THESIS ABSTRACT

FACTORS INFLUENCING RAILWAY JOURNEYS IN JAMAICA M.A.

Darrell A. Norris Department of Geography

The objectives of this Thesis are to discover the ways in which passenger journeys by rail in Jamaica are made, and to define groups of railway users by the criteria of certain measurable attributes of their journeys. A railway journey is considered to include the necessary additional journeys to and from the station, and particular attention is paid to the cost, distance, and modes of travel of these integral parts of the journey. Data from 620 interviews conducted in the summer of 1969 are the basis of the analysis, which includes the use of correlation-regression techniques, of Chi Square analyses, and the application of Stepwise Multiple Discriminant Analysis. The presence in the interview sample of persons who make the same journey on occasion by road or rail forms the basis for a conclusion partially devoted to the nature of the competition between rail and road public transport in Jamaica.

FACTORS INFLUENCING RAILWAY JOURNEYS IN JAMAICA

by

Darrell A. Norris

A Thesis submitted to the Faculty of Graduate Studies and Research in partial fulfilment of the requirements for the degree of Master of Arts.

Department of Geography

McGill University

Montreal

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PREFACE

This thesis is the result of research conducted in Jamaica in the summer of 1969. The research problem is confined to passenger journeys on the Jamaica railway, the way in which they are made, and the definition of groups of railway users by the criteria of certain measurable attributes of their journeys. Particular attention is paid to the additional journeys to and from the station origin and destination, as integral parts of the railway journey. The analysis is based on the results of a sample of 620 railway passengers. Supplementary information concerning the interviewing procedure adopted, the role of freight traffic, and the disparity between the interview sample and a fuller sample of journeys taken from Jamaica Railway Corporation records, is presented in Appendices 8, 9 and 10. It is believed that this additional information serves to place the study in its proper context. No attempt is made to review the whole problem of transport services in Jamaica, a task undertaken by Lamarre Valois International, a Canadian firm of consultants, financed and assisted in their task by the Jamaican government.

Data relevant to the role of transport in the Jamaican economy are scarce, and a historical approach to this theme, such as that taken by Taaffe, Morrill and Gould (1963) for West Africa, would be difficult to adopt. Works by Anderson (1845) and Espeut (1887) reflect attitudes to the improvement of transport in nineteenth century Jamaica, while Maunder

(1954) has discussed in two papers both the development and significance of internal transport in the island.

The changing fortunes, and ownership, of the Jamaica railway have been reviewed by Bennett (1968). Fox (1937) and Bland (1937) discussed the malaise of the railway when the effects of road competition were first being felt. The operation of the system was transferred in 1960 from the Jamaica Government Railway to the Jamaica Railway Corporation. Since the decline of the banana trade, the railway has become increasingly dependant on the shipment of bauxite and alumina as a source of revenue. Passenger receipts, however, are still important, as is the availability of an inexpensive transport medium to the Jamaican population. It is the object of this thesis to discover the circumstances under which this medium is used.

ACKNOWLEDGEMENTS

In the preparation of this thesis, I have received much valuable assistance. My return air fare to Jamaica, and the ten weeks of research there, were financed by a generous grant from the Caribbean Project of the Department of Geography, McGill University. Professors Hills, Innes and Lundgren gave advice before and during the summer's fieldwork. Their familiarity with the Caribbean environment was often a source of gratitude. Thanks must also be extended to Mr. U. H. Salmon, the General Manager of the Jamaica Railway Corporation, to Mr. P. W. S. Choules, its Traffic Manager, and to the stationmasters and many others in the staff of the Corporation. Their many favours ranged from a free pass on the railway to unrestricted access to the Corporation's traffic records. Without their advice, information, and kindnesses, the research could not have been undertaken. Thanks must also go out to Mr. E. L. Stewart, Director of the Island Licensing Authority; to Mr. Jones and Mrs. Kadoo of the Rural Bus Association of Jamaica; to Mr. Levy, Principal Assistant Secretary to the Ministry of Public Utilities and Housing; to Mr. Clarke, Traffic Engineer to the Ministry of Communications and Works; and to Mr. P. Lefvert, of the United Nations, attached to the Town Planning Department, Kingston. I owe a debt of gratitude to John Stainfield, my graduate colleague in Jamaica, who shared the driving, the accomodations, the sun, and the occasional disappointments; and to Stanley Iton, Nadia Wakulin, and Gil Williams, also of the Caribbean Project in the summer of 1969. Thanks also to my Jamaican hosts; to Mrs. Lalor and Joyce in Kingston; to Mr. and Mrs. Parchment, of Whitehouse, in Westmoreland parish; to Professor B. Floyd, of the Department of Geography, the University of the West Indies, Mona, Kingston; and to the University itself. John Tibert, of the Department of Geography at McGill, rewrote the computer program which produced Figures 30 to 41, on a Calcomp plotter. Bryan Cook and Hardy Granberg, both of the same Department, also gave valuable advice during the period in which the interview data were processed by the computer. Finally, I offer my deepest thanks to Col. and Mrs. James B. Chubbuck of Altoona, Pennsylvania, where the thesis was completed, for their patience and encouragement, and to their daughter, Jeanne, my wife.

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CHAPTER ONE

PUBLIC TRANSPORT BY ROAD AND RAIL IN JAMAICA

The main line of the Jamaica railway, 113 miles in length, links Kingston with the second largest centre of the island, Montego Bay, serving en route Spanish Town, May Pen, upper Manchester and St. Elizabeth parishes and the western edge of the parish of St. James (Figure 1). A branch line from Spanish Town links Port Antonio by rail to Kingston, via the north coast, Annotto Bay and Bog Walk. Current passenger services exist on a second branch line which links Frankfield, in the upper Rio Minho valley, with May Pen on the main line.

There are 45 passenger stations over 205 route miles. Services provided on the main line include two diesel railcar passenger trains per day in each direction, and two 'mixed' (passengers and general goods) trains. A similar service is provided on the Port Antonio line, but the Frankfield branch is served by mixed trains only. About 25 per cent of total receipts are from passenger services. The traffic in bauxite and alumina constitutes the railway's main source of revenue. The reader is referred to Appendix 9 (page 136 below) for a brief discussion of freight traffic on the railway.

In recent years the number of passengers carried on the system has fluctuated around one million per annum, with a low of 801,074 journeys made by rail in 1962.

The system is single track throughout most of its length, with train passing points at stations. The journey between Kingston and Montego Bay by diesel railcar lasts 4 hours 30 minutes, at an average speed of 25 miles per hour. Mixed trains are slower, and, owing to their dual role as goods trains, do not always arrive or depart at scheduled times.

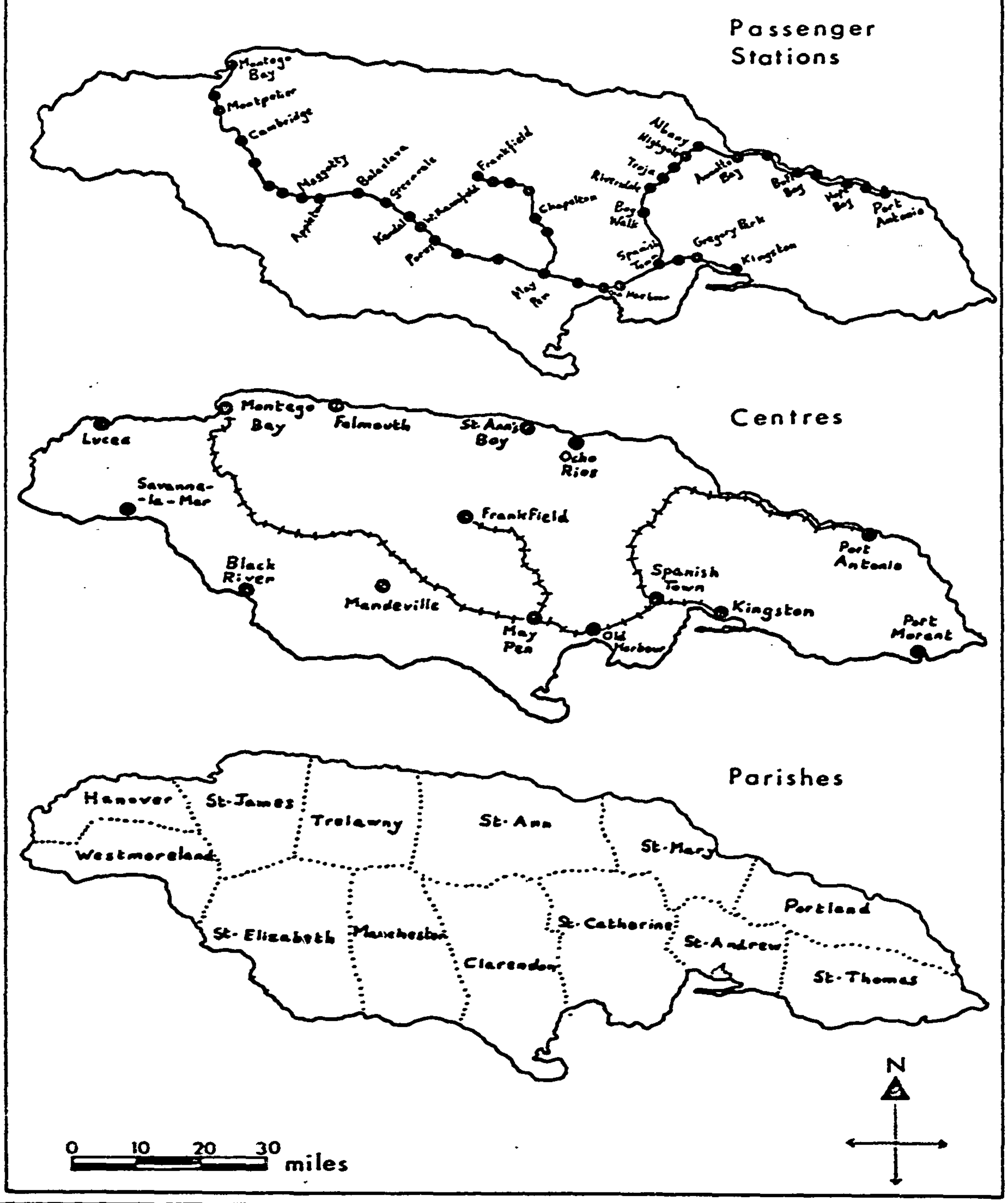
The time taken to travel by rail between Kingston and Montego Bay compares favourably with comparable road times. By car, average speeds beyond 30 miles per hour are difficult, if not impossible, to maintain. The fastest bus services between the two points, via the north coast, require five hours for the trip, and other routes between Kingston and Montego Bay are taken by services between two and six hours greater in duration.

Rail passenger rates in Jamaica are inexpensive. With the exception of some market truck services, rail travel is cheaper per mile than any other form of mechanical transport.

Although Jamaica is a densely settled island, Kingston, with 376,520 persons and 23.4 per cent of the total population in 1960, is the only large urban centre. Kingston is more than 16 times larger than Montego Bay. Rural population in Jamaica is both dense and dispersed, especially in those areas through which the railway passes. The most recent survey of Jamaican service centres and population distribution is that by Lefvert (1968).

Island transport services reflect this population

FIG. 1


Passenger Stations
Montego Bay
Montpelier
Cambridge
Maggotty
Appleton
Balaclava
Greenvale
Kendal
Williamsfield
Porus
Frankfield
Chapelton
May Pen
Old Harbour
Spanish Town
Gregory Park
Kingston
Bog Walk
Riversdale
Troja
Highgate
Albany
Annotto Bay
Buff Bay
Hope Bay
Port Antonio
Centres
Lucea
Montego Bay
Falmouth
St. Ann's Bay
Ocho Rios
Savanna-la-Mar
Frankfield
Black River
Mandeville
May Pen
Old Harbour
Spanish Town
Kingston
Port Antonio
Port Morant
Parishes
Hanover
St. James
Trelawny
St. Ann
St. Mary
Westmoreland
Portland
St. Elizabeth
Manchester
Clarendon
St. Catherine
St. Andrew
St. Thomas
N
0
10
20
30
miles

distribution. In Kingston the Jamaican Omnibus Services buses provide frequent services between the central area and the suburbs. Fares of 4, 7, 10, or 13 pence average abcut 1.5 pence per mile [1]. Kingston is also the focus of the network of rural bus services, though other, generally more circuitous, services terminate in Montego Bay, Mandeville, May Pen, and the smaller market towns of the island. In May, 1969, 364 vehicles were currently authorised as stage carriers by the Island Licensing Authority.

An unknown number of vehicles licensed as contract carriers (i.e. the vehicle, and not the privilege to travel thereon, must be hired) or carriers of goods operate illegally on fixed routes, charging a fare per person per distance travelled. Taxis are numerous in Kingston, but in rural areas their function is taken over by private cars, the request for payment by the owner taking the form "Give me what you can afford". In general, the relative importance of unlicensed passenger vehicles rises with the remoteness of the area in which they operate. Minibuses, seating 12 persons, called 'pirates' in Jamaica, charge more than the statutory limit of

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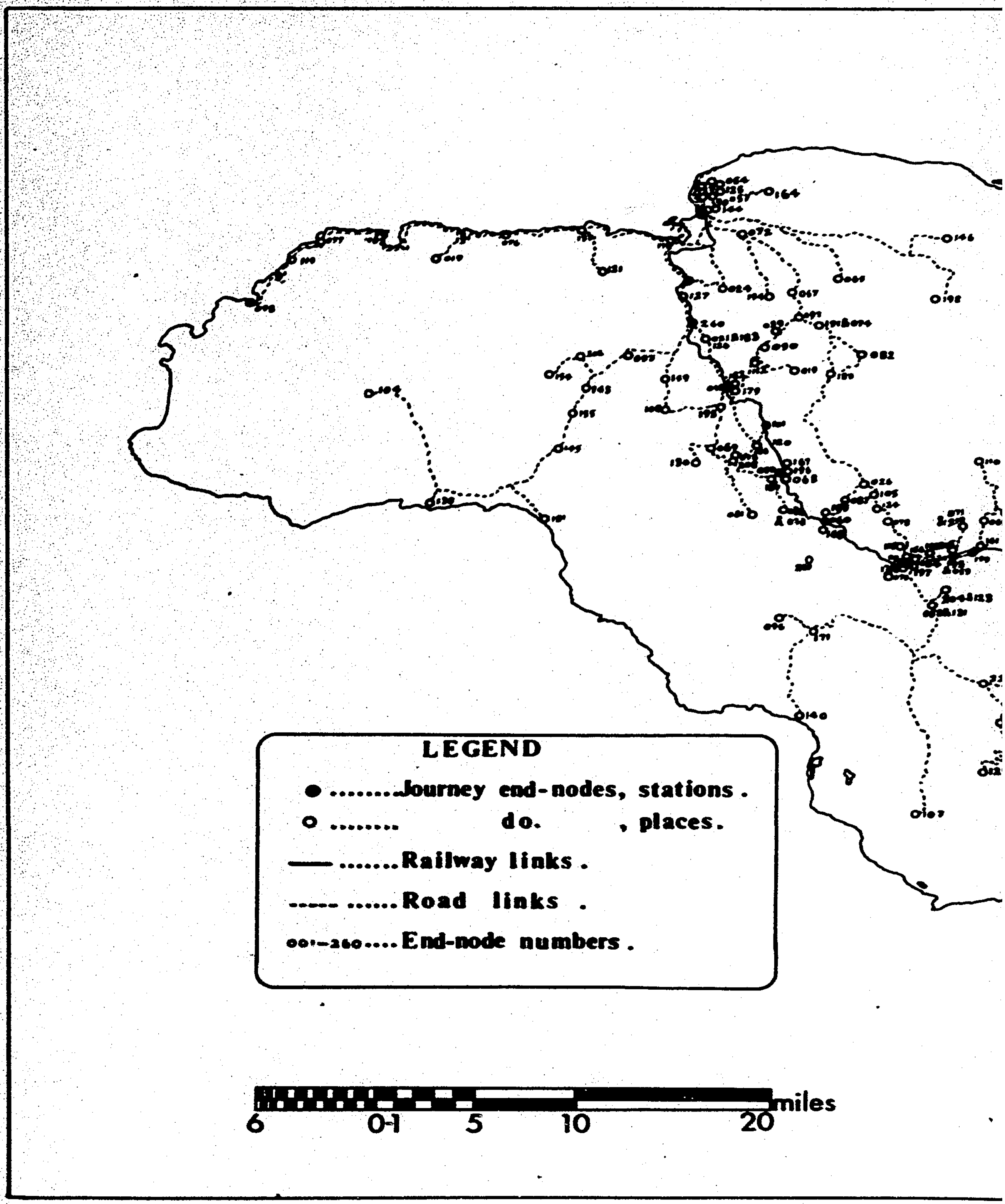
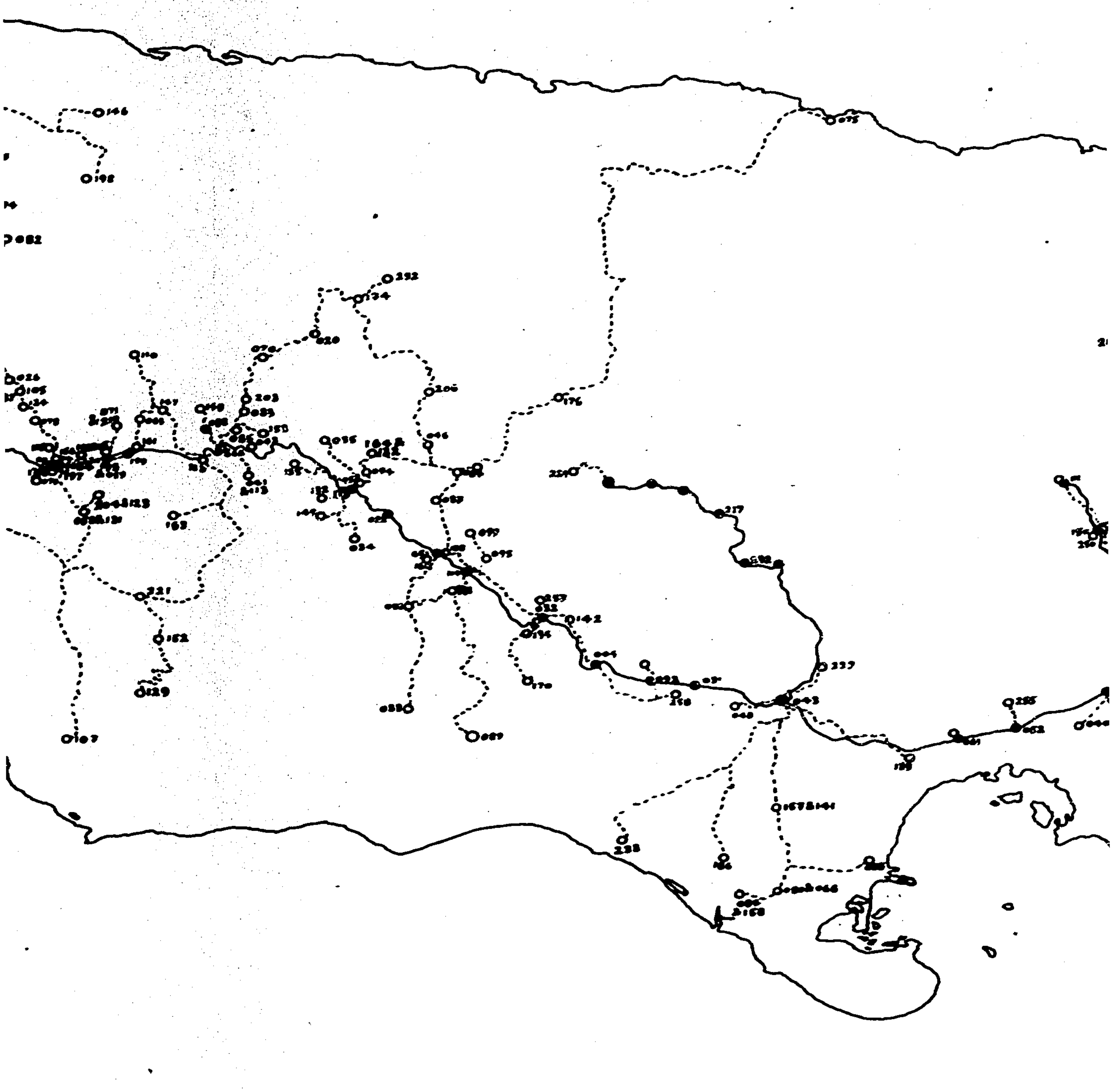
1. In the period June-August 1969, when the data for this study were collected, decimalisation had not been effected in Jamaica. Prices are cited throughout in old pence. Since September 1969, 1.2 old pence = 1 cent, 12 old pence = 1 shilling = 10 cents, 10 shillings = 1 dollar = 100 cents. Prices must be multiplied by 0.832 for the conversion of old pence to new cents.

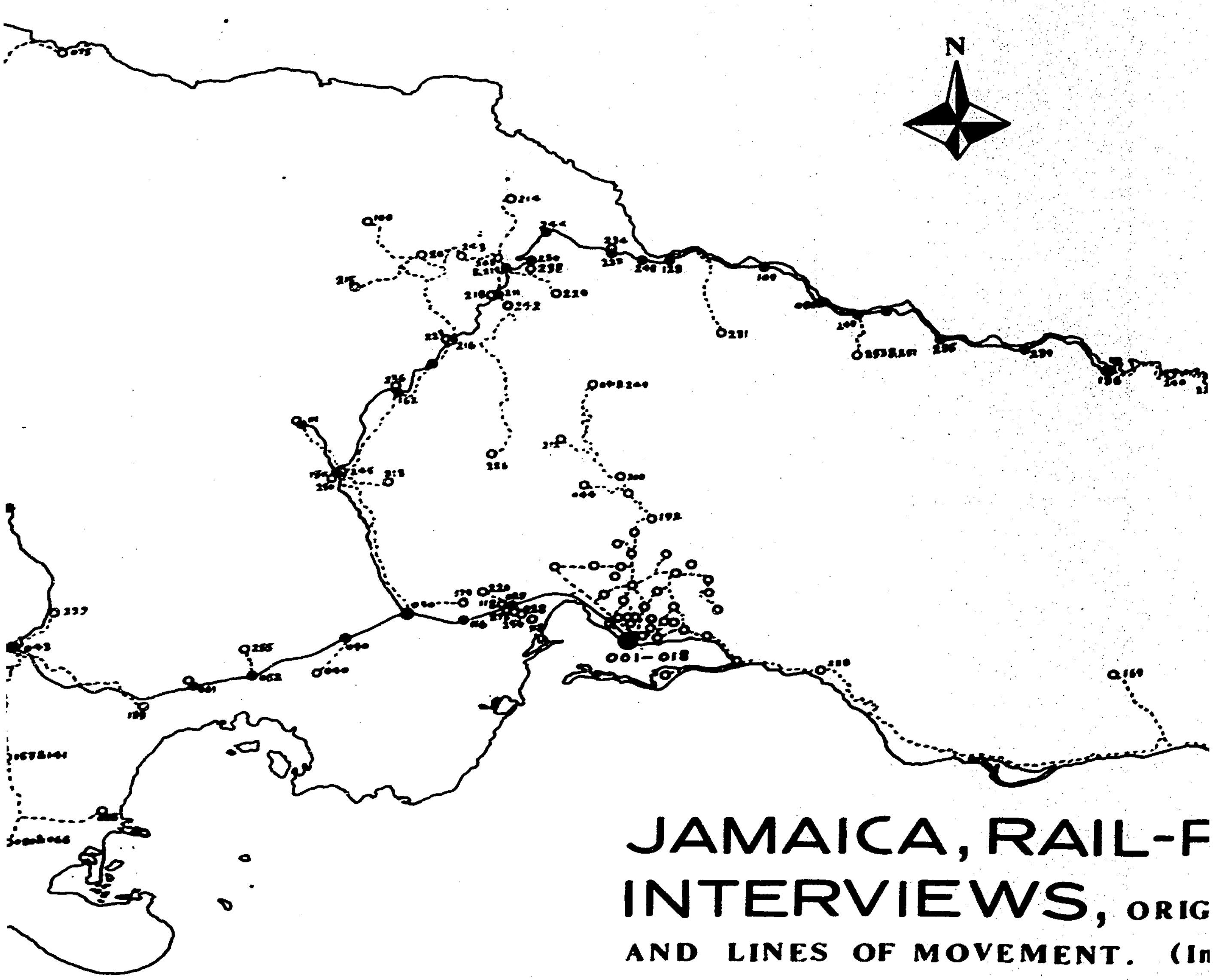
twopence per mile for legally operated buses, but penetrate the most remote populated areas of the island. Fares on market trucks are cheaper. The one-way journey by truck to Kingston from the region south of Lucea, a road distance of 160 miles, costs about 150 pence, with a surcharge proportionate to the weight of goods carried. Prices are variable, as in each district there is a tendency to charge as much as the traffic will bear.

The real cost of a rail journey must include the expense of travel to and from the station by road. For many potential rail journeys, this extra cost and distance may be an important factor in the choice between the road or rail journey between two points in Jamaica. The fact merely of the railway's favourable cost rate and average speed over a given distance, therefore, gives an illusory picture of the real nature of the competition between road and rail passenger services in Jamaica.

The study begins with a description of the interview sample intended to represent the range of journeys made on the railway. In Chapter Three the distributions of several journey variables are discussed. Relationships between certain variables are suggested through the use of correlation-regression analysis in the next chapter, while in Chapter Five an attempt is made to distinguish grouped cases in the sample by independent measurable journey attributes, and to show the possible relationship between certain group classifications by the use of Chi Square analysis. The usefulness of such classifications is tested by Discriminant Analysis in Chapter Six. Critical comments, and a general conclusion, follow in the final chapter.

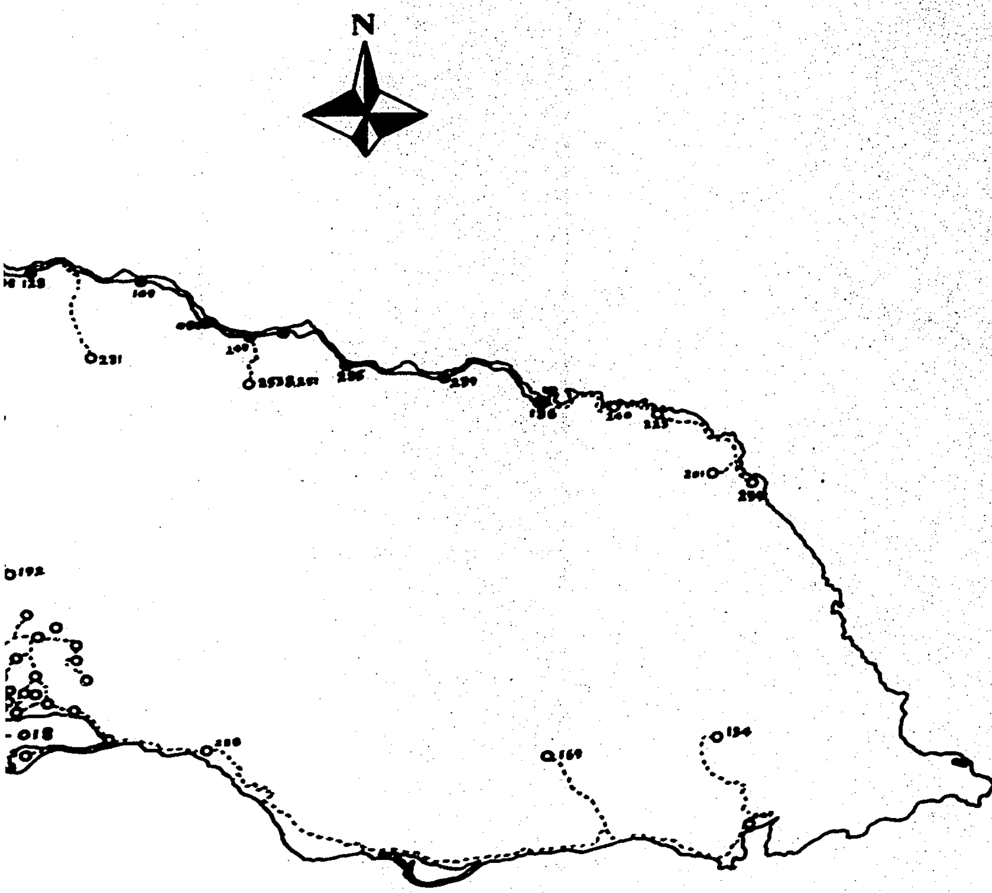

LEGEND
● ....Journey end-nodes, stations .
o .... do. , places.
........Railway links .
........Road links .
001–260.....End-node numbers .
6
0-1
5
10
20
miles





JAMAICA, RAIL-F
INTERVIEWS, ORIG
AND LINES OF MOVEMENT. (In

FIG. 2



JAMAICA, RAIL-PASSENGER NTERVIEWS, ORIGINS, DESTINATIONS, ND LINES OF MOVEMENT. (Interview Sample – 620)

CHAPTER TWO

THE INTERVIEW SAMPLE

Since the information required for the study was available neither as Railway Corporation records nor as Jamaica Government statistics, a questionaire was prepared and interviews were made on the railway system during the available period of research in Jamaica. During the thirteen days actually spent in interviewing passengers, a total of 620 interviews were gathered on eighteen trains. The sample represents about 1.5 per cent of the passengers travelling on the system on the days covered. Most interviews were conducted on trains, with only a small proportion of the 620 being drawn from railway stations.

The decision to conduct the interviews on trains was made for a number of reasons. While an objective of the sample was to collect data which would truly reflect the range of journeys on the system, the relative proportion of journeys emanating from and terminating at each station was not a factor which the writer intended to isolate in the analysis, could not be adequately represented by the sample size taken, and was in any case available in the form of Railway Corporation records. Also, interviewing exclusively on station platforms would have been inefficient. On most station platforms, on most days, and for the majority of the trains, fewer respondents were available than could have been questioned on the train in an equivalent period of time. Moreover, the time wasted in getting to and from the stations would have greatly exceeded the time spent in interviewing. Finally, bias could have been introduced into the sample by interviewing all those persons arriving well before a train's departure, and few, if any, of the latecomers. If the time of arrival at the station is related to the distance travelled to the station, or to the mode of transport employed in getting there, as seems likely, then two important variables in the study could have been irretrievably biased.

The interview response rate on trains was very high. Of 641 persons questioned, only 21, just over three per cent, refused to give information. In part the high response rate must be attributed to the Jamaican's traditional love of conversation and lack of inhibition with strangers. The interview circumstances on the train were also particularly favourable, since the interview involved no real sacrifice of time for the respondents and was indeed something to engage their interest during their journey. Once a small number of persons had been questioned in a railway carriage, the doubts of the remaining occupants about the procedure were overcome [1]. An informal atmosphere was gained at the expense

1. This was especially true if one of the first persons inter--viewed was considered by the other passengers to be capable of judging the good intentions, or otherwise, of the interviewer. Into this category fell ministers,market-women,public officials, businessmen, and adherents to the black power movement.

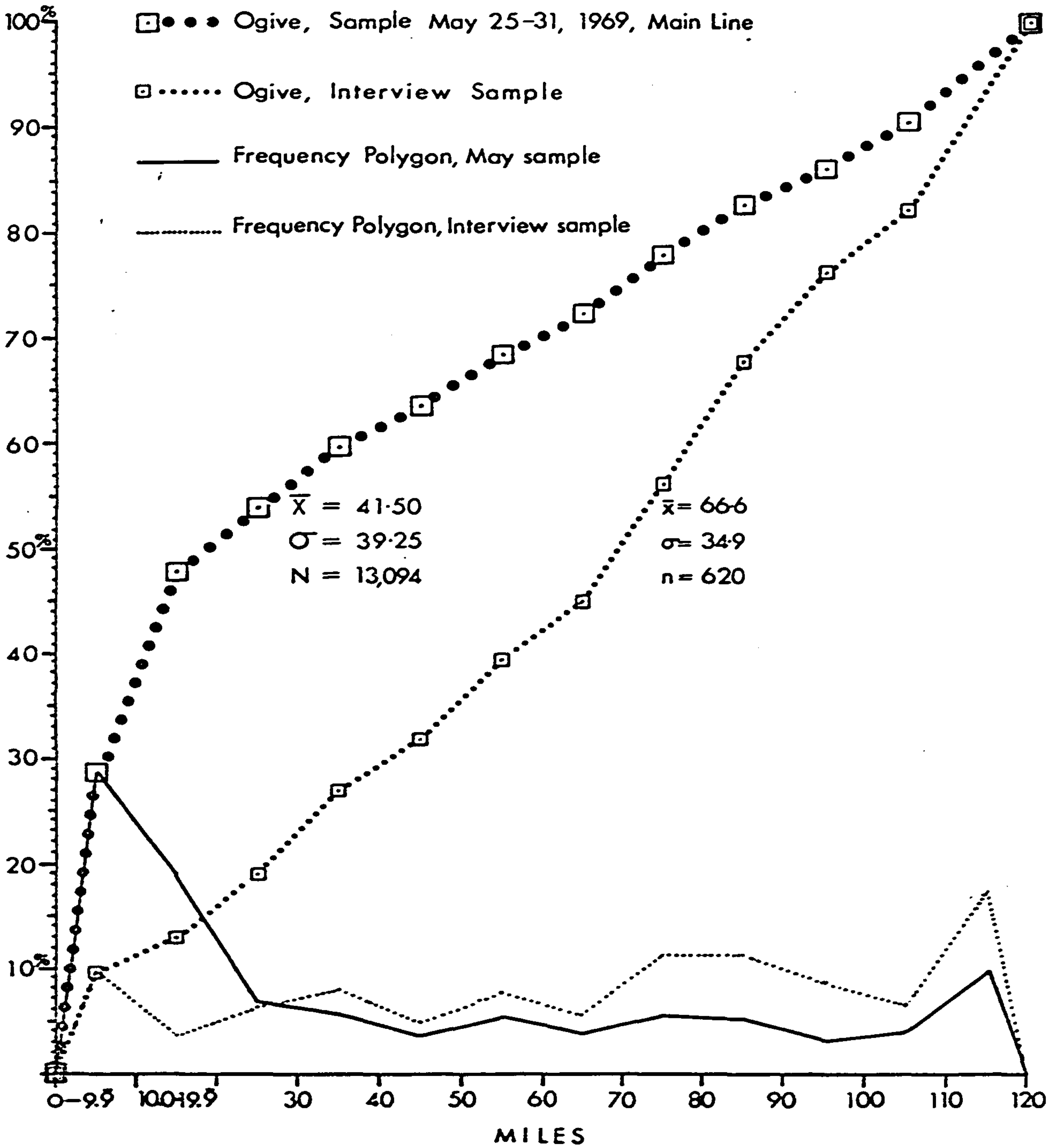
of the time spent on the interview. The reader is referred to Appendix 8 (page 131 below) for a fuller description of the field interviewing technique.

The objective was a random sample. If this objective was attained, a sample of 620 cases from a population of 36,000 exceeds the required number at the .01 significance level and falls slightly short of being representative of an infinite population.

The interviewing procedure adopted was to move repeatedly from one end of the train to the other, stopping at every vacant seat adjacent to a passenger or group of passengers not yet interviewed. Two problems arose using this method. Overcrowded trains limited movement and the writer's ability to record information. Persons making long-distance rail journeys were more likely to be interviewed than persons travelling a short distance who would spend less time on the train. In Figure 3, the frequency polygon of rail journey distance for the interview sample may be compared with that of all main line rail journey distances for the last week of May 1969. The interview sample clearly failed to reflect the large proportion of rail journeys, 47.4 per cent, less than 20 miles in length. Cumulative percentage frequency distributions, ogives, also summarise the disparity between the two samples in Figure 3, and the means and standard deviations of the two distributions are given.

Figure 2, the map of all origins, destinations and routes which occurred in the interview sample, is therefore more likely to reflect the hinterland of the railway

FIG. 3 FREQUENCY DISTRIBUTIONS, RAIL JOURNEY DISTANCE

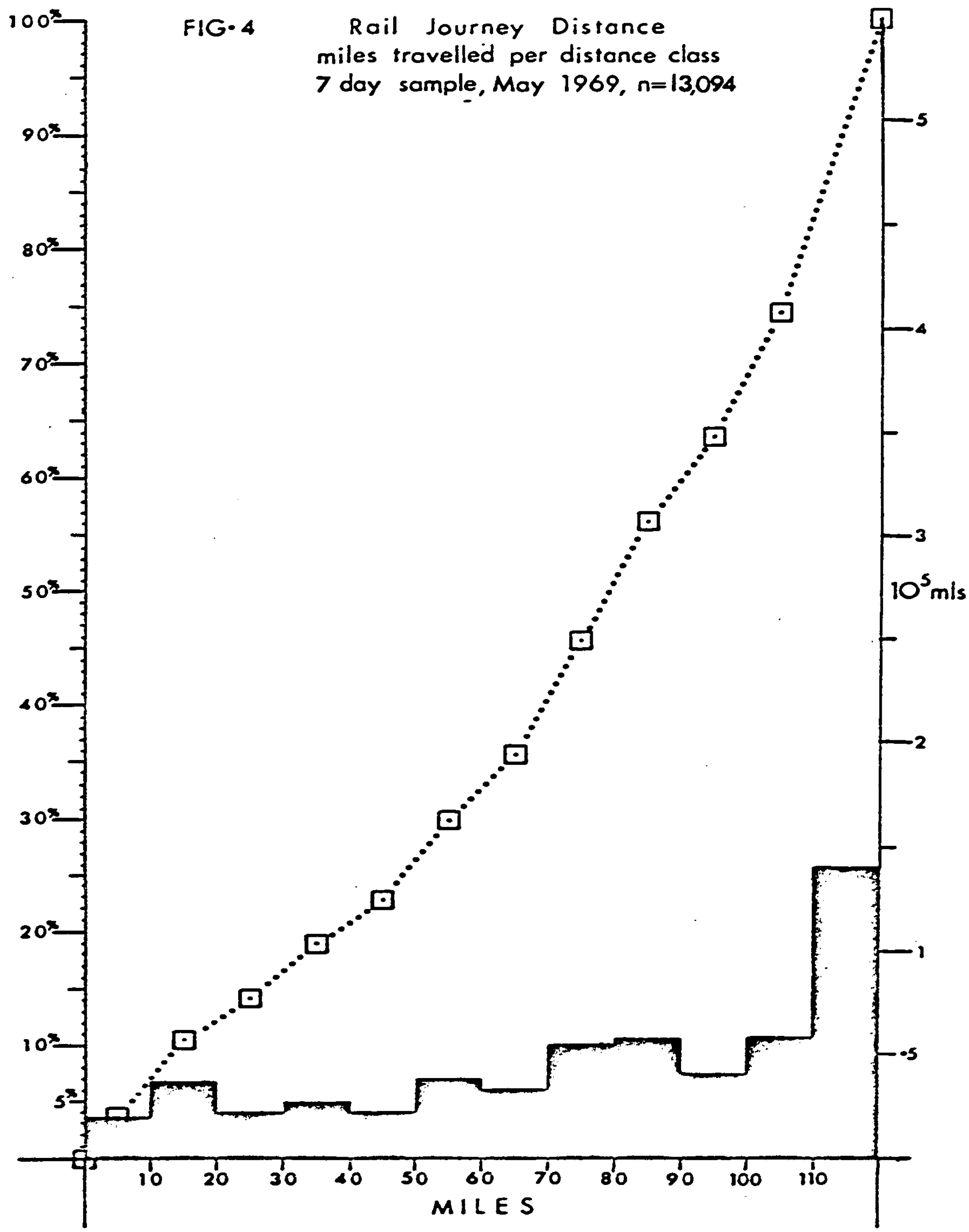


for journeys made over medium and long distances, and less likely to adequately reflect the dense cluster of journey end nodes within close proximity to the station for short distance journeys.

It is noteworthy that 57.4 per cent of all journeys less than ten miles in length, for the week's sample in May 1969, are between Kingston and Gregory Park (the first station west of Kingston), while journeys between Kingston and Spanish Town account for 35 per cent of all journeys between 10.0 and 19.9 miles in length. To some extent, then, the journeys missing from the sample are suburban in character.

By multiplying the number of cases in each class by the class mean of distance travelled, an approximation of the number of miles travelled in each class during the sample week is obtained (Figure 4). This may be interpreted further as approximating to the total time spent by persons in each distance class on the system. The similarity between Figure 4 and the interview sample distribution in Figure3 suggests that the time spent in conducting each interview (about 15 minutes) and the probability of a passenger being interviewed measured by the time spent on the train, were important determinants of the composition of the interview sample.

It must be conceded, then, from the outset of this study, that its conclusions will in no way be valid for all journeys made on the railway system. The prime objective of

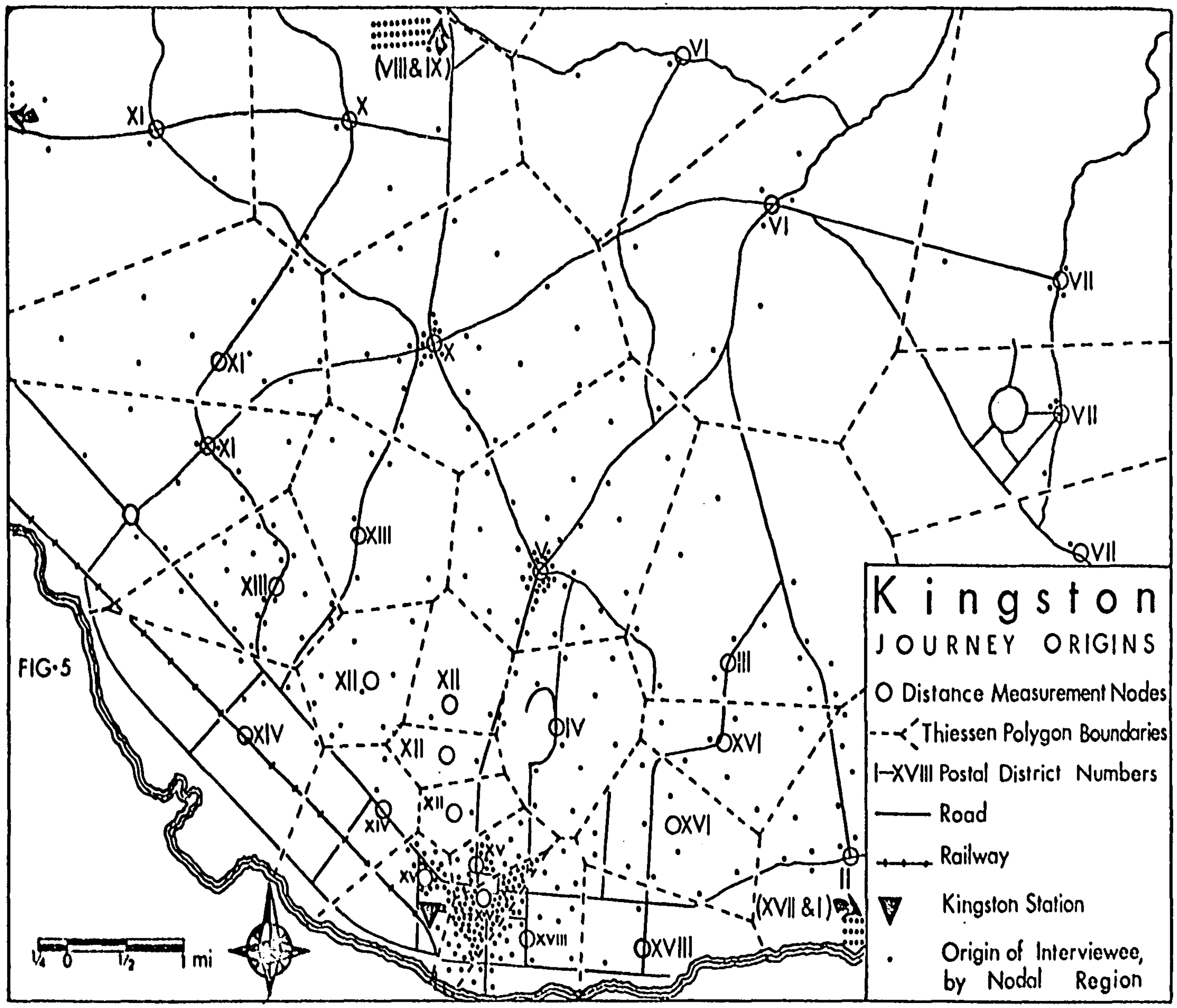

FIG• 4
Rail Journey Distance
miles travelled per distance class
7 day sample, May 1969, n=13,094
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
5%
10
20
30
40
50
60
70
80
90
100
110
MILES
5
4
3
2
1
·5
10^5mls

the study, however, is to demonstrate the relationships within and between journey parameters and the attributes of the individuals making the sampled journeys. Since the added journey to and from the station is an important variable under consideration, the criticisms made above of station as against on-train interviews still hold.

On the field interview sheets were recorded the following items of information describing each person and his or her journey. Sex, day travelled, train ticket class and estimated age group were entered at the start of each inter--view. The respondent was then asked his station origin and destination. From this information, and the train ticket class, could be calculated later the distance and cost of the rail journey. Entries were then made for the respondent's ultimate origin and destination. For rural areas, the replies varied between the name of a district and the name of a village or postal agency within a district. Origins and destinations within Kingston could be narrowed down to 1 of 18 postal districts, and usually to neighbourhoods within districts. When the places specified had been located on Jamaican 1-50,000 maps, or on the Rand McNally map of Kingston, the road distance travelled to and from the station was measured, to the nearest tenth of one mile. These places are mapped in Figure 2, and listed by place number in Appendix 1. Where no evidence other than the district of origin was available, the population centre of gravity of the district was taken to be the point of origin or destination. In Kingston, distance measurement nodes were substituted for centroids (Figure 5). These nodes corresponded to centres of activity or movement within postal districts, and were on J. O. S. bus routes. Thiessen, or mid-point, polygons were described about these nodes, and, unless other information was available concerning the origin or destination of a passenger within a nodal region, he was assigned the distance of the measurement node from Kingston station.

For each passenger, the mode of transport used travelling to and from the station was recorded. The respondent was then asked how much the journey to the station had cost, and how much the journey from the station would cost, to the nearest penny if possible. For journeys by foot or private car a constant unit rate per mile was applied. Foot journeys were charged at one penny per mile or part thereof, and private car journeys were charged at sixpence per mile (the charge being divided equally between the occupants of the car on the same journey). The rationale behind the derivation of these rates may be found in Appendix 2.

The respondent was then asked the purpose of the journey. In the first hundred interviews, the choice of reply was completely open. On the basis of these replies were developed the following classes; Personal, Business, Leisure, Shopping, Work, and Market-selling.The first class was felt to be amorphous and unsatisfactory, but practical difficulties


FIG·5
Kingston
JOURNEY ORIGINS
O Distance Measurement Nodes
Thiessen Polygon Boundaries
I–XVIII Postal District Numbers
Road
Railway
Kingston Station
Origin of Interviewee, by Nodal Region
¼ 0 ½ 1 mi
(VIII & IX)
(XVII & I)

inhibited a fuller breakdown. Personal journeys included not only persons visiting relatives, but also social visits to friends (which could also be construed as leisure journeys), and persons visiting a concubine or common-law spouse elsewhere in the island. Business journeys also covered a wide spectrum, which in practice overlapped with personal and shopping journeys.

A similar course of action was adopted with journey frequency. The first hundred interviews indicated that replies of "daily", "once a week", or "once a month" were made with confidence. Multiples of a week or a month were tentative responses, and estimates of frequencies less than once a month were most unreliable."Twice a year", "once a year", and "less than once a year" were the most common replies for low frequency journeys. The following frequency classes were therefore chosen; Rare ($<$ once in 6 months), Irregular ($\geqslant$ once in 6 months and $<$ once a month), Monthly, $<$ once a week and $>$ than once a month, Weekly, $<$ once a day and $>$ once a week, and Daily ($\geqslant 5$ times a week).

Finally, the respondent was asked whether the same journey had ever been made by road rather than by rail, and if so, by what mode of transport and at what cost. The road distance was later measured between the ultimate origin and destination, and entered as the distance of the 'alternative whole journey'.

The problem of incomplete interviews did not arise, as the information requested of the respondents was in the main no more than the information they needed themselves in order to complete their journey. Nonetheless, the writer met considerable difficulty in locating places of origin and destination from Jamaican patois responses, which were recorded phonetically during the interview if the respondent was unable to spell, as was often the case.

The above journey variables, singly or in ratio or additive combinations, constitute the raw data for analysis.

Kish (1959, page 335) has pointed out the advantages to be gained from a large number of sampling units. Some measure of the variability of the observed effects may be obtained, since the probability of the occurrence of extreme cases rises with the size of the sample. Mere size, however, does not guarantee randomness, and we have seen above that the interview sample is not representative with regard to the distribution of rail journey distance. Had the interview sample satisfied this criterion of being representative, it is likely that other, unknown, criteria would have been violated. As McGinnis (1958) points out "It is not true that one can uncover 'general' relationships by examining some arbitrarily selected population...There is no such thing as a completely general relationship which is independent of population, time and space" (McGinnis, 1958, page 412).

We have not discussed the possibility of bias being introduced by the interviewer. Such bias is likely to be more marked when value judgements, rather than statements of fact, are requested of the respondent. The writer does not agree with Henriques' (1953, page 53) pessimistic view of the European investigator's chances of success in Jamaican society:

> ...because of the very nature of the material, and because of the colour conscious personality of the individual involved, the European investigator is at a great disadvantage in gathering data. The acute colour consciousness of the West Indian inhibits him from giving information to someone who represents the values he himself is lacking but trying to attain. Some information will be forthcoming, but much of it will be garbled and dressed to suit what the informant thinks are the ideas of the white investigator.

Probably because of the relatively impersonal nature of the questions asked, the writer did not meet the problem cited by Henriques, with the exception of the occasional respondent who would exaggerate the cost of his journey. When, however, such respondents were confronted with the impossibility of the estimates they had given, the 'true' value would come to light amid mutual amusement. Distance perception was not a theme of the study, and the map was considered a better judge than the Jamaican of the distance travelled on the journey.

Feldman, Hyman and Hart (1951) offer evidence of interviewers' bias in a Denver community study conducted in 1949. Without means of comparison, interviewer bias in this study must remain a matter for conjecture only.

Analysis, then, proceeds on the basis of 620 interviews which are known not to be a random sample in the sense that each passenger had an equal chance of being interviewed, but may represent the contribution of rail journeys of varying distance to the total journey mileage travelled on the system during a given time period. Some additional comments and data concerning the discrepancies between the interview sample and the actual pattern of journeys may be found in Appendix 10 (page 142 below). The classification of journey attributes, and the accuracy of the distance and cost measurements, are also open to criticism, but represent the limit that could be achieved in the context of the study. The possibilities of bias introduced by the interviewed or the interviewer cannot be excluded. Conclusions drawn from the following analysis, therefore, must be weighed against the critical comments above.

CHAPTER THREE

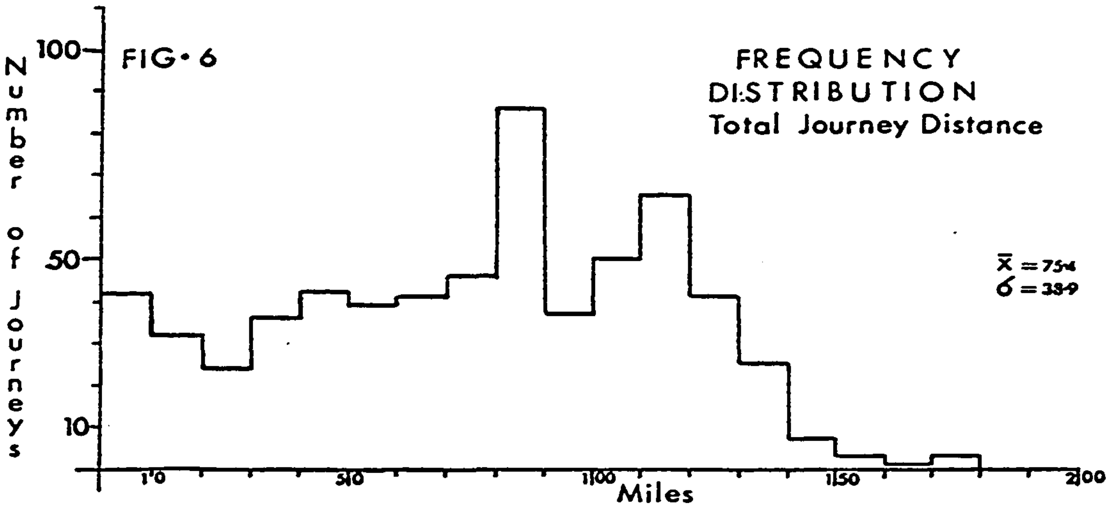
PRELIMINARY ANALYSIS

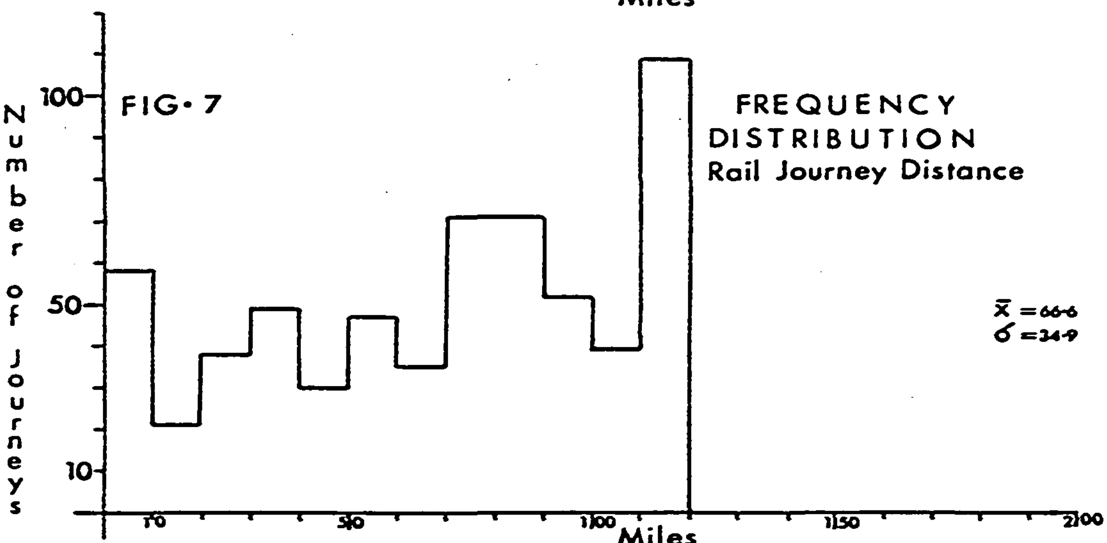
At this point in the study it is appropriate to examine the frequency distributions and univariate statistics of the journey variables. The transformations made necessary to satisfy the conditional criterion of normality in further analysis will also be noted.

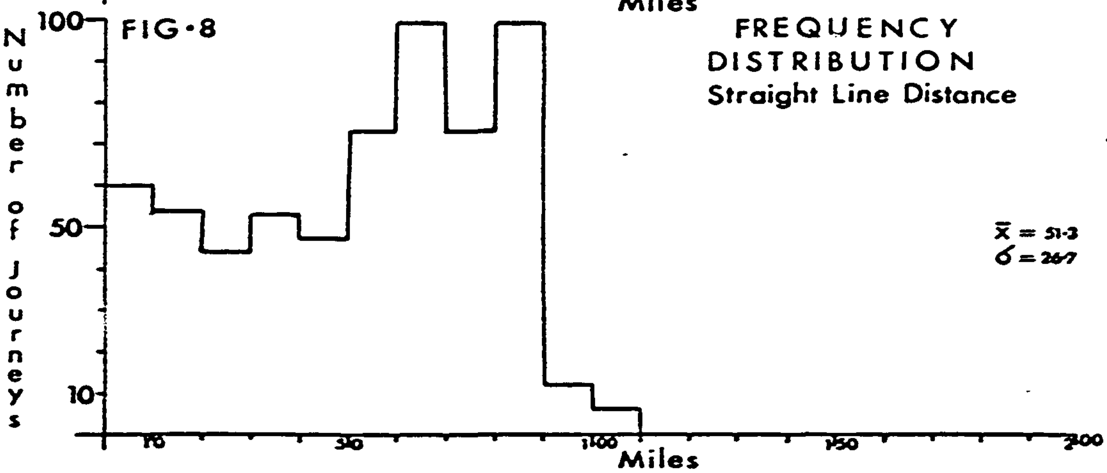
Figures 6, 7, and 8, on page 21, summarise the differences between the three variables Total Journey Distance, Rail Journey Distance, and the Straight Line Distance between the ultimate origin and destination.

In the terms of this study, 113 miles is the maximum value that rail journey distance can take. Changing trains is deemed to be a break in the journey. For example, a rail journey on the Port Antonio line is considered to be part of the added journey if it follows or is followed by a journey on the main line towards Montego Bay. Given the discussion of this variable in the preceding chapter, little significance should be attached to the mean value of 66.6 miles beyond direct comparison with the means of Straight Line and Total Journey distance, respectively 51.3 and 75.4 miles.

The variable Straight Line Distance cannot exceed a value of 145 miles in Jamaica, the distance between Morant Point in the east and South Negril Point in the west. The straight line distance between Kingston and Montego Bay, 80


FIG· 6
FREQUENCY DISTRIBUTION
Total Journey Distance
Number of Journeys
100
50
10
10
50
100
150
200
Miles
x̄ = 75.4
σ = 38.9


FIG· 7
FREQUENCY DISTRIBUTION
Rail Journey Distance
Number of Journeys
100
50
10
10
50
100
150
200
Miles
x̄ = 66.6
σ = 34.9


FIG·8
FREQUENCY DISTRIBUTION
Straight Line Distance
Number of Journeys
100
50
10
10
50
100
150
200
Miles
x̄ = 51.3
σ = 26.7

miles, is reflected in the histogram in Figure 8, for few journeys in the sample exceed this value.

There is, however, no fixed upper limit to the values which the variable Total Journey Distance can take. In this study we define a journey as ending when the activity of travelling is replaced by some other activity which is not itself part of the journey. Return journeys, therefore are outside the scope of this study (despite the fact that market passengers in the study are charged a rail journey cost equal to half the price of their market return ticket). The shape of the histogram in Figure 6, therefore, is in part a reflection of our empirical definition of a journey. The tailing of the distribution in Figure 6 beyond 113 miles reflects not only the lower probability of longer journeys occurring, but also the decision mechanism which rejects the railway as a mode of travel when the effort and distance involved in getting to and from the station become excessive.

Despite the high values of the standard deviations of the distributions in Figures 6, 7, and 8, and the low coefficients of Symmetry and Kurtosis (Table 3-1, variables 8, 1, and 7 respectively), no transformation in the computer program Normstand [1] could render any improvement in normality

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1. For a brief description of this program, see Appendix 4.

TABLE 3–1

SYMMETRY AND KURTOSIS OF SIXTEEN VARIABLES BEFORE AND AFTER TRANSFORMATION FOR BOTH WHOLE AND A.W.J. AFFIRMATIVE SAMPLES

Indices of Symmetry and Kurtosis are zero when data is Normally Distributed

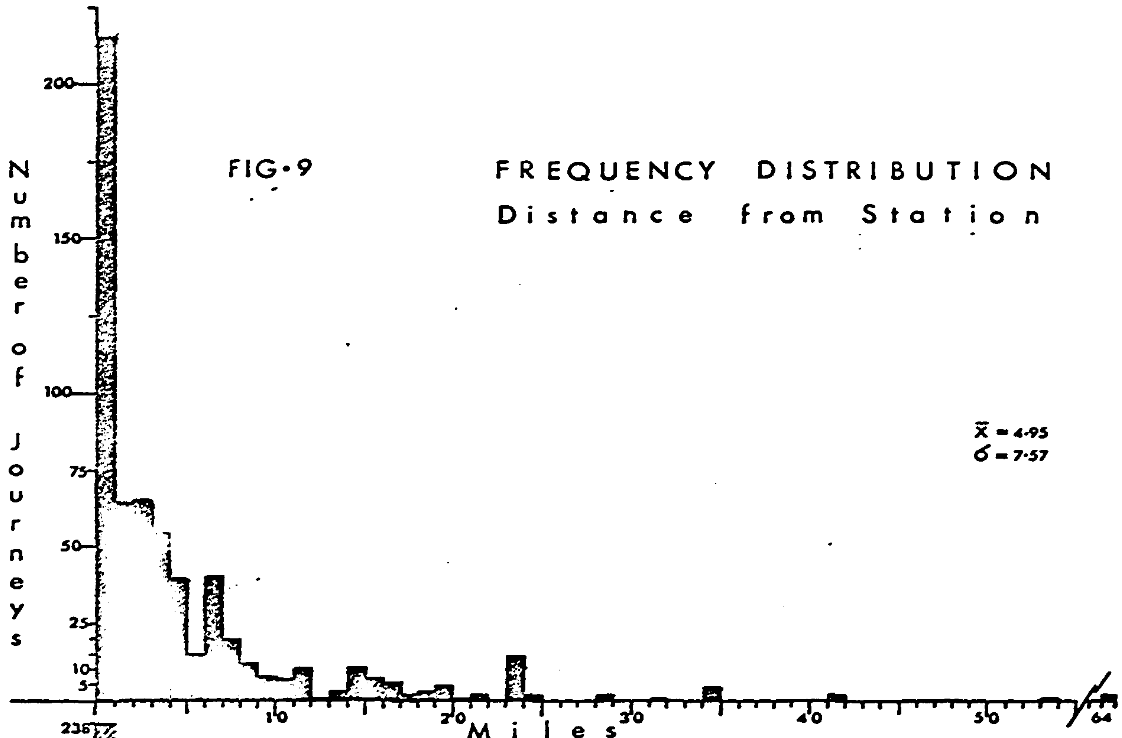
Variable	Whole Sample n = 620					A.W.J. Affirmative n = 227				
	Ordinary		Trnfmn Selected	Transformed		Ordinary		Trnfmn Selected	Transformed	
	Symm	Kurt		Symm	Kurt	Symm	Kurt		Symm	Kurt
1	−2·67	−5·79	—	—	—	0·04	−4·46	—	—	—
2	46·67	126·12	LOG	3·00	−2·60	23·82	60·51	LOG	0·78	−2·45
3	35·12	87·37	LOG	−0·25	−5·35	13·41	15·03	LOG	0·32	−3·70
4	2·37	−4·68	—	—	—	1·75	−3·85	—	—	—
5	60·78	241·53	LOG	6·16	−2·99	18·83	36·13	LOG	2·21	−2·90
6	79·68	456·03	LOG	0·99	−6·70	51·89	290·92	LOG	1·45	−4·19
7	−2·77	−5·70	—	—	—	0·07	−4·42	—	—	—
8	−1·38	−4·40	—	—	—	0·67	−3·84	—	—	—
9	23·59	62·21	$\sqrt[3]{\ }$	−1·42	1·80	9·04	17·89	$\sqrt{\ }$	0·83	−0·99
10	30·08	42·05	LOG	−2·20	−0·32	13·70	11·51	LOG	−1·12	0·05
11	57·59	265·99	LOG	26·43	54·66	19·36	48·38	LOG	10·59	15·76
12	68·17	327·97	LOG	15·80	31·85	32·61	139·33	LOG	8·67	15·43
13	20·99	28·49	LOG	−4·17	0·63	9·49	9·29	$\sqrt[3]{\ }$	0·81	−0·57
14	27·63	106·47	$\sqrt[3]{\ }$	1·01	−0·59	5·84	1·49	$\sqrt{\ }$	1·23	−1·64
15	—	—	—	—	—	0·67	−4·24	—	—	—
16	—	—	—	—	—	7·04	0·38	$\sqrt[3]{\ }$	1·69	−2·92

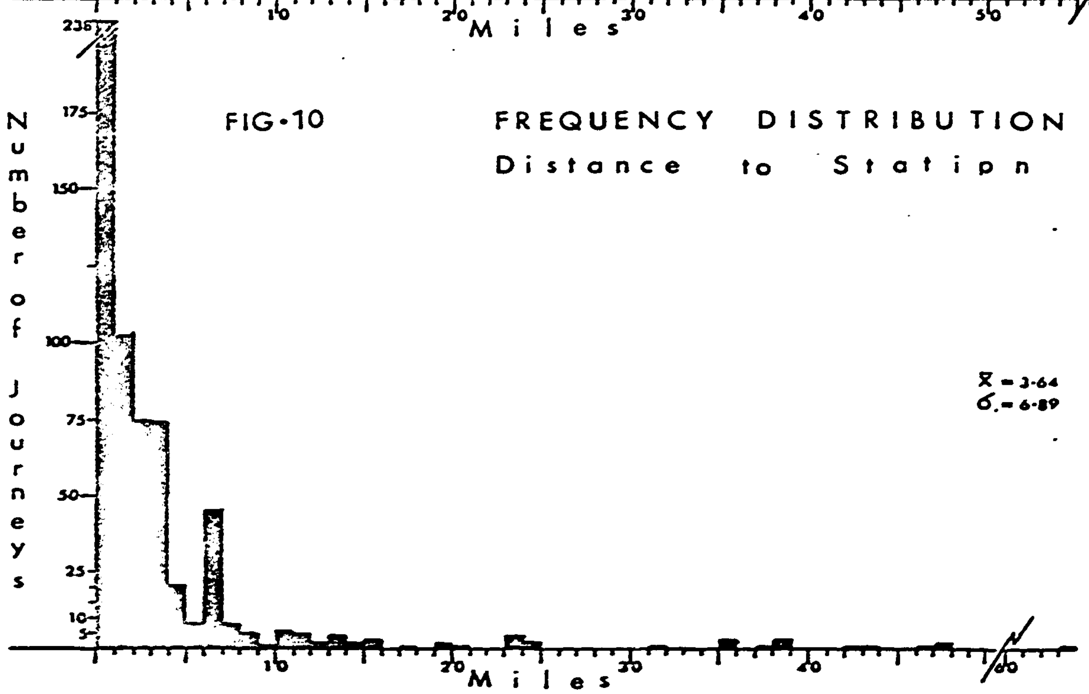
over the original distributions. Winer (1962, page 6) points out that the more the population distribution differs from a bell-shaped distribution, the larger the sample size must be for the central limit theorem to hold. The central limit theorem states that the sampling distribution of the means of random samples will be approximately normal in form regardless of the form of the distribution.

Table 3-1 summarises the improvement in symmetry and kurtosis for the variables on which transformation was effected, and includes the original symmetry and kurtosis coefficients of the distributions of all 16 variables. The process was repeated for the 227 cases in the sub-sample of those persons who had at some time made an alternative journey by road. The key to the variable numbers may be found in Figure 28, Chapter 3, below.

The histograms of Distance Travelled to Station and Distance Travelled from Station are given in Figures 9 and 10. The log-normal character of these distributions is reflected in the effectiveness of the transformation in Table 3-1. More than one third of all journey origins are within one mile of the station, and three quarters are within four miles. There appear to be more destinations than origins at distances between 4 and 24 miles from or to the station. The difference between the figures is graphically illustrated in Figure 11.

Since the nomenclature of origin and destination is reversed on the return journey, the disparity between the two


FIG·9
FREQUENCY DISTRIBUTION
Distance from Station
Number of Journeys
Miles
$\bar{x}$ = 4·95
σ = 7·57


FIG·10
FREQUENCY DISTRIBUTION
Distance to Station
Number of Journeys
Miles
$\bar{x}$ = 3·64
σ = 6·89

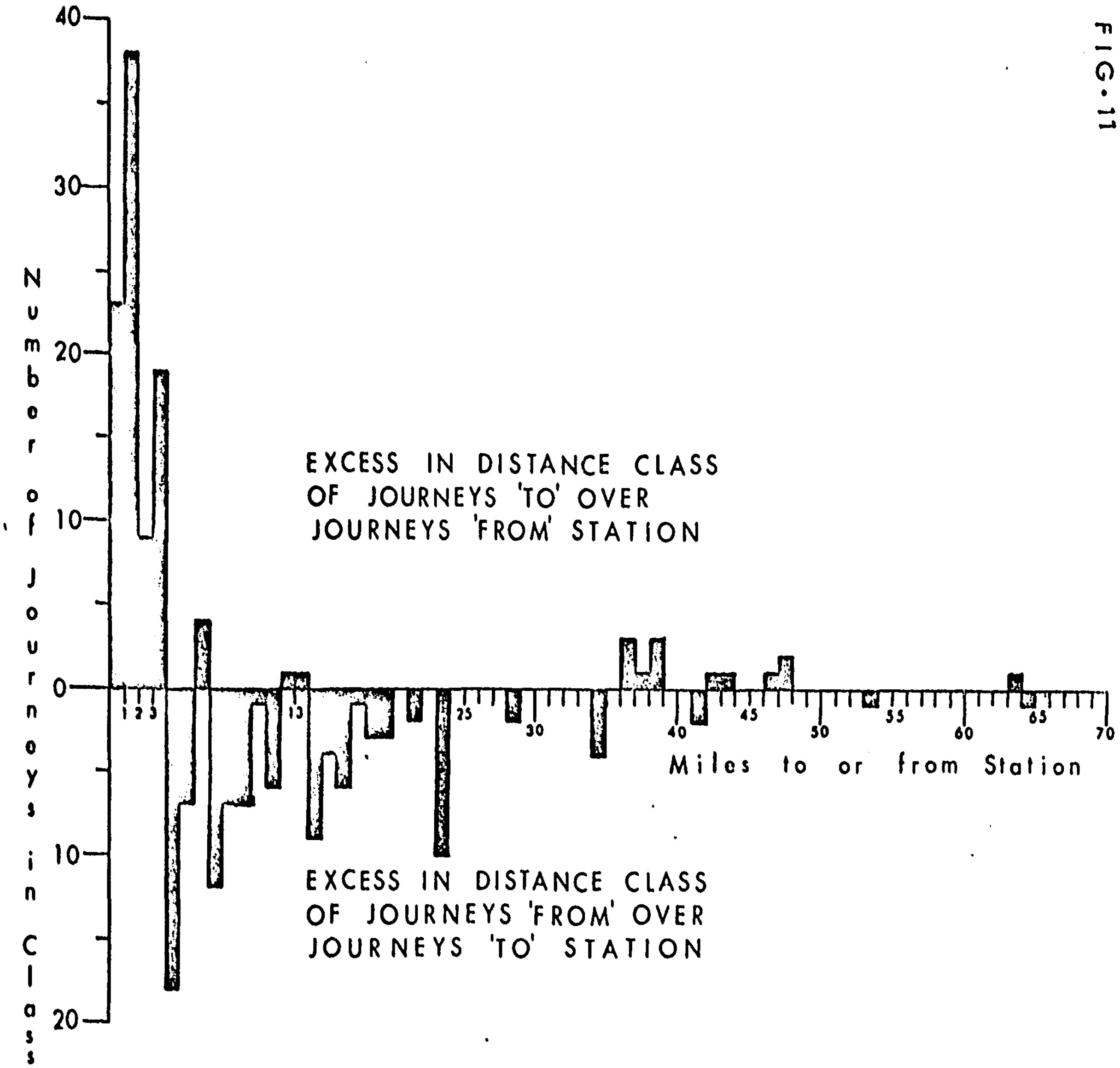

Number of Journeys in Class
40
30
20
10
0
10
20
1 2 3
13
25
30
40
45
50
55
60
65
70
Miles to or from Station
EXCESS IN DISTANCE CLASS OF JOURNEYS 'TO' OVER JOURNEYS 'FROM' STATION
EXCESS IN DISTANCE CLASS OF JOURNEYS 'FROM' OVER JOURNEYS 'TO' STATION

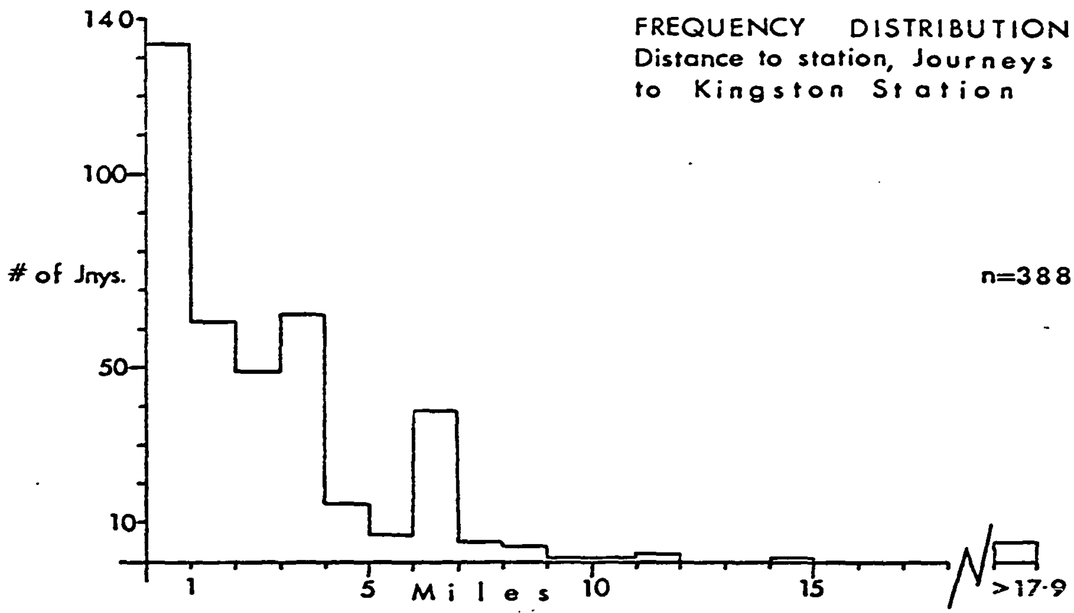
FIG-11

variables could occur under only three conditions. There may be a substantial number of one-way journeys made on the railway, with the distance of the origin point from the origin station being a stronger determinant of the decision to make or not make the journey, and therefore shorter, than the distance of the destination point from the destination station.

A second possibility is that a large number of return journeys are made with the outbound or return leg partially by rail, but not both. In this case that half of the return journey made partially by rail would minimise the distance travelled to the station relative to the distance travelled from the station. One could explain this by the amount of 'information' concerning the journey available to the passenger on the outward as opposed to the return leg. Under this argument the outward leg would be made by rail owing to the cheap rates per mile and the close proximity of the origin station. The cost, difficulty or distance encountered in reaching the final destination from the destination station would then result in the decision to make the return journey throughout by road.

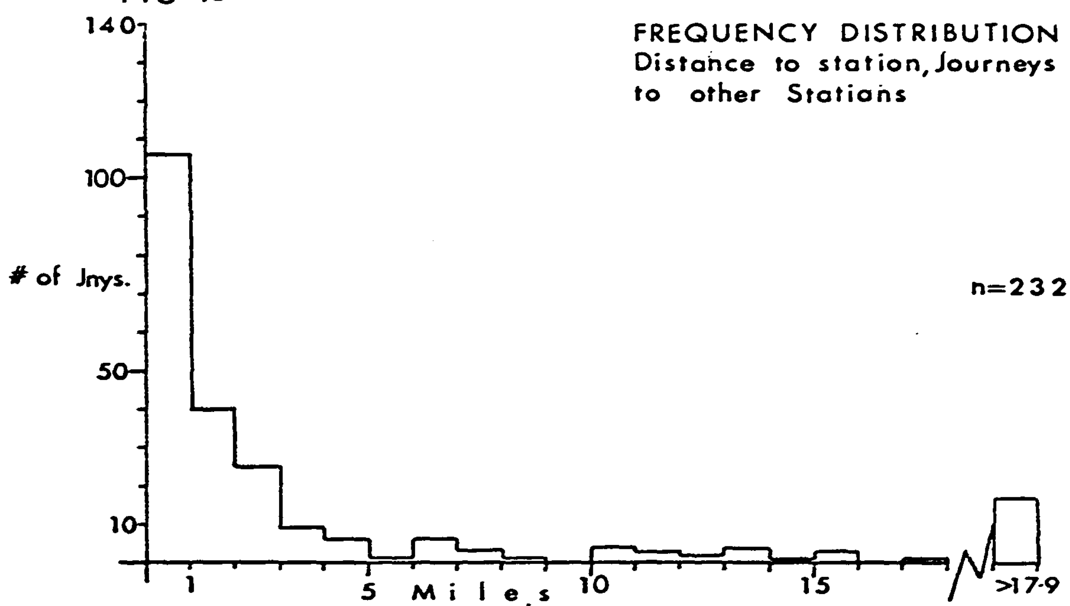
The third and final possibility is that the apparent disparity in Figure 11 is the result of sample bias. The most likely source of such bias lies in the preponderance of Kingston as an origin station (Figure 14), and lower relative significance as a station destination (Figure 12). The influence of Kingston in the former figure is to increase the proportion of journeys within four miles of the station.

FIG. 14



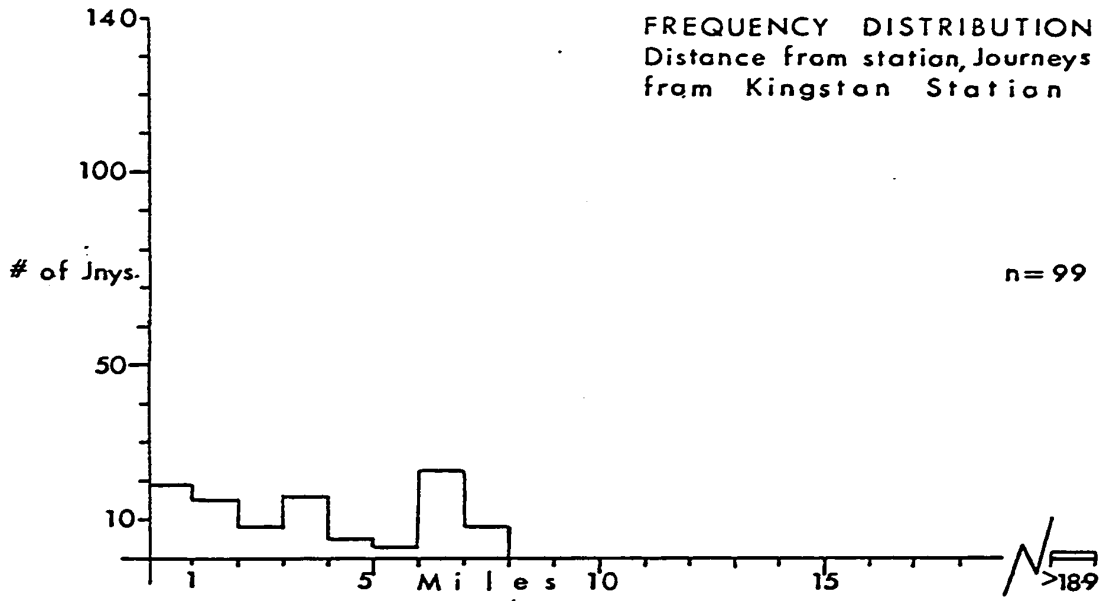
140
100
50
10
# of Jnys.
FREQUENCY DISTRIBUTION
Distance to station, Journeys to Kingston Station
n=388
1
5
Miles
10
15
>17·9

FIG. 15



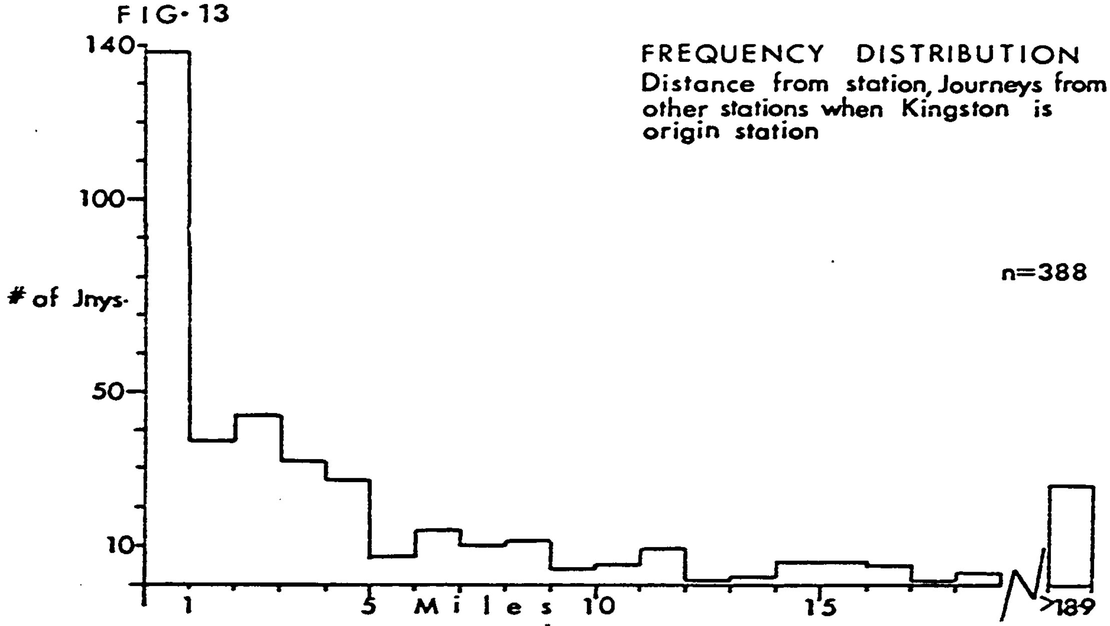
140
100
50
10
# of Jnys.
FREQUENCY DISTRIBUTION
Distance to station, Journeys to other Stations
n=232
1
5
Miles
10
15
>17·9

FIG. 12



140
100
# of Jnys.
50
10
1
5
Miles
10
15
>189
FREQUENCY DISTRIBUTION
Distance from station, Journeys from Kingston Station
n=99

FIG. 13



140
100
# of Jnys.
50
10
1
5
Miles
10
15
>189
FREQUENCY DISTRIBUTION
Distance from station, Journeys from other stations when Kingston is origin station
n=388

Thus a combination of Figures 14 and 15 produces the distrib- -ution in Figure 10. On the other hand, Figure 12 includes only 15.8 per cent of the 620 cases in the sample, and the small number of cases beyond a distance of eight miles from the station is not reflected in the distribution for the whole sample (Figure 9), for which Figure 13 is the stronger determinant. Also, the relative absence in Figure 12 of persons travelling one mile or less from the station may be attributed to the fact that these cases were interviewed mainly on afternoon or evening trains, when the proportion of persons destined for the central area of the city would be smaller.

The evidence therefore suggests the third condition stated, that sample bias has produced the disparity between Figures 9 and 10, which should in theory be identical. Though it is possible that one or both of the first two conditions also apply to some degree, the data as sampled is inappropriate to test either possibility.

One would expect Figures 17 and 16, the histograms respectively of Cost of Journey to and from the station, to reflect the differences noted above between the distance variables to which they are related. The value of two thirds of the cases in Figure 17 is less than ten pence, but only one half of the cases in Figure 16 fall into this category. Both variables are Log-normally distributed. The closeness of fit (Table 3-1) of variables 5 and 6 to the log-normal

FIG. 16

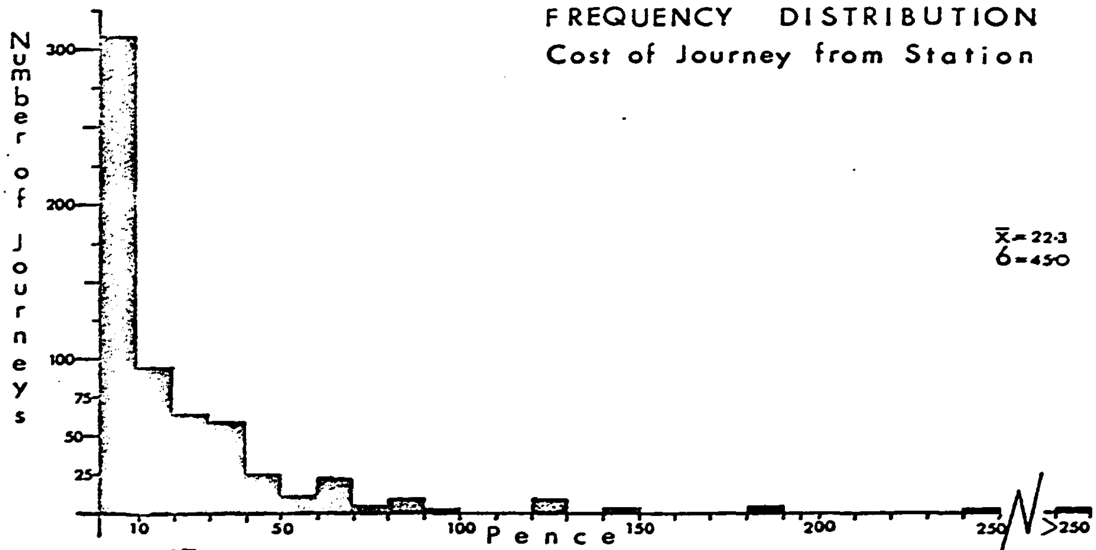
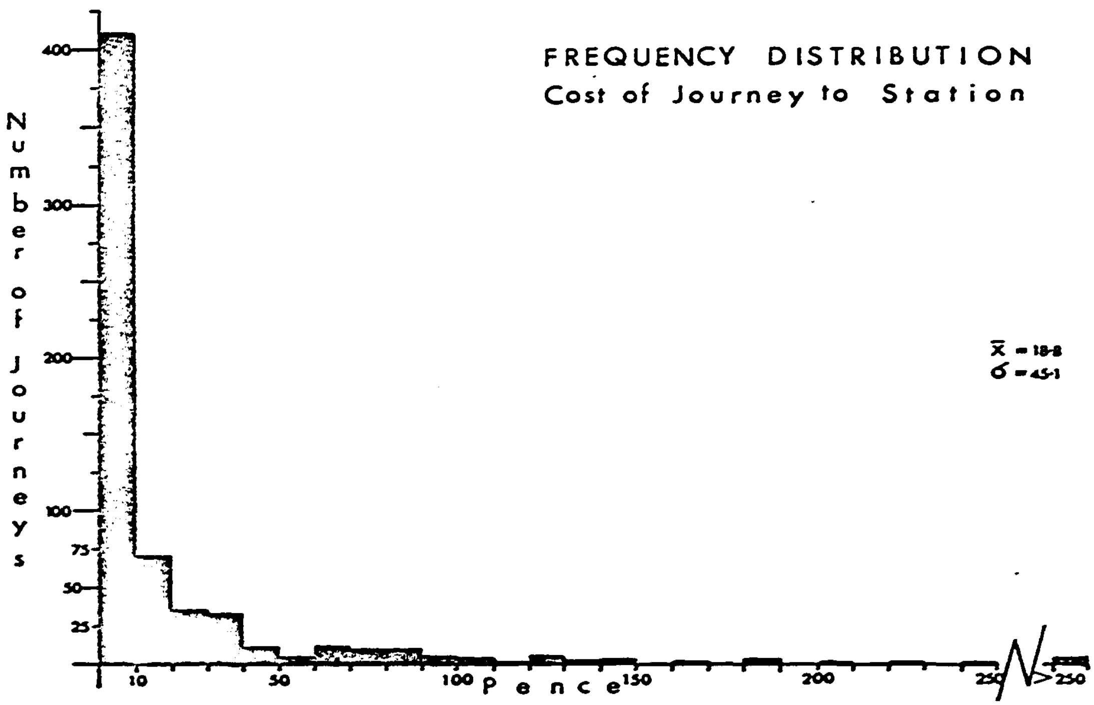

FREQUENCY DISTRIBUTION
Cost of Journey from Station
Number of Journeys
300
200
100
75
50
25
10
50
100
150
200
250
>250
Pence
$\bar{x}$ = 22·3
σ = 45·0

FIG. 17


FREQUENCY DISTRIBUTION
Cost of Journey to Station
Number of Journeys
400
300
200
100
75
50
25
10
50
100
150
200
250
>250
Pence
$\bar{x}$ = 18·8
σ = 45·1

distribution is surprising in view of the varied costs per mile for different modes of travel which are compressed into a single variable. The largest values for either variable in Figures 16 and 17 do not of course necessarily reflect correspondingly large distances to or from the station. In the main such values represent the cost of taxi journeys made over relatively short distances.

Cost rates per mile by rail vary between 0.75 pence for passengers on market return tickets, 1.083 ($1\frac{1}{12}$) pence for second class mixed train passengers, and 1.5 pence for second class passengers on diesel railcars [1]. There is a minimum charge for the latter of 18 pence.

The histogram of Rail Journey Cost (Figure 19) is sensitive to the differential fare structure in that it is not obviously identical in shape to Figure 7. When, for each case, the added journey cost to and from the station is combined with the rail journey cost to yield the variable Total Journey Cost, the distribution in Figure 18 is obtained. No transformation available in the Normstand program could effect a significant improvement in the distribution statistics of the variable Rail Journey Cost (Table 3-1,

---

1. The number of first class passengers travelling on the railway (on diesel railcars only) is so small that it would have been extremely difficult to obtain a representative or in any way balanced sample had such persons been included. It was consequently decided to sample second class passengers only.

FIG-18

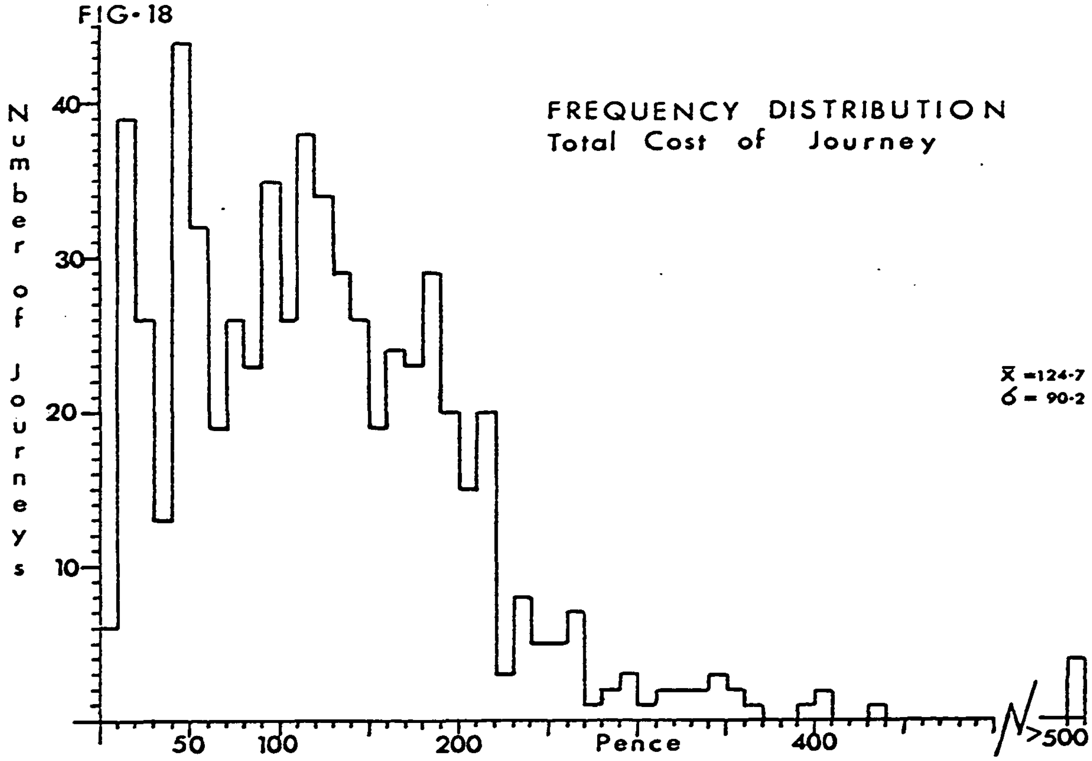
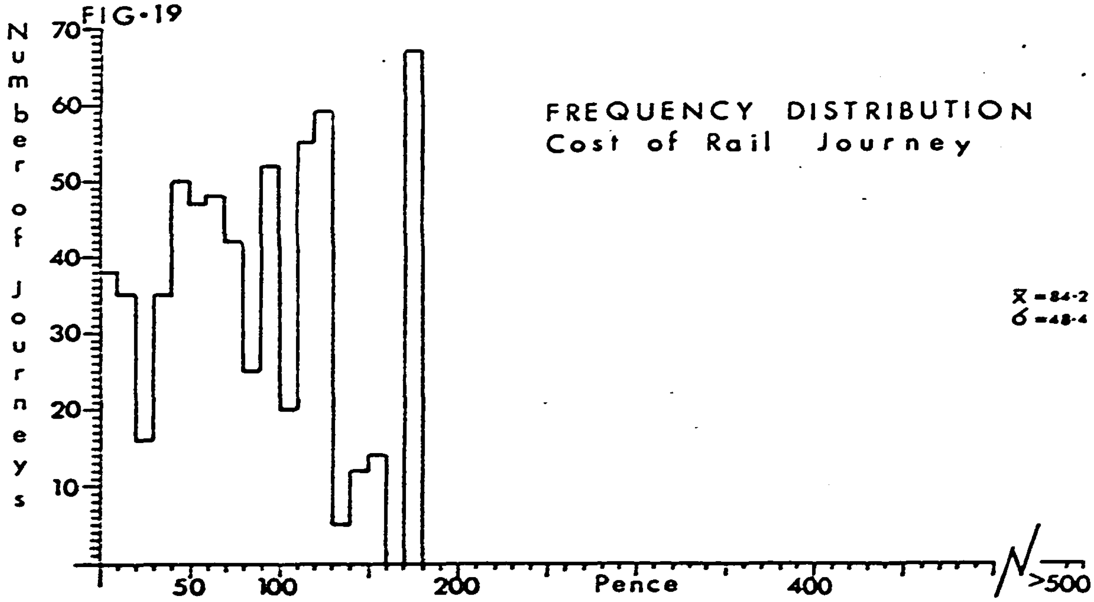

FREQUENCY DISTRIBUTION
Total Cost of Journey
Number of Journeys
40
30
20
10
50
100
200
Pence
400
>500
X̄ =124·7
σ = 90·2

FIG-19


FREQUENCY DISTRIBUTION
Cost of Rail Journey
Number of Journeys
70
60
50
40
30
20
10
50
100
200
Pence
400
>500
X̄ =84·2
σ =48·4

variable 4). In the case of Total Journey Cost, variable 9, a cube root transformation compensates for the positive skew--ness, and a close approximation to normality is achieved in the transformed distribution.

The relationship between Total Journey Cost and Total Journey Distance is indicated in Figure 20, the histogram of Cost per Journey Mile. The bimodal peak of this distribution must be accounted to the difference in cost per mile on mixed and diesel trains. In general, lower values in the distribution (the classes less than one penny per mile) are market journeys, while the majority of the cases in the classes greater than twopence per mile include a car, taxi, or pirate journey to or from the station. As in the case of the added cost and distance variables, the transformation selected is logarithmic, (Table 3-1, variable 12).

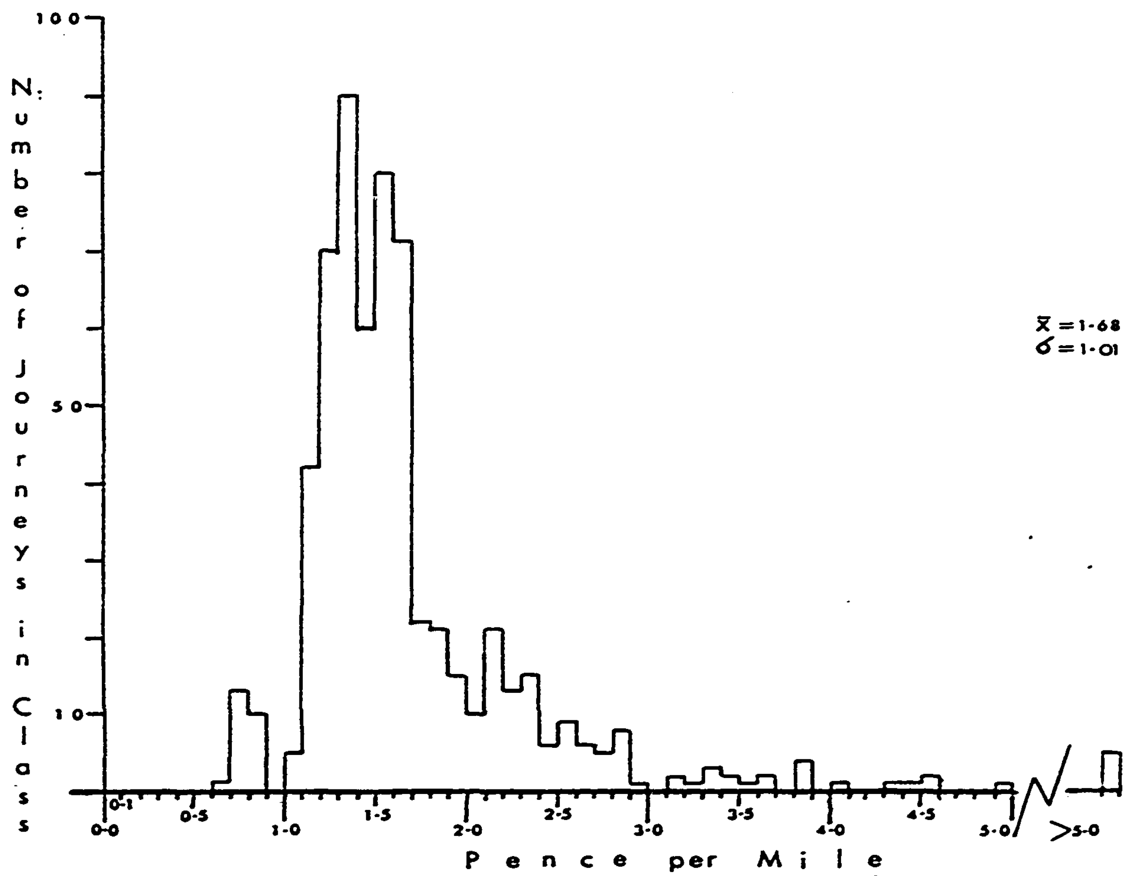
A feature of the distribution in Figure 20 worthy of note is the apparent break in slope at 1.7 pence per journey mile. The sudden reduction in the number of cases in the classes exceeding this value suggests the existence of a decision threshold, a division between subsets in the sample differing in their evaluation of economy versus ease of travel, their consequent choice of mode,and their ability, in financial terms, to make such a choice. The break in slope may also be related to a threshold value for added journey distance, beyond which journeys by foot to or from the station are rare, resulting in greater costs per added mile, which in turn

FIG. 20

FREQUENCY DISTRIBUTION

$\frac{\text{Total Journey Cost}}{\text{Total Journey Distance}}$

(Pence per Mile)

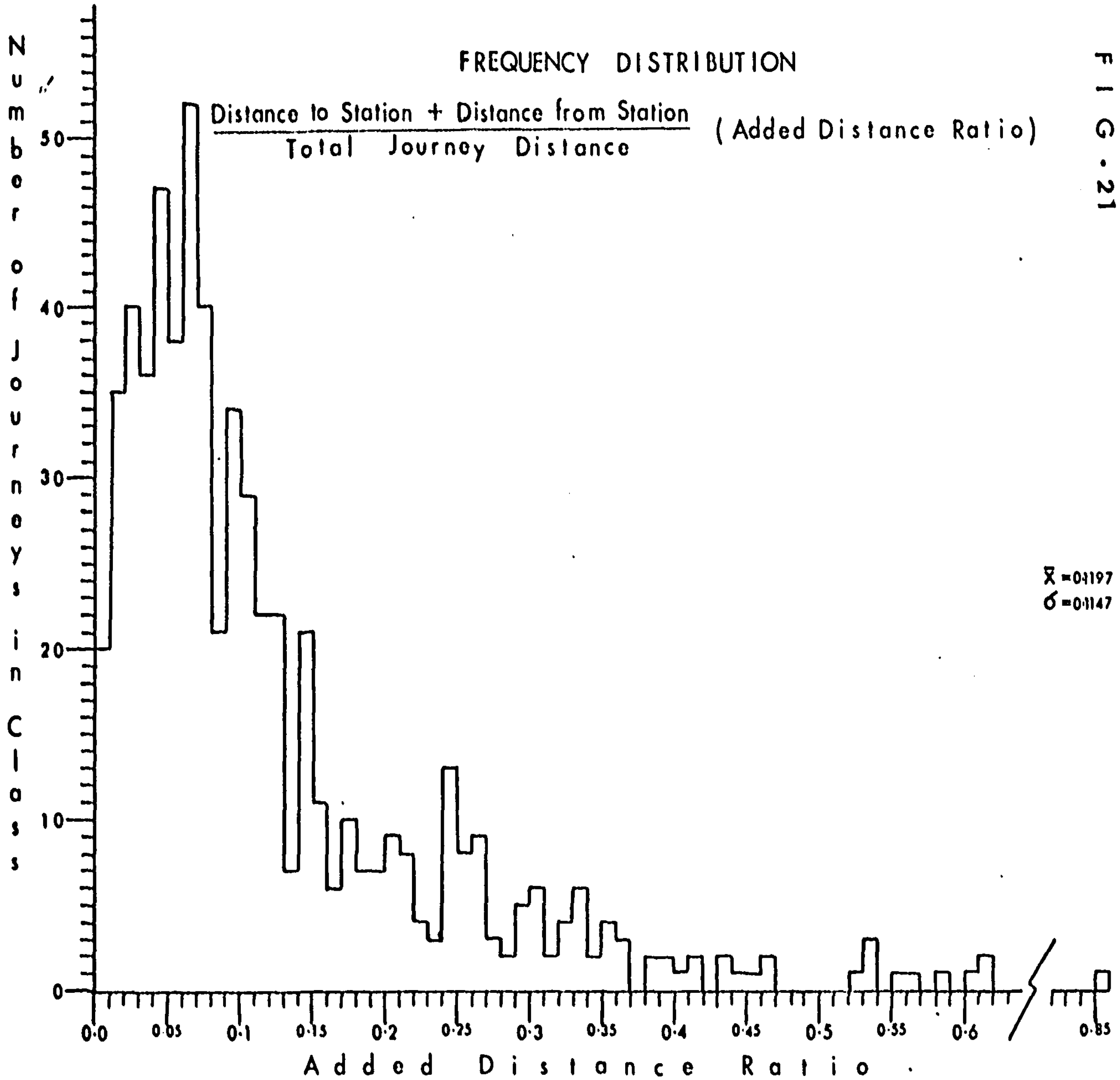


would yield greater costs per journey mile.

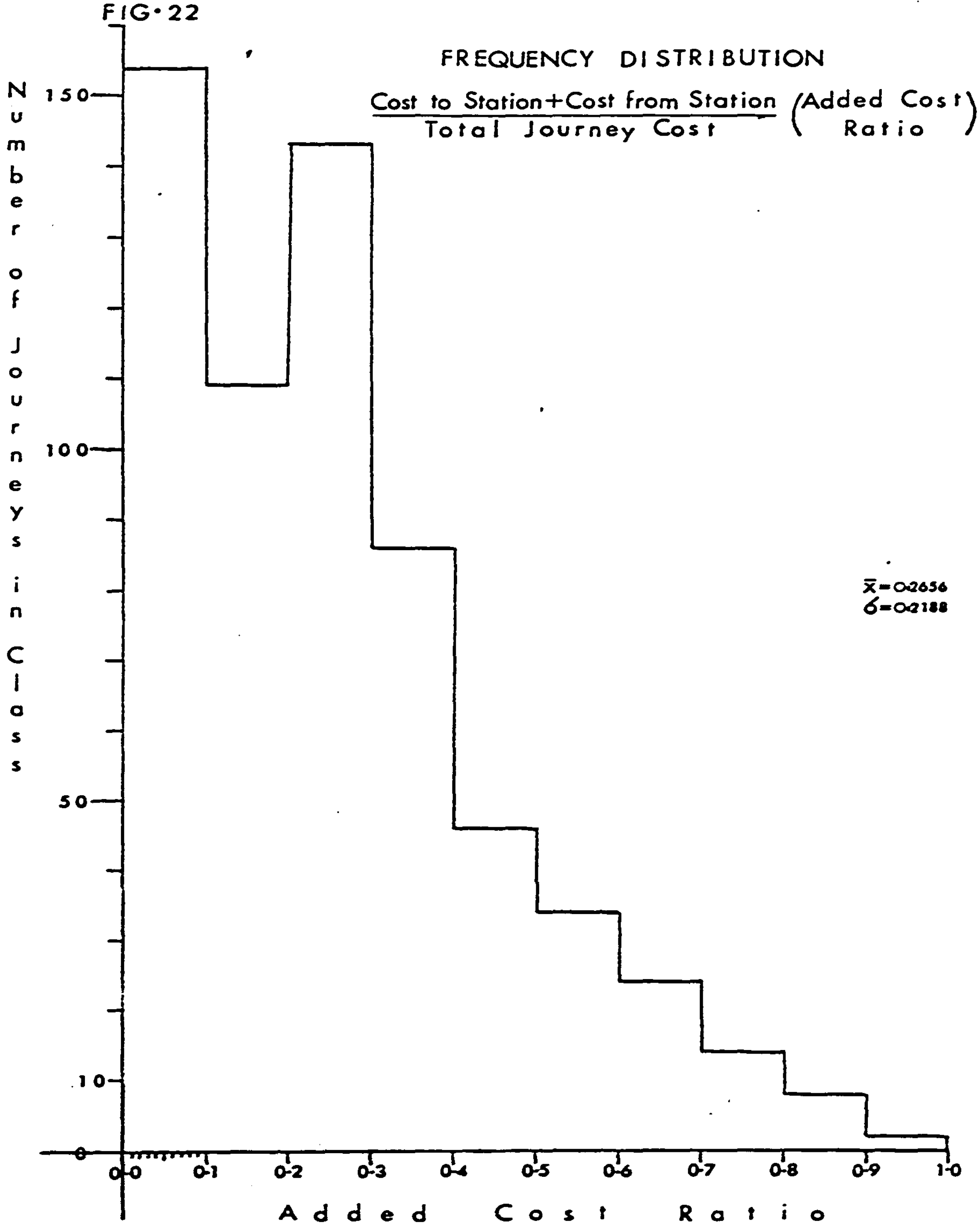
Comparison of Figures 21 and 22 lends tentative support to the suggestion that the break in slope in Figure 20 is a result of the existence of distinct subsets of passengers differing in their journey characteristics. Figures 21 and 22, the ratios respectively of added distance to total distance and added cost to total cost (Table 3-1, variables 13 and 14), are both positively skewed distributions, the latter to the extent that in two cases the added cost of travelling to and from the station is .9 or more of the total cost of the journey. A peculiar feature of the histogram for the Cost Ratio (Figure 22) is the bimodal character of the distribution. This pattern is not repeated for the Distance Ratio (Figure 21). Even with a class interval of .01 the distribution is clearly unimodal. The large number of cases for which the Cost Ratio assumes a value between 0.2 and $0.2\bar{9}$ is likely to be associated either with the fundamental distinction between the rates charged on mixed and diesel trains, or with the mode of transport employed on the added journey.

Hitherto, journey cost has been measured as an absolute value summing the component costs from origin to destination, or as a ratio value of cost per journey mile. For low values of the latter variable, if associated with a circuitous path between the origin and destination, the ratio will not give a good measure of the real cost of travelling between two points in Jamaica. Similarly, if the path taken

FIG · 21


FREQUENCY DISTRIBUTION
Distance to Station + Distance from Station / Total Journey Distance (Added Distance Ratio)
$\bar{X} = 0.1197$
$\sigma = 0.1147$
Number of Journeys in Class
0
10
20
30
40
50
0·0
0·05
0·1
0·15
0·2
0·25
0·3
0·35
0·4
0·45
0·5
0·55
0·6
0·85
Added Distance Ratio

FIG·22

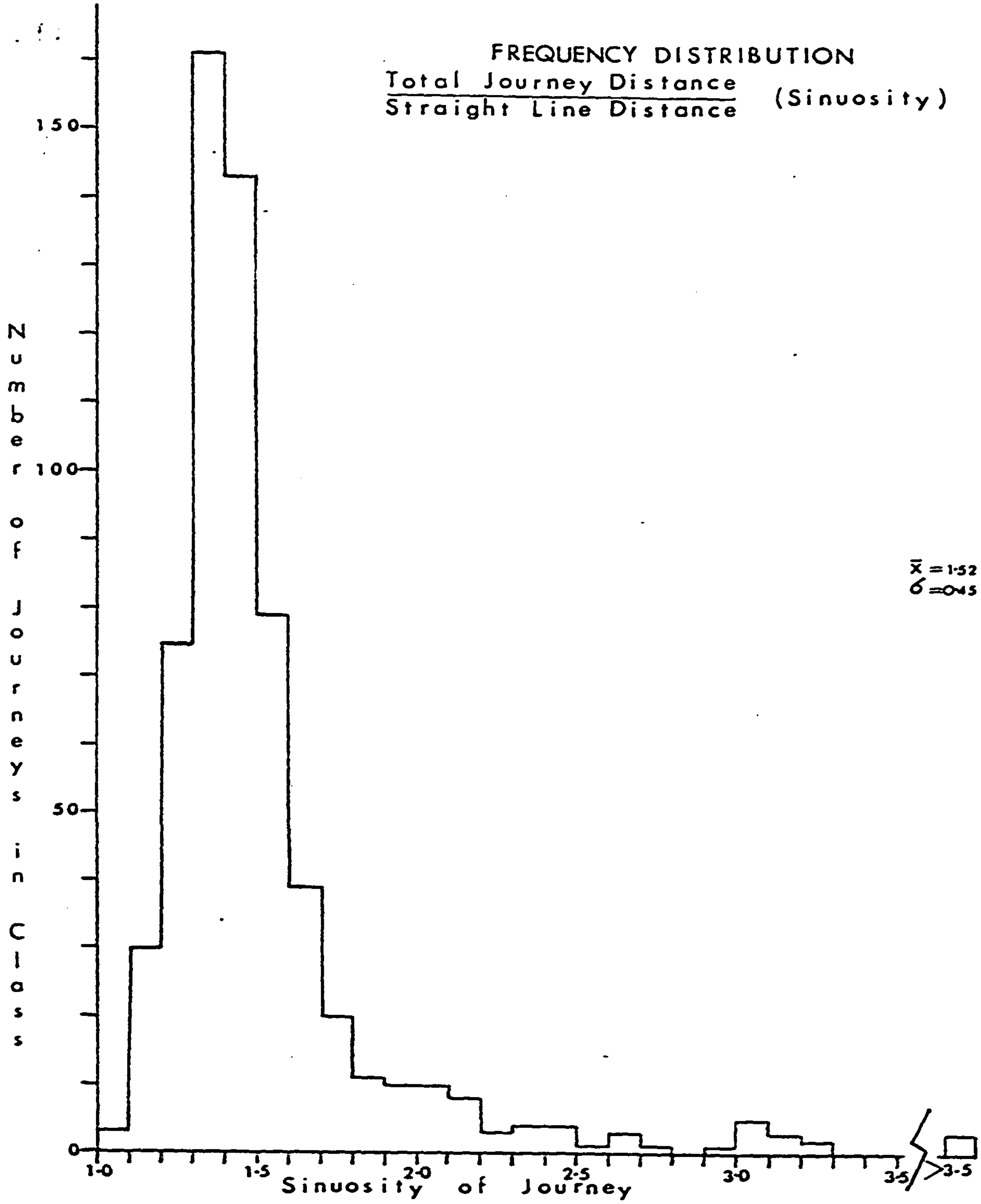

FREQUENCY DISTRIBUTION
Cost to Station+Cost from Station / Total Journey Cost (Added Cost Ratio)
Number of Journeys in Class
150
100
50
10
0
0·0
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
Added Cost Ratio
x̄=0·2656
σ=0·2188

approaches a straight line, a high cost per mile may obscure the relative efficiency of the journey.

Given the existing rail and road route network in Jamaica, and the spatial pattern of public transport services and their cost, there exists for every point in the island a minimum cost of reaching any other point. There can be drawn about each point a surface of isocost lines interpolated from those points for which the minimum cost of travel is known. A set of least cost paths, geodesics, can then be drawn from the central point, which in their trajectory to each point of destination will be orthogonal to the isocost lines of the surface. Warntz (1965) has demonstrated such a surface for Murfreesboro, Tennessee. Thus a deviation from a straight line path between two points may not necessarily be a more expensive route to follow, and, given a fixed pattern of routes and services, as in Jamaica, the cost surface is anisotropic and few minimum cost paths will be straight lines.

Approaching reality further, we note that the pattern of interaction will be such that few minimum cost paths will in practice be used at all, and that certain paths will be used to a far greater extent than others. The demand for transport along these paths will be such that tran--sport services will be in competition and will achieve economies of scale, and the cost to the consumer may fall. Along other paths the low demand will justify only sporadic provision of services with high unit costs per mile to the

FIG·23



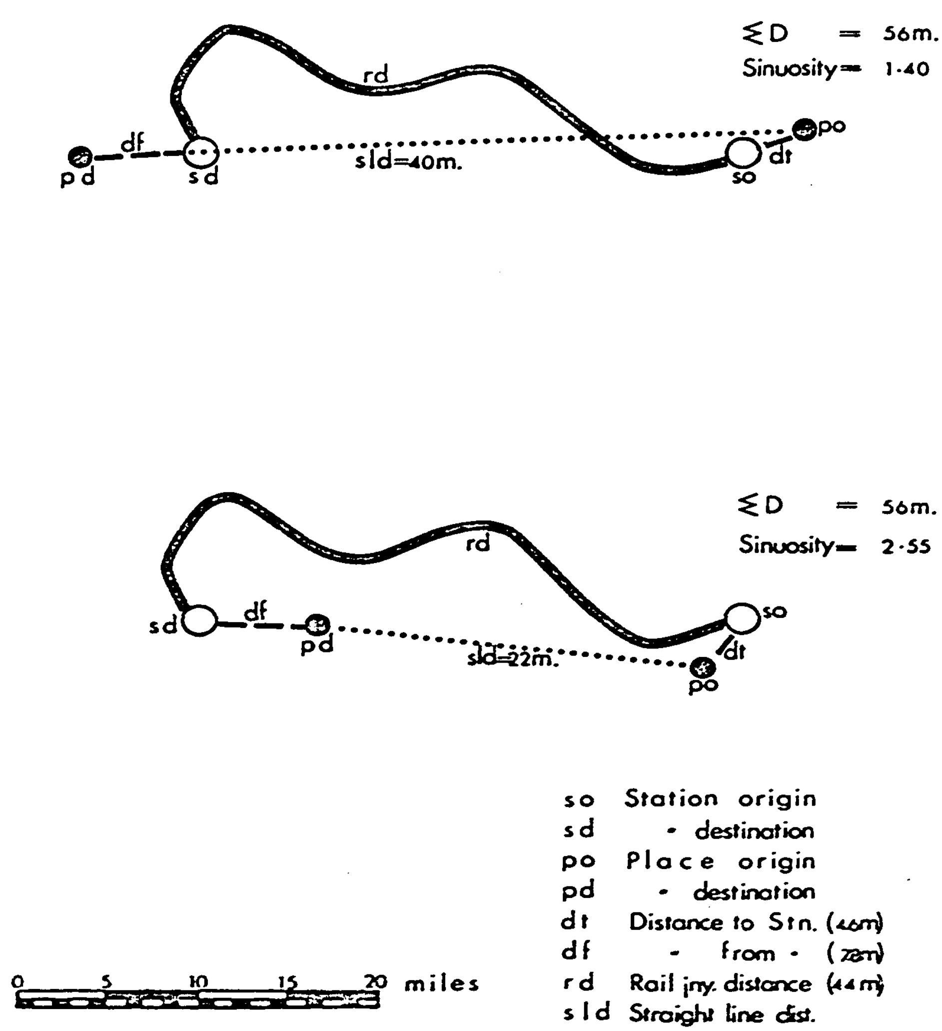
FREQUENCY DISTRIBUTION
Total Journey Distance / Straight Line Distance (Sinuosity)
$\bar{x}$ = 1·52
σ = 0·45
Number of Journeys in Class
150
100
50
0
1·0
1·5
2·0
2·5
3·0
3·5
>3·5
Sinuosity of Journey

consumer. Moreover, the spatial pattern of public transport services will always be such that an added journey by foot, however short, will be made, at a cost, to a point where such services are available, and from a point at some distance from the ultimate destination. The problem is complicated further if the individual is substituted for the community, if full information to the individual is not assumed, and if the possession or non-possession of private means of transport is entered as a factor in the derivation of the least cost surface.

Again, a journey along a least cost path is optimal only when monetary cost is assumed to be the single criterion. The value of other factors; time, comfort, safety, status; is ignored. The trade-off between these factors and cost is in reality complex, and varies between individuals in a population. The information available to the individual is likely to be no less incomplete than cost concerning the values of these contributory factors. In practice the scales employed are likely to be perceived, customary, and ordinal. Thus, "Car travel is faster than train travel", "Train travel is safer than bus travel", "The bus is more convenient than the train", and so on. One would expect that the emphasis laid on each scale depends in part on the nature of the journey. Comfort and safety may rank higher for leisure journeys, speed for business journeys, cost for work journeys, and even perhaps the possibility of social interaction for personal or other types of journey. That distance and cost are

FIG • 24

SINUOSITY

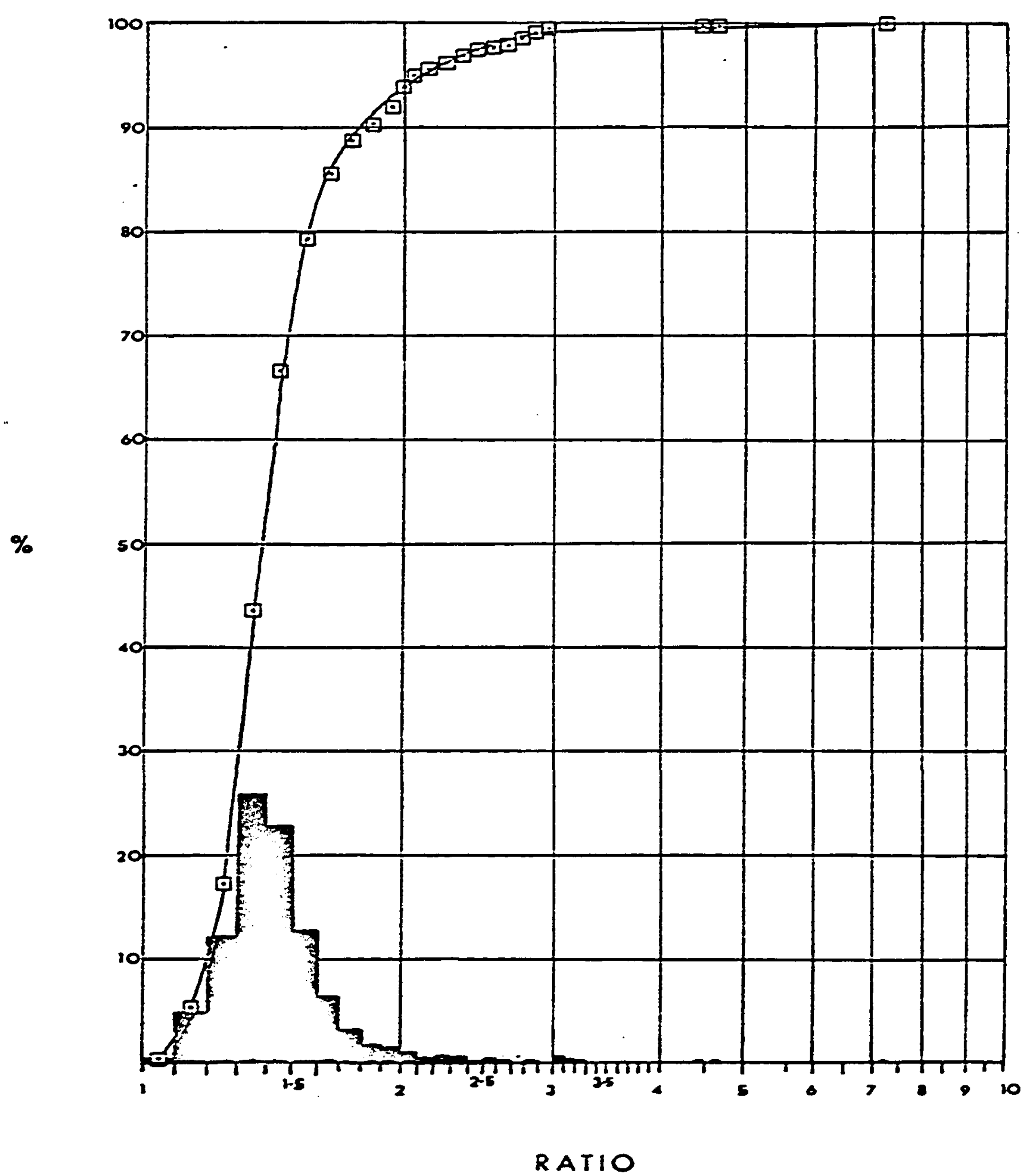


the crucial journey variables, and that other factors may be treated as 'noise', are assumptions based partially on the apparent strength of distance and cost to discriminate between journeys, and partially on the great difficulty of reliably measuring the other supposedly influential factors.

Figure 23, the histogram of the variable Sinuosity, is interesting in view of the preceding discussion. Sinuosity, the ratio of the path to the direct distance, has been used by Schumm (1963) and Smart and Surkan (1967) in the analysis of drainage basin characteristics. Schumm proposed categories of channel sinuosity (for example, 'tortuous' = sinuosity greater than 2.00) which are unsatisfactory in that they involve unnecessary loss of information with no commensurate gain in ease of analysis. Timbers (1967, page 392) obtained a histogram of what he termed 'route factors' (i.e. sinuosity) between 780 pairs of British towns linked by road. The mean value of 1.17 arrived at in the study by Timbers may be compared with the mean of 1.52 in Figure 23. Although the histogram presented by Timbers exhibited the positive skewness present in Figure 23, in only one case did the route factor between two towns exceed a value of 1.50.

The modal class, 1.30 to 1.39, in Figure 23, may be associated with journeys for which the Added Distance Ratio (Figure 21) is minimised. The sinuosity ratio of the railway over the direct distance between Kingston and Montego Bay stations is 1.41 . Values below this figure are obtained for

FIG·25 SINUOSITY LOG—NORMAL DISTRIBUTION



journeys across the flatter terrain between Kingston and Porus. For example, the sinuosity index for the journey between May Pen and Spanish Town stations is 1.10 . Journeys within the steeper terrain between Porus and Montego Bay, or along the circuitous Port Antonio line, are associated with greater values of sinuosity. Thus the sinuosity index for the rail route between Kingston and Port Antonio is 2.35 .

The location of the ultimate (place) origin and destination with respect to the station origin and destination is also an important determinant of the sinuosity of the journey. Figure 24 demonstrates the variation in the value of the ratio that this factor may cause, by holding component distances by road and rail constant and varying only the location of the ultimate origin and destination.

That very indirect journeys are made in many of the cases in the sample can be seen more clearly in Figure 25, the cumulative percentage frequency distribution of the Sinuosity variable. Following the transformation to a log--normal distribution (Table 3-1, variable 11), the ordinate in Figure 25 is a logarithmic scale, and the transformed histogram is included on the graph. The sinuosity index of 33.61 per cent of the journeys in the sample exceeds a value of $1.4\bar{9}$, and 7.89 per cent exceed $1.9\bar{9}$. Only 5.83 per cent of the journeys have a sinuosity index less than 1.20.

If we exclude the possibility that the Jamaicans in the sample deliberately maximise the circuity of their journey,

FIG. 26

FREQUENCY DISTRIBUTION
Cost of Alternative
Whole Journey (n=227)

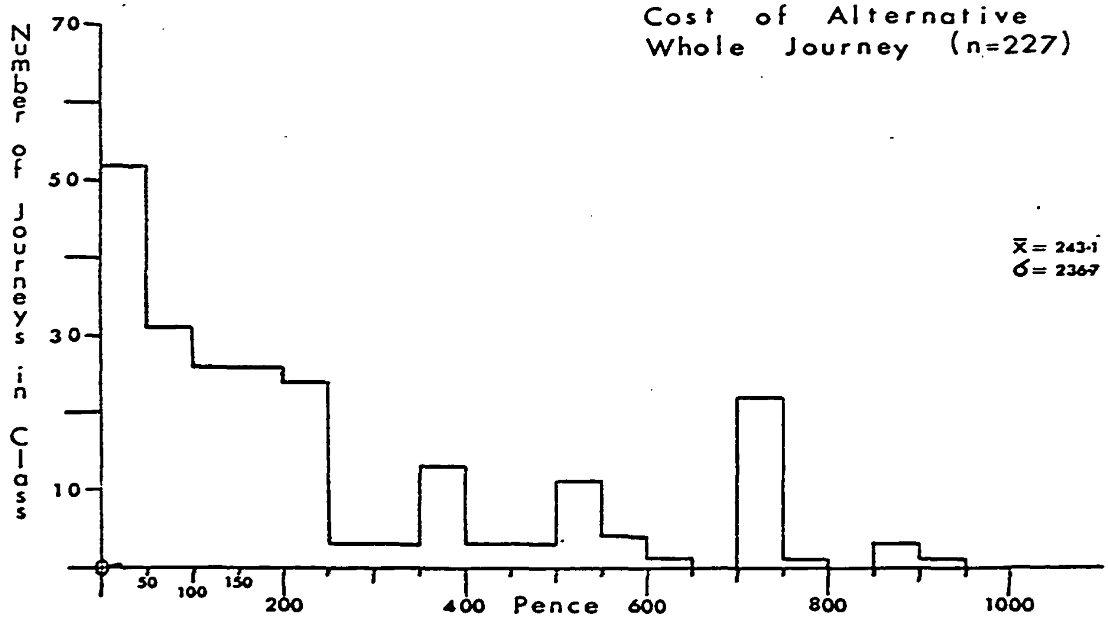
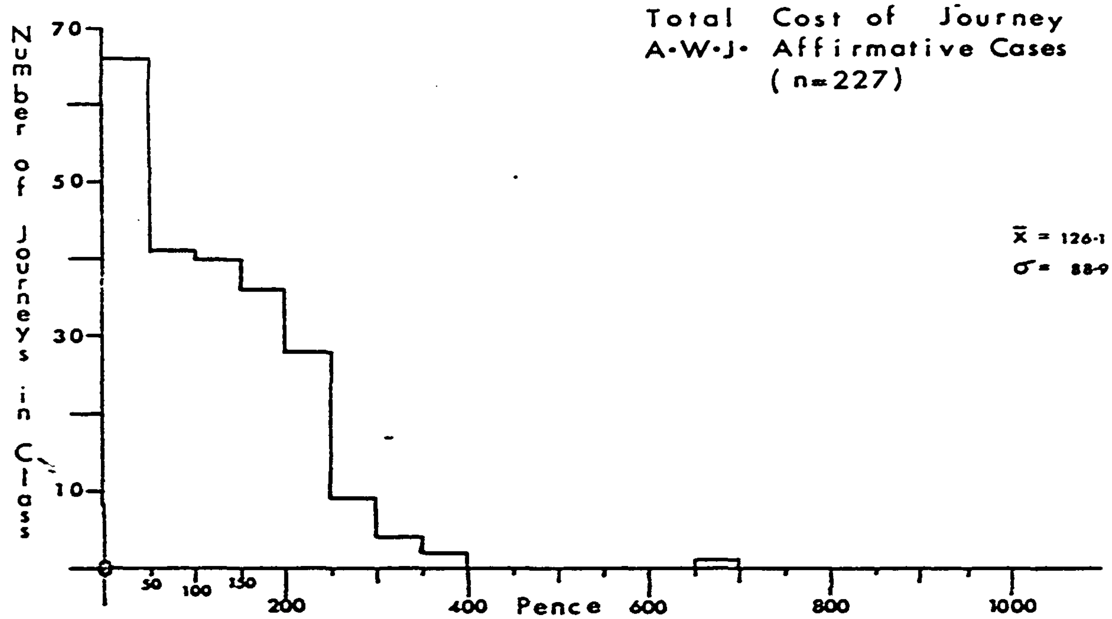


FIG. 27

FREQUENCY DISTRIBUTION
Total Cost of Journey
A.W.J. Affirmative Cases
(n=227)



we are left with two hypotheses explaining the distribution in Figure 23. Either the majority of the values for sinuosity represent minima, for all practical purposes, for pairs of points in Jamaica, or the values reflect a choice to minimise cost at the expense of extra distance and time. Support for the former hypothesis might be found in the comparable road distances between pairs of points in the island. The road distance between Kingston and Montego Bay, for example, is 120 miles, exceeding by 7 miles the rail distance between the two places. Rural bus routes often do not take even the direct road distance between pairs of points.

Licensed carriers operating bus services are entitled to charge twopence per mile, and a minimum fare of one shilling (twelve pence). For the Jamaican, then, even if his origin and destination are at a considerable distance from the nearest stations, the use of the railway for part of his journey may represent a substantial saving in cost.

Some indication of this saving may be gained from Figures 26 and 27, histograms respectively of the cost of the alternative journey by road for the 227 persons in the sample who at some time had made such a journey, and of the journey they were making when interviewed. The mean value of the distribution in Figure 18, 124.7 pence, for the whole sample of 620 persons, is almost identical to that of the 227 persons in Figure 27, 126.1 pence, for the same variable. The mean value of the cost of the alternative journey for these 227 cases is 243.1 pence. The modal classes in Figure 26 may be identified as characteristic alternative journeys. For example the cases in the class 700 to 749 pence include those journeys by private car between Kingston and Montego Bay (120 miles at 6 pence per mile).[1]

Some of the problems raised in this chapter will be subjected to further analysis. The general discussion above, however, has also been an attempt to suggest hypotheses which, even if they do not lend themselves to further analysis in this study, point to the possible relationships within and between rail journeys, and are suggestive of further studies in the future.

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1. The modes of travel used in the 227 alternative journeys were as follows; Bus, 114 cases; Car, 76 cases; Pirate, 23 cases; and 14 cases by Truck.

CHAPTER FOUR

CORRELATION-REGRESSION ANALYSIS

The previous chapter confined discussion to the distributions of the journey variables expressing characteristic features of the journeys made by the 620 persons in the interview sample. The natural sequel to this approach is to ask whether, given a range of values for one variable, X, an estimate may be made for the values taken by another variable, Y. In correlation analysis a functional relationship between X and Y is not assumed. Since the interview sample is not a controlled experimental sample, factors other than X must be assumed to determine the value of Y. These factors, and the random error constant, are unknown. The model then takes the form of a simple linear regression:

$$Y = \underline{a} + \underline{b}X$$

where $\underline{a}$ is the intercept and $\underline{b}$ is the slope of the regression line, and the equation expresses a line which minimises the deviation sums of squared values of actual against predicted Y. An excellent review of the simple linear model may be found in Krumbein and Graybill (1965, Chapter 10, pages 223-247).

The correlation coefficient $\underline{r}$ is a measure of how 'good' the quantity X is as a predictor of Y, and is computed from the formula:

$$\underline{r} = \frac{(SSXY)}{\sqrt{(SSX^2)(SSY^2)}}$$

where SSXY is the sum of the products of the deviations from the mean $\bar{x}$ and the mean $\bar{y}$, (SSX^2) is the sum of the squared deviations from the mean $\bar{x}$, and (SSY^2) is the sum of the squared deviations from the mean $\bar{y}$. The correlation coefficient r may take any value in the range -1.00 (perfect negative correlation) through 0.00, meaning the variables are not correlated (in linear terms at least), to +1.00 (perfect positive correlation).

In the computation of r, however, measurement errors of the values of X or Y, or both, are overlooked, as are the sampling errors of both variables. In the former case, the plotted point on a scatter diagram is no more than one of a number of points that might be located along a line if measurement error is present in X or Y, and within a rectangle if measurement error is present in both variables (Carson, 1968). In the latter case, values of X or Y are assumed to be representative of the true values which, owing to the circumstances of the investigation or the size of sample, cannot all be measured. Values of the variables Frequency of Journey per Annum, Cost to and Cost from station, Total Journey Cost, and the unit cost per mile variables, thus involve some degree of sampling error, owing to the method by which the frequency variable was derived (Appendix 5), and the assumptions concerning the cost of foot and car journeys (Appendix 2). The variables Distance to and Distance from the station are also subject to sampling error in cases where an approximation only is possible in defining the points of origin and destination. The rounding of the other distance variables to the nearest mile isthe other major source of error in the study, in this case measurement error.

If the measurement or sampling errors, or both, are intercorrelated, the correlation coefficient may be greater or less than if exact values of X and Y had been used in the computation. The standard error of estimate, S.E., of the linear model, however, is calculated on the assumption that the predicted values of Y from X are deviations from exact values. This assumption, as noted above, is not always satisfied. The formula for the standard error of estimate is:

$$S.E._{\underline{yx}} = \sqrt{\frac{\Sigma(Y - Y')^2}{N}}$$

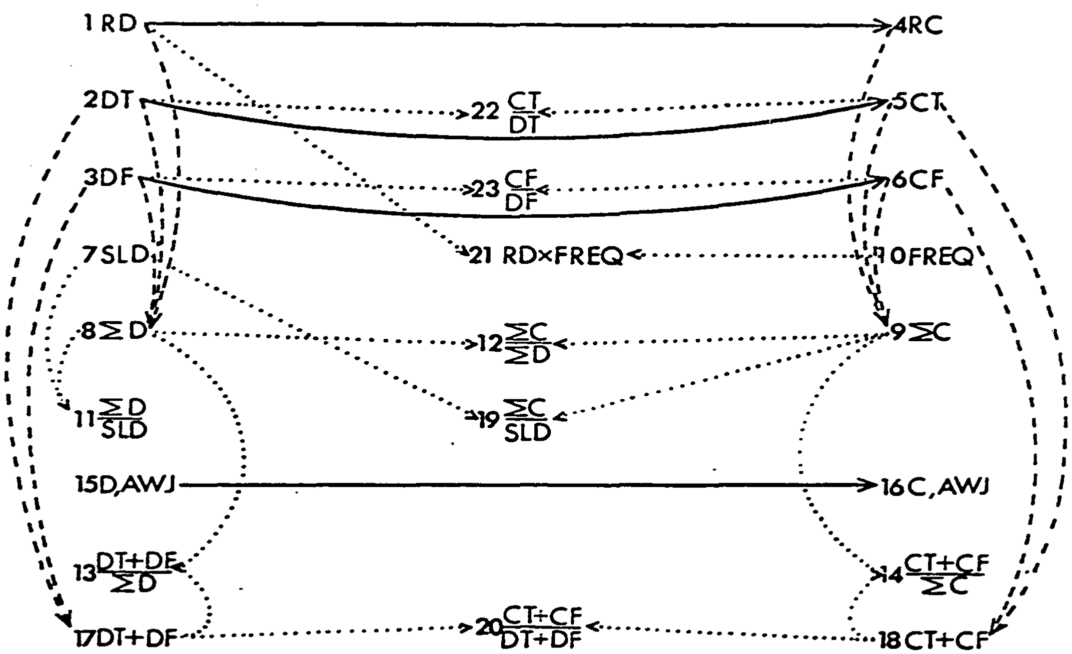
where the subscript <u>yx</u> denotes the prediction of Y from X, Y is the measured value of a single case, Y' is the predicted value for the case, and N is the total number of cases predicted. In the bivariate normal distribution, 68 per cent of the cases Y' will lie within one standard error of the true value Y. If the measurement and sampling errors of the variables exceed the value of the standard error of estimate, considerable doubt may be cast on the validity of the correlation value or the linear model.

In practice the linear model may be used to express a relationship which is curvilinear in form. Krumbein and Graybill (1965, page 240), note that such a model may be valid as a first approximation, at least within stated limit values of X and Y. The operational advantages of the linear model are noted by Ezekiel and Fox (1959).

Intercorrelation between two variables renders the derived correlation coefficient spurious. Figure 28 summarises the linkage between the twenty-three variables measuring journey attributes on interval or ratio scales, demonstrating the degree of dependence of certain variables upon others. A correlation coefficient between two variables which are not of independent origin is not a reliable measure of their association. In this study the value of any cost variable for a particular case is not independent of its concomitant distance variable, nor is the value of a variable derived from the summation of the values of other variables independent of those variables. Similarly, the value of a ratio is dependent upon the values of the variables from which the ratio is derived. These three contingencies are respectively denoted in Figure 28 as primary, secondary, and tertiary linkage.

Figure 29, the correlation matrix for the first 16 variables, therefore excludes entries of correlation coefficients thought to be spurious in the context of the conditions specified in the previous paragraph. The remaining entries give the values of $\underline{r}$ of pairs of variables

FIG· 28 VARIABLE LINKAGE



LEGEND

——————→ Primary Linkage

- - - - - - → Secondary Linkage

·········→ Tertiary Linkage

1 Rail Distance	9 Total Journey Cost	17 Added Distance
2 Distance to Station	10 Journey Frequency	18 Added Cost
3 " from "	11 Sinuosity	19 Cost per Real Mile
4 Rail Cost	12 Cost per Mile	20 Cost per Added Mile
5 Cost to Station	13 Added Distance Ratio	21 Miles per Annum
6 " from "	14 Added Cost Ratio	22 Cost per Mile to Stn.
7 Straight Line Distance	15 Distance; Alt. Wh. Jny.	23 Cost per Mile from Stn.
8 Total Journey Distance	16 Cost ; " " "	

for the whole sample of 620, and for the 227 cases in which an alternative journey had been made. Note that the transformations effected on the variables differed in certain instances between the two samples (Table 3-1, and Figure 29). Direct comparison of two r's is possible only when the transformations are identical.

The variables Straight Line Distance and Total Journey Distance are correlated with a value r = +0.9555 in the whole sample and +0.9719 in the Alternative Whole Journey Affirmative sample. The equation for the former sample is:

$$\Sigma D = 4.0149 + 1.39148.L.D. \text{ miles}$$

with a standard error of estimate of 11.498 miles. The corresponding equation for the A.W.J. Affirmative sample is:

$$\Sigma D = 1.4202 + 1.4543S.L.D. \text{ miles}$$

with a standard error of estimate of 2.0534 miles. Despite the difference in intercepts the two equations are almost identical as predictors of Total Journey Distance from a known Straight Line Distance. The difference in standard error values is probably due to the tendency for smaller samples to contain proportionately fewer extreme values, or residuals. There is also the possibility that persons able to make the journey by other means would not be among the extreme residual cases in Figure 30, which is the linear regression about the scatter of the two variables for the

FIG·29 CORRELATION MATRIX, VARIABLES 1—16, Whole Sample n:620, and A.W.J.Affirmative Sample n : 227

Correlation Coefficients in left-hand matrix refer to whole sample, in right-hand matrix to A.W.J. sample

Transform'n	—	LOG	LOG	—	LOG	LOG	—	—	$\sqrt[3]{}$ \ $\sqrt{}$	LOG	LOG	LOG	LOG \ $\sqrt[3]{}$	$\sqrt[3]{}$ \ $\sqrt{}$	—	$\sqrt[3]{}$
Variable	1 RD	2 DT	3 DF	4 RC	5 CT	6 CF	7 SLD	8 ΣD	9 ΣC	10 FREQ	11 ΣD/SLD	12 ΣC/ΣD	13 DT+DF/ΣD	14 CT+CF/ΣC	15 D,AWJ	16 C,AWJ
1 RD		+ •3005	+•6019		+•4790	+•6224	+•9739			−•5250					+•9592	+•7909
2 DT	+•1899		+•2682	+•2705		+•2287	+•3163			−•2970					+•3109	+•2626
3 DF	+•3602	+•1041		+•5559	+•2947		+•6233			−•4335					+•6168	+•5237
4 RC		+•1726	+•3332		+•4754	+•5610	+•9209			−•4729					+•9221	+•7570
5 CT	+•2802		+•1098	+•3114		+•3533	+•4771			−•3505					+•4812	+•4377
6 CF	+•4424	+•1399		+•3781	+•2179		+•6431			−•4590					+•6102	+•5568
7 SLD	+•9612	+•2159	+•3865	+•8668	+•2760	+•4694		+•9719	+•8804	−•4910		+•0434	−•2030	+•0527	+•9559	+•7743
8 ΣD							+•9555		+•9022	−•5371				+•0837	+•9539	+•7800
9 ΣC							+•7919	+•8368		−•5570			−•1054		+•8601	+•7684
10 FREQ	−•3326	−•2605	−•2588	−•3183	−•3131	−•2638	−•2921	−•3688	−•4200		−•2493	−•0534	+•0950	−•0955	−•5061	−•5010
11 ΣD/SLD										−•2700			+•3716	+•1722	+•0215	+•0598
12 ΣC/ΣD							−•0835			−•0967			+•1966	+•5678	+•0458	+•1236
13 DT+DF/ΣD							−•2229		−•0613	−•0353	+•3792	+•2126			−•1872	−•1680
14 CT+CF/ΣC							−•0380	+•0205		−•1285	+•1952	+•5613			+•0341	+•0845

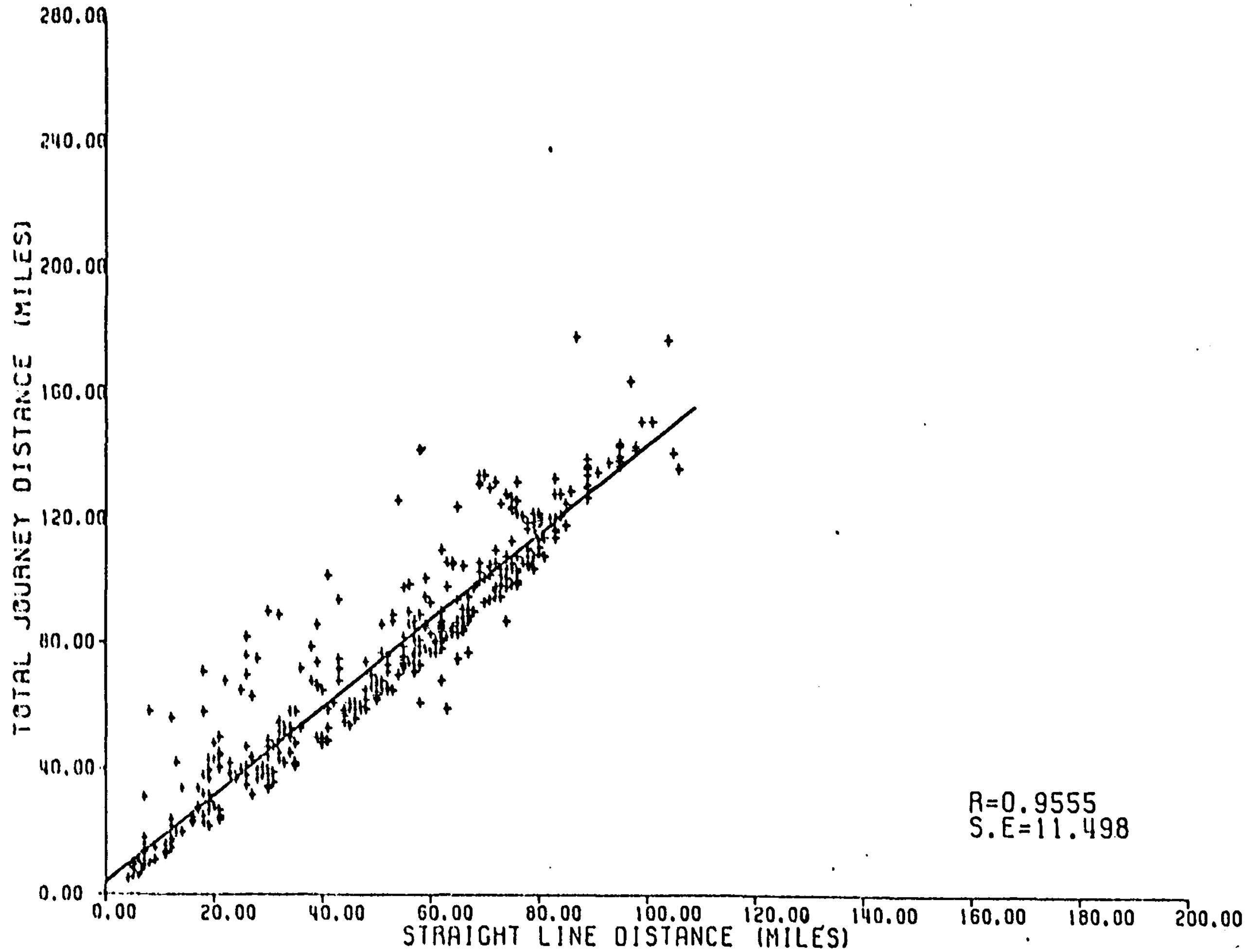
Blank matrix entries occur when coefficient is spurious, owing to intercorrelation of variables

For key to variable numbers, symbols and linkage, see FIG·

FIG.30 STRAIGHT LINE DISTANCE VS. TOTAL JOURNEY DISTANCE

REGRESSION ON TOTAL SAMPLE N=620

Y=4.0149+1.3914X



whole sample. Such extreme cases represent high or low values of the variable Sinuosity. High sinuosity values might be associated with journeys made rarely, or with journeys for which no alternative route exists. Low sinuosity values might indicate a rail journey so efficient and direct that an alternative route is not considered. We shall return later to this general problem.

Also of interest is the high correlation between Total Journey Distance and the Distance of the Alternative Whole Journey, for the 227 cases in the A.W.J. Affirmative sample. The correlation coefficient is +0.9539 between the standard scores of the two variables (Figure 29), and +0.9824 for actual values of the variables in miles. The closeness of fit in Figure 31 yields the equation:

$$\Sigma D = 0.3952 + 0.9839 D.A.W.J. \text{ miles}$$

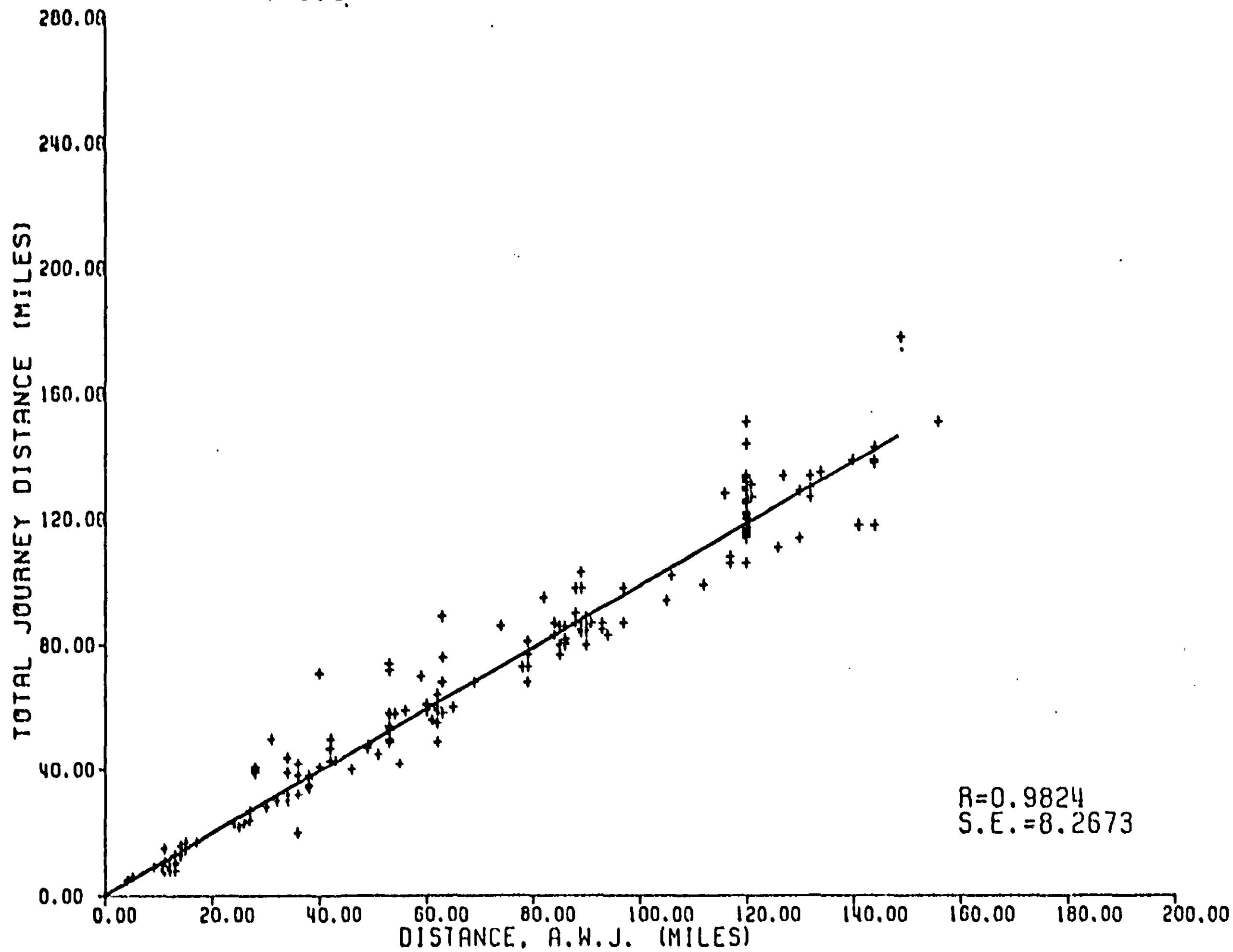
with a standard error of 8.2673 miles. There is no reason to suppose that persons making an alternative road journey do so because such a journey involves a lower route mileage. That is not to say, however, that the road journey may not be more convenient.

The remaining correlations in Figure 29 greater than +0.9000 do not merit extensive discussion. The high correlation of Rail Journey Distance with both Straight Line Distance and the Distance of the Alternative Whole Journey adds to above comments only in that it indirectly suggests a fairly constant ratio between Rail Journey and Added Journey

FIG. 31 DISTANCE, A.W.J. VS. TOTAL JOURNEY DISTANCE

A.W.J. AFFIRMATIVE, REGRESSION ON SAMPLE N=227

Y=0.3952+0.9839X



distance. The correlation between Rail Cost and the Distance of the Alternative Whole Journey is of course rédundant by virtue of the bond between rail cost and rail distance.

Returning to the comparison of the interviewed and alternative journeys, we note a correlation coefficient of +0.7684 between their cost (Figure 29, right-hand matrix, variables 9 and 16), comparing their standard scores, and of +0.7899 when the transformed values are compared. The linear equation for the latter is:

(1) $\sqrt{\Sigma C} = 0.7749 + 1.6686\sqrt[3]{C,A.W.J.}$ square root pence

with a standard error(of the square root)of ∓ 2.6552. Substituting 100 pence for the cost of the alternative journey, we obtain:

$$\sqrt{\Sigma C} = 8.5237$$
$$\Sigma C = 72.5 \text{ pence}$$

When the regression is reversed, the correlation coefficient is identical, and the equation is:

(2) $\sqrt[3]{C,A.W.J.} = 1.7991 + 0.3739\sqrt{\Sigma C}$ cube root pence

with a standard error (of the cube root) of ∓ 1.2569. Substituting 72.5 pence for the Total Cost of the Journey, we obtain:

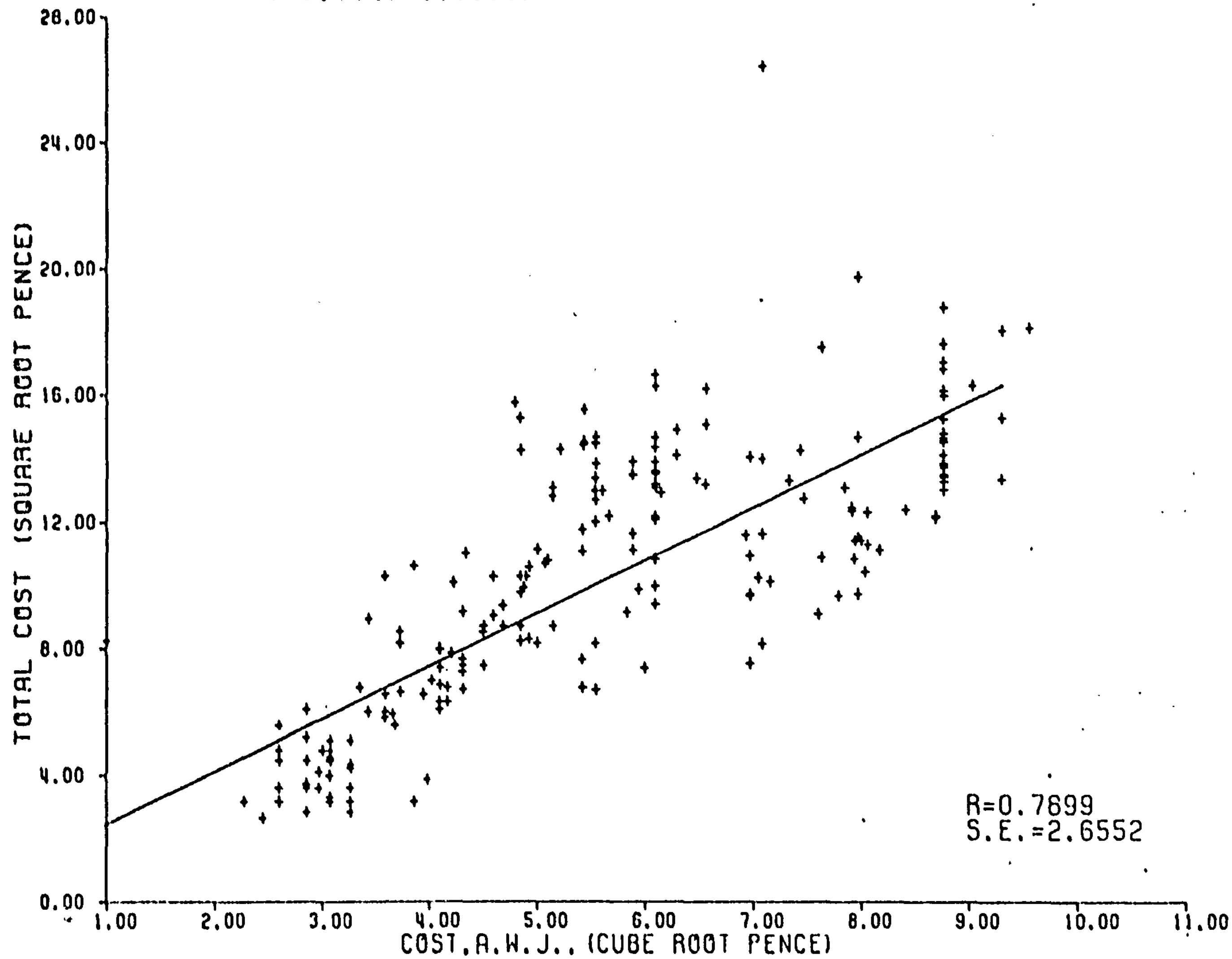
$$\sqrt[3]{C,A.W.J.} = 4.98$$
$$C,A.W.J. = 123.5 \text{ pence}$$

Figure 32 illustrates the linear model equation (1) above. The correlation coefficient of the same variables <u>before</u> transformation is only +0.6516, and the corresponding equation

FIG.32 TOTAL COST (V.9) VS. COST A.W.J. (V.16)

A.W.J. AFFIRMATIVE, REGRESSION ON SAMPLE N=227

Y=0.7749+1.6686X



is as follows:

$$\Sigma C = 57.6434 + 0.2543C, \text{A.W.J. pence}$$

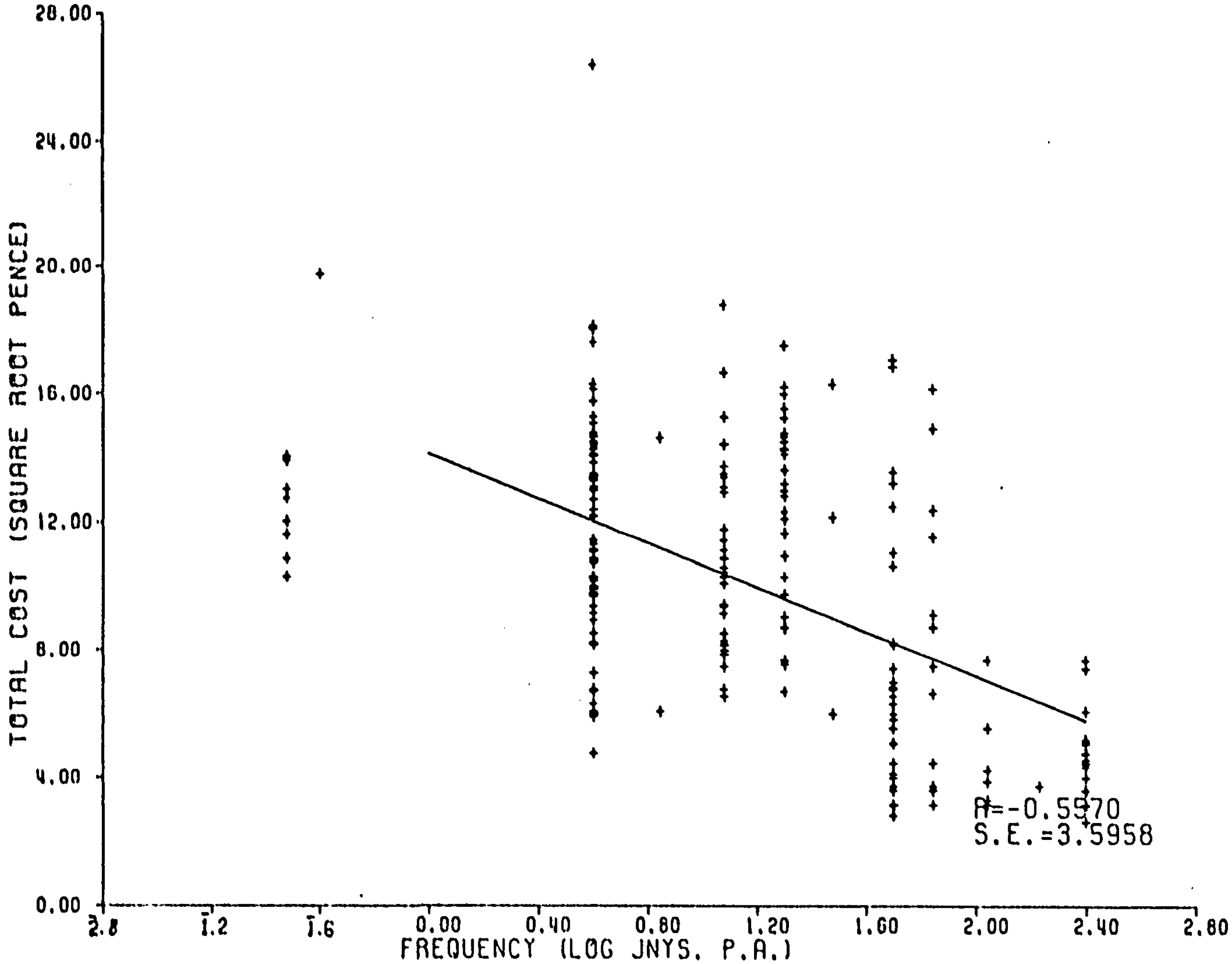
with a standard error of estimate of 70.241 pence. In summary, those individuals in the sample making the journey between their point of origin and destination other than partly by rail, do so only at greater cost. The difference between the two journey costs is greater when the costs themselves are greater. The scatter in Figure 32, however, is relatively even about all points along the regression line, suggesting that the disproportionate increase in the cost of the alternative journey does not deter its occurence even when the costs differ by a factor of three or more. Since it was noted above that the alternative journey involves no significant reduction in distance over the sampled journey using the railway, its occurence can only be explained by variables excluded from this study, such as time, convenience, comfort, and social attitudes.

It is possible to elicit one more item of interest relevant to the summary in the previous paragraph. One would expect journey frequency to be inversely related both to journey cost and journey distance. If we arbitrarily take a value for $\underline{r}$ of ∓ 0.5000 to be meaningful (given at least a level of significance of .005), then the correlation coefficients between Journey Frequency and other variables in Figure 29 for the whole sample are disappointing. $\underline{r} = -0.4200$ for Frequency and Total Journey Cost, but is lower in all other cases. In part this weak relationship must be due to the factors outside the scope of this study which affect journey frequency, but which

FIG.33 JOURNEY FREQUENCY VS. TOTAL JOURNEY COSTS

A.W.J. AFFIRMATIVE, REGRESSION ON SAMPLE N=227

Y=14.132-3.4759X



cannot be experimentally controlled, and are statistical 'noise'. In part too the inaccuracy of the frequency variable must be acknowledged. Despite these qualifications, however, values of r between Frequency and other variables are greater for the 227 cases in the Alternative Journey sample. Table 4-1 summarises the relevant correlation coefficients in Figure 29.

TABLE 4-1 Correlation Coefficients between Frequency and other Variables, for the whole and Alternative Journey samples (all significant at the 99% confidence level).

	Variable name and number	9 ΣC	8 ΣD	1 RD	15 D,A.W.J.	16 C,A.W.J.
n = 227	10 FREQ	-.5570	-.5371	-.5250	-.5061	-.5010
n = 620	10 FREQ	-.4200	-.3688	-.3326	-	-

The scatter diagram and linear model for Total Journey Cost versus Journey Frequency, for the 227 cases in the Alternative Whole Journey (A.W.J.) Affirmative sample, are given in Figure 33. The equation for the transformed variables is:

$$\sqrt{\Sigma C} = 14.132 - 3.4759\log FREQ \text{ square root pence}$$

with a standard error for the derived value of ∓ 3.5958, as a square root.

The null hypothesis, that the difference between values of r in Table 4-1 for the two samples can be accounted for by chance alone, may be tested by comparing the correlation coefficients of Total Journey Distance and Journey Frequency.

Since the transformations differ for the variable Total Journey Cost, a direct comparison of the r values for the two samples between this variable and Journey Frequency is not possible, useful as it would have been in the light of the relative strength of the linear model cited in the previous paragraph.

The standard error of the difference between two independent z coefficients is:

$$\sigma_{dz} = \sqrt{\frac{1}{N_1 - 3} + \frac{1}{N_2 - 3}} = \sqrt{\frac{1}{617} + \frac{1}{224}} = 0.078$$

and the corresponding z coefficients of the two r's -0.5371 and -0.3688 are 0.60 and 0.39. The formula for $\bar{z}$ is:

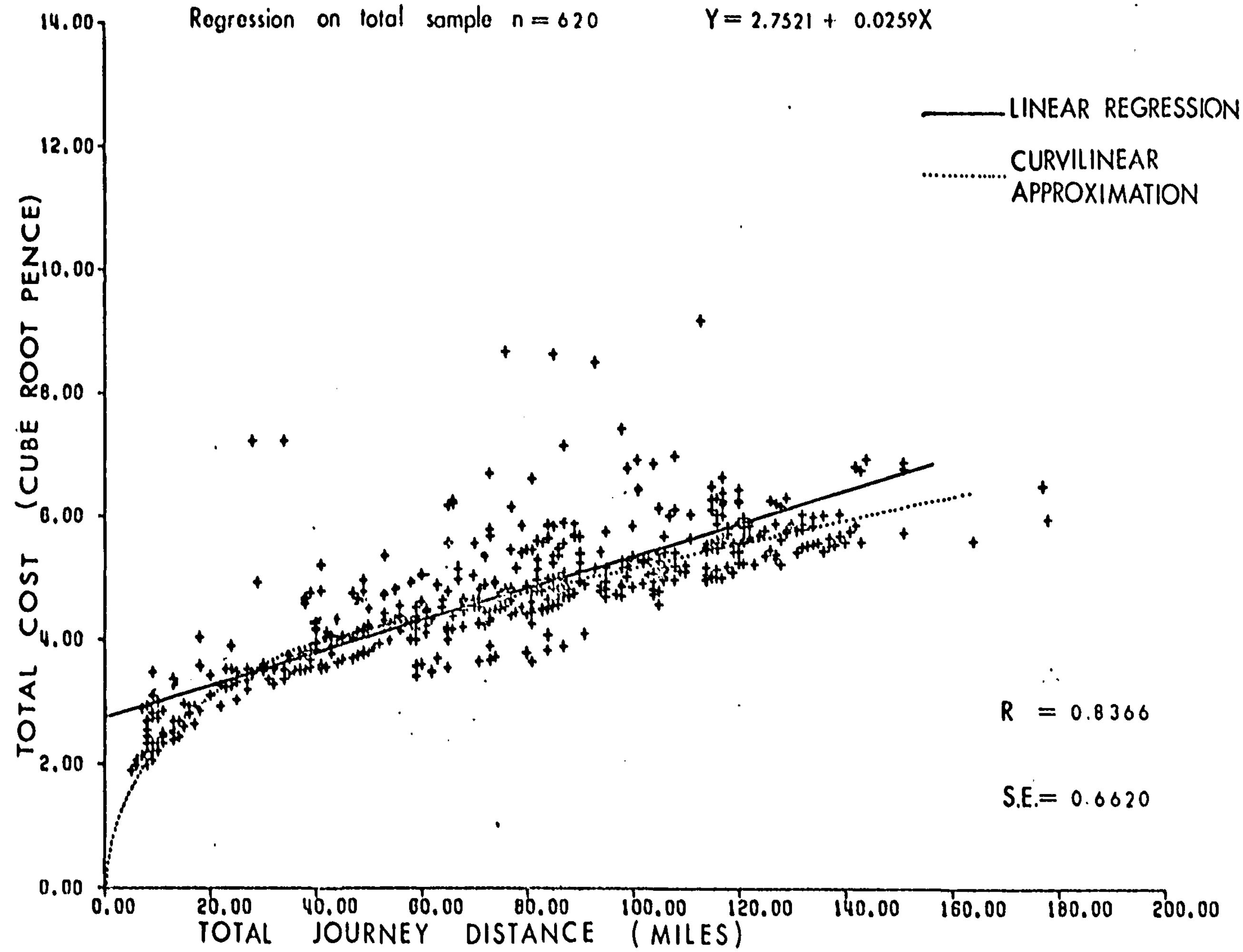
$$\bar{z} = \frac{z1 - z2}{\sigma_{dz}} = \frac{0.60 - 0.39}{0.078} = 2.69$$

Since the sampling distribution of Fisher's z is normal, the sampling distribution of z1 - z2 is also normal, and $\bar{z}$ may be interpreted as a standard score. The difference in $\bar{z}$'s deviates from a difference of 0.0 to the extent of 2.69σ, which is significant at the .005 level. The null hypothesis of no difference in the z values is therefore rejected, and thus the original null hypothesis of no significant difference between the r values for the two samples is also rejected. The above method was taken from Guilford (1965, pages 189-190).

Why should Journey Distance and Journey Frequency be more highly correlated for the sample of persons who had made an Alternative Journey than for the whole interview sample? The mean frequency in journeys per annum for the A.W.J. Affirmative sample (n=227) is 24.979, while for the A.W.J. Negative sample (n=393) it is 44.808. The mean length of the interviewed journey (i.e. Total Journey Distance) is greater for the former, 78.998 miles, than for the latter, 69.189 miles. Thus although there are more long journeys in the A.W.J. Affirmative sample, they are made less frequently. One possible explanation is that the option on the alternative journey itself tends to reduce the frequency of the interviewed journey. Also, the correlation between Journey Cost and Journey Frequency suggests that although the interviewed journey is less expensive than the alternative journey in the majority of the 227 A.W.J. Affirmative cases, both may be so expensive at increasing distances that the journey is made irregularly or rarely. Similarly, when cost is low and frequency per annum is high, the absolute difference in journey cost will not discourage the occasional substitution of the road for the rail journey. Adherence or otherwise to a set method of travelling between two points does seem to be reflected in the strength of the relationship of Journey Cost and Distance to Journey Frequency.

It was mentioned above (pages 51-52) that the linear model might be a close approximation to the relationship between two variables, for specified ranges of values of those variables, even if the actual relationship were curvilinear. In Figure 34, for example, the linear model provides a good

FIG·34 TOTAL JOURNEY COST VS. TOTAL JOURNEY DISTANCE



estimate of Journey Cost from Journey Distance for distances between 30 and 120 miles. For distances approaching zero and greater than 120 miles, however, cost is overestimated. Otherwise the equation:

$$\sqrt[3]{\Sigma C} = 2.7521 + 0.0259\Sigma D \text{ cube root pence}$$

holds. The extreme positive residuals in the scatter in Figure 34 are possibly associated with the pursuance of part of the journey by taxi, while positive residuals closer to the regression line may be associated with car or pirate journeys to or from the station. Using the above equation to estimate cost per journey mile over a range of distances gives the following results (Table 4-2).

TABLE 4-2 Estimation of Cost per Journey Mile from selected values of Total Journey Distance and predicted values of Total Journey Cost.

Total Journey Distance miles	Total Journey Cost pence	Cost per Journey Mile pence
10	27	2.7
20	35	1.8
30	44	1.5
40	55	1.4
50	67	1.3
60	80	1.3
70	96	1.4
80	112	1.4
90	132	1.5
100	153	1.5
110	176	1.6
120	202	1.7
130	230	1.8
140	260	1.9
150	292	2.0
160	327	2.0
170	365	2.1
180	406	2.2

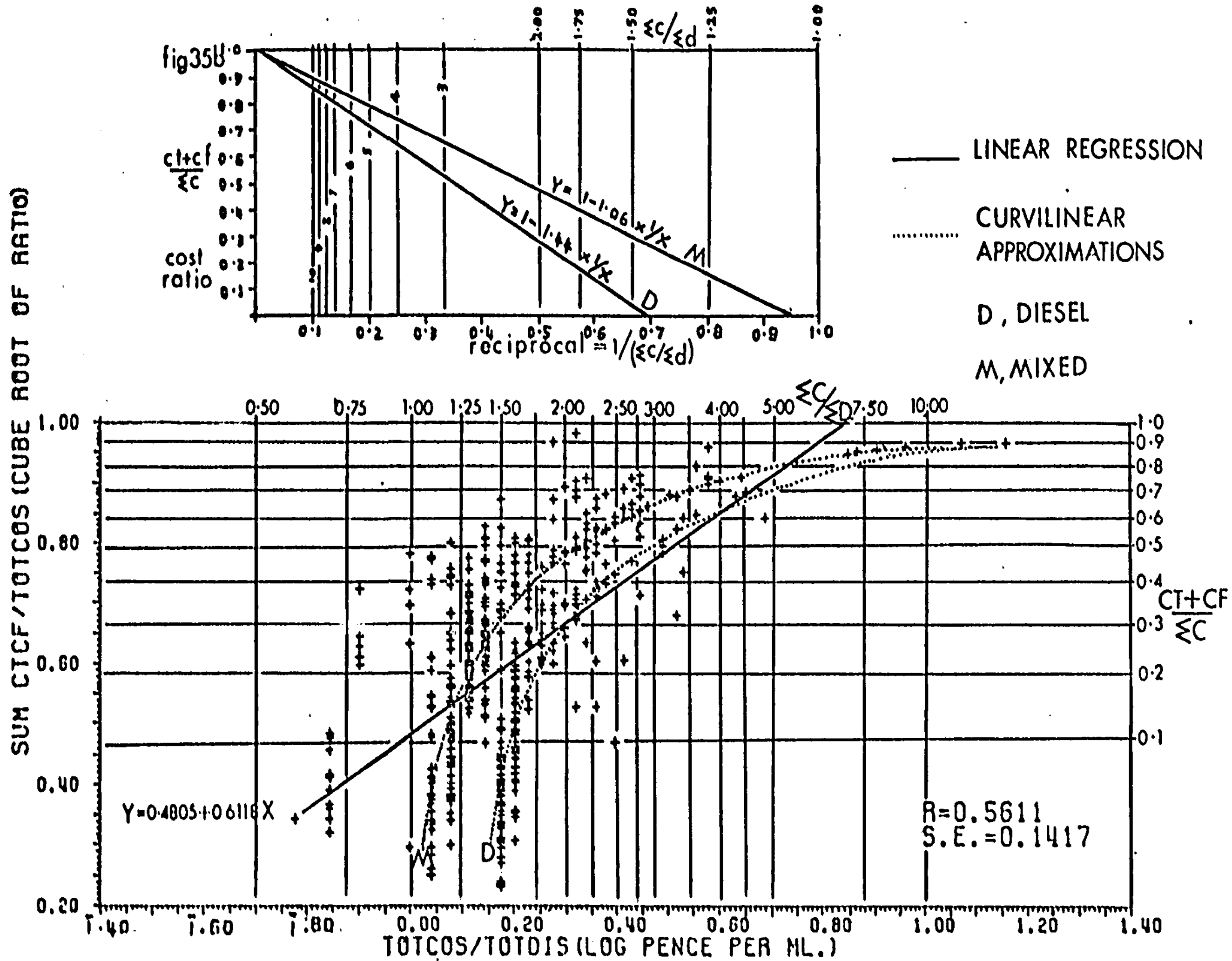
The minimum predicted value of cost per journey mile, 1.3 pence, occurs at 50 and 60 miles, suggesting a minimisation of the added journey cost as a proportion of the total journey cost at about these distances.

Mean cost per journey mile, however, is fundamentally influenced by the rates charged on mixed and diesel trains. Reference has been made above (page 34) to the bimodal distribution in Figure 20 which is supposedly related to the railway rate structure. The value of added journey cost as a proportion of total journey cost should therefore also be sensitive to these two basic rates, particularly in cases where the rail cost is by far the largest item in journey expenditure. In addition, the constant rate per mile applied to foot journeys should accentuate this sensitivity, since such journeys are characteristically of short distance, and are therefore associated with low values of added cost as a proportion of total cost. In 130 cases the whole added journey to and from the station was made by foot, 21 per cent of the total interview sample.

The inadequacy of the linear model to express the nature of the relationship between the Added Cost Ratio and Cost per Journey Mile is demonstrated in Figure 35. Despite a correlation coefficient of +0.5611, the standard error of estimate of ∓ 0.1417 of the predicted value, as a cube root, renders the linear model almost entirely worthless as a predictor, a point made with equal weight by the scatter of the

FIG.35 V.14, SUM CTCF/SUM COST VS. V.12, SUM COST/SUM DIST.

REGRESSION ON TOTAL SAMPLE N=620



points in Figure 35. Rather the scatter seems to consist of two distinct curvilinear relationships. It is suggested that the curves in Figure 35, which are freehand approximations, express distinct models applying to second class mixed and diesel train passengers. It is further suggested that both models describe a bivariate distribution that is satisfied by the equation:

$$Y = \underline{a} - \underline{b}\,\frac{1}{X}$$

when Y is the Cost Ratio, with limit values of 0.0 and 1.0, and $\frac{1}{X}$ is the reciprocal of the Cost per Journey mile. Figure 35B illustrates the transformation of the curvilinear approximations in Figure 35 to a pair of linear equations, when a reciprocal scale is employed for values of X, and actual Y values are used. The respective equations for mixed and diesel trains are:

$$(1)\quad \frac{CT + CF}{\Sigma C} = 1 - 1.06 \times (1/(\Sigma C/\Sigma D))$$

$$(2)\quad \frac{CT + CF}{\Sigma C} = 1 - 1.44 \times (1/(\Sigma C/\Sigma D))$$

Since the legal maximum rate on Jamaican licensed stage carriage services is twopence per mile, the above equations may be used to calculate the permissible value of the Added Cost Ratio before the rail journey ceases to be competitive with a road journey by bus over the same distance. For mixed trains this value is 0.47 and for diesel trains 0.27. When the Added Cost Ratio is zero, the equations predict values of 1.05 and 1.43 pence per mile respectively for mixed and diesel trains. The real values under these conditions are 1.17 and 1.50 pence per mile. The difference does not seriously question the usefulness of the model. The model can also be used to assess the consequences of a change in the prevailing rates on the railway. Thus, without commensurate increases in bus rates, there would be a sharp reduction in the area served by the railway as rail rates approached twopence per mile.

This chapter has not exhausted all possible discussion of the relationships suggested in the correlation matrix. The correlation between Rail Journey Distance and the Distance Travelled from the Station is +0.6019, far higher than that between the former variable and Distance Travelled to the Station (+0.3005). The difference may be related to the sample bias discussed on page 27 above. Curvilinear relationships such as that in Figure 35 may be masked by low correlation coefficients in Figure 29. On the other hand correlation coefficients derived from variables for which symmetry or kurtosis coefficients exceed 1.95 are not as reliable as one would wish.

It is felt that the approach already initiated in this chapter is the one most worthy of further analysis, that is, the attempt to detect group differences in the sample. With the Alternative Whole Journey Affirmative cases verified as a distinct group by the comparison of correlation coefficients, and the mixed and diesel train passengers distinguished by a simple graphical approach, it is appropriate to move on to other possible group differences, and to other suitable modes of analysis.

CHAPTER FIVE

GROUP DIFFERENCES

The individual making a rail journey in Jamaica is to some extent limited in his freedom of choice, in how it is made, at what cost, and how often, if indeed the journey can be made at all. Within these limitations, however, we might expect characteristic types of individuals and of journeys to emerge. It is the object of this chapter to identify these journey types and the characteristics which distinguish them one from another, with some attempt to explain these differences where they exist.

Journeys are made for a variety of reasons; they are made with a purpose. The purposes defined by the Jamaicans interviewed were placed within the sixfold classification of 'personal','business', 'work','leisure', 'market', and 'shopping' journeys. Intuitively, journeys are made for more than six purposes. Moreover, the six purposes stated above are not necessarily mutually exclusive. They do at least, however, represent a form of Jamaican self-classification.

Do journeys made with different purposes vary with respect to measured variables of cost, distance and frequency? The journeys in the sample were made with varying frequencies. Can a group of journeys classed into a given frequency range be recognised by other attributes?

Each rail journey is preceded and followed by an added journey to and from the station. The distance travelled from the station may be reduced from a continuous variable to supposedly distinct classes, for ease of analysis. The mean values for certain variables may differ for each distance class, and suggest changes in the way in which the journey is made as the added journey distance increases.

The combined mode-class grouping attempts to define distinct pairs of modes of travel employed in getting to and from the station. It is likely that certain paired combinations will be associated with characteristic costs and distances, for example journeys by foot both to and from the station. Other combinations, for instance a taxi journey with a foot journey, may defy description or explanation, other than in the context of the individual journey rather than of the group into which it is classified.

This chapter, then, deals with two interlinked themes. Given a set of classifications, can we say more about the way Jamaican rail journeys are made under certain conditions, and given a set of measured attributes which are continuous variables, can we make some assessment of the usefulness or otherwise of the set of classifications? As Harvey (1969, page 326) points out, classification may be regarded as a means for searching reality for hypotheses, or for structuring reality to test hypotheses. Brown (1963, page 168) has warned against useless classification:

> When someone produces a 'bulky system' he must also answer the implied question, "A system for what?" He cannot merely reply "It organises the data." <u>Any</u> criterion will organise data—will order items into

> classes— but only some systems of classification will be scientifically useful.

If the criterion of usefulness is placed foremost, then this chapter should continue and widen the objective of prediction stressed in the previous chapter; prediction, that is, set in a probabilistic framework and in the knowledge that the interview sample is not random. Popper (1957) points out that:

> Ordinary predictions in science are conditional...They assert that certain changes... will be accompanied by other changes. The historicist does not, as a matter of fact, derive his historical prophecies from conditional scientific predictions....He cannot possibly do so because long term prophecies can be derived from scientific conditional predictions only if they apply to systems which can be described as well-isolated, stationary, and recurrent. These systems are very rare in nature, and modern society is certainly not one of them.

Models of predictive value developed in this study are of value only as long as the circumstances in which they are set are unchanging. The form that a journey takes is inextricably bound to the society in which it is made, to its value system, its social structure, and to the pattern of interaction in the space economy.

In the previous chapter (Figure 29) we note a value of $\underline{r} = +0.7919$ for the variables Straight Line Distance and Total Journey Cost, for the whole sample n = 620. Before the application of standard scores the relationship is:

$$\sqrt[3]{\Sigma C} = 2.8744 + 0.0357 \text{S.L.D. cube root pence}$$

$$\underline{r} = +0.7915 \quad \text{S.E.} = 0.7383 \quad \text{sign. } .001$$

Does this equation apply to all predetermined groups of cases in the total of 620 with an equal chance of error in the estimate of journey cost from straight line journey distance? Figures 36 to 41 are scatter diagrams of these two variables for the cases in each of the six journey purpose groups. For each scatter, a regression line has been fitted freehand, and the corresponding equation has been included on each Figure. For work, leisure and business journeys (Figures 37, 39 and 38) the scatter suggests a close positive correlation. The large number of cases (n = 288) classified as personal journeys are more widely scattered in Figure 36, suggesting that this group contains many dissimilar individuals in respect of cost and straight line distance. Since 23 of the 32 shopping journeys (Figure 41) were made within 12 miles of central Kingston, the extension of the regression line to include values of up to 80 miles is of doubtful validity, despite the good fit obtained. In the case of higgler journeys, journeys to sell at market, all but 7 of the 42 journeys were between 45 and 70 miles in length. Moreover, the range of costs incurred within these straight line distances was between approximately 40 and 240 pence (Figure 40). Explanation for the latter variation lies in the inclusion of the transport charges on the higglers' goods in the total journey cost, the apparently arbitrary nature of such charges, the variety of means by which the goods were carried, and the range of weights transported varying between higglers and between types of good. The clustering of the straight line distance values is due to the common

FIG. 36 PERSONAL JOURNEYS, COST VS. STRAIGHT LINE DISTANCE
SCATTER ON SAMPLE N=288

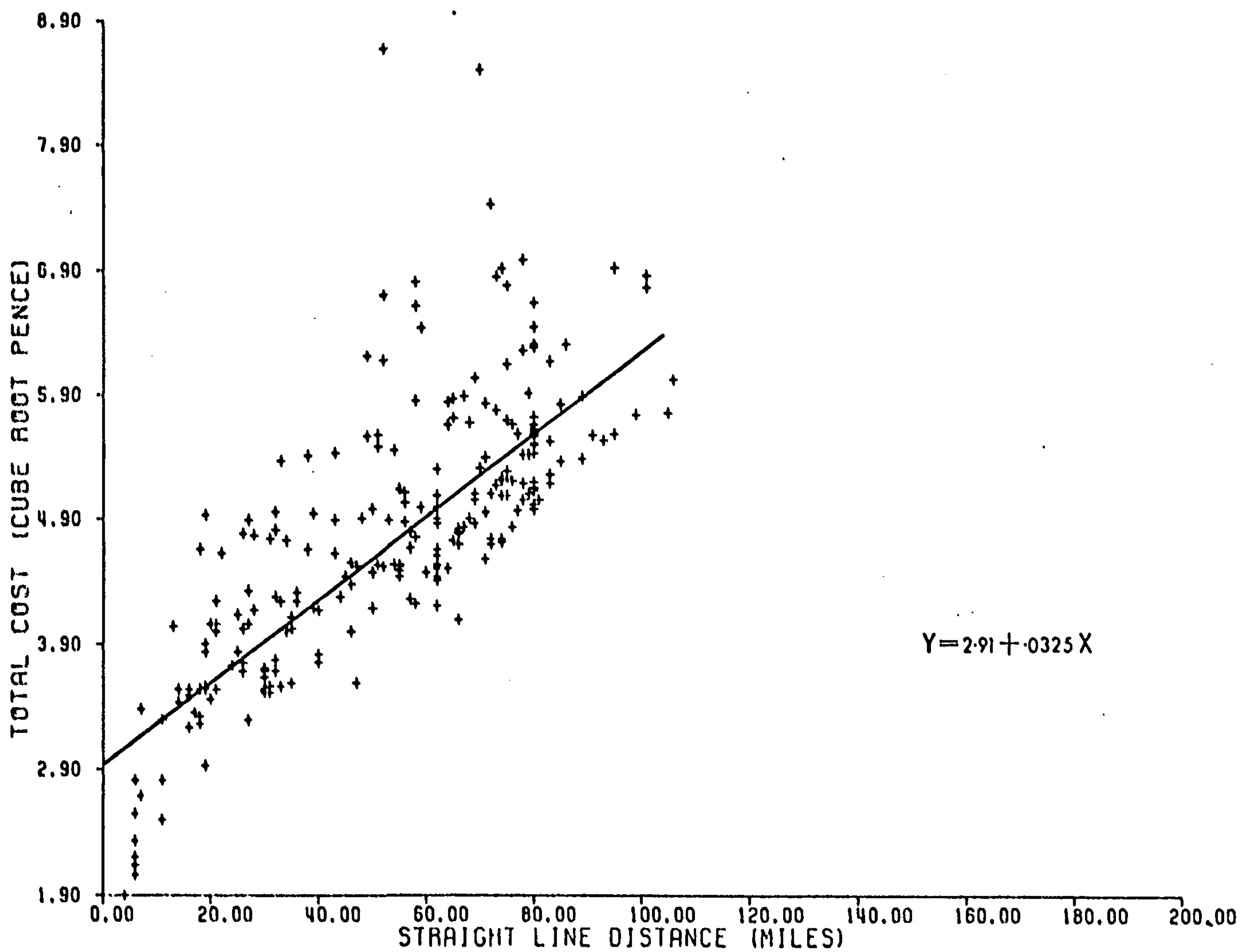


FIG.37 WORK JOURNEYS, COST VS. STRAIGHT LINE DISTANCE

SCATTER ON SAMPLE N=98

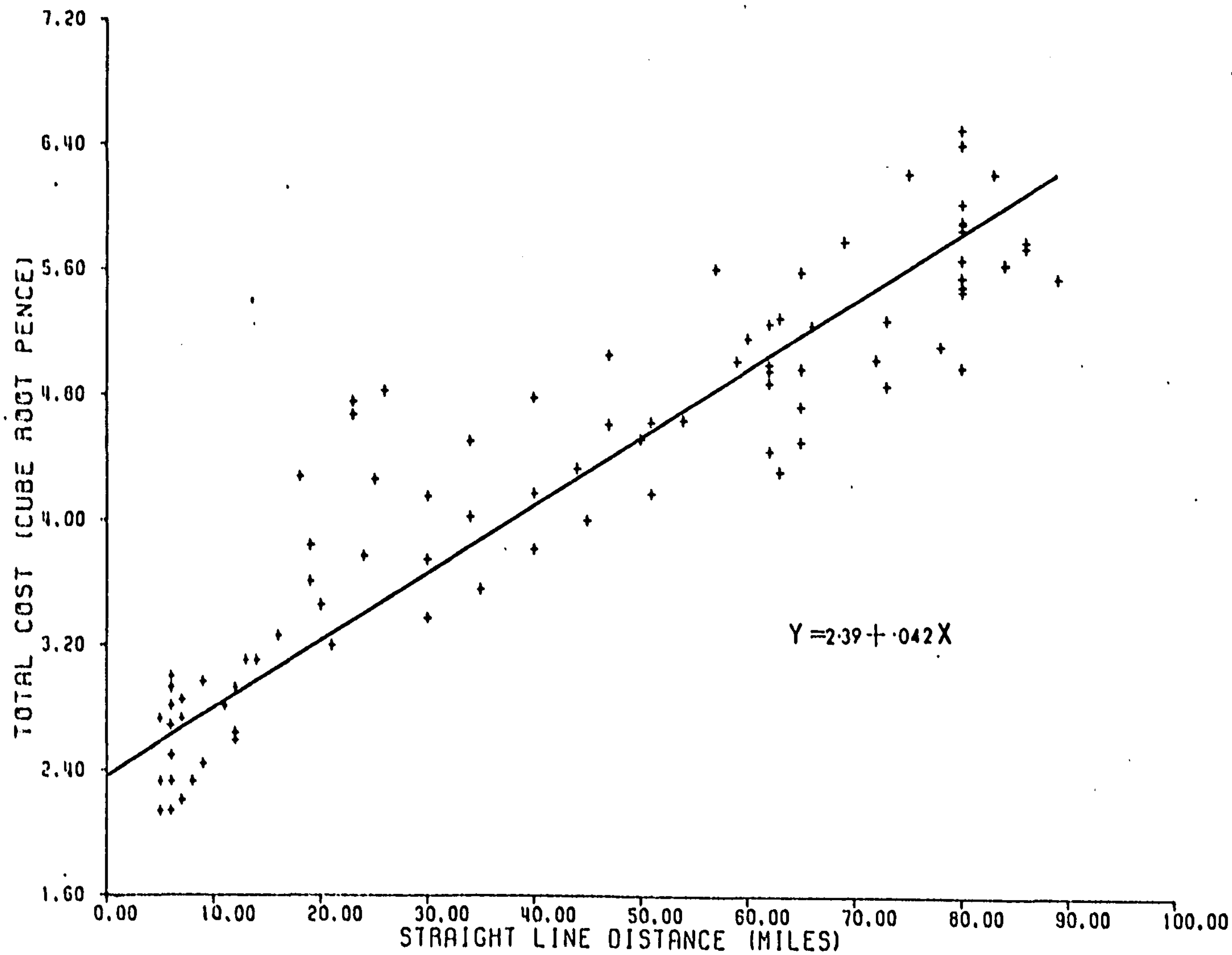


FIG.38 BUSINESS JOURNEYS, COST VS. STRAIGHT LINE DISTANCE

SCATTER ON SAMPLE, N=93

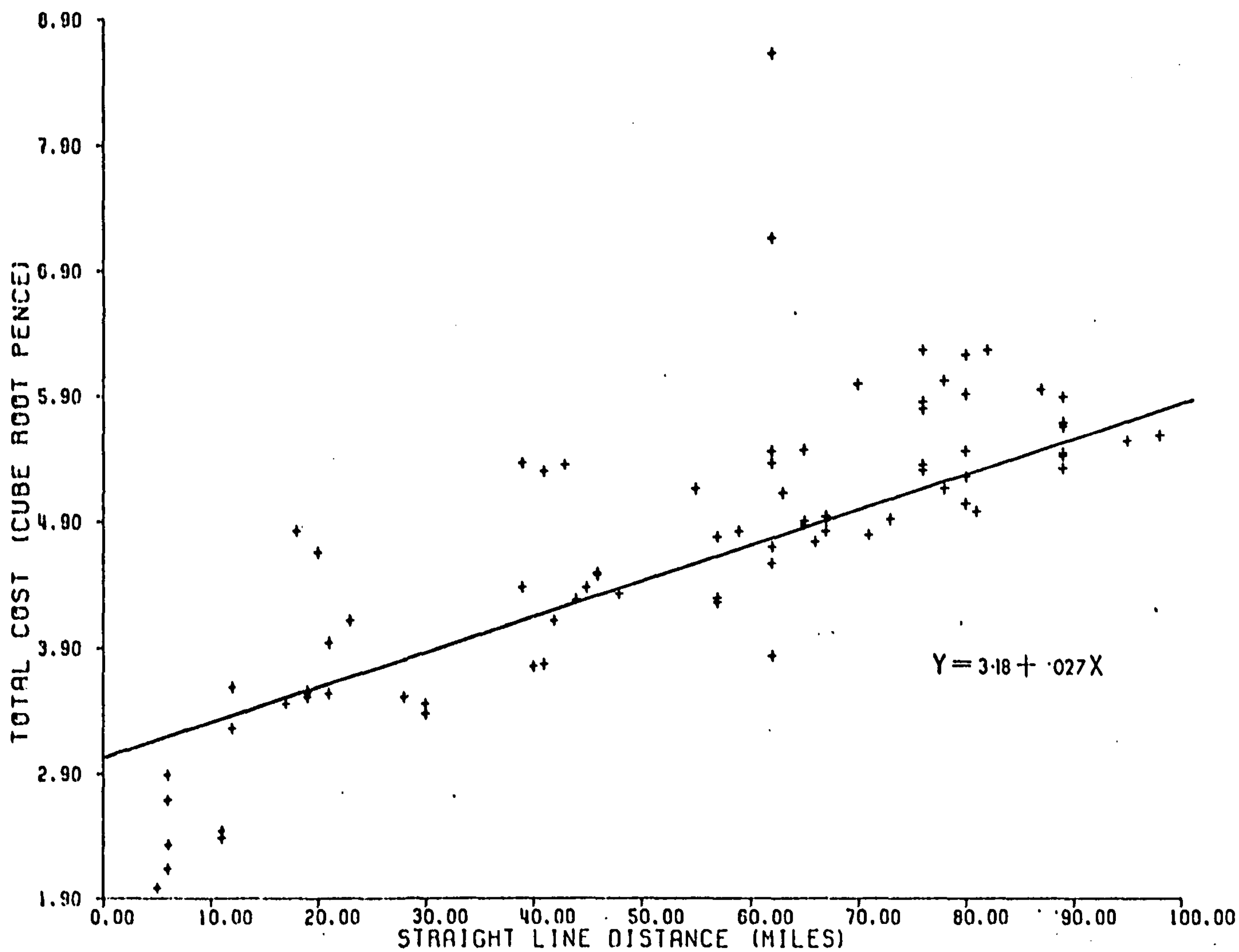


FIG. 39 LEISURE JOURNEYS, COST VS. STRAIGHT LINE DISTANCE

SCATTER ON SAMPLE N=67

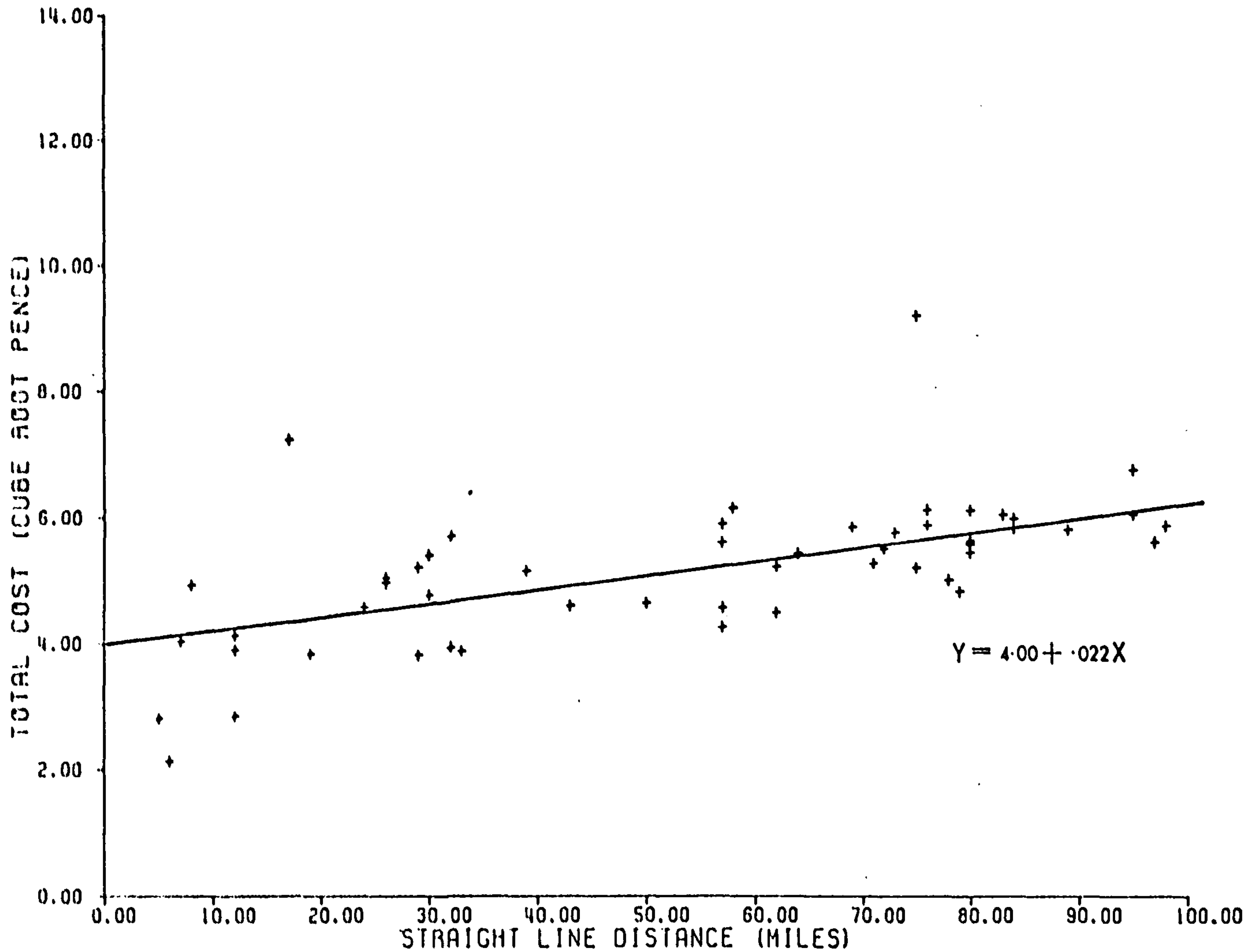


FIG.40 HIGGLER JOURNEYS, COST VS. STRAIGHT LINE DISTANCE

SCATTER ON SAMPLE N=42

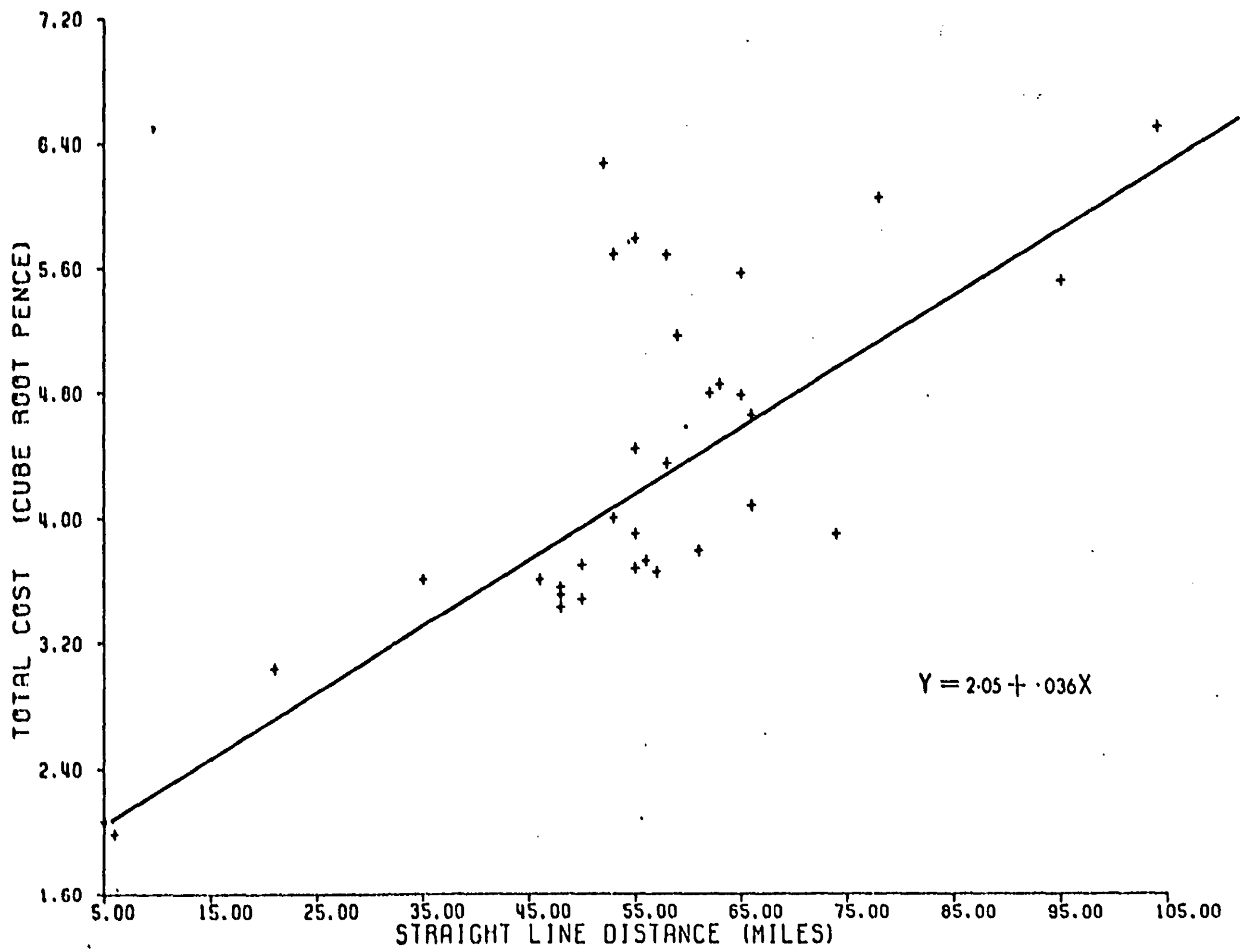
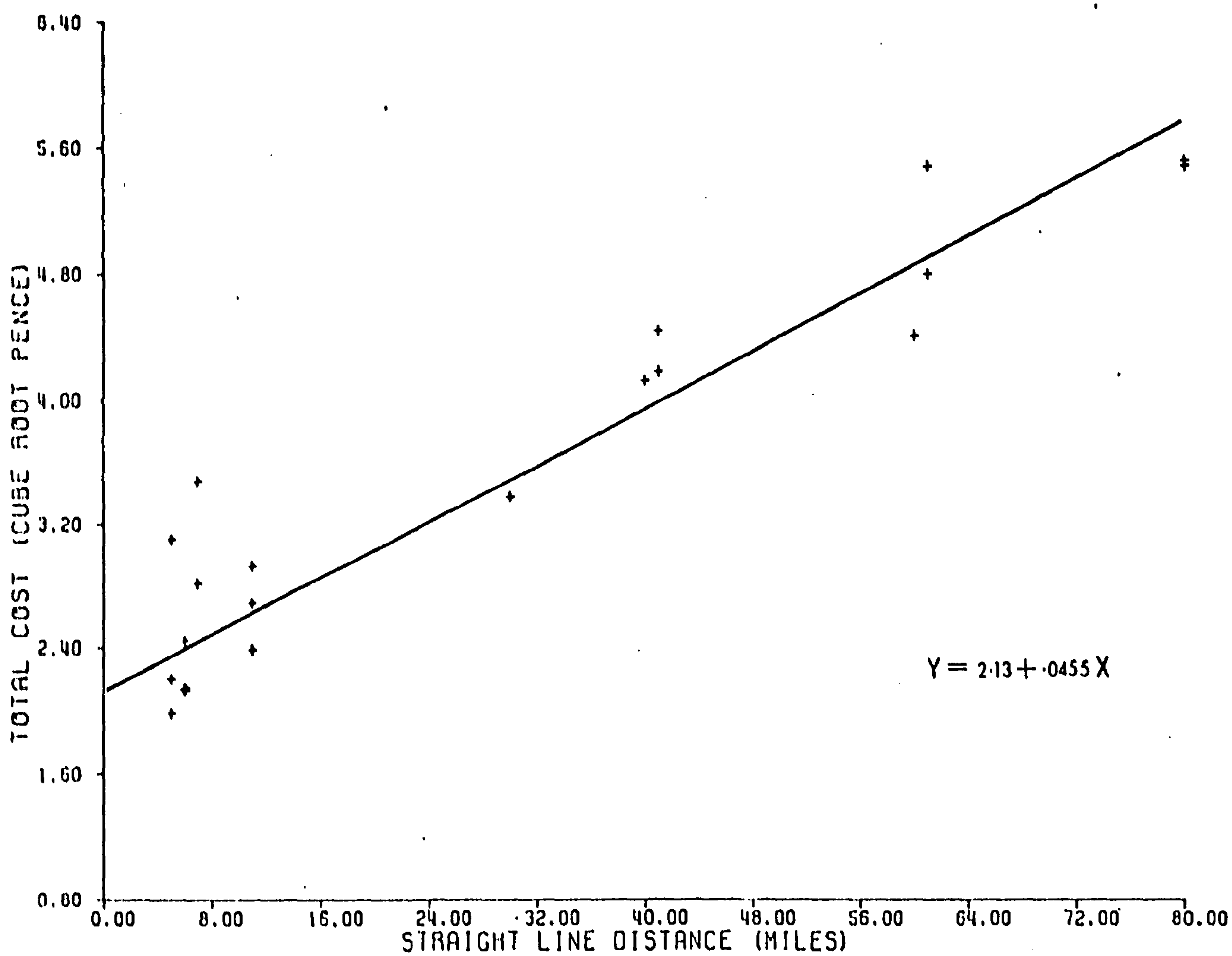


FIG. 41 SHOPPING JOURNEYS, COST VS. STRAIGHT LINE DISTANCE

SCATTER ON SAMPLE N=32



origin of the train-travelling higglers on the main line in areas around Maggotty, Balaclava, and Appleton stations, in St. Elizabeth parish (Figure 1). It is difficult to see how the cost of the return journey to Kingston, with goods, leaves any profit to speak of for many of these women, since they can carry relatively little on a single trip, usually ground provisions offering a low return per unit weight. Henriques (1953, page 76) commented:

> The grower is not compelled to sell to government, he may sell to a 'higgler'. These are generally women who find it a very satisfactory occupation as it gives them the maximum of independence. They travel around the countryside buying and transporting the produce to the best market which is often that of the capital. There would appear to be very little profit in the transactions as they have to pay the rail fare to Kingston and the cost of somewhere to sleep when they are there. However, it is an occupation which gives them full scope for the Jamaican habit of long conversations about nothing in particular, and they are no-one's servant

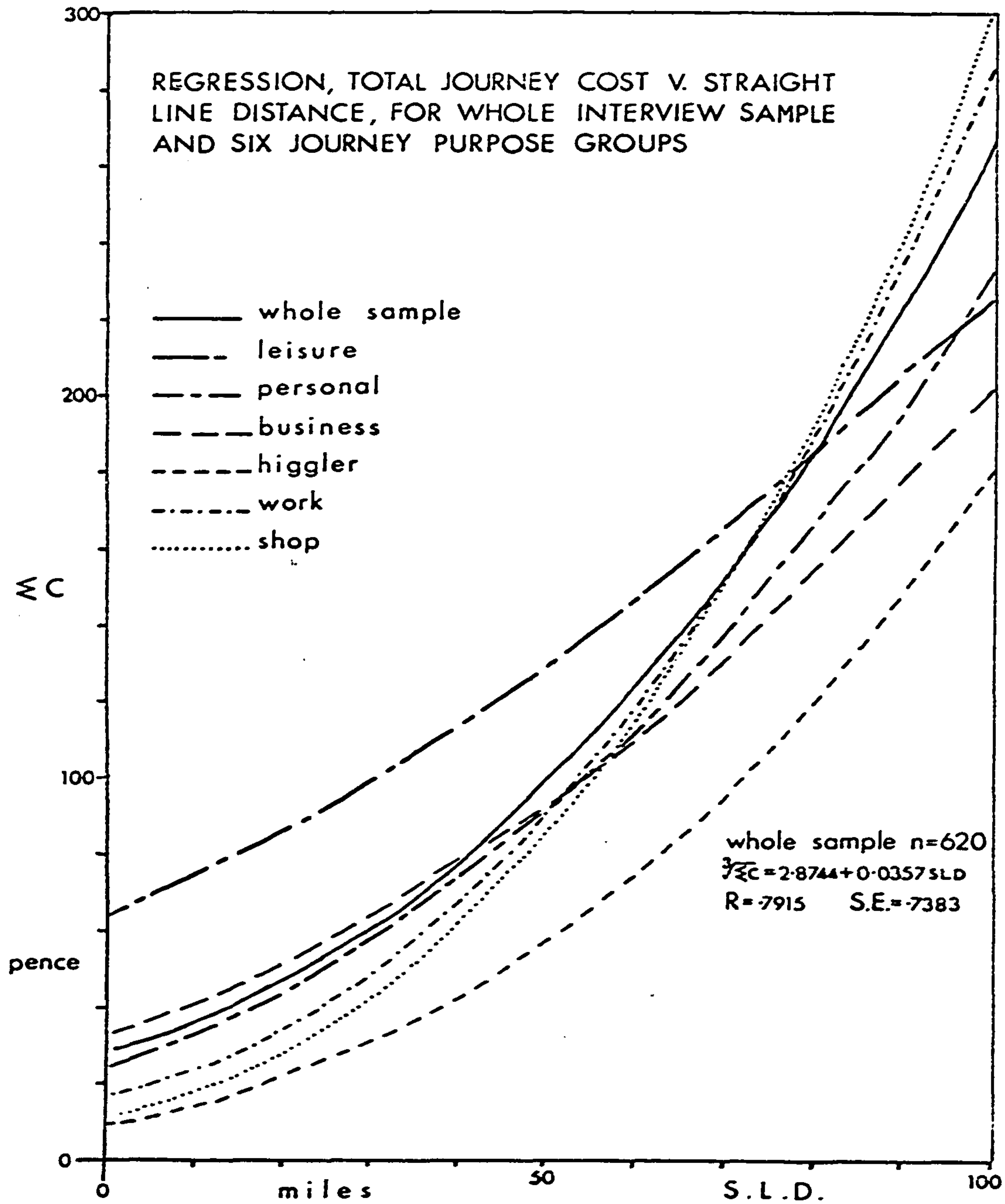
The journey to Kingston, at least for higglers travelling by rail, usually takes place twice a month. The passage quoted above does not make clear the fact that most higglers now travel by truck to Kingston except those with easy access to the railway, for the cost of moving the load by road to the station is prohibitive other than over short distances or in cases where a mule is used for this task. The Port Antonio line is also much used by higglers, who travel to Kingston from the area between Bog Walk and Annotto Bay stations, but few of these were included in the interview sample.

The equations derived in Figures 36 to 41 should not be treated as more than first approximations. The r values, standard errors of estimate, and levels of significance have not been calculated, and the regression lines were estimated by the freehand method. Their use is deliberately confined to an illustrative function in Figure 42, which combines the linear regressions for the six journey purpose groups and for the whole sample, with real values of journey cost substituted for the cube root values in Figures 36 to 41.

Leisure journeys are clearly associated with higher cost per real mile, especially for low values of straight line distance. The concessionary fares available to market passengers on the railway make the higglers the cheapest travelling group, though as noted above the range of costs they incur for a given straight line distance cannot adequately be reflected in a linear model. Work and shopping journeys are inexpensive over short distances, and in any case do not occur beyond approximately 80 straight line miles. Personal and business journeys are indistinguishable using the criterion of cost per real mile, except for extreme distance values between 80 and 120 miles, when the model predicts a higher cost per real mile for personal journeys.

Since 80 miles is the maximum straight line distance that can be travelled without a substantial increase in the length of the added journey (Kingston to Montego Bay is 80 miles direct), the rapid increase in cost beyond this value

FIG·42


REGRESSION, TOTAL JOURNEY COST V. STRAIGHT LINE DISTANCE, FOR WHOLE INTERVIEW SAMPLE AND SIX JOURNEY PURPOSE GROUPS
whole sample
leisure
personal
business
higgler
work
shop
300
200
100
0
ΣC
pence
0
miles
50
S.L.D.
100
whole sample n=620
$\sqrt[3]{\Sigma C} = 2{\cdot}8744 + 0{\cdot}0357\,SLD$
R=·7915
S.E.=·7383

predicted by the linear model for the whole sample is not unrealistic, given that rail cost per mile is uniformly less than vehicle cost per mile. This preliminary examination of grouped cases does not discourage further and more rigorous analysis.

Journey purpose and journey cost are related. Is this relationship partially accountable by differences in cost per mile paid on the railway? That is, does the composition of the travelling public on mixed, diesel and market class tickets differ significantly? Since the latter are sold exclusively to one group, this must be the case for higgler journeys. For the remaining journey purpose groups, however, the Chi Square (x^2) test may be used to test the null hypothesis that the composition by purpose on mixed and diesel trains is not significantly different.

The general formula for Chi Square:

$$x^2 = \sum \frac{(fo - fe)^2}{fe}$$

where fe is the expected value in a contingency table and fo the actual value, may be replaced by the formula:

$$x^2 = N(\sum(f^2rk/frfk) - 1)$$

where frk is one matrix entry, fk is a column total, and fr a row total. Table 5-1 is a contingency table for the number of cases in each of five journey purpose groups travelling on either mixed or diesel train second class tickets. The necessary computations are

TABLE 5-1 Chi Square Analysis, Contingency Table, Matrix of Five Journey Purpose Classes and Two Train Types

	MIXED	DIESEL	(fr)	(f^2rk)	
PERSONAL	179	109	288	31,900	11,800
WORK	31	67	98	960	4,450
BUSINESS	68	24	92	4,620	576
LEISURE	20	47	67	400	2,210
SHOPPING	24	8	32	576	64
(fk)	322	255	577		

	M	D (frfk)		($f^2rk/frfk$)		x^2
P	93,000	73,500		.3420	.1600	.5020
W	31,600	25,000		.0303	.1780	.2084
B	29,600	23,400		.1560	.0245	.1085
L	21,600	17,100		.0185	.1290	.1475
S	10,300	8,150		.0558	.0078	.0636
			x^2	.6027	.4993	1.1020

$$x^2 = N(\sum(f^2rk/frfk) - 1) = 577(1.1020 - 1) = 58.8$$

$$df = (r - 1)(k - 1) = (5 - 1)(2 - 1) = 4$$

reproduced in the Table, giving a Chi Square of 58.8. The null hypothesis is rejected at the .001 significance level, for with 4 degrees of freedom a Chi Square as great as 18.465 would occur by chance only once in a hundred samples. Since Chi Square is additive, the relative contribution of different matrix entries is also of interest, of Personal and Business journeys to the Chi Square for mixed train travel, and of Leisure and Work journeys to diesel train travel. It is worth mentioning that many of these work journeys are weekend journeys to Kingston from the bauxite mining operation at Revere, near Maggotty station.

The Chi Square test is not a very powerful one. Using the expected cell frequencies, based on the proportions in the sample travelling on mixed and diesel trains (.56 and .44 with the market class excluded), it was possible to compute a comparable Chi Square from the first equation cited above on page 86. This gave a value of 62.81, slightly greater than the 58.8 arrived at in Table 5-1. Manipulation of class groups, reducing the degrees of freedom present, can give widely differing values for Chi Square. One component in the contingency table (in this instance personal journeys) may account for a large proportion of the discrepancy contributing to the Chi Square for the whole table. We know that the 'personal' journey is an amorphous classification. Could a third factor, an unknown property of mixed train passengers, for example: reticence, inability to express information in precise terms, have caused the difference in the proportion of personal journeys on mixed and diesel trains? Rao (1952, pages 191-200) follows through the formal logic of the Chi Square test, and offers constructive criticism of the method (page 200); "It must be emphasised that the object of the test is first to establish departure from independence in a general way. For this it is enough to use a valid test which is simple to compute. Afterwards more refined tests may be used to examine some portions of the contingency table."

A second Chi Square test established the independence or otherwise of Purpose and Frequency of Journey. To avoid cell entries containing few or no cases, the Frequency class groups were reduced to three, as follows, less than once monthly, once monthly to less than once weekly, and equal to or greater than once weekly.

The results obtained are reproduced in Table 5-2, though the complete sequence of calculation, already reviewed in the previous Table, has been omitted.

TABLE 5-2 Chi Square Analysis, Contingency Table, Matrix of Sixe Journey Purpose Classes and Three Frequency Classes derived from Seven Journey Frequency Groups

	$<$1M	$\geqslant$1M-$<$1W	$\geqslant$1W	(fr)	(f^2rk/frfk)			x^2
PERSONAL	176	81	31	288	.3600	.1400	.0213	.5213
WORK	15	20	63	98	.0077	.0250	.2540	.2867
BUSINESS	48	26	19	93	.0830	.0420	.0244	.1494
LEISURE	54	8	5	67	.1460	.0059	.0024	.1543
MARKET	3	22	17	42	.0007	.0708	.0430	.1145
SHOPPING	2	6	24	32	.0004	.0069	.1130	.1203
(fk)	298	163	159	620	x^2 .5978	.2906	.4581	1.3465

$x^2 = 620(1.3465 - 1) = 215$

$df = (6 - 1)(3 - 1) = 10$

The Chi Square value, 215, in Table 5-2 may be compared with the required Chi Square of 29,588 for 10 degrees of freedom at the .001 significance level. The null hypothesis that the groupings are not dependent is therefore rejected. Examination of Table 5-2 reveals the tendency for shopping and work journeys to be made with the greatest frequency, and leisure journeys with the lowest frequency. Both personal and business journeys are made on the whole with a low frequency, the frequency for the latter being only slightly greater. Higgler journeys are the only group for which the dominant journey frequency is between less than once monthly and once weekly. It is perhaps not coincidental that the greatest cell entry is for personal journeys made less often than once monthly, 28.4 per cent of all journeys, and contributing .266 of the total x^2 as a proportion. This may merely support the view that journeys of unspecified purpose tend to be made with unspecified frequency.

The Chi Square test was also used to test the degree of dependence of the Journey Frequency and Combined Mode-Class groups. The distributions of modes of travel employed in getting to and from the station are almost identical (Table 5-3). Figure 43, however, illustrates the difficulty in deciding what are the significant pairings of modes when there are 50 possible pairs. Classes 4, 5, 6, 8 and 9 were amalgamated, since they contained an insufficient number of cases for analysis. Any pair of modes including a taxi or pirate

TABLE 5-3 Comparison of Cell Frequencies, Modes of Journey to and from Station, and overall frequency for sample.

MODE CLASS	CLASS NO.	NO. OF CASES TO STATION	NO. OF CASES FROM STATION	TOTAL NO. OF CASES	% OF CASES IN SAMPLE
Foot	0	241	255	496	40.1
Bus	1	233	243	476	38.7
Car	2	49	42	91	7.5
Taxi	3	62	45	107	8.7
Truck	4	2	-	2	0.2
Train	5	5	1	6	0.5
Cycle	6	-	-	-	-
Pirate	7	28	27	45	3.7
Handcart	8	-	6	6	0.5
Motor-cycle	9	-	1	1	0.1
All Modes		620	620	1240	100.0

journey was classed into one of two groups, since the possibly unusual nature and exceptional expense of these journeys was an object of interest. Car journeys were isolated in the same way, in combination with a foot or bus journey or a journey by another car. Paired foot journeys, foot and bus journeys, and paired bus journeys were placed into three separate classes. Remaining possible combinations were placed in the class 'other'. Thus seven combined mode-class groups were arrived at (Table 5-4). In the Chi Square test the category 'other' combined modes were omitted from the contingency table

TABLE 5-4 Number of Cases in each Combined Mode-Class Group

CLASS	NO. IN CLASS	% OF TOTAL
FOOT-FOOT	130	21.0
FOOT-BUS	172	28.0
BUS-BUS	114	18.4
FOOT/BUS/CAR-CAR	59	9.4
PIRATE-TAXI, x-TAXI	85	13.6
x-PIRATE	46	7.4
OTHER	14	2.2
TOTAL	620	100.0

The results in Table 5-5 demonstrate the rejection of the null hypothesis that the two groupings are not dependent. With 10 degrees of freedom the necessary Chi Square at the .001 significance level is 29.588, while the computed Chi Square is 101. Higher journey frequencies, characterised by paired foot journeys or by foot and bus journeys, and lower frequencies, characterised by paired bus journeys or by journeys made partly by car, taxi or pirate, are more clearly defined than the intermediate frequency class. It is suggested that the apparent relationship between Journey Frequency and the modes of travel employed in getting to and from the station is related partially to the relative costs of such modes, partially to the distances over which they are usually employed, and partially to the difficulty of the journey which the use of certain modes reflects.

TABLE 5-5 Chi Square Analysis, Contingency Table, Matrix of Six Combined Mode Classes and Three Frequency Groups

	<1M	⩾1M⩽1W	⩾1W	(fr)	(f^2rk/frfk)			x^2
FOOT-FOOT	35	26	69	130	.0328	.0334	.2350	.3012
FOOT-BUS	69	50	53	172	.0940	.0935	.1047	.2922
BUS-BUS	74	33	7	114	.1630	.0614	.0028	.2272
x-PIRATE	24	13	9	46	.0425	.0235	.0113	.0773
P-T, and x-T	52	23	10	85	.1090	.0400	.0075	.1565
B/F/C-CAR	40	11	8	59	.0925	.0131	.0069	.1125
(fk)	294	156	156	606	x^2 .5338	.2649	.3682	
								1.1669

$x^2 = 606(1.1669 - 1) = 101$

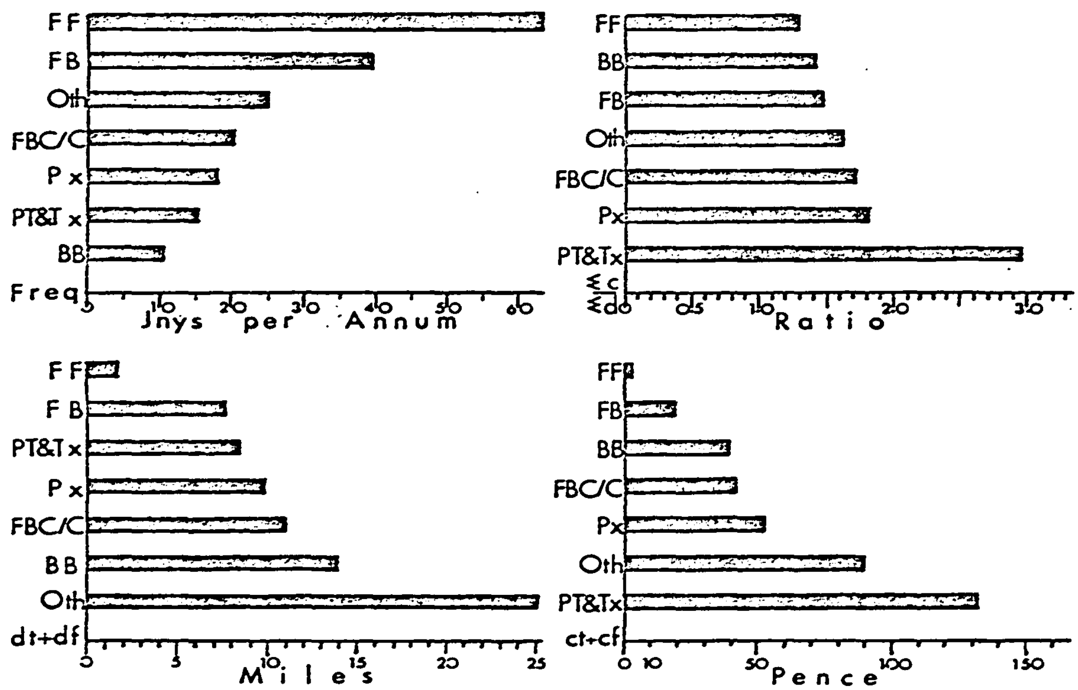
$df = (6 - 1)(3 - 1) = 10$

Four journey variables were chosen as being possibly indicative of the factors discussed in the previous paragraph. Figure 44 illustrates the difference in the mean values of four variables; Frequency, Added Journey Distance, Cost per Journey Mile, and Added Journey Cost; for the seven Combined Mode-class groups. Since the distribution of these variables before transformation is not normal, and because their standard deviations are large, the mean values should not be taken as being more than comparative in value, and then only with reservations.

Journey Frequency varies between a mean of 63 journeys per annum for journeys in which the added journey is made entirely by foot, and a mean of 11 journeys per annum for cases

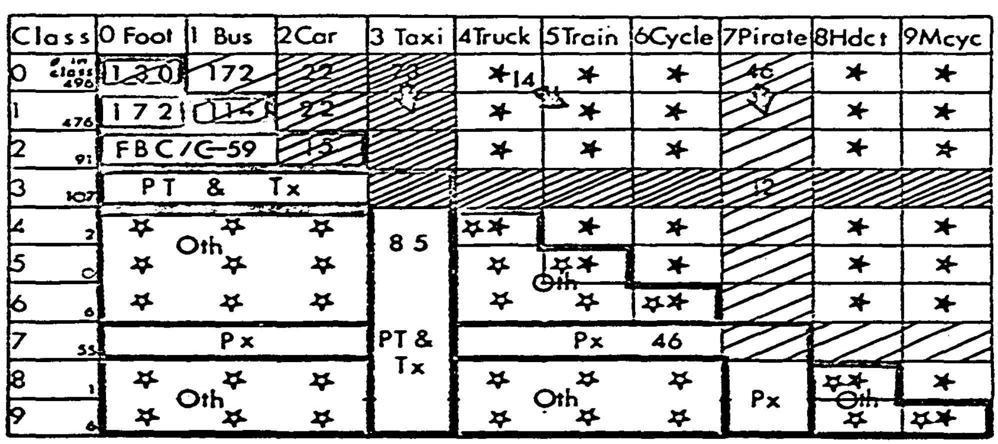
FIG·44

MEAN VALUES OF FOUR VARIABLES FOR SEVEN COMBINED MODE CLASSES



FIG·43

COMBINED MODE CLASS COMPOSITION AND DECOMPOSITION



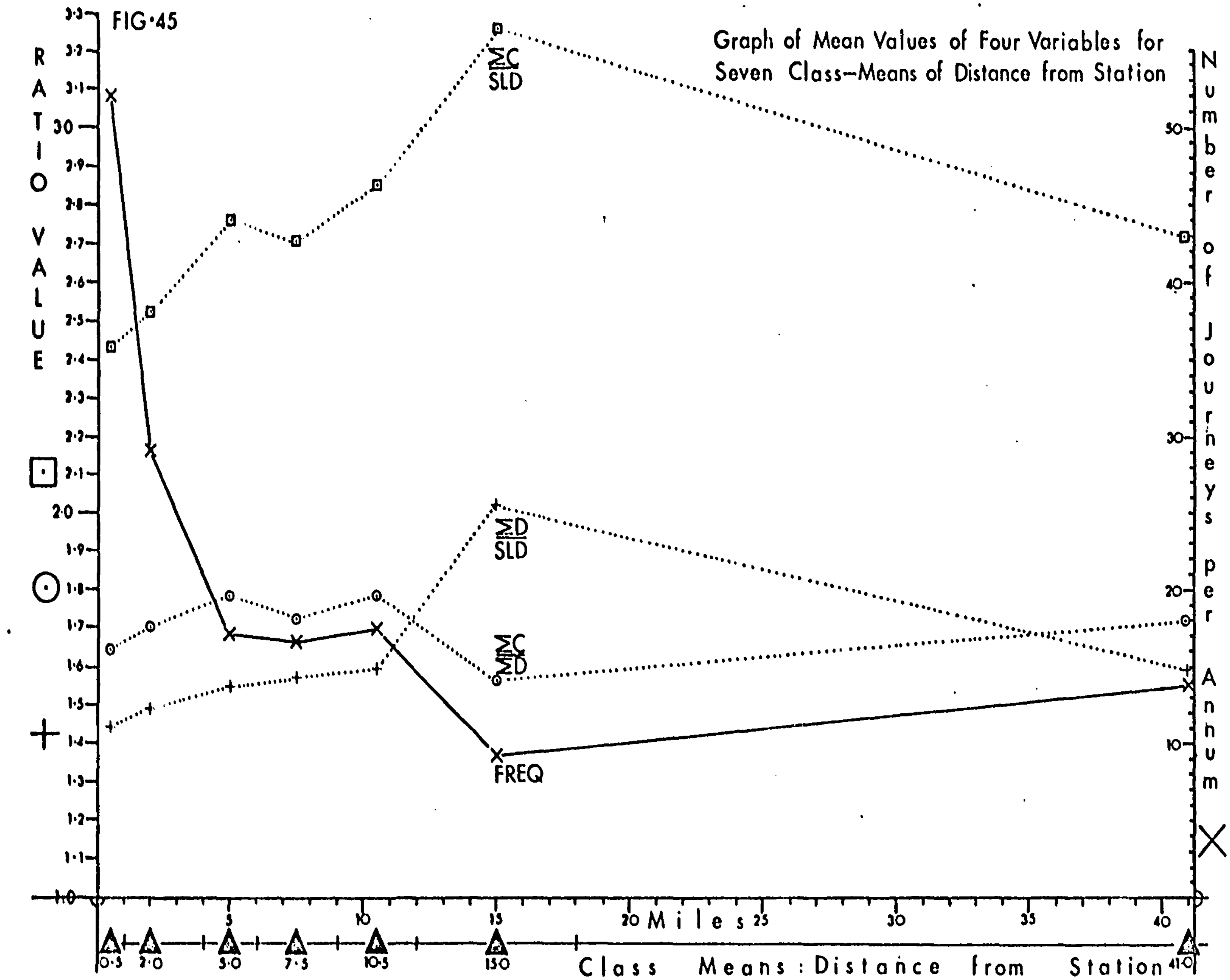
in which a bus journey is made both to and from the station. The class-means from high to low journey frequency are ranked not by the real cost per added mile of the modes but apparently by their convenience in terms of likely journey and waiting time. Thus foot transport, implying proximity to the station, ranks highest, while private car transport, implying the ability to reach the station in a short (and at the right) time, ranks higher than journeys involving the use of taxis or pirates. These in turn, however, despite their high cost per mile, are faster and involve less delay than rural bus services. Without data for journey time and waiting time it is not possible to substantiate the relationship suggested above.

The ranking of the mean values for Added Journey Distance (dt + df) in Figure 44 is generally similar to that of the Frequency variable, though reversed. The juxtaposition of the ranking of car and taxi journeys may be related to the fact that real cost per mile falls with greater distance for the former rather more than it does for the latter, mainly in the form of spreading the cost of vehicle depreciation.

The bar-chart of mean pence per journey mile per combined mode-class demonstrates the smoothing effect caused by the dominance of the Rail Journey Cost as a proportion of the Total Journey Cost (Figure 44). Only for journeys partly made by taxi does the Cost per Journey mile exceed twopence. Similarly, mean values for Added Journey Cost exceed 50 pence only for journeys in the 'other' category (which include train journeys to or from the station), and for journeys made partly by pirate or taxi. Since the use of pirate vehicles is largely confined to rural areas in Jamaica, this high added cost reflects the real inaccessibility of such areas, for even if unlicensed passenger vehicles fill a void left by licensed bus services, the cost of travelling on such vehicles over a considerable distance in difficult terrain may often prove to be an effective barrier to mobility for the individual Jamaican.

The last section of this chapter deals with possible differences in the way journeys are made when the distance travelled from the station falls within stated values. Examination of Figures 9 and 10 suggested seven groups of cases. Despite the close approximation to Log-normal distributions, breaks in slope seemed to occur at intervals 1, 4 6, 9, 12 and 18 miles. Though combination of all cases in Figures 9 and 10 would have been preferred for the purposes of the following discussion, practical considerations limited analysis to the 620 values of the Distance Travelled from the Station variable.

The mean value of four variables for each Added Distance class is presented graphically in Figure 45, with each mean value plotted against the class mid-point (Note that this mid-point is not necessarily the median or mean value of the cases in each group)


FIG·45
Graph of Mean Values of Four Variables for Seven Class–Means of Distance from Station
RATIO VALUE
Number of Journeys per Annum
ΣC / SLD
ΣD / SLD
ΣC / ΣD
FREQ
Miles
Class Means : Distance from Station
0·5 2·0 5·0 7·5 10·5 15·0 41·0

As one would expect, mean journey Frequency is greatest when the distance travelled from the station is less than 1 mile. It is lowest for the 12-18 mile class group. Sinuosity is greatest for this class-group, and is notably lower for distances between 18 and 64 miles. Cost per journey mile is greatest for the cases between 9 and 12 miles, and lowest, not for very short distances, but for the cases in the group 12-18 miles. In contrast, Cost per Real mile is lowest for journeys wherein the distance travelled from the station is less than 1 mile, rises to a maximum between 12 and 18 miles, and falls off somewhat for greater distances.

At first sight, there does not appear to be any single model which explains at the same time the variation in the mean values of all four variables, which seem to contradict one another, particularly in the range 12-18 miles.

Consider, however, the following arguments. The relationship between Journey Distance and Straight Line Distance is such that when the Rail Journey Distance accounts accounts for most of the former, the ratio $\Sigma D/S.L.D.$ is approximately equal to 1.4. Greater values of Sinuosity occur when the paths taken to and from the station differ markedly from the axis of direction of the journey (Figure 24). When the Added Journey Distance is a small proportion of the Total Journey Distance, this directional difference is not likely to have a marked effect on the Sinuosity value. As absolute distance values for one or both added journeys increase, unless Rail Journey Distance increases in direct proportion, the effect of the directional difference will be more marked. Beyond a certain value for Added Journey Distance, however, the directional deviation of certain potential journeys is so evident that the travellers are aware of this factor, and the journey is made other than by rail, or not at all. It follows, therefore, that journeys made with an added distance beyond this unstated value are approximately uni-directional, and have a relatively low Sinuosity index (Figure 45). That journeys with a Sinuosity exceeding 2.0 are made at all may be explained by their low cost per journey mile (Figure 45, class group 12-18 miles). Nonetheless the inconvenience and delay of such journeys is perhaps reflected in their low mean frequency per annum. Of course, the mean sinuosity of these journeys is such that their cost per real mile is the highest (3.3 pence) of any class group. Translated into the Jamaican context, the above arguments suggest that a journey from Lucea to Port Morant via Kingston and Montego Bay is more efficient, and likely to be made more regularly, than a journey from Bog Walk to Christiana via Spanish Town and Kendal, despite the greater added distance of the former example. These examples point out that it is not valid merely to see the potential traffic area of the railway as a set of approximate circles drawn about each station on the system, or indeed to see each circle as bounding a cone representing a distance decay function around each station, even if allowances are made for the pattern of radial feeder roads, variations in road transport services, travel times, local relief, or population distribution. The total pattern of journey occurrence is an amalgam of a set of individuals' journeys, each of which is the result of a decision function. In each case this decision function represents the evaluation of available journey costs and distances (and, presumably, times and other perceived advantages and disadvantages) and the choice of an acceptable compromise.

This chapter has reviewed a second level of analysis of the journeys in the interview sample. Beyond treatment of all 620 interviewees as cases in a sample from a single population, there exists the second level of searching for discrete groups within the sample which have certain elements in common which distinguish them from other groups. A possible third level is the consideration of the spatial distribution of the 620 cases, which would naturally lead to the derivation of residual surfaces for different variables or combinations of variables, and the search for local factors responsible for such residual variations (Chorley and Haggett, 1965). Journeys, which are linear and not areal or punctal phenomena, do not lend themselves well to this third level of analysis. Moreover, 620 cases are inadequate to describe an area as large as that of Jamaica. The final section of this study, therefore, returns to the second level cited above, seeking further evidence of the validity of apparent group differences in the sample.

CHAPTER SIX

STEPWISE MULTIPLE DISCRIMINANT ANALYSIS

In previous chapters we have shown the way in which the variables employed in this study were derived (Chapter Two), discussed the distributions of the more important continuous variables (Chapter Three), attempted to arrive at predictive equations of one variable from another (Chapter Four) and covered the general theme of differences and relationships between groups in the sample (Chapter Five). At each stage of the study, interesting relationships have emerged. Just as the results of the correlation-regression analysis should be cast in doubt by the assumed presence, to an unknown degree, of measurement and sampling error, and by the departure from normality indicated, even after variable transformation, by the indices of symmetry and kurtosis, so the preceding discussion of group differences depends on the validity of the groups themselves as reasonably independent and recognisable sets within the sample set of 620 cases.

Suppose that in the rail-travelling population there are n groups: A, B, C ... Q, distinguishable by a single criterion, and represented in the sample. Two types of error may arise: (1) The combination of unlike groups: (A+B)(C+L)(O+Q)

(2) Imprecise definition of group boundaries, so that an artificial sorting of the groups is effected: (A+B)(A+C)(B+C).

A third possibility is that groups are defined which are not in reality groups at all, to the extent that no rigorous criteria exist to assign new cases to existing groups, that the definition is circular, and that the classification is not, in fact, useful.

The technique, Discriminant (or Discriminatory) Analysis, assumes that some prior classification of the data is given. Kendall (1957, page 144) states that "it is not the object of the inquiry to find what is the best way of dividing heterogeneous material into populations or classes." In the general case, Haggett and Chorley (1969, page 252) define the problem in discriminant analysis as one of allocating "individuals to a correct population with a minimum of error, usually on the basis of single or multiple measurements of the individual, and a prior set of similar measurements on individuals whose origin is known." Suspended judgements are not considered, the use of the technique assumes that objects to be classified belong to one of the groups specified.

Discriminant analysis has obvious applications in geography, wherein classification, both monothetic and polythetic, is a continuing theme. King (1967) has used the technique in a paper on urban growth patterns in Ontario and Quebec between 1951 and 1961. Black (1967) used multiple discriminant analysis to separate the characteristics of the built from the unbuilt potential planar links of the Maine railway network linking centres with more than 2000 inhabitants in the decade 1840-1850. From a set of potential discriminating variables, seven hypotheses were put forward to explain the selection of links actually constructed, of which three, combined into a single multiple regression equation, resulted in only an 11 per cent misclassification of the cases.

In this study, however, the problem is solely to test the suitability for analysis of previously defined groups when measured journey characteristics are employed as dependent variables. Specifically, do the journey Frequency and Purpose groups differ sufficiently in measures of cost, distance, or (for the latter group) frequency to be independently distinguished by those variables. Veldman (1967, page 268) states that the problem in multiple discriminant analysis is to " determine the extent and manner in which previously defined groups of subjects may be differentiated by a set of dependent variables operating together." Other reviews of the application of discriminant analysis to classification procedures may be found in Casetti (1964) and Sebestyen (1962).

For this study the multiple stepwise discriminant analysis program BMD07M was used to conduct the following computations (see Appendix 7):

(1) Select, in a stepwise manner, those variables which most efficiently discriminate between predetermined groups.

(2) Derive, at each step, multiple linear discriminant functions for the initial classification, the score of each case on these functions, and the group centroid for each class.

(3) Compute the distance of each case from each class centroid, identify the shortest distance for each case, and allot that case to the appropriate group.

The output with which we are concerned is, therefore, for a single prior classification of the 620 cases, those variables which in combination minimise the misclassification of cases in stage (3) on the previous page, their relative significance in performing this role assessed by their respective F values, and the classification matrix, summarising the pattern of correct and incorrect assignment of cases into the various groups specified. This matrix should allow some judgement of the usefulness of the classification to this study, in which the basic question is "How and why do journeys differ?"

The formal logic of the computations involved is given good coverage by Rao (1952) in Chapters Eight and Nine. The latter chapter deals with the Mahanabolis D^2 statistic (pages 354-361), upon which the classification procedure in BMD07M is based. King (1969, pages 204-215) places the general problem of classification and optimal grouping in a geograph-ical frame of reference.

In applying stepwise multiple discriminant analysis to the journey Frequency classes, ten variables were made available, transformed as listed in Table 3-1. Table 6-1 below summarises the discriminatory power of eight of the variables. Two variables, Cost per Added Mile, and Cost per Journey Mile, were not included as discriminant variables since they did not fulfil the conditions for inclusion listed in Appendix 7.

TABLE 6-1 Stepwise Multiple Discriminant Analysis, Journey Frequency Classes, F values of variables entered.

STEP NO.	VARIABLE NO.	VARIABLE NAME	F VALUE TO ENTER
1	8	Total Journey Distance	27.6370
2	11	Sinuosity	14.9287
3	7	Straight Line Distance	4.7833
4	18	Added Journey Cost	2.6862
5	12	Cost per Real Mile	3.1247
6	17	Added Journey Distance	2.1742
7	22	Cost per mile to Station	1.3458
8	23	Cost per mile from Station	0.8777

At the second step, when only the variables Total Journey Distance and Sinuosity were included, the minimum degree of misclassification was achieved. Table 6-2 summarises the cases classified into each group on the basis of the multiple discriminant function. The F value at this step was 21.09761, with 12 and 1224 degrees of freedom (significant at the .001 level).

The F matrix in Table 6-3, below, tests the null hypothesis that there is no difference between pairs of groups with respect to the distributions of the discriminant variables, Total Journey Distance and Sinuosity. With 2 and 612 degrees of freedom, an F value of 4.61 or more rejects the null hypothesis at the .001 significance level. The mean values of the two variables for each group are entered in Table 6-4.

TABLE 6-2 Frequency Group Reclassification of Cases

	RARE	IRREG	MTHLY	W-M	WKLY	D-W	DAILY	Old Group Totals
RARE	22	20	1	3	5	3	7	61
IRREG	26	106	12	29	35	16	18	242
MTHLY	16	29	3	12	8	7	1	76
W-M	8	29	1	21	18	5	5	87
WKLY	1	18	1	10	21	3	25	79
D-W	5	7	1	1	6	3	20	43
DAILY	1	0	0	0	5	1	25	32
New Group Totals	79	209	19	76	99	38	101	

TABLE 6-3 F Matrix, Paired Journey Frequency Classes

	RARE	IRREG	MTHLY	W-M	WKLY	D-W	DAILY
RARE	[illegible]						
IRREG	37.08	[illegible]					
MTHLY	17.74	1.67	.....				
W-M	28.24	0.79	1.10	.....			
WKLY	42.19	20.91	12.07	9.61	.....		
D-W	25.78	22.14	12.69	13.11	2.67	.....	
DAILY	49.19	57.07	39.68	40.39	17.20	7.70	.....

TABLE 6-4 Mean values of Total Journey Distance and Sinuosity for Seven Journey Frequency classes.

	RARE	IRREG	MTHLY	W-M	WKLY	D-W	DAILY	
TOTAL JNY DISTANCE	79.46	87.33	82.34	82.06	59.47	49.16	17.50	miles
SINUOSITY	1.84	1.45	1.51	1.47	1.38	1.47	1.43	ratio

values cited for sinuosity are the antilogarithm of the mean of a logarithmic distribution.

The discriminatory power of the variable Total Journey Cost with respect to the variable Journey Frequency has already been shown in Figure 33 in the form of a regression model. As a variable, however, Journey Frequency is perhaps too discontinuous to be used reliably in correlation-regression analysis, and yet too continuous to be successfully broken down into classes on an ordinal scale. Beyond the generalisation that Rare journeys are associated with high Sinuosity values, and that Daily journeys tend to be made over shorter distances, Table 6-4 does not indicate that these two variables are sensitive indicators of Journey Frequency. They are, however, more sensitive in combination than any of the other variables made available. We may therefore, from the F values in Table 6-1, reject the notion that aspects of the added journey, or cost per real or journey mile, are strong constraints on journey frequency.

Table 6-2 reveals that 201/620, or 32.5 per cent, of the cases were classified into the correct group on the basis of the smallest D^2 statistic. If the seven classes are reduced to three as in the Chi Square analysis in the previous chapter, the percentage correct classification rises to approximately 51.6. In general, extreme cases are misclassified into nearly adjacent classes, while Irregular, Monthly, and Weekly-to--Monthly journeys are scattered over a wide range of frequencies.

To summarise, Total Journey Distance and Sinuosity can together discriminate between journeys made with a very high or very low frequency. Their failure to do so for middle frequency ranges may be accounted for partially by the weak nature of the relationship, and partially by the inaccuracy of many interviewees' estimates, particularly of those whose journeys were classified as Irregular.

In applying the same technique to the Journey Purpose classification, we obtain Table 6-5. Of the twelve variables made available, two, Sinuosity and Added Journey Distance, failed to achieve an F value large enough for their inclusion in the set of discriminant variables. In view of the role of Sinuosity in discriminating between Frequency classes, and the Chi Square analysis suggesting a relationship between Purpose and Frequency, this result is surprising. Before the first step, however, the F value of the variable Sinuosity was 12.2378, falling to 6.6327 after Frequency had been entered, and to 1.8775 at the second step when Cost per Real Mile was entered. Most of the variance explained by Sinuosity was therefore accounted for by the first two variables of the discriminant function.

By the tenth step 274 of the 620 cases were correctly classified into their predetermined journey purpose classes. In the Group F matrix at this step, all groups were deemed significantly different at the .001 level on the basis of the discriminant function, with the exception of Personal and Business journeys. The Group reclassification matrix at the tenth step is reproduced in Table 6-6.

TABLE 6-5 Stepwise Multiple Discriminant Analysis, Journey Purpose Classes, F Values of variables entered.

STEP NO.	VARIABLE NO.	VARIABLE NAME	F VALUE TO ENTER
1	10	Journey Frequency	52.6574
2	19	Cost per Real Mile	13.3847
3	18	Added Journey Cost	11.6394
4	21	Miles per Annum	7.5593
5	20	Cost per Added Mile	7.5293
6	12	Cost per Journey Mile	10.3786
7	8	Total Journey Distance	3.5524
8	22	Cost per Mile to Station	2.8005
9	23	Cost per Mile from Station	2.5323
10	7	Straight Line Distance	1.3030

TABLE 6-6 Purpose Group Reclassification of Cases

	LEIS	PERS	BUSS	WORK	SELL	SHOP	Old Group Totals
LEIS	37	12	5	7	4	1	69
PERS	50	101	59	38	25	15	288
BUSS	10	19	30	19	4	7	89
WORK	7	5	14	57	4	12	99
SELL	2	1	2	3	31	3	42
SHOP	0	1	0	8	6	18	33
New Group Totals	106	139	110	132	74	56	

As previously suspected, Personal and Business journeys are the two most heterogeneous groups in the sample, if indeed they may be termed groups at all. In contrast, Leisure, Work, Higgler (Sell), and Shopping Journeys are discriminated with greater than 50 per cent accuracy by the ten variables in the function. The basic difference appears to lie between journeys which offer economic returns, in the lower right-half of Table 6-6, and journeys made for recreational, social, or quasi-social reasons, in the upper left of the matrix. On this criterion, only 152, or 24.5 per cent, of the cases were misclassified, and of these 78 were supposedly 'personal' journeys. Table 6-7 illustrates this difference with the mean values of the first four variables entered (At this step, 365 cases were misclassified, compared with 346 at the tenth step).

TABLE 6-7 Mean Values of Journey Frequency, Cost per Real Mile, Added Journey Cost, and Miles per Annum, for Six Journey Purpose classes.

	LEIS	PERS	BUSS	WORK	SELL	SHOP	
Frequency	2.18	6.48	9.07	36.95	26.50	51.75	jys.p.a.
Cost per Real Mile	3.22	2.30	2.22	2.36	1.53	2.00	pence
Added Journey Cost	30.58	20.60	19.12	10.75	15.90	4.50	pence
Miles per Annum	152	379	501	1545	1554	852	miles

Values cited for all four variables are the antilogarithms of means of logarithmic distributions.

In general it can be said that work, higgler and shopping journeys are made more often, at a lower real cost per mile (excluding work journeys), involve a lower cost in travelling to and from the station, and are associated with larger values for total mileage travelled per annum, than the other three journey purpose classes. However, work, higgler and shopping journeys constitute only 28.1 per cent of the cases in the interview sample. It is almost certain that such journeys are under-represented, since, as demonstrated in Chapter Two, persons making journeys over a short distance were less likely to be interviewed. Nonetheless, the social, quasi-social, or recreational journey is an important source of rail passenger revenue. Not only is this type of journey difficult to place reliably into sub-categories, but it is also difficult to justify these sub-categories on the basis of a set of dependent variables. It is not easy to describe or explain the nature of journeys made irregularly with, as it were, no single purpose in mind, that incur perhaps unpredictable costs over a wide range of distances. Despite the large size of the interview sample, therefore, between and within group variation are such that it is not possible to say with confidence either that certain types of journeys are made in different ways, or that all journey types sampled are fundamentally identical with respect to measurable journey attributes. This conclusion is based on the difficulty of establishing adequate a priori definitions of journey types.

CHAPTER SEVEN

CONCLUSIONS

Judgements made on the basis of the preceding analysis must be qualified in a number of respects. In their study on the Philadelphia metropolitan fringe, Brush and Gauthier (1968, page 169) discuss the relative significance of distance, time and travel cost as measurements relating to consumers' choices of alternative destinations:

> Measures of time overcome many of the difficulties inherent in distance measurements. Perhaps travel costs would be the preferred measure especially in view of the hypothesis that the theoretical value of a trip represents some balancing of travel costs, in their broadest sense, against probable rewards or satisfactions. The difficulty with travel costs, however, is that at the present state of knowledge they are difficult to establish and measure. For this reason it was decided to use mean travel time as the most useful measurement for ordering clusters of destinations with respect to each zone of origin.

Empirical observation of the low relative importance of journey time for many Jamaicans, the difficulty of reliably estimating time spent on the journey (especially waiting time), and the low opportunity cost of time in the Jamaican context, led to the decision to exclude journey time from the set of variables measured. Measures of cost, however, are entirely dependent on the quality of the estimates of unit cost per mile for foot and car journeys (Appendix 2). Loss of accuracy is, of course, already inevitable when a constant, rather than a fluctuating, charge per mile is levied on such journeys in the sample.

Second, one is faced by the possibilities of sample bias, in this case a known under-representation of short journeys, and of response bias. The preponderance of irregular and personal journeys may be a reflection of the unwillingness of the interviewees to give substantive answers, or of their inability to be more specific about the frequency and purpose of their journey when it is made sporadically, and on impulse.

Boulding (1968, page 86) points out that "the further we diverge from regular or habitual behavior the less certain are we of the consequences", yet at the same time there exists "the primary image of time as an essentially cyclical phenomenon." Lynch (1960) also treats the environment in terms of the image that substitutes for objective realities. There has been no attempt in this study to separate the nature of the image of the Jamaican rail journey from that of the journey itself. In retrospect, one regrets the oversight of failing to ask interviewees how far they thought they were travelling. Whorf's (1950) study of the Hopi indians revealed that these people:

> ...conceive time and motion in the objective realm in a purely operational sense — a matter of the complexity and magnitude of operations connecting events — so that the element of time is not separated from whatever element of space enters into the operations."(Whorf, 1950, page 69)

The following extract from the proceedings of the Eastern Area Licensing Authority tribunal reveals a similar identification of time, space, and activity on the part of one Jamaican higgler[1].

> Q. How many times do you go to Kingston?
> A. Only one time, Sir, I go Wednesday morning and return Thursday...
> Q. You don't know what time it [the bus] leaves Port Antonio?
> A. I don't know...
> Q. How come?
> A. Mi nah check it, mi stan' up out a mi gate an wait.
> Q. You can help us better than that, you know, Miss ..., you must know when you take the express.
> A. Mi tek it up at Prospect you know sah.
> Q. Dem doan have any clock where you go?
> A. A' out a road mi wait pon the bus.

The problems of identifying the images of distance, of deviate paths, of the relative advantages of various transport media, and of the time elapsed during and between journeys, are all, we feel, worthy of further analysis.

Shepard (1964, page 257) comments on the difficulty people encounter in arriving at subjectively optimum decisions:

> One source of the subjective non-optimality of such decisions seems to be man's demonstrable inability to take proper account, simultaneously, of the various component attributes of the alternatives; that is, although he will probably experience little difficulty in evaluating the alternatives with respect to any one of these subjective attributes, a considerable number of experiments...indicate that his ability to arrive at an overall evaluation by weighing and combining or 'trading off' all of these attributes at the same time is likely to be less impressive.

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1. Reproduced from the verbatim notes of the Eastern Area Licensing Authority meeting at Port Antonio, 26th. May, 1969, now in the records of the Island Licensing Authority, Kingston

It must be assumed that those persons in the sample who make their journey on occasion other than by rail do so for what are to them valid reasons. Table 7-1 reveals that they differ from those individuals who do not make an alternative journey in two previously unmentioned respects.

TABLE 7-1 Mean values of eight variables for Alternative Whole Journey Affirmative and Negative Groups.

	A.W.J.YES	A.W.J.NO	
FREQUENCY	24.98	44.81	journeys per annum
TOTAL JOURNEY COST	127.78	119.45	pence
TOTAL JOURNEY DISTANCE	79.00	69.12	miles
COST PER JOURNEY MILE	1.67	1.71	pence per mile
STRAIGHT LINE DISTANCE	54.03	46.60	miles
SINUOSITY	1.53	1.51	ratio
ADDED JOURNEY DISTANCE	8.75	8.32	miles
ADDED JOURNEY COST	43.48	36.94	pence

They make the rail journey, on average, just over half as often, and they pay slightly more, and more per mile, in travelling to and from the station. Yet because of the greater mean Total Journey Distance, the effect of the greater added cost is lost, and the mean cost per journey mile for this group is slightly less than that for those persons who on no occasion make the alternative journey. We are therefore drawn to the conclusion that if any characteristic distinguishes the former group in its occasional choice of the road transport alternative, it is its perception of the cost of travelling to and from the station as adding more to the unit cost per mile of the journey than it actually does. Since the cost of the alternative journey is invariably higher than that of the rail journey, we must also conclude that the difference represents the value to the Jamaican of a more convenient journey, without changes or delays. Without full cooperation between the Jamaica Railway Corporation and the island bus companies, in the provision of adequate feeder services, at the right time, and on time, this situation is unlikely to change.

The large number of cases with Sinuosity values exceeding 1.5, nearly 30 per cent of the sample, suggests that many railway users rely on its low cost per mile, and are prepared to follow a deviate path to take advantage of this economy. With the exception of higglers, however, individuals in this group are, by virtue of their enforced economy, also unlikely to make such a journey more than once or twice a year.

In Chapter Four a higher correlation between Journey Cost and Frequency was found for the Alternative Journey Affirmative than for the Whole sample. This relates to the preceding paragraph to the extent that for those financially able to make the alternative journey, both high and low rail and added journey costs will be zones of indifference; the former in relative terms (as the proportion of the journey cost that is added increases), and the latter absolutely (since the cost of both the alternative and the sampled journey would be low).

The predictive model for the Added Cost Ratio, developed in Chapter Four, demonstrates the extent to which the railway could compete with Jamaican public road transport, were cost the single criterion in the choice of route and the mode of travel employed. This simple relationship does not exist, for the cheapness of the railway is mainly valued by those who in any case could not afford any other means of travel.

The group relationships noted in Chapter Five are of interest from a descriptive standpoint, though the subsequent chapter shows up the dangers inherent in group definition, and, by extension, of attaching too great a significance to the mean values of a range of variables for groups that may exist on paper only. Perhaps the most interesting relationship suggested in Chapter Five is the apparent increase in the 'efficiency' of the journey when the distance from the station to the destination exceeds a value up to which efficiency has consistently fallen. This 'directional bias' may be the result of a decision process at work, or may result from local factors, the configuration of the island and the location of the railway within it. The possible existence of such a process is worthy of close attention.

The geographer has viewed transport in a number of ways. Networks, as linear patterns, have been considered monothetically in isolation; historically; as cause, or effect, or both, of other spatial distributions; or have more recently been reduced, for more convenient and rigorous analysis, to planar or non-planar graphs defined by edges and vertices, with common properties described by graph-theoretic indices. Network flows have also received considerable attention, usually as evidence of interaction between points on a surface. The measurable attributes of journeys have usually been regarded as reflections of competition between centres for trade areas, of the spatial pattern of employment opportunities, or of the more general themes of migration and social mobility. This study has attempted none of the above tasks. The set problems were to establish the character of railway journeys in Jamaica, isolate the factors involved in the way in which they are made, and establish, where possible, the relationships between such factors. The study has been partially successful in each of these objectives.

APPENDIX 1

Listed below in alphabetical order are the places which were either origins or destinations in the interview sample. For each place the place number is given, for reference to Figure Two, and the respective station origin or destination is listed, with the distance, in miles, between the station and the place also entered.

PLACE NUMBER	PLACE NAME	STATION NAME	DISTANCE
084	Alley	May Pen	14.4
128	Annotto Bay	Annotto Bay	0.4
174	Albert Town	Balaclava	18.1
203	Auchtembeddie	Balaclava	3.2
063	Aberdeen	Appleton	3.4
244	Albany	Albany	0.4
202	Alexandria	Montego Bay	10.2
193 and 059	Appleton	Appleton	0.4
160	Barratt Piece	Kendal	1.0
062	Balaclava	Balaclava	0.4
204	Bartons	Maggotty	4.7
134	Bath	Kingston	42.3
041 and 113	St. Pauls	Balaclava	2.2
205	Bagdale	Appleton	1.0
130	Belvedere	Cambridge	3.4
094	Bethany	Green Vale	2.9
021 and 183	Bickersteth	Cambridge	3.4
139	Barbican	Montego Bay	15.6
108	Betheltown	Cambridge	6.1
		Montpelier	7.4
258	Belle Plain	Rock Halt	2.4
147	Ben Lomond	Balaclava	5.5
		Siloah	5.5
227	Blue Hole	Port Antonio	7.6
180	Chesterfield	Stonehenge	1.7
126	Bickersteth	Montpelier	1.1
140	Black River	Maggotty	19.6
086	Buff Bay	Buff Bay	0.4
228	Bull Bay	Kingston	9.9
213	Jackson	Bog Walk	2.4
150	Bog Walk	Bog Walk	0.2
052	Bushy Park	Bushy Park	0.9
234	Burton	New Hall Halt	1.0
132	Bushy Park	Green Vale	1.9

250	Bybrook	Bog Walk	0.7
049	Cambridge	Cambridge	0.2
091 and 249	Castleton	Annotto Bay	12.0
181	Cave	Montpelier	21.6
079	Carisbrook	Maggotty	2.4
178	Cameron Hill	Maggotty	1.0
101	Catadupa	Catadupa	0.2
044	Cavaliers	Kingston	11.6
207	Carron Hall	Highgate	6.4
		Troja	7.8
		Spanish Town	31.5
028	Caymanas Park	Gregory Park	0.6
179	Central Village	Spanish Town	2.8
099	Chantilly	Williamsfield	4.5
232	Chapelton	Chapelton	0.4
159	Chester Castle	Montpelier	4.4
046	Christiana	Green Vale	7.9
		Kendal	8.4
245	Church Road	Bog Walk	1.0
166	Marchmont	Cambridge	5.9
119	Cousins Cove	Montego Bay	34.2
229	Clonmel	Highgate	5.3
045	Clarendon Park	Clarendon Park	0.2
153	Comfort Hall	Balaclava	3.1
102	Coaker	Appleton	2.3
		Maggotty	3.6
058 and 131	Newton	Maggotty	3.2
088	Content	Balaclava	2.7
095	Davyton	Williamsfield	2.5
243	Dean Pen	Highgate	3.2
198	Deeside	Montego Bay	13.4
048	Denbigh	May Pen	2.3
240	Drapers	Port Antonio	4.4
026	Elderslie	Maggotty	6.2
187	Flamsteed	Montego Bay	15.0
231	Enfield	Annotto Bay	9.1
031	Four Paths	Four Paths	0.2
259	Four Paths	Ipswich	4.9
138	Freetown	May Pen	8.3
036	Ginger Hill	Catadupa	8.5
		Stonehenge	2.8
167	Gardiner	Stonehenge	2.0
096	Giddy Hall	Maggotty	14.8
172	Gimme-me-bit	May Pen	10.2
083	Glasgow	Balaclava	4.6
190	Glen Devon	Montego Bay	2.2
116	Grange Lane	Grange Lane	0.2
144	Glanville	Montego Bay	2.5
098	Green Island	Montego Bay	34.3
133	Greenland	Green Vale	3.9
053	Green Vale	Green Vale	0.2

029,118,225 and 256	Gregory Park	Gregory Park	0.2 and 0.4
224	Grantham	Frankfield	2.5
022	Grove Place	Grove Place	0.2
151	Spring Garden	Balaclava	17.2
035	Harry Watch	Green Vale	3.8
214	Heywood Hall	Richmond	9.3
146	Hampden	Montego Bay	13.9
142	Whitney Turn	Porus	1.3
040	Hartlands	Hartlands	2.4
235	Hope Bay	Hope Bay	0.4
157 and 141	Hayes	May Pen	7.8
107	Watchwell	Maggotty	23.8
218	Hopewell	Richmond	1.0
060	Ipswich	Ipswich	0.4
246 and 219	Highgate	Highgate	0.4
155	Haddo	Montpelier	9.6
125	Irwin	Montego Bay	3.9
220	Independence Cy.	Gregory Park	2.0
194	Hopeton	Montego Bay	7.6
084 and 158	The Alley	May Pen	14.0
124	Jointwood	Maggotty	4.5
179	Jubilee	Cambridge	0.8
170	Harmons	Porus	4.4
051	Kendal	Kendal	0.2
176	Aenon Town	Kendal	15.4
191 and 074	Kensington	Montego Bay	11.0
201	Islington	Kingston	64.2
143	Knockalva	Montpelier	6.4
001 to 018	Kingston (see Figure Five, page 15)	Kingston	
069	Lambs River	Cambridge	4.5
175	Latium	Montego Bay	7.9
077	Lances Bay	Montego Bay	28.3
089	Lancaster	Williamsfield	17.4
152	Leeds	Balaclava	16.9
111	Linstead	Bog Walk	3.3
080 and 066	Lionel Town	May Pen	11.8
065	Lottery	Montego Bay	10.4
106	Lucea	Montego Bay	23.5
025	Maggotty	Maggotty	0.6
184	Mahoe	Maggotty	1.9
164 and 122	Maidstone	Green Vale	4.7
129	Malvern	Maggotty	23.4
		Balaclava	24.8
056	Mandeville	Kendal	3.9
		Williamsfield	4.4
120	Marchmont	Catadupa	1.8
148	Marlborough	Balaclava	3.3
082	Maroon Town	Appleton	20.9
027	Montego Bay (also 0.4, 1.4, and 4.6)	Montego Bay	0.2

217	Morgan's Pass	Morgan's Pass	0.4
043	May Pen	May Pen	0.5
260	Montpelier	Montpelier	0.2
171	Middle Quarters	Maggotty	14.2
233	Milk River	May Pen	11.2
127	Mount Carey	Anchovy	1.2
173	Mile Gully	Green Vale	0.2
054	Mount Salem	Montego Bay	1.2
185	Merrywood	Ipswich	1.0
087	Mulgrave	Ipswich	2.4
		Appleton	10.6
212	Mount Ogle	Kingston	14.3
038	Ginger Hill	Stonehenge	3.5
034	Buy Land	Grove Place	4.2
163	Elim	Balaclava	7.4
033	Newport	Williamsfield	6.5
105	Niagara	Maggotty	8.3
168	Norway	Ipswich	0.9
061	Old Harbour	Old Harbour	0.5
117	Passage Fort	Gregory Park	1.9
210	Paradise	Maggotty	4.0
100	Pembroke Hall	Highgate	12.2
		Kingston	47.8
081	Pisgah	Catadupa	10.1
112	Plum Park	Cambridge	3.9
047	Port Morant	Kingston	38.6
136	Port Antonio	Port Antonio	0.6
032	Porus	Porus	0.4
254	Fair Prospect	Port Antonio	13.1
154	Porter's Mountain	Montpelier	11.1
110	Quickstep	Appleton	7.7
121	Haddington	Montego Bay	14.2
135	Redberry	Porus	1.7
085	Red Ground	Balaclava	2.8
177	Reading	Montego Bay	4.1
078	Retirement	Maggotty	3.3
186	Racecourse	May Pen	12.3
115	Revere	Maggotty	1.3
211	Richmond	Richmond	0.6
162	Riversdale	Riversdale	0.5
092	Rock Halt	Rock Halt	1.1
181	Royal Flat	Williamsfield	1.5
024	Roehampton	Montego Bay	6.1
		Anchovy	3.2
195	Retrieve	Cambridge	2.0
042	Rose Valley	Balaclava	2.8
215	Guys Hill	Troja	8.9
206	Lorrimers	Williamsfield	16.3
057	Salisbury	Montego Bay	1.0
199	Siloah	Siloah	0.2
222	Sevens	May Pen	2.9
055	Salt River	May Pen	14.4

221	Santa Cruz	Balaclava	14.1
		Maggotty	12.0
072	Salters Hill	Montego Bay	4.3
169	Seaforth	Kingston	37.2
076	Sandy Bay	Montego Bay	13.6
251 and 253	Skibo	Buff Bay	5.7
		Darling Spring	3.3
138	Savannah la Mar	Montpelier	23.9
064	Spaldings	Kendal	6.4
164	Somerset	Montego Bay	4.0
030	Spanish Town	Spanish Town	0.4
182	Senior	Cambridge	1.5
093	Springfield	Cambridge	7.1
188	Shooters Hill	Williamsfield	2.3
067	Spring Mountain	Montego Bay	8.3
		Cambridge	9.2
255	Spring Village	Bushy Park	1.4
208	Seaford Town	Cambridge	5.9
050	Stonehenge	Stonehenge	0.1
075	St. Anne's Bay	Porus	53.0
073	St. Leonards	Catadupa	3.2
239	St. Margaret's Bay	St. Margaret's Bay	.4
068	Summer;s Hill	Stonehenge	1.0
210 and 071	Thornton	Appleton	2.1
070	Troy	Balaclava	6.5
216	Troja	Troja	0.4
149	Topsham	Green Vale	3.1
257	Trinity	Porus	1.0
103	Union	Balaclava	1.3
		Appleton	5.1
252	Ulster Spring	Balaclava	15.4
156	Vauxhall	Appleton	1.5
037	Walderston	Kendal	3.5
020	Warsop	Balaclava	9.8
097	Waterworks	Montpelier	5.0
192	Waterworks	Kingston	7.0
039	Welcome Hall	Cambridge	7.5
145	Whithorn	Montpelier	15.1
		Cambridge	17.1
114	Williamsfield	Williamsfield	0.2
242	Williamsfield	Richmond	1.0
109	Windsor Castle	Windsor Castle	0.4
161	Windsor	Appleton	1.4
226	Zion Hill	Richmond	16.1

APPENDIX 2

DERIVATION OF COST RATE PER MILE FOR FOOT AND CAR JOURNEYS

A. CAR JOURNEYS

Assumptions ITEM	COST L. s. d.	COST PER MILE pence
Purchase of vehicle	600 - -	
Life of vehicle	(4 years)	
Depreciation, uniform	150 per annum	
Mileage, in 4 years	(50,000 miles)	
Depreciation, per mile	2.87	2.87
Repair and maintenance	100 per annum	0.48
Fuel consumption, per gallon	(25 miles)	
Cost, fuel, per gallon	4 6	
Cost, fuel, per mile	2.16	2.16
Tax and insurance, per annum	L.75	
Tax and insurance, per mile	1.44	1.44
		6.95
Resale value of vehicle	200 - -	
Resale value, per mile usage	0.96	0.96
		5.99

The figure of sixpence per mile can only be an approximation. The true value, though, is not likely to fall short of this amount to the extent that the use of a private car ceases to be the most expensive form of transport covered in the study, with the exception of some taxi journeys.

B. FOOT JOURNEYS

Assumptions AVERAGE CALIFORIC INTAKE ON FOOD ITEMS IN JAMAICAN DIET, CALORIFIC CONTENT AND PRICE PER UNIT WEIGHT, COST PER DAY

	Fats	Cers	Stch	Sugs	Puls	Vegs	Frts	Meat	Fish	Milk
Cals per Day	193	789	243	379	104	9	238	99	57	117
Pence per Lb.	18	18	9	8	18	9	9	54	48	6
Cals per Lb.	600	1460	380	1600	940	120	160	596	748	272
Pence per Day	5.80	9.75	5.74	2.13	1.99	0.07	13.4	8.90	3.66	2.59

Total Calories per Day 2244.

Total estimated pence per day: 54.11 pence.

Mean calorific consumption per hour: 93.4

Mean estimated cost per hour: 2.25 pence.

Estimated cost per walking hour: 2.82 pence.

Miles per walking hour, circa 2.5

Cost per walking mile, circa 1.0 pence.

The ability of many Jamaicans to obtain much of their food outside the retail market system casts doubt on the accuracy of this figure, quite apart from the tenuous nature of the calculations and the inadequacies of the data.

Daily calorific intakes and itemised percentages were taken from: Platt, Dr. B. S., The Farmer's Food Manual, Chapter 5, Values of Food in Jamaican Dietary, published by the Jamaica Agricultural Society, 1957.

Costs per unit weight were estimated from the prevailing prices of food items in Jamaican stores and markets in the summer of 1969.

APPENDIX 3

COMPOSITION OF SAMPLE BY GROUPS

TOTAL Sample size: 620.

SEX Male 275, Female 345.

AGE Under 18 years, 61; 18-30 years, 292; over 30 years 267.

TICKET 2nd class mixed, 327; 2nd class diesel, 257; market, 36.

DAY TRAVELLED M., 40; T., 129; W., 116; Th., 93; F.,192; S.,50.

PURPOSE Pers., 288; Work, 98; Buss, 93; Leis., 67; Sell,42;Shop,32.

FREQUENCY Rare 58, Irreg 240, Monthly 76, Monthly to weekly 87, Weekly 81, Weekly to daily 45, Daily 33.

ALTERNATIVE JOURNEY Affirmative 227, Negative 393.

MODE OF TRAVEL, ALTERNATIVE JOURNEY, Bus 114, Car 76, Pirate 23, Truck 14.

MODE OF TRAVEL, TO OR FROM STATION Foot 496, Bus 476, Taxi 107, Car 91, Pirate 55, Other 15.

COMBINED MODE-CLASSES, TO AND FROM STATION Foot-bus 172,Foot-foot 130, Bus-bus 114, x-Taxi 73, x-Pirate 46, Foot-car 22, Bus-car 22, Car-car 15, Pirate-taxi 12, Other 14.

APPENDIX 4

PROGRAM NORMSTAND

This program tests the normality of distributions using the technique developed by Snedecor (1956). The transformations available are: Log_{10}, Square Root, Cube Root, Squared, and Cubed. Given that transformation which results in the lowest coefficients of symmetry and kurtosis, the program also standardises the variable (i.e. $\bar{x} = 0$ and x values are in standard deviations about the mean). Aside from the limited number of transformations available, a problem in the use of this program is that if all available transformations fail to satisfy the criteria for symmetry and kurtosis (equal to or less than 5.0), that transformation, or the original distribution, which fails least to do so will not necessarily be selected, owing to the stepwise sequence of tests and the absence of an IF statement for this contingency.

APPENDIX 5

DERIVATION OF THE FREQUENCY VARIABLE

Note that the units of the time measurement scale:

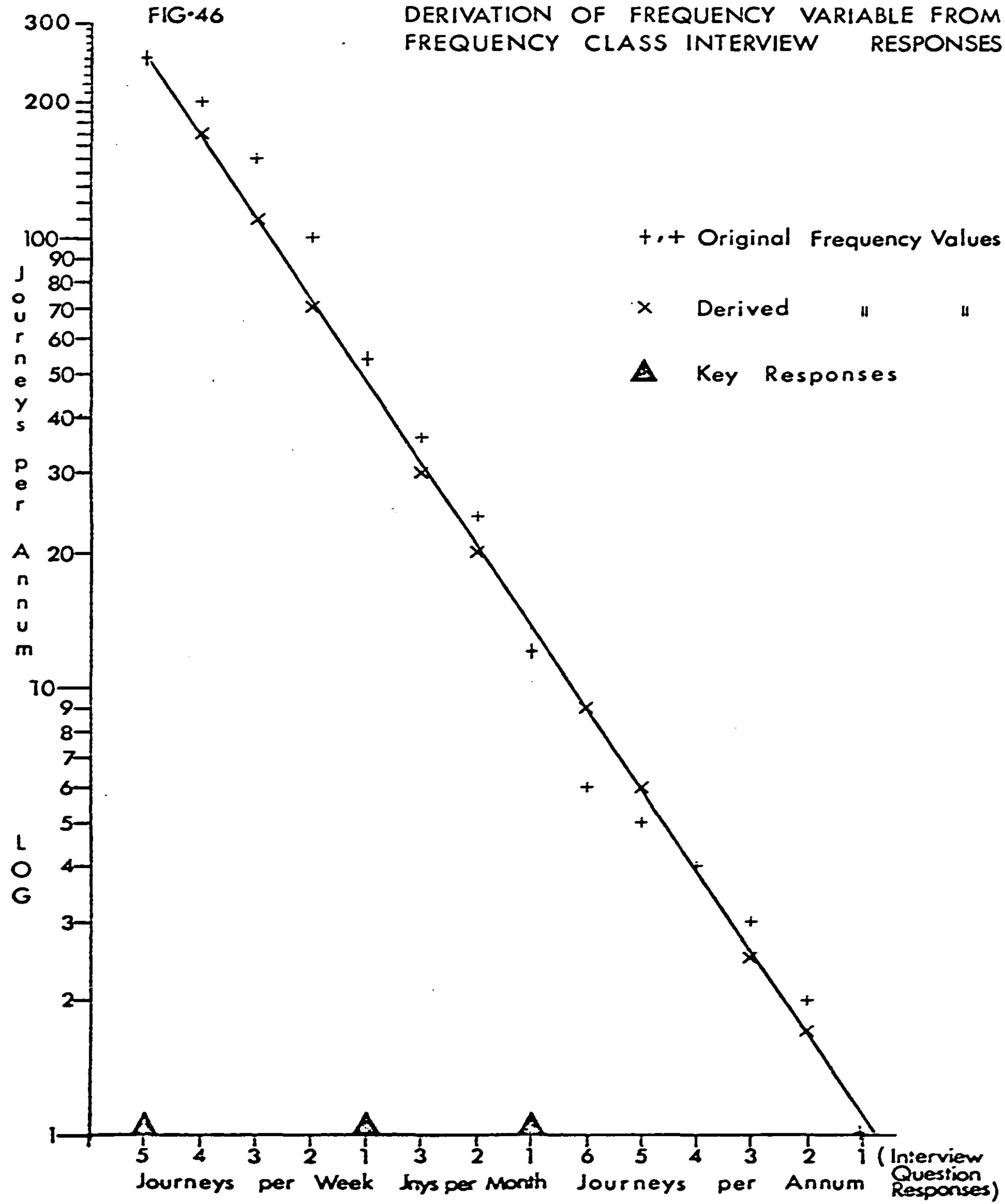
<u>DAY - WEEK - MONTH - YEAR</u>

if expressed as values of the daily unit, approximate to a logarithmic series: 1 - 7 - 30 - 365 .

The ordinate scale of Figure 46 divides the question responses in the interview sample into equal class intervals, frequency multiples, that is, of one week, one month, or a year.

Of these responses, the replies 'daily' (= 5 times a week), 'monthly', and 'weekly' were felt to be the most reliable, owing to the coincidence of the time and activity

FIG·46 DERIVATION OF FREQUENCY VARIABLE FROM FREQUENCY CLASS INTERVIEW RESPONSES



cycle. The abscissa of Figure 46 is a logarithmic scale for values of journeys per annum. Coordinates are plotted expressing the equivalent number of journeys per annum for each question response.

A best-fit line is fitted through the points for daily, weekly, monthly and yearly journeys. Values for other responses are estimated from this linear fit, rather than taking the responses at their face value. The derived values are as follows, in journeys per annum;
DAILY 250.0, 4 TIMES WEEKLY 170.0, 3 TIMES WEEKLY 110.0, TWICE WEEKLY 70.0, WEEKLY 50.0, 3 TIMES MONTHLY 30.0, TWICE MONTHLY 20.0, MONTHLY 12.0, 6 TIMES YEARLY 7.0, IRREGULAR 4.0, RARE 0.3.

APPENDIX 6
PROGRAM CORREG

This subroutine performs correlation-regression analysis on ordinary, transformed, and standardised data. Correlation matrices for the regression of Y on X, and X on Y, are included in the output, as are the linear equations for all pairs of variables, with standard errors of estimate, and coefficients of determination. Significance at the .001, .005 and .002 levels is specified.

APPENDIX 7

PROGRAM BMD-07M STEPWISE MULTIPLE DISCRIMINANT ANALYSIS

This program performs a multiple discriminant analysis in a stepwise manner. At each step one variable is entered into the set of discriminating variables. The variable entered is selected by the first of the following equivalent criteria:

(1) The variable with the largest F value

(2) The variable which when partialed on the previously entered variables has the highest multiple correlation with the groups.

(3) The variable which gives the greatest decrease in the ratio of within to total generalised variance.

The program, revised to January 6th 1967, was written by Paul Sampson, a member of the staff of the Health Sciences Computing Center, University of California Los Angeles, (Dixon, 1967).

APPENDIX 8

A NOTE ON THE FIELD INTERVIEWING TECHNIQUE ADOPTED

The dates on which interviews were conducted are listed in Table 8-1. A sample field interview sheet is illustrated in Figure 47. Entries on such a sheet were made during the course of a conversation, of variable length, with each respondent. The opening gambit of the interviewer was to make it immediately clear to the respondent that this was part of a personal (i.e. not official) survey being undertaken by the author in connection with his work at a Canadian college. The respondent was told that the purpose of the survey was to find out how and why people make railway journeys in Jamaica, and was asked whether he or she would mind answering a few questions about his or her journey. As noted in the text (page 8 above), only three per cent of the individuals approached failed to respond to the relaxed, and sometimes rather drawn out, preliminary explanation and polite request.

A typical fully successful interview followed the sequence below, after information had been entered in rows a, b, and c in Figure 47.

Question. Which station are you travelling to?

Answer. Buff Bay (entered in row e, Figure 47).

Q. Which station have you come from?

A. Kingston (d).

TABLE 8-1 Dates and Trains on which Interviews were conducted during Period of Research.

DAY	DATE		TRAIN-TYPE	NUMBER OF PERSONS INTERVIEWED
Friday	June	27	Mixed	48
Saturday	June	28	Diesel	26
Saturday	June	28	Mixed	24
Monday	June	30	Mixed	40
Friday	July	4	Mixed	42
Tuesday	July	15	Mixed	50
Tuesday	July	15	Diesel	12
Wednesday	July	16	Diesel	27
Wednesday	July	16	Mixed	43
Tuesday	July	22	Diesel	27
Tuesday	July	22	Mixed	29
Thursday	July	24	Mixed	38
Friday	July	25	Diesel	49
Friday	July	25	Diesel	40
Wednesday	July	30	Mixed	24
Tuesday	August	5	—— *	11
Wednesday	August	6	Mixed	10
Wednesday	August	6	Diesel	12
Thursday	August	7	Diesel	45
Thursday	August	7	Mixed	10
Friday	August	8	Diesel	13

*Interviews on August 5 were conducted at Kingston station.

Q. After you get to Buff Bay, where are you going to?

A. Skibo (g).

Q. How will you get to Skibo from Buff Bay?

A. By bus (k).

Q. Do you know how much it will cost on the bus from Buff Bay to Skibo?

A. One and fourpence (m).

Q. Before you got on the train at Kingston station did you come from somewhere else in Kingston or from outside Kingston?

A. From Kingston, from Havendale (f).

Q. Would that be in Kingston 8?

A. Yes (f).

Q. How did you get from Havendale to Kingston station?

A. By bus, to the Parade (j).

Q. And how much was the bus fare ?

A. One and a penny (l).

Q. You were visiting Kingston and live in Skibo?

A. Yes.

Q. Visiting friends or relatives perhaps?

A. Yes, I was staying with friends.

Q. Any other reason? Shopping, business, anything like that?

A. Yes, I had business to attend to in Kingston.

Q. And is that why you came?

A. Yes (h).

FIG. 47 FIELD INTERVIEW SHEET

Interview	Number	a	610
	Sex	b	male
Age	Class	c	18 – 30
Station	Origin	d	Kingston
	Destination	e	Buff Bay
Place	Origin	f	Havendale, K8
	Destination	g	Skibo
Journey	Purpose	h	business
Journey	Frequency	i	rare
Mode	To Station	j	bus
	From Station	k	bus
Cost	To Station	l	1/1
	From Station	m	1/4
Alternative Journey	Mode	n	car
	Cost	o	—

Q. Do you make this journey by rail very often?

A. No, not often.

Q. As much as twice a year?

A. No, not even that often (i).

Q. Do you ever travel between Skibo and Kingston by bus or car?

A. Yes, by car (n).

Many respondents required a more protracted and oblique form of questioning when the elicited responses did not form a coherent pattern. Occasionally an interim rather than ultimate place origin or destination would be given, or the mode of transport to or from the station would be interpreted by the respondent as the walk from or to the bus stop. The problems of the respondents' pronunciation of and inability to spell place names were substantial.

The data were later supplemented by the various rail and road distances, the rail cost, and interpolated foot and car journey costs where necessary. Each interview was then retabulated. The responses were all coded, and punched on to data cards.

APPENDIX 9

A NOTE ON FREIGHT

The shipment of alumina and bauxite accounts for more than fifty per cent of the gross revenue of the Jamaica Railway Corporation. The processing or extraction of bauxite takes place at a number of points served by the railway network: the Kirkvine Works between Kendal and Williamsfield stations, Woodside near May Pen, Pleasant Farm near Linstead and Bog Walk, and Revere near Maggotty. Ocean shipments are made from Rocky Point and Port Esquivel on the south coast, at the end of railway branch lines extending respectively from Jacob's Hut near May Pen, and from Bodle's Junction near Old Harbour. The amount of bauxite and alumina carried by the railway rose from 624,779 tons in 1955 to 2,257,000 tons in 1966, while revenue from the traffic almost doubled over the same period. In contrast, passenger traffic has fluctuated around the one million journeys per annum mark, with increased receipts being largely due to the introduction of the diesel railcars offering faster service at higher fares.

Once the mainstay of the railway system, the share of banana shipments as a proportion of total receipts has dwindled from 63 per cent in 1938-9 to 20 per cent in 1947-8 and less than 10 per cent in 1966. In 1969 only one station on the system, Kendal, still handled bananas in bulk consignments.

These were shipped, as in the more active past, to the wharf at Port Antonio. A number of inter-related factors may partly explain the railway's almost complete exit from the business of shipping bananas. Given the economic inefficiency of break--of-bulk points over short hauls, truck competition was already significant before the Second World War (Bland, 1937). Between 1938 and 1949 the proportion of main road mileage that was asphalted rose from 11 to 27 per cent. The dispersal of the banana producing areas and the decline in banana exports are also important factors. The whole process merits a separate study.

Of the other freight shipments that are unrelated to the bauxite industry, only the shipment of citrus fruits rates as a regular, large and lucrative business. The remaining items, largely produce destined for public markets, are shipped in small consignments by a large number of individuals and are charged at unrealistically low freight rates. A small volume of miscellaneous goods is received by the stations, which consists largely of consignments of dry goods and merchandise shipped from Kingston wholesale establishments. Mail deliveries by rail are not now a significant source of revenue. Finally, the market passengers on the railway are permitted to carry so much produce free of charge, above which a surcharge is levied at the conductor's discretion.

At one end of the spectrum of freight shipments, then, the traffic associated with the bauxite industry underpins the

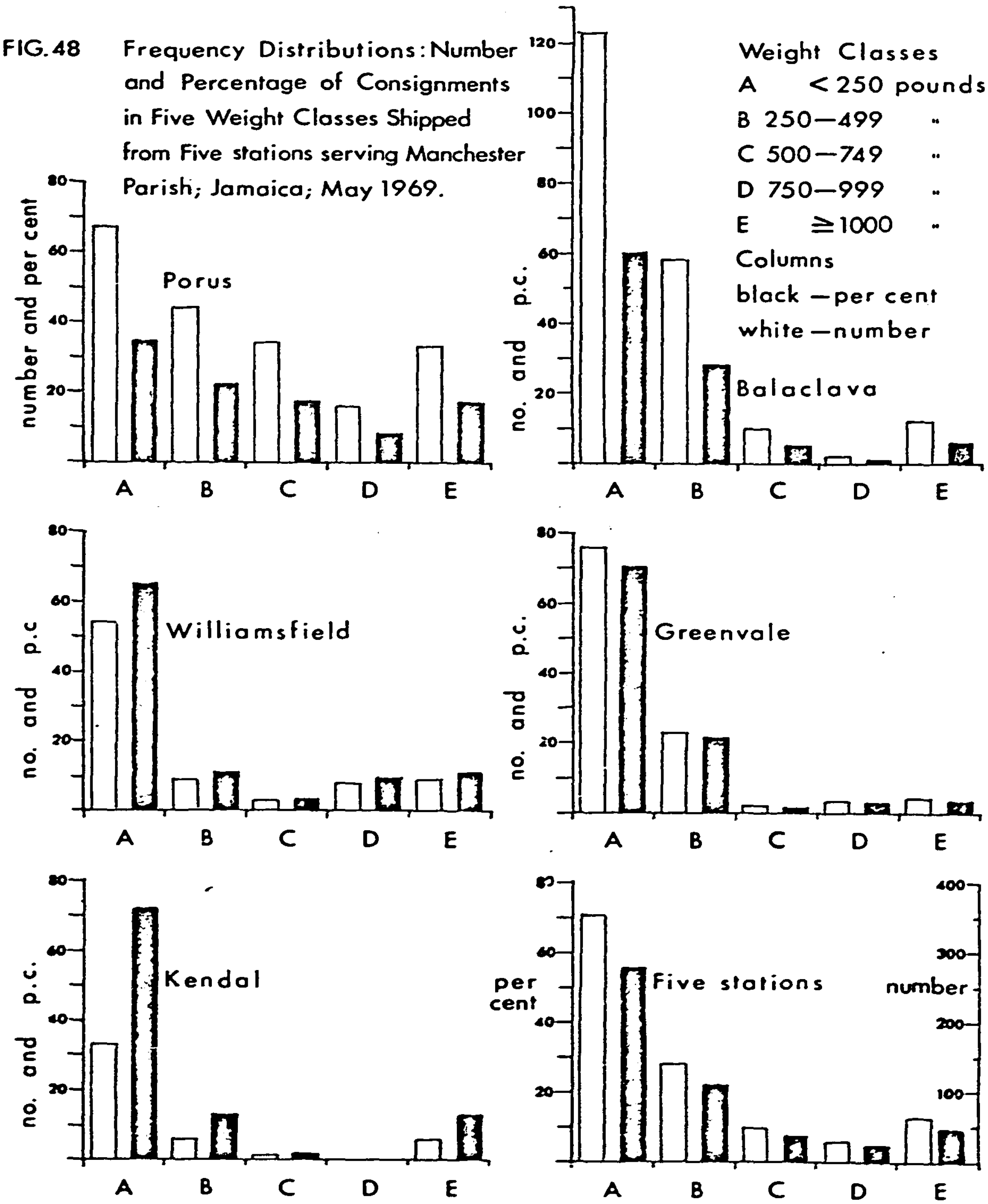


FIG. 48 Frequency Distributions: Number and Percentage of Consignments in Five Weight Classes Shipped from Five stations serving Manchester Parish; Jamaica; May 1969.

railway as a viable enterprise, while at the opposite extreme, the railway, in its' handling of small shipments at artificially low rates, subsidises the traditional small-scale marketing of ground provisions and fruits. The island-wide pattern of market truck services, however, limits the area around each station within which individuals make use of this service provided by the railway. Small-scale freight shipments by the railway are therefore analogous to its' passenger services in that both more nearly approximate a public service than a paying proposition, and both, even at the low rates offered, are of limited areal impact.

Figure 48 illustrates the predominance of consignments less than 250 pounds in weight shipped from the five stations serving Manchester parish. The data are drawn from the invoices of outgoing goods made out at the stations, and refer to the month of May, 1969. Twenty-six of the thirty-three consignments shipped from Porus exceeding one thousand pounds in weight were destined for Montego Bay, and all were shipments of citrus fruit. Of the Kendal consignments, the two banana shipments weighed 416,082 pounds, while the forty-four other consignments together amounted to only 11,963 pounds. Five of the nine Williamsfield consignments exceeding one thousand pounds were produce of the Pioneer Chocolate Company, Williamsfield, and were destined for Kingston. Three of the four largest Greenvale consignments were of oranges, shipped to Montego Bay by an enterprising local higgler. The larger Balaclava shipments were also of citrus fruit, the consignments being shipped to nearby Appleton and to Port Antonio. Of 707,228 pounds of goods shipped from the five stations during May 1969, 416,082 pounds were accounted for by the two Kendal banana shipments, and a further 75,469 pounds consisted of the 53 fruit shipments exceeding 1000 pounds in weight. It is interesting to note that none of the latter were destined for Kingston, despite the fact that 294 of the 636 consignments were shipped to the capital (121 were shipped to Montego Bay, 30 to Appleton, and five other stations — Spanish Town, Old Harbour, May Pen, Montpelier, and Port Antonio — were the recipients of more than 10 consignments).

It is not possible to discover from the goods invoices the exact origin and destination of outgoing shipments. Taken as it is from only one month's shipments from five stations, the brief description above serves only to illustrate the points made earlier in this appendix. Similarly, the frequency distributions in Figure 48 are no more than suggestive of the differences between individual stations in both the absolute number and the weight distributions of the consignments shipped. A full analysis of the role of the railway in the small-scale marketing system would demand a large interview sample of the type undertaken in this study for passenger travel. We believe that such a study would reveal that the benefits derived from this service provided by the railway accrue not to the railway itself but to its customers. We also believe that the hinterlands around each station from which market class passengers are drawn are relatively limited in extent.

APPENDIX 10

SOME ADDITIONAL COMMENTS ON THE DISCREPANCIES BETWEEN THE SAMPLED JOURNEYS AND JOURNEY CHARACTERISTICS AS EXEMPLIFIED BY JAMAICA RAILWAY CORPORATION RECORDS.

From the records kept by the Jamaica Railway Corporation it was possible to estimate the degree to which the interview sample was representative of all journeys made on the system during the period covered. For example, the discrepancy in the frequency distribution of distances travelled (Figure 3, page 10 above) is discussed in the text on page 9 and a possible explanation is advanced on page 11 above. The May sample cited in the text consisted, for each station on the system, of the number of tickets sold of each type on each day during May 1969, and of the pattern of destination stations of the journeys made during the last week of May 1969. These data can serve a comparative purpose only, however, in that the crucial variables concerning the added journeys to and from the station are available only by way of the interview sample. The following comments expand the theme of discrepancies between the interview sample and a more complete inventory of journeys, and point out some character--istics of the pattern of journeys which can be inferred only from the comprehensive records.

The interviews collected as described in Table 8-1 (page 132 above) were drawn from diesel and mixed trains in the proportions 41.77 and 58.23 per cent respectively. The 90,240 journeys made during May 1969 [1] were divided almost equally between mixed and diesel train travel, the respective percentages being 51.22 and 48.78. This disparity reinforces the statement (page 11, above) that the conclusions of the thesis cannot be held to be valid for all journeys made on the system.

The sampling framework was also weak with respect to the proportion of journeys made on each day of the week. The interview sample, distributed by days interviewed, is tabulated below with the corresponding distribution for the last four complete weeks in May (May 4th-31st).

TABLE 10-1. Number and Percentage of Interviews Sampled on each Day of the Week, and Comparable Data for May 1969.

		MON	TUE	WED	THU	FRI	SAT	SUN	TOTAL
INTERVIEWS	numbers	40	129	116	93	192	50	-	620
	per cent	6	21	19	15	31	8	-	100
MAY 1969	numbers, th.	14.2	10.4	9.5	11.7	11.3	17.1	5.3	79.5
	per cent	18	13	12	15	14	21	7	100

(May numbers in thousands, percentages rounded to whole numbers)

---

1. This figure excludes journeys made by season ticket holders (school-children) during that period: 118 season tickets were issued during May 1969. We have not been able to determine the average number in circulation at any one time.

From Table 10-1, sampling lacunae on Mondays, Saturdays and Sundays are self-evident. It was not possible, for example, to establish from the interview data the extent to which the way journeys are made varies from weekdays to weekends.

In the interview sample, Kingston was the origin or destination station of 78.5 per cent of the journeys made. Of the 18,218 journeys made between the 25th and 31st of May 1969, 9,104, or almost 50 per cent, were to or from Kingston. Table 10-2 demonstrates the variation between the stations in the contribution of ticket sales to Kingston as a percentage of total ticket sales. Only 7 of the 31 stations for which records are kept (excluding Kingston station) exceed the mean value of 34 per cent of departures being destined for Kingston station. The mean value of 50 per cent is achieved when the 4,427 departures <u>from</u> Kingston station are taken into account. The disparity between the values of 50 and 78.5 per cent is probably related not only to the tendency of the sampling method to under-represent short journeys (page 10, above), but also to the ultimate origin and destination of the interview traverse often being Kingston, and to the relative neglect of journeys made on the Frankfield and Port Antonio branch lines, which from Table 10-2 are generally less Kingston oriented than the main line.

In Figure 49 the journeys made on the system between May 4th and 31st are presented as individual daily totals.

TABLE 10-2 Tickets Sold To or From Kingston during the last Week of May 1969: Individual Station Totals.

LINE	STATION	JOURNEYS TO KINGSTON	JOURNEYS TO ELSEWHERE	TOTAL	KINGSTON AS % OF TOTAL
Frankfield	Frankfield	87	351	438	19.8
	Chapelton	32	123	155	20.7
Port Antonio	Bog Walk	72	414	486	14.8
	Linstead	112	134	246	45.6
	Riversdale	37	133	170	21.7
	Troja	57	197	254	22.5
	Richmond	123	256	379	32.5
	Highgate	84	233	317	26.5
	Albany	17	104	121	14.1
	Annotto Bay	11	168	179	6.2
	Buff Bay	23	233	256	9.0
	Hope Bay	8	119	127	6.3
	Port Antonio	121	366	487	24.9
Main	Gregory Park	1244	346	1590	78.5
	Spanish Town	584	1221	1805	32.5
	Old Harbour	81	170	251	32.2
	May Pen	193	616	809	23.9
	Four Paths	7	42	49	14.3
	Porus	117	200	317	36.9
	Williamsfield	85	228	313	27.1
	Kendal	37	92	129	28.7
	Greenvale	86	146	232	37.0
	Balaclava	171	533	704	24.3
	Appleton	127	178	305	41.6
	Maggotty	152	358	510	29.8
	Ipswich	26	244	270	9.6
	Catadupa	57	245	302	18.8
	Cambridge	84	312	396	21.2
	Montpelier	186	141	327	57.0
	Anchovy	51	100	151	33.8
	Montego Bay	605	1111	1716	35.5
	TOTALS	4677	9114	13791	34.0

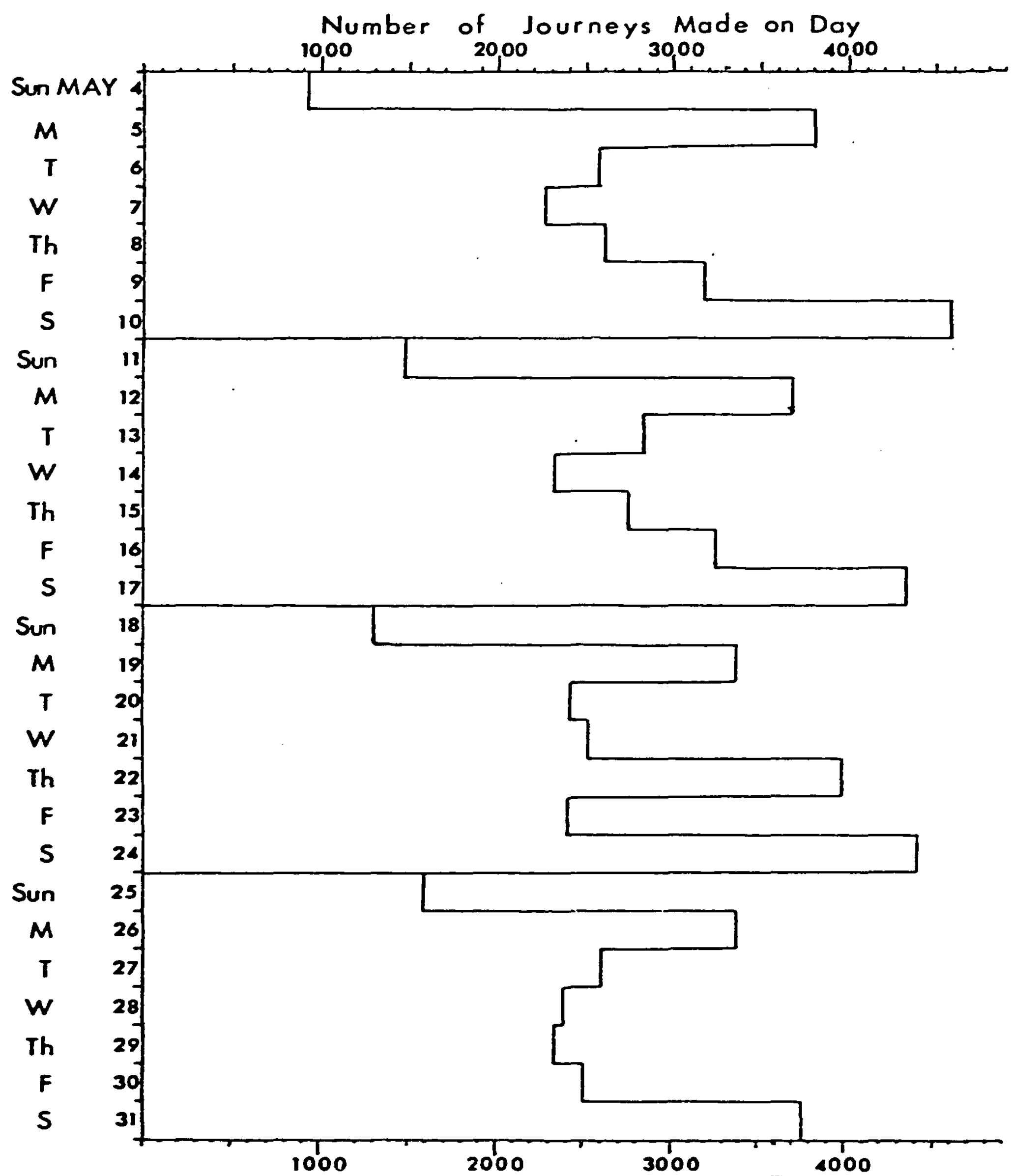
Journeys from Kingston... 4,427

Journeys to and from "... 9,104

Total Number of Journeys 18,218

To and from Kingston as percentage of total 50.0

FIG.49 THE WEEKLY CYCLE



Without further analysis, and accepting the occasional divergence from the norm (for example the Thursday and Friday preceeding Whitsunday, May 25), the weekly cycle appears to emerge clearly. Further research might examine the relationship between travel behaviour -- the central theme of the foregoing study, spatio-temporal journey patterns, and the pattern and periodicity of economic activity in Jamaica.

REFERENCES

Anderson, J.

1845: Report on Mechanical Improvements in Tropical Agriculture and the Manufacture of Sugar. Kingston, The Jamaica Times.

Bennett, A. A.

1967: The Jamaica Railway. International Railway Progress 1967-8. Published by the Railway Gazette.

Black, W. R.

1967: Growth of the Railway Network of Maine, a Multivariate Approach. University of Iowa, Department of Geography, Discussion Papers, 5.

Bland, E. M.

1937: Report on the Jamaica Government Railway. Report to the Colonial Secretary. Jamaica Railway Corporation, Kingston. 25 pp.

Boulding, K.

1968: The Image. University of Michigan Press. 175pp.

Brown, R.

1963: Explanation in Social Science. London.

Brush, J. E., and Gauthier, H. L. Jr.

1968: Service Centers and Consumer Trips. University of Chicago, Department of Geography, Research Papers, 113. 182 pp.

Carson, M.

1968: Some Problems with the Use of Correlation Techniques in Morphometric Studies. Unpublished paper. 17 pp.

Casetti, E.

1964: Multiple Discriminant Functions and Classificatory and Regional Analysis by Discriminant Iterations. Technical Reports 11 and 12, Office of Naval Research. Research project, Department of Geography, North-Western University.

Dixon, W. F., Ed.

1967: Biomedical Computer Programs. University of California Press. Berkely, Los Angeles.

Espeut, The Hon. W. B.

1887: The Advantages to Result from Railway Extension. Popular Lectures to the Institute of Jamaica.

Ezekiel, M., and Fox, K. A.

1959: Methods of Correlation and Regression Analysis. Wiley. New York. 548 pp.

Feldman, J. J., Hyman, H., and Hart, C. W.

1951: A Field Study of Interviewer Effects on the Quality of Survey Data. Public Opinion Quarterly. Winter 1951-2, 734-761.

Fox, H. R.

1937: Comments of the Acting Director of the Jamaica Government Railway on Major Hammond's Report. Jamaica Government Railway. 25 pp.

Guilford, J. P.

1965: Fundamental Statistics in Psychology and Education.

Haggett, P. and Chorley, R. J.

1965: Trend-Surface Mapping in Geographical Research. Transactions and Papers, Inst. Br. Geogs., 37, 47-67

1969: Network Analysis in Geography. Edward Arnold. London. 348pp.

Henriques, F.

1953: Family and Colour in Jamaica. Macgibbon and Kee. London. Second Edition 1968, 208 pp.

Kendall, M. G.

1957: A Course in Multivariate Analysis. London

King, L. J.

1967: Discriminatory Analysis of Urban Growth Patterns in Ontario and Quebec. Annals A.A.G. , 57, 566-578.

1969: Statistical Analysis in Geography. Prentice Hall. 288 pp.

Kish, L.

1959: Some Statistical Problems in Research Design. American Sociological Review, 24 (3), 328-338

Krumbein, W. C. and Graybill, F. A.

1965: An Introduction to Statistical Models in Geology. McGraw Hill. 475 pp.

Lefvert, P. O.

1968: An Inventory and Classification of Urban Settlements in Jamaica. Volume 2, including Areas of Population of Town Districts by Parishes. Report, U.N. Special

Funds Project, Assistance in Physical Development Planning. Town Planning Department, Kingston. 78 pp.

Lynch, K.

1960: The Image of the City. M.I.T. Press. Cambridge. 194 pp.

Maunder, W. F.

1954: The Significance of Transport in the Jamaican Economy. Social and Economic Studies, 3 (1).

1954: Notes on the Development of Internal Transport in Jamaica. Social and Economic Studies, 3 (2).

McGinnis, R.

1958: Randomization and Inference in Sociological Research. American Sociological Review, 23, 408-414.

Platt, Dr. B. S.

1957: Values of Food used in Jamaican Dietary. The Farmer's Food Manual, Chapter 5. Jamaica Agricultural Society.

Popper, K. R.

1957: The Poverty of Historicism, London.

Rao, C. R.

1952: Advanced Statistical Methods in Biometric Research. Wiley. 390 pp.

Schumm, S. A.

1963: Sinuosity of Alluvial Rivers on the Great Plains. Bull. Geol. Soc. Am., 74, 1089-1100.

Sebestyen, G. S.

1962: Decision-Making Processes in Pattern Recognition. London.

Shepard, R. N.

1964: On Subjectively Optimum Selections among Multivariate Alternatives. In, Shelley, M. W. and Bryan, G. L., Eds., Human Judgements and Optimality., 257-281.

Smart, J. S. and Surkan, A. J.

1967: The Relation between Mainstream Length and Area in Drainage Basins. Water Resources Research. 3 (4) 963-974.

Snedecor, G. W.

1956: Statistical Methods. Iowa State College Press.

Taaffe, E. J., Morrill, R. L., and Gould, P. R.

1963: Transport Expansion in Underdeveloped Countries, a Comparative Analysis. Geographical Review, 53 (4), 503-529.

Timbers, J. A.

1967: Route Factors in Road Networks. Traffic Engineering and Control, 9, 392-394.

Veldman, D. J.

1967: Fortran Programming for the Behavioral Sciences. Holt, Rinehart, and Winston. 406 pp.

Warntz, W.

1965: A Note on Surfaces and Paths and their Applications to Geographical Problems. Michigan Inter-University Community of Mathematical Geographers, Discussion Papers, 6.

Whorf, B. L.

1950: An American Indian Model of the Universe. _International Journal of American Linguistics_, 16, 67-72.

Winer, B. J.

1962: _Statistical Principles in Experimental Design._ McGraw Hill. 672 pp.