miles. Between 5 and 3 locations, therefore, the range averages slightly under 100 miles. The final reductions to 2 and 1 locations involve ranges of 570 and 430 miles. Clearly by this stage the region is approaching the maximum flexibility in its choice of locations. An increase in the capacity to overcome distance brings a substantial increase in the choices open for the location of economic activity. This is clearly demonstrated in Figure 2.4 which also shows two curves, one MX, the result of choosing at each stage the maximum possible distance; the other, MN, the curve when the minimum distance is chosen at each stage. The progressive disparity between these two curves underscores the three sectors previously described. There is the restricted choice between 11 and 6, in which it matters little whether the maximum or minimum curve is chosen; the beginning of choice between 5 and 3 locations when the difference begins

2.4 Location Range



to assume significant proportions; finally the area of necessary choice, since the differences are now so great that substantial penalties are attached to sub-optimal choices.

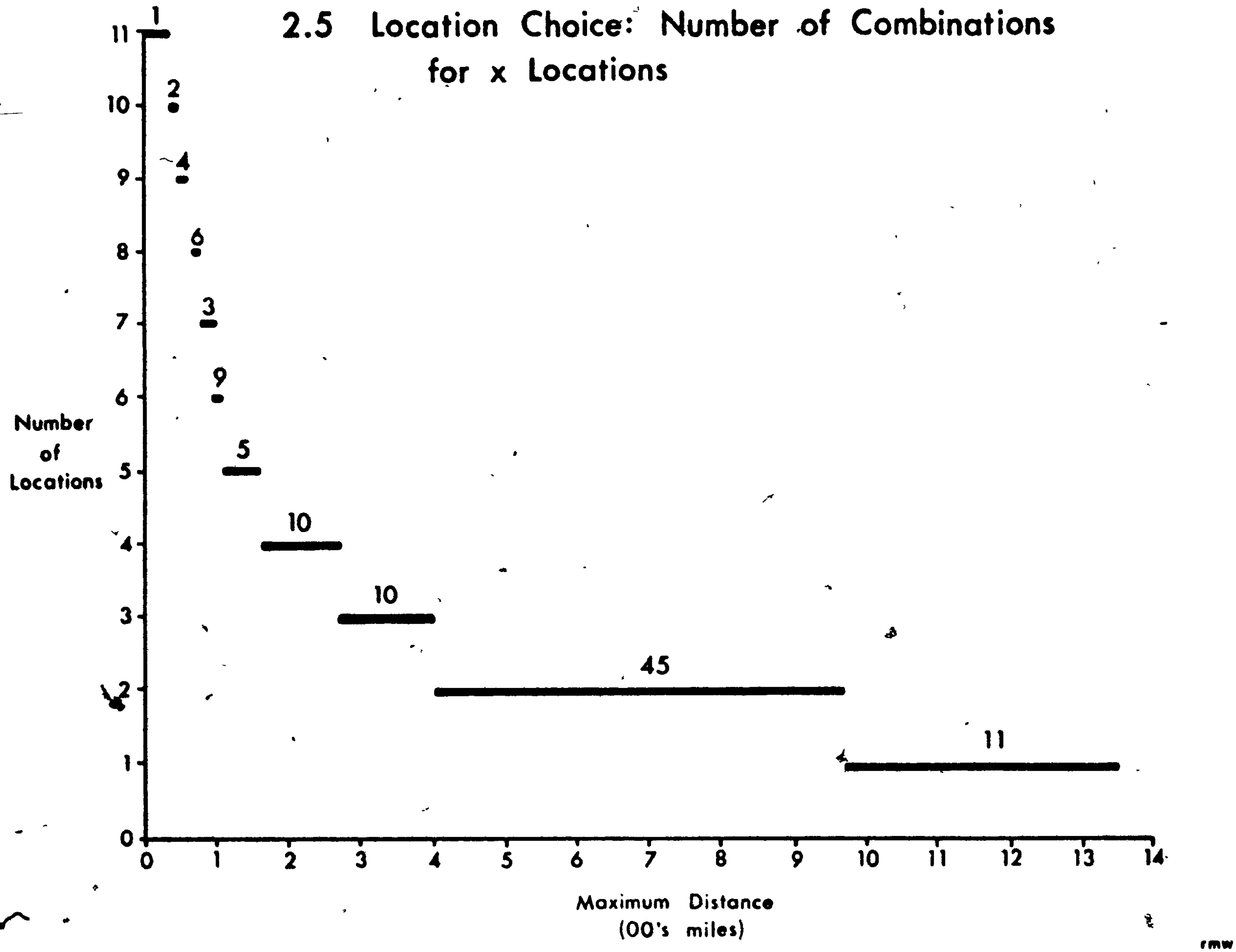
Location Choice

The range of choice imposed by any given number of locations varies over certain distances but also sets a limit to the number of combinations from which a choice can be made. When 11 locations are required, there is a single combination which is possible. When the maximum distance is set at 40 miles, ten locations are required and we have no choice over nine of them, since they all fall outside the maximum distance constraint. However, nodes 3 and 4 are within 40 miles of each other, so we can choose either of these for the tenth location. In essence, there are only two choices offered. A similar reasoning is used to deduce the number of choices open for each number of locations and the results are described in Figure 2.5. From a very small choice when the number of locations is large, the magnitude of choice increases only slowly to 6 when eight locations are required, fluctuating between 6 and 10 over those distances which require from seven to as few as three locations. It is only when two locations are required that the magnitude of choice is really large, 45, a figure which almost equals the total choice for all the preceding arrangements (50). Finally, there are eleven choices when a single location is all that is required.

Order of Choice

The number of choices open at any stage are not equal to the maximum number for the particular arrangement. For example, when three locations are required, the range is 125 miles i.e. from a minimum of 275 to a maximum of 400 miles. At the lower end of 275, there is only one combination

2.5 Location Choice: Number of Combinations for x Locations



which satisfied the conditions and our three locations are 1, 6, 11. However at 300 miles there is a choice between 1, 6, 11 and 1, 8, 11. Likewise we need to raise the distance to 350 miles before our choice is expanded to include node 5. The choice is now between the combinations 1, 6, 11; 1, 8, 11; and 1, 5, 11. When the distance is set at 380 miles, there is a fourth choice added, that of 1, 7, 11. It should be noted that no other choices enter the solution when three locations are required. To add to our choices would require raising the maximum distance to over 400 miles, but it can be seen that at 400 miles only 2 locations are required.

The foregoing makes it clear that the nodes of the system enter the choice at any level in a certain order which is determined by the maximum distance constraints. This order is outlined in Figure 2.6 for those cases where six or less locations are required. In each case, the bracketed nodes are those essential to the solution, while the order of entry into the choice process is indicated on the segments of the curve. For example, when five locations are required, nodes 1, 3, 9 and 11 are essential, while the fifth appears as a choice in order of 7, 4 and 10.

Static Solution

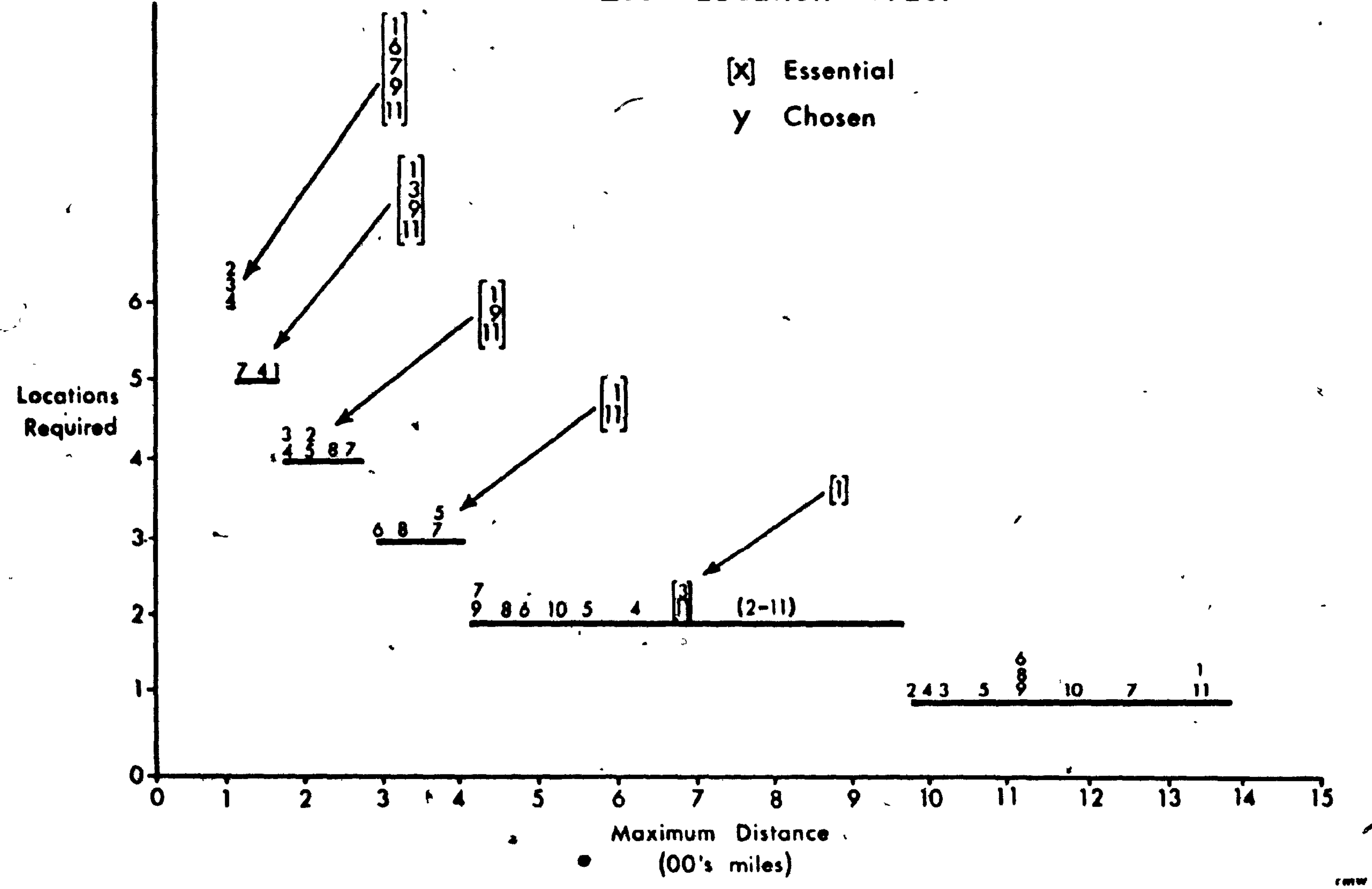
From Figure 2.6, it is possible to identify the best choice at each stage. The solutions at 6 or less locations are presented below.

Best Choice Solutions

Locations Required	6	5	4	3	2	1
	1	1	1	1	1	2
	6	3				
Essential	7					
	9	9	9			
	11	11	11	11		
	2	7	3	6	7	
Choice--1 of	3		4		9	
	4					

If, therefore, there is a progressive reduction in the number of locations,

2.6 Location Order

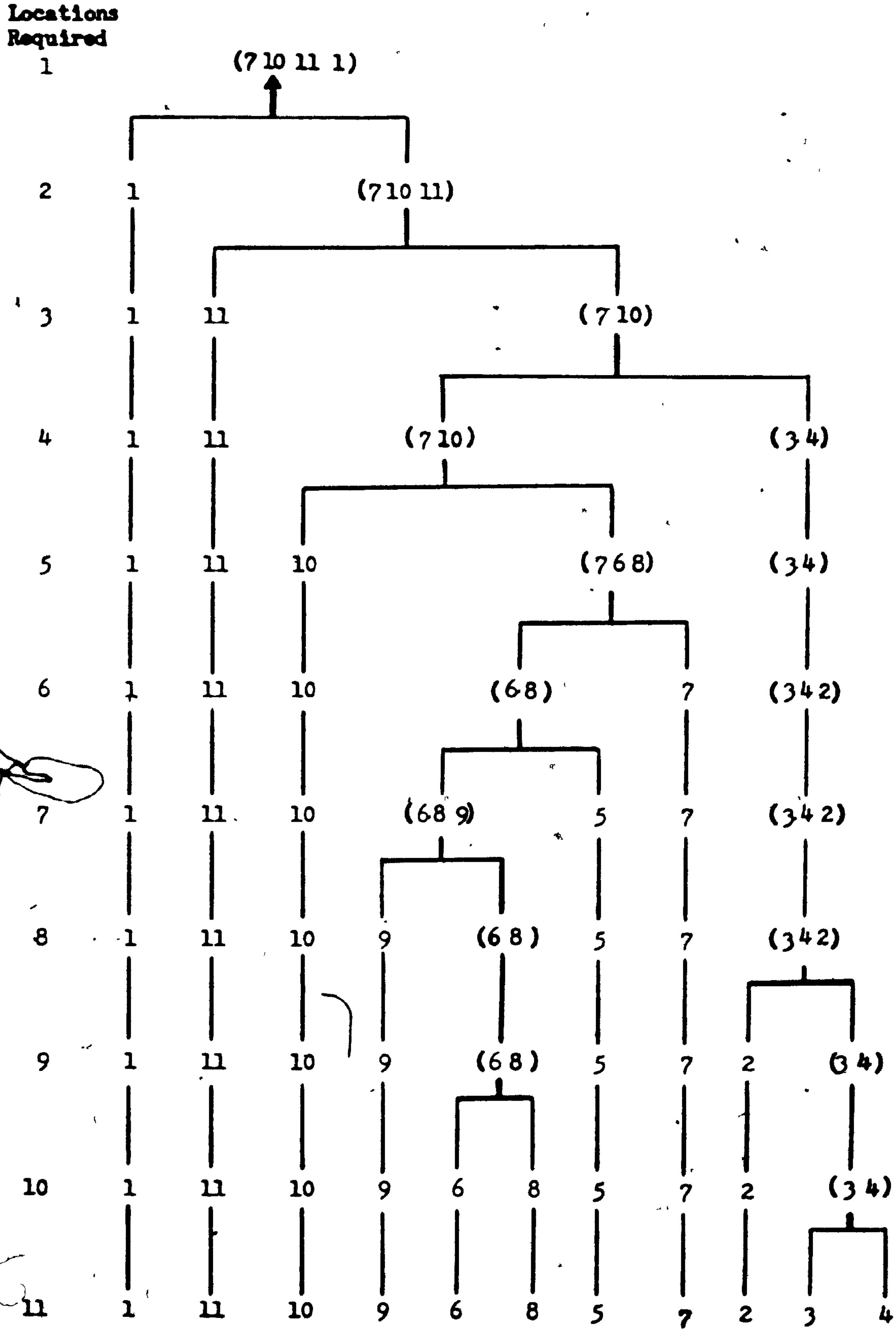


and the maximum distance is to be as small as possible, the choice at six would be node 3. To reduce to five locations requires the death of node 6 and the solution is a best choice. Reducing to four can lead to a best solution if node 7 dies, but to reach a best choice at three requires the death of 9 and 3 and the birth of a location at 6. To reach the best two locations necessitates the departure of node 6 and the reappearance of 7 or 9. Finally the best single location is node 2 which has long since disappeared from consideration. This illustrates that the application of the "best choice" solution at each stage would as a process give rise to the intermittent entry and exit from the system of selected nodes, and is clearly an inefficient strategy for the location of activity. What is necessary is a strategy of location which does not give rise to this birth and death process, but which allows the choice at each stage to represent a long-run strategy which ensures that the choices made at any stage will present feasible solutions at a later stage. The goal will be a minimization of transport costs in the long run.

Dynamic Solution

Such a solution procedure has been investigated by Scott in particular.[7] His solution was to devise a decision tree and to proceed backwards from the final outcome to make the most suitable choice consistent with both the preceding and following choices. This technique has been modified here to produce a location decision tree which will form the basis of a long-run solution to the problem. The results are in Figure 2.7. For comparison, the solutions in this long-run strategy are listed for six or fewer locations.

FIGURE 2.7.—LOCATION DECISION TREE FOR LONG-RUN STRATEGY



Long-Run Strategy

Locations Required	6	5	4	3	2	1
	1	1	1	1	1	
Essential	7					
	10	10				
	11	11	11	11		
Choice--1 of	6	7	7	7	7	7
	8	8	10	10	10	10
and	2	2			11	11
--1 of	3	3	3			1
	4	4	4			

The differences are clear and the solution is very different. At stage six, node 9 of the best choice has been eliminated for node 10. Noting that by stage four the choice for the last node is between nodes 3 and 4, at stage six a choice is made, say 3, and kept until stage three when it disappears. At stage five the choice between 6 and 8 must then compete with 7 for the final entry in the solution. But since by stage four, both 6 and 8 are out of consideration, then 7 is chosen at stage five and remains. The solution at stage three shows that 1 and 11 are essential and the choice is now between nodes 7 and 10. At stage two, a choice is required between 7 and 10, and 11, and when a single location is all that is necessary, node 1 joins those three in the choice. This long-run strategy is based on the principle that a choice between nodes should be made according to its relative location with respect to the whole system. Accordingly, to minimize transport in the region, we choose that node whose minimum aggregate distance is smallest. Hence at stage four, we choose 7 in preference to 10 and the solution is 1, 11, 7,3. Reducing to three then simply eliminates node 3. At stage two, the choice is now reduced to 7 and 11, and by our stated principle, 7 is chosen over 11. Finally, node 7 is a clear choice over node 1 for the single location.

Competition

Such a dynamic system shows the outcome of a competitive strategy which is resolved according to transport minimization principles and is therefore useful in assessing the effects of transport on location in the system. It indicated those nodes likely to establish themselves as the strongest competitors for two reasons. At the outset, the most isolated nodes are least affected by competition and remain secure for internal suppliers. Transport expansion then brings within reach places which have already lost their domestic suppliers to competitors and are thereafter dominated by existing locations. In the long run the most peripheral nodes of 1, 7, 10 and 11 survive to dominate the system, with 7 emerging as strongest.

NETWORK STRUCTURE

Network Development

The principle of maximum distance which defines patterns and choices of location within a given system in the manner described in the preceding sections also defines a pattern of network growth among the nodes. If the transport capacity is limited to a certain distance at a given time, then only links equal to or less than this limiting length are possible. Hence the structural properties of the network has a relationship to the maximum distance to be found within the network.

In describing the development of the transport network under the maximum distance constraint, use will be made of simple graph-theoretic ideas which are now well known in the literature of transportation geography and will not be discussed here.[8] The assumption of a totally disconnected network as an initial condition is easily interpreted as the condition of zero capacity to transport. The maximum distance will then be progressively increased, and it will be assumed that all links which satisfy the prevailing distance constraint will be added to the network. Using the distance matrix, the development of the network has been plotted in a series of figures for maximum distances up to 275 miles and these are shown in Appendix B. In the last two diagrams the new links added at 400 and 500 miles are shown so as to maintain the clarity of the diagrams. No attempt is made to represent new links beyond this stage.

Structural Properties[9]

Throughout, there are eleven nodes in the system and these may each have a direct link to every other node in the complete network. The maximum number of links in an undirected graph is given by

$$L_{max} = \frac{n(n-1)}{2}$$

From this, a connectivity index, γ, may be computed which relates the observed number of links to the maximum possible. Expressed as a percentage, this becomes

$$\gamma = \frac{L}{\frac{n(n-1)}{2}} \times 100$$

ranging from 0 to 100.

A second property of importance for a system is that of choice. If the direct routes between any two places is inoperative, the existence of an alternative connection allows the system to function without breakdown. This property can be measured by the α index, which relates the number of circuits in a network to the maximum possible. The number of circuits is given by

$$U = L - N + G$$

Hence

$$\alpha = \frac{L - N + G}{\frac{n(n-1)}{2} - (n-1)}$$

Like the γ index, the α index ranges from 0 to 100. These two indices are combined with the elementary values of the number of nodes, number of links and circuits to describe the structural properties of the network under varying maximum distance constraints. The solutions represent the type of network possible for each distance constraint.

Structural Properties of Network and Maximum Distance

Distance in Miles	n	l	l_{max}	γ	α	u	U_{max}
45	11	1	55	1.8	0	0	45
60	11	2	55	3.6	0	0	45
75	11	4	55	7.2	0	1	45
90	11	5	55	9.0	0	1	45
105	11	6	55	10.9	0	1	45
110	11	7	55	12.7	0	1	45
115	11	8	55	14.5	0	1	45
120	11	10	55	18.2	2.2	2	45
150	11	13	55	23.6	8.8	5	45
275	11	23	55	41.8	31.1	14	45
400	11	36	55	65.[illegible]	60.0	27	45
500	11	41	55	74.5	71.1	32	45
700	11	45	55	81.8	80.0	36	45

$$\gamma = \frac{L}{\frac{n(n-1)}{2}} \times 100 \qquad \alpha = \frac{L - n + g}{\frac{n(n-1)}{2} - (n-1)} \times 100$$

n = number of nodes
l = number of links
g = number of subgraphs
l_{max} = maximum number of links
γ = % connectivity
α = % redundancy
u = number of circuits
U_{max} = maximum number of circuits

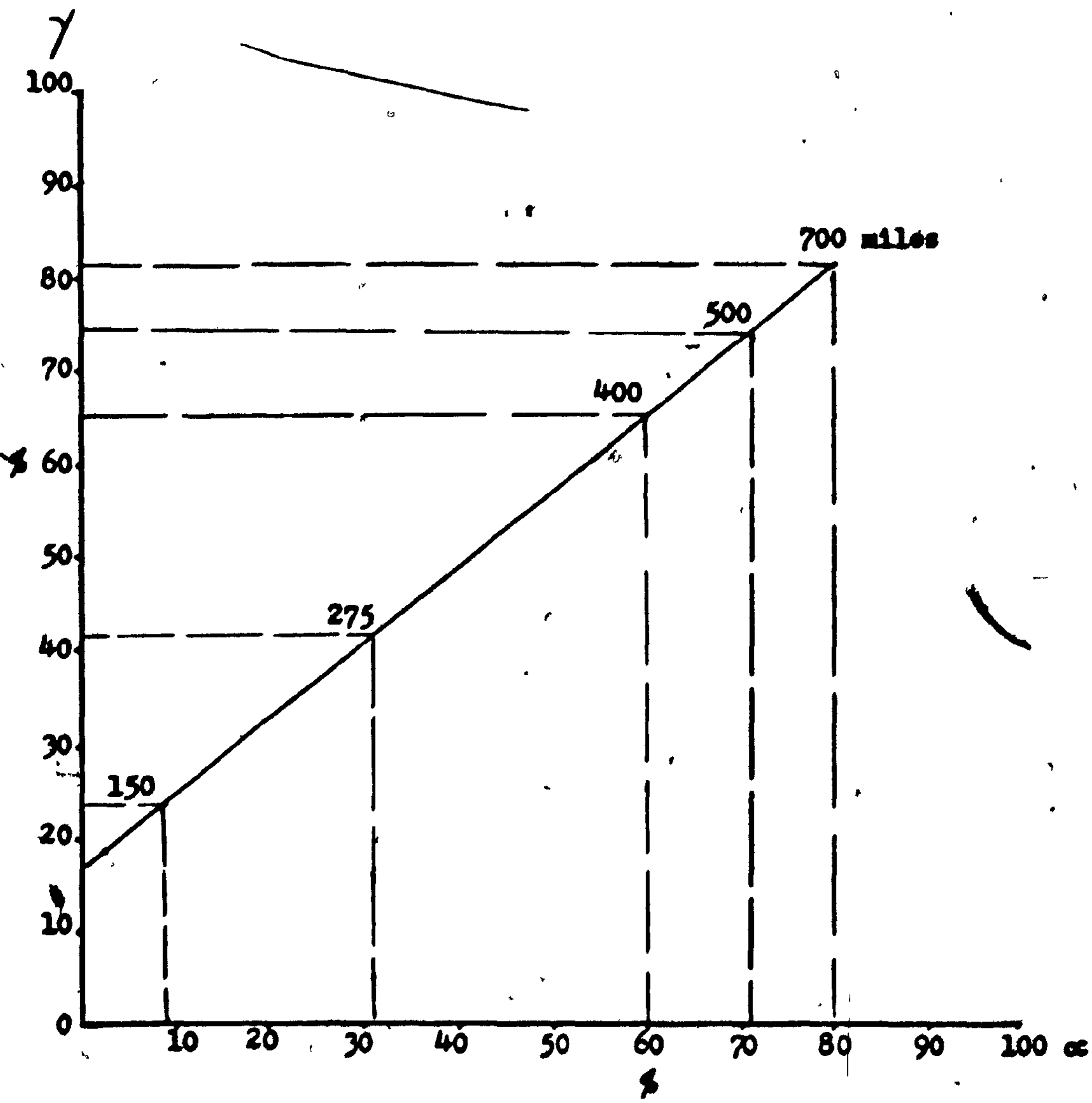
The slow growth of the network up to 150 miles is clear from the values of those properties. Of a maximum of 55 links only 13 are possible at this value, and there are only 5 circuits. The connectivity is therefore only 23.6%, with the degree of circuitry only 8.8%. Between 150 and 275 miles the connectivity almost doubles to 41.8% while the α index now reaches 31.1%. The system therefore is beginning to develop alternative routes. At 400 miles, the connectivity is 65.4% or almost 2/3 of the maximum and the α has risen to 60%. At 500 miles the number of links is now 41 for 75% and there are 32 circuits out of a possible 45. The maximum distance must be raised to 700 miles before the γ and α indices reach similar levels of 80%. By this time, only the links and circuits with node 1 remain outside the network, even though there is a complete network among the remaining 10 nodes.

The relationship between the γ and α indices is plotted in Figure 2.8. Note that the γ reaches a value of more than 15 before the α is greater than zero. The values of these indices at maximum distances of 150, 275, 400, 500 and 700 have been drawn in, so that the quadrant is divided into areas which fall within the various zones. It is thus possible to compare the values derived from a network with those of the theoretical networks determined in this way.

Nodal Properties

The changing status of individual nodes with respect to the network can also be shown to vary with the distance constraint. As we have suggested that the important routes in a shipping network are the direct ones, the nodal property which most clearly measures this is the concept of degree, which is a measurement of direct connections to a given node. In the system of 11 nodes, the maximum number of direct connections is 10, and this is so for all nodes. The changes in degree are given for distance values up to 500. The distance at which nodes attain the degree value of 9 is an indication of how quickly they can develop direct links to all nodes except node 1. Nodes 7 and 9 reach this value first at a 400 mile distance,

FIGURE 2.8.--THE RELATIONSHIP BETWEEN THE γ AND α INDICES UNDER MAXIMUM DISTANCE CONSTRAINTS



while it takes 500 miles before nodes 6, 8 and 10 reach a similar level. Nodes 4, 3 and 2 follow in that order.

The Variation of Nodal Degree with Distance

Nodes	1	2	3	4	5	6	7	8	9	10	11
45			1	1							
60			1	1		1		1			
75		2	2	2		1		1			
90		2	2	2		1		2	1		
105		2	2	2	1	2		2	1		
110		2	2	2	1	2		2	2	1	
115		2	3	2	2	2		2	2	1	
120		2	3	2	2	3	2	3	2	1	
150		2	3	3	4	4	2	4	3	1	
275		3	4	5	7	7	5	6	5	4	
400		7	7	7	8	8	9	8	9	6	3
500		8	8	8	8	9	9	9	9	9	5

SYNTHESIS

Propositions about Interisland Transport

From the analysis so far, certain propositions may be derived.

1. For every given distance at which the capacity to transport is fixed, there is a minimum number of locations required to serve the total market.

2. The number of locations varies inversely with the capacity to transport.

3. The capacity to transport can be increased by changes in shipping technology. The introduction of motor vessels, for instance, involved a substantial increase in this capacity.

From propositions 2 and 3, we may derive number 4.

4. The more advanced the technology, the fewer the number of locations needed to serve the region.

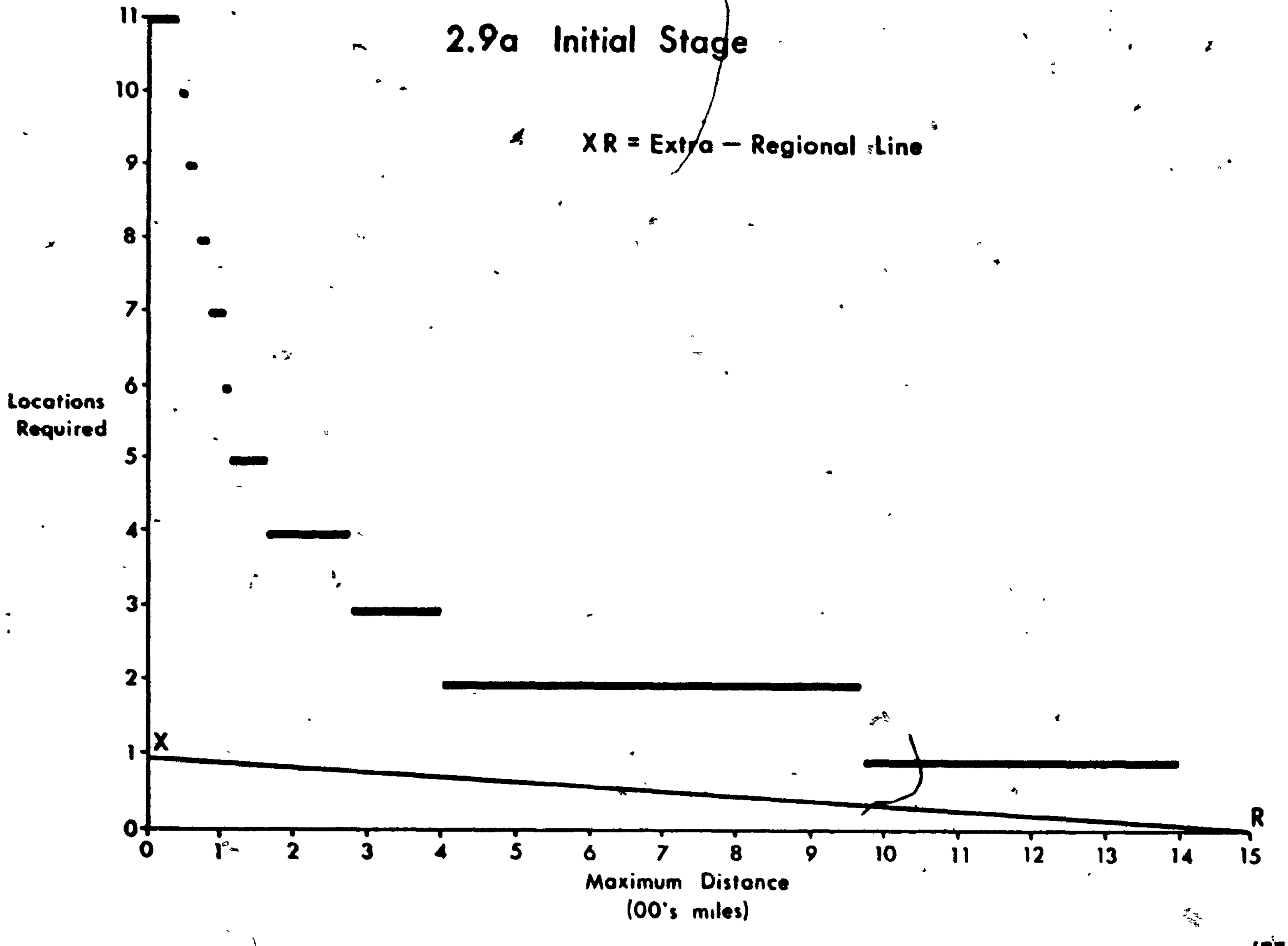
5. For each distance, network properties are defined and limited.

Regional Development

These propositions may now be applied to the region to show the relationships between transport and regional structure and the changes introduced over time as the transport capacity expands.

An absence of interisland economy.--An initial stage may be postulated in which no unit receives any supplies from other units. Regional transport capacity is zero. A unit must either foster domestic producers or find suppliers outside the region. Using the distance/locations curve, this stiuation is represented in Figure 2.9a where XR begins at 1,500, i.e. outside the maximum range for the region, and ends below the 1-location mark as there are no regional suppliers. For simplicity we will assume there are 11 domestic and no outside suppliers. It allows a solution when competition is at its strongest leading to a more powerful long-run solution.

Early schooner economy.--The interisland economy begins with the introduction of simple ships of limited operating range. In our case, these are schooners first propelled by sail, of 50-100 NRT. The transport capacity is slowly expanded up to say 100 miles. As a result there is set in motion a competitive process as those units within the transport range of each other compete. Certain direct links are now possible in the early schooner economy along which the trade flows will converge. But at each stage of the concentration process there is a certain order of choice imposed by the distance constraints. Yet this range of choice is so small as to be of minor significance. For instance the schooner economy enters the stage when seven locations are required at a transport distance of 80 miles, but at 100 miles only six locations are required. The minimum cost solutions at 80 and 100 would hardly represent such savings as to give a decided advantage to a location chosen at 80 miles. As the maximum distance increased,

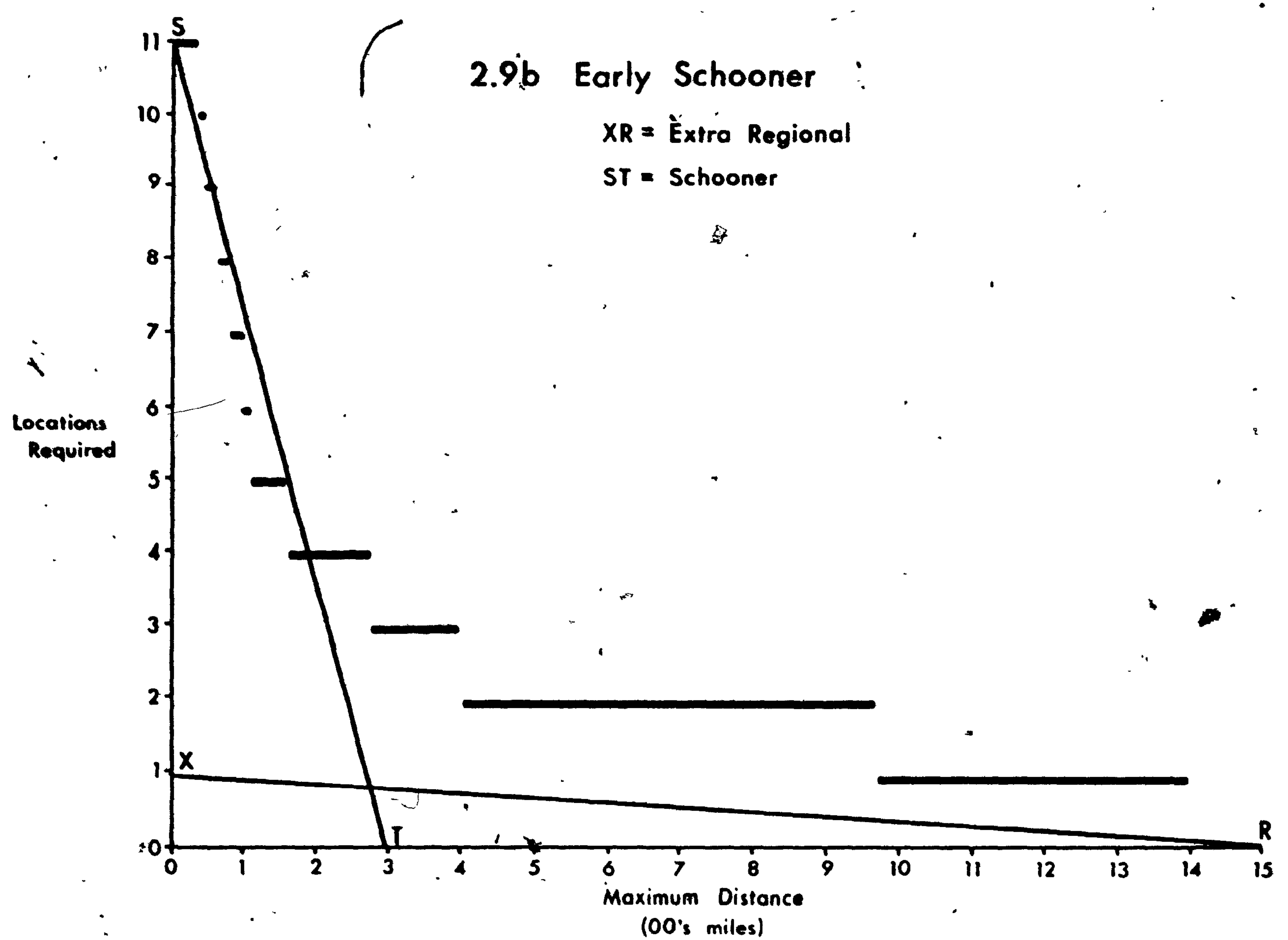


2.9a Initial Stage
XR = Extra — Regional Line
Locations Required
Maximum Distance (00's miles)
X
R
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
rmw

the concentration of activity into fewer centres partitioned into those which, because they were outside the operative distance, found it necessary to retain their domestic suppliers, and those inside the operative distance which survived the new competition. In the more peripheral locations which survived, it became attractive to introduce forms of transport which would allow them to participate in the regional economy. Motor vessels begin to be introduced.

Late schooner economy.--As the operative distance goes beyond 120 miles, motor vessels become more and more attractive and are being introduced by more and more units until motor vessel activity comes to outweigh the schooner for the region as a whole. For instance, 50% of all ship entries may now be motor vessel. To fight for their competitive position, schooner owners install engines. Thus there is a dual diffusion of motor vessels on the one hand, and of engines on sailing vessels on the other as a response to this increase in operative range. In contrast to the motor vessels, engines are expected to diffuse outwards from the more central units, while the outer units all display a more rapid increase in steam and motor entries.

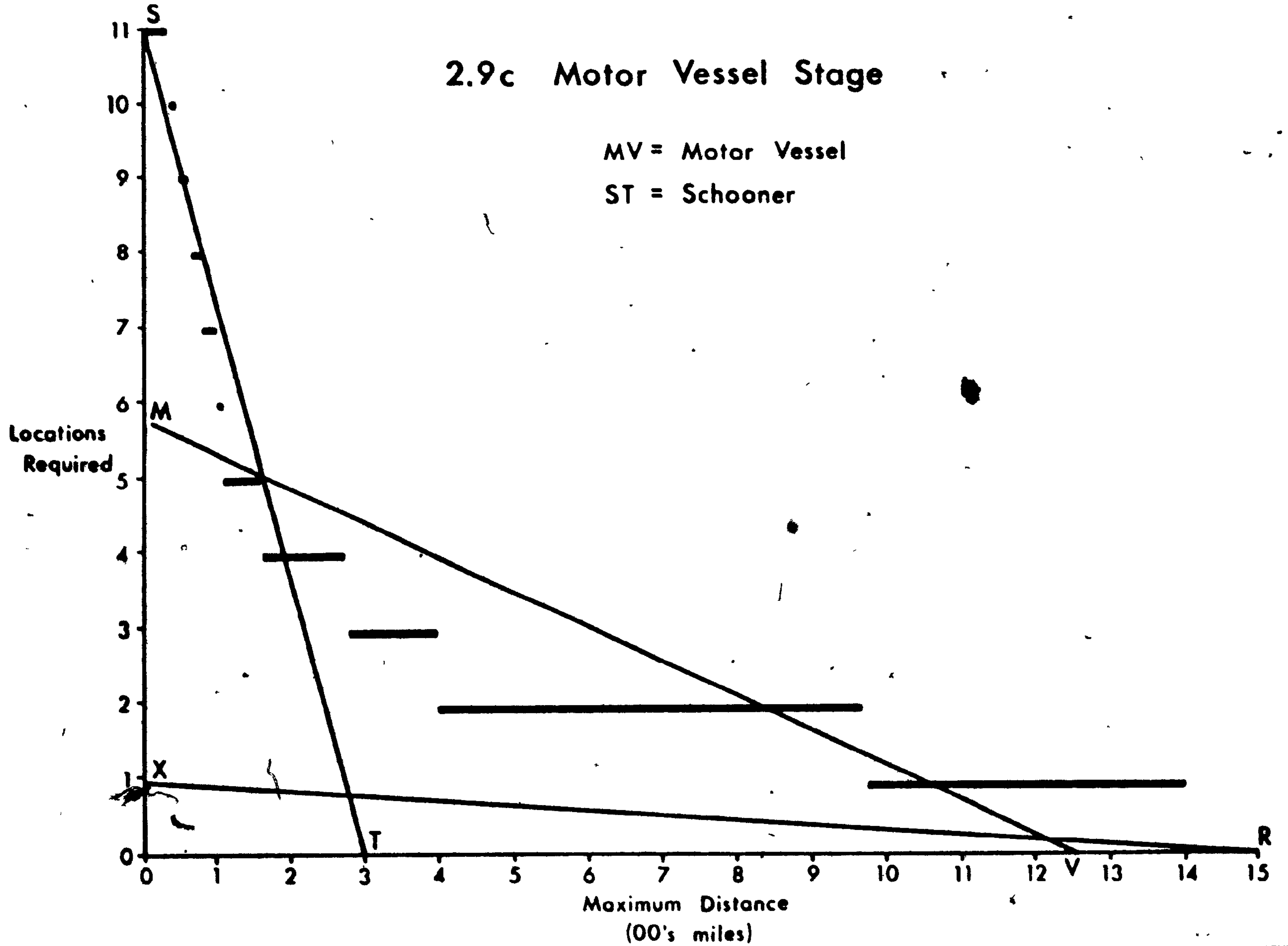
Motor vessel economy.--The ascendancy of the motor vessel is clear by the time the operational distance has reached 150. By 160 miles, only four locations are required for there is this capacity to cover longer distances. The network possible now has many more links and circuits. With a connectivity of about 25%, circuits to the order of 10% of the maximum appear. We may assume that while the schooners may be confined to the older and shorter links, the motor vessel would be employed in the new, longer, direct links, thereby establishing the new circuits. It also means greater competition along the shorter links where both schooner and motor vessel operate while the longer links fall to motor vessel alone. Hence those nodes associated with the motor vessel would be at an advantage over the schooner


2.9b Early Schooner
XR = Extra Regional
ST = Schooner
S
X
T
R
Locations Required
11
10
9
8
7
6
5
4
3
2
1
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Maximum Distance
(00's miles)
rmw

nodes. Since we propositioned that the outer links would be more closely associated with the motor vessel, the passage of the interisland economy into the motor vessel stage should bring in train the strengthening of the peripheral units and the progressive weakening of the central ones. The rapid demise of the competitive position of the schooner is demonstrated by the steep slope of ST in Figure 2.9b.

The motor vessel made possible further concentration of supply into fewer locations as the range of transport increased, but it also opened up greater choice in the locations which could act as supply points. With only four or three locations necessary at ranges between 160 and 400 miles, there are 10 combinations which could supply the region. The competitive process is engulfing the region. The central units more closely tied to the schooner lose their advantage to the other units because of the extending range.

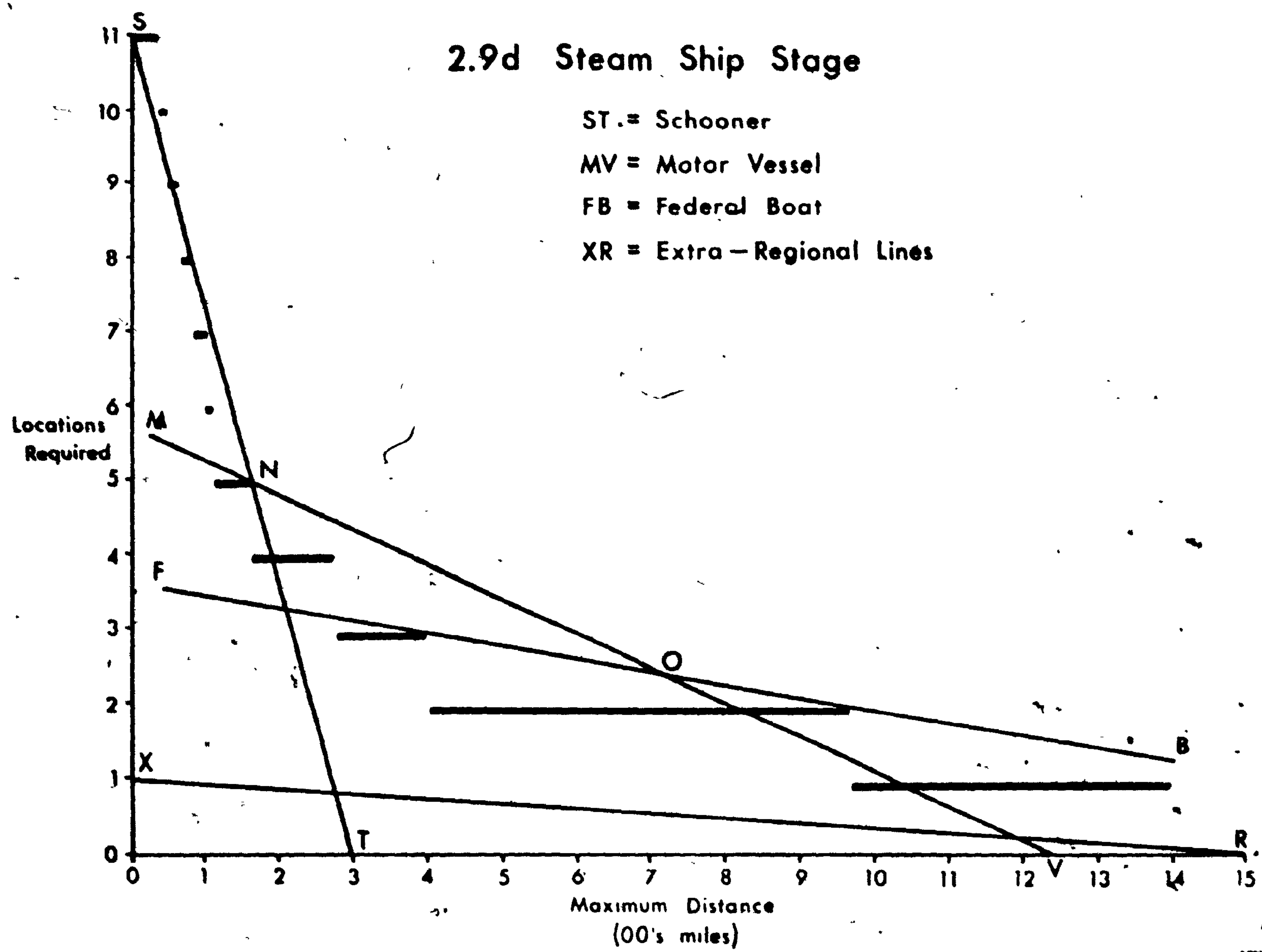
<u>Federal boat economy</u>.--The motor vessel might have continued to be the dominant organising mode in the interisland economy were it not for the decision of the politicians to introduce ships not only of greater range (15 knots speed) but also of much greater size. Whereas the motor vessels were of 150-600 tons, the Federal Boats were of 3,000 tons size. The operative distance was therefore increased rapidly making possible the culmination of the consolidation process, since a single location could now serve the region. Equally the choice had now come full circle so that theoretically any one unit was available, though node 2 was the minimum distance choice. But by this time the competitive process had already eliminated 2, and, as has been suggested, was already favouring the peripheral nodes 1, 7, 10 and 11. The movement into Federal Boat economy was certain therefore to lead to the progressive dominance of the outer nodes. If, in addition, the Federal Boats happened to follow some schooner routes and if


2.9c Motor Vessel Stage
MV = Motor Vessel
ST = Schooner
Locations Required
Maximum Distance (00's miles)
S
M
X
T
V
R
0 1 2 3 4 5 6 7 8 9 10 11
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
rmw

these, too, were already being followed by motor vessels, then the competitive position of the schooner would be further eroded. The entry of the Federal Boats is set at 1,400 miles in Figure 2.9d. and crosses MV, the motor vessel curve at 0, or a distance of 700 miles.

A Transport Frontier

In Figure 2.9d, the curve SNOB outlines a hypothetical transport frontier along which the interisland economy is seen to travel. The structural properties of the network and the patterns of locations are defined along this frontier in ways described in earlier chapters, but always within ranges established by the distance constraints. This frontier is a frontier of innovation for the sectors of the curve SN, NO and OB are determined by different modes of transport. The precise relationships between the schooner, motor vessel and Federal Boat curves of Figure 2.9d are empirical matters, though the widening location range after 150 miles seems to suggest a change of organisation. Clearly alternative relationships would define the characteristics of our types of economy somewhat differently. Yet, whatever the relationships, we can always specify the location patterns, the range of choice, and the associated network structure. Likewise the nature of change along the transport frontier can always be specified. It should be noted that the successive partitioning of activity between schooner, motor vessel and Federal Boat, means a change in definition of the transition from one type of economy to another. The foregoing analysis also points to certain relationships for individual nodes and activities, <u>all</u> of which should be seen as subject to *ceteris paribus* assumptions.


2.9d Steam Ship Stage
ST = Schooner
MV = Motor Vessel
FB = Federal Boat
XR = Extra-Regional Lines
Locations Required
Maximum Distance
(00's miles)
S
M
N
F
O
B
X
T
V
R
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Propositions about Individual Nodes

1. The more peripheral the position, the greater the degree of self supply, the more central the node, the more likely to be supplied by a different node.

2. The more peripheral the location, the earlier the introduction of technological improvements.

3. The more central the node, the longer early technical forms will survive.

From the preceding propositions we may derive number 4.

4. The more peripheral the location, the greater the likelihood the node will engage in motor vessel economy; the more central the node, the greater the likelihood of participation in the schooner economy.

Propositions about Individual Activities

1a. The greater the number of territories in which a given activity exists, the shorter the distance it has to be transported.

1b. The shorter the distance to be transported, the more suitable for schooner transport; the greater the distance the more suitable for motor vessel.

2a. The more suitable for motor transport the greater the likelihood it will be bcated in the peripheral nodes.

2b. The greater the likelihood of location in the peripheral nodes, the longer the activity is likely to remain located in the peripheral nodes.

Advantages of Approach

The approach to a theory of interisland transport through the notions of maximum operational distance and its associated patterns of location within defined networks has a number of advantages. It leads to solutions which are independent of size of the units, though the market areas defined would vary in size. It can be used no matter how many units are involved. The relationships are not time-dependent, though the effects of time can be judged. The rate of change, of course, has to be empirically determined for the particular region. It allows both short-run and long-run strategies to be determined and their relative merits assessed. Most important of all from the point of view of Caribbean literature, it presents a framework for the discussion of both the region as a whole and of the relationships of a particular unit to the region. Likewise the behaviour of either can be described over time. In addition, certain tentative propositions about the organisation of individual economic activities are also forthcoming. Finally, even though this thesis has concerned itself with sea transport, the theory and methodology could be employed in an analysis of air transport.

NOTES

1. C. Toregas and C. Revelle, "Binary Logic Solutions to a class of location problems," Geographical Analysis, vol. 5, no. 2, April 1973.

2. The presentation here closely follows that of Toregas and Revelle, but minor modifications have been made.

3. F. Hyde, Shipping Enterprise and Management, (Liverpool: Liverpool University Press, 1967).

4. C.F. Burgess, "Problems of Intra-Caribbean Transportation," Monthly Bulletin, Caribbean Commission, February 1954, pp. 152-54.

5. ECLA, Small Vessel Shipping in the Eastern Caribbean, (Port of Spain, 1970).

6. E.B. Doran, The Tortola Boat: Characteristics, Origin, Demise. Supplement to Mariner's Mirror, vol. 56, no. 1, January 1970.

7. See in particular A.J. Scott, "Optimal decision processes for a class of locational problems," Regional Science Association, Papers, vol. XXVI, 1971, pp. 25-35, and A.J. Scott, "Dynamic Location-Allocation Systems," Environment and Planning, vol. 3, no. 1, 1971, pp. 73-82.

8. See (1) K.J. Kansky, The Structure of Transportation Networks, University of Chicago Paper no. 83, 1963.
   (2) L. Ford and D. Fulkerson, Flows in Networks, (Princeton: Princeton University Press, 1962).
   (3) R. Chorley and P. Haggett, Network Analysis in Geography, (London: Arnold, 1969).
   (4) E. Taaffe and H. Gauthier, The Geography of Transportation, (Englewood Cliffs: Prentice Hall, 1973).
   (5) R. Potts and R.M. Oliver, Flows in Transportation Networks, (New York: Academic Press, 1972).

9. The indices used in the discussion can be readily found in Taaffe and Gauthier, Chapters 4 and 5.

PART II

TRANSPORTATION AND INEQUALITY

Truth, Lie, so close they
defy
inspection, and are built into autonomy by naive fools....

LeRoi Jones, "Green Lantern's Solo"
in The Dead Lecturer, p. 67.

CHAPTER THREE

THE LOCATION OF ECONOMIC ACTIVITY IN THE EARLY 1950'S

The flows which passed between the islands were confined to channels dictated by the shipping network in existence, but the nature and size of these flows were determined in the first instance by the structure of production in the islands. This chapter describes the structure of production in the Caribbean in the early 1950's so as to make clear the initial advantages which existed before a regional shipping service was introduced.

Data Source

Much of the discussion of trade relationships has focussed on the question of the size of individual units, and size has been measured in terms of population, area, gross national product, etc. These surrogates are not sufficiently closely related to economic activity to give a meaningful estimate of the likely use of transportation networks. More appropriate would be the number of activities, or number of firms, for we have argued before that it is cargo transport and not passenger transport which is the main function of the shipping network in the Caribbean. Fortunately, a survey of industrial activity was conducted by the now defunct Caribbean Commission in 1952 which detailed all activity in each island. This survey, entitled The Composition and Structure of Caribbean Industry, divided activity into Basic Production, Primary Processing and Secondary Processing. For each activity, branches were listed; for example in the Basic activity of cereal production, there were four branches; rice, corn, millet and other. The survey was consistent and thorough and was applied to all of the islands. Whatever omissions and misclassification there might be, there is little reason to suppose these are not random, and the survey can be considered the best estimate for the early 1950's. It is the only survey of activity in the Caribbean at the level of activity branches that exists for the Caribbean as a whole since 1950, and will provide the basic information for the discussion of the early Caribbean economy. Part of the classification is shown at the end of this chapter.

Themes

Two themes have characterised the discussion of inter-regional trade in the Caribbean. The first--that small size meant a narrow resource base--led to the view that the larger islands held some advantage in industrial production and would dominate interisland trade. The second--that the level of economic activity was critical for industrial production--led to the same conclusion. Both these versions of the size argument seemed to be clearly demonstrated by the use of the surrogates mentioned earlier. It is important to explore the nature of any such advantages, if we are to see the likely effects of the transport network. If there were advantages to certain islands, then the transport network might or might not constrain flows to the advantage of islands already blessed. If there were no well-developed advantages in the early 1950's, then it is possible that the transport network was instrumental in partitioning the advantages after 1954.

NATURE OF ECONOMIC ACTIVITY

Distribution between Branches

By 1952, attempts to broaden the economic base of the islands had given rise to a number of enterprises for the processing of basic materials. This meant, then, that those activities with a large number of branches offered more possibilities for the development of primary or secondary processing; in addition there might be many secondary processes based on a single branch of basic activity. We can ask, therefore, what was the distribution of branches of activity as a whole.

Table 3.1 and Figure 3.2 show the distribution of branches of activity in 1952. These show clearly that the economies were not being highly diversified, for 55% of all activities had 3 or fewer branches and 75% had less than 7 branches. The upper end of the distribution, marking the diversified activities, plunges sharply with only 11% of all activities having more than 10 branches. The number of very diversified activities was small--secondary processing of petroleum products being the lone activity with 17 branches. A size distribution such as this is not unusual for industrial activity, which often exhibits a distribution which conforms to the log-normal.

Distribution between Places

The existence of activities with many branches did not necessarily mean that each island shared in these activities, for the many branches might all be found in a single island. Economic activity might therefore be classified according to the number of islands in which a particular activity was found. In Table 3.3, activities are classified as basic, primary processing, and secondary processing and for each category its distri-

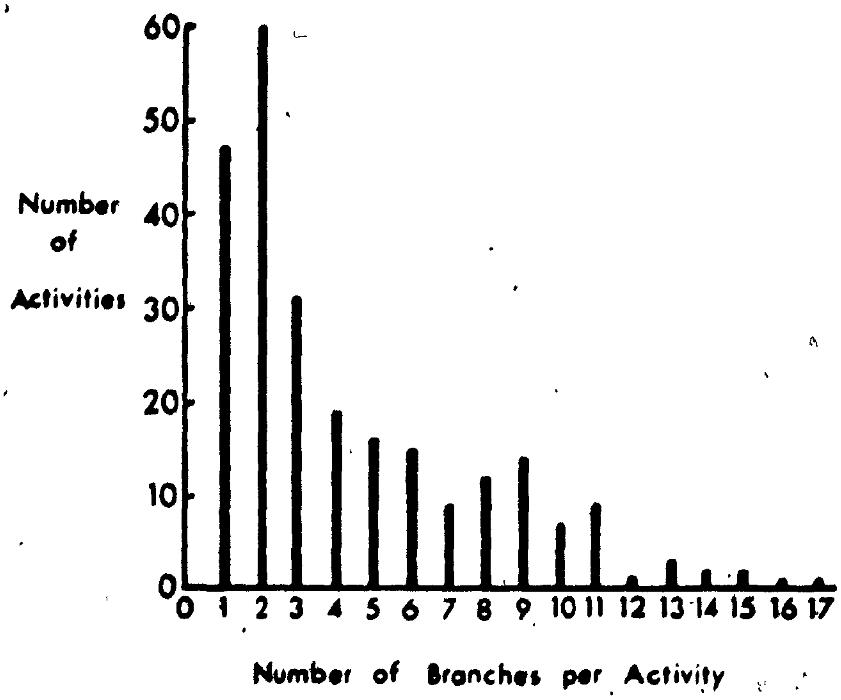
TABLE 3.1

SIZE DISTRIBUTION OF ECONOMIC ACTIVITY

No. of Branches	No. of Activities	%	Cumulative %
1	47	19	100
2	60	24	81
3	31	12	57
4	19	8	45
5	16	6	37
6	15	6	31
7	9	3.5	25
8	12	5	21.5
9	14	5.5	16.5
10	7	3	11
11	9	3.5	8
12	1	.4	4.5
13	3	1.2	4.1
14	2	.8	2.9
15	2	.8	2.1
16	1	.4	1.3
17	1	.4	.9

3.2 Economic Activity: 1952

The Distribution of Branches within Activities



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bution between islands is shown. For example, there were 58 primary processing activities to be found in one island only, 6 which could be found

TABLE 3.3

Number of Activities in X number of Places

	Total	1	2	3	4	5	6	7	8	9	10	11
Basic	48	5	1	6	3	5	3	8	5	3	3	6
PP	153	58	35	15	7	6	9	4	9	4	4	2
SP	110	39	28	21	8	2	1	-	1	1	3	6
Total	311	102	64	42	18	13	13	12	15	8	10	14

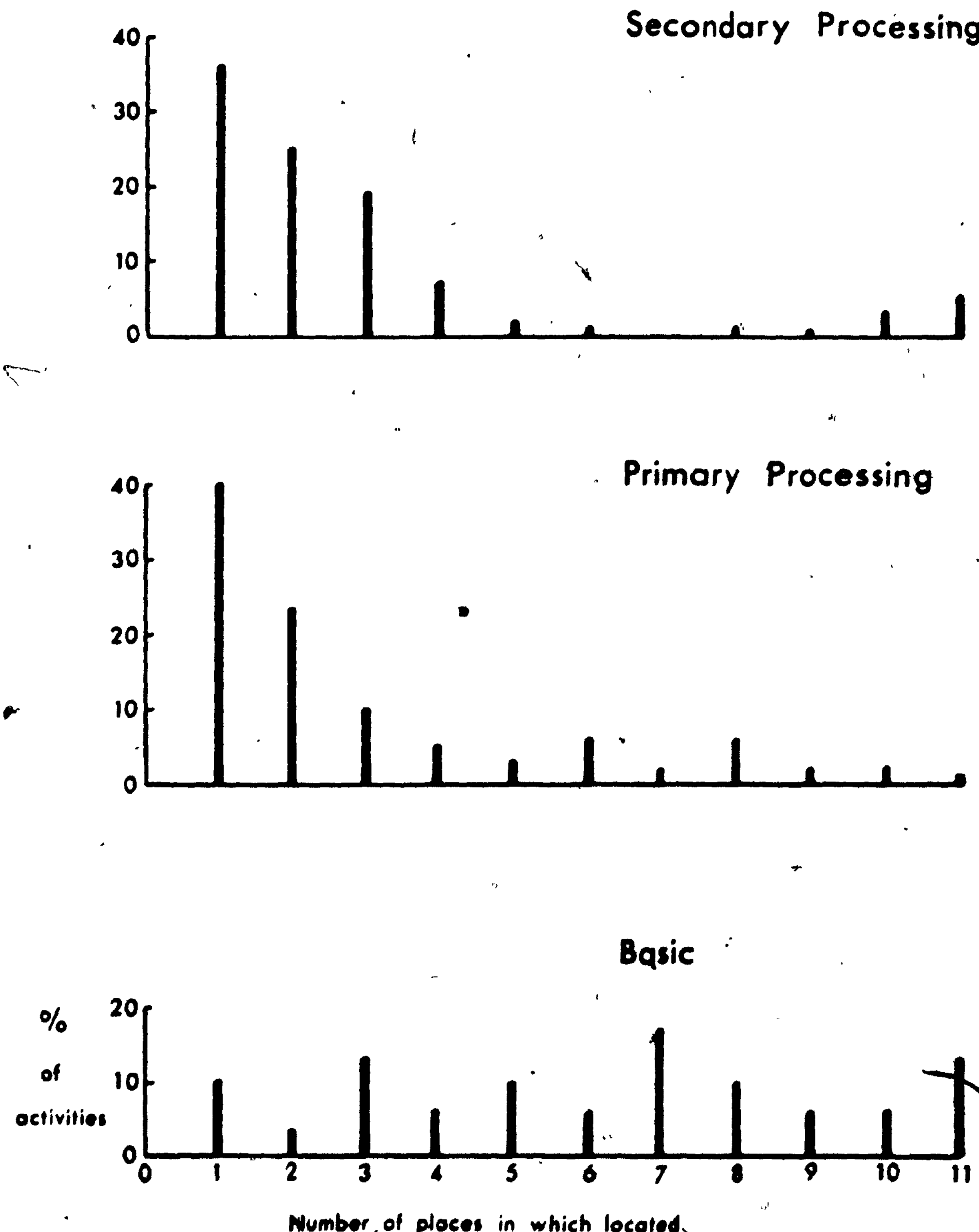
in five islands each, and 2 only to be found in eleven islands. From this table we can see how widespread particular activities were in 1952. Of a total of 311 activities, 33% are found in one location only and 67% in less than 4 locations. In Table 3.4, the cumulative percentage is shown for each category.

TABLE 3.4

% of Activities in X or more Places

		11	10	9	8	7	6	5	4	3	2	1
Basic	(1)	13	19	25	35	52	58	68	74	87	90	100
PP	(2)	1	3	5	11	13	19	22	27	37	60	100
SP	(3)	5	8	9	10	10	11	13	20	39	64	100
Total	(4)	5	8	11	16	18	20	22	28	42	63	100

We have noted earlier that the resource base was held to be of importance for industrial activity. It might be expected, then, that primary and secondary processing would be distributed in the same manner as basic



3.5 THE SPREAD OF ECONOMIC ACTIVITIES

activity. Alternatively, if the level of development is the important consideration, then the distribution of basic, primary and secondary processing should follow the distribution of total activity. To test these two assertions, the Kolmogorov maximum deviation test statistic was calculated from Table 3.4.

Maximum Deviation

Expected Distribution (Basic)	K
(1) - (2)	.50*
(1) - (3)	.55*
(1) - (4)	.46*

Expected Distribution (Total)	K
(4) - (1)	.46*
(4) - (2)	.06
(4) - (3)	.09

Level of Significance

When N = 11, 5% K = .391
2% " = .436
1% " = .468

When the expected distribution is basic activity, then there is a difference in distribution of primary processing, secondary processing and total activity which is significant in each case at the 2% level. We can therefore reject the assertion that basic endowment showed the same distribution as further processing activities. When the expected distribution is total activity, only basic activity shows a distribution which is significantly different. We may conclude therefore that the level of activity is related to the distribution of primary and secondary processing. We should bear in mind however that, as Table 3.3 shows, basic activity accounts for only 1/6 of the total number of activities, and its influence on the level of activity may be suppressed by the 5/6 of primary and secondary activity.

Degree of Concentration

If there was a significant difference between basic activity and the rest, what was the nature of the difference? The answer seems to lie in the degree of concentration. If we take 4 locations as the measure of concentration, we can trace the different degrees of concentration. From Table 3.6, we see that only 32% of basic activity is concentrated, while for primary processing, secondary processing and total activity the figure is at least 78%. If we regard 3 locations as the measure of concentration, then only 1/4 of basic is concentrated while other categories range from 2/3 to 4/5.

TABLE 3.6

Activities located in

	1-4		5-11		1-3	
	No.	%	No.	%	No.	%
Basic	15	32	33	68	12	25
PP	115	78	38	22	108	70
SP	96	87	14	13	88	80
Total	226	78	85	22	208	67

The next section considers how individual islands fared against this general background.

DISTRIBUTION BETWEEN NODES

Three questions are of importance for the understanding of the initial advantages in economic activity. Did some islands have a more favourable endowment in basic production? Did this lead to a greater development of primary and secondary processing? Did these advantages lie with the peripheral or central nodes?

Consider first the distribution of branches of activities between the islands as shown in Tables 3.7a and b, and the cumulative percentages shown in Table 3.8.

TABLE 3.7

a) Distribution of Branches: 1952

Number

	Total	J	T	Gy	B	G	L	V	D	A	K	M
Basic	301	42	33	28	23	30	26	26	21	26	23	23
PP	488	122	84	51	31	36	33	34	27	27	26	17
SP	315	86	84	38	31	14	11	9	14	13	7	8
Total	1,104	250	201	117	85	80	70	69	62	66	56	48

b) Number located in

	Peripheral	Central	Total	%
Basic	126	175	301	27
PP	288	200	488	45
SP	239	76	315	28
Total	653	451	1,104	100

TABLE 3.8

Cumulative % of Branches

		M	K	D	A	V	L	G	B	Gy	T	J
Basic	(1)	7.7	15.4	22.4	31	39.5	48	58	66	75	86	100
PP	(2)	3.5	8.5	13.75	19	26	32.5	40	46.5	57.5	75	100
SP	(3)	2.5	4.5	9	13	16	19.5	24	34	46	72.75	100
Total	(4)	4	9	14.5	20.5	26.7	33	40	47.7	58.3	76.5	100
Equal	(5)	9	18	27	36	45	54	63	72	81	90	100

If there was an equal distribution of branches of activities, then the cumulative distribution would be as given in (5) above. The Kolmogorov maximum deviation test can be used to test whether the distribution of basic activity was significantly different from an equal distribution. The maximum deviation in this case is .06, and we have already seen that a difference of .391 is needed for the 5% level of significance. We are therefore unable to assert that the differences are anything other than chance differences, and suggest that basic endowment did not confer any special advantage to particular islands.

Did a special advantage develop for primary and secondary processing? Since these all are elaborations of basic products we might expect there would be no significant differences between the distribution of branches of basic activity, and primary and secondary processing.

	Maximum Deviation:	K
Basic/PP	.195	5% = .391
Basic/SP	.34	10% = .352
Basic/Total	.183	20% = .308

Once again the maximum deviations do not even reach the 10% level of significance, though secondary processing closely approaches it. We cannot reject the suggestion of no differences, and must conclude that the distribution of primary, secondary and total activity showed differences which were no greater than could be expected by chance, though secondary processing showed tendencies which might in time establish a significant difference.

What if the level of activity was the controlling characteristic? The maximum deviation from the cumulative distribution of total number of branches of that of primary processing is .015, while that of secondary processing is .16. Neither of these deviations is significant at any reasonable level. We have already shown there is no significant difference for basic activity. We may conclude that the differences between the level of activity and the distribution of basic, primary and secondary processing reflect nothing more than chance differences.

Even if there were nothing more than chance differences, was there a tendency for the central nodes to be over or under represented? The total number of branches is 27% basic, 45% primary processing and 28% secondary processing. If these proportions are used to predict the expected distribution for each island, then the shortfall or excess can be estimated from the actual totals, given in Table 3.7a.

TABLE 3.9

Expected Number of Branches

	M	K	D	A	V	L	G	B	Gy	T	J
Basic	13	16	17	19	19	20	23	24	33	57	71
PP	21	24	27	28	30	30	34	36	50	86	107
SP	14	16	18	19	20	20	23	25	34	58	72
Total	48	56	62	66	69	70	80	85	117	201	250

Over(+) and Under(-) Representation

	M	K	D	A	V	L	G	B	Gy	T	J
Basic	+10	+7	+4	+7	+ 7	+6	+7	-1	-5	-24	-29
PP	- 4	+2	0	-1	+ 4	+3	+2	-5	+1	- 2	+15
SP	- 6	-9	-4	-6	-11	-9	-9	+6	+4	+26	+14

For basic activity, 7 islands are over represented--the central nodes--while the remaining 4 under represented are the peripheral: Barbados, Guyana, Trinidad and Jamaica. The situation is completely reversed for secondary processing where the peripheral islands are the ones over represented while the central nodes are all under represented. Both groups are over and under represented in primary processing. We may conclude that chance differences were producing a situation in which the central islands of Montserrat, St. Kitts, Antigua, Dominica, St. Vincent, St. Lucia and Grenada showed larger than expected shares in basic activity and less than expected shares in secondary processing, while the peripheral territories of Jamaica, Trinidad, Barbados, and Guyana enjoyed larger than expected shares in secondary processing. Both groups had a fair share of primary processing.

It has been shown that primary and secondary processing are both more concentrated than basic activity. It may be that concentrated activity tended to be located in the central rather than the peripheral nodes. Concentration has earlier been defined as a restriction to 4 or fewer territories. Even though a small proportion of activity may be concentrated i.e. located in less than 4 territories, the actual territories may vary. An activity might be found in the 4 peripheral nodes only, another in 4 of the central nodes only; still another may occur in some combination of members of both groups.

TABLE 3.10

Number of Activities
Located in Peripheral Nodes only

	No. of Places					
	1	2	3	4	1-4	1-3
Basic	5	-	1	-	6	6
PP	51	28	7	1	87	86
SP	38	27	17	5	87	82
Total	94	55	25	6	180	174

Of 311 activities, 180 or 58% are located in the four peripheral nodes only, and these occur in 4 or fewer locations; in 3 locations only, the corresponding figure is 55%. The advantage of the peripheral locations is clearer when types of activity are taken into consideration. For example 80% of secondary processing is concentrated in 4 or fewer locations, in each case these locations are the peripheral nodes, while for primary processing the figure is 58%. For basic activity however, only 12½% were activities to be found in the 4 peripheral nodes only.

SUMMARY

Seen in the aggregate, economic activity in the Caribbean in the early 1950's showed three major characteristics:

1. A large number of activities each with a small number of branches (less than 3) coupled with a small number of activities with a large number of branches (10 or more).

2. The size distribution of primary and secondary processing branches differed significantly from that of basic production.

3. The branches of primary and secondary processing tended to be concentrated while basic activity was not.

For the individual islands:

1. Basic activity showed only chance variation from an equal distribution of branches.

2. There was no significant difference in the distribution of basic, primary or secondary activity, nor between any of these and the level of activity as measured by the total number of branches. Hence neither the structure nor the level conferred any unusual advantages to particular places.

3. Chance variations however were tending to produce fewer than expected secondary branches and more than expected basic branches in the

central islands, while the peripheral islands had fewer than expected basic branches and greater than expected numbers of secondary branches.

4. Secondary processing was the most concentrated of all activity, and its concentration in the peripheral nodes of Jamaica, Guyana, Trinidad and Barbados tended to be larger than expected. Of all occasions when an activity was concentrated into 4 or fewer locations, 80% of the time those locations were the peripheral nodes.

In short, the structure and level of economic activity had not yet conferred any disproportionate benefit on any territory in the Caribbean. What little benefit existed did fall to the peripheral nodes, and took the form of a small over-endowment in secondary processing activities--especially those which were restricted to the four peripheral nodes only. If transportation was to aid in the reduction of inequalities between the territories, then it would have to ensure that these emerging differences did not blossom to confer undue advantage. The manner in which transportation was organised would be of importance and to this we will now turn.

SOME EXAMPLES FROM THE ACTIVITY CLASSIFICATION

A BASIC PRODUCTS

Cereals

1.1 Corn
1.2 Millet
1.3 Rice, unhulled
1.9 Other cereals

Starches

2.1 Arrowroot
2.2 Cassava
2.3 Dasheen
2.4 Eddoes
2.5 Sweet Potatoes
2.6 Tannia
2.7 White Potatoes
2.8 Yams
2.9 Other

Sugars

3.1 Sorghum
3.2 Sugar Cane
3.9 Other

Fish

19.1 Crustacea and Molluscs
19.2 Fresh Fish
19.3 Turtle
19.9 Other

Dairy Products & Eggs

22.1 Eggs in the shell
22.2 Milk
22.9 Other dairy products

B PRIMARY PROCESSING

Cereals

1.1 Cornmeal, corn starch, falernum
1.2 Stock feed
1.3 Hulled and polished rice, rice meal
1.9 Bran

Starches

2.1 Arrowroot flour and Starch
2.2 Cassava flour, meal and starch, tapioca
2.3 -
2.4 -
2.5 Canned sweet potatoes
2.6 X X X
2.7 Dehydrated potatoes, prepared potato chips
2.8 X X X
2.9 X X X

Sugars

3.1 Sorghum molasses and syrup
3.2 Raw sugar, refined sugar, icing sugar, fancy molasses boiled candies
3.9 X X X

Fish

19.1 Canned lobster, canned shrimps
19.2 Frozen fish, salted fish
19.3 Canned turtle
19.9 Shark liver oil

Dairy Products & Eggs

22.1 Frozen eggs in the shell
22.2 Condensed milk, butter, cheese, ice cream
22.9 X X X

C SECONDARY PROCESSING

Beverages

Rum
Other distilled and blended products
Beer

Tobacco

Cigarettes
Cigars and cheroots

Knitted Goods

Cotton underwear
Hosiery

Rubber Products

Rubber footwear
Tyre retreading

Wood and Cork Products

Boxes and crates
Cooperage products
Wooden handles
Wooden novelties

Wearing Apparel

Children's and infants' wear
Felt hats
Fur coats
Men's and boys' clothing
Men's and boys' shirts
Straw hats and straw goods
Women's and girls' dresses, skirts and blouses
Other wearing apparel

CHAPTER FOUR

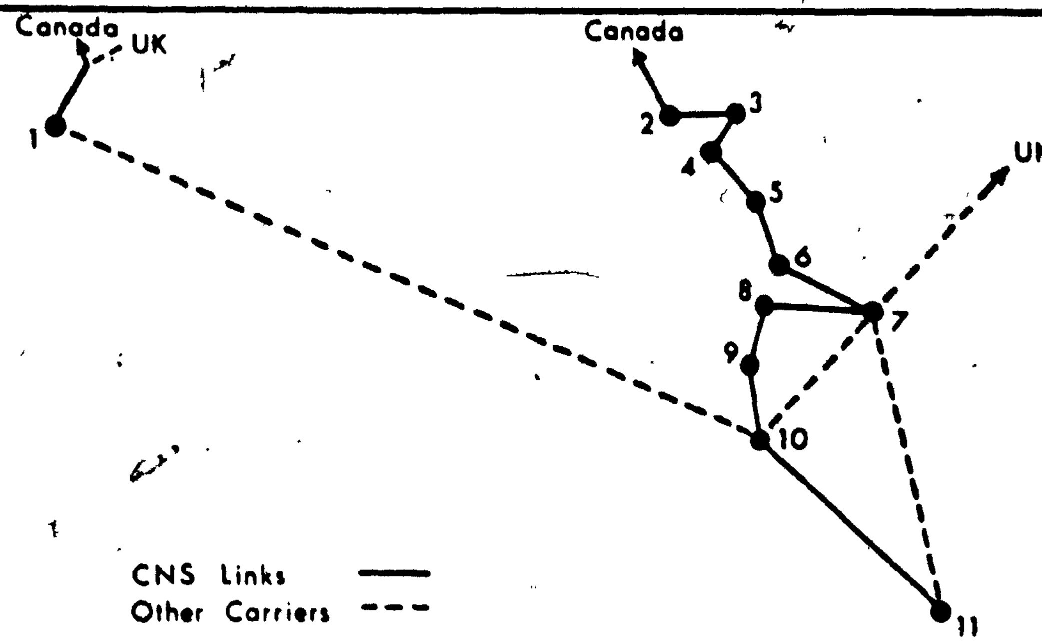
THE INTERISLAND NETWORK IN 1954

In this chapter, the shipping network of the early period will be reconstructed and its characteristics described by simple graph-theoretic analysis. The links, circuits, and connectivity will be used to compare the types of network which the schooners, motor vessels and transoceanic lines formed in the Caribbean, and to show the differential advantages conferred on the peripheral and central islands with respect to connectivity, mode of transport, and time. Finally there is a comparison of the way in which units were ordered by the network then existing and the ordering of underlying distance, to show the extent to which the structure of transportation had transformed the theoretical advantages.

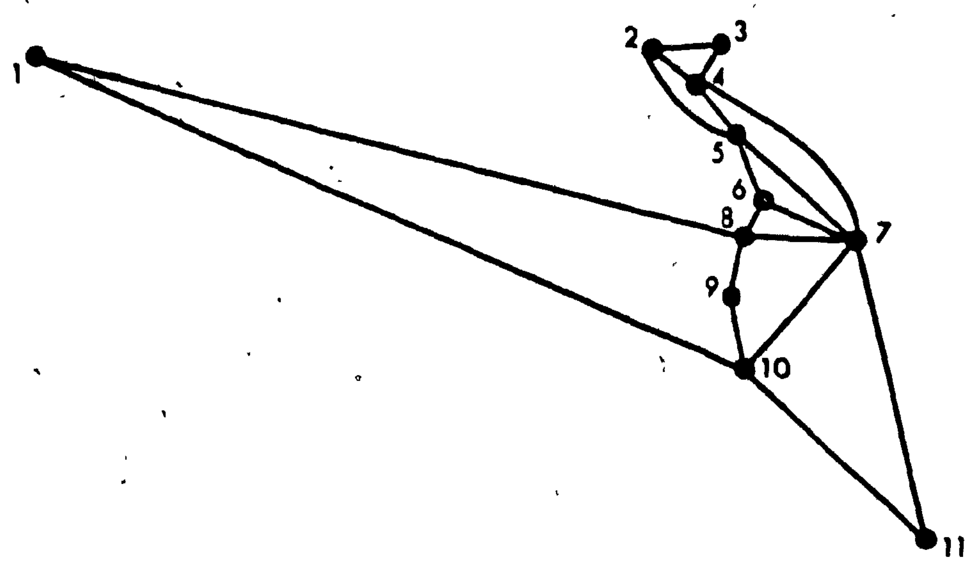
CONNECTIVITY

The Shipping Network in the Period 1950-1954

The transoceanic liners provided a partial network of connections in the early fifties. The Canadian National Steamships established a regular route through the eastern islands with their "Lady Boats" but did not provide a link to Jamaica, as their services were linked to Canada from St. Kitts. Other European lines called at some of the larger territories but did not attempt to link the islands. In general there was a direct connection from outside the region to each island, but a scarcity of regional connections. The network formed by the transoceanic lines in the Caribbean may be represented by the undirected graph in Figure 4.1a with connectivity matrix 4.1b. From this we may note that Barbados and Trinidad have



4.1a Network of Transoceanic Lines, 1954



4.2a Motor Vessel Network, 1954

MATRIX 4.1b

Connectivity Matrix of Transoceanic Network

	J	K	A	M	D	L	B	V	G	T	Gy	Degree	Rank
J	x	0	0	0	0	0	0	0	0	1	0	1	10.5
K		x	1	0	0	0	0	0	0	0	0	1	10.5
A			x	1	0	0	0	0	0	0	0	2	6
M				x	1	0	0	0	0	0	0	2	6
D					x	1	0	0	0	0	0	2	6
L						x	1	0	0	0	0	2	6
B							x	1	0	1	1	4	1.5
V								x	1	0	0	2	6
G									x	1	0	2	6
T										x	1	4	1.5
Gy											x	2	6
												24	

Number of links $= \frac{24}{2} = 12$

Number of circuits = 2

Diameter = 7

Connectivity = 21.8%

$\alpha = 4.4\%$

MATRIX 4.2b

Connectivity Matrix of Motor Vessel Network

	J	K	A	M	D	L	B	V	G	T	Gy	Degree	Rank
J	x	0	0	0	0	0	0	1	0	1	0	2	10
K		x	1	1	1	0	0	0	0	0	0	3	7
A			x	1	1	0	0	0	0	0	0	3	7
M				x	1	0	1	0	0	0	0	4	4
D					x	1	1	0	0	0	0	5	2
L						x	1	1	0	0	0	3	7
B							x	1	0	1	1	6	1
V								x	1	0	0	4	4
G									x	1	0	2	10
T										x	1	4	4
Gy											x	2	10
												38	

Number of links $= \frac{38}{2} = 19$

Number of circuits = 9

Diameter = 4

Connectivity = 34.5%

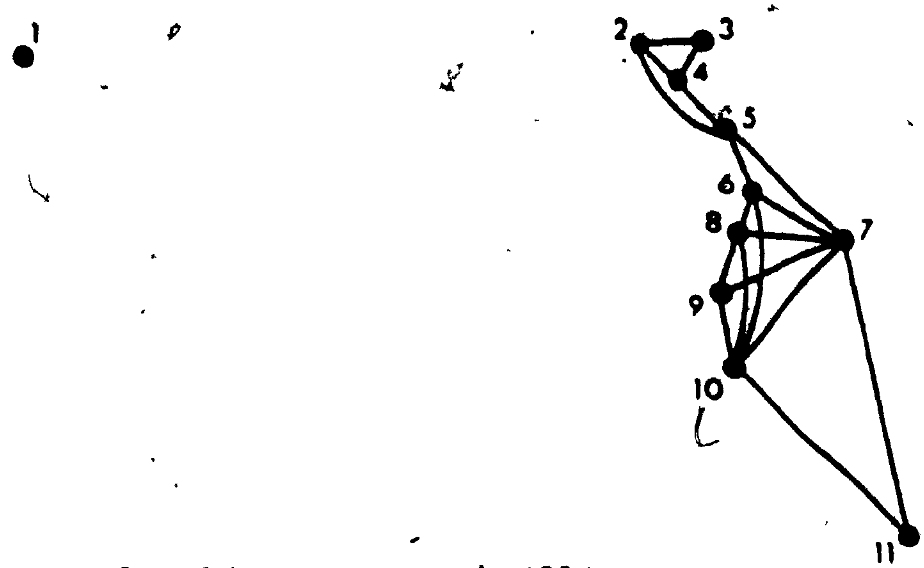
α = 20.0%

maximum connectivity and since the graph is undirected, maximum accessibility; Jamaica and St. Kitts minimum, with all others intermediate values. Trinidad has 3 out of 4 connections with the peripheral territories, while Barbados has equal connections with both groups. Jamaica's only link is with Trinidad, while Guyana is linked to Trinidad and Barbados. The only circuits are between Barbados, St. Vincent, Trinidad and Guyana. Finally St. Kitts, Antigua, Montserrat, Dominica and St. Lucia can only be reached via Barbados, and can only reach the Windwards, Trinidad and Guyana through Barbados. This, then, was the foreign contribution to the regional network.

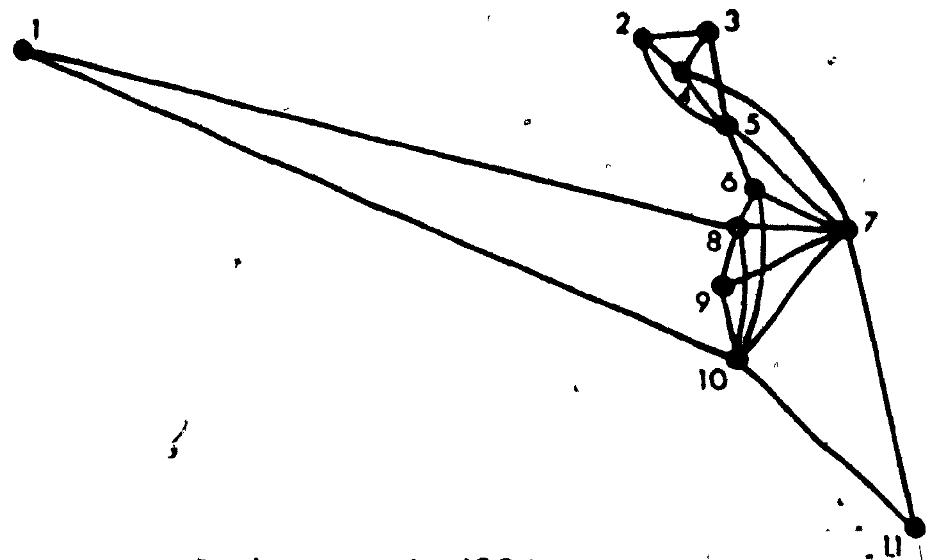
The Local Component

Motor vessels were being introduced into the regional shipping system in the early 1950's, though it is difficult to tell at what rate. Service was not uniform. The network reconstructed here in Figure 4.2a is based on the survey by the Caribbean Commission in 1953. The motor vessel network is clearly a more complete network with many circuits. Yet Jamaica can only be reached through St. Vincent and Trinidad. If we once again group nodes according to their positive degree, then Barbados is most connected--with Dominica, Montserrat and Trinidad, next in order. Circuits have been developed between the Leewards and Dominica as opposed to the network of the transoceanic lines.

The final element of the network is that of sailing vessels, shown in Figure 4.3a. This has been reconstructed from the same survey as that for motor vessels. The corresponding connectivity matrix is in Matrix 4.3b. Jamaica cannot be reached by schooner but all others can be. Trinidad now has additional circuits which raise its connectivity to the level of Dominica. Now there is a direct connection between Trinidad and St. Lucia. Antigua can now be reached from Trinidad by a 3-link journey via



4.3a Schooner Network, 1954



4.4a Total Network, 1954

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MATRIX 4.3b

Connectivity Matrix of Schooner Network

	J	K	A	M	D	L	B	V	G	T	Gy	Degree	Rank
J	x	0	0	0	0	0	0	0	0	0	0	0	11
K		x	1	1	1	0	0	0	0	0	0	3	7.5
A			x	1	1	0	0	0	0	0	0	3	7.5
M				x	1	0	0	0	0	0	0	3	7.5
D					x	1	1	0	0	0	0	5	2.5
L						x	1	1	0	1	0	4	4.5
B							x	1	1	1	1	6	1
V								x	1	1	0	4	4.5
G									x	1	0	3	7.5
T										x	1	5	2.5
Gy											x	2	10
												38	

Number of links = 19

Number of circuits = 10

Connectivity = 34.5%

α = 22.2%

MATRIX 4.4b

Matrix of Total Network Connections

	J	K	A	M	D	L	B	V	G	T	Gy	Degree	Rank
J	x	0	0	0	0	0	0	1	0	1	0	2	10.5
K		x	1	1	1	0	0	0	0	0	0	3	8
A			x	1	1	0	0	0	0	0	0	3	8.0
M				x	1	0	1	0	0	0	0	4	5.5
D					x	1	1	0	0	0	0	5	3.5
L						x	1	1	0	1	0	4	5.5
B							x	1	1	1	1	7	1.
V								x	1	1	0	5	3.5
G									x	1	0	3	8.0
T										x	1	6	2
Gy											x	2	10.5
												44	

Number of links = 22

Number of circuits = 12

Diameter = 4

Connectivity = 40.0%

α = 26.6%

St. Lucia, in addition to journeys via Barbados or Grenada through Dominica. Guyana, at the other end of the network, remains connected by 2 links as in the motor vessel network. The direct link between Barbados and Montserrat is missing from the schooner network but Barbados is now connected directly to Grenada.

Comparison of the Networks

The total network is shown in Figure 4.4a with its connectivity matrix in 4.4b. In it, redundant links have been omitted, that is, links shown represent those routes traversed by at least one mode.

TABLE 4.5

Comparison of Four Networks from 4.1, 4.2, 4.3 and 4.4

	Transoceanic	MV	Schooner	Total Network
No. of Links	12	19	19	22
No. of Circuits	2	9	10	12
Diameter	7	4	3	4
Connectivity (γ)	21.8%	34.5%	34.5%	40.0%
Alpha (α)	4.4%	20.0%	22.2%	26.6%

Connectivity

The region defined was based on the extremal principle that shippers in a unit would prefer direct sea voyages to destination rather than tranship or suffer intermediate delays. It is what may be called the "shipping region". It is also a completely connected network. From Table 4.5 the total connectivity of the network formed by all three components, transoceanic, motor vessel and schooner, is only 40.0%. The Moyne Commissioners clearly had reason to complain: shippers could expect to find only 40% of the routes they desired in operation! The motor vessel and schooner.

networks separately afford slightly more than a 33% satisfaction as opposed to the 22% of the transoceanic lines. The addition of this network adds to the schooner and motor vessel system a mere 5.5% connectivity.

Diameter

The diameter measures the longest path in a graph, or its extent. The total network has a diameter of 4, but increases are experienced with the motor vessel and transoceanic lines. The significant increase to 7 of the latter is a clear reflection of its poorly developed structure. It represents a network that is still linear.

Links

The number of links is another measure of the development of the network. Once again there is no significant difference between the schooner and motor vessel networks, but a substantial difference from the transoceanic is shown by both of these. The number of links in the transoceanic network is approximately 50% of those in the total network.

Number of Circuits

Differences are even greater between the transoceanic network and the others in respect of number of circuits. The existence of circuits guarantees alternative paths to destinations; hence the number of circuits is a measure of safety in the network, in case of breakdown of particular links. This is important in shipping where strikes in one port may put one route out of service. There are only 2 circuits in the transoceanic network compared to 9 in the motor vessel, 10 in the schooner and 12 for the total network.

MODES

Competition in the System

Competition may exist where there are many routes between any two points, i.e. route competition, or where different modes of transport cover the same route--schooner, motor or steam. In network terms, the latter is represented by modal redundancy, while the former is measured by the alpha index, the ratio of observed fundamental circuits to the maximum possible number of circuits.

Modal Redundancy

Matrix 4.6a shows network connectivity by the various modes. For 11 of 22 routes, there are three modes of transport, schooner, motor vessel and transoceanic. Doubtlessly these operate with different frequencies; yet they represent possible choices for the movement of commodities along routes. The remaining 11 routes are split 6 with 2 modes and 5 with 1 only. Of the 5 with a single mode, two routes are motor only, with 3 schooner only; of the 6 with two choices, 5 are between schooner and motor vessel, with 1 only between motor and transoceanic. The distribution of these routes is mapped in Figure 4.6b. Note that routes with a single mode are all linked to one of the peripheral territories, Barbados, Guyana, Trinidad or Jamaica. Also these routes establish direct connection to nodes for which there are alternative routes. No where did the transoceanic lines provide links where no others existed.

Route Redundancy

The alpha index measures the number of alternative ways of reaching various pairs of points in a network, and has been shown to have the follow-

MATRIX 4.6a

Total Connectivity by Mode

	J	K	A	M	D	L	B	V	G	T	Gy
J	x	-	-	-	-	-	-	M	-	MT	-
K		x	SMT	SM	SM	-	-	-	-	-	-
A			x	SMT	SM	-	-	-	-	-	-
M				x	SMT	-	M	-	-	-	-
D					x	SMT	SM	-	-	-	-
L						x	SMT	SM	-	S	-
B							x	SMT	S	SMT	SMT
V								x	SMT	S	-
G									-	SMT	-
T										x	SMT
Gy											x

Number of links with 3 modes = 11

Number of links with 2 modes = 6

Number of links with 1 mode = 5

S - Schooner

M = Motor Vessel

T = Transoceanic line

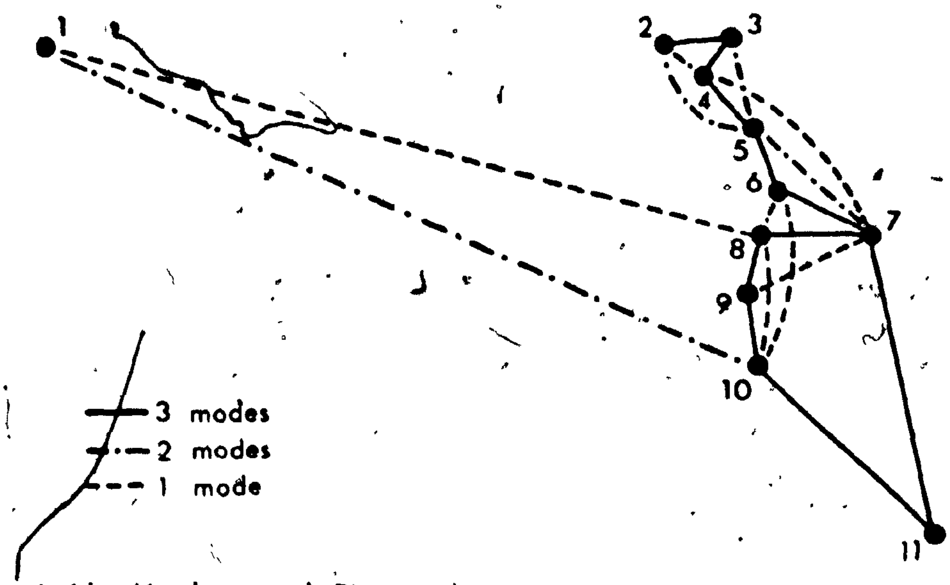
ing values:

Transoceanic = 4.4%
Motor Vessel = 20.0%
Schooner = 22.2%
Total Network = 26.6%

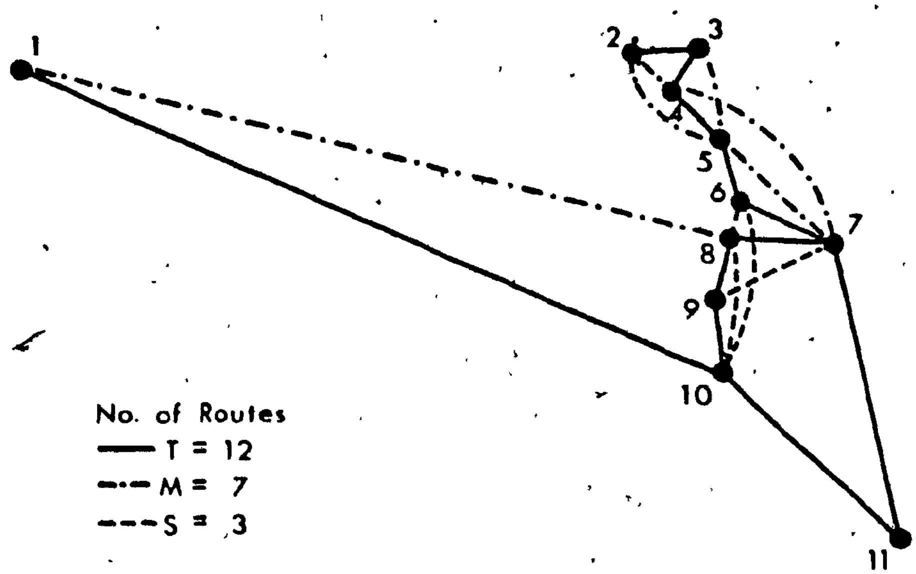
With 26.6% as the highest value, the regional transportation network clearly did not have a very high degree of safety built into it. This suggests that the reliance on domestic or extra regional suppliers was very high for each unit. The schooner network was the best developed with respect to circuits but only marginally better than the motor vessel system. The transoceanic system was of no significance here.

Maximum Distance Comparisons

Our judgment of the development of these networks can be refined if we compare them not to the properties of the "complete network" as we have done, but to those defined by the maximum distance constraints. The maximum distance in the motor vessel network is the 1,190 miles between Jamaica and Trinidad, while that in the schooner network is 400 miles from Barbados to Guyana. At a maximum distance of 1,190 miles, the γ and α indices should both be of the order of 96%; whereas at 400 miles the corresponding values are 65.4 and 60.0. From this, the degrees of underdevelopment in the motor vessel and schooner networks are more clearly perceived. The maximum distance values for the motor vessel network are approximately those of the "complete network"; hence the degree of underdevelopment is serious. The schooner network, however, had about 55% of its theoretical connectivity value and 37% of its theoretical value for the development of circuits. In this sense the region was in the stage of schooner economy for it would seem that it was the schooner network which provided the best developed system, despite the introduction of an as yet weakly developed motor vessel network.



4.6b Modes and Routes



4.7b Fastest Time Links - by Mode, 1954

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Among and Between

The importance of differential development may be illustrated by partitioning the nodes into the peripheral set of Jamaica, Barbados, Trinidad and Guyana, and the central Leewards and Windwards. The distribution of links may now be analysed in terms of whether they fall among or between either of these two sets of territories.

Networks	Among		Between
	Peripheral	Central	
Motor Vessel	4	9	6
Schooner	3	9	7
Total	4	9	9
Theoretical Maximum	6	21	28

The number of links among the 4 peripheral territories is at least 50% of the maximum in all cases and sometimes reaches 66%, whereas those among the central units never reaches 45%. For links between the two groups, the values are about 21% for the motor vessel network, 25% for the schooner rising to 32% for the total network. The structure of the networks already held the tendency for greater interaction between the peripheral units than between the central ones. There was also the possibility for the peripheral nodes to divert some interaction from the central ones through the poorly developed set of links between the two groups.

TIME

Time in the Networks

Using the values for the average speed of the vessels outlined earlier, a fastest time matrix of direct connections is compiled in Matrix

MATRIX 4.7a

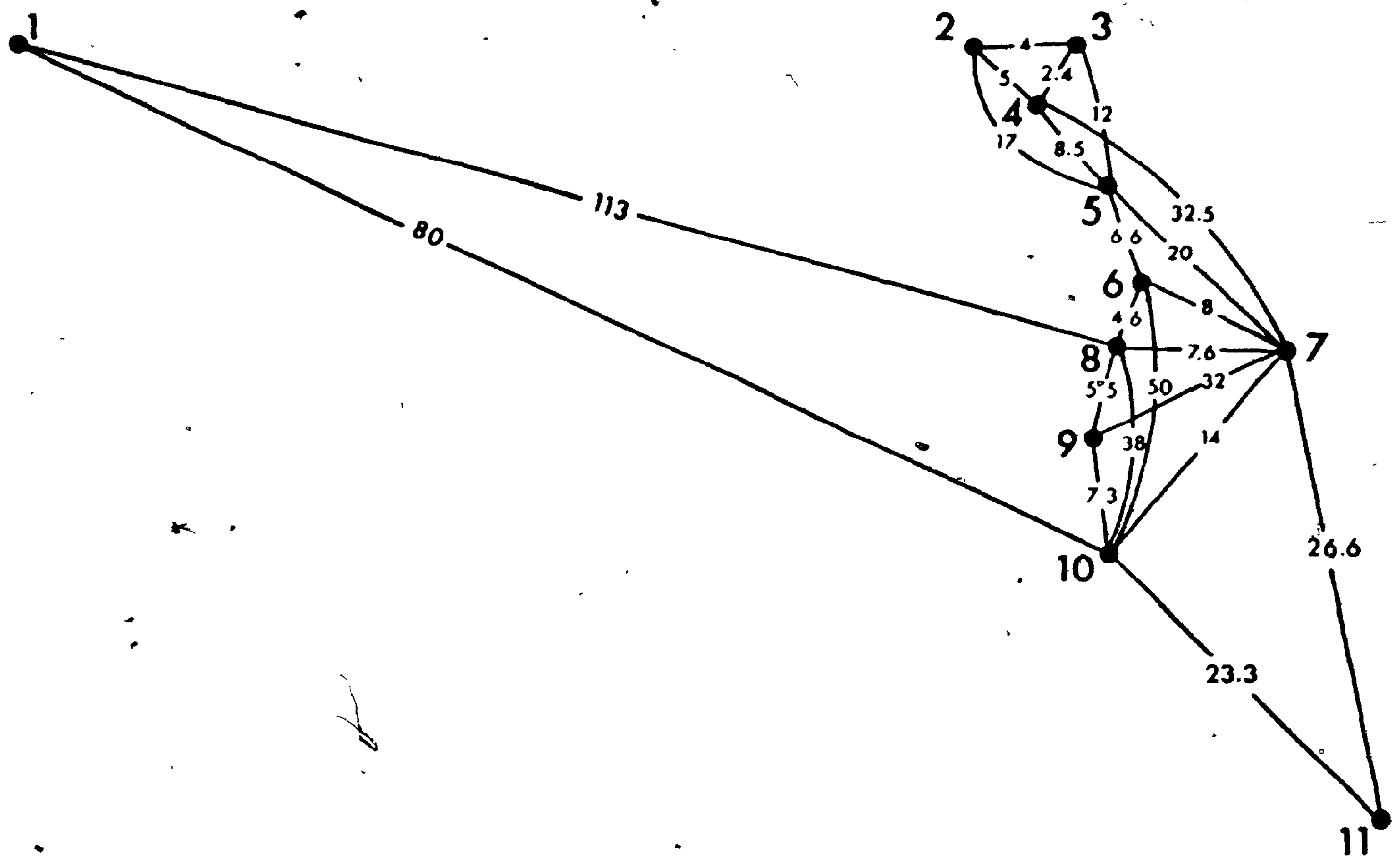
Fastest Times Matrix (Direct Connections) in Hours

	J	K	A	M	D	L	B	V	G	T	Gy
J	x	-	-	-	-	-	-	113	-	80	-
K		x	4	5	17	-	-	-	-	-	-
A			x	24	12	-	-	-	-	-	-
M				x	8.3	-	32.5	-	-	-	-
D					x	6.6	20	-	-	-	-
L						x	8	4.6	-	50	-
B							x	7.6	32	14	26.6
V								x	5.5	38	-
G									x	7.3	-
T										x	23.3
Gy											x

4.7a and plotted as a network of modes and times in Figures 4.7b and 4.7c. Since fastest time depends on the mode of transport, direct routes are not always the fastest links between two nodes. For example, for Trinidad, the direct route to St. Vincent by schooner takes 38 hours while a 2-link route via Grenada (Trinidad, Grenada, St. Vincent) would take (7.3 + 5.5) hours or 12.8 hours by steamer. From Barbados to Grenada there is a direct route of 32 hours by schooner but an indirect route via St. Vincent takes 13.1 hours by transoceanic line.

The development of these more lengthy direct routes is a reflection of the penalties involved in crossing nodes. So far we have considered only link costs, in time. But we may estimate that an intermediate stop to discharge cargo, if the mode does not change, or to trans-ship, if there is a change, involves costs in time. In general these costs may be estimated at 24 hours per node, as any of the schedules would show. If we include these node penalties of 24 hours into our earlier calculations the route from Trinidad to St. Vincent via Grenada is increased from 12.8 hours to 36.8 hours as opposed to 38 direct; that from Trinidad to St. Kitts via Grenada, St. Vincent, St. Lucia, Dominica, and Montserrat, now takes an extra 120 or 158.3 hours. Likewise the route from Barbados to Grenada via St. Vincent now takes 37.1 hours compared to 32 direct. The introduction of node penalties makes the development of direct routes understandable, for on practically every circuit, the direct route takes less time than the indirect but penalised route. Furthermore, these direct routes suffer less competition as shown earlier.

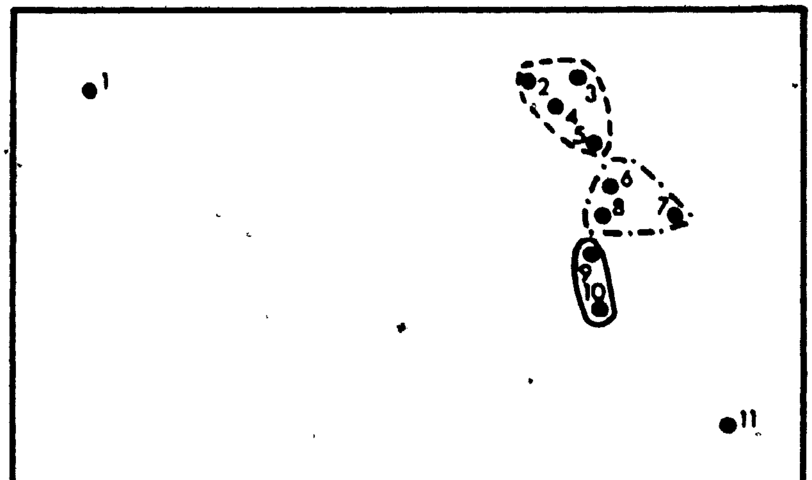
No account has been taken of waiting time where changes of mode are to be made. For example, ignoring node penalties, the route from St. Lucia to Trinidad via St. Vincent and Grenada takes 4.6 + 5.5 + 7.3 or 17.4 hours compared to 50 hours direct by schooner. But from St. Lucia to St. Vincent



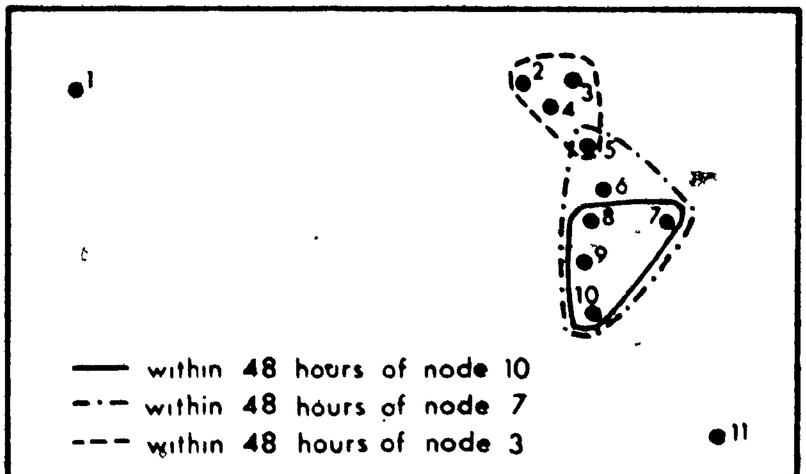
4.7c Fastest Time in Hours, by Route - 1954 is by motor vessel, whereas the rest of the trip is by transoceanic liner. It would be necessary for a liner to be available at the right time for this complete journey to be possible in the fastest time. Extending the argument, there is a time advantage for the direct but slower route wherever the waiting time at St. Vincent for a cargo liner exceeded say 36 hours. Given the 3-week or monthly schedules then common for the liners of the 50's, it is easy to see why there developed other schooner and motor vessel routes. There existed considerable time advantages in the shadow area of waiting times. The absence of reliable data on schedules makes it impossible to pursue this further, but there is clear evidence that node and waiting penalties made direct connections, however slow, the fastest times between the nodes of the system. The analysis of time adds clear justification for the development of the "shipping region" as the network of direct connections between the nodes.

Time Surfaces and Patterns of Dominance

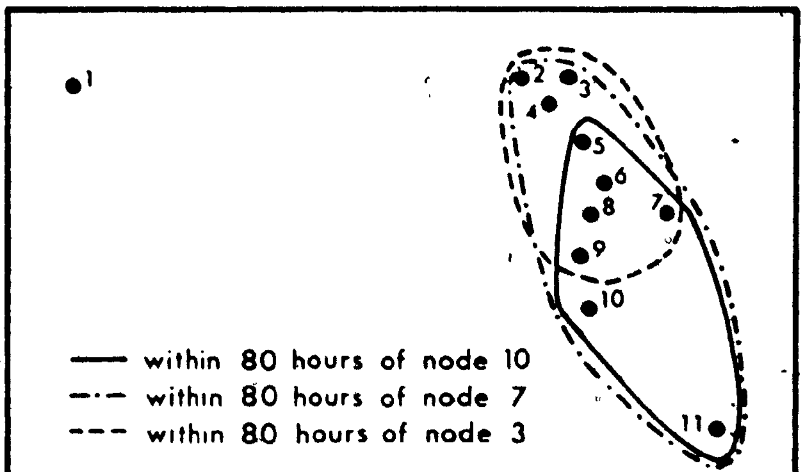
The longest link in the schooner network was the 400 miles from Barbados to Guyana. If this represented the distance constraint, then from Chapter Two we note that two locations could serve the entire region, and the combination which minimised transport was Jamaica and Barbados. This 400 mile constraint represented 80 hours of travelling time by schooner; hence 80-hour surfaces are drawn around Barbados, Trinidad and Antigua. Jamaica is clearly outside the travelling distance; Barbados just manages to serve the remaining units within 80 hours on the actual network, as long as no stops occur. In other words the journey from Barbados to St. Kitts is computed as the sum of the time from Barbados to Dominica and Dominica to St. Kitts. If any penalties are imposed for crossing nodes, or if any waiting time is involved, then it is not possible to serve the entire area



4.8a 24-Hour Schooner Surface, 1954



4.8b 48-Hour Schooner Surface, 1954



4.8c 80-Hour Schooner Surface, 1954

from the minimum two locations. This is so because of the degree of under-development of the network already described.

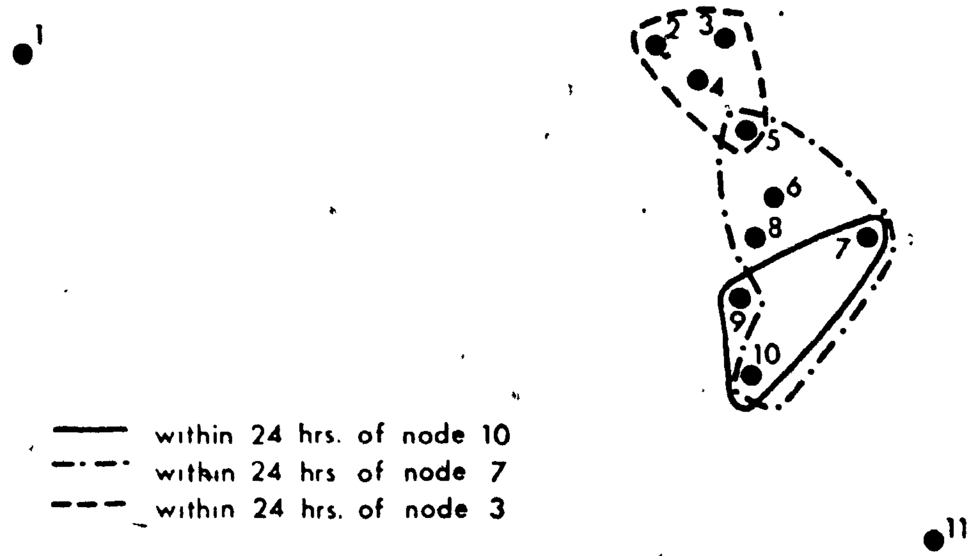
The 24-hour surface.--The 24-hour surface is equivalent to a travelling distance of 120 miles which required 5 locations to serve the area. In Figure 4.8, the long-run solution of Jamaica, Barbados, Antigua, Trinidad and Guyana have their 24-hour surfaces entered. There is a clear division of the market according to the direct links of the schooner economy.

The 36-hour surface.--If the time is increased to 36 hours the influence of Barbados is expanded to compete with Trinidad for the market of Grenada. This is the only change in the system.

The 48-hour surface.--Significant changes occur when the time is increased to 48 hours. Trinidad can now compete for the influence of St. Vincent and Barbados, while Barbados has extended its possible range not only to Trinidad itself, but northwards to Dominica. The area of influence of Antigua remains limited whatever the time, and is now being invaded by Barbados. The superior position of Barbados with respect to the system is clearly seen and gives some insight into the nature for its theoretical long-run advantage.

Time in the Motor Vessel Network

The introduction of motor vessels added a new dimension to the time surfaces for it changed the distribution and patterns of influence. The 24-hour surface is shown in Figure 4.9 for the same locations. Barbados and Trinidad are now within 24 hours of each other, while Dominica is also within 24 hours of Barbados. The field of Antigua remains the same as throughout the schooner network. The structure of the motor vessel system was such that an extension of the time to 48 hours extended the reach of Trinidad to Guyana only, while it pushed that of Barbados not only to Guyana



4.9a 24 Hour Motor Vessel Surface, 1954

4.9b 48 Hour Motor Vessel Surface, 1954

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but as far north as Montserrat. Clearly within these early networks, Barbados had a considerable advantage over Trinidad with respect to domination of the Leewards and Windwards. Jamaica was always outside the system, while Guyana entered only when the travelling time was extended to the theoretical value of 80 hours.

The networks which had been developed by the early 1950's held such properties as to give a consistent advantage to Barbados over Trinidad, while imposing a restriction on the field of influence of Antigua that not even the introduction of motor vessels could alleviate. Only changes in the structural properties could remedy these limitations.

NETWORK STRUCTURE AND REGIONAL STRUCTURE

It has been suggested that the regional structure would tend to assume the characteristics of a shipping region. To what extent had the network structure described approached that of a shipping region? The rank order of centrality in the shipping region may be compared with the connectivity ranks of the various networks and the total network, as in Table 4.10.

One may conclude that the total network structure did not approach that of the ideal shipping region as the correlation coefficient does not even approach the 90% level of probability. The transoceanic, motor vessel and schooner networks were tending to transform the accessibility of the various islands in a manner which was markedly different from that of the shipping region. It will be necessary to see in a later chapter how the flow of tonnage took place within these networks and at the nodes.

TABLE 4.10

Comparison of Rank Connectivity and MAD

Node	(1) MAD	(2) Total Network	(3) Schooner Network	(4) MV Network	(5) TO Network
1	11	10.5	11	10	10.5
2	8	8	7.5	7	10.5
3	7	8	7.5	7	6
4	5	5.5	7.5	4	6
5	3	3.5	2.5	2	6
6	1.5	5.5	4.5	7	6
7	6	1	1	1	1.5
8	1.5	3.5	4.5	4	6
9	4	8	7.5	10	6
10	9	2	2.5	4	1.5
11	10	10.5	10	10	6

when

			Level of Probability
$R_{12} = 0.50$		1.73	$t_{10} = 1.83$
$R_{13} = 0.47$		1.6	$t_{50} = 0.703$
$R_{14} = 0.47$	student's t =	1.6	
$R_{15} = 0.38$		1.23	

CHAPTER FIVE

TRANSPORT CHANGE

By the end of 1954 the Caribbean governments had acted on their agreement to organise a shipping service. The network which had developed by that time has been described in Chapter Four. This chapter traces the changes in routes which took place after 1954, the tonnages and flow of ships to each island, and the structure of freight rates, paying particular attention to the relationship to distance. An attempt is then made to identify the trends which these conditions set in motion and to see whether there was a differential benefit to one of the two groups of territories we have identified.

ROUTES

The immediate effect of government action was, as has been described in Chapter One, to provide a ship for a regional service. In January of 1955, the "West Indian" began a route from Jamaica to Trinidad, calling at all the islands en route. In this way, the gap between Jamaica and the Leewards was closed and it has remained closed since then. This has been the major change in the network since 1954. This change reduced the diameter of the network to 3 from 4 but more importantly, it brought Jamaica within a 2-link journey of every other unit while it did not change the position of the other peripheral nodes of Guyana, Trinidad and Barbados. The route was linear, and from St. Kitts to Trinidad it followed a path which we have already shown was covered by the transoceanic carriers, motor vessels, and schooners. The transoceanic lines quickly withdrew from the route so the change was really a substitution of the new service for the old, rather than any increase in available tonnage. The route did not extend to Guyana. Now the greatest tonnage will always be available at the ends of a linear route so that it was Jamaica and Trinidad which derived the greatest advantage, since those were the two ports where the ship became empty. Any intermediate point had less than 100% of cargo space available to it. With 2,000 tons cargo capacity, the schedule called for 15½ round trips or a three weekly sailing from Trinidad and a 10 day voyage to Jamaica. This schedule meant for instance that it would be 18 days after its northward passage from Grenada before the West Indian would return to Grenada on its southbound journey. Now in Chapter Two we noted that Grenada was theoretically within 3 1/3 days of every other unit by schooner, and within 2 days by motor vessel. With the network in existence in 1954, Grenada was within 4½ days of every other territory by schooner. There was ample time for return voyages by schooner to any other point even if there was some delay in loading and landing cargo, since time at sea from Grenada and back was at most only half the time between visits of the West Indian. This example for Grenada only exemplified the general case that the schedule of the new regional service provided considerable shadow effect in the Windward and Leeward islands, such that it was not only possible but cheaper and faster to use the schooner or motor vessel. This only served to reduce the use that might have been made of the service by the central units.

Secondly since most of the cargo was picked up and deposited at Jamaica and Trinidad, it meant a considerable overtransportation: a circuitous route was being followed when a direct route would have been more appropriate. It could hardly be surprising, then, that a subsidy was necessary; or that despite a subsidy the service lost heavily, so that by December 1957 the West Indian was taken out of service. The ship was much too large for the trade, the route too circuitous and long.

The subsidy was about $600,000 and was apportioned between the islands. It might be argued that the more peripheral units would use the motor service more heavily than the central nodes so that their contribution to the subsidy should be greater. This suggests that there should be a relationship between the subsidy paid, and the centrality of a unit as we have measured it in Chapter One. Using Spearman's rank correlation coefficient, the correlation between rank of subsidy paid and rank of mean link length for the 11 units was = .745, while that with median link length was + .645--the former significant at the .01 level and the latter at the .025 level. We may conclude that the subsidy paid increased as we moved from the central units to the peripheral units, and could be considered to be structured in an appropriate way.

These early efforts produced a service with three features which have characterised all subsequent attempts at a shipping service. The route linked Jamaica to the Leewards and thereafter followed a route which was served by other modes; most of its cargo originated and was deposited at the two extremities; the service had to be subsidised. The demise of the West Indian did not end the service. The Oluf Sven and Herman Langreder, each of about 1,200 tons gross, were chartered in 1958. The reduced cargo space was more fully utilised and the schedules were better balanced for each island, since there were two ships instead of one. This service was therefore more successful than that of the West Indian, and marked the second phase of the interisland shipping efforts. Until 1962, when the Federal boats were delivered, chartered ships kept up the service. Between 1958 and 1960, 93% of all cargo was loaded at Trinidad on the northbound voyage and 55% was discharged between Antigua, St. Kitts and Jamaica; on the southbound route 89% was loaded at Jamaica and 51% discharged at Trinidad.[1] These figures confirm the notion that a motor vessel service would be more suitable for activity located in the peripheral nodes. Since the service did not reach Guyana, there could be no cargo from that source.

The third phase began in 1962 with the new Federal Maple and Federal Palm in operation. These were ships of 3,200 tons, and combined cargo and passenger transport. Like the old West Indian, they were larger than the trade demanded, subsidised heavily, and followed the schedule for the benefit of the passenger service. These ships have maintained the service on the linear route till 1971 when steps were taken to reorganise the service, the first of which was an extension of the route to Guyana.

TONNAGE

The motor ships brought into service between 1954 and 1970 increased the supply of tonnage available by large increments. We have already referred to the recommendations made by various government bodies and it is instructive to compare the results:

	Year	Recommended Tons		Actual	
Moyne Commission	1945	650	650	-	-
British Caribbean Shipping Committee	1953 1958	750	1,200	3,000 1,200	- 1,200
Federal Government	1961	-	-	3,200	3,200
ECLA	1971	778	500	1,500	(1,700)

By 1953, ships of 700-1,200 tons were being recommended. Yet a 3,000 ton ship was chartered--to be later replaced by ships closer to the required size. By 1961, ships of the 3,000 tons size were again brought into service only to repeat the heavy losses of the earlier ship. Even though

ECLA proposed ships of a modest size in 1971, those commissioned were once again twice the recommended size.

If the capacity of a motor ship is taken as half its tonnage, then the cargo capacity inherent in the recommendations of the Moyne Commissioners was equivalent to 325 tons over 30 voyages for a total of 9,750; the 1971 ECLA recommendations are for 750 tons over 30 voyages, or 22,500 tons.[2] Instead of going from 2 ships capable of 10,000 tons each to 2 ships of 22,000 tons each, the regional shipping service has consistently sought ships capable of 45,000 tons!

The motor vessels used in the Caribbean have been brought into service from other routes outside the region, whereas the schooners have all been built in the region. The centres of shipbuilding in the Caribbean are the smaller islands--the Grenadines, the Virgins and the Leewards. Rates of construction for these three areas are shown below for the period 1950-70.

TABLE 5.1

Construction Rates[3]
(Boats per Year)

	1950-59	1959-66
Virgin Islands	1.3	0.6
	1950-65	1961-69
Grenadines	2.3	0.5 (Schooners only)
	1948-57	
Leewards	3.2	

The capacity to supply new sail tonnage has been severely curtailed since 1960. Up to 1960, about six boats per year were launched in the region, but since then, the rate of construction has fallen to about a single boat per year. These boats have always been of wooden construction, and now carry auxiliary engines. Facilities for building steel hulls are available in Trinidad and Guyana, but a change to these locations of boat building has not yet been made.

As a result, the small vessel fleet has aged considerably; 60% was built before 1955 and is more than 20 years old. Only 15% was built after 1960, and few, if any, have been built since 1970.[4] Motor vessels offered 40 voyages of 140 tons or 6,400 tons capacity while schooners were capable of 30 voyages and 50 tons or 1,500 tons. The low replacement rate meant that older tonnage would have to be worked harder if the small vessels were to maintain their share of the trade. In 1954 the Caribbean Commission put the number of schooners at 100, oil tankers at 7 and motor vessels at about 18--all 125 registered in the Commonwealth Caribbean.[5] The fleet appears to have remained quite stable in size, for the ECLA survey of 1970 reported 135 vessels.[6]

The "peak" Problem

The demand pattern for outward bound tonnage is seldom balanced with the inward bound cargo. Hence costs can be incurred on both legs of a voyage but may be recovered only on say the outward bound voyage if there is no return cargo. Now the total tonnage needed for a particular route is not the average demand over the inward and outward voyages, but the maximum demand at the high point in the voyage. This is important for any scheduled service, but less so, for unscheduled routes where tonnage can be introduced and removed at short notice. Within the Caribbean networks, therefore, the peak problem is important for the transoceanic network, and occasionally for the schooners. Increasing the tonnage on the scheduled network raises the price of service. This in turn attracts the motor vessel service and makes it profitable even for the schooner to operate at lower rates. Further increases in the supply of motor and steam tonnage raise rates and make it profitable for more schooner tonnage to operate. In this way, a cycle of competition emerges which tends to keep all three sections in operation. The introduction of the Federal Shipping Service led to an increase in rates on certain routes, which in turn allowed schooners to operate within the shadows created by node and waiting time penalties at rates slightly lower than those offered by the scheduled service. In this way a competitive cycle was entered which still exists today.

FREIGHT RATES

The transoceanic carriers were members of the Conference of West Indian Trans-Atlantic Steamship Lines. Rates from and to Europe were the same for each port in the Caribbean, though there was variation between commodities. Occasionally there were surcharges for cargo carried beyond the first Caribbean port on the voyage. For example cargo loaded for St. Lucia in Europe might bear a surcharge if the vessel did not intend to sail to St. Lucia from Barbados. The Conference rates have retained their structure including the surcharge the central islands have had to pay, since most ships are bound for Trinidad, Barbados or Jamaica in the first instance.

At the beginning of 1954, the Inter-Colonial Minimum Freight Tariff Committee agreed to minimum rates for cargo between Barbados, Trinidad, Guyana and the Windwards and Leewards. These rates were applied on the liner companies' ships but held the same structure as the Conference rates—rates varied between commodity but not between port.[7]

The tariff of the Schooner Owners' Association differed from that of the Conference Lines. It was based not only on the commodity but also on distance. For example, on journeys northwards out of Barbados in 1954, the Caribbean Commission reported the cost to Dominica at $8.10 per ton, to Montserrat $9.20, to Antigua $10.50 and $11.50 to St. Kitts. The shorter voyages within the Leewards and from Dominica to the Leewards cost $7 per ton. There was some latitude to vary the actual rate for any commodity but the structure remained stable and well known throughout the area.[8] In 1970 the rates, according to ECLA, reflected the distance bias in the following way: a basic rate up to 100 miles, higher rates for 100 to 200 miles, and distinctly higher rates over 200 miles. An upper level of rates has been set by the Federal Boats since 1961 and a lower level is determined by competition among the small vessel operators.[9]

The tariff of the Federal Service made no reference to distance, and was in all respects similar to the Conference tariff. Kierstead and Levitt defended this arrangement on the grounds that the fixed charges were all paid for by the subsidy to which each unit had contributed. In their view, the only extra charges should be for cargo handling.[10] This argument is quite reasonable; but it ignores the fact that the central islands possessed an advantage in location relative to the region as a whole. A freight tariff which charged equal rates for all distances would remove this advantage from the central units and raise their freight charges to the same level as those of the peripheral units. The Federal Freight Tariff worked to the advantage of Jamaica, Trinidad and Barbados and to the disadvantage of the Windwards and Leewards. The schooner rates, on the other hand, preserved in some measure the locational advantages of the central islands.

SHIPPING

Schooner and Motor Vessel in the Caribbean

Within the shipping region we may expect to see the introduction of new modes of transport emerge from those nodes in the peripheral positions. Tonnage in the schooner class would disappear first from Jamaica and remain longest for St. Lucia and St. Vincent, our central points. The tonnage of steam and motor powered vessels entering Jamaica, Trinidad and Barbados is compared with that of Grenada. There is a steady increase in the steam tonnage entering Jamaica over the period 1947-67 with a similar rise from 10 to 12 million tons for Trinidad between 1950 and 1970. For Barbados tonnage levelled off between 1952 and 1961 but jumped to new levels following the opening of the deepwater harbour in 1962. A slow increase is reported for Grenada in the 1960's but the very low level of activity is the distinguishing characteristic.

The tonnage of sail (surrogate for schooner) entering is considered for the same period. At Jamaica, sail tonnage had reached insignificant proportions by 1951 and apart from isolated entries in 1957 and 1958, reached zero by 1962. At Barbados, the rise of steam was accompanied by a decline of sail tonnages up to 1962, but thereafter a revival seems to have occured. The increase in steam seems to have produced for sail the kind of response enumerated in an earlier section. For Grenada and St. Vincent, figures for the sixties show fluctuations in the sail tonnage but no real decline. More important, the level of activity equals that at Barbados, in contrast to steam activity. The importance of sail and steam to a particular node may also be judged by the number of entries. The number of sail entries is known for several nodes in the system. For Trinidad, there is an important increase from 250 in 1950 to over 2,000 in 1971. For Barbados, the decline in sail entries is less spectacular than that of the tonnages, with a tendency towards stability appearing after 1956. In the 1960's, activity at Grenada, Antigua and St. Vincent tended to operate at slightly higher levels than Barbados. The predominance of Trinidad is unmatched, but for the other territories, there is no sign of the immediate disappearance of sail entries.

In Table 5.2, the percentage of steam entries is shown for certain islands. Steam had completely saturated the Jamaican network by 1960. For Barbados, there is a continued rise in the proportion of steam, and by 1968 the level had reached 90%. In contrast, although steam entries had reached 95% at Trinidad by 1950, by 1970 the proportion had fallen to 68%. Sail therefore had managed to rise in importance at Trinidad despite the expansion of the whole system. Trinidad, therefore, appeared to be attracting more and more activity from the schooner network and also appeared to be relying more and more on this system for the distribution of its commodities. The early disappearance of sail from Jamaica is as expected, but the growing importance at Trinidad is not at first clearly understood.

The relative importance of sail and steam for the remaining islands may be judged from Table 5.2. Despite year to year fluctuations the percentage of steam entries did not show any significant increase by 1968 over the 1960 values, save at St. Lucia. Antigua, St. Vincent and Grenada showed widest fluctuations, whereas at Montserrat there was a small decline in steam, with a slight gain at St. Lucia and Dominica, where the gain was followed by a slight decline after 1966. It would seem that, as at Trinidad, the expansion of the system has benefitted both sail and steam in the central part of the regional system.

TABLE 5.2

Steam as % of Total Entries[11]

Node	A	M	D	L	V	G	B	T	J
1960	34	-	-	63	47	58	77	77	99.7
1961	60	-	76	-	54	60	76	74	99.97
1962	55	-	79	-	60	57	76	72	
1963	57	40	78	71	61	55	80	67	
1964	58	40	78	73	56	63	81	73	
1965	60	33	79	76	49	52	87.5	68	
1966	71	33	71	75	54	60	84	72	
1967	68	40	68	72	53	51	85	73	
1968	57	35	67	75	59	56	90	71	
1969				84	46	66	86.6	68	
1970				90	53	67	63.5	68	

Adaptation to Innovation

The preceding description shows how individual nodes would change their competitive position by introducing a new mode of transport, the motor vessel, with an extended range. In this way, nodes outside the competitive area might join it, while others may find it possible to extend their field of influence. It has also been shown that the increase in the supply price of transport allows an expansion of the old means of transport. It may also set in motion an adaptive process of greater long-run importance. If price increases make it sufficiently profitable, then some of the schooner operators may install engines, thereby extending the range of their operations and the reliability of service. We may expect therefore that the introduction of motor vessels would be paralleled by an increase in the installation of engines on the schooners, i.e. a move towards auxiliary schooners.

The evidence for the installation of engines on the schooners is scanty and conflicting. Reporting in 1954, Burgess claimed that a minority of the vessels had auxiliary power engines.[12] Doran, however, found that in 1956, 50% of the schooners in the Leeward islands had auxiliary engines but only 7½% of the sloops.[13] O'Loughlin gives contradictory opinions on the subject. In 1967, she claims "many wooden schooners continue to trade successfully in the West Indies but the majority have auxiliary motors."[14] In 1968 we are told that "while only a few have been motorised, there is no sign of the immediate extinction of these schooners."[15] In a survey of operations at Barbados in 1966, Blenman found that about 60% of the schooners carried engines.[16] An ECLA survey claimed that by 1968, 100% of the schooners carried engines.[17] The evidence seems to indicate that the introduction of engines on to the schooners proceeded steadily over the 15 years from 1953 to 1968.

The evidence on new boats launched in the main shipbuilding areas is a possible corroboration of this trend. The ECLA study noted that all new tonnage built since 1966 has been of the motor variety.[18] Doran, too, points out that no new tonnage registered in the Virgin Islands since 1960 has been without engines.[19] In the Grenadines, according to Adams, only 4 schooners (all motor-powered) have been launched between 1961 and 1969.[20] All evidence indicates that by the late 1960's the schooner operators had adapted to the motor vessel competition by the installation of engines on their boats. This perhaps pushed their operating speed up to a maximum of 7-8 mph thus bringing their range much closer to that of the motor vessel, thereby reducing the critical advantages of the new transport.

CHANGES

The effects of the changes in routes, tonnage and the structure of freight rates can be traced through the flow of tonnage to particular islands over time. The number and tonnage of ships and the cargo arriving and leaving would change in time with the strength of the various factors, and show up as trends. To investigate these trends, a series of runs tests were conducted, using the total number of runs up and down as the test statistic, and the cumulative probability of the observed number of runs up and down or fewer as the criterion for determining the level of significance. In this way, it was possible to test for trend against the hypothesis of random fluctuations. If the cumulative probability of the observed number of runs or fewer was less than .01, the hypothesis of randomness was rejected. The runs test proved useful since the number of observations varied, covered different time periods, and was sometimes quite small. In the case of Montserrat, information was for the greater part lacking.

Numbers

Total.--If the conditions outlined affected all islands equally, then there would be no difference in the changes of the flow of ships to each island, i.e. over time the number of ships entering would rise or fall in a random pattern. Table 5.3 gives the pattern of increases and decreases at each island for various periods up to 1970, and the summary information for the runs tests. We should note that the information for the total number of ships entering includes all ships and does not always refer to cargo ships only. For 3 of the peripheral territories--Barbados, Trinidad and

TABLE 5.3.--Runs Test: Total Number of Ships Entering

	J	B	T	Gy	G	V	L	D	M	A	K
1946											
47		+	+								
48	+	+	+								
49	-	+	+								
1950	+	+	-								
51	-	-	+				-				
52	+	+	+				-				
53	+	+	-	+			-				
54	-	+	-	+	+		+				
55	+	+	+	+	+	+	+				
56	+	-	+	-	-	+	+				
57	+	+	+	-	+		+				
58	+	+	+	-	+	+	+				
59	+	+	+	-	+	+	+				
1960	+	+	+	+	+	-	+			-	
61	-	-	-	+	-	+	+			+	-
62	+	+	-	+	-	-	-	-		+	+
63	+	+	+	-	-	-	+	+		-	-
64	+	+	-	-	-	+	+	+	+	+	-
65	-	-	-	+	+	+	+	+	-	+	+
66	+	+	-	+	-	-	+	-	+	+	-
67	+	+	+	+	+	+	+	+	-	+	-
68		+	+	+	+	+	+		+	-	-
69		-	+	-	-	-	+		-		-
1970		+	-		+	-	-				+
N	21	25	25	18	18	17	21	7	7	10	11
R	11	11	10	6	9	8	5	4	6	5	6
P	.1202	.0084*	.0018*	.0009*	.10	.064	.000*	.56	1.	.24	.34

N = Number of observations
R = Number of runs
P = Probability of R runs in N observations
* = Significant at .01 level

Guyana--we can reject the hypothesis of random fluctuation and suggest a positive trend; of the central islands only for St. Lucia can the hypothesis be rejected.

Steam.--Using the same procedure on data in Table 5.4 for steam entries, the hypothesis of random change is rejected for Barbados and Antigua, in both cases the alternative of a positive trend is accepted.

Sail.--For all the units covered in Table 5.5 for sail entries, the hypothesis of randomness is accepted so that we can say that during the 1960's for which the data are more plentiful, the number of sail entries showed only random fluctuation. It should however be borne in mind that the number of runs at Barbados over the long period 1946-70 had a cumulative probability of .0294 suggesting that there was something quite close to a trend developing.

Percentage of sail entries.--If the number of sail entries did not show any trend, then perhaps the dependence on sail, as measured by the percentage of sail entries, might do so. Table 5.6 presents the evidence for this test. In the test covering 9 islands, only at Barbados could the hypothesis of randomness be rejected. We may conclude that the degree of dependence in sail showed only random variation over the period, save at Barbados, where the dependence declined.

Tonnage

Total.--The number of ships may not reflect the complete picture because of variations in size. Here, similar tests are applied to the tonnage of ships entering. Of the units in the region, only at Jamaica was there a tendency for the total tonnage entering to increase systematically, all other units showing random changes. (Table 5.7.)

TABLE 5.4.--Runs Test: Number of Ships Entering: Steam

	J	B	T	Gy	G	V	L	D	M	A	K
1946											
47		+									
48	+	+									
49	+	+									
1950	-	+									
51	+	+									
52	+	+									
53	+	+									
54	-	+									
55	+	+									
56	+	-									
57	+	+									
58	+	+				+					
59	+	+									
1960	+	+				+					
61	-	-			-	+				+	
62	+	+			-	-		-		+	
63	+	-			-	-	-	+		+	
64	+	+			-	-	+	+		+	
65	-	-			+	+		+		+	
66	+	-			+	-		-		+	
67	+	+			-	+	+	-		+	
68		+			+	-	+	+		-	
69		-			+	-	+				
1970		+			+	+	-				
N	21	25			11	12	8	8		9	
R	9	11			4	7	3	4		2	
P	.0117	.0084*			.0239	.45	.075	.31		.0014*	

N = Number of observations
R = Number of runs
P = Probability of R runs in N observations
* = Significant at .01 level

TABLE 5.5.--Runs Test: Number of Ships Entering: Sail

	J	B	T	Gy	G	V	L	D	M	A	K
1946											
47		-									
48	-	+									
49	-	-									
1950	+	-									
51	-	-	+								
52	+	-	+								
53	-	-	+								
54	+	-	-								
55	+	-	+								
56	-	-	+								
57	+	-	+								
58	+	+	-								
59	-	+	+								
1960	-	-	-			-					
61	-	+	-		-	-				-	
62	-	+	+		+	-		-		+	
63		-	+		-	-		+		-	
64		+	-		-	+	-	+		+	
65		-	+		+	+		-		+	
66		+	-		-	-		-		-	
67		+	-		+	+	-	+		+	
68		-	+		-	+	+	-		+	
69		-	+		-	-	-				
1970		+	+		+	-	-				
N	16	25	22		11	12	8	8		9	
R	9	12	11		8	5	3	5		6	
P	.30	.0294	.0674		.88	.0529	.0749	.67		.76	

N = Number of observations
R = Number of runs
P = Probability of R runs in N observations
* = Significant at .01 level

TABLE 5.6.—Runs Test: Percentage of Sail Entries

	J	B	T	Gy	G	V	L	D	M	A	K
1946											
47		-									
48	-	-									
49	-	-									
1950	+	-									
51	-	-	+								
52	+	-	-								
53	-	-	+								
54	+	-	-								
55	+	-	+								
56	-	-	+								
57	+	-	+								
58	+	+	-								
59	-	o	+								
1960	-	-	-			-					
61	-	+	+		-	-				-	
62	-	0	+		+	-		-		+	
63		-	+		+	+		+		-	
64		-	-		-	+	-	0	0	-	
65		-	+		+	-	-	-	+	-	
66		+	-		-	+	+	+	0	-	
67		-	-		+	-	+	+	-	+	
68		-	+		-	+	-	+	+	+	
69		+	+		-	+	-				
1970		+	+		-	-	-				
N	16	25	21		11	12	8	8	6	9	
R	9	8	13		7	7	3	4	3	4	
P	.3	.000*	.46		.65	.45	.075	.31	.41	.15	

N = Number of observations
R = Number of runs
P = Probability of R runs in N observations
* = Significant at .01 level

TABLE 5.7.--Runs Test: Total Tonnage Entering

	J	B	T	Gy	G	V	L	D	M	A	K
1946											
47		+	+								
48	+	-	-								
49	+	+	+								
1950	+	+	+								
51	-	+	+				+				
52	+	+	+				-				
53	+	-	-				-				
54	+	-	+				+				
55	+	+	-			+	-				
56	+	-	+			+	+				
57	+	-	+			-?	+				
58	+	-	+			-	-				
59	+	+	+	+		-	+				
1960	+	+	+	+	+	+	+			+	
61	-	-	-	-	+	+	+			+	+
62	+	+	+	+	-	+	+	-		-	-
63	+	+	+	-	-	-	-	+		+	-
64	+	+	+	+	+	+	+	+		+	-
65	-	-	-	+	+	+	+	+		+	+
66	+	+	+	+	+	-	+	-		-	+
67	-	-	-	+	-	-	+	+		-	+
68		-	+	+	+	-	-				+
69		-	+		+	+	+				+
1970		+	+		+	+	-				-
N	21	25	25	11	12	17	21	7		9	11
R	8	13	13	5	5	7	12	4		4	4
P	.0023*	.08	.08	.12	.0529	.016	.26	.56		.15	.024

N = Number of observations
R = Number of runs
P = Probability of R runs in N observations
* = Significant at .01 level

Steam.--There is sufficient information for the test for Jamaica, Barbados and the Windward islands. Of these, only for Jamaica can we reject the hypothesis of random fluctuations in the steam tonnage entering. (Table 5.8.)

Sail.--The tonnage of sail entering the same islands is used in Table 5.9. Random fluctuations occur at each island, save Barbados, where a significant downward trend occurs.

Cargo

The number and tonnage of ships determine the cargo capacity available; hence the cargo loaded and unloaded would be corroborative evidence of the trends associated with shipping. Runs tests were applied to the changes in cargo loaded and landed in the same way.

Cargo IN.--The cargo landed showed random fluctuations save at Grenada and at St. Lucia, where there was a significant positive trend.

Cargo OUT.--The cargo loaded at Trinidad and Antigua showed significant trends--positive at the former and negative at the latter. At the other islands random fluctuations were taking place (Table 5.11).

SUMMARY

The changes in the conditions of transport brought about by government action were quite distinct. In 1954 the gap between Jamaica and the Leewards was closed and a large addition to steam tonnage was made. These conditions prevailed till 1958 when there was a change of schedule, for two smaller ships were used rather than one. Routes remained constant. In 1962 two new ships were brought into service but they were much larger, almost doubling the cargo capacity. Routes remained consistent and so conditions remained stable till 1970. However, by 1966, there was a change in the political arrangements as the Free Trade Area took shape. It would seem that

TABLE 5.8.—Runs Test: Steam Tonnage Entering

	J	B	T	Gy	G	V	L	D	M	A	K
1946											
47		+									
48	+	-									
49	+	+									
1950	+	+									
51	-	+									
52	+	+									
53	+	-									
54	+	-									
55	+	+									
56	+	-									
57	+	-									
58	+	-									
59	+	+									
1960	+	+				+					
61	-	-			+	+					
62	+	+			-	+		-			
63	+	+			-	-		+			
64	+	+			+	+	+	+			
65	-	=			+	+	-	+			
66	+	+			+	-	+	-			
67	-	-			-	-	+	+			
68		-			+	-	-				
69		-			+	+	+				
1970		+			+	+	-				
N	21	25			11	12	8	7			
R	8	13			5	5	4	4			
P	.0023*	.082			.12	.053	.31	.56			

N = Number of observations
R = Number of runs
P = Probability of R runs in N observations
* = Significant at .01 level

TABLE 5.9.—Runs Test: Sail Tonnage Entering

	J	B	T	Gy	G	V	L	D	M	A	K
1946											
47		-									
48	-	-									
49	-	-									
1950	+	-									
51	-	-									
52	+	-									
53	-	-									
54	+	-									
55	+	-									
56	-	-									
57	+	-									
58	+	+									
59	-	-									
1960	-	-				-					
61	+	-			-	+					
62	-	-			+	-		-			
63		+			0	-		+			
64		+			-	+	-	+			
65		-			+	+		-			
66		+			-	-	+	-			
67		+			+	+	-	+			
68		-			+	+	-				
69		-			-	+	-				
1970		+			+	-	-				
N	16	25			11	12	8	7			
R	11	8			8	7	3	4			
P	.77	.000*			.88	.45	.075	.56			

N = Number of observations
R = Number of runs
P = Probability of R runs in N observations
* = Significant at .01 level

TABLE 5.10.--Runs Test: Cargo IN

	J	B	T	Gy	G	V	L	D	M	A	K
1946											
47											
48											
49											
1950											
51											
52											
53			+								
54			-								
55			-								
56			+								
57			+								
58			+				+				
59			-				+				
1960	+		+			+	+				-
61	+		-			-	+			+	-
62	-		+		-	-	+	+		+	+
63	+	+	-		-	+	-	+		0	+
64	-	+	?		+	+	+	+	+	-	-
65	+	-	?		+	-	+	0	+	+	+
66	-	+	-		+	+	+	-	+	+	-
67	+	+	-		+	+	0	+	-	-	-
68	+	+	+		+	-	-		+	-	0
69		+	+		+	+	+		+		+
1970		+				+	+				+
N	10	9	18		9	12	14	7	7	9	11
R	7	3	≥8		2	7	5	3	3	4	6
P	.83	.0257	.0306		.0014*	.45	.0079*	.19	.19	.15	.34

N = Number of observations
R = Number of runs
P = Probability of R runs in N observations
* = Significant at .01 level

TABLE 5.11.--Runs Test: Cargo OUT

	J	B	T	Gy	G	V	L	D	M	A	K
1946											
47											
48											
49											
1950											
51											
52											
53											
54			+								
55			+								
56			+								
57			+								
58			+				-				
59	-		-			-	+				
1960	-		-			-	-				o
61	-		+			+	+			+	-
62	+		+		+	+	+	+		-	+
63	-		+		+	-	+	-		-	o
64	+		-		-	+	+	+		-	-
65	+	+	-		+	-	+	+		-	-
66	-	+	-		-	+	-	-		-	-
67	-	-	-		+	+	-	+		-	-
68		-	-		+	-	+			-	-
69		+	+		-	+	+				+
1970		0					-				-
N	10	7	17		9	12	14	7		9	11
R	5	3	5		6	8	7	5		2	5
P	.24	.19	.0003*		.77	.73	.15	.89		.0014*	.12

N = Number of observations
R = Number of runs
P = Probability of R runs in N observations
* = Significant at .01 level

decisive changes took place at about four year intervals. Throughout the period 1954-70, freight rates remained stable in structure, with the steam carriers ignoring the effects of distance while sailing vessel rates reflected the friction of distance.

These conditions led to a situation in which the traffic tended to increase at Trinidad, Barbados, Guyana and St. Lucia, with random fluctuations at the remaining ports. Steam vessels tended to increase systematically in number at Barbados and Antigua. Sail disappeared from Jamaica by 1962, as expected the earliest in the region, but showed random fluctuations in the rest of the region. The dependence on sail, however, confirmed our proposition that it would be greatest in the central nodes and least in the peripheral. Not only did the dependence disappear at Jamaica, but at Barbados there was a significant decline in evidence. In the central nodes, however, the dependence on sail showed only random fluctuations.

The tonnage entering showed a systematic increase only at Jamaica, due to a significant positive trend in steam tonnage. Sail tonnage showed an equally significant decline at Barbados. In the rest of the region both sail and steam tonnage showed random changes. The combined effects of numbers and tonnage showed up in the changes in cargo. The cargo landed can be taken as a measure of the attractiveness of a place or its dependence on other suppliers. Two islands show a significant tendency for the cargo landed to increase and both are central islands--Grenada and St. Lucia. This adds some support for our notion of how the question of supply would work. Cargo loaded likewise measures the propensity to supply other areas and we have suggested that changes in transport would favour the peripheral nodes. Trinidad, a peripheral node, showed a significant tendency to increase the cargo loaded while Antigua, a central node, showed an equally significant decline in its capacity to supply other areas. The remaining areas in both cases showed random changes only.

The periodic changes in the transport conditions produced in the main random changes at the units of the region. Where definite trends developed, whether increases or decreases, they tended to conform to the proposition we have advanced in earlier chapters--that improvements in transport would tend to benefit the peripheral rather than the central nodes. We have examined here the flow of ships; it is important now to see what this meant for trade.

NOTES

1. B.S. Keirstead and K. Levitt, Inter-territorial Freight Rates and the Federal Shipping Service, (Mona: ISER, 1963) Tables IX and X.

2. ECLA, Analysis of Steps for Reorganisation of the West Indies Shipping Service, (Port of Spain, 1971).

3. Calculated from: Doran, The Tortola Boat, pp. 23-24, for the Virgin Islands; J.E. Adams, "Maritime Industry in the St. Vincent Grenadines," American Neptune, vol. 32, July 1972, pp. 186-87, for the Grenadines; Doran, "Commercial Sail in the Leewards," American Neptune, vol. 24, no. 2, April 1964, pp. 100-01, for the Leewards.

4. See further, E.H.M. Blenman, Interisland Shipping in the Eastern Caribbean, (Unpublished M.A. Thesis, University of Calgary, 1970) Chapter Six; and ECLA, Small Vessel Shipping in the Eastern Caribbean, (Port of Spain, 1970).

5. Caribbean Commission, "Caribbean-owned Shipping Facilities in Relation to Intra Caribbean Trade and Travel," Caribbean Economic Review, vol. VI, December 1954, pp. 101-45.

6. ECLA, Small Vessel Shipping, pp. 16-17.

7. Caribbean Commission, pp. 125-27.

8. Caribbean Commission, pp. 115-16, 125.

9. ECLA, Small Vessel Shipping, pp. 27-32 and Appendix 3.

10. Keirstead and Levitt, pp. 9-10.

11. Calculated from: Abstract of Statistics, Windward & Leeward Islands, & Barbados, 1971; West Indies & Caribbean Yearbooks, 1950-70.

12. C.J. Burgess, "Problems of Intra-Caribbean Transportation," Monthly Bulletin, no. 7, February 1954, (Port of Spain: Caribbean Commission, 1954) pp. 152-54.

13. Doran, "Commercial Sail," pp. 95-110.

14. C.E. O'Loughlin, The Economics of Sea Transport, (London: Pergamon Press, 1967) pp. 200-01.

15. __________, Economic and Political Change in the Leeward and Windward Islands, (New Haven: Yale University Press, 1968) p. 106.

16. Blenman, Chapter 7.

17. ECLA, Small Vessel Shipping, pp. 16-17.

18. ECLA, Small Vessel Shipping, p. 20.

19. Doran, The Tortola Boat, p. 52.

20. Adams, p. 186.

CHAPTER SIX

INEQUALITIES OF TRADE

Chapters Three and Four outlined the distribution of economic activity and the shipping network in existence when a regional shipping service began operations. The changes in transport conditions since 1954 have been detailed in Chapter Five and an attempt has been made to identify the way in which the flow of ships to the various islands has been affected. Likewise the main trends in the flow of cargo have been indicated. Theory suggested that with time the peripheral nodes would tend to capture the markets of the central nodes as transportation improved. One would expect therefore that the share of regional trade of the peripheral units would increase between 1954 and 1970. In Chapter Five it was shown that significant changes in the transport conditions took place in 1954, 58, 62, 66, and 1970, giving periods of four years over which a certain stability prevailed. Allowing, then, for random fluctuations we might expect the share of trade in each of these periods to remain stable. Using data on the value of inter-regional trade, the share of each island in each four-year period is shown in Table 6.1 for the period 1948-1970. The value of exports from each unit was used to construct a trade matrix for each year. These values were then averaged for each 4-year period, to give the value of exports from each unit to every other unit. Finally the proportions were calculated by converting each share to a percentage of the total of each unit. The period 1948-50 covers 3 years only. To arrive at percentages in Table 6.1, divide each value by 100.

The Distribution of Trade: 1950-1970

The pattern of trade may be more clearly understood from Table 6.2 which shows whether the share of trade of a particular unit increased or decreased in each time period. In 1948-50 Trinidad and Guyana accounted for 75% of the trade; indeed 97% of the trade took place between Guyana and territories as far north as Dominica, but by 1970 this proportion had fallen to 87% as Jamaica increased its share of trade, while Dominica, St. Lucia, Barbados and St. Vincent all lost ground. The units at each end of the chain all increased their shares of trade. The effects of the introduction of the regional shipping service in 1955 shows up in the pattern of changes. In the period 1955-58 only Jamaica and Trinidad increased their share of trade; all others lost, even Guyana--for the service did not extend beyond Trinidad. The withdrawal of the West Indian in 1957 and its replacement by smaller ships seemed to have slowed the pace at which Trinidad was increasing its share of regional trade, but not that of Jamaica; with the arrival of the Federal Boats after 1961, both once again increased their shares. Trinidad now accounted for 57% and Jamaica had raised its share from 1.7% to 6.3%. Guyana's share had fallen from 30% in 1948 to 25% in 1963-66; Barbados, from 11% to 6%. For the first time since 1951-54, three of the smaller islands, St. Kitts, St. Lucia and Grenada, managed small increases. The Free Trade Agreements of 1967-68 once again are reflected in increases by Trinidad, which raised its share of trade to 60% and Jamaica to 12% while the remaining units lost ground. Throughout the period 1948-1970, only on one occasion did any of Dominica, St. Lucia, St. Vincent and Barbados manage to increase its share of trade, and Dominica, St. Lucia and St. Vincent have been shown to be the most central nodes. If runs tests are applied to the pattern of changes over time we can conclude that at Dominica, Barbados and St. Vincent there was

TABLE 6.1

Share of Regional Trade: 1948-70

Year	J	K	A	M	D	L	B	V	G	T	Gy
48-50	017	0114	0014	0002	02	03	11	05	01	45	30
51-54	038	013	009	001	014	026	089	034	013	455	308
55-58	043	008	0014	0007	01	0225	08	03	003	5674	234
59-62	055	0064	0011	0009	0089	019	06	024	0029	556	266
63-66	063	0088	0008	0005	008	022	059	019	0045	5684	246
67-70	12	004	004	0002	006	015	057	014	0028	602	175

TABLE 6.2

Changes in the Share of Trade: 1948-70

51-54	+	+	+	+	-	-	-	-	+	+	+
55-58	+	-	-	-	-	-	-	-	-	+	-
59-62	+	-	-	+	-	-	-	-	-	-	+
63-66	+	+	-	-	-	+	-	-	+	+	-
67-70	+	-	+	-	-	-	-	-	-	+	-
N	6	6	6	6	6	6	6	6	6	6	6
R	1*	4	3	4	1*	3	1*	1*	4	3	4

P -(R = 1)= .0028 N = Number of Observations

P -(R = 2)= .0861 R = Number of Runs

a significant downward trend matched at Jamaica by an equally significant upward trend. At all the other units, random fluctuations occured.

If one looks at the incidence of increases, separating an outer group of units--Jamaica, Guyana and Trinidad--and comparing the number of increases with those of the rest of the region, the results are given below:

	Number of -	Number of +	
J + T + Gy	4	11	15
Rest	31	9	40
	35	20	55

From this the hypothesis that there was no difference in the frequency of increases between the two groups of units may be tested. Using Fisher's exact test, the probability of having the above distribution of +'s and -'s, given the marginal totals, is given by:

$$\frac{15!\ 20!\ 35!\ 40!}{4!\ 11!\ 9!\ 31!\ 55!} = .0007$$

One may conclude there is a significant difference between the distribution of increases and decreases in the two groups, i.e. that Jamaica, Trinidad and Guyana tended to increase their share of trade to a greater extent than could be explained by chance.

If the share of trade of the 4 larger territories over the same period is considered, the changes in the distribution of trade are as follows:

Percentage of Trade

Year	Peripheral	Central	Year	Peripheral	Central
48-50	87.7	12.3	59-62	93.7	6.3
51-54	89.0	11.0	63-66	93.64	6.36
55-58	92.44	7.56	67-70	95.4	4.6

The reduction of the share of trade of the central units to one-third the level of 1948-50 is clear testimony of the loss. When one considers that total trade increased by 200% between 1957 and 1970 from 57 million $EC to $EC 150 million, the true nature of the disadvantage to the central islands is revealed.[1] The conclusion remains that, even though there was no undue disadvantage in the distribution of activities in the early 1950's, the changes in transportation since then have been accompanied by a decline in the share of trade of the smaller central islands--a decline that is greater than anything that could be explained by random changes.

The changes in the shares of trade described above have been measured using the value of trade. Ideally, it would be best for the purposes of analysing the flows in the transport network to consider cargo tonnages. Unfortunately figures of cargo tonnages between the islands of the Caribbean are not available, hence one cannot be certain that the terms of trade, (i.e. average value per cargo ton of exports against average value of imports,) have not been working against the central islands consistently since 1950. Two factors caution against this. First, it has been shown in Chapter Three that there were no clearly developed advantages in endowment which gave a decidedly better prospect to the peripheral territories. Secondly, for Trinidad, the only unit for which dollar values per ton of cargo can be computed, it can be shown that exports to Guyana were consistently lower in value between 1960 and 1970, while exports to Jamaica, Barbados, Grenada, St. Lucia and St. Vincent showed no significant difference in value. For imports over the same period, dollar values per ton of cargo were higher for imports from Jamaica and lower from Grenada; imports from Barbados, Guyana, St. Lucia and St. Vincent did not differ consistently in value between 1960 and 1970. In these circumstances, it is most unlikely that the terms of trade could exert more than nominal influence on the distribution of trade.

The Effects of the Transport Network

To suggest that the changes in transport conditions since 1954 have worked to the disadvantage of the central, less developed units is to assert that their share of trade would have been greater if such changes had not taken place. It has already been shown that the changes in the type of vessel used, the schedule, availability of cargo space, and structure of freight rates worked to the advantage of the peripheral units. It remains now to show that the structure of the network since 1954 exerted an influence which also worked to the disadvantage of the central units.

The routes between the various units have been described by a connectivity matrix. All flow between the units must take place along one or other of these links. A connectivity matrix such as this can be used as a probability matrix, provided some means can be devised to measure the probabilities of flow along the various routes. As long as the probabilities of transition can be estimated, the matrix takes on the properties of a stochastic matrix, one of the most important of which is the existence of a limiting distribution, i.e. a long-run distribution towards which the system moves.[2] If the transition probabilities do not change over time, then the process can be described by a discreet Markov chain. The well known properties of the finite Markov chain will be used here to estimate the influences of the transport network: the existence of a limiting distribution which describes the inherent tendencies; its tendency to converge rapidly on the limiting distribution, to be independent of the original distribution.[3] To arrive at estimates of the distribution of trade between the 11 units, three things are required:

1. An original distribution of trade.

2. Time periods over which transitions are expected to occur.

3. A matrix of transition probabilities.

In all cases, the original distribution of trade will be that of 1954--the period before government activity in transportation. As the conditions have been shown to be stable over 4-year periods, transitions will be held to take place every 4 years. In any event, yearly transitions over the 15-year period to 1970 would take the distribution much closer to the equilibrium distribution. The method of estimating the transition probabilities will be the source of differences in the estimates provided.

Estimate I: Equiprobable

Given a fixed number of routes to any node, all cargo entering and leaving must follow these routes. Thus in the network of 1954, outlined in Chapter Four, Jamaica was connected to Trinidad and St. Vincent only. Under the assumption of equiprobable flow, 50% of Jamaica's Caribbean trade would flow via Trinidad and 50% via St. Vincent. Using the connections of the 1954 network and the assumption of equiprobable flow, transition probabilities have been estimated as in Matrix 6.3. These are then combined with the 1954 distribution of trade to provide the Markov chain estimates of the distribution of trade in 1958, 62, 66, 1970 as well as the long-run distribution of trade, which we have described as the tendency inherent in the transport network. These are shown in Table 6.4a. The most striking result of these estimates is the reduction in the shares of Trinidad and Guyana from 76% in 1954 to 23% in 1970. The reduction takes place in each period, but is most severe in the period 1955-58. This suggests that the introduction of a regional service should have reduced their

MATRIX 6.3

Transition Matrix: Equiprobable Flow 1954

	J	K	A	M	D	L	B	V	G	T	Gy
J	-	-	-	-	-	-	-	.5	-	.5	-
K	-	-	.34	.33	.33	-	-	-	-	-	-
A	-	.34	-	.33	.33	-	-	-	-	-	-
M	-	.25	.25	-	.25	-	.25	-	-	-	-
D	-	.2	.2	.2	-	.2	.2	-	-	-	-
L	-	-	-	-	.25	-	.25	.25	-	.25	-
B	-	-	-	.14	.14	.14	-	.14	.14	.15	.15
V	.2	-	-	-	-	.2	.2	-	.2	.2	-
G	-	-	-	-	-	-	.33	.33	-	.34	-
T	.17	-	-	-	-	.16	.17	.16	.17	-	.17
Gy	-	-	-	-	-	-	.5	-	-	.5	-

TABLE 6.4

a) Distribution of Trade: Estimate I

	J	K	A	M	D	L	B	V	G	T	Gy
OD	038	013	009	001	014	026	089	034	013	455	308
58	084	006	007	023	026	095	252	115	097	204	091
62	058	013	013	045	069	096	170	166	093	205	072
66	068	03	03	046	068	103	184	140	092	179	06
70	059	035	035	059	083	096	170	145	084	176	058
IT	046	068	068	089	112	09	16	113	069	139	048

OD = Original Distribution - 1954

IT = Inherent Tendency - Limiting Distribution

b) Percentage of Trade

Year	Peripheral	Central
54	89	11
58	63	37
62	50	50
66	49	51
70	46	54
IT	39	61

shares of trade but in fact it did not. Likewise, there should have been a redistribution of trade in favour of the remaining nodes--in particular the Windwards and Leewards. From 1% to 3% each in 1954, their shares should have moved to from 4% to 15% in 1970. When the share of the central nodes is compared with that of the peripheral, the shares are as given in Table 6.4b. The peripheral units take 63% in 1958 but by 1962 there should have been an equal division; and by 1970, the central units of the Windwards and Leewards should have pushed their share up to 54%. In the long run, the equiprobable network would tend to direct 61% of trade flows to the central units and 39% to the peripheral Jamaica, Barbados, Trinidad and Guyana. Each territory would account for at least 5% of total trade.

Estimate II: Capacity Weighted

The flow along each route is unlikely to be equal, for we have shown that different types of vessel were used. Hence, the cargo capacity along each route varied. The transition probabilities may be estimated to take account of this by using the size of the ships on each route as weights, and taking into account all types of ships on a given route. The average size of ship in 1954 was given as

	Tons
Transoceanic	11,250
Federal Boat	3,000
Motor Vessel	600
Schooner	150

If the schooner is given a weight of 1, then the motor vessel is weighted 4, and the Federal Boat 20. These sum to 25. If a transoceanic liner is weighted 75, then any route covered by all 4 types of vessel has a weight of 100. A weight of 75 corresponds to 11,250 tons for the transoceanic liners, and this was about their maximum size in the 1950's. These weights are then applied to Table 4.6a which gives connectivity by modes, to which

MATRIX 6.5

Transition Matrix: Capacity Weighted 1954

	J	K	A	M	D	L	B	V	G	T	Gy
J	-	.19	-	-	-	-	-	.04	-	.77	-
K	.15	-	.77	.04	.04	-	-	-	-	-	-
A	-	.49	-	.49	.02	-	-	-	-	-	-
M	-	.024	.479	-	.478	-	.019	-	-	-	-
D	-	.02	.02	.47	-	.47	.02	-	-	-	-
L	-	-	-	-	.485	-	.485	.025	-	.005	-
B	-	-	-	.003	.014	.27	-	.27	.003	.22	.22
V	.02	-	-	-	-	.025	.475	-	.475	.005	-
G	-	-	-	-	-	-	.005	.4975	-	.4975	-
T	.232	-	-	-	-	.003	.235	.003	.292	-	.235
Gy	-	-	-	-	-	-	.5	-	-	.5	-

Weights - Schooner = 1
Motor Vessel = 4
Federal Boat =20
Transoceanic =75

TABLE 6.6

a) Distribution of Trade: Estimate II

	J	K	A	M	D	L	B	V	G	T	Gy
OD	038	013	009	001	014	026	089	034	013	455	308
58	108	012	011	012	015	033	29	034	148	21	[illegible]27
62	051	026	015	014	026	087	146	158	079	28[illegible]	113
66	073	018	027	021	052	057	242	083	159	169	099
70	043	029	025	039	042	092	159	149	089	239	094
IT	044	054	084	086	09	088	159	09	087	148	07

OD = Original Distribution 1950-54

IT = Inherent Tendency

b) Percentage of Trade

Year	Peripheral	Central
54	89	11
58	73.5	26.5
62	59.5	40.5
66	58.3	41.7
70	53.5	46.5
IT	42	58

the Federal Boat links must be added. The weights for all routes to each node are then summed and converted to percentages. For example, Jamaica is connected to St. Kitts by Federal Boat for a weight of 20; to St. Vincent by motor vessel for 4; to Trinidad by motor vessel and transoceanic line for a weight of 79. The total of all units to Jamaica equals 103. The final probabilities are then .19 to St. Kitts, .04 to St. Vincent and .77 to Trinidad. The rest of the transition matrix has been constructed in the same way. The original state is the 1954 distribution of trade. Estimates for each period to 1970 and the inherent tendency are presented in Table 6.6, while the transition matrix is in Matrix 6.5. The estimates for the periods to 1970 tend to fluctuate at all nodes. Yet once again the share of Trinidad and Guyana is reduced to between 26 and 40%. The redistribution of trade to the Windwards and Leewards is not as marked as in the equiprobable network. Again the estimates suggest that the greatest reallocation would take place in 1958, when Barbados and Jamaica would increase their shares. The changes for St. Kitts, Antigua, Montserrat tend to be small, so that by 1970 their shares range from 2.5 to 4%. St. Lucia, St. Vincent and Grenada manage to raise their shares to around 10% each by 1970, from 1954 values of 1% to 3%. In the long run Barbados has about 16%, Trinidad 15%, and the others, shares ranging from 4 to 9 percent.

Estimate III: Cargo Shares

The existence of a ship on a particular route is no guarantee its capacity will be used. To escape the bias towards large ships in the previous estimates the transition probabilities may be calculated according to the importance of particular types of ships for the carriage of cargo. For the most recent period, ECLA reports that 50% of all cargo was carried by small vessels, i.e. schooners and motor vessels, 20% by the Federal Boats and 30%

MATRIX 6.7

Transition Matrix: Cargo Weighted 1954

	J	K	A	M	D	L	B	V	G	T	Gy
J	-	.15	-	-	-	-	-	.3	-	.55	-
K	.092	-	.458	.225	.225	-	-	-	-	-	-
A	-	.4	-	.4	.2	-	-	-	-	-	-
M	-	.1724	.3448	-	.3448	-	.138	-	-	-	-
D	-	.143	.143	.285	-	.285	.144	-	-	-	-
L	-	-	-	-	.38	-	.38	.2	-	.04	-
B	-	-	-	.0869	.1086	.2174	-	.2174	.0217	.174	.174
V	.14	-	-	-	-	.165	.33	-	.33	.035	-
G	-	-	-	-	-	-	.048	.476	-	.476	-
T	.2	-	-	-	-	.0275	.23	.0275	.285	-	.23
Gy	-	-	-	-	-	-	.5	-	-	.5	-

Weights - Schooner = 1

Motor Vessel = 4

Federal Boat = 2

Transoceanic = 3

TABLE 6.8

a) Distribution of Trade: Estimate III

	J	K	A	M	D	L	B	V	G	Y	Qy
OD	038	013	009	001	014	026	089	034	013	455	308
58	097	011	008	018	025	041	283	055	143	199	12
62	048	025	015	037	057	083	153	172	081	234	095
66	073	028	032	041	07	084	208	109	127	148	08
70	048	041	037	057	081	087	164	148	083	184	075
IT	045	073	083	096	116	087	154	101	071	119	054

OD = Original distribution 1950/54
IT = Inherent tendency

b) Percentage of Trade

Year	Peripheral	Central
54	89	11
58	70	30
62	53	47
66	51	49
70	47	53
IT	37	63

by transoceanic carriers.[4] These values give the following weights:

Transoceanic		3
Federal Boat		2
Motor Vessel	5	4
Schooner		1

which are then applied to the matrix of modes to arrive at a transition matrix which reflects the importance of particular kinds of vessels. The weight of 5 for small vessels refers to the period 1966-70. The proportion of trade carried by small vessels was almost certainly higher between 1954 and 1966 so that the influence of the small vessel routes over the period is perhaps understated. The cargo weighted transition matrix is given in Matrix 6.7. Again for Jamaica, the route to St. Kitts by Federal Boat is weighted 2, to St. Vincent by motor vessel 4, and to Trinidad by transoceanic liner and motor vessel 7—for a total of 13. The final transition probabilities are then .15 to St. Kitts, .3 to St. Vincent and .55 to Trinidad. The procedure is then completed for the remaining units. Estimates of the share of trade in each period are then derived and are shown in Table 6.8, as well as the limiting distribution.

Comparison of the Estimates

The three estimates may now be compared with the actual distribution of trade, using the 1970 predictions as the basis of comparison, as in Table 6.9a. In Table 6.9b the estimated values of the equiprobable, capacity weighted and cargo weighted estimates are subtracted from the actual distribution of trade in 1970. All three estimates predict smaller shares for Jamaica, Trinidad and Guyana than was the case in 1970, and larger shares for the remaining territories. More of regional trade had moved to the outer ends of the network than would have been expected given the structure of the network.

TABLE 6.9

a) Share of Trade: 1970

	Actual (1)	Equiprobable (2)	Capacity (3)	Cargo (4)
J	12	059	043	048
K	004	035	029	041
A	004	035	025	037
M	0002	059	039	057
D	006	083	042	081
L	015	096	092	087
B	057	170	159	164
V	014	145	149	148
G	0028	084	089	083
T	602	176	239	184
Gy	175	058	094	075

b) Comparisons

	1-2	1-3	1-4	2-3	2-4	3-4
J	+	+	+	+	+	-
K	-	-	-	+	-	-
A	-	-	-	+	-	-
M	-	-	-	+	+	-
D	-	-	-	+	+	-
L	-	-	-	+	+	+
B	-	-	-	+	+	-
V	-	-	-	-	-	+
G	-	-	-	-	+	+
T	+	+	+	-	-	+
Gy	+	+	+	-	-	+

The predictions of the three transition matrices are then compared with each other in the same way. When compared with the equiprobable network, the capacity weighted estimates tend to predict smaller shares for Barbados and all points north to Jamaica, and larger shares for St. Vincent, Grenada, Trinidad and Guyana. The cargo weighted network however seems to offer only random differences from the equiprobable network. When compared with the capacity estimates, the cargo weighted network tends to underpredict for Dominica to Jamaica, and over predict in the south of the region.

We have seen that the peripheral units held the overwhelming proportion of trade and tended to increase their share over the period. How do the predictions compare with the reality?

TABLE 6.10

Share of Trade: Jamaica, Barbados, Trinidad, Guyana: 1954-1970

Year	Actual	Equiprobable	Capacity	Cargo
00	89	89	89	89
58	92.44	63	73.5	70
62	93.7	50	59.5	53
66	93.64	49	58.3	51
70	95.4	46	53.5	47

The actual share of trade increased between 1954 and 1970, while all the predictions record a decrease. The predicted value for 1970 is about one half the actual value for the equiprobable and the cargo weighted networks, and is slightly higher for the capacity weighted. The former are the ones which give the small vessels their greatest values relative to the steam ships.

The tendencies inherent in these networks all move towards a reduction of the share of the peripheral nodes to between 37% and 42% of total trade and a corresponding rise for the central islands. Clearly the structure of the network held tendencies which would have produced a distribution of trade very different from that which took place between 1954 and 1970. The inequalities of trade would have been great, for all predictions allocate about 50% of trade to Jamaica, Barbados, Trinidad and Guyana in 1970. That they held almost twice as large a share suggests that the non-structural aspects were equally important in shifting the balance of trade.

NOTES

1. See H. Brewster and C. Thomas, The Dynamics of West Indian Economic Integration, (Mona: ISER, 1967) Chapter 2; and ECLA, Carifta Countries: Overview of Economic Activity, (Port of Spain, 1971).

2. See further K.J. Tinkler, "The Physical Interpretation of Eigenfunctions of Dichotomous Matrices," I.B.G., March 1972, pp. 17-45.

3. J. Kemeny and J. Snell, Finite Markov Chains, (New York: Van Nostrand, 1960).

4. ECLA, Small Vessel Shipping in the Eastern Caribbean, (Port of Spain, 1970) p.8.

CHAPTER SEVEN

INTERISLAND TRANSPORTATION AND REGIONAL INEQUALITY

The use of transportation for the reorganisation of Caribbean space by the governments of the region began in 1955 with the establishment of a shipping service which was intended to be the central link in a plan for integration. The movement towards integration was guided by three ideas--that transportation should bridge the gap between the islands and provide for current and future trade; that each territory should participate in and benefit from the integration process; the process should over time reduce the inequalities within the region. Now the fundamental purpose of any transport mode is to transform the effects of distance. Hence both the extent of participation and the degree of inequality in the region would be affected by the way in which interisland transportation was organised and developed in response to the underlying bias of distance.

The production of export crops has been a long standing characteristic of Caribbean economies, which has only been modified in part since 1950. The result is that by far the greater proportion of output is destined for the rest of the world, with less than 10% destined for Caribbean markets. Thus the models of the economy which dominate current thinking prove of little assistance in dealing with interisland transport which then appears to be critical for only a small fraction of Caribbean economy. Here a conception of the interisland economy is advanced in which the disparate locations, with their particular endowments, are tied together by flows of goods. In such an economy, the nature of the transport network and the conditions of transport are central to the attainment of any degree of integration. The movement of goods needs to overcome the bias of distance! The three ideas of integration thinking have therefore been made central to the theory of interisland transport advanced. From the simple assumption that there is no transportation between the units, and so no trade, an attempt was made to explain how the types of transportation would make it possible for each unit to participate in the regional economy. Now the types of vessel used in the Caribbean differed with respect to size, and speed. Hence the kind of changes which followed their introduction also differed. So, too, as the transport capability increased, even the most distant parts of the region came within the reach of trade. The result was that in the long run any one point could supply the whole region with any commodity it produced. There was thus a relationship between the limits of transportation set by the capability of the vessels and the minimum number of locations that were needed to supply any commodity to the entire region.

Yet it was always the outermost locations which would need to retain a domestic supply the longest--until transportation had brought other suppliers within reach. The long-run effect of these arrangements was simply that there was more incentive to create domestic producers in the outer areas. When, therefore, new forms of transportation were introduced, these outer suppliers were in a position to dominate the regional market. Essentially, this was the bias of distance inherent in the Caribbean, which transport changes served only to accentuate.

In 1954 when a shipping service was being planned, the economies of the various islands were not very different in structure. Basic primary production was rather evenly distributed between the islands. Most activities consisted of one or two branches, so the possibilities of primary or secondary processing were very much the same for most economic activities. There was the odd exception--like oil--with 17 branches of secondary processing at that time. Individual activities however were not equally widespread. Basic production was the most varied. Some of it was restricted to one or two places, some activities were to be found in 9, 10, or 11 places; the rest not quite as restricted, not quite as widespread. Primary and secondary processing, however, consisted of activities which were, in the main, each restricted to 4 or fewer places. If there was to be any initial advantage to any unit, it would have to be found in those activities of primary and secondary processing which were very highly concentrated.

From our analysis of the economies of the Caribbean in the early 1950's, the most developed--as measured by the total number of branches of activity--were the outer units of Jamaica, Trinidad, Guyana and Barbados; the central Windwards and Leewards accounted for only 40% of all branches of activity. Basic production ranged from the 21 branches of Dominica to 42 at Jamaica; primary processing from 17 at Montserrat to 122 at Jamaica; secondary processing 7 at St. Kitts to 86 at Jamaica. Despite these extremes, analysis did not reveal any tendency for activity to be concentrated at particular territories that could be held to be significant. This is not to say that individual activities were not concentrated in single places; what this meant was that no individual location was blessed by being the sole supplier of a large number of products.

The transport system which had developed by 1954 consisted of a reasonably well developed set of connections from the Windwards and Leewards to Barbados and Trinidad by small schooners, which did not extend to Jamaica. In addition motor vessels, larger and with engines, were being introduced, and these brought Jamaica into the regional system. These were the two types of vessels on which a regional transportation system depended, for the ocean liners never provided such a service, even though their ships did provide some connections between the islands. Their schedules were too infrequent and their size too great for the small cargoes to be transported the short distances between the islands. Likewise the schooners were too slow and too small for the journey to Jamaica. Yet, by 1954, the distribution of activity and the organisation of transport had produced a situation in which 89% of inter-regional trade was accounted for by Jamaica, Trinidad, Guyana and Barbados—units occupying the most peripheral locations in the region. It has been shown, however, that the 1954 network held within it the long-run tendency to reduce the share of the peripheral units to about 40% and could have reduced their share to about 50% by 1970 (the equi-probable Markov chain estimates)—provided the structure of the network did not change to increase the connectivity of the outer units, or the other transport conditions did not change to the disadvantage of the central islands. But change they did.

The regional shipping service which began in 1955 immediately linked Jamaica to the Leeward islands, though it never really sustained a link to Guyana. Secondly, the ships were large (3,000 tons) and ran from Jamaica to Trinidad, making these the two points where the greatest capacity was available. As these were the two best developed islands, they were able to take advantage of the cargo space provided. The new service therefore was in the main a method of carrying cargo from Jamaica to Trinidad. Since the ships called at all islands on route, it provided opportunity for Trinidad and Jamaica to capture the markets of the central islands. What was the effect of this increase in connectivity? When the capacity of the various ships is taken into account, our analysis suggests that by 1970, the share of the larger Jamaica, Trinidad, Barbados and Guyana would be about 54% (capacity weighted Markov chain estimates). Taking the extent to which the types of ship have been used, their share has been estimated at 47% for 1970 (cargo weighted Markov chain estimate). These estimates suggest that even with the new service, the capacity of the various links would constrain flow in such a way that the larger islands should have experienced a reduction in their share of trade even if the new service would make the reduction smaller than it otherwise would have been. In fact, regional inequality increased, for the share of trade of the more developed islands increased to 95% by 1970, while that of the less developed central islands fell from 11% to 5%. The new service did not confer any advantages on them, and since freight rates were equal for all journeys in the region, it meant that they were paying higher rates on the average to overcome the bias of distance by means of the Federal ships. The equal rate was held to be justified because of the payment of a subsidy for the operation of the regional shipping service which was apportioned among the islands in a way that seemed to conform with the level of development; but this only removed the advantage of relative location enjoyed by the Windwards and Leewards. The Federal Shipping Service still requires a subsidy, it carried only 20% of regional trade by 1970--even less than the oceanic lines, and it has, in all probability, widened rather than narrowed inequalities in the region.

Three features of the changes in transportation stand out as significant. First, the new routes tended to increase the connectivity of the outer islands, but merely covered routes already in existence for the central islands. The regional service might have gained from the ocean lines some of the Jamaica and Trinidad trade, but was likely to gain only from the small vessels in the Eastern Caribbean. Secondly, the large size of the ships and their lengthy schedules made them more suitable for cargo on the long haul (Jamaica to Trinidad) than for the short hauls in the Eastern Caribbean. This has happened in the past, and is inherent in the economics of steam ships, which are most efficient at sea rather than in port. The ships have simply been too large and the schedules too slow for the Eastern Caribbean. The analysis showed that it was possible for schooners to make several return voyages in the period between visits of the one ship, and could do so even with two ships in the service. Thirdly, the equalisation of freight rates in the region raised the freight costs of the Leewards and Windwards relative to that of Jamaica, Barbados, Trinidad and Guyana. This only reduced further the usefulness of the ships to the central less developed islands.

The ECLA proposals for reorganisation of the Federal Shipping Service after 1970 call for extension of the route to Guyana, and the introduction of a trunk route from Jamaica to Trinidad, Guyana and Barbados.[1] These new routes would raise the connectivity of the outer units only. No new routes are proposed for the central islands. Secondly, one ship only would call at the smaller islands instead of the present two, reducing the existing frequency of service. New ships have been commissioned of 3,000 ton size. The arrangements are justified on the grounds that, along with a sizeable increase in freight rates, the service should be better able to balance revenue and expenditure and hopefully reduce the subsidy needed. The proposals advanced are the mirror image of past arrangements and can be expected to produce the results outlined in the preceding chapters--an increase in the inequality of trade in the Caribbean. It is hardly surprising that the less developed islands have protested the latest stage of the integration process so vigorously.

The arguments advanced here should not be interpreted as a suggestion of a return to schooners and sloops. It suggests rather that the transport problems of the smaller islands could be better satisfied by vessels with the characteristics of the small vessels which relate to size, routes and frequency of service. The regional shipping service ought to provide small motor vessels which could provide a better service of the type now offered by the small vessels or make it possible and profitable for the existing small vessels to provide a better service. Given the problem of the age of the vessels and the decline of boat building, the former might be more expedient than the latter.

The smaller central islands need frequent connections by vessels suitable for small cargoes if their fledgling activities are to capture any of the markets in the Eastern Caribbean. Likewise, it has been shown that good connections to the peripheral territories are essential if the central territories are to become attractive for the location of new regional enterprises.

For example, if, as Brewster and Thomas suggested, the regional market for canned meat products could support several plants at a minimum economic size of 350,000 cans,[2] the theory outlined here suggested that the maximum distance it would be necessary to transport these goods, given four such plants, could be as low as 225 miles, if Jamaica, Guyana, Barbados and Antigua were the locations selected.[3] Now one plant of 350,000 cans would be insufficient for the Jamaica market; one plant of the same size would be too large for the Antigua market. The Antigua plant could then supply St. Kitts and Montserrat on the one hand and Dominica on the other. The former would need small vessels while the latter would be best handled by the larger motor vessels. If such a procedure could be systematically applied over a range of activities in the regional market, it could in the long run lead to an increase in the number of secondary processing industries located in the central smaller islands, a balancing of the loads on the transport network and ultimately a reduction in the inequalities of trade in the region.

It may well be, as the Carifta Secretariat commented in 1971, that "the absolute indispensability of a shipping service to regional economic integration and through it to meaningful regional economic development seems somehow not as generally recognised as would have been expected."[4] Keirstead and Levitt may be correct in their belief that freight rate policy is an inadequate instrument for economic development.[5] Nevertheless the planners of a shipping service for the Caribbean ought to be mindful of the relationship between transportation and regional inequality in the fifties and sixties, if interisland transport is to be successfully welded to the social goals of the Caribbean. For in the Caribbean group of islands, technical innovations in transportation have always brought with them the inherent tendency to shift trade outwards to the periphery, whatever the economic arrangements, thereby increasing the degree of inequality within the region.

If this is to be avoided in the future, the shipping network should be arranged so that the old establishments in the central islands stand a fair chance not only of retaining their markets but also of serving some of the larger peripheral ones. Such a service would have three elements: (1) smaller vessels than the Federal Boats currently in use should travel with much greater frequency between the central islands; (2) the peripheral territories of Jamaica, Trinidad, Guyana and Barbados could be served by larger ships on a route which would not include the central islands; (3) a less frequent connector service might link Trinidad, Barbados and say Antigua. It would then be possible to allow freight rates to reflect the relative locational advantage of the islands since they could vary on each service according to distance. These, coupled with a sincere attempt to locate new export enterprises in the central islands, could serve to reduce the inequalities which have been so sharpened since 1950.

NOTES

1. ECLA, Analysis of Steps for the Reorganisation of the West Indies Shipping Service, (Port of Spain, 1971).

2. H. Brewster and C. Thomas, The Dynamics of West Indian Economic Integration, (Mona: ISER, 1967) pp. 303.

3. See Chapter Two.

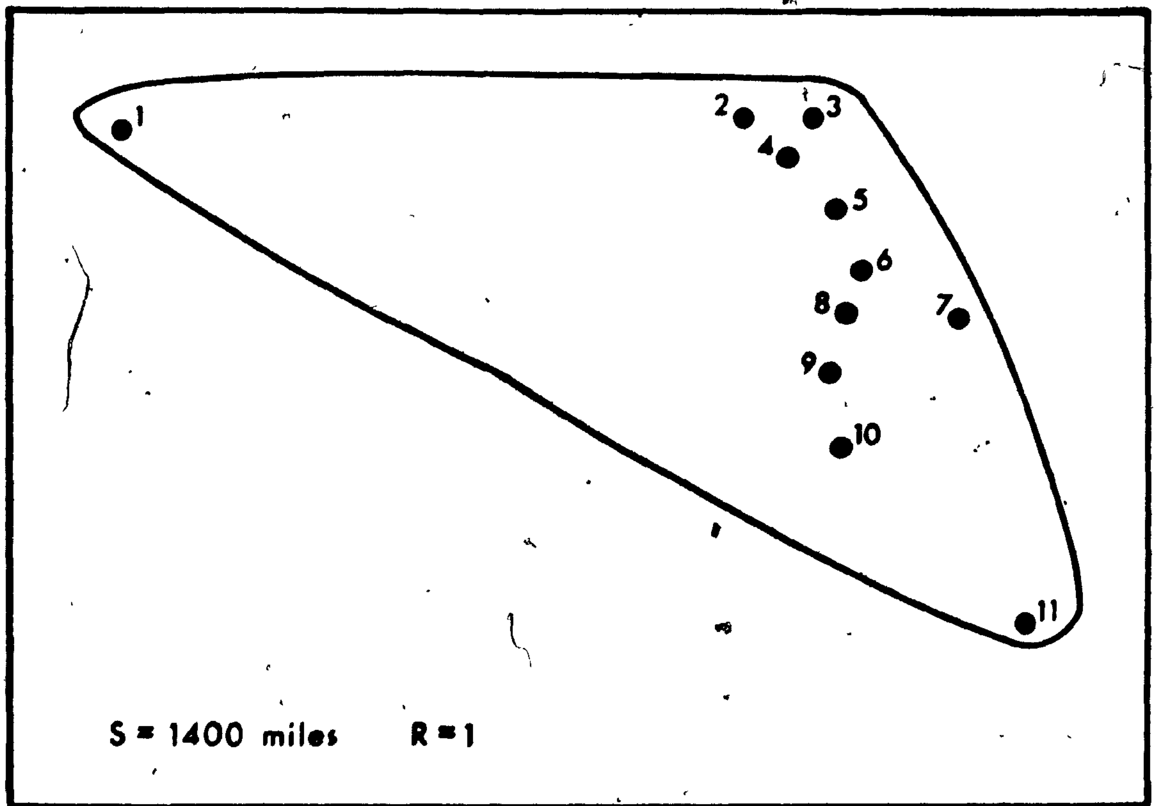
4. CARIFTA Secretariat, West Indies Shipping Corporation: a Decade of Service, (Georgetown, 1971) p. 4.

5. B.S. Keirstead and K. Levitt, Inter-territorial Freight Rates and the Federal Shipping Service, (Mona: ISER, 1963) p. 23.

APPENDIX A

SOLUTIONS TO THE LINEAR PROGRAM

S = Maximum Distance
R = Number of Locations Required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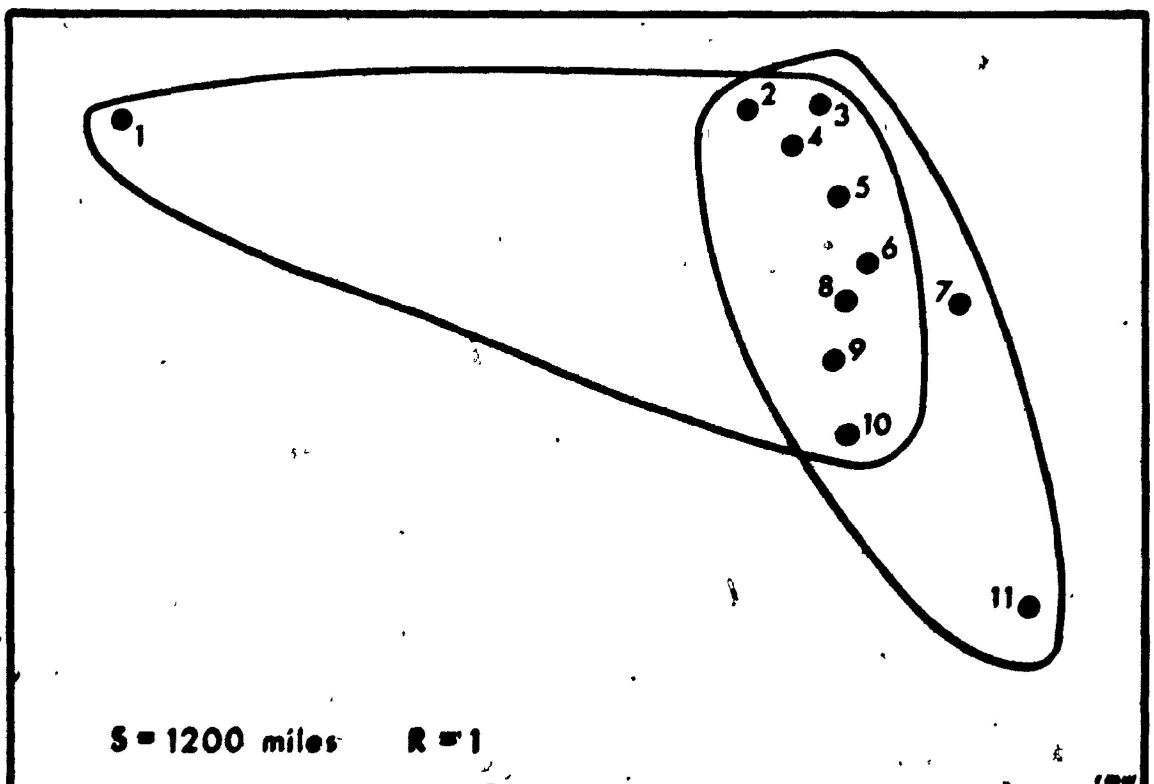
11
S = 1400 miles
R = 1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11
S = 1200 miles
R = 1

S = 1,400 miles

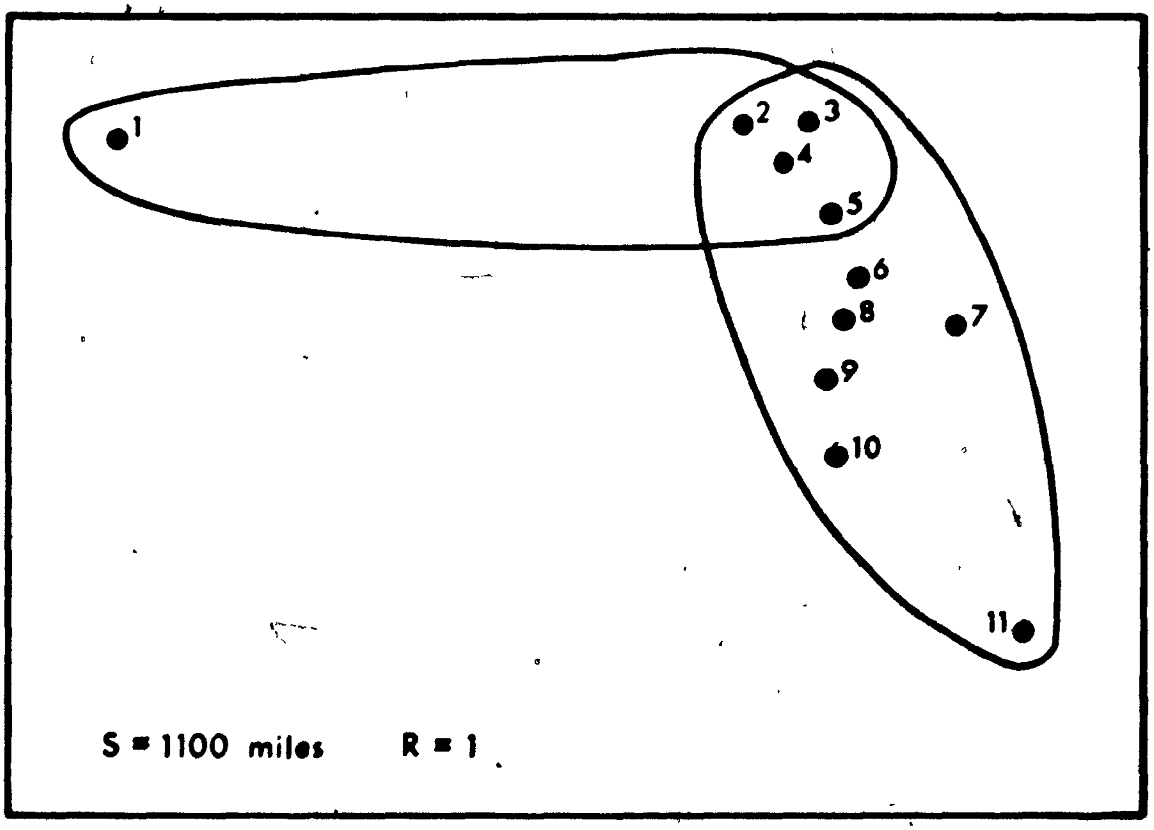
Demand Surface	Dominant Demand
1 (1 - 11)	
2 (1 - 11))	
3 (1 - 11)	
4 (1 - 11)	
5 (1 - 11)	
6 (1 - 11)	D_1 = (1 - 11)
7 (1 - 11)	
8 (1 - 11)	
9 (1 - 11)	
10 (1 - 11)	
11 (1 - 11)	

		Essential	Solution Choice	Locations
Supply Point 1	Covers D_1		1	
2	- D_1		2	
3	- D_1		3	
4	- D_1		4	
5	- D_1		5	
6	- D_1	1 of	6	1
7	- D_1		7	
8	- D_1		8	
9	- D_1		9	
10	- D_1		10	
11	- D_1		11	

S = 1,200 miles

Demand Surface	Dominant Demand
1 (1 - 6, 8 - 10)	D_1 = (1 - 6, 8 - 10)
2 (2 - 11)	
3 (2 - 11)	
4 (2 - 11)	
5 (2 - 11)	
6 (2 - 11)	D_2 = (2 - 11)
7 (2 - 11)	
8 (2 - 11)	
9 (2 - 11)	
10 (2 - 11)	
11 (2 - 11)	

			Solution	
		Essential	Choice	Locations
Supply Point 1	Covers D_1			
2	- D_2 + D_1		2	
3	- D_2 + D_1		3	
4	- D_2 + D_1		4	
5	- D_2 + D_1		5	
6	- D_2 + D_1	1 of	6	1
7	- D_2		8	
8	- D_2 + D_1		9	
9	- D_2 + D_1		10	
10	- D_2 + D_1			
11	- D_2 + D_1			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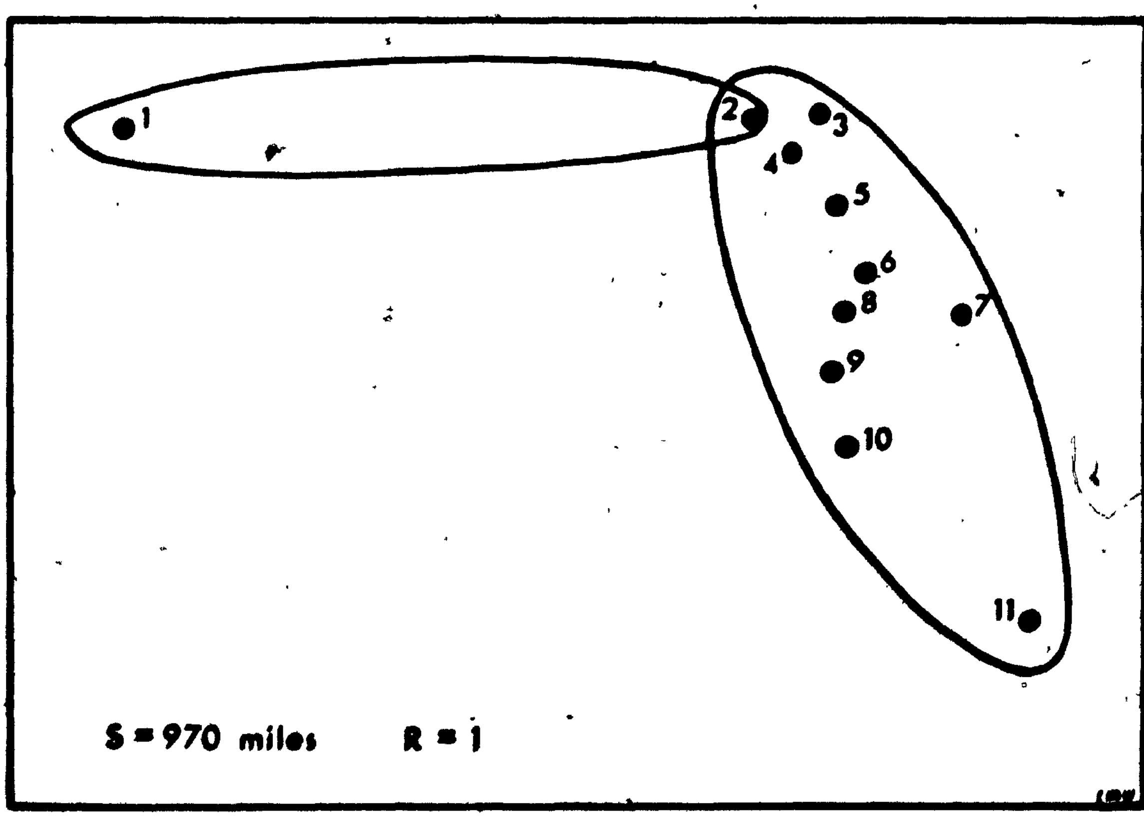
11
S = 1100 miles R = 1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9
10
11
S = 970 miles R = 1

S = 1,100 miles

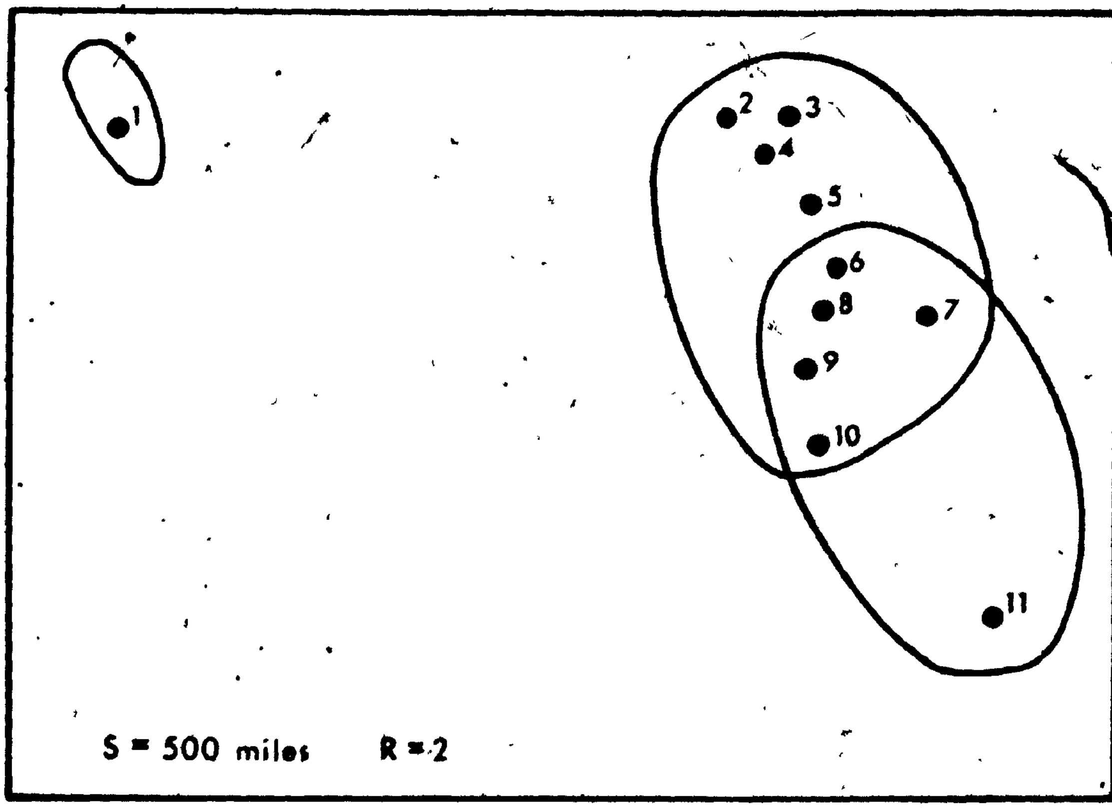
Demand Surface	Dominant Demand
1 (1 - 5)	
2 (1 - 11)	
3 (1 - 11)	D_1 = (1 - 5)
4 (1 - 11)	
5 (1 - 11)	
6 (2 - 11)	
7 (2 - 11)	
8 (2 - 11)	D_2 = (2 - 11)
9 (2 - 11)	
10 (2 - 11)	
11 (2 - 11)	

		Solution: Essential	Choice	Locations
Supply Point 1	Covers D_1			
2	" $D_1 + D_2$			
3	" $D_1 + D_2$			
4	" $D_1 + D_2$		2	
5	" $D_1 + D_2$		3	
6	" D_2	1 of	4	1
7	" D_2		5	
8	" D_2			
9	" D_2			
10	" D_2			
11	" D_2			

S = 970 miles

Demand Surface	Dominant Demand
1 (1 - 2)	D_1 = (1 - 2)
2 (1 - 11)	
3 (2 - 11)	
4 (2 - 11)	
5 (2 - 11)	
6 (2 - 11)	D_3 = (2 - 11)
7 (2 - 11)	
8 (2 - 11)	
9 (2 - 11)	
10 (2 - 11)	
11 (2 - 11)	

		Solution Essential	Choice	Locations
Supply Point 1	Covers D_1			
2	" $D_1 + D_2$	2		1
3	" D_2			
4	" D_2			
5	" D_2			
6	" D_2			
7	" D_2			
8	" D_2			
9	" D_2			
10	" D_2			
11	" D_2			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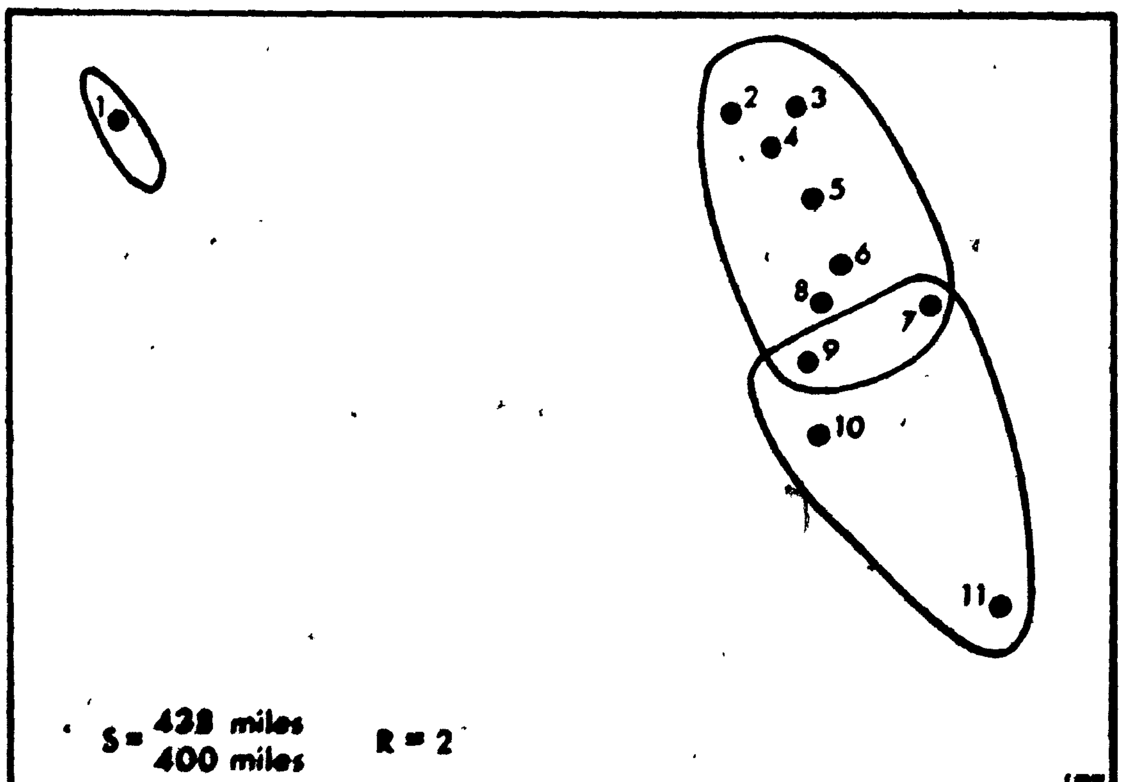
11
S = 500 miles
R = 2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10
11
S = 428 miles
400 miles
R = 2

S = 500 miles

Demand Surface	Dominant Demand
1 (1)	D_1 = (1)
2 (2 - 10)	
3 (2 - 10)	
4 (2 - 10)	
5 (2 - 10)	
6 (2 - 11)	D_2 = (2 - 10)
7 (2 - 11)	
8 (2 - 11)	
9 (2 - 11)	
10 (2 - 11)	
11 (6 - 11)	D_{11} = (6 - 11)

Solution

Supply Point	Covers	Essential	Choice	Locations
1	D_1	1		
2	- D_2			
3	- D_2			
4	- D_2			2
5	- D_2			
6	- D_2 + D_{11}		6	
7	- D_2 + D_{11}		7	
8	- D_2 + D_{11}	1 of	8	
9	- D_2 + D_{11}		9	
10	- D_2 + D_{11}		10	
11	- D_{11}			

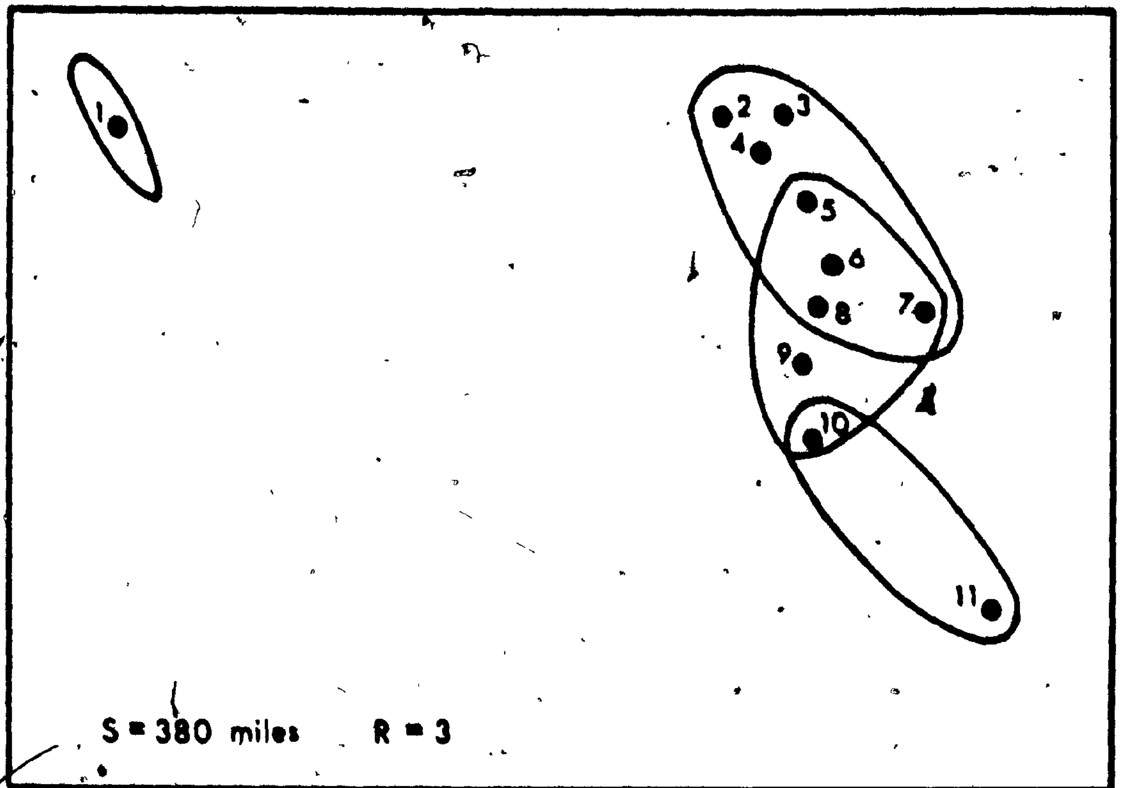
S = 438 miles

Demand Surface	Dominant Demand
1 (1)	D_1 = (1)
2 (2 - 9)	
3 (2 - 9)	
4 (2 - 9)	
5 (2 - 9)	D_2 = (2 - 9)
6 (2 - 9)	
7 (2 - 11)	
8 (2 - 9)	
9 (2 - 11)	
10 (7, 9 - 11)	
11 (7, 9 - 11)	D_{10} = (7, 9 - 11)

Solution

		Essential	Choice	Locations
Supply Point 1	Covers D_1	1		
2	" D_2			
3	" D_2			
4	" D_2			
5	" D_2			
6	" D_2			2
7	" D_2 + D_{10}	1 of	7	
8	" D_2			
9	" D_2 + D_{10}		9	
10	" D_{10}			
11	" D_{10}			

Solution as above when S = 400 miles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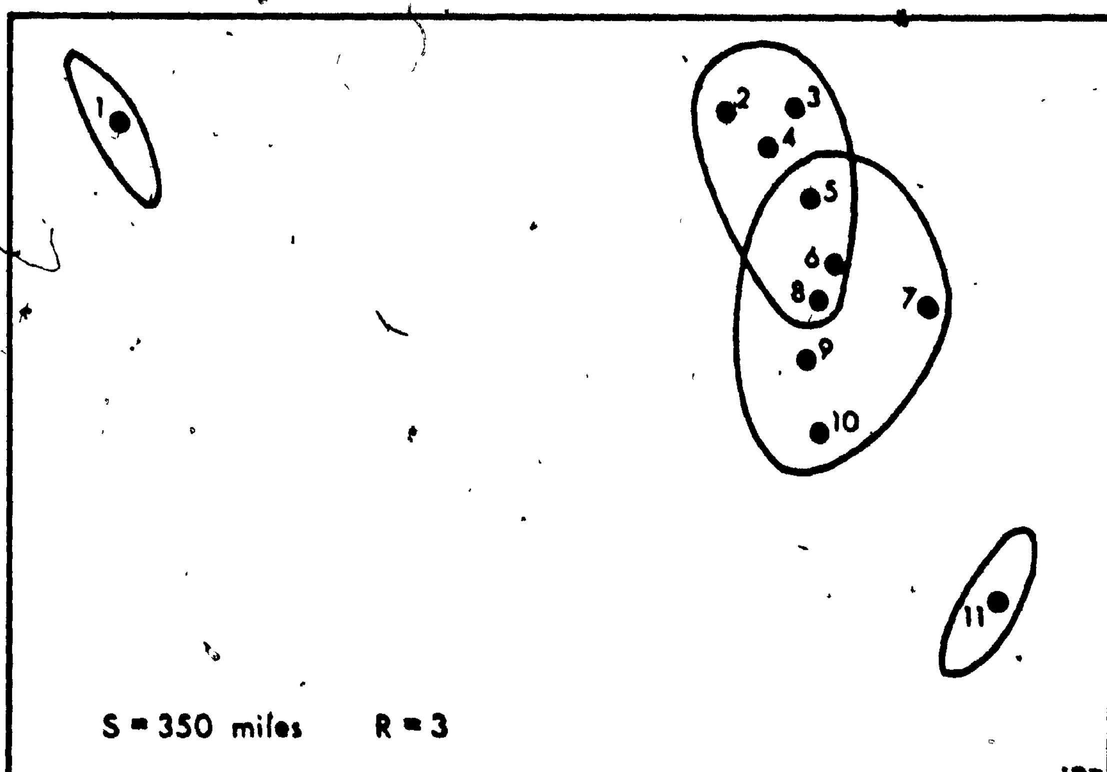
11
S = 380 miles R = 3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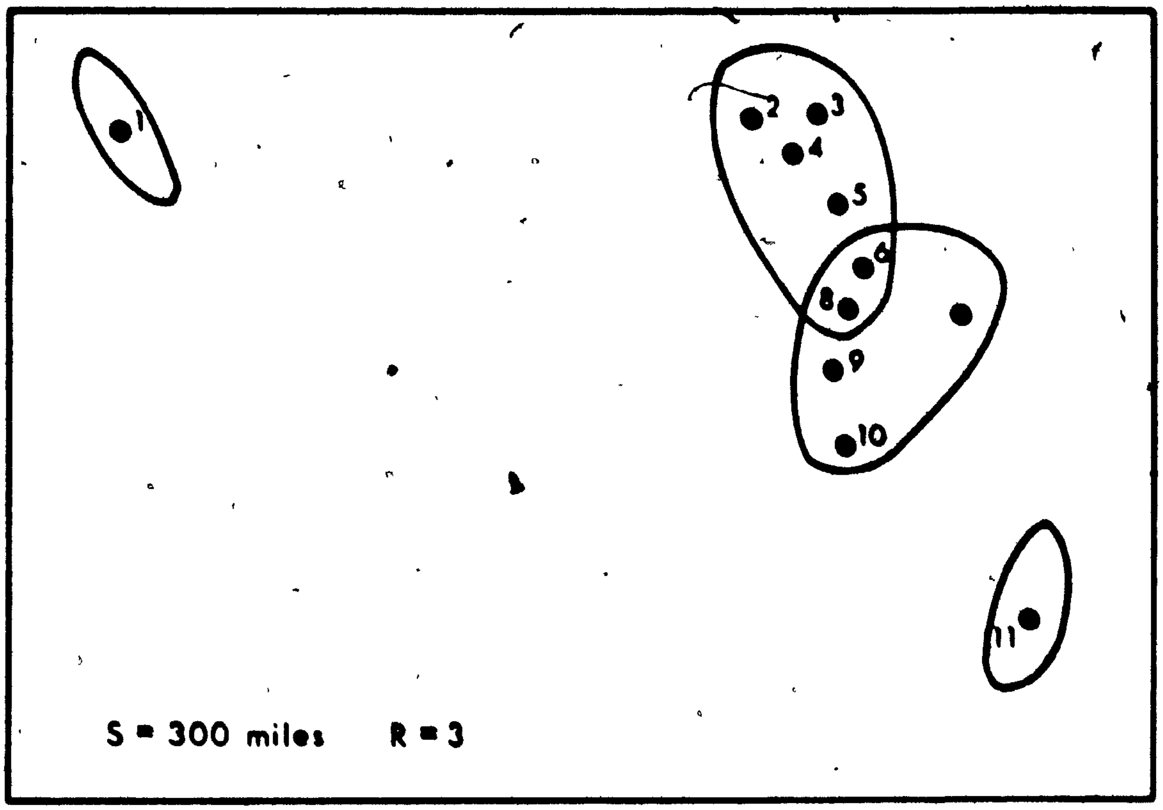
11
S = 350 miles R = 3

S = 350 miles

Demand Surface		Dominant Demand
1	(1)	D_1 = (1)
2	(2 - 6, 8)	
3	(2 - 8)	
4	(2 - 9)	D_2 = (2 - 6, 8)
5	(2 - 10)	
6	(2 - 10)	
7	(3 - 10)	
8	(2 - 10)	D_{10} = (5 - 10)
9	(4 - 10)	
10	(5 - 10)	
11	(10 - 11)	D_{11} = (10-11)

		Solution: Essential	Solution: Choice	Solution: Locations
Supply Point 1	Covers D_1	1		
2	- D_2			
3	- D_2			
4	- D_2			
5	- D_2 + D_{10}	1 of	5	3
6	- D_2 + D_{10}		6	
7	- D_2 + D_{10}		7	
8	- D_2 + D_{10}		8	
9	- D_{10}			
10	- D_{10} + D_{11}	1 of	10	
11	- D_{11}		11	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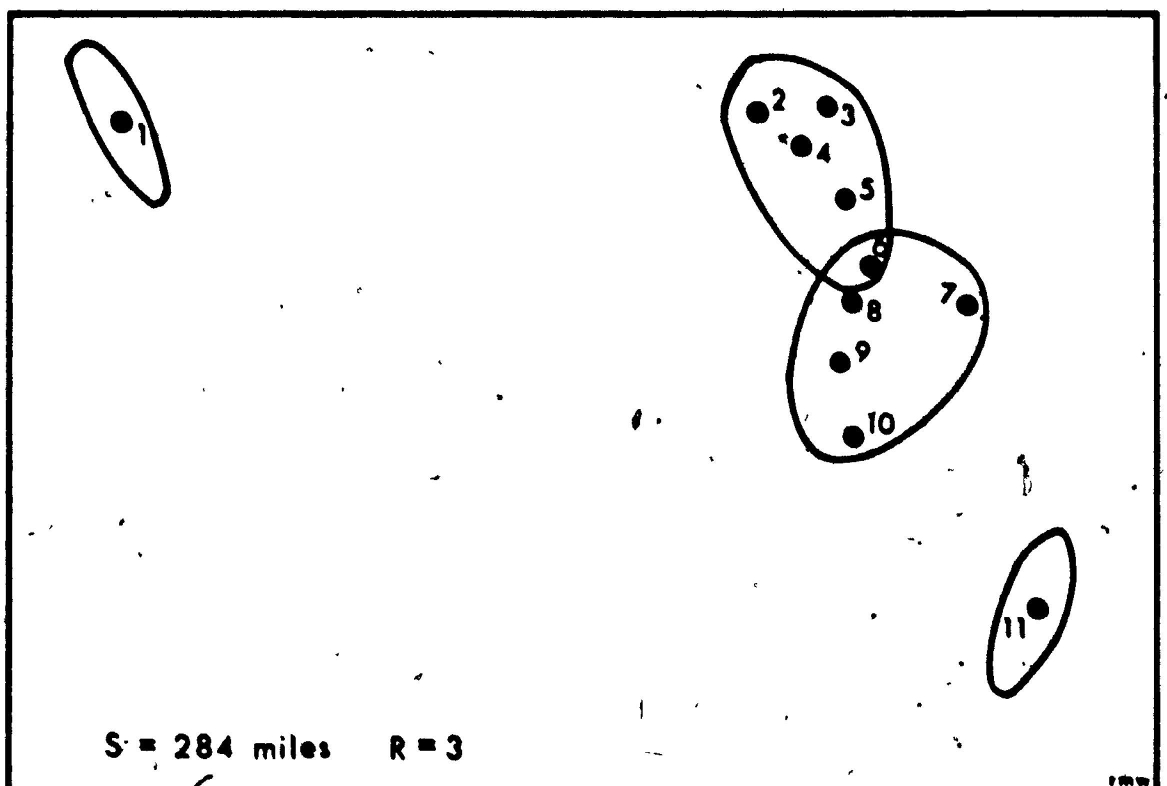
10
11
S = 300 miles
R = 3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11
S = 284 miles
R = 3

S = 300 miles

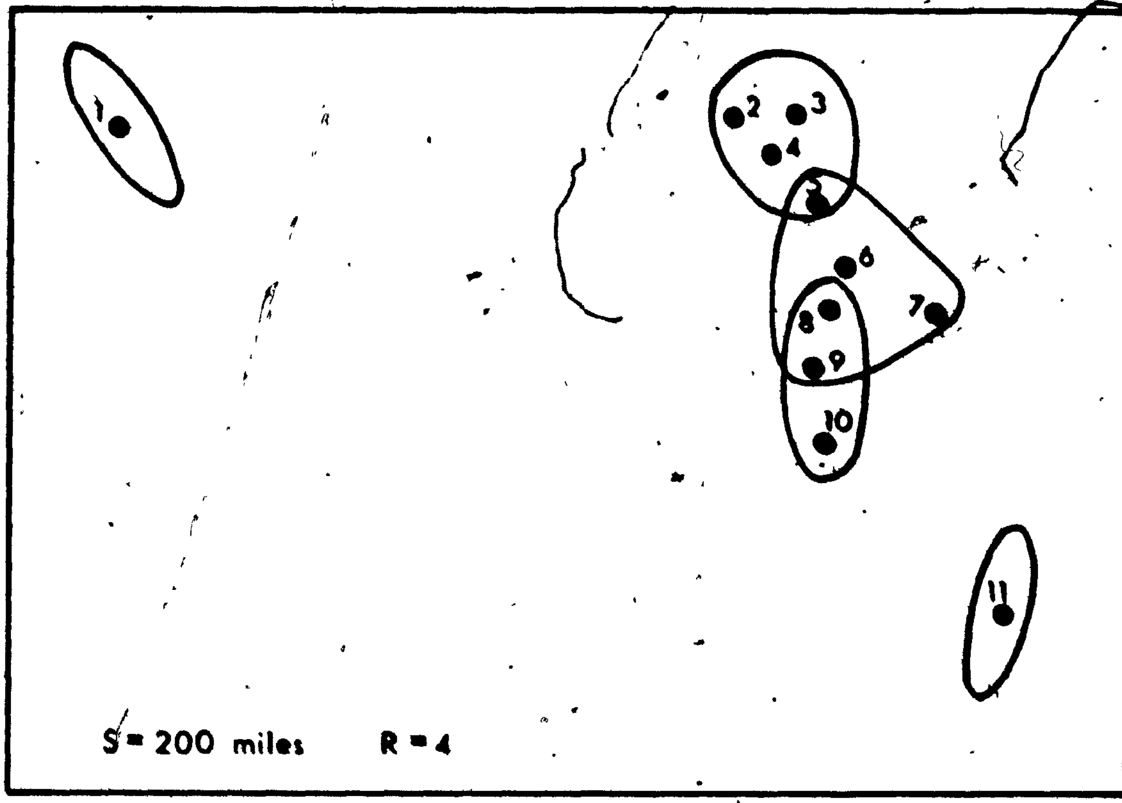
Demand Surface		Dominant Demand
1	(1)	D_1 = (1)
2	(2 - 8)	
3	(2 - 8)	
4	(2 - 8)	D_2 = (2 - 8)
5	(2 - 8)	
6	(2 - 10)	
7	(6 - 10)	D_7 = (6 - 10)
8	(2 - 10)	
9	(6 - 10)	
10	(6 - 10)	
11	(11)	D_{11} = (11)

		Solution: Essential	Choice	Locations
Supply Point 1	Covers D_1	1		
2	- D_2			
3	- D_2			
4	- D_2			
5	- D_2			3
6	- D_2 + D_7		1 of 6, 8	
7	- D_7			
8	- D_2 + D_7			
9	- D_7			
10	- D_7			
11	- D_{11}	11		

S = 284 miles

Demand Surface		Dominant Demand
1	(1)	D_1 = (1)
2	(2 - 6)	
3	(2 - 6)	
4	(2 - 6)	
5	(2 - 6)	D_2 = (2 - 6)
6	(2 - 10)	
7	(6 - 10)	
8	(6 - 10)	D_7 = (6 - 10)
9	(6 - 10)	
10	(6 - 10)	
11	(11)	D_{11} = (11)

		Solution: Essential	Choice	Locations
Supply Point 1	Covers D_1	1		
2	- D_2			
3	- D_2			
4	- D_2			
5	- D_2			
6	- D_2 + D_7	6		3
7	- D_7			
8	- D_7			
9	- D_7			
10	- D_7			
11	- D_{11}	11		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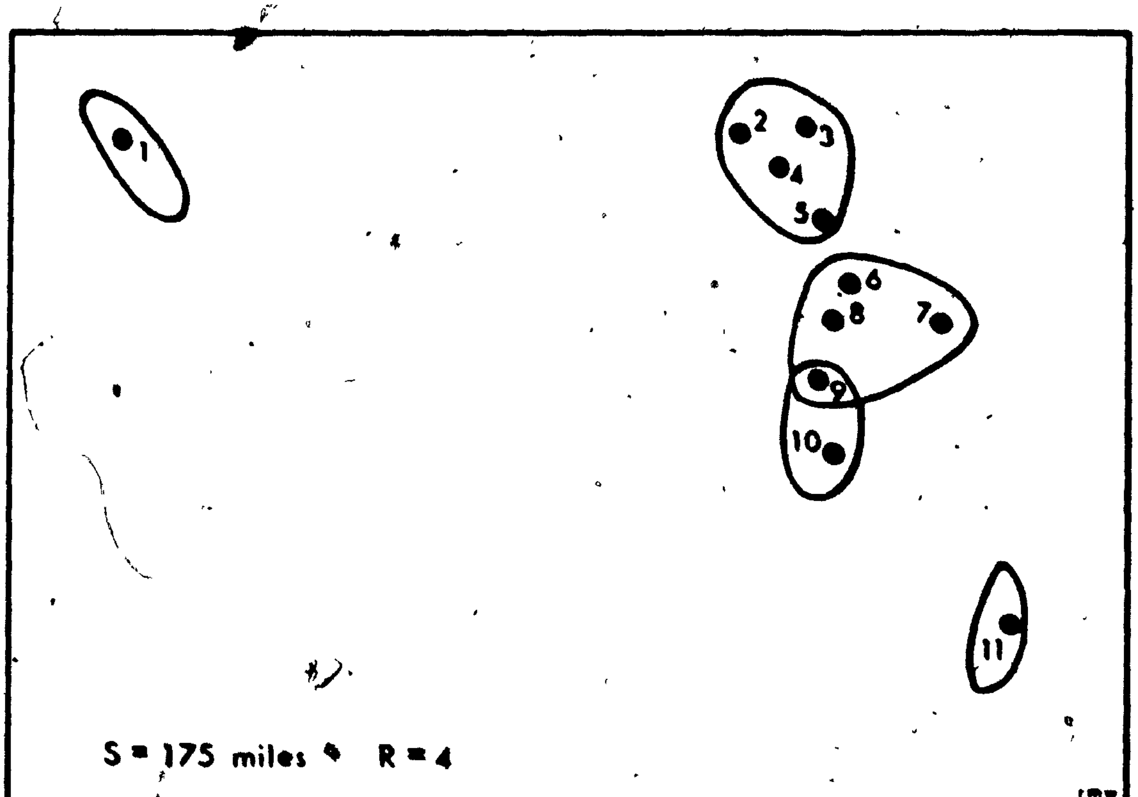
S = 200 miles
R = 4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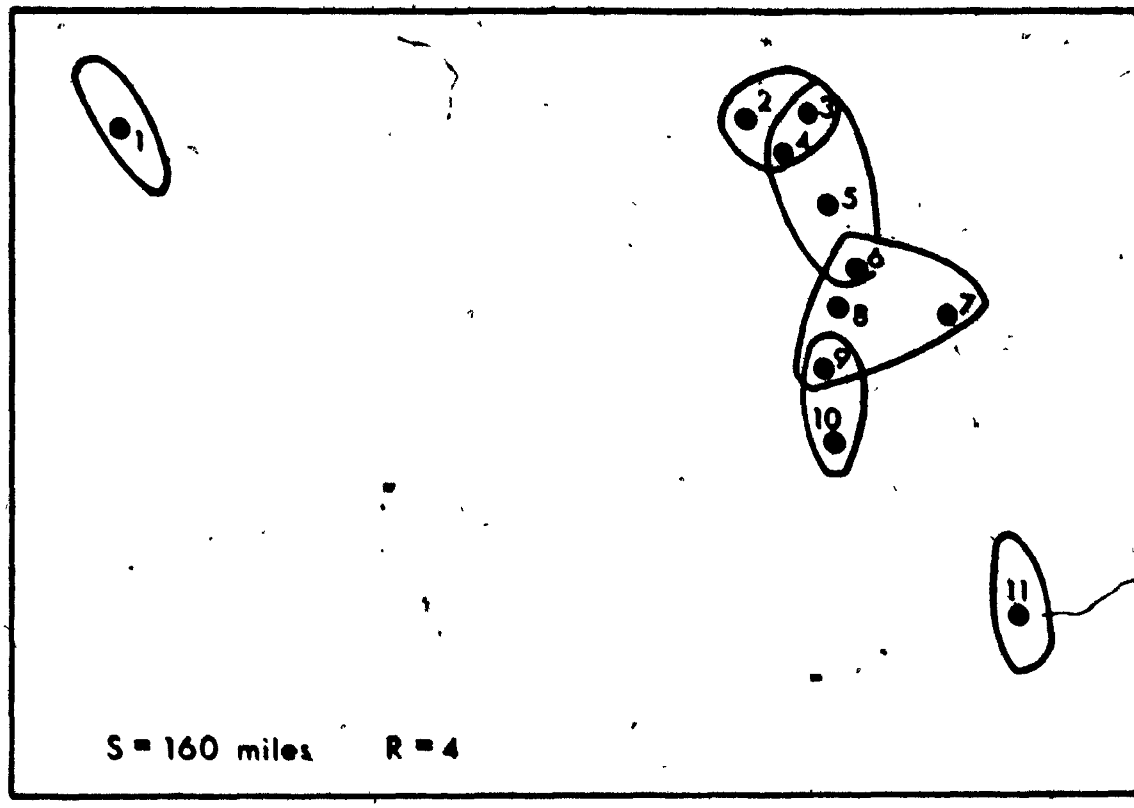
11
S = 175 miles
R = 4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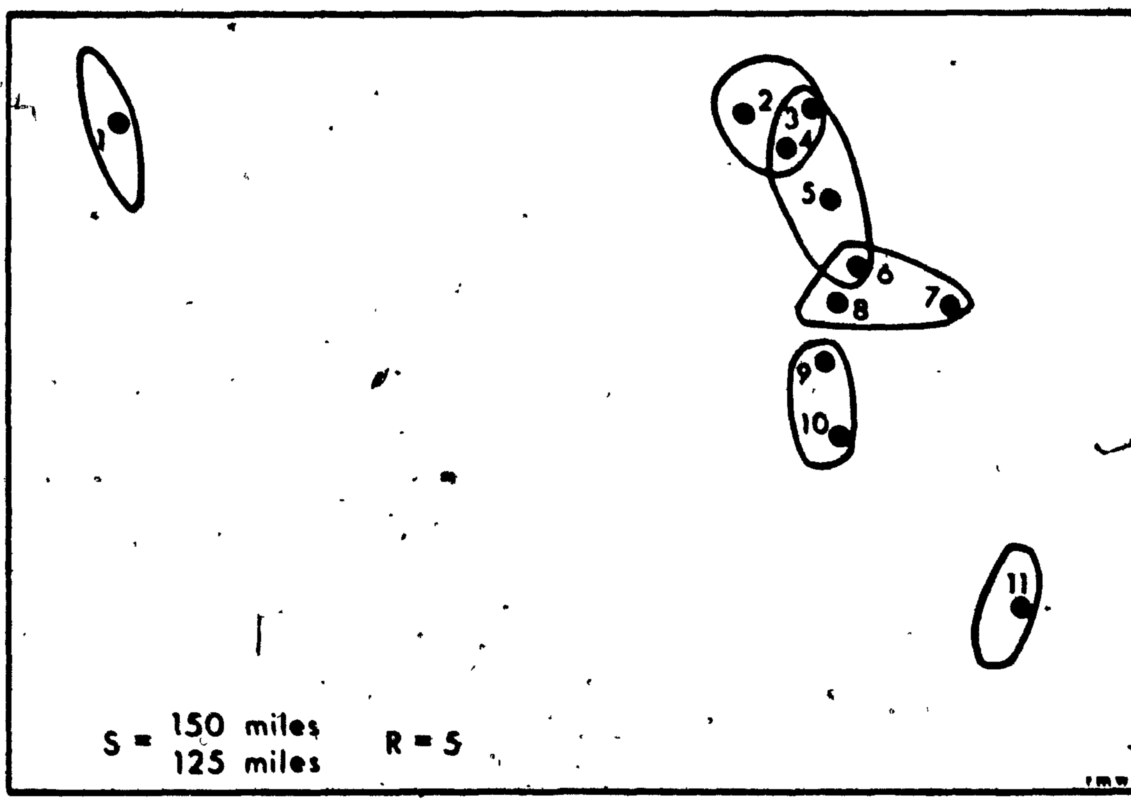
11
S = 160 miles R = 4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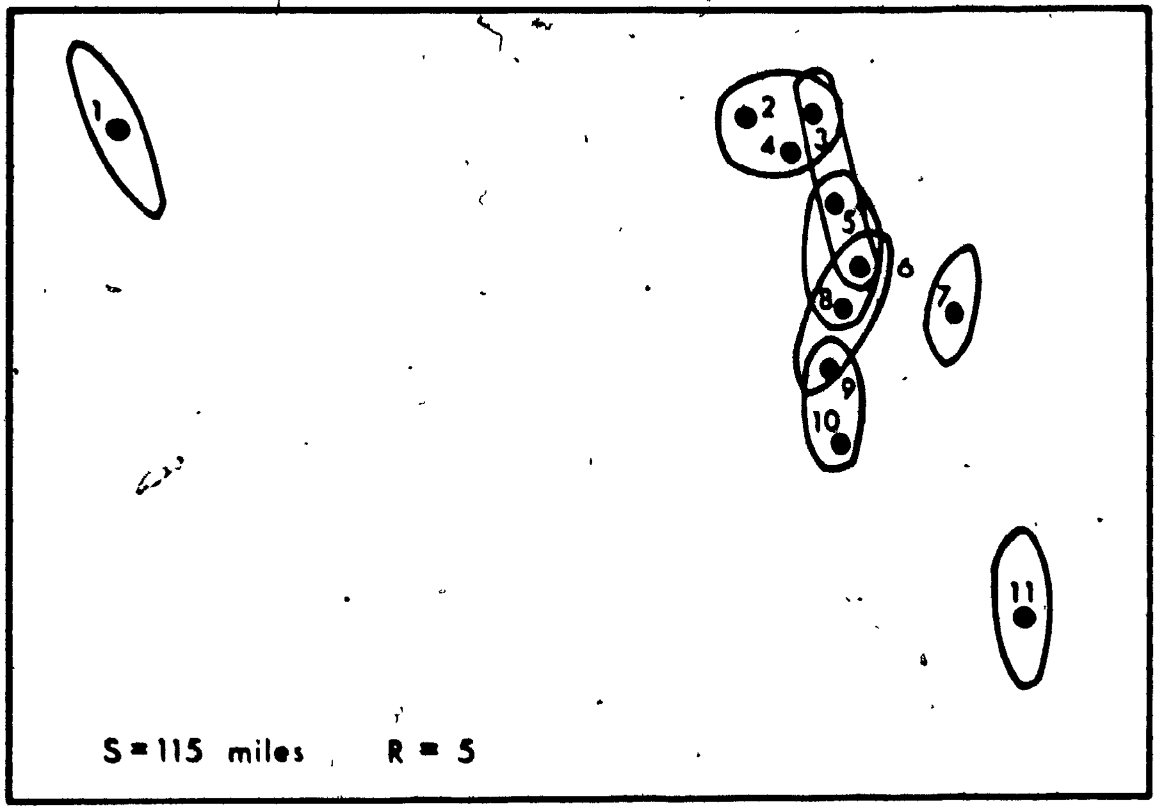
11
S = 150 miles
125 miles
R = 5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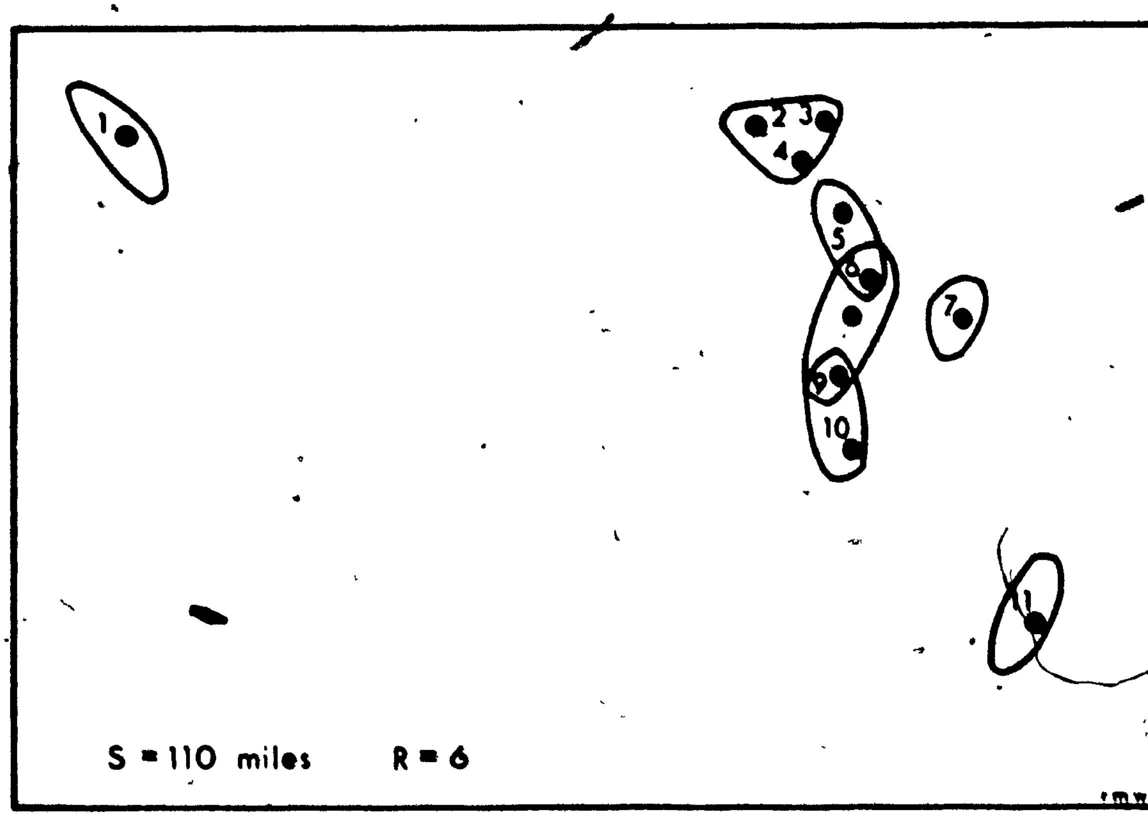
11
S = 115 miles   R = 5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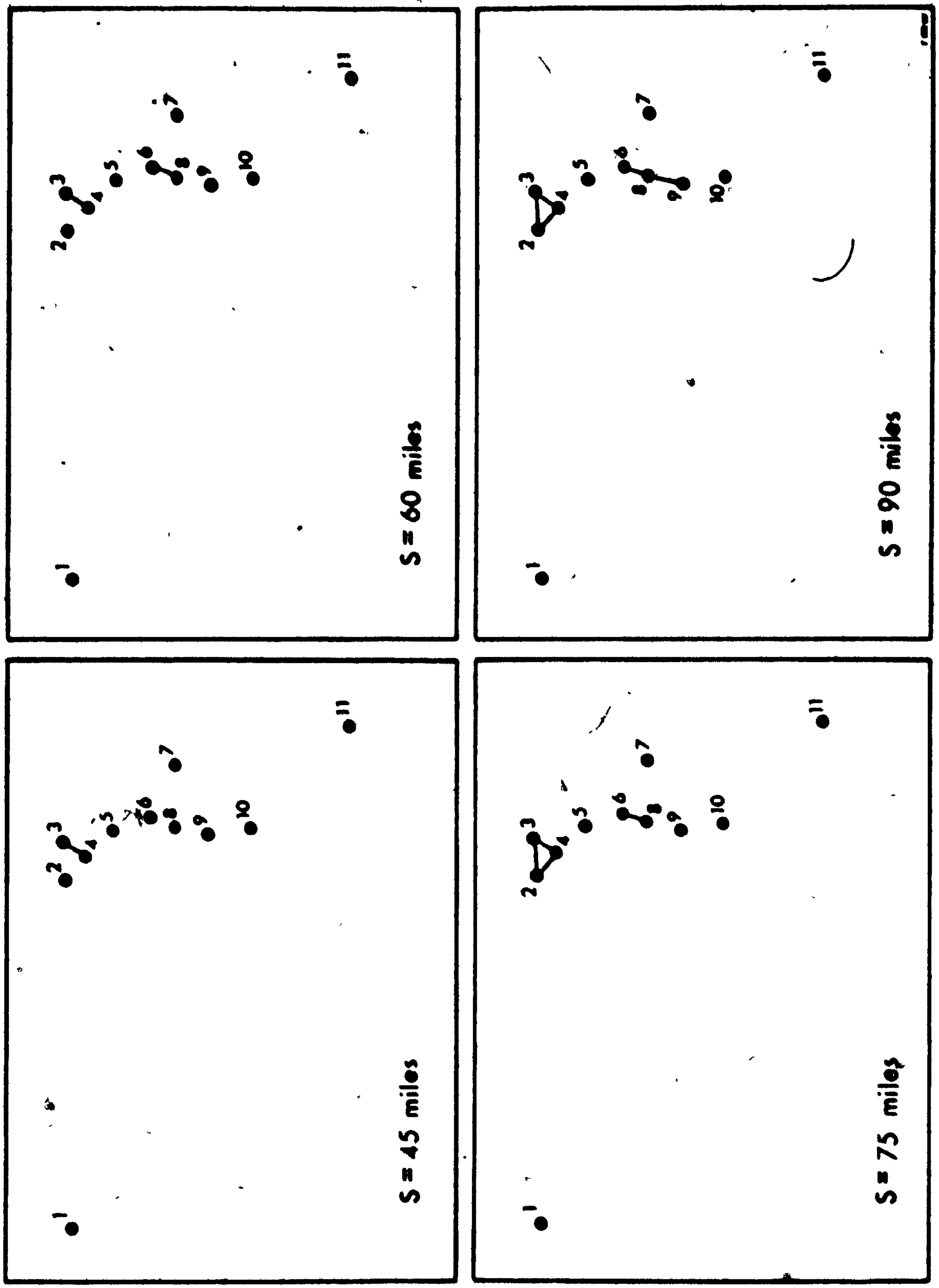
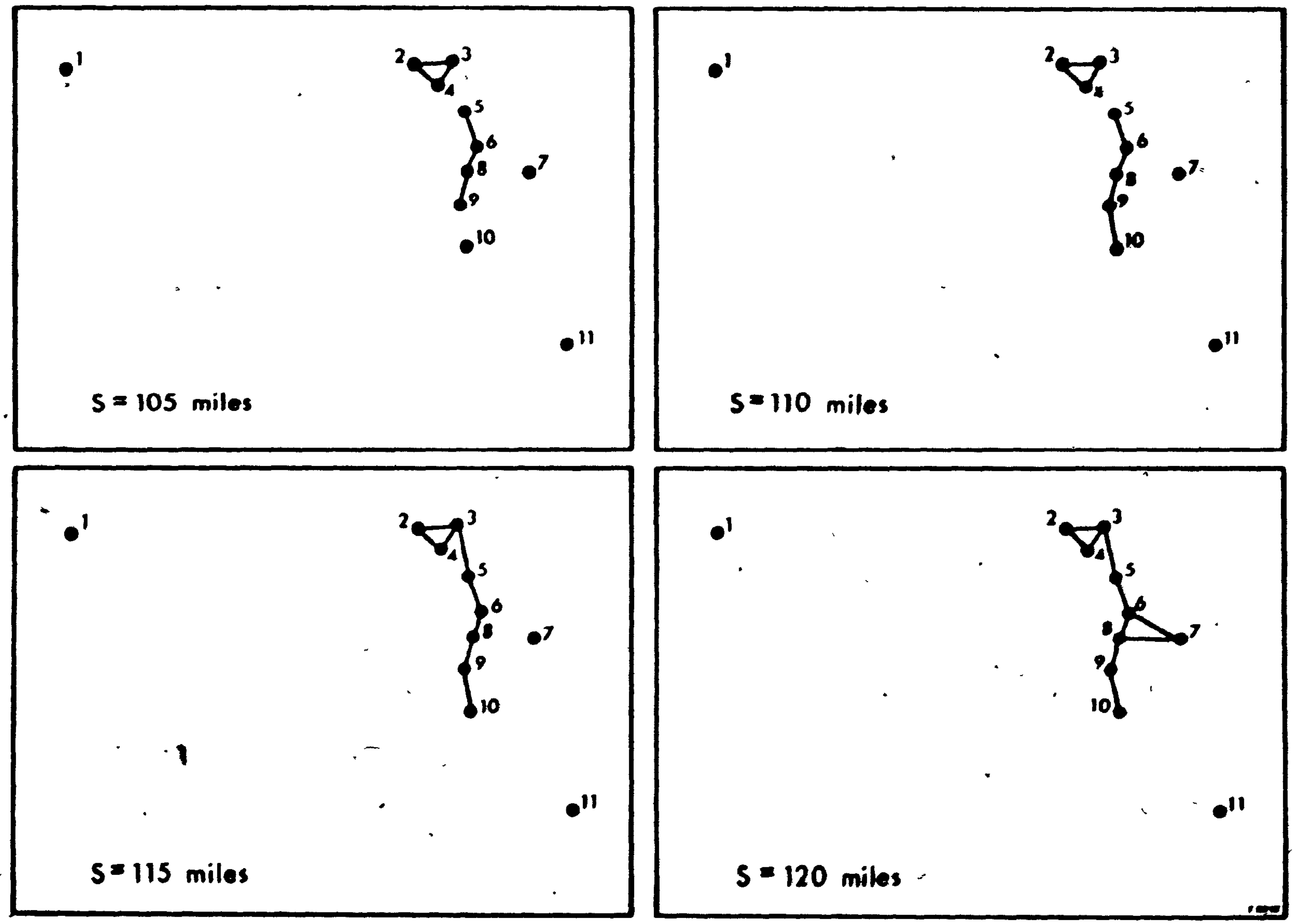
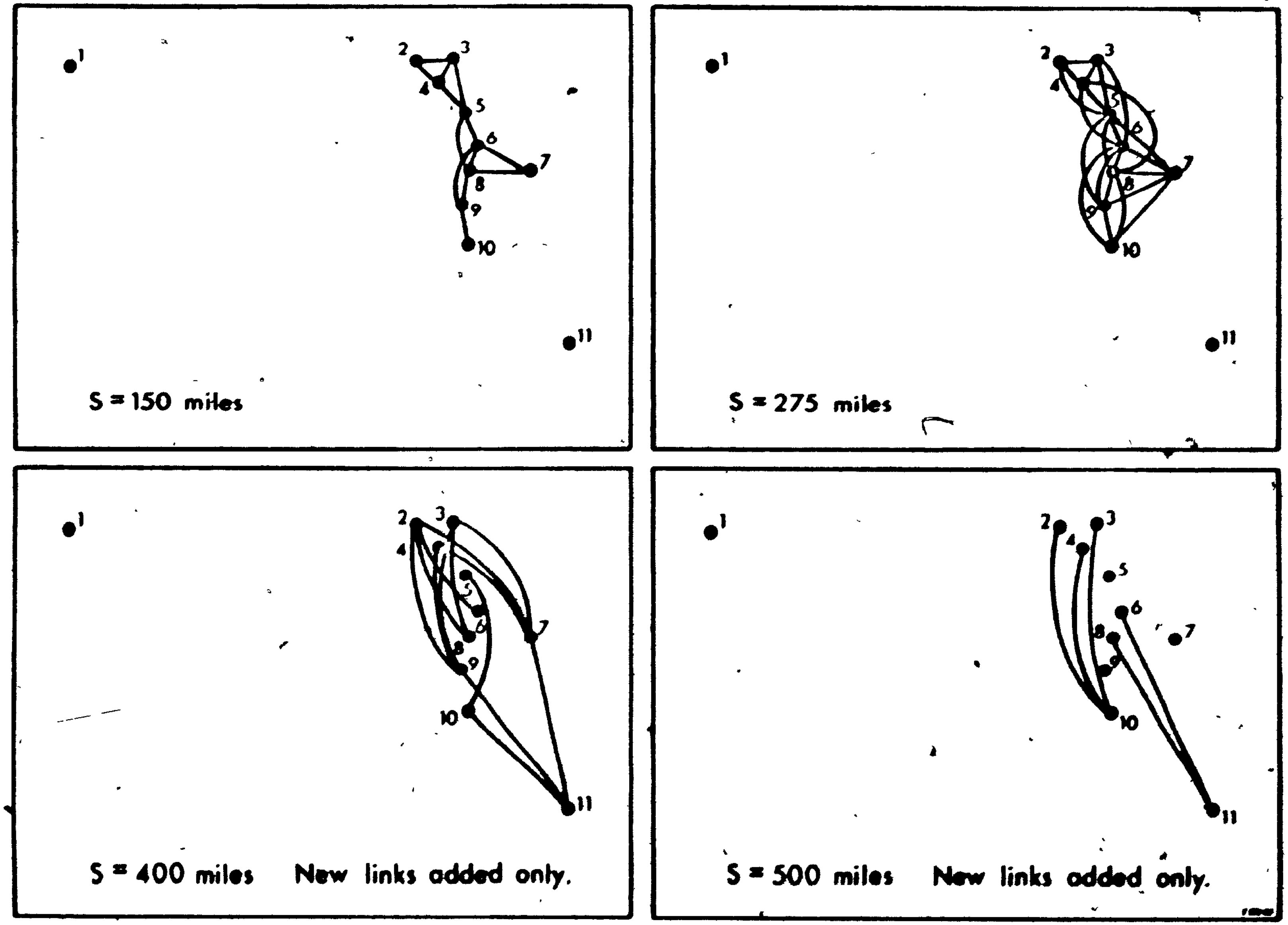
6
7
9
10
1
S = 110 miles   R = 6
tmw

APPENDIX B

STAGES IN THE DEVELOPMENT OF THE SHIPPING NETWORK UNDER MAXIMUM DISTANCE CONSTRAINTS


S = 60 miles
S = 45 miles
S = 90 miles
S = 75 miles


S = 105 miles
S = 110 miles
S = 115 miles
S = 120 miles
1
2
3
4
5
6
7
8
9
10
11


S = 150 miles
S = 275 miles
S = 400 miles New links added only.
S = 500 miles New links added only.
1
2
3
4
5
6
7
8
9
10
11

APPENDIX C

SHIPPING STATISTICS

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JAMAICA

	SHIPS ENTERING						CARGO[2]	
	TOTAL		STEAM		SAIL			
	No.	NRT[1]	No.	NRT[1]	No.	NRT[1]	IN	OUT
1946								
47	642	1,499	621	1,493	21	6		
48	772	1,715	760	1,713	12	2		
49	771	1,962	767	1,960	4	1		
1950	774	2,159	764	2,157	10	2		
51	773	2,148	769	2,148	4	.3		
52	883	2,429	877	2,429	6	.4		
53	1,044	2,853	1,043	2,852	1	.05		
54	1,017	2,980	1,014	2,979	3	.2		
55	1,147	3,085	1,140	3,079	7	7		
56	1,152	3,235	1,148	3,234	4	.3		
57	1,230	3,380	1,206	3,327	24	53		
58	1,386	3,845	1,347	3,755	39	89	1,200	7,111
59	1,449	4,212	1,428	4,212	21	1	1,380	6,318
1960	1,492	4,593	1,487	4,593	5	.2	1,563	6,373
61	1,443	4,388	1,441	4,388	2	.7	1,484	7,374
62	1,519	4,721	1,519	4,721	-	-	1,614	8,870
63	1,557	4,751	1,557	4,751	-	-	1,623	7,633
64	1,599	5,075	1,599	5,075	-	-	2,300	8,935
65	1,526	4,910	1,526	4,910	-	-	2,338	9,848
66	1,645	5,369	1,645	5,369	-	-	2,601	9,875
67	1,688	5,355	1,688	5,355	-	-	2,729	10,429
68								
69								
1970								

[1] NRT = Net Registered Tonnage in 000's of tons.

[2] Cargo in 000's of tons.

ST. KITTS

	SHIPS ENTERING						CARGO[2]	
	TOTAL		STEAM		SAIL			
	No.	NRT[1]	No.	NRT[1]	No.	NRT[1]	IN	OUT
1946								
47								
48								
49								
1950								
51								
52								
53								
54								
55								
56								
57								
58							56	50
59							53	50
1960	278	338					49	49
61	269	350					55	51
62	271	329					56	51
63	269	319					55	50
64	259	313					58	47
65	284	329					55	44
66	276	342					54	40
67	269	486					54	39
68	258	502					55	41
69	209	886					67	35
1970	282	680						

[1]NRT = Net Registered Tonnage in 000's of tons.

[2]Cargo in 000's of tons.

ANTIGUA

	SHIPS ENTERING						CARGO[2]	
	TOTAL		STEAM		SAIL			
	No.	NRT[1]	No.	NRT[1]	No.	NRT[1]	IN	OUT
1946								
47								
48								
49		453	-	445	-	8		
1950		560	-	552	-	8		
51		554	-	547	-	7		
52		-	-	-	-	-		
53		-	-	-	-	-		
54		381	-	375		6		
55								
56								
57								
58								
59	618							
1960	605	443	325	-	280	-	48	22
61	636	492	370	-	266	-	53	24
62	688	775	397	-	291	-	56	22
63	681	601	404	-	277	-	56	21
64	765	660	454	-	311	-	48	19
65	842	758	517	-	325	-	71	12
66	1,035	2,708	743	-	295	-	138	2
67	1,128	2,488	768	-	360	-	136	6
68	783	2,187	418	-	365	-	132	3
69								
1970								

[1]NRT = Net Registered Tonnage in 000's of tons.

[2]Cargo in 000's of tons.

MONTSERRAT

	SHIPS ENTERING						CARGO[2]	
	TOTAL		STEAM		SAIL			
	No.	NRT[1]	No.	NRT[1]	No.	NRT[1]	IN	OUT
1946								
47								
48								
49								
1950								
51								
52								
53								
54								
55								
56								
57								
58								
59	591							
1960	602							
61	-						2	9
62	-						-	-
63	410		160		250		10	1
64	564		228		336		13	1
65	504		168		336		21	1
66	600		200		400		22	1
67	440		164		276		21	-
68	465		159		306		22	1
69	445		-		-		23	-
1970	-		-		-		-	-

[1]NRT = Net Registered Tonnage in 000's of tons.

[2]Cargo in 000's of tons.

DOMINICA

	SHIPS ENTERING						CARGO[2]	
	TOTAL		STEAM		SAIL			
	No.	NRT[1]	No.	NRT[1]	No.	NRT[1]	IN	OUT
1946								
47								
48								
49								
1950								
51								
52								
53								
54								
55								
56								
57								
58								
59								
1960								
61	542	745	229	696	303	49	38	33
62	480	549	251	524	219	25	40	44
63	550	638	310	604	240	33	43	36
64	641	815	353	775	288	39	65	52
65	662	1,009	378	975	284	34	65	59
66	590	822	357	803	233	19	62	46
67	644	944	342	914	302	30	66	64
68	585	-	398	-	187	-	-	-
69								
1970								

[1]NRT = Net Registered Tonnage in 000's of tons.

[2]Cargo in 000's of tons.

ST. LUCIA

	SHIPS ENTERING						CARGO[2]	
	TOTAL		STEAM		SAIL			
	No.	NRT[1]	No.	NRT[1]	No.	NRT[1]	IN	OUT
1946								
47								
48								
49								
1950	717	501						
51	678	593						
52	669	469						
53	626	310						
54	846	501						
55	907	492						
56	1,042	618						
57	1,086	635	255	546	523	29	27	35
58	1,183	550	267	475	554	26	29	23
59	1,233	610	-	-	-	-	38	41
1960	1,262	702	552	-	-	-	42	38
61	1,477	813	-	-	-	-	58	53
62	1,446	852	-	-	-	-	68	56
63	1,496	821	340	739	426	23	63	59
64	1,629	872	354	784	424	22	79	66
65	1,696	1,000	-	-	-	-	81	89
66	1,714	1,081	409	980	419	22	95	79
67	1,725	1,176	437	1,086	369	16	95	58
68	2,064	1,051	458	938	537	13	76	74
69	2,178	1,626	578	1,508	357	10	110	83
1970	1,833	1,442	496	1,342	180	7	147	74

[1]NRT = Net Registered Tonnage in 000's of tons.
[2]Cargo in 000's of tons.

BARBADOS

	SHIPS ENTERING						CARGO[2]	
	TOTAL		STEAM		SAIL			
	No.	NRT[1]	No.	NRT[1]	No.	NRT[1]	IN	OUT
1946	861	823	311	794	550	29		
47	948	1,229	428	1,201	520	28		
48	963	1,096	439	1,068	524	28		
49	1,004	1,288	555	1,265	449	23		
1950	1,016	1,652	593	1,629	423	23		
51	968	1,784	596	1,764	372	20		
52	993	2,106	639	2,088	354	19		
53	994	2,074	650	2,057	344	18		
54	1,023	2,062	683	2,045	340	17		
55	1,028	2,269	757	2,254	271	14		
56	967	2,082	715	2,069	254	13		
57	1,033	2,027	787	2,014	246	12		
58	1,094	2,020	800	2,005	294	15		
59	1,277	2,200	945	2,189	332	14		
1960	1,287	2,371	1,011	2,359	276	12		
61	1,232	1,735	949	1,723	283	12		
62	1,486	2,646	1,233	2,635	253	11	197	
63	1,663	3,553	1,339	3,537	324	15	178	
64	1,790	3,595	1,423	3,578	367	17	197	22
65	1,600	3,570	1,400	3,568	200	12	195	23
66	1,652	3,675	1,385	3,660	267	15	234	29
67	1,797	3,049	1,519	3,033	278	16	246	27
68	1,863	3,008	1,696	3,000	167	8	253	25
69	993	1,423	861	1,418	132	5	276	27
1970	1,646	2,416	996	2,360	650	56	317	27

[1]NRT = Net Registered Tonnage in 000's of tons.

[2]Cargo in 000's of tons.

ST. VINCENT

	Ships Entering						Cargo[2]	
	Total		Steam		Sail			
	No.	NRT[1]	No.	NRT[1]	No.	NRT[1]	In	Out
1946								
47								
48								
49								
1950								
51								
52								
53								
54	427	713						
55	469	838						
56	510	913						
57	-	-						
58	684	767						
59	928	432	448	412	480	20	42	35
1960	700	541	450	440	387	11	46	33
61	721	564	503	556	324	13	45	29
62	669	624	494	615	319	14	37	32
63	523	560	382	554	341	13	41	37
64	590	626	360	616	399	16	49	37
65	643	756	386	745	327	14	45	40
66	612	698	381	690	340	10	54	37
67	648	612	408	602	273	17	55	40
68	712	563	365	546	347	17	47	45
69	622	574	286	556	336	18	56	44
1970	568	833	302	822	266	11	70	55

[1] NRT = Net Registered Tonnage in 000's of tons.

[2] Cargo in 000's of tons.

GRENADA

	SHIPS ENTERING						CARGO[2]	
	TOTAL		STEAM		SAIL			
	No.	NRT[1]	No.	NRT[1]	No.	NRT[1]	IN	OUT
1946								
47								
48								
49	581							
1950	892							
51	615							
52								
53								
54	806	557	398	533	408	14		
55	852							
56	573							
57	750							
58	973							
59	1,030	446						
1960	1,259	638	731	619	528	19		
61	1,164	949	710	933	454	15	57	17
62	1,157	902	660	885	497	17	55	19
63	1,082	815	603	797	479	17	53	22
64	812	837	521	825	291	11	59	20
65	1,082	991	566	971	516	20	63	30
66	1,081	1,156	654	1,139	427	16	72	25
67	1,204	1,109	605	1,091	599	19	74	31
68	1,331	1,173	778	1,154	553	21	79	35
69	1,289	1,253	846	1,238	443	15	91	28
1970	1,334	1,541	893	1,524	441	17		

[1] NRT = Net Registered Tonnage in 000's of tons.

[2] Cargo in 000's of tons.

TRINIDAD

	SHIPS ENTERING						CARGO[2]	
	TOTAL		STEAM		SAIL			
	No.	NRT[1]	No.	NRT[1]	No.	NRT[1]	IN	OUT
1946	2,383	8,266						
47	3,106	10,349						
48	3,158	10,236						
49	4,336	10,35[illegible]						
1950	4,297	10,756						
51	4,876	13,096	4,256		620			
52	5,109	15,283	4,461		648		7,023	6,665
53	4,940	13,486	4,150		790		6,234	7,234
54	4,895	13,568	4,239		656		6,677	8,077
55	5,020	13,930	4,151		869		7,051	8,451
56	5,448	15,382	4,273		1,175		7,817	9,296
57	5,652	16,499	4,429		1,223		7,648	9,233
58	5,880	17,405	4,731		1,149		7,532	10,378
59	6,545	21,515	4,860		1,685		9,095	11,474
1960	7,083	21,739	5,420		1,663		10,803	13,214
61	6,240	18,567	4,640		1,600		12,569	14,933
62	5,835	20,617	4,183		1,652		14,822	15,002
63	6,076	20,636	4,094		1,982		14,144	16,972
64	6,065	22,859	4,390		1,675		14,661	16,745
65	5,891	19,833	4,186		1,705		17,799	20,316
66	5,738	22,688	4,129		1,609		17,397	21,520
67	5,831	22,250	4,279		1,552		15,681	22,613
68	6,225	23,175	4,399		1,826		17,853	23,533
69	6,539	24,352	4,646		1,893		18,641	23,468
1970	6,334	25,427	4,361		1,973		-	-

[1] NRT = Net Registered Tonnage in 000's of tons.

[2] Cargo in 000's of tons.

GUYANA

	SHIPS ENTERING						CARGO[2]	
	TOTAL		STEAM		SAIL			
	No.	NRT[1]	No.	NRT[1]	No.	NRT[1]	IN	OUT
1946								
47								
48								
49								
1950								
51								
52								
53								
54								
55								
56								
57								
58	2,152	1,716						
59	2,152	1,836						
1960	2,393	2,445						
61	2,452	2,385						
62	2,518	2,743						
63	2,270	2,151						
64	2,114	2,395						
65	2,363	2,683						
66	2,425	2,987						
67	2,513	3,333						
68	2,633	3,851						
69								
1970								

[1]NRT = Net Registered Tonnage in 000's of tons.

[2]Cargo in 000's of tons.

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STATEMENT ON ORIGINALITY

This thesis makes the following contributions:

TO TRANSPORTATION GEOGRAPHY

1. A theoretical investigation of the influence of technical change in transportation on patterns of location.
2. Extends the maximum distance solution to the location set-covering problem to specify the order of sub-optimal choices and the structure of the transport networks which should accompany them.
3. Demonstrates how matrix approaches to transportation network analysis and Markov chains may be successfully combined to explore the long term effects of transport policies.

TO CARIBBEAN GEOGRAPHY

1. An integrated theory of interisland transportation which outlines the way in which transport change would influence the development of a regional economy.
2. An empirical investigation of the relationship between transportation and regional inequality between 1950 and 1970.