DIFFUSION OF SUPERCENTRES

DIFFUSION OF SUPERCENTRES

IN

ENGLAND AND WALES

By

MICHAEL DAVID SANDERSON, B.A., M.C.D.

A Research Paper

Submitted to the Department

of Geography

in Partial Fulfillment of the Requirements

for the Degree

Master of Arts

McMaster University

1975

Abstract

In the last ten years Britain has witnessed a revolution in retailing, partly through rationalization of operations within the retail trade, and partly as a response to external demands for change resulting from suburban growth, increased affluence and changes in consumer attitudes towards shopping. A major result of these factors has been the growth and spread of an innovation in retailing which has come to be called the "out-of-town Superstore or Hypermarket", or the more inclusive term, "Supercentre" used in this paper.

Qualitative analysis of this growth, outlined in Sections two and three of this paper, indicates that diffusion of this innovation conforms to the hierarchical-expansion diffusion model in the earlier stages, with evidence of neighbourhood effects during the later stages of infilling, at the same time following the urban hierarchy in overall growth.

Quantitative analysis, employing the multiple linear regression model, which is described in Section four, tested the validity of several hypotheses relating to the influence of "economic" or "market" factors in determining the growth and spread of Supercentres. The results indicate that these factors partially explain diffusion of this innovation between 1964 and 1972.

ACKNOWLEDGEMENTS

I wish to thank Dr. Leslie J. King, my supervisor, my wife Martha, and my secretarial staff: Leslie, Leona and Rhonda. Without their combined guidance, patience, insistance and technical skills, I would not have been able to complete the paper.

Michael D. Sanderson
Calgary, 1976

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

TABLE OF MAPS

1.0 INTRODUCTION

This study is concerned with the diffusion of a technological innovation within the distributive sector of the British economy, namely the growth and spread of the Supercentre shopping outlet in the British urban system. The two main goals of this investigation are: firstly, to describe the spread of the innovation through space and time; and secondly, to analyse the factors that have affected the spread since 1964.

One may ask why a study of this nature is necessary or useful. Yet, those concerned with the environment are acutely aware of the impact that technological changes can have on society, continually subjecting it to new pressures.

In the last ten years British planning has faced just such a situation. British retailing has begun to undergo a revolution; this is partly the result of external forces such as developments in North America and Europe, and partly the result of increasing pressures from within the British retailing sector as well as British consumer tastes in shopping. A major consequence has been increasing demands from many of the large multiple trading companies to expand their operations on to peripheral sites around Britain's towns and cities. Increasing numbers of local authority planning agencies are faced with applications from Tesco, Woolco, Fine Fare, Carrefour to develop Supercentre outlets either in isolation or as part of larger peripheral, planned shopping centres.

This paper does not propose to discuss the finer planning implications of Superstores or Hypermarkets (common names for Supercentres). It will, however, provide planners, geographers, and others with some probable answers concerning how and why this innovation has developed. The approach chosen in this study emphasizes the role of economic factors in influencing differential spread of the innovation through the British urban hierarchy. This approach is based on the assumption that a retailer or developer will choose as a primary location a site which, based on economic criteria, will be a viable concern. That is, the entrepreneur will choose the most profitable location.

The study proceeds from a brief review of the concept of diffusion in Section 2.0, to a qualitative description of what a Supercentre is, and the conditions that appear to have determined the growth and spread of the innovation, in Section 3.0. Finally in Section 4.0, the diffusion process is subjected to quantitative analysis in an effort to support the hypotheses developed from the discussions in Section 3.0.

2.0 THE CONCEPT OF DIFFUSION

2.1 Diffusion: The Concept

As Y.S. Cohen states:

> Diffusion studies, especially those concerned with the spread of innovations, are assumed to be necessary for understanding a major phenomenon in human life, namely change.

He goes on to consider the term change:

> change is assumed to be the phenomenon of acceptance of new modes of behaviour or new ways of doing things. Thus, a society can be said to have experienced change if its technology, institutions, customs or, in general, its way of life are different at one point of time than at another. (1)

The classical definition is, however, that offered by Katz, Levin and Hamilton, who write:

> . . . the process of diffusion may be characterized as the (1) acceptance, (2) over time, (3) of some specific item - an idea or practice, (4) by individuals, groups or other adopting units, linked (5) to specific channels of communications, (6) to a social structure and (7) to a given system of values or culture. (2)

Under these two sets of definitions, change can be technological in nature, social, economic, political, or environmental. Diffusion is the process of spatial growth and spread of an innovation over time. Diffusion studies have examined the problem of change in all these various areas, and to review even briefly the situation in all these fields would be fruitless. Most relevant to this research are, however, the economic studies, a major interest of which has been the impact of technological innovations on economic growth and development.

As stated in the introduction, this study considers the diffusion of a particular technological innovation - the Supercentre. Before defining the particular phenomenon, or describing the growth, it is useful to consider in more precise terms the "typical" technological innovation. R. Nelson defines the innovation from the economist's point of view:

> Innovation is here defined as the process by which new products and techniques are introduced into the economic system. Successful innovation results in the capability of doing something that could not be done before, or at least not as well, or so economically. (3)

It is within this definition that this author believes the Supercentre (whether Superstore or Hypermarket) to be a true innovation in retailing. Some would argue that it is just a much larger supermarket, and in many respects this is true for the Supercentre sells a wide range of food goods. Yet the superstore or hypermarket does, "result in the capability of doing something that could not be done before, or at least not so well, or so economically". (4)

The Supercentre concept has at last provided the large retailer with the opportunity to apply greater economies of scale to his delivery, distribution and merchandising of foodstuffs, and other non-food convenience and durable goods. Only by increasing the physical structure of the building to a size that provides greater on site warehousing, wider sales aisles, greater shelf space, and easier accessibility, could these new economies be attained.

2.2 Diffusion: The Process

Establishing the viability of the Supercentre as a true technological innovation in retail trading, it remains to provide a

basis from which to examine the growth and spread, and this necessarily means a brief review of the form that diffusion might take. In geographic writing, which is the source of much of the work in diffusion, the term has two distinct meanings:

1) Expansion: The process by which the phenomenon spreads through a population from region to region. Over time intensification of the adoption takes place in the region of origin, as well as growth to new regions.

2) Relocation: Also a spatial spread of an innovation over time, but the phenomenon evacuates the old region over time, moving its growth to a new region from T1 to T2.

When considering the urban hierarchy within which a technological innovation such as the Supercentre is spreading, the expansion model is accepted as being representative of growth. Again, two further sub-types can be identified:

1) Contagious Expansion: The rate of adoption depends upon direct contact, and is strongly distance determined. That is, a distance decay function has significant influence on growth and spread. This model assumes poor communication, other than by direct contact between entrepreneurs. Commonly called the "neighbourhood effect".

Effectively, this means that, other things being equal:

> elements of culture will be taken up first by societies which are close to their points of origin and later by societies which are more remote or which have less direct contacts. (5)

The probability is greater that a centre closer to the original point of adoption will adopt in the next time period, than a centre which is

further removed.

2) Cascade-Hierarchical Expansion: The process that transmits a phenomenon through a regular graduation of order, classes or hierarchies. Cascade diffusion is assumed to be always downward from large centres to smaller ones. If movement can be either up or down the urban hierarchy the term hierarchical diffusion is more common. (6) In other words:

> . . . the higher the ranking of a potential adoption unit in that hierarchy, the greater the chance of adoption before units that are lower on the hierarchy. (7)

Summarizing, Section two defines the concept of diffusion in as concise a manner as possible, what the term implies, and how it can relate to the growth and spread of a technological innovation, that is, how the diffusion process operates in an urban system. It is clear that regardless of innovation type, the notions of neighbourhood and hierarchical effects play, to a varying degree, a role in the growth and spread of an innovation. In Section three, these two fundamental concepts are used in a more practical sense as the diffusion of the Supercentre phenomenon in England and Wales is discussed in purely qualitative terms, in an attempt to explain why it occurred, and how the phenomenon has spread.

3.0 THE DIFFUSION OF THE SUPERCENTRE IN ENGLAND AND WALES

3.1 A Context for Growth

Why did this form of retailing emerge in the early 1960's to challenge existing merchandising practices in the convenience-food sector of British retailing? An answer to this question is necessarily involved and at times complicated but can be summarized as being the result of the following factors:

1) Rapid rises in the Suburban Population, and correspondingly, a decline in the population of the central core areas of Britain's large cities and towns.

2) Rapid increases in household income and expenditure.

3) Reflecting rising affluence, the household mobility increased as a result of greater car ownership.

4) Increasing competitiveness within the retailing sector.

The influence these four factors have had on the emergence of new retail developments is summarized by J. C. Barlow, in the Sunderland Shopping Report:

> In the period up to and immediately following the Second World War the choice of where to shop was governed by distance from the home and the ease of access by public transport to competing facilities. Changing economic circumstances however have produced a large increase in personal affluence though also a corresponding increase in labour costs. These changes, coupled with a major reorganisation of the population, have created a situation where consumers are more mobile and have become more selective. They are being catered for by a retailing trade which has rationalised itself into larger units, employing less people and which competes intensively for the available custom. (8)

Between 1961 - 1971, Britain's overall population growth was 5.4%. This modest figure does however disguise the substantial changes in population redistribution which in effect, dramatically shifted the demand for retail facilities. Specifically, the suburban population growth around the major cities and towns has been substantial, conversely, central urban areas have been suffering a decline during the same period. Of the twenty-five urban areas under investigation, twenty witnessed substantial suburban growth, as high as 42.8% during the period 1961 - 1971. Only five of the twenty-five areas suffered a decline in suburban population, and these averaged only 4.8%. During the same period, eighteen of the twenty-five urban areas suffered a decline in central area population, some by as much as 20.2%. (See Appendix A).

Between 1962 - 1970, household income and expenditure for the United Kingdom increased by 63% and 45% respectively which in terms of purchasing power is equivalent to rises of 22% and 10%. Also, in terms of retail pressures, most of the increased expenditure was in durable sales, convenience sales in real terms had remained level since 1961. (9) The consequence of these changes was increased competition by retailers for the consumer purchasing power.

A major indicator of this rising affluence has been the rapid growth in the number of private cars licensed. Between 1961 - 1971 there was a 100% increase. Again, in the sample used in this study, rises of up to 30% occurred between 1966 - 1971. Use of the car for shopping, especially during evenings and weekends, and by women drivers has also shown a marked increase.

Within the context of population changes, increasing affluence and greater consumer mobility, retailing has begun to undergo a revolution of its own. While the number of units in Britain declined by 11% between 1961 - 1971, there have been several noticeable trends:

1) Decline of the independent shop at the expense of growth in the multiple sector both in absolute terms and in percentage of trade.

2) Decline in the co-operative store.

3) A rise in the average size of shop units.

The Hypermarket and Superstore have developed as a result of the retailers' desire, firstly, to increase efficiency of the internal operations by increasing the scale, and secondly, to cater to the more mobile car-borne shopper. As Barlow states:

> . . .a new form of competition has evolved, mainly the out of town centre, the hypermarket and the retailing warehouse (or Superstore). These forms of trading take advantage of non-central locations with their relatively cheap rents, and construction costs, their high accessibility due to the provision of large car parks and their large economies of scale, to offer highly competitive prices. (10)

Given these underlying factors, it remains to consider the Supercentre phenomenon as a technological innovation developing as a response to the needs of the retailer of foods and inexpensive household goods, firstly to increase internal efficiency, and secondly to cater for changes in consumer retailing patterns. The growth and spread of the innovation through the urban hierarchy in England and Wales has been a response to satisfy these objectives.

3.2 What is a Supercentre?

For the purposes of this study the term Supercentre is more appropriate than either Superstore or Hypermarket (the latter originating in France, the former unique to Britain), as it allows both forms of development to be included within a single definition. In effect, a hypermarket is simply a larger scale superstore, having greater car parking facilities, and a wider range of convenience and durable goods. The N.E.D.O. Report of April, 1971, defines a hypermarket as a:

> large retail unit with at least 25,000 ft. sq. of selling area, situated outside the conventional commercial centres and located on the edge of or outside a town. Food and Non-Food goods are sold by self-service and the store is surrounded by large car parking facilities. (11)

This definition, along with an analysis of the characteristics of existing superstore facilities and hypermarkets in Britain, form the basis for identifying the sample used in this study. Therefore, a Superstore or Hypermarket (i.e. a Supercentre) must be:

1) Located in an off-centre location which can be suburban, edge of town, or out-of-town; and should

2) Have a minimum of 25,000 sq. ft. of selling space.

3) Provide significant free parking at ground level for customers.

4) Offer a wide range of goods under one roof, primarily convenience items but also a limited range of inexpensive durable household goods. Sales must be made via the self-service technique.

5) Cater primarily to the car-borne shopper and is orientated towards the one-stop shopper.

6) Be owned and operated by a single company.

7) Include some provision for amenities, i.e. play space for children.

Within these criteria, several potential Supercentres were eliminated, i.e. the Woolco stores at Telford New Town and Runcorn New Town, as they were recognized as being integral with the Town Centre and therefore not in a peripheral position in competition with the existing retail facilities.

3.3 Growth and Spread of the Supercentre

According to the criteria outlined, twenty-five adoption units (urban centres which had Supercentres on their peripheries) were identified by the end of 1972. Multiple adoption of Superstores of Hypermarkets around individual cities would have increased this sample slightly but since the objective was to identify when and why the first Supercentre opened in a city, that is, the inter-urban spread of the innovation through the hierarchy, intra-urban growth was ignored as being too small to lend itself to accurate statistical analysis. (Appendix A).

Initial adoption of the Supercentre concept occurred in 1964 when GEM Supercentres, an American organisation which operated out-of-town discount stores, began opening similar stores in Britain. Initially, they opened two Supercentres, one (80,000 sq. ft. gross) at West Bridgeford, about 2½ miles south of the centre of Nottingham, and another (85,000 sq. ft. gross) at Cross Gates, about 4 miles from the centre of Leeds, Yorkshire. (12)

Growth, however, was slow, probably due to the fact that relative profitability of entry of a new retail form into an area depends upon the size of the eventual market in that area, marketing costs, the costs associated with innovating (given a positive rate of interest) and the expected rate of acceptance (by consumer, other retailers, and other bodies such as planning agencies and environmentalist groups). (13)

The British consumer in 1964 was possibly not quite ready to accept the large scale out-of-centre store, and one stop shopping by car. Car ownership per family was still quite low at that time, which would have reduced the potential market of this type of store. Whatever the reasons, GEM encountered problems and opened no further stores. Eventually they were bought out in 1968 by Associated Dairies, who again took the plunge and began to open further stores in 1969 under the name ASDA Superstores. Prior to this date however, another type of out-of-centre development appeared in the form of WOOLCO checkout department stores, where there were food sales, but the emphasis was now given to durable goods and other non-food convenience items. ASDA, WOOLCO, Carrefour, and Fine Fare all offer between 30% and 40% of the floor space to food sales, the remainder to non-food items, GEM only offered food sales in their first stores.

The first Woolco development was built in 1967 at Oadby, near Leicester, followed in 1968 by a store in the Hampshire Centre, three miles north of Bournemouth.

Not until 1969 did the rapid spread of the innovation begin, when five new stores were opened. Table One indicates the rate of growth and magnitude of development between 1964 and 1972.

Table One

Rate of Growth and Magnitude of Adoption of Supercentres in England and Wales, 1964-72

Year	Number of Newly Adopting Urban Areas	Total Building Area of Supercentres in Given Year ($Ft.^2$)
1964	2	169,000
1965	0	-
1966	0	-
1967	1	80,000
1968	1	114,000
1969	5	277,000
1970	3	257,000
1971	5	249,000
1972	8	446,500
1964-72	25	1,423,500

Two points become apparent from an examination of Table One and Figure One. Firstly, initial growth was slow and only after five years did it begin to accelerate. Secondly, adoption of the innovation has not yet peaked, in fact the trend appears to be one of acceleration providing further evidence to support the Logistic Curve model of diffusion growth.

Reviewing the rate of growth of the Supercentre phenomenon, an exponential trend is evident. The remainder of this section is devoted to answering the question of why the innovation has grown in the manner it has, that is, how the spread process has occurred and been influenced. Although looking at the spread of a phenomenon in maps is not a substitute for rigorous analysis, some things can be

Cumulative Growth of Supercentres 1964 - 1972

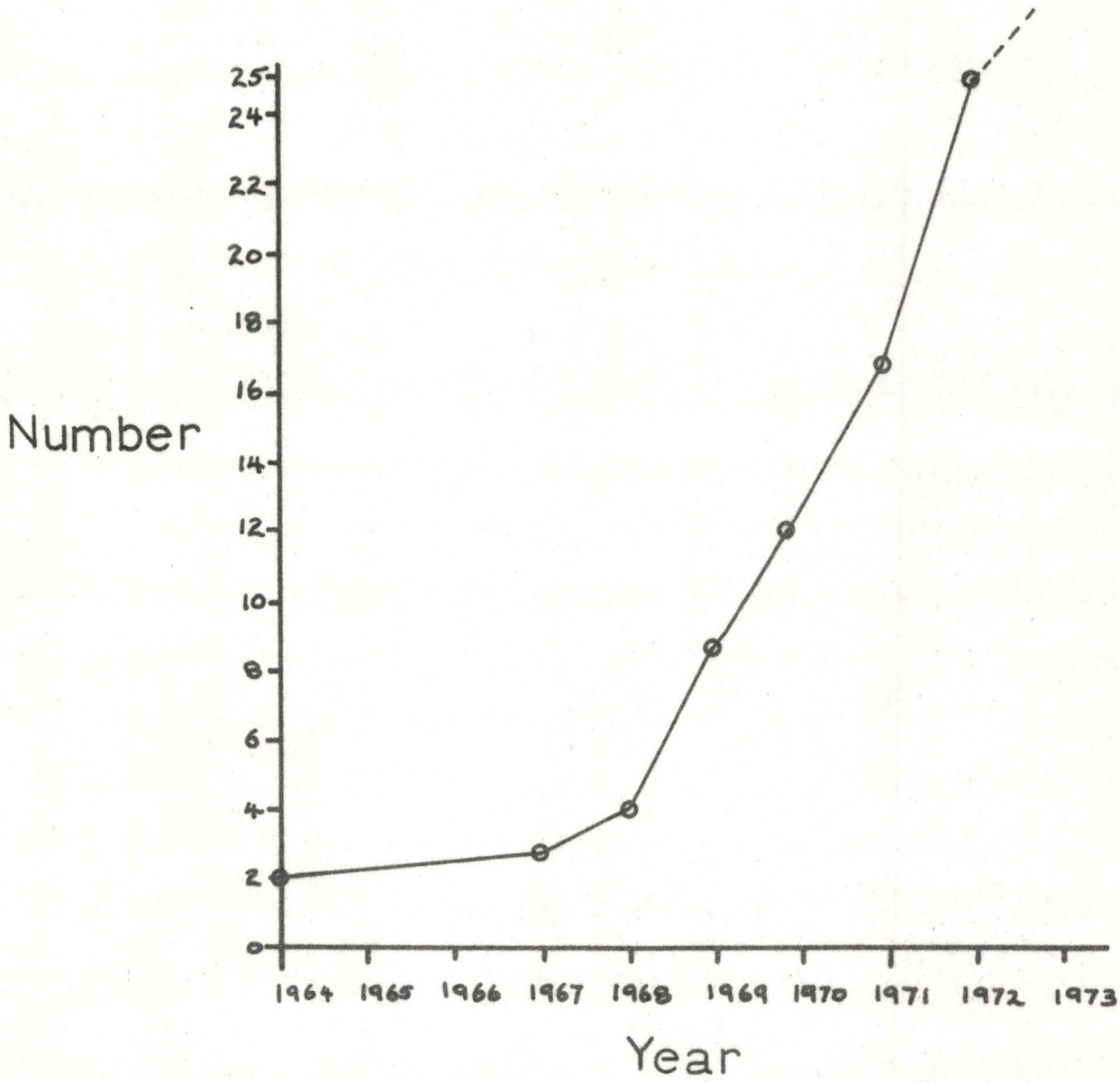


Figure One

learned. Map One outlines the spatial course of diffusion by date of adoption.

The initial centres of adoption were Leeds and Nottingham, the former, the largest urban centre in the Yorkshire and Humberside Region; the latter, the largest metropolitan area in the East Midlands Region. The first Woolco store, opened in 1967, was located in the suburbs of Leicester, the county town and the second largest city of the East Midlands Region. The second Woolco store was opened in suburban Bournemouth, although not the largest single city on the south coast, is the centre of the largest catchment population south-west of Portsmouth and Southampton.

From these first four centres, the spread of the innovation has been for the most part hierarchical. In 1969, Supercentres were opened in Sheffield and Bradford, the second and third largest cities in the Yorkshire and Humberside Region. In 1970 the first supercentre in the Northern Region was opened in the suburbs of Newcastle, the largest urban centre in the region. By the end of that year the North-West and West Yorkshire area was proving to be the primary area of growth, as smaller sub-regional centres such as Rochdale, Rotheram and Widnes adopted. Of the first twelve Supercentres opened between 1964 and 1970, seven would appear to conform closely to the hierarchical model of diffusion while five appear to have resulted from the neighbourhood effects, yet even these appear to be sub-regional centres. In summary, this first period indicates that initial spread of the innovation into previously unoccupied areas was via the hierarchical model; later infilling growth was via the neighbourhood

model, but still influenced by the position of the urban centre in the local urban hierarchy.

The new adopters in 1971 and 1972 also clearly support the hierarchical model, as all thirteen were either the largest urban centres of a region, such as Cardiff, or were county towns, and major sub-regional centres such as Portsmouth, Norwich, Exeter, Peterborough, and Northampton.

The pattern of diffusion through the urban system of England and Wales has followed several clearly recognisable stages:

Stage One: Initial Adoption of the Innovation by Major Regional Urban Centres. (Leeds, Nottingham).

Stage Two: Spread through the upper levels of the national urban hierarchy. (i.e. Bradford, Sheffield, Newcastle).

Stage Three: Some infilling of the hierarchy between regional centres - intensification, within one region, i.e. the N.W. and W. Yorkshire, centres such as Widnes, Rotheram.

Stage Four: Spread and later growth in areas further removed from the initial centres and areas of adoption, still conforming to the hierarchical, (the areas being regional and sub-regional centres) then neighbourhood model.

These trends and stages have resulted in twenty of the twenty-five adoption centres being located north of the Severn-Wash line. Of the five remaining centres that adopted south of this line, all but one adopted after 1971.

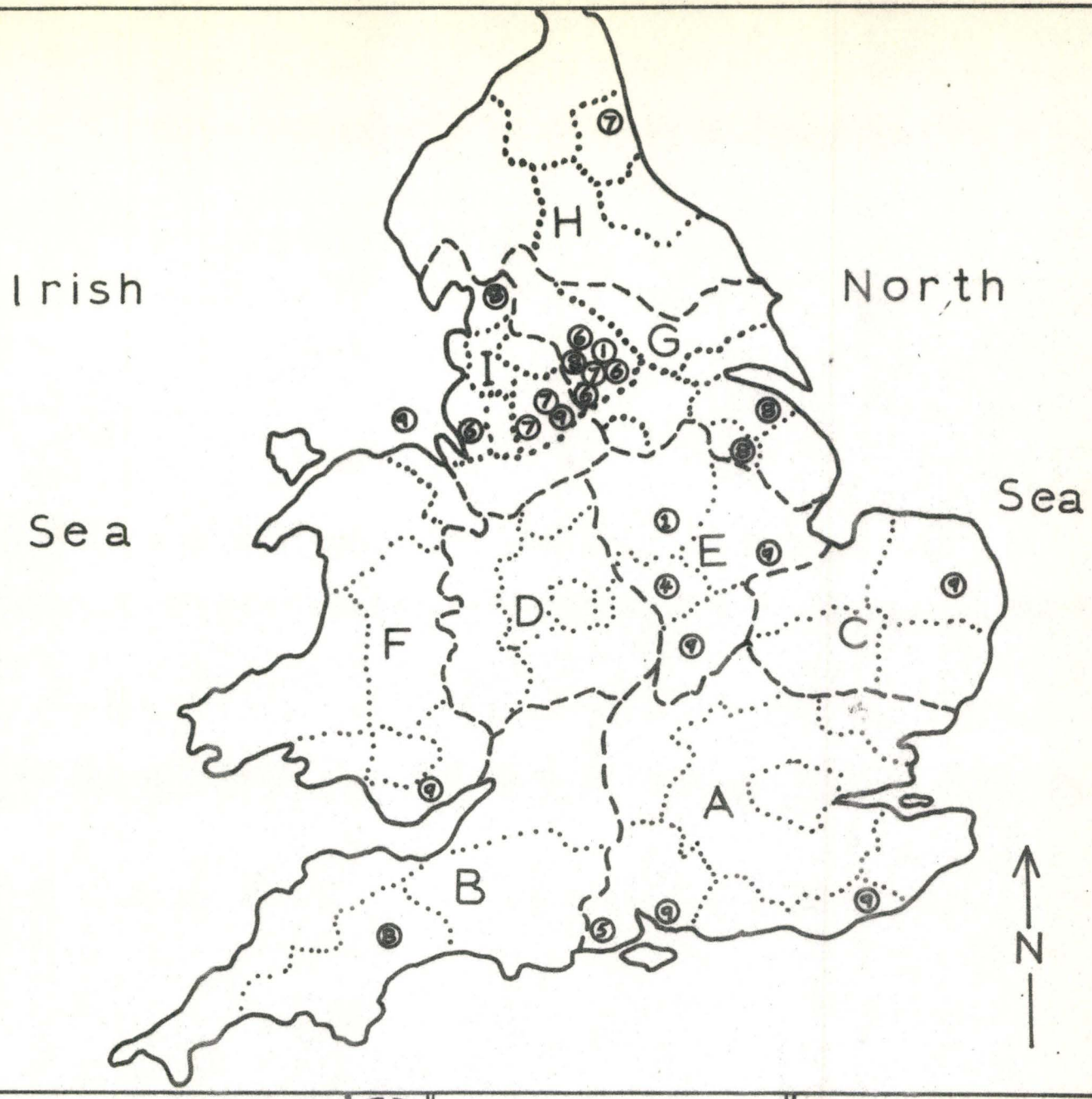
In general, the spatial spread between 1964 and 1972 suggests that the diffusion of Supercentres did proceed according to the urban

hierarchy. It is specifically evident that within regions and sub-regions, the largest or second largest city or town always adopted before other towns. Also, the diffusion process reveals that within the urban system of England and Wales, larger cities adopted earlier than smaller ones, even though in both cases generally they may be the largest city or town in a specific area.

Map One shows that all regions in England and Wales have at least one adoption centre, with one exception: the West Midlands, centred on the Birmingham connurbation. This is not to say there have been no applications in this region, as a number of inquiries have been held to consider major proposals around Newcastle Under Lyne and other towns.

In summary, the diffusion of the Supercentre in England and Wales has revealed a growth which has concentrated in the North West and West Yorkshire areas, and only in the later stages spread southwards and eastwards to the small centres down the national hierarchy. Table Two indicates the extent of this process.

The assumption has been that an entrepreneur will locate a supercentre in an urban area which offered the maximum economic opportunity combined with the least possible resistance; resistance in terms of opposition from established retailers, consumer reaction, environmentally concerned groups, and planning officials and politicians. This hypothesis would appear to account for the lack of development around Birmingham, London and Bristol, (14), three natural areas for supercentre growth. Resistance has been high as noted by the number of planning refusals. The urban centres which have



Standard Regions: Boundaries (H)
Sub-Regions : "

Region
A - south-east
B - south-west
C - norfolk
D - west-midlands
E - east-midlands
F - wales
G - yorks.-humber
H - northern
I - north-west

urban centre adopting a supercentre in: year	code	no.
1964	①	2
65	②	0
66	③	0
67	④	1
68	⑤	1
69	⑥	5
70	⑦	3
71	⑧	5
72	⑨	8

MAP ONE

SPREAD OF SUPERCENTRES IN ENGLAND AND WALES 1964 to 1972

Table Two

Magnitude of Adoption by Region, 1964-1972

YEAR OF ADOPTION	REGION S.W.	S.E.	Norfolk East	E. Midlands	W. Midlands
1964	0	0	0	1	0
1965	0	0	0	0	0
1966	0	0	0	0	0
1967	0	0	0	1	0
1968	0	0	0	0	0
1969	0	0	0	0	0
1970	0	0	0	0	0
1971	1	0	0	0	0
1972	0	2	1	2	0
	1	3	1	4	0

YEAR OF ADOPTION	REGION Wales	N.W.	Yorks. & Humberside	Northern
1964	0	0	1	0
1965	0	0	0	0
1966	0	0	0	0
1967	0	0	0	0
1968	0	0	0	0
1969	0	2	3	0
1970	0	1	1	1
1971	0	1	3	0
1972	1	2	0	0
	1	6	8	1 = 25

adopted the innovation have offered resistance, but it would appear to have been weaker than around Birmingham and London for example. Given an area which offered more advantages for growth, (i.e. the North West of West Yorkshire), the entrepreneur will locate a new store in the urban centre offering greatest economic potential.

In Section four the general conclusions about supercentre growth and spread as a function of economic potential, which in

turn is a function of changing consumer habits, suburban growth, size of catchment area, are put to a rigorous analytical test.

4.0 THE DIFFUSION PROCESS: ANALYSIS

4.1 Major Hypotheses

The major hypothesis of this study is that market factors are are involved in the process of diffusion of supercentres in England and Wales. Although it has been pointed out that there are other possible influences which have determined the spread of the innovation it is assumed that entrepreneurs consider them as resistance and still develop on the most suitable sites, if permitted. Therefore, it is further hypothesized that market factors are the dominant influence in the diffusion process and are capable of explaining variation between adoption units and time.

The term "market factors" is, however, a broad one and not easily defined. It could imply an economic analysis of the availability of investment capital in a particular city vis-a-vis alternative investment opportunities for the entrepreneur.(15) This type of study is beyond the scope of this paper, yet in order to operationalize the term in a manner which provides access to relevant, accurate data, a number of variables must be chosen which can be assumed to affect and represent demand for new facilities.

4.2 Variables and Data Collection

The major hypothesis of this study requires that a relationship be tested between date of adoption of a supercentre by an urban centre (dependent variable), and certain measures of economic potential of the

market of a given urban area, using "market variables" (independent variables). Choice of the independent variables was based on a desire to reflect as closely as possible the probable influence of each on the market, as well as being measures of the potential of each individual market. Two types of market factors were finally selected:

1) Primary Economic Variables: reflecting market potential of an urban area.

2) Secondary Variables: reflecting the influence of demand generated by a given urban area, i.e. rates of suburban growth, and car ownership.

Using these two general types of variables, three specific groups were then considered:

A) Population Characteristics of the adoption centre.

B) Car Ownership Characteristics.

C) Retail Turnover Characteristics.

Population (POP) Variables were subdivided into:

i) Total Catchment Population. (X1 = POP)

ii) Suburban Population Growth. (X2 = SUBPOP)

iii) Central Area Growth. (X3 = CAPOP)

iv) Overall Growth. (X4 = OVGROW)

The POP variable reflects overall catchment population of the urban centre. The remaining three population variables relate to growth of the market, in overall terms or specific sectors of the market, i.e. the central areas or the suburbs.

Car Ownership (CO) variables included:

i) Total Population with access to one or two cars. (X5= CARPOP)

ii) Number of Households with Two Cars. (X6= TWOCAR)

iii) Number of Suburban Households with One or Two Cars (X7= OTCAR)

iv) Total Number of Households with One or Two Cars. (X8= OVGROW)

v) Ratio of Two Car/One Car Households in the Suburbs (X9= RATSCAR)

vi) Ratio of Two Car/One Car Households for the Total Urban Area. (X10= RATTCAR)

The six variables relating to Car Ownership were considered necessary firstly, to provide a more realistic measure of the actual potential catchment population (as recorded from the Hampshire Centre Survey, where nearly 90% of the customers arrived by car), (X5, X7, X8), and secondly, to relative affluence of the market. Variables X9 and X10 and X6 measure the wealth of the market in each urban area. Also, car ownership is a good surrogate measure of mobility.

Retail Turnover (TURN) was subdivided into six variables:

i) Total Retail Turnover for Area (X11 = TURN)

ii) Total Convenience Goods (i.e. Food items, and inexpensive household wares). (X12 = CONV)

iii) Percentage of Total Turnover in the Central Trading Area. C.B.D. (X13 - CBDTURN)

iv) Percentage of Convenience Goods to Durable Goods. (X14 = CONDUR)

v) Turnover Per Head of Population. (X15 = TURNPOP)

vi) Convenience Goods Turnover Per Head of Population. (X16 = CONPOP)

Variable X11, TURN (Turnover, Total Retail), again provided a third measure of total Market Potential of an individual adoption centre. In addition, Total Convenience Turnover (CONV) was considered desirable to measure the probable expected market of a Supercentre, which is primarily aimed at serving the convenience good type market. Percentage of Convenience goods to Durables was necessary to measure the need within the convenience sector. Percentage of total turnover in the C.B.D. (X13) is a measure of the strength of the central area shopping as a competitor for the Supercentre. Finally, the ratios of convenience goods turnover per head of population, as well as total turnover per head of population were included as measures of expenditure differentials between areas, factors which an entrepreneur might consider in assessing potential Supercentre sites.

4.3 Data Collection

Given the requirements of the three variable groups, the next stage was to collect the data necessary to employ the sixteen variables in testing the hypothesis concerning the importance of market factors. Up to this point the terms; urban centre, central area, suburbs, hinterland, have been used in a rather loose fashion. Therefore, it was necessary to define the spatial areas that constitute the total urban centre which make up a single potential adopter. These areas have been formulated on the basis of predicted travel distances to a Supercentre, that is, how far the car-borne consumer will travel to shop at the store. Considerable work has been carried out in this area, primarily by entrepreneurs, but also by certain local authorities who

have been attempting to study the impact of such stores and centres on existing retail facilities. A good example is the study made of the Hampshire Centre (a Woolco development), on the outskirts of Bournemouth, Hampshire.

The survey of shopping habits, carried out by Retail Outlets Research Unit in 1972, four years after the Hampshire Centre opened, revealed that nearly 90% of their sample were car-borne, and as Table Three following indicates, approximately two-thirds of the customers lived within a twenty minute drive of the centre, and four-fifths were within one-half hour car journey.

Table Three

Travel Mode/Journey Time

Mode	Minutes						
	0 - 4	5 - 9	10-19	20-29	30-59	60+	D/K
Car	7.5	17.6	39.9	15.8	11.6	6.0	1.6
Bus	3.4	17.7	37.9	20.7	20.7	0.0	-
Foot	16.6	36.4	35.1	4.6	4.6	2.6	0.1
TOTAL Journeys	8.2	19.1	39.5	15.0	11.1	5.7	1.4
Cumulative TOTAL	8.2	27.3	66.8	81.8	92.9	98.6	1.4

(Source: The Hampshire Centre, Bournemouth, p. 16)

Converted into simple distance terms,

> . . . 24% of the Centre's trade originates from within 1 mile, 12% from 1 - 2 miles, 7% from 2 - 3 miles, 22% from 3 - 5 miles and 30% from over 5 miles. (16)

The consensus of opinion reached in studies of this type is that a Superstore, or Hypermarket could expect to attract customers

from within a 25 minute travelling time, with an inner zone of drive time of 15 minutes or less being of extra significance. (17)

Given these two figures of 0 - 15 minutes and 16 - 25 minutes, zones from which a Supercentre expects to draw 60% and 35% of its total (5% is chance trade), the next step was to convert distance as measured in time to distance measured in miles. The Greater Peterborough Shopping Study (1973) provided useful conversion tables for average speed by type of road. Table Four outlines the findings of the Peterborough Development Corporation regarding average road speed by road type.

Table Four

Road Type	Average Speed (M.P.H.)
A1 (Primary road)	60
A1 through settlements	50
Other A,B, and Fen roads	40
C class and other non-urban roads	30
High quality urban roads (motorway standard)	35
Other urban roads	20

(Source: Peterborough Development Corporation).

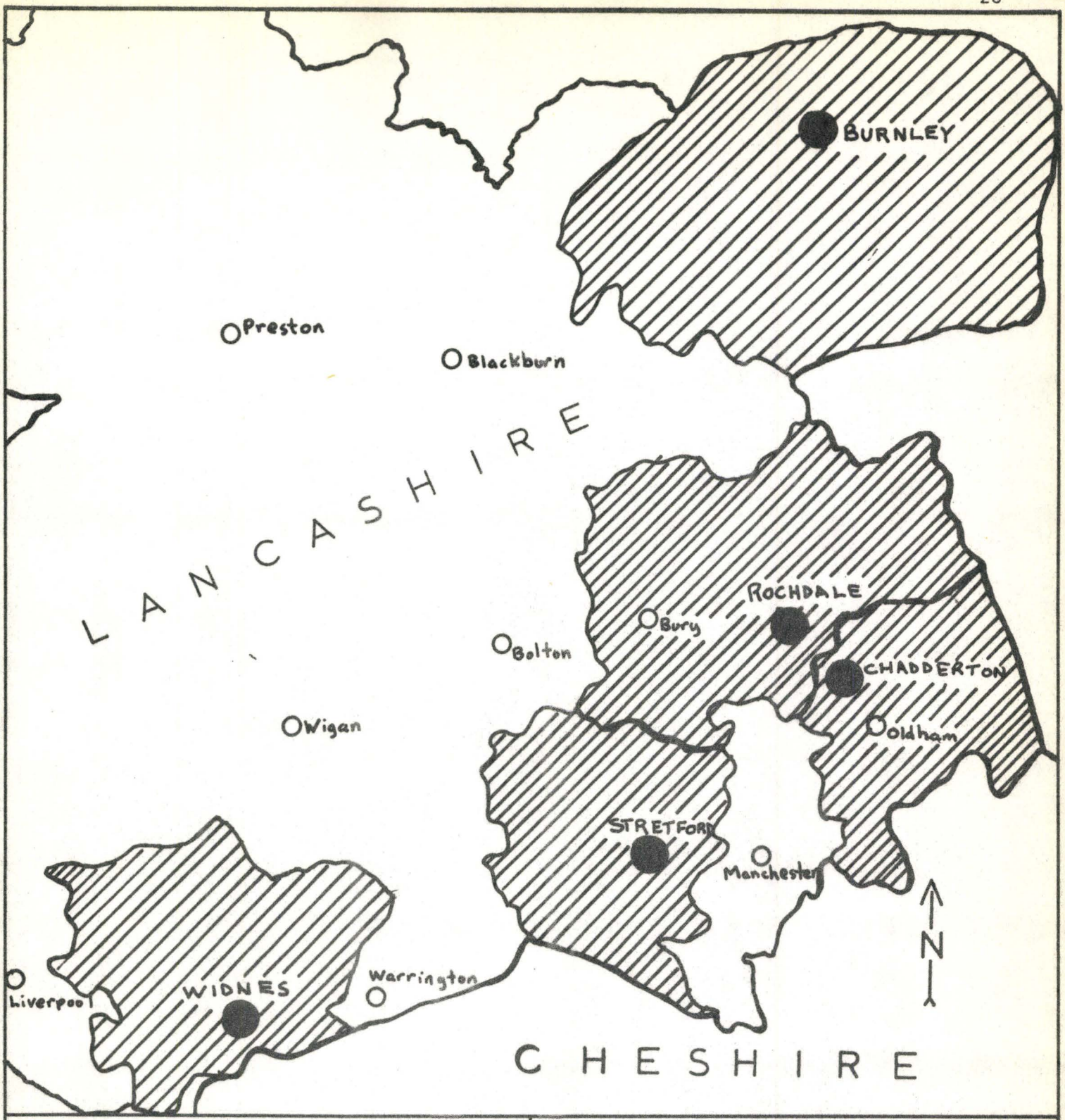
As indicated, the greater proportion of the roads considered, (similar to other roads in Britain) were assigned speeds of between 20 and 40 M.P.H. It was assumed that the greater proportion of all shopping trips would be made on these types of roads, therefore, an overall average speed of 30 M.P.H. was adopted. Impedence resulting from congestion was assumed to add a further 5 minutes to a journey. (18) The result was that the extent of a catchment zone was between 5 miles and 10 miles, therefore were possible, the mean of 7.5 miles was

adopted as the radius of a catchment area of any given adoption centre. In order to facilitate collection of the necessary data, local authority boundaries were followed in nearly every case, thereby somewhat distorting the catchment area limits.

A final point about the assignment of catchment zones concerns the situation where two supercentres are located closer than 7.5 miles. In this type of situation, potential trading areas were as far as possible, divided equally, following Local Authority boundaries. The best example of this type of split occurs in the case of the ASDA Superstores at Pudsey, outside Bradford, and Morely, outside Leeds. Maps Two and Three indicate the catchment areas of the Supercentres in Lancashire and West Yorkshire.

All the necessary data was calculated for a base year of 1966, despite the fact that two of the Supercentres had been built prior to this. 1966 was chosen over 1961 as the necessary data about car-ownership, population, and turnover would be more representative of the existing situation in England and Wales immediately prior to the period of growth and spread of the innovation.

Population: Population figures were drawn from the 1961 and 1971 Full Census and the 1966 10% sample census, and collected for each Local Authority within each of the individual catchment areas. Suburban population was considered to be all Local Authorities surrounding the major urban centre. For example, Bradford's central area is defined as the old county borough; the suburbs, all the remaining local authorities within the Bradford catchment zone, including Pudsey, where the Supercentre was located.



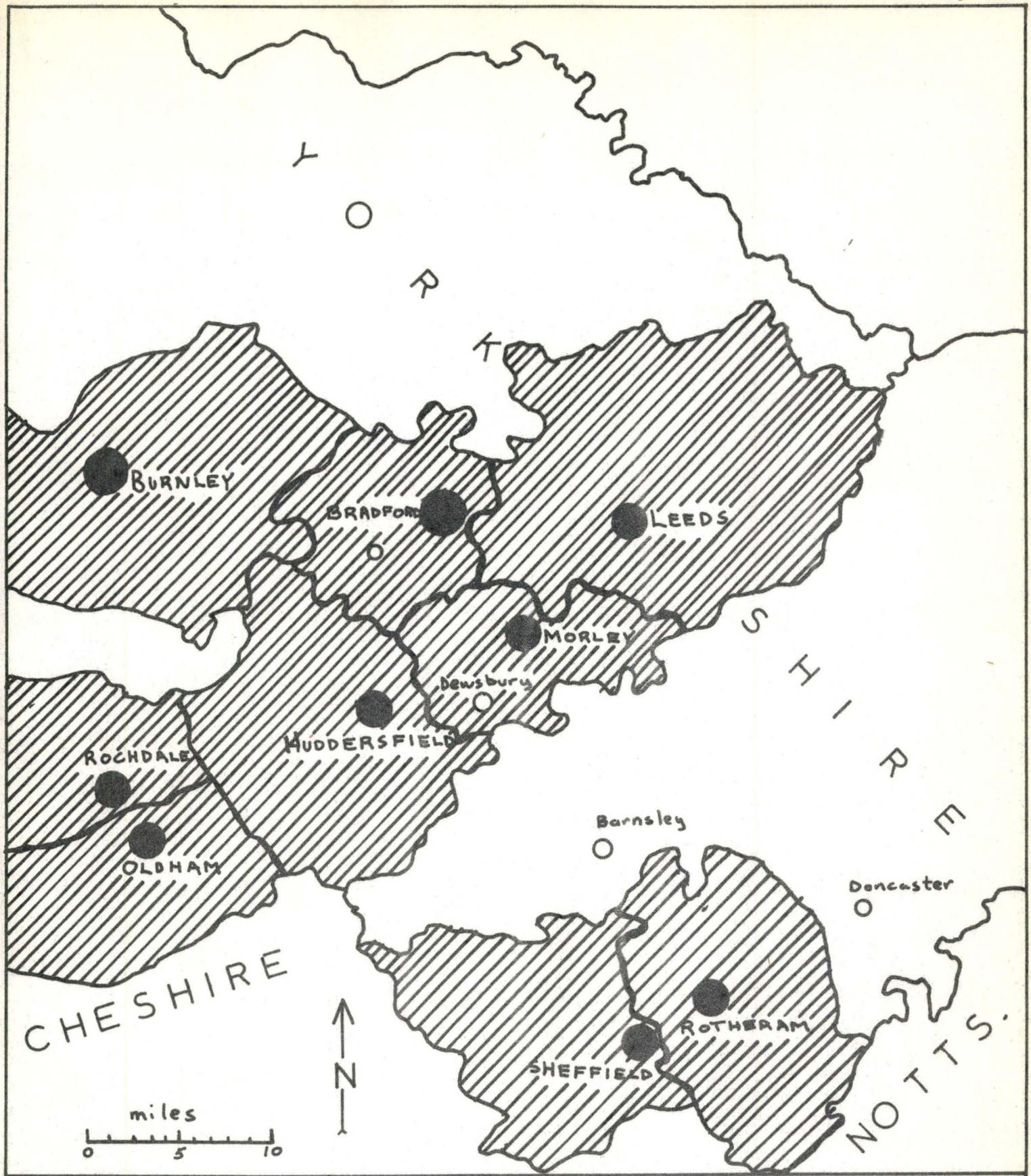
boundary
catchment area
location of supercentre
other major cities

miles
0 5 10

MAP TWO

CATCHMENT AREAS:

LANCASHIRE SUPERCENTRES



boundary
catchment area
location of supercentre
other major cities o

MAP THREE
CATCHMENT AREAS:
WEST YORKSHIRE
SUPERCENTRES

Car Ownership: Once again the 1966 and 1971 Census figures were drawn upon for the required data.

Retail Turnover: The most recent retail turnover figures were those presented in the 1961 Census of Distribution. These figures were considered to be somewhat out of date and not truly representative of the growth of consumer expenditure, as well as changes in population distribution during the period 1961 - 1966. The following formula was therefore adopted from the Greater Peterborough Shopping Study to calculate 1966 turnover figures for consumer goods, durables, and percentage of turnover in the Central Shopping area of each zone. (19)

$$\text{Local Turnover 1966} = \text{Local Turnover 1961} \times \frac{\text{Net expenditure per head, 1966}}{\text{Net expenditure per head, 1961}} \times \frac{\text{Local Population 1966}}{\text{Local Population 1961}}$$

This calculation assumes that local expenditure was roughly equal to the national average, which grew from a base of 100 in 1961 to 114 in 1966, a 14.0% real growth.

After collecting the relevant data and calibrating the ratios of expenditure, growth or decline etc. for population and car ownership, the next stage was to consider the implications each of these various independent variables would or should have on the adoption of the innovation by specific urban centres.

4.4 Hypotheses Related to Independent Variables

Set A: Population Variables

i) The greater the population size in 1966 of an adoption unit (POP), the earlier will be the time of adoption.

ii) The greater the rate of growth of the suburbs (SUBPOP), the earlier will be the time of adoption.

iii) The greater the decline in Central Area population (CAPOP) the earlier will be the date of adoption.

iv) The greater the overall rate of grwoth (OVGROW) of a potential urban centre, the earlier the time of adoption.

These four hypotheses are based on the expected impact of suburban growth on demand for more accessible retail facilities. Since population size is regarded as roughly representative of potential market size, if an area is experiencing faster growth, the market is similarly growing. Retail developers of Supercentres desire to locate in areas with initially large population, which in addition are experiencing high rate of growth, especially in the suburbs.

Set C: Retail Turnover

i) Urban areas with larger overall retail turnover (TURN) would adopt first.

ii) Urban areas with larger sales of convenience goods (CONV) would adopt the innovation earlier.

iii) Urban areas with greater per capital sales of convenience goods (CONPOP) and overall sales (TURNPOP) will adopt earlier.

iv) Urban areas where the central retail area has a smaller proportion of total sales will adopt earlier (CBDTURN).

---

* See page 31(a) for Set B: Car Ownership

Set B: Car Ownership

(i) Areas with large car owning populations will adopt first (CARPOP), (OTCAR) and (TOTCAR).

ii) Urban areas with a greater percentage of two car households will adopt first. (RATSCAR and RATTCAR).

Since the Supercentre has been shown to cater primarily to the car-born shopper, it is expected that new stores would first be built in areas with large car owning populations. The relationship is expected to be similar to that shown with POP, but somewhat stronger. Two car households imply greater affluence, and possibly greater numbers of female drivers, therefore it is further hypothesized that in urban areas, or suburban areas with more two car households in relation to one car families, Supercentres would develop first.

v) Percentage of Convenience goods turnover to total sales could act either as a stimulant to early development or as a hindrance, therefore the effect is unpredictable (CONDUR).

Since Supercentres rely on convenience goods (both food and non-food) for a significant proportion of their sales, urban areas where convenience goods turnover is large, (CONV), as well as having greater per capita sales of these types of goods, should attract the entrepreneur to the market earlier. TURN is once again a raw measure of overall market potential of the urban centres as were CARPOP and POP. Per capital sales levels are also expected to influence the rate of adoption. In areas where CONPOP and TURNPOP are high, earlier adoption is predicted because the entrepreneur will want to tap a market which has already established high rates of return per head of population.

It is further hypothesised that in urban centres where the central sales area account for a smaller proportion of total sales, Supercentres will be established earlier. CBDTURN is a measure of the relative strength of the urban centres major shopping area. CBD's which are strong imply little retail development in the suburbs, resulting from a lack of need in that area and major attraction of the CBD for all types of goods. Supercentres are expected to be built later in this type of situation. Conversely, however, strong CBD's may imply a lack of facilities to meet growing demands in the suburbs, therefore Supercentres could fill a gap in demand. Finally, the affect of CONDUR is unpredictable as it could either reflect a market of growing potential, or an already saturated market which could not support any further provision of convenience facilities.

Using these three groups of independent variables to represent market factors and influences related to growth in demand, and the assumptions about them, the hypotheses about the predicted influence each variable would have on the dependent variable date of adoption of the Supercentre were tested.

The following results are based on the application of the least-squares multiple linear regression model to the data described previously, paying due regard to the assumptions, and potential problems which might occur during analysis. An exposition of this method is outlined in Appendix D.

4.5 Results

A Simple Correlation Matrix was developed as the basis for choosing possible combinations of independent variables and to reduce the possible occurrence of multi-collinearity. Appendix B outlines the matrix obtained. Applying a Fishers Z transformation based on the statistic:

$$Z = \frac{Zr - Zp}{Z_r} \qquad \text{where} \qquad Z_r = \frac{1}{n - 3} \qquad (4.5.1)$$

n = Sample Size

p = Coefficient of Linear interdependence between the respective distributions of a pair of variables.

Confidence limits on the Simple "r" correlation scores were calculated permitting confidence limits to be established. The result

was that for a sample of 25, correlations greater than or equal to $\pm$ 0.4178 were identified as significant at the 95.0% confidence level. The correlation matrix between year of adoption (Y_1) and the sixteen independent variables (X_1 -- X_{16}) indicates that five variables (X_1, X_5, X_6, X_{11}, and X_{12}) were significantly correlated with Y_1. The remaining eleven variables did not indicate a significant degree of linear interdependence. The remainder of the matrix was used to identify relationships between the independent variables which could contribute to multi-collinearity. As Huang states, " If r_{ij} are large, say 0.80 or greater, we see that pairwise collinearity is serious." (20) However, once more than k = 2 X variables are used, the problem is more difficult to identify. One way has been to determine whether or not the "b" estimates are sufficiently large relative to their respective standard errors, to achieve statistical significance. If the "b" estimates are not significant, while the equation as a whole registers a very high "R^2". multi-collinearity may be present.

In this study it was expected that multi-collinearity could be avoided by eliminating any pairs of variables which achieved an "r" value of $\pm$ 0.75. Similarly, in order to allow for the fullest inclusion of all possible variations the lower limit of "r_{ij}" of 0.4178 was relaxed to include all correlations $\pm$ 0.25. The range $\pm$ 0.25 to $\pm$ 0.75 meant that the negative effects of including paired variables which might lead to multi-collinearity would be eliminated, at the same time allowing the greatest number of X variables to be used in combination to identify the primary and secondary influences contributing to the diffusion of Supercentres.

Using the matrix as a sifting process, five variables were identified as exhibiting significantly high linear assocation with Y. Variables X_1, X_5, X_6, X_{11}, and X_{12}, representing measures of total catchment population, total car owning population, and total turnover, all had "r" correlations greater than or equal to 0.4178. Using the lower standard of "r" greater than or equal to $\pm$ 0.25, variable two (Rate of Suburban Population Growth, X_2) also becomes significant. As Figure 2 reveals, several of the remaining variables are also important in that they link the three groups of variables relating to Turnover, Population, and Car Ownership. Figure 2 also reveals that variables X_3, X_4, and X_{13} are not significantly correlated with any other variables and thus, were considered of little further significance in the regression model.

Six of the variables were established as primary influences, and a further seven, as secondary influences. The regression model was then run in a number of different combinations, paying due regard to the limitations of sample size, and the necessity to eliminate potentially severe multi-collinearity.

Using combinations of three, four and five independent variables, seventeen multiple linear regression equations were applied to the data. In order to assess the significance of the goodness of fit of each equation, a two stage test was developed. Firstly, the coefficient of Multiple Correlation "R" was tested for its statistical significance. Once again, the Fishers Z transformation was used, with modifications, such that,

Significant Correlations of Multiple "R" (≥ 0.40)

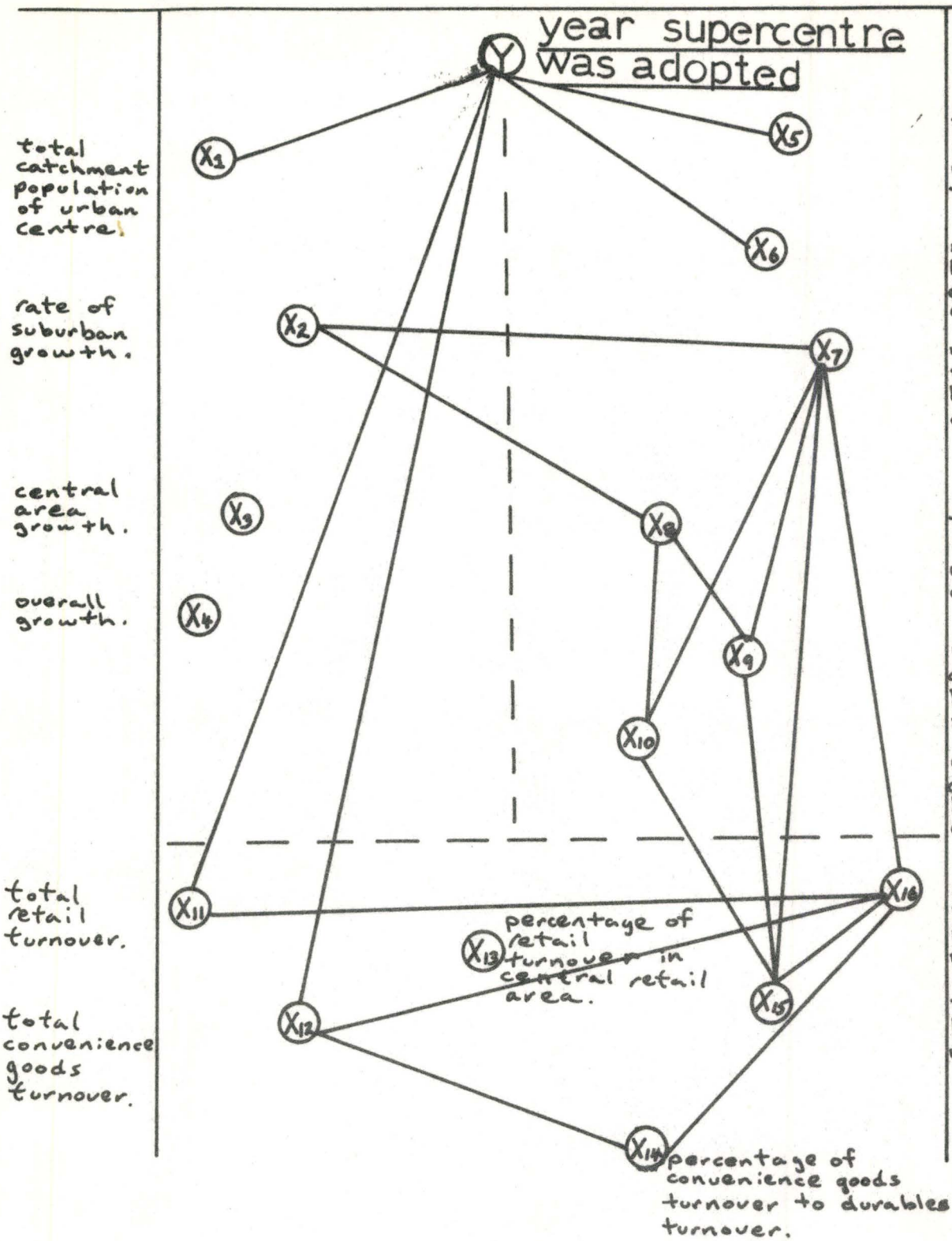


Figure Two

(4.5.2) $Z_R = 1 / N-k-2$ Where N - - sample size
k - - degrees of freedom of the regression equation.

Using this equation it was determined that for an equation with five variables, values of "R" $\geq$ 0.2088, and for two variables, R $\geq$ 0.1849 were significant at the 95.0% confidence level.

On this basis, eleven of the equations had statistically significant Multiple Correlation "R" values, such that the Null Hypothesis ($B_1=B=_2...B_k = 0$, or zero association) could be rejected.

Step two tested the significance of the goodness of fit of the entire set of variables in the equations, once again correcting for degrees of freedom. Snedcors Joint F Test was employed on R^2, and resulted in five equations being significant at the more rigorous level of 99.0%. Table Five identifies the five equations.

This does not mean that the individual regression coefficient estimates of "B" (the "b" coefficients) are all significant. As Table Five indicates, while all five regression equations are significant using the F Test, the Students t test reveals that less than one-half the regression coefficients proved significant at the 95% confidence level.

Using this twofold sifting process, equations four and five were dropped as including too many "b" coefficients which were not significant, as well as having the lowest values of R^2. Also, the "b" coefficients which proved significant, such as X_{11} - - Total Retail Turnover, were only alternative measures of total market size, and did not reveal linear relationships as strong as variables X_1 - - total

Table Five

Significant Multiple Linear Regression Equations (99.0% Level)

Equation 1

$$Y = 1.211 + \underset{(31.7)}{0.01025\ X_1}^{(*)} + \underset{(17.8)}{0.1180\ X_2}^{(*)} + \underset{(2.8)}{0.1135\ X_3} + \underset{(0.7)}{0.0409\ X_9} - \underset{(10.7)}{0.01078\ X_{14}}^{(*)}$$

$R^2 = 0.638$
$R = 0.798$
$F - 6.70$

Equation 2

$$Y = 2.547 + \underset{(39.8)}{0.0232\ X_5}^{(*)} + \underset{(0.02)}{0.00605\ X_8} - \underset{(11.0)}{0.1079\ X_{14}}^{(*)}$$

$R^2 = 0.502$
$R = 0.709$
$F - 7.06$

Equation 3

$$Y = 11.52 + \underset{(31.9)}{0.639\ X_6}^{(*)} - \underset{(11.5)}{0.2774\ X_{10}}^{(*)} - \underset{(7.3)}{0.3180\ X_{14}} - \underset{(0.3)}{0.0403\ X_{15}} + \underset{(4.4)}{0.2067\ X_{16}}$$

$R^2 = 0.554$
$R = 0.744$
$F = 4.72$

Equation 4

$$Y = 2.389 + \underset{(2.5)}{0.0829\ X_8} + \underset{(41.1)}{0.05431\ X_{11}}^{(*)} - \underset{(2.5)}{0.1137\ X_{14}}^{(*)} - \underset{(4.7)}{0.01689\ X_{15}}$$

$R^2 = 0.507$
$R = 0.712$
$F = 5.15$

Equation 5

$$Y = 6.8297 + \underset{(34.1)}{0.0456\ X_{11}}^{(*)} - \underset{(12.1)}{0.1735\ X_{14}} - \underset{(0.3)}{0.02057\ X_{15}} + \underset{(0.3)}{0.05627\ X_{16}}$$

$R^2 = 0.481$
$R = 0.694$
$F = 4.63$

(Figures in brackets are per cent variance explained by each independent variable). (COefficients significant at the 0.05 level ---*)

population, and X_5--total car owning population.

Before further conclusions could be about the causality relationships represented by the three equations (#'s 1, 2, and 3), it was necessary to analyse the performance of the models in terms of their residuals. In other words, whether or not the assumptions about the estimate of "u" (the individual error terms "e") were being upheld.

4.6 Performance of the Multiple Linear Regression Models

The residuals, or error term's were calculated and plotted for equations one, and three (appendix C, Figs. 3, 4, 5, 6) in order to determine whether or not autocorrelation, hetroscedasticity, and non-normality were present, thereby affecting the confidence placed on any conclusions about the results obtained.

Autocorrelation:

A Durbin-Watson Test employing the statistic d; a weighted ratio of the sum of squared differences in successive residuals, was applied to the residual terms "e" (Eqn. 4.6.1) of equations one and three.

$$d = \frac{\sum_{t=2}^{N} (e_t - e_{t-1})^2}{\sum_{t=1}^{N} e_t^2} \qquad (4.6.1)$$

where: e--error terms
N--sample size

This statistic tested the null hypothesis of no auto-correlation. The results indicate that neither of the two models was positively auto-correlated, and the presence of negative autocorrelation was inconclusive. (Figs. 3, 4 plot the residuals (e_t) against their own past values (e_{t-1})).

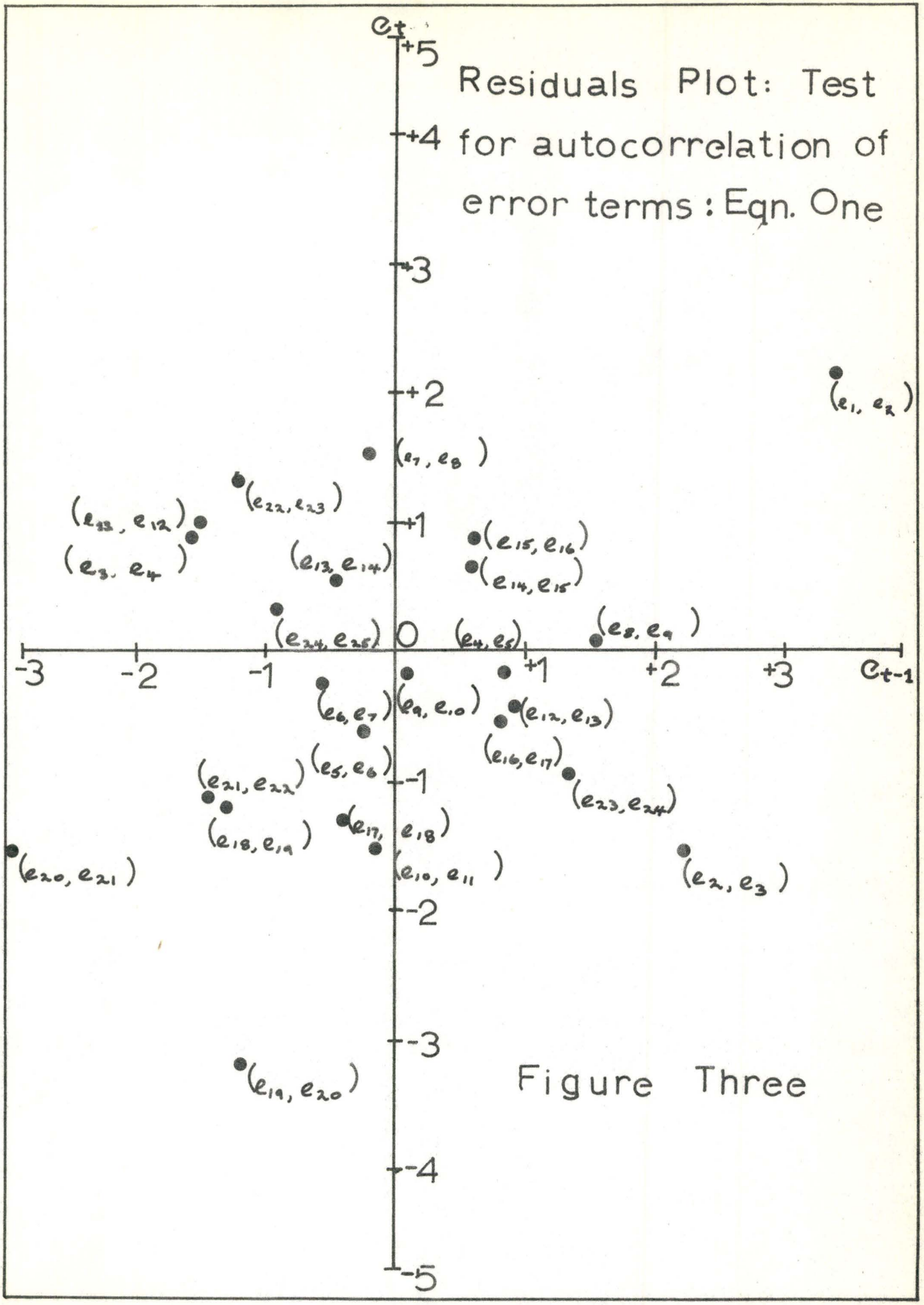


Figure Three

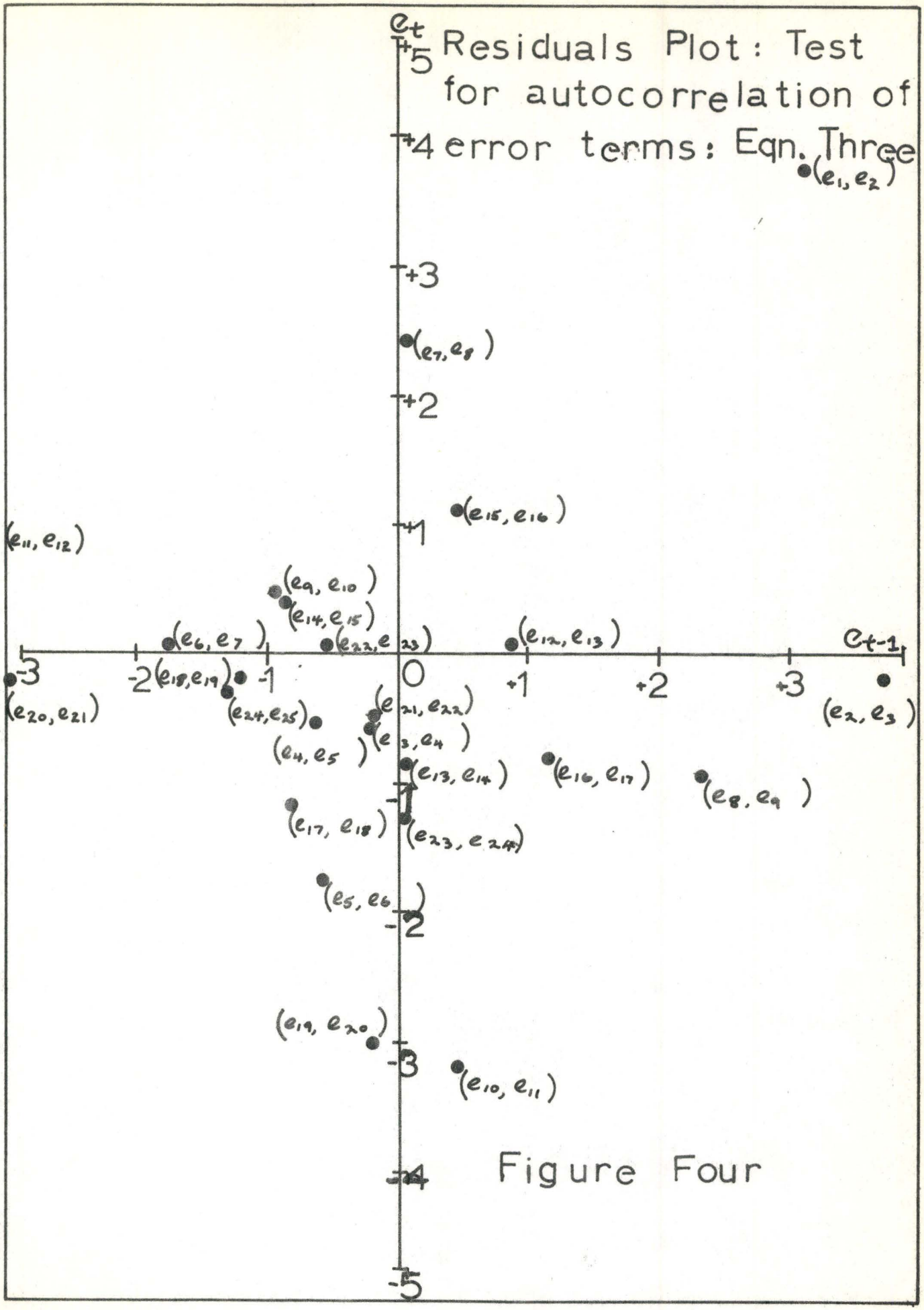

Residuals Plot: Test for autocorrelation of error terms: Eqn. Three
e_t
e_{t-1}
+5
+4
+3
+2
+1
-1
-2
-3
-4
-5
-3
-2
-1
0
+1
+2
+3
(e_1, e_2)
(e_2, e_3)
(e_3, e_4)
(e_4, e_5)
(e_5, e_6)
(e_6, e_7)
(e_7, e_8)
(e_8, e_9)
(e_9, e_{10})
(e_{10}, e_{11})
(e_{11}, e_{12})
(e_{12}, e_{13})
(e_{13}, e_{14})
(e_{14}, e_{15})
(e_{15}, e_{16})
(e_{16}, e_{17})
(e_{17}, e_{18})
(e_{18}, e_{19})
(e_{19}, e_{20})
(e_{20}, e_{21})
(e_{21}, e_{22})
(e_{22}, e_{23})
(e_{23}, e_{24})
(e_{24}, e_{25})

Figure Four

Hetroscedasticity:

To test for violation of assumption three concerning homogeneity of error term variance, the residuals of equations one and three were plotted: X on Y predicted. The results are outlined in Figure 5 and 6, and indicate that there is no conclusive evident tendancy for the scatter of Y on X to widen or narrow appreciably anywhere along the range of X. On this basis, both assumptions three and four concerning the least squares estimators of "u" ("e") have been supported such that there is no bias, inconsistency, or inefficiency in the co-efficients of the models. The remaining assumption concerns normality of the distribution of the error term. In order to justify any statements about the causality relationships between the diffusion of Supercentres in England and Wales between 1964 and 1972, and "market factors" this assumption must hold.

Normality of Error Term Distribution:

Using tests developed by G.W. Snedecor,[21] two types of departure from the normal were evaluated. Firstly, whether or not the distribution of the error term was asymmetrical, or skewed, the mean and median being different. Secondly, if the distribution is symmetrical, whether or not kurtosis is present, that is, if there is either an excess or a deficit of values of "e" concentrated near the centre of the distribution.

Once again, the error term distributions of equations one and three were used to test for normality. Mean square and average of the third powers of the deviation from the mean were used to derive "g_1" a measure of skewness. The closer to zero "g_1" the more symmetrical will be the distribution. A positive "g_1", indicates an excess in the

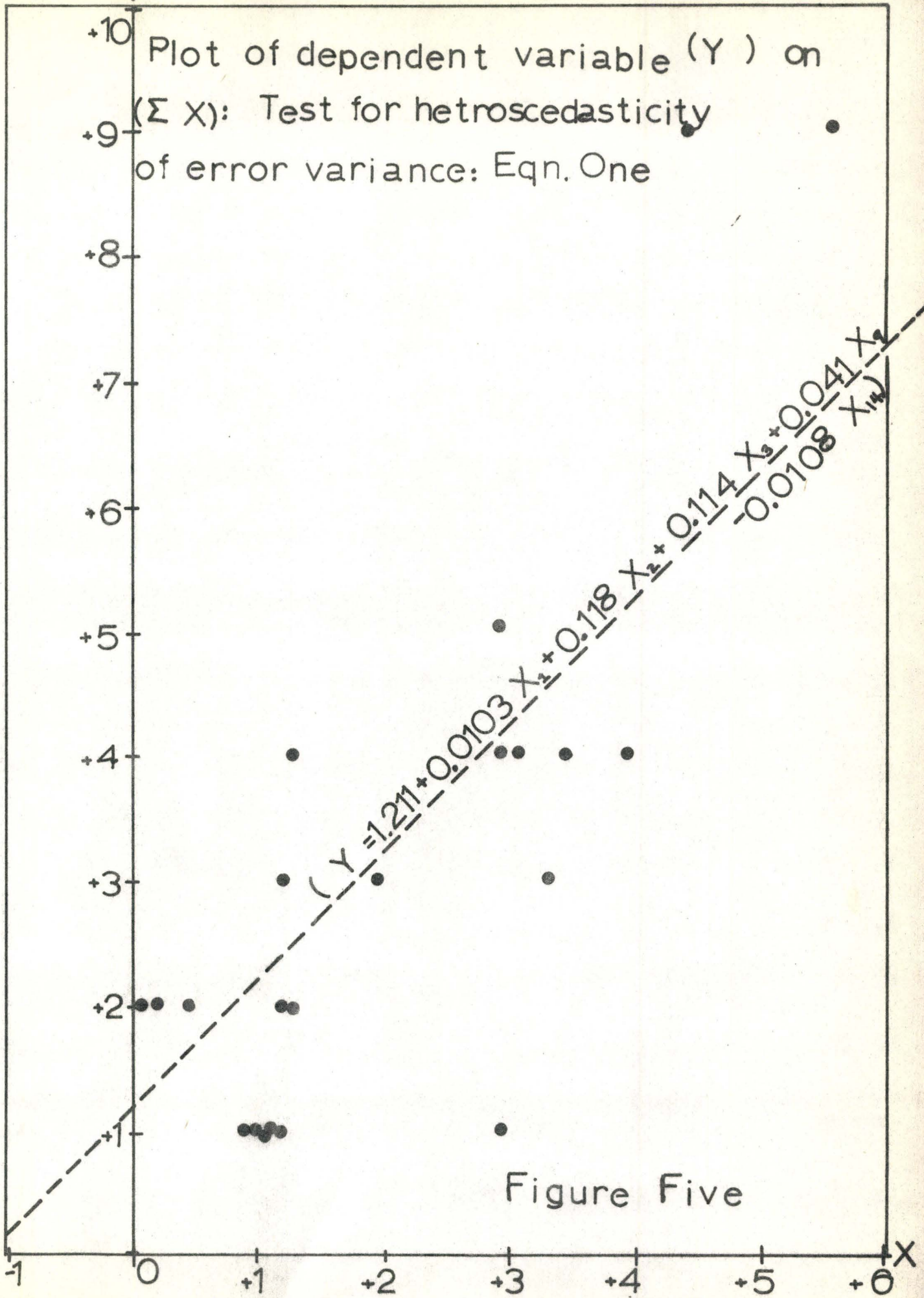
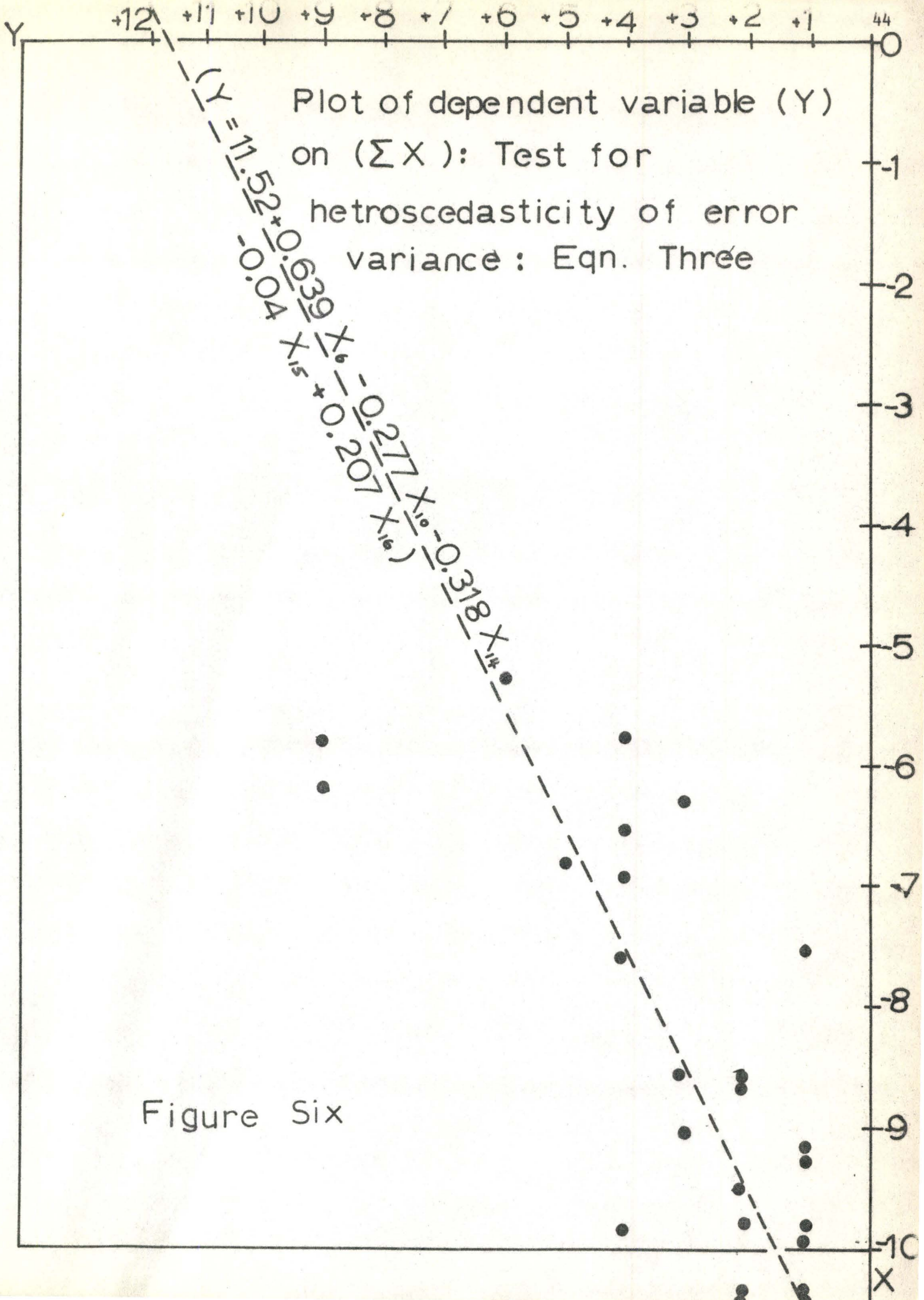

Y
+10
+9
+8
+7
+6
+5
+4
+3
+2
+1
Plot of dependent variable (Y) on
(Σ X): Test for hetroscedasticity
of error variance: Eqn. One
(Y = 1.211 + 0.0103 X1 + 0.118 X2 + 0.114 X3 + 0.041 X4
-0.0108 X14)
-1
0
+1
+2
+3
+4
+5
+6
X

Figure Five



Plot of dependent variable (Y) on (ΣX): Test for hetroscedasticity of error variance: Eqn. Three

Figure Six

number of items smaller than the mean, and vice versa. The measure of kurtosis is derived using the sum of the fourth powers of deviation from the mean, and produces "g_2".

The results of the two tests are outlined in Table Six. After performing a "t" test of significance at the 99.0% confidence level, neither "g_1" or "g_2" for both equations proved significant, indicating that the distributions of the error term "e" in both equations do not significantly depart from normal either in skewness, or kurtosis.

Table Six

Tests of Normality

	"g_1"	"g_2"	t_{g_1}	t_{g_2}
Equation 1	0.37	-0.44	0.8043	-0.4731
Equation 3	0.48	1.444	1.0435	1.1225

where t_{g_1} and $t_{g_2} = \frac{gk}{S_{g_k}}$

Sg_k--Standard error
t and 99.0% level--2.326
infinite degrees of freedom

On the basis of the results of the three tests carried out on the residual error terms, it is concluded that the three major least-squares assumptions (#'s 3, 4 and 5) have been supported. Therefore, inferences and conclusions about the relationships represented in the three significant equations, based on the various tests of significance can be made with greater confidence and reliability.

4.7 The Critical Independent Variables

Application of the tests of significance to the individual regression coefficients "b", to the overall regression equations, and derivation of the Coefficients of Determination and Multiple Correlation indicate that equations one, two, and three explain most of the diffusion of Supercentres, and are the best linear fit. However, rather than discuss each of the three equations separately, emphasis is given to those variables which were revealed to be significant through out the analysis. Overall, eight of the sixteen variables originally used proved significant either individually, or in one of the three equations, with respect to year of adoption Y.

Table Seven

Significant Independent Variables and Their Contribution

Variable	Description	Contribution: Positive/Negative
X_1	Total Catchment Population, 1966	Positive
X_2	Surburban Population Growth, Percentage, 1960-1966	Positive
X_5	Total Population with access to One or Two Cars, 1966	Positive
X_6	Number of Households with access to Tow Cars, 1966	Positive
X_{10}	Ratio of Two Car/One Car Hslds. in Total Urban area, 1966	Negative
X_{11}	Total Retail Turnover for area, 1966	Positive
X_{12}	Total Convenience Goods Turnover in urban area, 1966	Positive
X_{14}	Percentage of Convenience Goods Sold to Durable Goods Sales	Negative

In terms of the contribution of each variable to the regression equation, variables, X_1, X_2, X_5, X_6, X_{11}, and X_{12} are all positive factors as was originally hypothesized. With the exception of X_2, all the variables explain between 30.0% and 40% of the total variance, and each in one form or another, measures the absolute magnitude of total market size, in terms of population, access to automobiles, size of affluent market, and turnover.

Variable X_2 is a measure of the growth of a particular segment of the potential market for Supercentres and is shown to contribute positively, explaining over 17.0% of the variance in equation one. Once again the contribution was as hypothesized.

The remaining two variables, X_{10}, and X_{14} both contribute greater than 10.0% of the total variance in the particular equations in which they

are located, but both contribute negatively. In the case of variable X_{14} it was hypothesized that this type of contribution may be the case. The possibility of saturated markets (a high ratio of convenience goods sales to durable sales) could retard early adoption of Supercentres. The results for variable X_{10} -- Ratio of two car hslds. to one car hslds, 1966 must be viewed with some caution. In only one equation (#3) did the "b" coefficient prove significant. When used in other equations, the sign fluctuated between positive and negative, and was never proved significant. Therefore the precise influence on date of adoption is uncertain. Tables Eight and Nine outline the "t" values for the eight variables mentioned and their respective signs, further indicating that with the exception of X_{10}, the remaining seven are the primary measures of "market factors" and without fear of introducing multi-collinearity, can in themselves explain greater than 60% of the total variance with respect to date of adoption of Supercentres--Y.

4.8 Summary and Conclusions

Multiple Linear Regression Analysis has revealed that seven variables critically influenced the date of adoption of Supercentres in England and Wales between 1964-1972. The causal influences hypothesized in section 4.4 with respect to each of these seven, have been supported. Specifically, the factors summarized in equations one to five (Table Five) significantly explain between 48% and 64% of the variation in adoption of Supercentres by the twenty-five urban centres during the years 1964-1972. An urban centre adopted the Supercentre innovation earlier:

TABLE EIGHT

t Values for Eight Significant Variables

	X_1	X_2	X_5	X_6	X_{10}	X_{11}	X_{12}	X_{14}
1	5.41	2.62						2.35
2	4.05							2.10
3			4.37					2.12
4				4.56	2.36			
5								
6							2.27	
7						3.56		
8								
9								
10						4.08		2.17
11							3.33	2.71
12								
13								
14							3.48	
15						4.17		
16								
17								

TABLE NINE

Sign of Regression Coefficients for the Eight Significant Independent Variables

	X_1	X_2	X_5	X_6	X_{10}	X_{11}	X_{12}	X_{14}
1	+	+						-
2	+							-
3			+					-
4				+	-			
5								
6								
7							+	
8						+		
9								
10						+		-
11							+	-
12								
13								
14							+	
15						+		
16								
17								

1. If Initial Total Catchment Population in 1966 was larger (X_1)
2. If the Percentage of Suburban Population Growth around the Urban Centre between 1961-1966 was greater (X_2)
3. If the Total Population with access to one or two cars in 1966 was greater (X_5)
4. If the Total Number of households with two plus cars in 1966 was greater (X_6)
5. If Total Retail Turnover in 1966 was greater (X_{11})
6. If Total Convenience Turnover in 1966 was greater (X_{12})
7. If the Ratio of Total Convenience goods Turnover to Durable Goods Turnover, 1966, was smaller (X_{14})

The remaining variables did not significantly contribute to the rate of adoption of Supercentres. These variables include: Central Area Growth, 1961-1966 (X_3): Overall Growth in Total Population (X_4); Number of Suburban Households with One or Two Cars (X_7); Total Number of Households with One or Two Cars (X_8); Ratio of Two/One Car Households in the Suburbs (X_9); Ration of Two/One Car Households in the Total Area (X_{10}); Percentage of Turnover in Central Area (X_{13}); Total Turnover per head of population (X_{15}); and Convenience Goods Turnover per head of population (X_{16}).

Lack of significant contribution by these variables indicated that several of the original hypotheses were not supported, particularly the affect of Central Area Decline, Growth in the Total Population (Market), and Percentage of Turnover in the Central Area. These results are partially explained by the lack of significant growth in Britains urbanized population. Insignificance of Central Area Turnover to Supercentre Diffusion possibly resulted because Supercentres cater primarily to the convenience trade, and therefore, are not in direct competition with the C.B.D., which is primarily durable oriented. The negative affect of variable X_{14} (Ratio of Convenience Sales/Durable Sales) confirms this conclusion.

Diffusion of Supercentres between 1964-1972 has been positively linked to a number of "primary economic factors" composed of population

car ownership and turnover characteristics. Specifically, these variables relate to Total Catchment Population (X_1); Total Mobile Population (X_5); Total Retail Turnover (X_{11}); and Total Convenience Turnover (X_{12}). In addition, significant contributions are made by three of the "secondary variables", positively by the Rate of Suburban Growth (X_2), and Number of Two Car Households (X_6), and negatively by X_{14}, Saturation of the Convenience Goods Market. The remaining secondary factors listed previously do not appear to significantly contribute to the process. At this point in the discussion it must be acknowldged that with only twenty-five observations identified, and the fact that up to five variables were introduced in both the significant equations, (No. 1 & 3), the number of degrees of freedom is not very great. Because of this limitation, caution must be used in interpolating too much from the results.

Although a number of the secondary variables were not significant, and overall, results were not as high as expected, given the limitations of the data, and the techniques used, there was sufficient evidence to support most of the major hypotheses, and to conclude that Diffusion of Supercentres was a function of a combination of a number of the "primary and secondary economic variables" previously discussed, which together can be called "market factors". The study has linked Supercentres growth between 1964-1972 to the potential an urban centre offers an entrepreneur in terms of market as measured by total catchment population, size of mobile population, rate of growth of particular segments, and saturation of the potential market.

It has been statistically proven that the first urban centres to adopt Supercentres were those in the upper levels of the national and regional urban hierarchies, which were the centres having the greatest potential market in terms of population, car owning population, turnover, and suburban growth. It is these centres which have adopted the Supercentres first. Earlier, mention was made of several centres which should have adopted the Supercentre innovation, but did not, examples being London and Birmingham. Little explanation can be given for major urban centres which were non-adopters, except that distances between urban centres in Britain is considerably smaller, therefore Supercentres serving one area also serve in many cases adjoining urban areas. Further, considerably opposition still remains on the part of environmental groups, planning agencies, politicians, and retailers in established areas, to any new retailing innovation. Numerous applications have been made to develop Supercentres on the peripheries of Birmingham, London and other major centres which do not appear in Appendix A. A study of planning applications would prove very useful completing a study of the influence of "market factors", however access to data of this type would be most difficult. As Y.S. Cohen adds;

> "the existence of the complexity and selectivity indicates that much remains to be desired in order to fully understand the spread of entrepreneurial innovations. It seems that in depth understanding of the spread must involve investigation of investment behaviour and market perception by entrepreneurs. Amount factors that influence the entrepreneur's

behaviour; familiarity with the local market conditions, leadership, and foresignt, seem to be very important."

The present study has gone part of the way to answering some of the questions raised by Cohen in understanding how and why a particular type of retailing practice has grown and spread through the urban hierarchy of England and Wales. It has been shown that given a free choice of locations, the entrepreneur will choose the site offering the greatest potential in relation to the market being served by the Supercentre.

REFERENCES

1. Yehoshua S. Cohen, Diffusion of an Innovation in an Urban System, (University of Chicage, Dept. of Geography, Research Paper No. 140, 1972), page 4.

2. Elihu Katz, M.L. Levin and H. Hamilton, "Tradition of Research on the Diffusion of Innovation", Am.Soc. Review, XXVIII (1963), p. 240, in Y.S. Cohen, p.9.

3. Richard Nelson, "Innovation", International Encyclopedia of the Social Sciences, 1968, VII, p. 339.

4. Ibid, p.339, (My own emphasis)

5. Ralph Linton, The Study of Man, (New York, 1936), p. 328-329, in Y.S. Cohen, p. 14

6. Peter Haggett, Geography, A Modern Synthesis, (New York, London, 1972), p. 349.

7. Cohen, Op. Cit., p. 15.

8. J.E. Barlow, Shopping Report, Sunderland, (Sunderland, 1973), p. 4.

9. Ibid., p. 6

10. Ibid., p. 12

11. Shopping Capacity Sub-Committee, National Economic Development Organisation, The Future Pattern of Shopping, (H.M.S.O., 1971)

12. Gerald Eve and Co., Glasgow, Report on Aspects of Future Shopping Provision, (Glasgow, 1971), p. 6

13. Zvi Grilches, "Hybrid Corn: An exploration in the Economics of Technological Change", Econometrica XXV (1957), p. 501-22.

14. E.J.L.C. Steen, Cribbs Causeway Out of Town Shopping Centre Enquiry, (Bristol, 1972), p. 68

REFERENCES

cont'd

15. Cohen, Op. Cit., p. 46

16. D. Thorpe, and P.T. Kivell, et. al., The Hampshire Centre, Bournemouth, A Study of an out of town shopping centre, (Retail Outlets Research Unit and Bournemouth County Borough, 1972), iv.

17. Steen, Op. Cit., p. 70.

18. Planning Research Applications Group and Peterborough Development Corporation, Greater Peterborough Shopping Study: Technical Report, (Reading, 1973), p. 32.

19. Ibid., p. 34.

20. D.S. Huang, Regression and Econometric Methods, (New York, 1970), p. 154.

21. G.W. Snedecor, Statistical Methods, (Iowa, 1956), pp. 199-202.

22. Cohen, Op. Cit., p. 109.

23. W.C. Mitchell, Statistical Package for the Social Sciences, (New York, 1971), p. 175.

24. E.J. Kane, Economic Statistics and Econometrics, (New York, 1968), p. 355

25. Ibid., p. 278.

26. Ibid., p. 278

APPENDIX A

Basic Information on Adoption Centres:

Urban Centre	Year Super-centre Opened	Year Code (Map One)	Type of Centre	Dist. from C.B.D.	No. of Car Spaces	Gross Retail Floor Space	Population Growth: 1961-1971 Percentage. Suburbs	Central Area
Notting-ham	1964	1	Superstore	2.0	950	84,000	+18.4	-6.7
Leeds	1964	1	Superstore plus Precinct	3.5	400	158,000	+25.3	-5.7
Leicester	1967	4	Superstore	2.0	700	80,000	+42.8	-6.9
Bourn-mouth	1968	5	Superstore plus Strip	3.0	1,750	130,000	+18.8	-9.4
Sheffield	1969	6	Superstore	4.0	200	50,000	-13.6	+5.6
Bradford	1969	6	Superstore	3.0	1,000	89,000	+ 8.6	-5.7
Rochdale	1969	6	Superstore	2.0	700	38,000	+ 0.1	+6.5
Widnes	1969	6	Superstore	1.5	700	50,000	+10.0	+8.2
Rotheram	1969	6	Superstore	1.0	500	50,000	+ 3.9	-2.2
Stretford	1970	7	Superstore plus Precinct	2.0	ND	100,000	- 0.8	-11.4
Morley	1970	7	Superstore	1.0	ND	53,000	+ 2.1	+10.8
Tyneside	1970	7	Superstore plus Strip	3.0	900	104,000	+ 4.7	-20.2
Burnley	1971	8	Superstore	6.0	400	46,000	- 1.4	- 6.9
Lincoln	1971	8	Superstore	1.0	500	50,000	+23.3	- 7.2
Grimsby	1971	8	Superstore	1.5	ND	36,000	- 1.7	- 4.1
Exeter	1971	8	Superstore	2.0	ND	16,500	+ 0.7	+ 0.7
Nuddersf-ield	1971	8	Superstore plus Strip	2.0	ND	100,000	- 2.1	- 1.6
Oldham	1972	9	Superstore	2.5	ND	47,500	-11.7	-10.1
Cardiff	1972	9	Hypermarket	8.0	900	110,000	- 5.6	- 5.8
Folkstone	1972	9	Superstore	1.5	ND	26,000	+ 4.6	- 5.4
Peter-borough	1972	9	Superstore	1.0	ND	25,000	+37.5	-10.4
Norwich	1972	9	Superstore	8.0	ND	25,000	+15.7	- 2.3
Birkenhear	1972	9	Superstore	2.0	400	50,000	+ 3.9	- 4.9
Portsmouth	1972	9	Superstore	3.0	500	34,000	+21.1	-14.1
Northamp-ton	1972	9	Superstore plus Precinct-Mall	2.5	950	150,000	+22.0	+ 4.4

RRELATION COEFFICIENTS.

VALUE OF 99.0000 IS PRINTED
F A COEFFICIENT CANNOT BE COMPUTED.

APPENDIX B

	M (X_{12})	N (X_{11})	O (X_{13})	
N	-.96359			
O	-.15690	-.07982		
P	.54936	.34298	-.32728	
Q	.28215	.31644	.03243	-
R	.56874	.44943	-.19472	

B (Y)	C (X_1)	D (X_5)	E (X_6)	F (X_2)	G (X_3)	H (X_4)	I (X_7)	J (X_8)	K (X_9)	
.56321					.27054					
.02612	.05461				.13912	.20134				
.58470	.76183	.88664			.29180	.25964	.66960			
.26615	-.25184	-.14913	-.01281		.20217	.13790	.83460	.75745		
.02817	-.25403	-.20572	-.17481	.08386	.11678	.10690	.75738	.82211	.9	
-.02149	-.19870	-.19153	-.07337	.23980	-.25152	-.18691	-.02978	-.48162	-.1	
.13631	-.24679	-.08124	.25067	.47683	-.27107	-.19329	.00155	-.44084	-.1	
-.15847	-.58525	-.35162	-.01216	.41166						
.04403	-.32662	-.15310	.20579	.35065	.26422	.36375	-.04019	.18510	.1	
-.09351	-.30762	-.09669	.30627	.28326	-.07610	-.04188	-.02487	-.24594	-.1	
.44729	.00273	.85235	.74348	-.16960	-.16116	.15635	.65418	.36788	.5	
.59316	.92897	.90148	.80315	-.10099	-.09680	.03120	.49777	.11175	.3	
.05133	-.04265	-.04681	-.13380	-.10634						
-.11440	.38011	.31960	.25951	-.12481						
.12836	-.01120	.04089	.28359	.26190						
.01023	.20104	.20869	.33278	.17691						

APPENDIX C

Residuals For Equations One and Three (Table Five)

Observation N	Residual Value Equation One	Residual Value Equation Two
1.	3.39	3.12
2.	2.23	3.70
3.	-1.57	-0.22
4.	0.83	-0.67
5.	-0.26	-0.60
6.	-0.66	-1.75
7.	-0.18	0.03
8.	1.52	2.35
9.	0.02	-0.98
10.	-0.14	0.49
11.	-1.51	-3.20
12.	0.92	0.87
13.	-0.43	0.05
14.	0.56	-0.87
15.	0.58	0.46
16.	0.83	1.13
17.	-0.44	-0.84
18.	-1.30	-1.20
19.	-0.12	-0.22
20.	-3.17	-3.00
21.	-1.45	-0.14
22.	-1.23	-0.59
23.	1.32	0.05
24.	-0.98	-1.33
25.	0.30	0.28

APPENDIX D

Recalling that the objective is to support the prime hypothesis that diffusion of the innovation is a function of several factors and influences which combined are called "market factors", it was necessary to find a technique which could handle the input of several independent variables while at the same time establishing their relationship with the dependent variable.

Multiple Linear Regression Analysis was chosen as the most suitable technique for several reasons. Firstly, it provides the facility to study the linear relationships between a number of independent variables and a series of dependent variables, at the same time taking into account the relationships between the independent variables. (23) Secondly, M.L.R. (Multiple Linear Regression) is suited to this type of problem, where inferences about the relationship must be made based upon estimates of individual relationships between independent variables and the dependent variable. Thirdly, M.L.R. provides for the precise determination of the separate effects of different explanatory factors, when the many variables affecting the result have not been (and perhaps cannot be) controlled experimentally. Finally, this technique is widely documented, thus providing a number of tests upon which confidence levels with regard to the significance of the results can be established.

Conceptually, the objective of Multiple Linear Regression is to derive a linear combination of independent variables which will correlate as highly as possible with the dependent variable. Equation D.1 represents the model:

$$Y_1 = B_o + B_1X_1 + B_2X_2 + \ldots \quad B_kX_k + u \qquad (D.1)$$

Y_1 - Dependent Variable

B_o - Constant

B_1---B_k Regression Coefficients

X_1---X_k Independent Variables

u --- Error Term (part of Y not explained by the X's) - Residuals.

In order to apply this equation to the problem, the principle of Least Squares is employed, which allows calculation of predicted Y values and the coefficients in Equation D.1 . in such a way that the squared errors of prediction are minimized. This method is necessary because of the inherent errors in the data employed in a study of this type. Due to the fallibility of the data, greater error variance will occur during analysis. Least Squares will minimize the errors of prediction.

The basic statistic which is derived from this formulae is the coefficient of Multiple Correlation, 'R'. The square of 'R' is R^2, the coeffecient of Multiple Determination. These two measures indicate the magnitude of the relationship between the dependent variable Y_1 and the independent variables X_1 to X_k. 'R' can be interpreted much like the single coefficient of correlation 'r', except the values obtained range from zero to one, as do the values for 'R^2', rather than from minus one to plus one as they do for 'r'. 'R' represents the magnitude of the relationship between each independent variable and the dependent variable. 'R^2' measures the magnitude of the linear combination of independent variables X_1 to X_k and the dependent variable Y_1. The closer to one the values of either 'R' or 'R^2', the greater is the goodness of fit of the posited relationship. In the present study, 'R^2' represents the percentage of variation in the date of adoption (Y_1) which is explained by the independent variables representing market factors. The fraction 1-'R^2' represents the percentage explained by variables not included in the list, or measurement error, in other words the residuals. (represented in Eqn. D.1 by the symbol 'u')

Use of the 'R' and 'R^2' statistics for interpretive purposes can only be made however, if the values obtained can be shown to be significantly different from zero. The two standard tests of significance employed are the Students Test, and the F Ratio Test. Both relate to the "hypotheses on the value of the individual regression coefficients 'b' (estimates of B) and the values of the entire set of such coefficients."

Specifically, the 't Distribution' (Students t) expresses the regression coefficient estimates 'b' in relation to their Standard Errors:

$$t_{1-k} = b_{1-k} / SEb_{1-k} \qquad (D.2)$$

therefore testing the hypotheses that the ratio of each of the coefficients 'b' to their Standard Errors is significantly different from zero. Effectively, the test determines whether or not each independent variable is adding anything significant to the regression, after taking into account all other X's in the regression. (represented by the value 'R'). The t Test is a test of the 'b''s, which are the partial regression coefficients.

The F Distribution Test expresses the ratio of explained variance over unexplained (the residual), once correction has been made for the degrees of freedom, and indicates whether or not the entire linear relationship expressed by the regression equation (and represented by 'R^2') is significant or not. Both statistics test the reli-

ability of the results against certain prescribed confidence limits, normally set arbitrarily before analysis begins. If the results do not meet these minimum levels of confidence (normally the 95.0% or 99.0% levels) then the null hypothesis of "no relationship" cannot be rejected. If the results do exceed the minimum level, the null hypothesis is rejected and the relationship between the dependent variable and the independent variables in question is said to be significantly different from zero not to be the result of pur chance.

Therefore, by calculating the "R's" and "R^2's", and then using the t Test on individual regression coefficients, and the F Ratio to test the overall equation, the relative efficiency of the different variables in the equation can be determined, at least as far as the statistical significance is concerned.

The preceding tests establish whether or not there is a linear relationship betwen dependent and independent variables. The hypotheses upon which this study rests however, require more than simply establishing a statistical relationship, before they can be said to be supported. Underlying the reliability of any inferential conclusions drawn from the results are several basic assumptions about the Least Squares Principle in Multiple Linear Regression Analysis, as well as the various component elements in the regression equation. It is necessary therefore, to list these assumptions and briefly explain their relevance in determining whether or not the results of the analysis can be sufficiently trusted to draw inferential conclusions about the relationship between date of adoption of a Supercentre and 'market factor'.

The Least Squares Assumptions

1. (Randomness) The individual errors or disturbances u_j are random variables, with finite means, variances, and convariances.

2. (Zero mean independent of X) Every disturbance u_j has zero expected value, irrespective of the value of X_j.

3. (Homoscedasticity) The variance of each u_j is the same for all j ($j = 1,....N$) and independent of X_j

4. (Nonautocorrelation of errors) The error terms of different observations are distributed independently of each other:

   $$E(u_j u_k) = E(u_j)E(u_k) = 0 \text{ for all } j \neq k, \quad j = 1,....N$$

5. (Normality) The density function of f(u) is normal.

6. (Properties of X) The exogenous variable X is measured without error and has finite mean and variance.

The Least Square Assumptions play a crucial role in the regression analysis. The parameter estimates ("b"), the R^2 values generated, and the t and F Ratio Tests of the hypotheses concerning the coefficient estimates are all based upon the untested assumptions about the probability distribution underlying "u". Since the t and F Ratio tests are internal tests, which use the information available within the sample to test the specific hypothesized values of the regression coefficients, a second set of tests is necessary to examine the residual error terms (u) for their randomness, as well as conformity to the other assumptions. Only by testing the validity of these assumptions can any confidence be placed in the parameter estimates as exhibiting the various properties described by the assumptions. These assumptions make the least-squares and maximum likelihood estimator coincide, thus ensuring that the former possess all the estimator properties of the latter. Following is a brief review of the minimum requirements for the various estimator properties, and the more obvious problems which must be tested for in order to check on the validity of results obtained through the 'R', 'R^2' values, and the t and F Ratio tests.

The unbiasedness of the least-squares estimator "b" of "B" depends upon the assumption about the interdependence of X and u. The unbiasedness of the least square estimator "a" of "B" depends upon the unbiasedness of the "B" estimate and the condition that "u" have a mean of zero.

Consistency of the estimator "b" is based upon all the assumptions with the exception of that ensuring "normality".

For efficiency, in other words, the best linear unbiased estimator (B.L.U.E.), the first five assumptions necessary for consistency must also be upheld.

Finally, in order to justify the use of t, F and z test procedures, and to establish the identity between least-squares and maximum likelihood estimators, the assumption of normality must be supported with regard to the distribution of the error terms "u". Unbiasedness, consistency and B.L.U.E. properties of the Least-Squares estimators do not depend upon this assumption however, only the validity of the various test procedures. Critical to the various properties described are the assumptions about homoscedasticity (#3) and non-autocorrelation of errors (#4).

To conclude this description about the method of analysis employed, brief mention must be made about three problems which could jeopordize any conclusions made on the basis of the results, there are: heteroscedasticity and autocorrelation, which occur in the error term estimates, and multi-collinearity, which concerns the independence of the variables X_j.

Autocorrelation implies some degree of stochastic dependence between successive values of the error term due to chance disturbances and the methods of collecting data, which incorporate smoothing and interpolation. Autocorrelation does not destroy the unbiasedness or even the consistency of the least-squares estimators, it does however, reduce efficiency, and leads to biased estimates not of "a", "B" or "u", but of their variances. It is necessary therefore to test the residuals to determine whether or not the null hypothesis of non-autocorrelation can be accepted or rejected. If rejected, the regression model may be regarded as inadequate. The inadequacy may lie in the failure to introduce certain variables, or that the disturbance term ("u") is time dependent.

Hetroscedasticity (Non-Homogeneity of Variance) means that the variance of the disturbance term "u" is not constant. The main effect of hetroscedasticity is again on the efficiency of the estimation of coefficients and testing of hypotheses.

The third problem facing any results obtained from the regression model is that of multi-collinearity. It is a technical problem which arises either in the population, or in the sample population when "various of the explanatory variables (X) stand in an exact or almost exact linear relation to each other." The results are that the least-square procedure allocates the sum of explained variation among the individual explanatory variables more arbitrarily and unreliably.

> "Multicollinearity results in parameter estimates "b" that are (1) discomforingly sensitive to changes in the precise model specification and the precise data set being employed, and (2) possessed of individual high standard errors. Ultimately, the confidence placed in the tests of significance of the various b_j estimates, such as the t and F tests is reduced."

The problem is not so much in detecting multi-collinearity, rather in determining the severity of multi-collinearity. This can be achieved by calculating the simple correlations for the pairs of independent variables. If (r_{ij}) are large, pairwise collinearity is serious. The question is how high should r_{ij} be before multi-collinearity is considered a problem. Klein suggests a rule of thumb that multi-collinearity is tolerable if r_{ij} is less than coefficient of Multiple Correlation "R", but this is only useful in pairwise correlation. If the number of independent variables exceeds two, the problem of multi-collinearity is much more subtle but evidence of its existance can be obtained if "R^2's" are registered as high, but no "b" estimate proves sufficiently large relative to its standard error to achieve statistical significance (employing the t test).

BIBLIOGRAPHY

Barlow, J.E. Shopping Report, Sunderland, (Sunderland, 1973).

Census of Distribution (H.M.S.O., London, 1961)

Census of Population, (H.M.S.O., London, 1961, 1966, 1971).

Cohen, Y.S. Diffusion of an Innovation in an Urban System, (Chicago University of, Chicago Illinois, 1972).

Department of Town and Country Planning Regional Shopping Centres in the North West of England, University of Manchester, (Manchester, 1964).

Eve G., and Company Glasgow: Report on Aspects of Future Shopping Provision, (London, 1971).

Haggett P. Geography: A Modern Synthesis, Harper and Row, (London, 1972).

Johnston, J. Econometric Methods, McGraw Hill Book Company, Inc. (London, 1963).

Jones, C.S. Regional Shopping Centres, Their Location, Planning and Design, (Business Book, London, 1969).

Kane, E.J. Econometric Statistics and Econometrics, Harper Row, (New York, 1968).

Kent County Council Planning Department Influence of Car Ownership on Shopping Habits, (Kent, 1964).

Kivell, P.T. "Retailing in Non-Central Locations" in: The Retail Structure of Cities, Occasional Publication No. 1, INSTITUTE OF BRITISH GEOGRAPHERS, Urban Study Group, (London, 1972).

Linton, R. The Study of Man, (New York, 1936).

Malinvaud, E. Statistical Methods of Econometrics, North Holland Publishing Co. (Amsterdam, 1966).

Mitchell, W.C. in Statistical Package for the Social Sciences, (New York, 1971).

Nelson, R. "Innovation", in International Encyclopedia of the Social Sciences, 1968, VII.

Planning Research Applications Group Greater Peterborough Shopping Study: Technical Report, Peterborough Development Corporation, (1973).

Cont'd

BIBLIOGRAPHY

Huang, D.S. "Regression and Econometric Methods", (John Wiley and Sons, New York, 1970).

Snedecor, G.W. Statistical Methods, (The Iowa State College Press, Ames, Iowa, 1956).

Shopping Capacity Sub-Committee, National Economic Development Organisation, The Future Pattern of Shopping, (H.M.S.O., London, 1971).

Steen, E.J.L.C. Cribbs Causeway Out of Town Shopping Centre Enquiry, (Bristol), 1972.

Theil H. Principles of Econometrics, (John Wiley & Sons, New York), 1971.

Titner, G. Econometrics, (John Wiley & Sons, New York) 1952.

Thorpe, D., and P.T. Kivell, et. al. The Hampshire Centre: Bournemouth, A Study of an Out of Town Shopping Centre, Research Report No. 6, Retail Research Unit: Manchester Business School, 1972.

Grilches, A. "Hybrid Corn, An Exploration in the Economics of Technological Change", Econometrica XXV, (1957).

Hoyt, H.J. "US Metropolitan Area Retail Shopping Patterns Part II, Sales Trends in Shopping Centres, 1958-1963", Urban Land, Vol. 25, April 1966.

Katz E., M.L. Levin & H. Hamliton "Traditions of Research on the Diffusion of Innovation", Am. Soc. Review XXVIII.

Pearson, N. "Notes on the Development of Shopping Centres in Canada", Journal of the Town Planning Institute, Vol. XLIII, Dec. 1956.

Percival, R.N. "Shopping Centres in Britian", Town Planning Institute, Journal of., Vol. 51, 1965.

Poole, M.A. & P.N. O'Farrell "The Assumptions of the Linear Regression Model", Transactions of the Institute of British Geographers, Vol. 52.

Waide, W.L. "Changing Shopping Habits and the Impact on Town Planning", Royal Town Planning Institute, Journal of, 1963.