RESIDENTIAL LOCATION AND ENVIRONMENTAL QUALITY:

AN ECONOMETRIC ANALYSIS

Dissertation submitted for the degree of Ph.D.

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This dissertation is the result of my own work entirely.

Graham John Davies

Contents

Preface

This dissertation is presented as a contribution to the theory and measurement of the residential location behaviour of households.

My interest in urban environment was initially stimulated by reading a book by Chermayeff and Alexander called 'Community and Privacy' in 1968 while I was an undergraduate student of Economics at Edinburgh University.

Subsequently I was encouraged by W.D.C. Wright and Professor Ian Stewart, of the Department of Economics, Edinburgh University and Professor Paul Brenikov of the Town and Country Planning Department of Newcastle University to continue this interest at the post graduate level.

On arriving in Cambridge in September 1970 as a research student attached to the Department of Land Economy I found many people with whom discussion helped to formulate my ideas. The wide range of disciplines from which they came illustrates for me at least the advantage of interdisciplinary communication and the lack of prejudice with which it is regarded in Cambridge.

I particularly wish to mention Eddie Local then of the Cavendish Laboratory with whom I had many useful discussions on urban systems and entropic processes, Angus Deaton of the Department of Applied Economics, Brian Robson of the Department of Geography and Robert Mackie, Stephen Boorman, Martin Evans and Wally Kumah, all then of the Department of Land Economy.

My researches would have been made a lot more difficult without the help of Professor Donald Denman and my supervisor Jeffrey Switzer who managed successfully to lead me in the way of sources of data and funds to collect them. Their general guidance is gratefully acknowledged.

My thanks are also due to Fisal Sabbah and Roger Butcher who have assisted me throughout with data preparation and computation.

Above all I wish to record that this study would not have been possible without the encouragement of Gwyn Evans of the Faculty of Economics and Politics. I have profited more than I could possibly measure from discussion with him and have been able to compute my results with the aid of the 'Factan' programme which he has developed for maximum likelihood factor analysis.

It remains for me to thank my wife who apart from coping with the burden of coding my data forms has unselfishly relieved me of many domestic duties so that this work might be completed.

Graham J. Davies
July 1973.

A Summary of the Contents

This work has been concerned with identifying and evaluating the attributes of housing which influence the household's choice of location. The work may be divided into three parts. Firstly, a part which examines the existing literature on residential location theory with a view to ascertaining its suitability or otherwise as a basis for an empirical analysis of household location preferences.

The view is taken (Chapter 1) that existing theory does not sufficiently accommodate environmental and neighbourhood amenity characteristics of residential locations, within a framework suitable for deriving testable hypotheses concerning their relevance.

The second part of the work presents a theoretical model of residential preference determination which incorporates a consideration of both environmental and 'accessibility' features of residential locations (Chapter 2). The emphasis is not however on the theoretical structure of the model which is seen under appropriate conditions to be no more than a traditional utility maximizing problem devoid of any general spatial interest. Rather the interest is with the need to provide an operational framework for calibrating the parameters of a general function relating rental[1] payments to both amenity and accessibility in the context of their particular spatial distribution for a specific case. An econometric and statistical procedure sufficient to accomplish such a parameterization is illustrated, along with a description of the data used in the empirical analysis, (Chapters 3 and 4).

The third part of the work presents the results of the analysis and is divided into two parts. One part, Chapter 5, identifying and evaluating the residential characteristics, and examining household socio-economic relationships with residential commodities, the other, Chapter 6,, suggesting, the relevance of the methods developed for an approach to environmental appraisal. An Appendix A describes, in greater detail than Chapter 3, the data and the sample. An extended Analysis of the results of a social survey, in addition, to the results of Chapter 5 is included. An Appendix B illustrates the questionnaires and data forms used in the data collection.

The work is perhaps characterised firstly by the concern with residential environment and its measurement at a microeconomic level. This approach required a concentration upon one urban area and data of specific house purchases, the socio-economic characteristics of households concerned and of the amenity and accessibility features of each location. Secondly, the work is characterised by the attempt to measure 'Engel's'

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1. Throughout this work "rental payments" refer to the prices paid by households for their house.

functions for the residential commodity bundle, for while other attempts to measure amenity have been made no attempt to identify expenditure functions at such a level of disaggregation is known to the author.

Graham J. Davies
July, 1973.

CHAPTER ONE

A Review of relevant Literature on the Theory of Residential Location

1.1. Introduction

The history books when they come to be written will surely record that man in the twentieth century, in his relationship with his urban environment, faced serious problems of understanding and hence of management. Not the least of these problems is that of interdisciplinary communications. Separate perceptions of metropolitan problems, deriving from the whole spectrum of social science, can but slowly procure an insight, in the absence of an interdisciplinary framework. Urban studies can then resemble an exercise in semantic flexibility as much as one of intellectual agility.

The problem for the analyst does not however lie solely with his lack of an interdisciplinary understanding. At a more fundamental level it is possible to question the adequacy of individual disciplines in providing a rationale for urban analysis. H.A. SIMON has remarked that

> "Economics has been moving steadily into new areas where the power of the classical equilibrium has never been demonstrated, and where its adequacy must be considered anew. In these areas the complexity and instability of his environment becomes a central feature of the choices that economic man faces."

In a metropolitan context the economist is indeed aware that the traditional tools of neo-classical marginal analysis are insufficient to handle the analytical problems raised. In the first place economic activity in towns is in large part related to the presence of agglomeration economies. Clustering of production outlets, in a spatial sense, to achieve productivity increases must form an integral part of urban economic analysis. Yet such activity, associated as it is with non-constant returns to scale, is not easily reconciled within the traditional economic model.

In the second place the urban economy is characterized by stimuli to which the agents of the system, producers, consumers and institutions, respond, but which cannot be readily accommodated within the market framework. This problem is best characterized by the presence of 'externalities' and 'public goods'. Here the question is how efficient resource allocation can take place when significant factors are excluded from the accounting framework, or in the case of public goods, included on needs criteria which are difficult to define save in an arbitrary sense.

It would be wrong to conclude that externalities have only a lexical significance. In fact they can seriously distort the allocation of resources. It is not unlikely that real resource costs are associated for example with the existence of pollution of the urban eco-system. The tools of economic analysis in the light of such problems appear rather crude and not a little blunt.

However some consolation does exist in the fact that 'public goods' and 'externalities', related in some way to land use, can apparently be appraised as to their relative importance. This is so under circumstances where individual consumers are able to influence the level of their consumption of external or public goods. Such circumstances do arise when the effects upon utility of these goods ('disgoods') are not uniformly dispersed over urban space. In this event differential payments for discrete urban locations are made, reflecting the relative attractiveness (unattractiveness) of particular sites, with respect to the existence of external effects.

This thesis will be concerned to identify and evaluate the environmental amenity associated with residential locations, by reference to the differential payments made for housing in a particular urban area. Before however, considering the appropriate residential location theory, it will be useful to examine briefly the relationship of urban location and rent theory in general.

1.2. Urban location and Rent theory

Urban location theory is concerned with understanding the behaviour which determines the allocation of land uses over urban space. Such an understanding requires an explanation for the variation in rental payments made for land. The rationale adopted in the literature in seeking to explain the pattern of rents has been in the main the marginalist analysis of economic theory. The argument may be sustained at the level of generality by requiring that locational expenditures in the form of rental payments are made by users of land who may be either producers or consumers. Such payments represent the site value to the user on the assumption that the owners of land are able to extract the maximum rent that the user is willing to pay. For producers, land and its locational attributes will bear some technical relationship to other inputs in the production process, so as to specify a production function where output is a function of these inputs. For the consumer, who may be meaningfully represented by the recreational or residential land user, a utility function may be specified which illustrates the manner in which satisfaction is derived from the consumption of a bundle of locational 'goods'.

In order to examine the nature of locational demand and the implications of this demand for the shape of the rent surface, it is only necessary to consider the distribution of locational attributes over urban space as given. For the urban firm or producer the demand for land and its locational attributes, whatever they might be, is a derived demand, derived from the demand for the finished product of the firm. The demand for any input into the production process of the firm is also influenced by the availability of alternative factors of production and their prices. The demand for land therefore can be said to depend upon the elasticity of demand for the final product the elasticity of supply of other factors such as labour and capital, the ease with which such factors may be substituted for one another and the relative importance of land in total production costs. It has been shown by HICKS (1946) that the elasticity of derived factor demand, varies directly with the relative importance in total factor costs of that factor, if the elasticity of final product demand exceeds the elasticity of substitution in production. Intuitively, this is reasonable, as on increasing output when demand for the firm's product rises, the firm will only increase its employment of a relatively expensive factor if it cannot easily substitute a cheaper factor, in securing the necessary increased output. It follows that the steeper the rent surface, the greater the elasticity of substitution, that is the faster that other inputs in production will be substituted for locational factors. Under conditions of perfect competition locational equilibrium occurs when the firm cannot reduce costs and increase its revenue by any relocation. This requires that the marginal productivity of all inputs in production be equal to their prices. Thus land rents are seen to be in a competitive factor market the marginal products of location. In the case where at one location there are many locational factors, rent is the sum of their marginal products.

This result forms the basis of the well-known marginal productivity theory of rent which became popular towards the end of the 19th century, following Wicksteed's analysis of the problem of whether rent was merely a residual after other non-land factors had received payment out of total revenue. Prior to Wicksteed's analysis two views regarding this problem had predominated. On the one hand, rent was regarded as a residual, on the other as being a factor price determined in the usual manner by the conditions of supply and demand.

Today the marginal productivity theory is widely accepted by locational analysts (RICHARDSON (1969), MUTH (1969), MILLS (1969)). There are however dissenting voices and it is worth considering therefore the demonstration by HAWTREY (1960) of the apparent inadequacy of marginal analysis for land. Hawtrey argues (p.115), that as land has no production cost, rental charges for its use are equal to its total production value and not its marginal value which properly is zero. Further land has no price in the sense that capital and labour have, as no economically identifiable unit which would generate a market price exists. Moreover

> "each plot of land is unique in its characteristics; plots have not the interchangeability which makes items of plant and capital equipment legitimately measurable in terms of price."

Perhaps more fundamentally, however, is his point that the price paid by producers for an increment of land bears no relation to that of the increment before or after,

> "their prices are purely fortuitous"

and of course no differential coefficient (marginal product) can exist without a continuous relationship,

"when he (the producer) is reckoning the effect of successive increments of capital he arranges them in order of cost-saving efficacy ...... down to the marginal items, which only just save the equivalent of their own cost. We may suppose his hypothetical capital outlay to increase continuously and the total cost saving efficacy of a specified capital outlay to be expressed as a function of the latter. The function exhibits a trend in virtue of which there is a significant differential coefficient in respect of the capital outlay, by which the marginal cost-saving efficacy (product) can be defined. Successive increments of land do not exhibit any such trend."

In defence of the marginal productivity theory it can be argued that land always has a production cost by virtue of the development costs necessarily undertaken to prepare it for its eventual use. The question then resolves as to whether the supplier of developed land is in bargaining position whereby he may expropriate more than enough to cover his development costs at the margin such that the total production value is paid in rent rather than the marginal value. If of course each plot of land is unique then the supplier of developed land is necessarily in a monopolistic situation. However it is perhaps reasonable to contend that the market in land is in fact sophisticated enough to be able to disaggregate the commodity in question into its locational attributes, attributes which are not unique to any one plot but which may differ in quantity. This disaggregation of land may not be explicitly made in terms of separate market goods but is most likely to be in the minds of the participants on the land market. This of course by no means rules out the possibility of monopolistic competition arising for other reasons.

There would appear then to be some justification for applying an incremental approach to land and its locational attributes. However, a similar but alternative argument is that even if marginal products exist it is not possible in practice to discern them for any factor and therefore improper to assign factor payments as though it were. In the context of land this is an appealing argument as developed land has capital, labour and enterprise embodied within it. The implication for rent and other factor payments is that they represent an arbitrary division of total product in accordance with criteria which may not be coincident with marginal products. This problem invokes the question of what criteria are appropriate for distributing factor payments between factors, a question to which this study is not addressed. However it does raise implications for the efficiency of rental values as a means of allocating land to its most 'productive use'. It is reasonable though to make the assumption that the arbitrary nature of factor payments exists between factor groups but not within factor groups, so that differential rents may still be regarded as expressing a measure of the relative efficiency of land in a particular use.

Having mentioned certain reservations about marginal productivity theory of rent it must be said that as an abstract vehicle for building a practical theory of location behaviour it is both useful and relatively simple.

Turning our attention to the consumer of urban land we find that the nature of his locational demands depend upon the tastes and preferences exhibited within some utility function. The rational consumer will allocate his income over a range of goods and services including a locational bundle of goods. He does so in a manner which maximizes the total satisfaction gained from these commodities. The quantity demanded of each commodity will depend upon its own price, relative prices and the consumer's income. The combination of goods purchased will be such that the ratio of marginal utilities to price will be equal to each other, such that no reallocation of expenditure between goods can yield a higher level of satisfaction. The question arises within the context of locational analysis as to whether the existence of a spatial dimension to the consumer's preference function necessarily requires a more complex theoretical formulation than that provided by the classical case.

1.3. Residential location and rent.

So far the analysis has been presented as though the production function and utility function are analogous, and to a certain extent they are. However, whereas the production function is purely objective in terms of measurable costs and output, the utility function is subjective depending upon 'tastes and preferences' and without any unambiguous cardinal measure. In explaining the behaviour of the urban rent surface with respect to consumer demand it is important to identify clearly then the locational attributes which enter the preference functions of individuals.

The explanation most widely adopted, follows the work of VON THUNEN (1826) and the well known theorem that rent represents the transportation cost saving, for carrying goods to a central market, over the cost associated with a more distant location. This theorem has influenced urban location theory to such an extent that today rent functions are almost exclusively related to some cost of overcoming distance.

The Von Thunian transport cost explanation of differential rent is analogous to RICARDO's (1821) differential fertility one. Both are reconcilable within the more general marginal productivity theory of rent. Apart from JAMES ANDERSON (1777) who couched the first analysis of differential rent in terms of fertility alone we find RICARDO (1821, Chapter 2) recognizing that "peculiar advantages of situation" may influence rent, while SMITH in the Wealth of Nations (Book V. ch.ii) remarks that rent

> "In country houses at a distance from any great town, where there is a plentiful choice of ground ... is scarcely anything"

and that for

> "country villas in the neighbourhood of some great town, is sometimes a good deal higher and the peculiar conveniency, or beauty of situation, is there frequently very highly paid for".

It is apparent that Smith recognized the importance of both distance and environmental beauty or amenity for residential location.

Since Smith and the classical writers two approaches regarding the nature of residential preference functions have predominated. The first is that approach which emphasises trade-off relationships between accessibility and space (density). The second is that approach which emphasises the role of environmental amenity, in determining residential location behaviour.

The most notable contribution to the first approach was given by HAIG (1926). Haig suggested a complementary relationship between rent and transport costs such that for any location rent was equal to "the saving in transport cost". Transportation was a means of overcoming the "friction of space"; transport costs together with rents making up the costs of friction. Haig believed that the sum of rents and transport costs was not a constant and to this extent his theory differs from Von Thunen's.

However if rent differences do not completely compensate for differential transport costs between sites, then rent must be something more than "savings in transport costs". A fundamental weakness of Haig's hypothesis is that no adequate explanation is given as to what else might be the determinants of rent.

1.4. Accessibility Models of Location.

In its simplest form the accessibility approach demonstrates a simple inverse relationship between rent and travel costs to some point of attraction, usually taken to be the centre of an urban area. This concept of accessibility is rationalized by assuming that all services and work places are centrally located. Central locations are thus associated with cheaper travel opportunities, a locational asset for which households are willing to pay rent. Under the conditions of perfect competition the market for housing generates a residential rent surface over an urban space such that households are indifferent as to where they locate, rents at any location being equal to the travel cost saving over the most distant location.

Clearly this approach is too simplistic. It is unlikely that travel cost savings are the sole locational attraction considered by households. Nor is it likely that travel costs where they are important are necessarily the outcome of central travel exclusively.

Theoretical developments since Haig's paper have however produced a more credible accessibility model. Notably ALONSO (1964) has considered a model where households can substitute between distance, the quantity of space and 'other goods and services' when allocating their income over the range of goods available to them. A utility maximizing framework is posited without however a specific functional form with its attendant testable implications being provided. This is not a criticism in so far as it is preferable to work directly with demand functions if an operational model is sought. Utility functions, if they exist at all, are an elusive concept for the empirical worker. The attention in Alonso's model is however firmly placed upon the theoretical equilibrium properties of the utility maximizing process. It is worth noting therefore the criticism of YAMADA (1971(a)) that Alonso does not derive conditions for the existence of a unique equilibrium solution to the household's locational problem. The difficulty arises in that the budget constraint function cannot be assumed to be linear as one of its arguments, land price, is not invariant with respect to distance, itself to be determined. While the price of 'other goods' is constant over space, the price of land in Alonso's model is not. It can be shown (YAMADA (1971(a) p.5-8) that without fixing either one of distance, quantity of space or expenditure upon 'other goods', multiple solutions to the maximization problem cannot be ruled out. There is no compelling reason why the non-linear budget constraint should be tangential to any indifference surface or plane, at a unique point. While I will return later to the points that I shall now make it should be noted at this juncture that my concern here is not with the uniqueness of equilibrium itself but with the simultaneous existence of a set of varying residential prices. In order to make presumptions concerning the values of amenities to individuals it is necessary to determine initially one of either units of quantity or prices per unit. With knowledge of a price-space function and of residential values, quantities of amenity can be determined. However apart from the problem of explaining the existence of varying prices for quantum units it would appear simpler in practice to determine prices having defined quantity units and having observed residential values, where the price per unit is fixed per period of time. The question of whether an individual could achieve a maximum of satisfaction at alternative locations is irrelevant for this discussion.

Yet it is the variability of rent (so far regarded as a land price) that gives to utility maximizing models a distinctly locational flavour.

In the model presented by MUTH (1969) the assumption that the quality of housing consumed be constant is made. Households allocate their income to travel expenditure and rent, both functions of distance, and 'other goods'. The budget constraint is given by

$$y = rx + p(k)q + T(k,y) \qquad (1 : 1)$$

where
- y is income
- r is the price of a composite market good
- x is a composite market good
- p is the price of land a function of distance, k.
- q is the quantity of space
- T is travel expenditure a function of income and distance

We are interested in the solution to the household's problem of maximising a utility function given by

$$U = U(x,q) \qquad (1 : 2)$$

subject to the subsidiary condition of the budget constraint. We may write the first order conditions of Muth's model as

$$U_x - \lambda p = 0 \qquad (1 : 3)$$

$$U_q - \lambda p = 0 \qquad (1 : 4)$$

$$-\lambda(qp_k + T_k) = 0 \qquad (1 : 5)$$

$$y - rx - p(k)q - T(k,y) = 0 \qquad (1 : 6)$$

giving as solutions the following,

$$U_x/r = U_q/p \qquad (1 : 7)$$

$$-q\ p_k = T_k \qquad (1 : 8)$$

In each case subscripts refer to partial derivatives.

Equation (1 : 7) gives the classical condition that the ratio of marginal utilities of each commodity to price are equal. Equation (1 : 8) implies that expenditure upon housing, price times quantity diminishes with distance from the centre, k, by an amount equal to the increase in travel costs. In this fashion a locational equilibrium is achieved whereby the residential land user cannot increase his income by any relocation. Equation (6) is the budget constraint.

This model excludes the possibility of variations in house type, residential amenity and of non-central travel. Muth introduces locational preference by explicitly introducing k in the utility function. This changes equation (1 : 5) in the following manner

$$U_k - \lambda(qp_k + T_k) = 0 \qquad (1 : 10)$$

so as to give solutions which now read

$$U_x/r = U_q/p = U_k/qp_k + T_k \qquad (1 : 11)$$

$$y = xr + qp(k) + T(k,y) \qquad (1 : 6a)$$

It follows that $-qp_k = T_k + \Gamma\, U_k/U_x$ (1 : 12)

from which it is apparent that if the right hand term on the right hand side of equation 12 is positive and greater than T_k then expenditure on housing will increase with distance from the centre. Muth maintains that this procedure "renders the theory devoid of any empirical content". It is true that no explicit explanation is given for locational preference other than accessibility but it is up to the theory to accommodate the facts and not vice versa.

WINGO (1961) presents a model derived directly from Haig's idea of a complementarity of rents and travel costs, rents just offsetting any advantage of accessibility. Travel costs include a valuation for the time spent travelling which is considered as an extension of working hours and valued at the marginal value of leisure i.e. the wage rate. Wingo accommodates the demand for space by making the quantity of land bought depend upon its price. Assuming a given availability of land Wingo's model is sufficient to derive both a population density and rent function for the urban area. While it does consider travel time and density it remains an accessibility model and as such does not accommodate amenity preferences.

An interesting approach is given by MILLS (1969) using, instead of a utility framework, Cobb-Douglas production functions for urban producers of output and producers of transportation services who may locate anywhere within the urban area but who transport their output to a focal distribution point within the city. Housing services may be considered as production outlets which generate commuter traffic to the focal point. Mills' model uses marginal productivity analysis to derive prices of output and transportation, land use and density distance functions along with rent functions for any size of urban area. A negative exponential form for the rent function is suggested as a plausible form, a theoretical result which is consistent with much empirical work, (CLARK, (1951), WINSTEN and SAVIGEAR, (1966)). Other results of interest are that land use densities and output per unit of land are directly related to rent. The fact that these results derive from the strong assumptions of the Cobb-Douglas form, particularly the unitary elasticity of substitution of inputs in production might suggest that an aggregative model of Mills' type would not perform well operationally. However the regressions reported by Mills for Chicago for various land uses including a residential one give results consistent with the a priori expectations of the model. It will be interesting to see how the model develops particularly with respect to a more precise specification of the nature of inputs into the production function. Especially so with regard to housing where accessibility may not be the only or the most important input.

NIEDERCORN (1971) suggests a residential model wherein households maximize a Cobb-Douglas utility function the arguments of which are quantities of living space and amounts of leisure time, which is related to journey to work time, itself a function of distance from a central location. A negative exponential form of residential rent is derived. However apart from a consideration of leisure time, which only indirectly might subsume a consideration of amenity, and then not in a comprehensive way, this model does not widen the scope for considering other than central locational attractions. Niedercorn's demonstration of the theoretical behaviour of a specific utility function is without any demonstration of its relevance to actual behaviour. This does not provide a "theoretical underpinning for Clark's findings" as the author suggests, (see CLARK, (1951)).

In summary the approach to residential preference functions which emphasises accessibility have extended Haig's work by including a consideration of 'quantity of space' consumed, travel time and leisure time values and by demonstrating that negative exponential rent functions and density functions are reconcilable with theoretical models as well as empirical. Without however considering whether topographical, physical and qualitative aspects of residential land are important determinants of location behaviour, such theoretical work lacks a generality necessary for wide acceptance. It is perhaps worth mentioning that over emphasis on accessibility models at a planning level may tend to encourage a diversion of investment funds toward improving transportation systems away from residential amenity improvement wherein significant positive benefits may lie.

1.5. The Environmental Approach.

The alternative approach to residential preferences has been that which has involved the role of environmental amenity. In the main this work has been of an empirical kind with little reference to any theoretical framework. The paper by STEGMANS (1969) suggested on the basis of opinion survey that residential amenity is a more dominant factor in determining locational behaviour of households than accessibility criteria, while the work of KAIN and QUIGLEY (1970) found that environmental factors were important for explaining variations in rent but that accessibility to the centre was unimportant, in a regression model of house prices and amenity factors.

There are three contributions however which have attempted to lay down a theoretical basis for considering environmental quality. The work of Yamada is strictly theoretical and bears close resemblance to the central accessibility models. YAMADA (1971(b)) considers that households trade-off, as well as accessibility and space, accessibility and environmental quality, and space and leisure. Utility is derived from a composite market good, space, time and accessibility and environmental quality. Leisure is introudced as a time variable. Expenditure on rent is related to distance from the centre in the usual inverse fashion. Distance affects utility both positively and negatively. Positively in that environmental quality is assumed to increase with distance and negatively in that accessibility decreases with distance. Utility is maximised subject to an income and time constraint, with possibilities for allocating time to work, travel and leisure. Yamada demonstrates that in a locational equilibrium, the benefit received by moving farther from the centre, equal to rent savings and improvements in the environment, are just offset by increases in travel cost.

A criticism of this model is that rent is not an explicit function of environmental quality, but an implicit function via the relationship that environment has with distance. If environmental benefits are to be identified operationally it must be through their effects upon rental expenditure. With a continuously declining rent function however environmental improvements would have always to be smaller in their rental impact than increased travel cost as distance from the centre increases. This restricts the generality of the model in an unnecessary fashion.

RICHARDSON (1971) has suggested a model where households maximise their consumption of space and 'amenity' subject to a budget constraint related to income and the price of land. Following his notation we may say that households behave so as to maximise a preference function

$$f(n,q) \qquad (1 : 13)$$

subject to

$$aY = Jn_m e^{-k} q_m^{dom} \qquad (1 : 14)$$

where

$$dom \ngtr dx$$

and n represents an environmental index; q the quantity of space consumed; aY is the capitalized expenditure on housing, a function of income Y; dom, the distance from the town centre to a location m; e is the Naperian logarithm, J and k are constant and dx the maximum distance that households are willing to live at.

Unfortunately this pragmatic approach tells us little regarding the derivation of the exponential land price distance function. Presumably this function is generated by the supply of and demand for competing land uses over the urban area. As regards residential land, demand will reflect amenity preferences and perhaps the desire for accessibility. Without an explicit rent function however the specific nature of residential demand cannot be distinguished.

The third and most recent theoretical formulation is given by NELSON (1972). He expresses dissatisfaction with the "classical residential location theory" which emphasises accessibility as the determinant of residential rent functions without a consideration of the effects of environmental and structural heterogenity of residential location. Nelson's rent function is defined in terms of the regular market goods either foregone or required, to compensate consumers for different amounts of residential goods available between different locations, in maintaining constant utility.

Nelson discusses the nature of residential goods prices which he regards as the derivative of rent with respect to the availability of residential goods. This rent change contingent upon a change in location and the availability of residential goods is described as an implicit price function. With knowledge of this implicit price function and of the price of regular market goods and by holding utility constant the levels of residential goods consumption are determined for different values of the implicit price function.

It is perhaps imprecise to regard marginal changes in rent contingent upon quantum changes in residential goods as a 'price function'. In fact prices are constant and it is the quantity which

$$aY = Jn_m e^{-k} q_m^{dom} \qquad (1 : 14)$$

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It is perhaps imprecise to regard marginal changes in rent contingent upon quantum changes in residential goods as a 'price function'. In fact prices are constant and it is the quantity which changes. This is sensible in that one would expect residential goods prices to be the same everywhere within a single market.[1] Nelson has moved nearer however on explicit recognition of the fact that rent functions are not price functions but expenditure functions representing the outlay on a bundle of residential goods and services which differ in quantity over urban space but not in price. This rationale removes immediately the problems raised by Yamada of non-linearity in the constraint function and allows a unique consumer equilibrium to exist for both market and locational goods. In fact it will be shown later that the residential location problem under these conditions is quite trivial reducing simply to the classical utility maximization solution.

Nelson's paper is most useful in illustrating how accessibility can be regarded simply as a locational good without further specification of how it should be measured or in what way rent specifically depends upon it. This is in contrast to those analyses which have been at pains to develop the most sophisticated of rent-distance functions.

Although Nelson does not say so explicitly, by implication his treatment of accessibility is in fact consistent with the view taken by geographers. INGRAM (1971) and CHORLEY and HAGGERT (1969) for example recognize that there exists a relative accessibility between points which may be integrated over all points on a surface. Such a generalized consideration of distance effects is long overdue in residential location analysis. Households travel in response to locational interdependencies and attractions from points other than the centre. Models which accommodate this point of view can serve to place the apparent empirical justification of negative exponential rent-distance-from-the-centre models in a wider perspective. Nelson's model is a most welcome contribution as a result.

However while it is not perhaps a serious criticism to mention that no operational basis for his model is indicated, it is unfortunate that Nelson's rent function was not explicitly derived in terms of accessibility and other locational goods. Generality in a model is useful in that it provides a framework for considering all relevant variables. Such a consideration involves of course the determination

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1 This point is amplified in Chapter Two below.

of the precise functional relationships of the variables and therefore specific formulations which can be tested against data are necessary. This has indeed been the advantage of central accessibility models in that simple models with readily testable rent distance relationships have been developed.

The theoretical background to the study of household's residential preferences would not be complete without a brief mention of the class of macro models developed by, amongst others, WILSON (1968, 70, 69). This work derives its rationale from certain notions of social physics especially the idea that the behaviour of micro-states (household locations) can be ascertained from a knowledge of the aggregate behaviour of a system; for example a residential-journey to work network and its associated travel cost. The use of the entropy maximising procedures of statistical mechanics are appropriate for spatial problems which can be set up in this way. The locational information which can be extracted from aggregate data such as a total travel network cost is useful in deriving planning models quickly and without the expense of surveying individual households so as to establish individual preference functions.

It appears however that only simple micro behaviour can be readily accommodated within 'entropy' models. To allow environmental preferences and a consideration of different classes of micro-states (age, size and income classifications) to be considered apparently requires a model of dimensions such that its calibration at the present state of the art is more difficult than micro economic behavioural measurements (see WILSON (1968)).

1.6. Summary.

In summary we can observe that in the main the marginalist analysis of economic behaviour has served as the vehicle for conducting the examination of residential location behaviour. The relationships between rental payments for residential land and the locational attributes of that land have concentrated upon distance and accessibility to some point of attraction as the determinants of the pattern of rents. There exists however reasonable doubt that such an approach has a sufficient generality to be widely acceptable, particularly with regard to the myopic view taken of the potential importance of environmental and amenity preferences. Yet there can be no doubt that such dimensions of residential existence are important in the minds of households.

The problem of incorporating environmental attributes of locations within a theoretical model appears to be that of providing a specific formulation of the relationship between rent, distance and environment. Naive assumptions relating environment to distance itself while having perhaps a pragmatic appeal do not give a basis for a generalized examination of rent patterns over space.

The implication is that a prerequisite for a generalised residential location model is the measurement of environmental goods. Only by identifying their existence can they be accommodated within the household's budgetary and utility framework. If however the theory of residential location is unsatisfactory the empirical contributions to the problem of environmental evaluation are even more so.

This thesis will be largely concerned with identifying and evaluating the environmental amenity associated with housing within the framework of a micro economic behavioural theory.

CHAPTER TWO

A Theoretical Framework

2.1. A Simple Residential Model

Despite the large volume of writing now available on residential location behaviour, no satisfactory theoretical model exists which accommodates both environmental amenity and accessibility in such a way that an operational framework can be readily deduced. This is in part due to the overconcern with accessibility and in part due to the 'nature of the beast'.

Residential amenity is difficult to define and regarded by some as impossible to evaluate. This view derives from the belief that residential amenity is a subjective good evaluated in the mind of the consumer and not in the market place. Hence no tangible manifestation of its worth is apparent for empirical analysis. NELSON (1972) suggests that consumer decisions can only be understood

> "where the consumer .... bases his decisions on variables with definable and measurable units".

It would be wrong however to conclude that consumers do not in fact make decisions pertaining to more abstract notions of their environment. Of course in investigating such vectors of the mind, variables reconcilable with statistical analysis and empirical observation are required in the first instance. It is not too difficult to suppose what variables these might be nor to provide for them arbitrary measuring devices. The real problem is that armed with an abundance of notions regarding the nature of residential amenity, how do we incorporate them within a theoretical rationale that lends itself to calibration?

The model developed below has as its prime objective the provision of such an operational framework.

The starting point as in neo-classical residential analysis is the description of a residential rent function.

$$f(i) = g(\underline{E}_i, T_i) \qquad (2 : 1)$$

where

where $f(i)$ is the rental outlay for the i^{th} location,

$\underline{E}_i$ is the vector of environmental expenditure associated with the i^{th} location and

T_i is a scalar, representing the travel expenditure associated with the i^{th} location.

We may consider for example the linear model

$$f(i) = h(k(\underline{E})_i - \alpha T_i) \qquad (2 : 2)$$

$$= h(G_i - \alpha T_i) \qquad (2 : 3)$$

where

$$G_i = k(\underline{E}_i) \qquad (2 : 4)$$

and G_i is a scalar.

In general there are point locational attributes, given by the $\underline{E}_i$ vector and relative point locational attributes, represented here by T_i. The latter can be regarded as indicative of the attributes and attractions of locations other than i, the benefit of which is consumed by the i^{th} locater after travel.

The linear formulation expresses rental payments made for a discrete location as the outlay for environmental attributes less the compensation for the inaccessibility to other points associated with that location. This compensatory payment is related to the travel outlay by the parameter α. Travel outlays if they are a direct function of distance enable this formulation to conform with the Von Thunian tradition that rent varies inversely with travel costs. At the level of theoretical abstraction however it is unnecessary to restrict the formulation in this way. This is especially so as in practice the shape of a rent surface for an area, depending upon the relative distribution of amenity and accessibility attributes, could be different for separate areas.

In the context of a utility maximising framework with

$$U = U(x,i) \qquad (2 : 5)$$

where

x is a scalar representing a non-residential good

i represents location in a continuous fashion

and with a household's budget constraint given by

$$\mu = px + \varphi(i) \tag{2 : 6}$$

where

μ is money income,

p is a non-residential good price

and

$$\varphi(i) = f(i) + Ti, \tag{2 : 7}$$

then the first order conditions for a maximum of U subject to μ are:

$$U_x' + \lambda p = 0 \tag{2 : 8}$$

$$U_i' + \lambda \varphi(i)' = 0 \tag{2 : 9}$$

$$\mu - px - \varphi(i) = 0 \tag{2 : 10}$$

where primes indicate partial derivatives.

A solution for equation (8) to (10) is given by

$$U_x'/p = U_i'/\varphi'(i) \tag{2 : 11}$$

which represents the usual result of classical theory that the ratios of marginal utility to price are equal for all goods.

Upon substituting equation (2:3) for f(i) in equation (2:7) we obtain

$$\varphi(i) = (1 - \alpha)Ti - Gi \tag{2 : 12}$$

and therefore

$$\varphi'(i) = [(1 - \alpha) Ti - Gi]' \qquad (2 : 13)$$

Substituting equation (2:13) for $\varphi(i)$ in equation (2:11) gives

$$U'_x / p = U'_i / [(1 - \alpha) Ti - Gi]' \qquad (2 : 14)$$

The denominator of the right hand side of (2:14) is no more than the change in locational expenditure (price times quantity) contingent upon a change in location. In the event that the prices of locational attributes are not constant over the area and without prior knowledge of the price location function, locational prices cannot be derived from (2:14) alone.

However, without loss of generality it can be assumed that locational attributes prices are invariant with respect to location, a tree or a decibel of birdsong being priced the same in any part of town.[1] Hence the change in locational expenditure must necessarily be the result of changes in the quantity of locational attributes available as location varies. In this case unit changes of quantity and hence expenditure allow the determination of locational prices.

The existence of varying prices would require an explanation of the existence of separate residential markets within the one urban area. While such a formulation would not necessarily be without reason the approach adopted throughout this work is that all households face the same set of residential goods prices. Variations in rent then reflect different quantities of available goods at each location.

By regarding residential goods prices as constant over urban space it is thus possible to incorporate locational decisions of households within traditional consumer theory. To understand the shape of the residential rent surface it is only necessary to know the quantities of environmental and accessibility features and their prices, for each location. The problem for the analyst resolves to one of identifying the relevant locational attributes and of determining

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1 Given that both prices and quantities of locational attributes are not uniquely predetermined with only expenditure being observed and given a degree of freedom with respect to the definition and measurement of quantity, price can be forced constant without any loss of generality.

their shadow prices. The problems raised in the previous chapter do not arise. Indeed the theoretical gymnastics associated with the derivation of exponential price-distance functions are seen to rely overmuch on implicit assumptions made about the distribution of accessibility and environment relative to a reference point.

2,2. Residential Goods-Characteristics Technology.

However this model is as yet unsatisfactory. This is so because the households' perception of residential amenity is likely to be an aggregate one. That is to say that households have an awareness of broad environmental characteristics which are made up of the complex of amenity variables. These characteristics might represent structural, aesthetic, accessibility and neighbourhood quality factors. The work of KAIN and QUIGLEY (1971) has in fact given evidence which suggests

> "that both the market and individual households evaluate residential quality in terms of fewer broader aggregates"

than the individual residential goods separately considered.

It would appear important then to provide a theoretical framework which accommodates the formation of aggregative preferences. With this in mind it would seem worthwhile investigating the theoretical ideas of amongst other IRONMONGER (1972) and LANCASTER (1966), the essence of which is that satisfaction is derived from 'characteristics' or 'wants' the production of which requires goods as inputs. Utility is then only indirectly related to goods by the relation between characteristics and goods. This relation is usually described in the literature as the 'consumption technology'. Such ideas have a long history and excellent pedigree in the writing of economics going back at least as far as Marshall (see IRONMONGER p.11). However little empirical work has as yet been done due largely to the difficulty of identifying 'characteristics' in practice. The model presented below is based upon the approach of Lancaster and Ironmonger but adapted to accommodate a concern for residential goods.

The consumer technology describing the relation between residential goods and characteristics is given by the linear equation (with matrix notation);

$$z = Ay \qquad (2:.15)$$

where

$z = z_i$ $i = 1,2, \ldots n$, is a vector of residential goods

$y = y_j$ $j = 1,2, \ldots m$, is a vector of residential characteristics

$A = a_{ij}$ is an n by m transformation matrix describing the consumer residential technology.

The A matrix is assumed to be constant and is singular. The z_i elements of z can be regarded as the variables representing the locational attributes of housing.

Consumers derive utility from characteristics rather than goods. It is useful for our purpose to assume that the utility function is separable in such a way that there exists a grouping of residential characteristics separate from other market goods. For expositional simplicity it will be assumed that for 'other market goods', goods-characteristics relationships are one to one. To confine attention to residential consumption it is assumed that goods other than residential are post-allocated to the household. Then the following utility function is maximised subject to the subsidiary conditions detailed;

$$U = U(x,y) \qquad (2 : 16)$$

$$px = M - qz \qquad (2 : 17)$$

$$z = Ay \qquad (2 : 18)$$

$$w = A'q \qquad (2 : 19)$$

where

$w = w_j$ $j=1,2, \ldots m$, is a column vector of residential characteristic prices

$q = q_i$ $i=1,2, \ldots n$, is a column vector of residential goods prices

M = Total money income

p = a vector of market goods prices corresponding to

x = a vector of market goods.

The first order conditions for utility maximisation are given by setting the first partials of V equal to zero where

$$V = U(x,y) - \lambda(M-px-wy) \qquad (2:20)$$

$$\partial V/\partial x = U_x + \lambda p = 0$$

$$\partial V/\partial y = U_y + \lambda w = 0 \qquad (2:21)$$

$$\partial V/\partial \lambda = M-px-wy = 0$$

A solution for which is;

$$U_x/p = U_y/w \qquad (2:22)$$

with marginal utility to price ratios for each good being equal.

It is clear that the maximisation problem is similar to the traditional classical case. The interest for locational analysis revolves around identifying the residential characteristics prices w given by equation (2:15). The procedure for obtaining such prices will be illustrated in Chapter 4. For the moment this discussion can be anticipated by outlining the approach adopted in this study.

In defining commodities uniquely care has to be taken to allow for qualitative differences between varieties of the same product. This problem was handled by HOUTHAKKER (1951) by assuming that quality affects product price in a continuous fashion. By examining price variations for different varieties it is possible to derive a unique commodity price independent of a quality price for that commodity. This technique forms the basis for the hedonic price measurement method where qualitative dimensions of a product are defined and related to product price. (GRILICHES, (1971)).

In this study we do not derive prices for the residential goods which make up house 'price' (expenditure) but rather for the characteristics which these goods provide. This in essence is done by relating house 'price' (residential goods expenditure) to the vector of characteristics which are obtained from the goods. In this way we are able to define a set of prices and quantities.

In the operational context of the analysis prices are necessary to identify relative values of amenity characteristics. It is not the purpose of this study however to examine the importance for demand of price per se. This would require a different approach with prices changing over time. Here it is assumed that prices are constant over space and the analysis will be conducted for a single time period.

It is worthwhile considering now the structure of the matrix of consumer technology, A. In the event that there are more goods than characteristics we are interested to know if there are any goods which will be redundant in providing a desired characteristics set.

IRONMONGER (1972) has shown that with a linear consumption technology an optimum satisfaction of wants (characteristics) requires that the number of discrete goods consumed will be less than or equal to the number of wants to be satisfied. This result follows directly from the 'laws' of linear programming an approach which may be used to determine the minimum number of goods required to obtain a given level of utility at least cost. The A matrix will be square, with an inverse and the number of goods equal to the number of wants exactly satisfied. LANCASTER (1972) suggests however that in an advanced economy there will generally be more goods than characteristics. For the individual consumer this situation would be inconsistent with an optimum set of characteristics in IRONMONGER's sense of an optimum, neither does Lancaster make clear the conditions when his situation would prevail.

In this study it is assumed that there will be more amenity goods consumed than characteristics into which the goods are inputs. This situation is to be expected where for instance there are both common want satisfying goods and unique want satisfying goods. The former are goods which satisfy a characteristic or want in common with other goods. A decision to consume such a good will depend upon its price relative to that of the other goods. The unique want satisfying good on the other hand has unique characteristics which make it desirable in itself. A good therefore which is both a common want satisficer and a unique want satisficer will be consumed even if it is relatively pricewise inefficient in providing a common want. Under such circumstances the order of the A matrix will be n by m with the possibility that $m > n$ i.e. the number of wants or characteristics is greater than the number of discrete goods, if unique wants are included.

2.3. Residential Expenditure.

Because of its relevance for most household diurnal activity, housing and locational expenditure is perhaps the most important outlay that a household makes. Eating, sleeping, travelling, recreating and working activities are all associated in some way with the chosen bundle of residential goods. The behavioural determinants of residential expenditure are then of no mean interest.

Engels paths for residential expenditure may be described in an $m + n + k$ dimensional space, consisting of m characteristics, n goods and k household socio-economic variables. Household size, age and occupational characteristics along with income, assets and social class make up this latter group.

Information about household residential choices occasioned by household socio-economic changes can be derived from studies of such Engels relations. Here the usual objective is to parameterize a relation between quantity consumed (or expenditure) for a commodity and income in addition to other household variables of the general form;

$$y_i = y_i(\mu, h, | w) \qquad (2 : 23)$$

where

h is a set of household socio-economic variables and the w prices are given.

We shall be particularly concerned to examine the inter-dependence of household socio-economic variables in determining the quality and quantity of residential consumption. It is a traditional problem of demand analysis to extract the effect of income on expenditure separately from the effect of household composition and size, income usually being regarded as the key variable. However in the case of housing it is important to understand the effect of all household variables. This is so as while income might be expected to be the most important determinant of the level of residential expenditure, household size and age/sex composition might be expected to play a large part in determining the type of residential bundle consumed at that level. The choice of a dependent variable lies between quantity consumed and expenditure, for a particular commodity. Expenditures, which refer to composite outlays for heterogeneous bundles of goods, may only with difficulty be broken down into quantities and prices which are unique for each good. Under such circumstances it may be preferable to work with expenditures rather than quantities.

In the event however that a unique commodity with a unique price facing all consumers can be defined, then the question of whether expenditure on quantity consumed is a more suitable variable for the Engels relation, becomes irrelevant. Both would give the same result except for a proportionality factor equal to the commodity price.

The rationale of this study is that the consumption of residential goods is identified via its relationship with house price and determined through its relationship with household income composition and other variables.

Particular attention is merited for the measure of income to be used. A household's consumption of goods may be related to its wealth, including asset ownership, savings and expected income, as well as to its current income. Expectations regarding future income are especially relevant considering that the availability of loan finance for house purchases is partly contingent upon the security of future income earning capacity.

Future income expectations are not explicitly taken account of in this study. This omission is justified to the extent that expectations of earning capacity are implicitly made by building societies through their attitudes to lending. Their lending behaviour is seen to be related to current income of borrowers but with the implication that they expect borrowers to be able to make future repayments of their loans, after accounting for a suitable degree of risk via their lending rate of interest.

It is of course true that borrowers need not necessarily borrow up to the maximum amount that building societies would allow on the basis of borrowers current income. This might be the case where for example a household's savings or other assets provided an alternative course of finance. In the event that savings and wealth are not highly correlated with incomes then the viability of current income as the determining variable is reduced.

The procedure adopted to allow for this consideration is by no means ideal but might be thought to remove the most serious source of any bias. House purchase is influenced especially by those monetary assets realized on the sale of a previous dwelling. Housing being a durable good has a capitalized value associated with it, that is its price. On resale of this capitalized asset the money value is retained net of depreciation and appreciation, and is available to finance any subsequent purchases. However similar houses in different locations undergo different changes in value hence this asset influence on consumption is not constant. To allow for this effect an asset variable can be constructed from knowledge of the household's previous location and from a locational house price index.[1] The value of this variable for each household can be equal to the value of the index for their previous location. Households who prior to their current house purchase did not possess a residential asset can be assigned an asset value of zero.[2]

In this study then current income, household size, age/sex groups, social class plus a 'measure' of the value of households' assets are to be used as the determining variables of household residential consumption relations.

2.4. Summary.

In summary the main points of this chapter have been that a model of residential location behaviour can be developed within a traditional utility framework. This can be achieved without making any special spatial assumptions save that locational prices facing households are constant over space. For price variation to exist over urban space, separate residential markets must exist side by side, and their existence be explained. It is suggested that it is more reasonable to suppose that a single market exists, where the costs of information do not preclude price competition and where differential rents are explained in terms of differential amounts of amenity.

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1 These asset variables were constructed from an index of regional property prices derived from the Occasional Bulletin 1969, of the Nationwide Building Society.

2 In the case where a logarithmic function is employed where the log. of zero does not exist an alternative procedure is employed where $v = \log(1 + A)$ where A is asset value.

In the 'distance' oriented accessibility models of residential location no conclusive proof was discovered for the strong behavioural assumptions made. It is evident in many urban situations that land prices and residential prices vary inversely with respect to central distance. Yet much evidence exists to suggest that households' perception of location incorporates far more than central travel opportunities. There is therefore the danger that the 'accessibility approach' amounts to no more than an ex post rationalization of land value patterns in terms of certain conveniently available distance functions.

A theoretical framework was outlined accommodating a consideration of a general class of residential 'goods', including both amenity and accessibility dimensions. It was shown that the shape of the rent surface depends critically upon the relative distribution of 'amenity' goods and 'accessibility' goods. The onus it was suggested was therefore for an operational analysis to explain the rent surface in terms of amenity prices, quantities and accessibility expenditures for a given distribution of the residential or locational goods.

It was further suggested that households obtain utility not directly from residential goods but indirectly from characteristics that these goods provide. An aggregated perception of the goods would require that the number of characteristics be less than the number of goods. It was considered however that if goods had unique characteristic properties then there would be more characteristics than goods. The analysis was couched in terms which allowed for these possibilities with the procedure for deriving shadow prices for amenity characteristics being briefly alluded to.

Finally, it was felt that an examination of expenditures by households upon residential goods properly defined would be facilitated by relating such expenditures to current household income and other household variables.

Discussion of the estimation procedures necessary to calibrate the relationships given in this chapter are provided in chapter 4. Of particular concern will be the procedure for deriving amenity shadow prices and for estimating income elasticities which are not confounded with household compositional effects.

CHAPTER THREE

Data Collection Methodology

> "whenever a study is based largely on the collection and compilation of primary data, probably more time and effort will be expended on this activity than on any other".
>
> Ferber and Verdoorn. Research Methods in Economics and Business.

3.1. Introduction : Sampling the Housing Market.

From the theoretical framework posited in Chapter 2, two operational objectives may be derived. In the first place there is a need to identify and evaluate in money terms the residential 'goods' which households perceive as making up their consumption of housing. In the second place behavioural relationships which can 'explain' a household's residential consumption in terms of its socio-economic characteristics require to be established. This chapter will outline the considerations taken account of in providing a sample of data sufficient to accomplish these objectives.

As a step towards achieving the first objective it is useful to set up the simple hypothesis that a household's expenditure on housing, represented by the purchase price of a house, comprises an outlay for a bundle of residential goods. House price in this sense is not a price at all but rather the sum of the product of a set of prices and quantities for the various residential goods. To test the validity of this hypothesis it will be necessary to establish the extent to which variations in house prices can be 'explained' by the variation of residential amenity from house to house.

An appropriate statistical procedure for examining the covariation of house prices and residential amenity requires of course data for both house prices and amenity. As well as the task of ascertaining an appropriate source for such data there is the prerequisite choice to be made of a suitable sector of the housing market. In so far as we are ultimately concerned with how households perceive their residential environment and make their locational choices in accordance with this perception, a market wherein prices reflect the value to the consumers concerned, is appropriate. This would not necessarily be the case for example in the public sector of the housing market. Here prices (rents) paid contain an element of subsidy which reflects the community's preferences for residential amenity as well as those of the individual households.[1]

Within the context of the private sector of the market however, certain problems are raised. It is unlikely for example that new house prices will adequately reflect market values. Pricing policies of builders, concerned with the recovery of production costs, may be such as to fix prices other than in accordance with the pressure of market demand. As a result an uncertain element of 'consumers surplus' is likely to be present in the market for new houses.

A further consideration is that of the proprietary rights associated with properties on the private market. Such rights impose positive or negative constraints upon the use to be made of property and hence can influence the utility to be derived from residential goods. It would be incorrect therefore to regard for example leasehold and freehold property as the same thing for the purposes of analysis. It is not however an object of this study to examine the relative importance of different tenurial structures. What is therefore required is that tenurial influences on behaviour be constant for the sector of the market chosen for analysis.

These considerations suggest that a sample based upon the 'second-hand', freehold sector of the private housing market would be most appropriate for deriving information on house prices and residential amenity.

3.2. Data on House Prices.

For the purpose of obtaining house price data several alternative sources can be considered. Data might be obtained from advertisements of houses for sale giving an 'asking' price. However serious disadvantages are associated with this source. In the first place it is difficult to establish, without questioning the household, the

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1 In the event that the subsidy element plus the contribution paid by the household is coincident with consumer benefits that would be received on the market then public sector housing would meet our data requirements. However this is not likely to be the case (see DESALVO (1971)). Indeed the evaluation of consumer benefits from public sector housing programmes requires estimates of the market value of housing units which can only be estimated independently of the housing programme itself.

actual selling price, which may be significantly different from the asking price. In the second place, as yet no established relationship between asking and selling prices exists. Such a relationship derived from a knowledge of the joint probability density of asking and selling prices could be made available. This however would require data on both asking and selling prices in the first instance.

An alternative data source is that of the estate agent dealing in the residential property market. This in fact was the source of all the house price data. Apart from the advantage of being able to obtain actual selling prices of properties there are other useful features of this source. Firstly estate agents can provide 'particulars' of each property detailing the facilities offered by the house. This is especially useful with regard to the provision of non-standard features of a property which may influence its price' such as central heating and double glazing. Secondly agents can usually provide an insight into special 'market' circumstances which might surround the sale of particular properties. This is useful in deciding whether or not a transaction superficially adequate for inclusion in the sample, ought to be in fact excluded on grounds of abnormal circumstance.

A useful data source which might be considered is that of building societies' records of loan-financed property. The amount of detail which is available will probably vary from society to society. However if this source is open to researchers it is well worth considering (see WILKINSON (1973)).

3.3. Data on Residential Amenity. (see Table 3.1.)

To obtain data on the amenity associated with the houses for which prices are available, it is convenient to distinguish two categories of residential good. Firstly there are the locational attributes of the site itself and its immediate environs, what we might call point locational attributes. These will comprise physical characteristics of the house and of the land use within an area about the house, incorporating neighbourhood environmental characteristics. Secondly, there are relative locational attributes which describe the location of the house in relation to other points on the urban area. Underlying this notion of relative location is the implicit assumption that locational advantages (disadvantages) are expressed through some medium of spatial actual selling price, which may be significantly different from the asking price. In the second place, as yet no established relationship between asking and selling prices exists. Such a relationship derived from a knowledge of the joint probability density of asking and selling prices could be made available. This however would require data on both asking and selling prices in the first instance.

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Distance has also been extensively used in the literature as a proxy for accessibility to points of interest to which travel is undertaken to obtain a locational good. This applies to 'journey to work' trips as much as to trips to recreational or service facilities. In the journey to work example the locational good is the opportunity to earn income. However, again on a priori grounds, this study will utilize a different measure of accessibility to points of interest to which travel is undertaken. Here we are interested in ascertaining the relationship between travel expenditure, a converse measure of accessibility, and house price. This is in strict accordance with the rent function described in the theoretical model of Chapter 2 and in keeping with Von Thunian tradition where differential rent is expressed in terms of differential travel cost advantages. This study has been unable therefore to justify using a proxy for accessibility based upon distance from the town centre but instead has required data on regular trips made by households for all purposes.[1] In fact distance from the town centre has been included as a relevant relative locational attribute descriptive of some notion of urbanity.

The implications that these considerations have for data collection are twofold. Firstly both field and map surveys of each location are required in order to obtain information pertaining to the point locational attributes. Secondly, while much of the

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1 This is no mean advantage where trip motivations as well as directions are not homogenous for the population under consideration. It allows for example retired persons who do not undertake trips to work but who regularly visit friends in the country to be accommodated within the analysis. This would not be the case where accessibility was measured from the centre and rationalized by assuming that all work places and facilities are centrally located.

relative locational attributes can be obtained by reference to maps, information regarding travel behaviour cannot. This requires a household questionnaire of the relevant households concerning the frequency, distance and mode of their travel.

TABLE 3.1. Residential Amenity Variables used in the Study.

Variable Group	Description	Measure
1. Dwelling and Plot Variables:-	(i) House Price	Selling Price
	(ii) House Type	Detached; Semi; Terraced
	(iii) Garage	Garage, Garage Space, Neither
	(iv) Age	Date of Construction Pre: 1918=0, 1919=1, etc.
	(v) Size	Number of Bedrooms
	(vi) Plot Size	Square Yards
2. Point Locational Variables:-	(i) Open Space	Acres within area of radii 1/8, 1/4, and 1/2 mile of Dwelling
Measured within an area of 1/2 mile radius of the Dwelling	(ii) Residential Land	Same as above
	(iii) Industrial and Commercial land	Same as above
	(iv) Density	Average density of Residential land use i.e. Plot Size/Dwelling Numbers Ratio within area of 1/2 mile radius
	(v) Arborial Amenity	Number of trees within 100 yards of the dwelling
	(vi) View	Degrees of Panorama with dummy variables for features of Parkland, Woodlands, Hills, Housing, Industrial/commercial land
3. Relative Locational Variables:-	(i) Noise and Nuisance	Distance from Main Road
	(ii) Noise and Nuisance	Distance from Railway
	(iii) Countryside	Distance from Green Belt
	(iv) City Centre (urbanity)	Distance from Centre
	(v) General Access	Travel Expenditure per annum of household on regular trips.

3.4. A Household Survey of Residential Preferences.

For the purpose of analysing the covariation between the two data sets of price and amenity it will be necessary to ensure that other influential variables are taken account of in some way. The most important influence is the effect of changes in demand and supply on market prices. In order to remove the effect of such changes the analysis will be of a cross-sectional, rather than a time-series type. Here the interest is then with analysing variations in price and amenity at one point in time rather than over time thus holding constant demand and supply.

An appropriate statistical procedure for establishing the relationship between house price and amenity would be to posit a regression model with price as the dependent and amenity as the independent variables. In the first place this procedure is useful providing as it does a measure of the 'goodness of fit' of the hypothetical relation between price and amenity. This measure, or coefficient of determination, provides a degree of belief in the relationship on the basis of its conformity with the statistical facts. In the second place the coefficients for each independent variable may be interpreted as shadow prices of amenity, explaining as they do the marginal contribution to house price of a unit of amenity.

It is important to recognize however that a regression analysis can lend support to our hypothesis but can in no sense prove it. While, in the tradition of Comte, truth may be represented by observable phenomena and scientifically verified facts, the question exists as to what degree of verification is necessary. As the statistical approach adopted in this study is inductive it would be useful to conduct a control experiment regarding the relevance of the chosen variables, rather than to rely upon ex post rationalization of regression results entirely.

Unfortunately control in the strict sense would be difficult to organise in the present study. This is so because it is almost impossible to obtain a sample of house prices pertaining to one point in time, for which all amenity variables are held constant. To hold each amenity variable constant in turn might be possible given sufficient time and data reserves but this alternative was outwith the budget of this study.

In order to examine the validity of the amenity variables then it was decided in the absence of a control (apart from holding time constant) to conduct a parallel experiment. This took the form of a social survey of residential amenity preferences of the households concerned. By such a survey it was hoped that an insight might be given into the relevance of different amenity factors for a study of household preferences. In itself this approach is not ideal as a parallel experiment because not all preferences would necessarily be expressed in expenditure terms. This will obviously be the case where desires transcend ability to pay. Moreover there is the inherent weakness of all such surveys that respondents will tend to give an ex post rationalization of criteria other than or in addition to that which initially motivated their choice. To an extent this problem can be minimized by a careful design of the questionnaire but it can never be entirely removed. However on balance it was felt that what insight a social survey would have would be worth having! Particularly so as it might be expected to reveal any serious discrepancy between variables used in the regression analysis and those felt to be important by households.

3.5. Household Data.

The second operational objective of the study is to derive behavioural relationships between a household's expenditure pattern for residential goods and its socio-economic characteristics. Such characteristics as might be expected to influence the expenditure pattern pertain to the size, age composition, income and occupational aspects of households. It is clear from chapter 2 that while we may be primarily concerned with establishing income-expenditure relationships, an allowance for the other factors is necessary. In order to obtain the necessary information a survey of the households in the sample is required. A questionnaire on household characteristics, on residential amenity preferences and on travel characteristics was prepared. The questionnaire was both structured and un-structured, corresponding to the straight-forward questions for socio-economic characteristics and to the more obtuse questions for obtaining preferences and attitudes. These latter questions were open-ended with the interviewer recording verbatim the answers given by the households.

3.6. Sampling Procedures adopted in the Study.

The data for the study was firstly collected from house prices and sales particulars made available by estate agents. Secondly a household survey of these houses was conducted to obtain data on residential preferences and socio-economic characteristics of the households. Thirdly field and map surveys of each house and its location were utilized to obtain data on the locational attributes for each site.

Due to the microeconomic approach adopted requiring detailed data for each observation in the sample the costs of data collection both in time and money were high. The study was as a result restricted to one urban area for which a sample of 210 houses was taken. The urban area chosen was Nottingham with a population of 210,000 and an estimated turnover in second-hand houses of some 5,000 per annum.

The criteria by which Nottingham was felt suitable for analysis were firstly that it has a well defined housing market extending approximately 12 - 15 miles from the city centre. The market is well defined in the sense that it is not influenced by the presence of nearby towns. This factor is partly facilitated by the diversified employment base which encourages economic activity and especially journey to work travel to be conducted within the Nottingham area. This is helpful insofar as if travel were made to other urban areas it would be a priori to achieve some locational benefit which ought properly to be included in the study. This would suggest that the two areas were interdependent for purposes of locational analysis. Such analysis would then require a more extensive spatial scale than adopted in this present study.

Secondly environmental variation over the urban area of Nottingham is sufficient enough to suggest that if the initial hypothesis is correct a definite pattern of covariation with prices can be established.

Thirdly net migration in the Nottingham area over the period 1960-1972 has been negligible. This it is suspected has contributed to the stability in residential prices which have not experienced wild fluctuations but a steady increase over the period. (see 3.7 for details of a price index for Nottingham). Stable prices are reassuring in that they indicate that changes in demand and supply have not been sudden or such that they warrant special attention.

Fourthly much of the residential demand in Nottingham is generated from households already residing in the Nottingham area. This factor was apparent after conversation with estate agents and building society managers whose opinion was reinforced in the actual sample where only 23% of households had previously lived outside the area. This should enable a comparison to be made of 'reasons for moving' within the area. The household questionnaire was accordingly designed to incorporate this dimension of the study.

The precision of numerical estimates derived from the sample data will be satisfactory under conditions of a probability or random method of sample member selection. Essentially we are concerned to ensure that each member of the population has an equal chance or probability of being selected. Unfortunately however, data collected from estate agents may not satisfy this requirement if the agents concerned specialise in specific ranges of property types. Ideally all agents would be sampled, thus extending the process of random selection to all property types handled. This was not a practical option and instead two agents with a broad range of property types on their books were sampled.

This procedure was reinforced by comparing the representative nature of the chosen sample range with the range of property derived from an independent random sample of Nottingham second-hand house sales. This data was provided by the Department of the Environment for the purpose of constructing an index of residential prices for Nottingham (see 3.7) and was used as a check on the representative nature of the data from agents.

It remains to mention the period of time chosen for the study. This was the year 1968 and was chosen with a view to ensuring the comparability of data based upon Ordnance Survey maps revised up to 1968 with the physical characteristics of the properties at the time of their sale. Not all sample members in fact were sales recorded in 1968. For those which were either 1969 or 1970 however prices were deflated utilizing a metropolitan hedonic index constructed for the purpose.

3.7. The Construction of a Hedonic Price Index for Nottingham Houses.

As is clear from the preceding it is necessary to construct an index of residential prices for the Nottingham area in order to obtain a set of prices deflated to a common base period. Data for this purpose was kindly made available by the Department of the Environment and referred to the period 1960 - 1970 for the Nottingham metropolitan and district area. As housing is not a homogenous commodity it was necessary to employ a hedonic index in measuring price changes. A hedonic index is an index which takes account of qualitative changes in commodities as well as providing a general expression for the average movement of their prices and quantities. It may be used to derive an index free of the effects of quality change or to further the investigation of quality itself.

The advantage of the hedonic index over a conventional index lies in its ability to identify price fluctuations contingent upon qualitative dimensions of a commodity separately from fluctuations in commodity value per se. In so far as there appears to be no inherent reason why qualitative changes and 'pure' price changes should move in the same direction or at the same rate, the advantage is by no means insignificant. We would never, or should never, construct a price index for a commodity group beef by using as our commodity standard for one year stewing steak and for another best sirloin. This would be to ignore quality change across a commodity group. Similarly, we should not ignore quality changes within a single commodity.

The rationale which supports the construction of hedonic indices is a simple one. It is posited that a commodity and its value is a composite sum of the qualitative dimensions and their associated values. Instead therefore of a single price and commodity, say for example, the price of a motor car, there exists a price and a quantum for each qualitative dimension, the products for which when summed give the automobile price. We recognise immediately therefore the fundamental idea that quality must in some way be measurable. In the example suggested, such 'qualities' can be represented by perhaps brake horsepower, fuel consumption, length of chrome trim, acceleration, leg room, length and whether the designer was an Italian or not! It is similarly easy to imagine qualitative dimensions for whatever commodity may be of interest. In general terms we may say that the price P of a commodity x is the linear sum of the prices, β, of the qualities, times the quantities of each quality Y pertaining to x, i.e.

$$P(x) = \beta_1 Y_1 + \beta_2 Y_2 + \ldots\ldots \beta_n Y_n \qquad (3 : 1)$$

or

$$P(x) = \sum_{i=1}^{n} \beta_i Y_i \qquad (3 : 2)$$

The problem of measurement resolves to that of identifying a set of unknown parameters representing quality prices, from a knowledge of the commodity price and dimensions of its quality.

It is well known that estimates for the β's are given by an ordinary least squares solution of the set of equations in x and y for a sample of data on the x's. A regression therefore of commodity prices on quality dimensions for a commodity with some quality variation over the chosen sample, is the basic methodology employed in hedonic measurements.

From the Department of the Environment data it was possible to derive the following qualitative dimensions of second hand housing:

(i) Type: terraced (either end terraced or inter-terraced houses detached or semi-detached.

(ii) Bungalow or not as the case may be.

(iii) Urban or rural; as indicative of the town life or the country one.

(iv) Size; here available as the number of bedrooms.[1]

(v) Presence of garage or not as the case may be.

(vi) Age of Dwelling measured as pre 1918=0, 1918=1, 1919=2, etc.

Now it is not suggested that these variables are in any sense comprehensive of housing quality or ideal for what part of quality they do purport to represent. In fact, this thesis is concerned with residential amenity on a larger scale pertaining as it does to neighbourhood environment and accessibility features. Nevertheless for constructing a hedonic index suitable for our purpose these variables will be shown to be adequate. It should be borne in mind

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1 MUSGRAVE (1970) has shown evidence that size measured by square feet is significantly correlated with number of bedrooms. This provides some justification for using bedrooms as a proxy for size in this study where square feet was not an available measure.

however that there are likely to be important qualitative dimensions which are not taken account of, a contingency for which we must provide in the analysis, in order to avoid biased estimates of the quality price parameters.

After experimentation it was established that the appropriate regression equation was given by

$$\bar{P} = \beta_o + \beta_1 Y_1 + \beta_2 Y_2 + \dots \beta_6 Y_6 \qquad (3:3)$$

where

$\bar{P}$ = estimated house price

β_o = the value of a small detached house

Y_1 = presence or not of a garage

Y_2 = age of dwelling

Y_3 = semi-detached or not

Y_4 = end terraced or not

Y_5 = inter terraced or not

Y_6 = largeness (i.e. with more than three bedrooms)

In order to make a suitable choice for the structure of the regression equation, the criterion of goodness of fit, or R^2, was chosen. Essentially we are interested in predicting as efficiently as possible the value of the dependent variable, expected house price. This represents our price index and is the linear sum of the independent variables times their coefficients. We require therefore as a test a statistic which examines the residual variance of this linear sum, such as R^2. The question of the 'significance' of individual variables, as opposed to their joint significance, raises a more difficult problem. While we are primarily interested in the estimate of price we should not necessarily attempt to improve the R^2 by including variables which are not significant at some level. This is possible only if there is strong a priori belief in the relevance of particular variables which may be statistically insignificant as a result of multi-colinearity or the omission of important variables.[1]

In the event it transpired that remarkably little multi-colinearity existed. As a result those variables which were not consistently significant at the 20% level were excluded. It is doubtful either if the variables concerned, urban/rural quality and bungalow quality, could be justified on strong a priori grounds alone. The remaining variables were almost exclusively significant at levels lower than 5% and on occasions lower than 2%, except as is evident from Table 3.2 for the years 1963, 64 and 1965 when the variable for garage was not significant at the 20% level. The procedure here, rather than to exclude garage altogether, was to regard its coefficient for those years as unknown. It is reasonable to suppose that on these occasions the information contained in the sample was inadequate for revealing the estimate for garage quality price rather than that garages were sometimes a relevant dimension of housing and sometimes not.

Improvements in the goodness of fit were made possible by excluding those observations which exhibited relatively high residuals. Such disparities between actual and expected price would be expected if the influence of other variables not included in the data was not constant over the sample. By excluding observations with relatively high residuals it was felt a sample would be obtained for which external influences were more constant.

It remains to consider the choice of an appropriate index number formula. A widely used procedure is to take both Laspeyres and Paasche formula and their geometric mean (Fisher's Ideal). An ideal index formula would be one which gave a unique expression for the general movement of prices and quantities and was interpretable in some utility or welfare sense.

Unfortunately it is extremely difficult to identify from empirical information an individual's utility function. Moreover interpersonal

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1 COWLING and CUBBIN (1972) take the view that as predicted values of the dependent variable are more stable in the presence of multi-colinearity (if it is constant over time) than individual coefficients and as we are interested more in the predicted value of the dependent variable, then variables whose significance is 'obscured' by multi-colinearity may be included, thus improving R^2, without jeopardizing the relevance of the estimated index for price.

TABLE 3.2.

Price - Quality Relationships for Housing in the Nottingham Metropolitan and District Area, 1961-1970

Dependent Variable : Price

Coefficients and (t values)

Year	Constant	Garage	Age	Semi-Detached	End Terrace	Inter-Terrace	Size Large or Small	R^2	$\bar{R}^2$	F	Degrees of Freedom
1961	2453 (11.18)	-348 (1.83)	8.48 (1.41)	-604.77 (2.94)	-1228.58 (3.61)	-1293.58 (4.72)	2007.62 (7.72)	.902	.875	33.67	6, 22
1962	2726 (15.27)	-496.48 (2.36)	15.28 (3.58)	-915.56 (6.63)	-1926.76 (4.59)	-1796.76 (7.29)	2991.26 (9.64)	.911	.895	56.37	6, 33
1963	2736 (17.05)	*	5.8 (1.5)	-656.87 (4.6)	-2196.14 (7.23)	-1648.49 (9.14)	1770.98 (4.63)	.849	.831	46.13	5, 41
1964	2803 (18.16)	*	18.53 (5.19)	-877.35 (8.11)	-1508.92 (6.33)	-1758.88 (7.58)/	2044.07 (7.43)	.832	.821	75.99	5, 77
1965	2886 (26.97)	*	16.72 (6.65)	-639.66 (6.78)	-1206.66 (5.03)	-1688.31 (12.54)	2595.88 (10.91)	.873	.866	127.78	5, 93
1966	3087 (30.47)	110.22 (1.40)	13.84 (6.48)	-656.35 (8.39)	-1179.64 (5.37)	-1915.25 (13.9)	2597.01 (12.31)	.851	.844	130.17	6, 137
1967	3256 (30.72)	247.38 (3.36)/	17.29 (7.44)	-861.98 (10.92)/	-1875.03 (10.59)	-1905.68 (13.91)	2060.62 (12.15)	.884	.879	183.9	6, 144
1968	3475 (28.76)	479.05 (4.17)	14.37 (5.67)	-912.09 (9.59)	-1301.34 (6.38)	-1789.18 (11.70)	3012.99 (12.88)	.891	.883	112.26	6, 82
1969	3240 (18.95)	739.31 (6.65)	22.06 (6.91)	-868.71 (7.46)	*	-1358.34 (7.02)	4093.17 (15.15)	.918	.913	191.88	5, 86
1970	3786 (34.44)	585.62 (6.96	10.42 (5.2)	-934.58 (12.0)	-1371.23 (7.9)/	-1774.39 (11.88)	2699.7 (11.62)	.835	.829	145.66	6, 172

* Coefficient Unknown

/ Median Value

comparisons of utility cannot be made in a unique manner. Traditional index formulae are therefore interpreted in some pragmatic and operational, although essentially arbitrary sense.

The Laspeyres index takes fixed weights chosen from a 'representative' year as the basis for comparison. In a dynamic context with rapid change in technology, tastes and consumer behaviour this has obvious disadvantages. The Paasche index on the other hand while it takes current weights for each year, understates price changes at a time of rising prices, unlike Laspeyres which exaggerates such changes.

Formulae have been devised which satisfy certain arbitrarily chosen statistical tests. An example is provided by Fisher's Ideal index. One such test is the time reversal test where the ratio of an index for time period 1 to one for period 2 multiplied by the ratio of indices for period 2 to period 1, should be unity. Another much used test is the factor reversal test which requires that the product of a price index (with quantity weights) and its quantity counterpart (with price weights) should produce an index of total value, i.e. If $P_1Q_1/P_2Q_2 = V$ then should $P_{1,2}Q_{1,2} = V$ where P refers to prices, Q to quantities and V to value.

Of the formula mentioned so far only Fisher's Ideal satisfies these tests. It has been shown however, JAZAIRI (1972), that any pair of conventional indices can be adjusted by a correction factor such that their geometric mean is an index satisfying the factor reversal test. The Fisher Ideal index is by no means unique. It was pointed out by FRISCH (1936) that a unique index can only exist if it is the solution to a set of interdependent equations in prices and quantities. Such an interdependence is not implied by the indices mentioned so far.

An index which is represented by the solution to such a set of equations and the necessary conditions for such a solution to exist have been demonstrated by KHAMIS (1972) and GEARY (1958). While it has not been demonstrated by what way, if any, this index may be related to utility, it does have certain attractive properties. The index I_t is given by the following relation;

$$I_t = \alpha e_t^{-1} \qquad (3:4)$$

where, α is a factor of proportionality and e_t is proportional to the purchasing power of money with,

$$e_t = \sum_i^n p_i q_{it} \Big/ \sum_i^n p_{it} q_{it}$$

$$(t = 1,2, \ldots m) \qquad (3:5)$$

and

$$p_i = \sum_t^m e_t p_{it} q_{it} \Big/ \sum_t^m q_{it}$$

$$(i = 1,2, \ldots n) \qquad (3:6)$$

These equations for n commodities and t time periods define an average commodity price p_i and a purchasing power factor e_t. The m+n equations are not independent and have

> "a unique and positive solution if and only if the set of n commodity flows cannot be split into two or more disjoint subsets of flows no pair of which has a commodity with positive quantity (q_{it}) in common" KHAMIS, (1972)

An advantage of this index is that the price level need not be defined for any one period,

> "thus avoiding problems of dimensional analysis associated with other techniques which are based on the arbitrary definition of a composite price or composite quantity unit for the complex of commodities comprising the flows whose solution will at best require an arbitrary choice of weighting coefficients" KHAMIS, (1972).

Another advantage follows from a property of the conditions for a unique solution whereby there need only be one year for which there is a positive quantum for a particular commodity. This allows the introduction of new commodities or qualities to be made without a reappraisal of indices for previous years where no such commodity existed.

The index is also useful in that there is no inherent reason why an ideal index should be the geometric mean of the product of a pair of conventional indices. The Khamis index need not lie between Laspeyres and Paasche, as must Fisher's Ideal, yet it still satisfies the usual arbitrary tests.

Moreover the index can be constructed over space, time and commodities without having to choose a particular location in space as a basis for comparison. This property is particularly useful for commodities like housing where there is a significant degree of regional variation in prices.

All the index formula mentioned so far were in fact utilized to construct a hedonic price index for Nottingham houses. The prices used were the coefficients for the quality variables and the weights the proportion of each qualitative characteristic in the sample. Table 3 shows the formula relevant to each index with prices (the β coefficients) represented by P and with quantity weights (the y's of the regression equation) represented by q. The subscripts t refers to time and it is understood that the index is summed over all commodities (qualities)

TABLE 3.3. Index Formulae

Index (I_t) t = 1961-1970	Formula
Laspeyres (chained)	$I_t/I_{t-1} = \dfrac{P_t Q_{t-1}}{P_{t-1} Q_{t-1}}$
Paasche (chained)	$I_t/I_{t-1} = \dfrac{P_t Q_t}{P_{t-1} Q_t}$
Khamis	$I_t = \alpha \dfrac{1}{e_t}$
Champerknowne	$I_t = \bar{P}_t / \overset{*}{P} Q_t$ where $\overset{*}{P}$ is the median price for each quality over the time period 1961-70 and $\bar{P}_t$ is the crude index of average price at time t.

The Champerknowne index has been suggested, COWLING and CUBBIN (1972) as an alternative hedonic index where shadow quality prices do not vary from year to year but are fixed at their median value. This is justifiable in so far as the quality prices are given by sample estimates of the true but unknown prices. The variation of these estimates in the short run might be expected to be unrelated to any structural price change for quality. The variance of the index can be reduced by taking the median shadow price as the estimate for each year. This index would tend to underestimate price changes due to long run changes in tastes and preferences for quality (see Table 3.4)

TABLE 3.4. The Indices, 1961-1970
1961=100

Price Indices

LASP.	PSCH.	FSHR.	KHMS.	CHMP.	Crude	Year
100	100	100	100	100	100	1961
111.1	110.9	111.9	113.0	111.4	109.5	1962
104.8	109.1	106.9	108.4	108.5	90.4	1963
114.5	125.5	119.9	122.9	118.6	121.2	1964
121.9	133.6	127.6	129.3	124.5	120.8	1965
125.7	137.7	131.6	134.0	127.8	133.0	1966
133.2	145.1	139.0	140.9	133.3	138.4	1967
146.0	154.7	150.3	151.5	141.7	151.4	1968
152.5	165.1	158.7	165.4	153.7	161.8	1969
153.3	164.0	158.5	165.1	152.0	173.9	1970

Quality Indices

Quality Indices are derived quite simply by dividing a conventional price index (not adjusted for quality) by a hedonic quality adjusted index. Quality indices show therefore the movement of quality itself over the period concerned. In the examples illustrated below a crude price index of average prices has been divided by the Fisher and Khamis indices.

FSHR.	KHMS.	Year
100	100	1961
98.9	96.9	1962
84.7	83.4	1963
101.1	98.6	1964
94.6	93.4	1965
101.1	99.3	1966
99.5	98.2	1967
100.7	99.9	1968
101.9	97.8	1969
109.7	105.3	1970

It is clear from the indices illustrated in Table 3.4 that a crude price index is quite inadequate for describing the movement of prices in the presence of quality change. This is especially so for the years 1962, 1963, 1965 and 1970 when qualitative changes were most prominent. Further analysis of the sensitivity of the quality indices to particular items of quality and their variations would be of interest. For the purpose of this study however, the deflation of all prices to the 1968 level by the Khamis hedonic price index, is all that is required.

CHAPTER FOUR

The Statistical Methodology

"A comparison of the facts of consumer behaviour with a theory purporting to describe them can only be made on the basis of some statistical model held either implicitly or explicitly."

Prais and Houthakker. The Analysis of Family Budgets C.U.P. 1971 (2nd edition)

4.1. Introduction

The econometric analysis required in this study should be such that it is possible to identify and evaluate residential goods, characteristics and their prices, along with estimates of the relationship between residential consumption and household socio-economic criteria. This chapter illustrates the statistical methodology utilized to accommodate these requirements.

The expenditure that a household makes for its location has been assumed to represent an outlay for a bundle of residential goods. In more precise terms we may say that the rental outlay for the i^{th} location, $f(r_i)$ is given by the expression

$$f(r_i) = \sum_{i=1}^{n} q_i z_i \qquad (4:1)$$

where q_i is the i^{th} price of z_i the i^{th} residential good. The first objective is to derive estimates of the q_i prices from information concerning total rental expenditure represented by house prices. The method which will be used to derive these prices is based upon the hedonic price measurement technique discussed in Chapter 3.

It will be recalled that in essence this technique determines expenditure on the residential bundle of goods as the linear sum of the estimated price times quantities for each item in the bundle. Given that the house prices represent residential expenditure then an unbiased estimate of house price can be obtained by an ordinary least squares solution to the regression of house price on the residential goods as independent variables.

The coefficients estimated for each independent variable show the marginal contribution of that variable to house price and may be interpreted as residential goods' prices.

Unfortunately in practice the situation is not so simple. In the first place it is quite likely that residential goods will be interrelated and interdependent. For example the density of an area may be related to the size and type of dwellings and the existence of panoramic view may be related to the quantity of open space. When variables in a relation are multicolinear and not independent of each other then parameter estimates may be indeterminate.[1]

In the second place following the discussion of Chapter 2 there is a priori reason to believe that residential 'characteristics' rather than goods are of greater significance for households. In fact this notion is useful in connection with the first problem for if it is possible to obtain linear combinations of the original 'residential goods' variables, representing <u>independent</u> characteristics, then the estimation procedure will avoid the problem of multicolinearity.

For these reasons we require an estimation procedure which will provide a statistical description of the structure of data of residential goods such that this structure is reconcilable with the consumption technological, goods-characteristics relationships of Chapter 2. The work of KAIN and QUIGLEY (1970) already referred to, is notable in that such a technique was used to examine the influence of physical and environmental attributes of residential neighbourhoods upon house prices. While their work was not concerned with providing a statistical analogue for any theory of residential location, it is instructive in the attempt made to use a 'factor analysis', a technique which will form the basis for this present study.[2]

4.2. <u>Factor Analysis and Goods - Characteristics relationships</u>

Factor analysis is a multivariate technique which describes a

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1 See JOHNSTON (1963) p.201-207 for a discussion of this problem.

2 A recent paper by WILKINSON (1973) similar in intent to my own work and utilizing a principal component analysis is discussed in an appendix to this chapter.

set of n variables in terms of a linear combination of m variables, where the m subset is smaller in number than the original variable set. As such it gives a more concise statistical description of the data. As only the n variables are actually observable the inference problem posed by a factor analysis is that of interpreting the m set of new variables (factors) in some meaningful way. In the present case it is hoped that such factors may be regarded as residential characteristics of some sort. The factors can be organized such that they are orthogonal to one another i.e. so that they are independent. With such factors (characteristics) as the independent variables in a regression model, with house price as the dependent variable, coefficients for each factor, which correspond to the w price vector of characteristics in the utility model of Chapter 2, may be obtained by least squares.

The factor analysis model itself corresponds to equation (2:12) with the addition of a stochastic term.
Thus

$$z = Ay + e \qquad (4:2)$$

where A is now a factor loading matrix of order n x m, $n > m$; y is a vector of orthogonal factors and e a stochastic vector of order n. The distributions of y and e are given as

$$y \sim N(o, I), \; e \sim N(o, \Delta) \qquad (4:3)$$

and the population variance-covariance matrix, Σ is given by

$$\Sigma = AA' + \Delta \qquad (4:4)$$

where Δ is the diagonal matrix in the diagonal entries of δ_i (i = 1,2,...n) representing the residual variances. When C is the observed variance-covariance matrix then in general it can be shown[1] that Maximum Likelihood estimates of A and Δ satisfy

$$\text{diag}\,(C - \Sigma) = o \qquad (4:5)$$

1 Readers interested in proofs are referred to KENDALL and STUART vol. III (1966) and LAWLEY and MAXWELL (1963).

and

$$\Sigma^{-1}A = C^{-1}A \qquad (4:6)$$

when

$$\Sigma = AA' + \Delta \qquad (4:7)$$

If the observed matrix is based upon N observations then for large N the criterion of -2 log λ, where λ is the ratio of the maximum of the likelihood given the hypotheses to the maximum in the unrestricted case, will be distributed as χ^2 on $[(p - m)^2 - (p + m)]/2$ degrees of freedom, if the null hypothesis that the m factors do explain the variability of the data for p variables, is observed, (LAWLEY and MAXWELL, (1963) p.23).

In order to estimate scores, or measurements of each factor, we use functions of the p variates, z_i with desirable properties. Clearly as the number of hypothetical variates, the m factors y and the p residuals e exceeds the number of observed variates z_i we cannot estimate the values of the m factors directly. However a least squares solution following BARTLETT (1938) can be used where the estimated factors are given by

$$\hat{y} = (A'\Delta^{-1}A)^{-1} A'\Delta^{-1} z \qquad (4:8)$$

Shadow prices for these characteristics can then be obtained by a least squares solution to the regression of house price on the estimated factor scores given by the diagonal matrix $\hat{y}$ for each house.

A rationalization of the factor analysis approach is that while the p variables z_i are expressed in terms of p + m variables which are not directly observable, a hypothesis concerning the variance-covariance of the z_i can be tested. These are assumed to be a linear sum of a diagonal matrix with positive elements and a matrix of rank m with positive latent roots. The value of m, the number of factors must be assigned in advance. From a sample set of z_i and information about the observed variance-covariance matrix a likelihood function may be expressed in terms of these and the population parameters. Maximization of the likelihood with respect to the unknown parameters will yield estimates of them. Further a χ^2 test is available for testing the null hypothesis that the true but unknown variance-covariance matrix is expressed by the linear combination of variables posited for the given number of factors.

It is well known, LAWLEY (1940), that while the Maximum Likelihood method provides a unique set of estimates for Δ, it does not uniquely determine the y factors. In fact there is an infinite set of possible orthogonal transforms of the factors satisfying the likelihood equations. It is up to the analyst to make a judicious and reasoned assessment of what will be essentially an arbitrary choice of factors at the level of statistical abstraction. Failure to interpret the factors in some meaningful way does not however invalidate the method. While it is useful to be able to identify factors which conform with some a priori notion of what housing might be in the mind of the consumer, it is possible that the variability of the data on the housing stock does not lend itself to ready interpretation. Factors which are linear combinations of the variables can still however be related to house prices in a regression analysis. Further the reduction of the dimensionality of this analysis from p to m variables is in itself a most useful result. It is not likely though that the inference problem of factor analysis will be intractable given that the structure of variables pertaining to the housing stock reflect past and present locational preferences of households.

4.3. Estimation procedures for Engels relations

In order to estimate the relationship between household income and residential expenditure both in total and for the separate residential characteristics it is necessary to ensure that

> "the measurement is not confounded by the effects of household composition which are often correlated with household incomes."
> BROWN (1954)

In point of fact there are two separate problems. Firstly the problem of possible linear correlation of the variables describing household characteristics and secondly the problem of non-linearity of the parameters of the relation between consumption and the household variables.

There are three alternative approaches to these problems. The first approach is that proposed by SYDENSTRICKER and KING (1921) and discussed at some length by PRAIS and HOUTHAKKER (1971). Briefly, this approach measures household expenditure per equivalent adult, using a specific equivalence scale which is different for each commodity. Household expenditure is then given as a function of the amount of household income per equivalent adult, using an equivalence scale which is the weighted average of the specific scales. Household standards of living are thus determined by both household income and household composition. In order to distinguish explicitly the two effects in practice, estimates of the specific equivalence scales are required. An iterative procedure for obtaining non linear forms of the relation by means of Probit Analysis is illustrated in PRAIS and HOUTHAKKER (1971), p.134-139.

The second approach derives from the paper by BROWN (1954) and provides a method of estimating income elasticities of demand, independently of the effects of household composition, without prior information on equivalent adult scales. This is achieved simply by classifying household into compositional groups, ordered by income within groups and estimating the income elasticity for each group separately. Consider for example the double-logarithmic form of the Engels relation $\log y_i = \alpha_i + \beta \log \mu$,

where y_i is consumption of the i^{th} residential characteristic, m is household income and α and β are parameters to be estimated. Taking into account specific equivalence scales we say that

$$y_i / \sum_j b_{ij} n_j = \alpha_i ({}^m/ \sum_j a_j n_j) \beta_i \qquad (4 : 9)$$

where

b_{ij} are coefficients depending on the i^{th} commodity and the j^{th} age-sex compositional group

n_j are the number of persons in the j^{th} age-sex group

and

a_j are coefficients depending only on the j^{th} age-sex group.

In linear form equation (4 : 9) may be written

$$\log y_i = \left[\log \alpha_i + \log \sum_j b_{ij} n_j - \beta_i \log \sum_j a_j n_j \right] + \beta_i \log \mu \qquad (4 : 10)$$

From equation (4 : 10) it is seen that the term outside the brackets on the right hand side, the income elasticity coefficient, is given independently of the household compositional influences. For each household compositional classification such Engels functions can be measured, the difference between each function being confined to the values of the intercepts; that is the functions should be a set of parallel lines.[1]

It will be noted that for this approach to be successful correlation of the household variables should be small. In the event that it is not then it will be difficult to construct groupings within which household variables are constant while income is variable. The problem which BROWN considers really concerns the question of the general but unknown functional relations between household variables rather than the problem of correlation in the linear form.

His approach is obviously useful where the prime objective is to secure a measure of income elasticity of demand[2] without necessarily investigating functional relationship of the independent variables.

A third approach is suggested by factor analysis. If the estimation problem is one of multicolinearity of the set of socio-economic variables describing households; then factors representing orthogonal linear combinations of these variables, rather than the variables themselves can be related to expenditure. While this approach avoids the estimation problem of multicolinearity it does not provide parameter estimates of the effects of the individual socio-economic variables. However in so far as household consumption decisions are seldom made on the basis of any single criterion alone but rather on the basis of several criteria together, this is not a serious drawback. Furthermore in the case of housing it is possible that both the nature and extent of residential expenditure will be determined by household size, age, sex, and income in an interactive manner, unsuitable for explicit identification of any one variables effect, yet which is in itself of interest.

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1 As each classification should yield an unbiased estimator of β_i, a hypothesis can be tested concerning the covariance of the set of estimated β_i's. If the null hypothesis, that no significant differences exist between β_i's, can be accepted then the mean value of β_i can be derived without any recourse to measurement of compositional effects.

2 The technique can however be used also to estimate equivalence scales see BROWN (1954) and DEATON and BROWN (1972).

This approach works by first estimating the factor loading matrix of the set of household socio-economic variables.[1] Secondly factor scores may be computed for each individual household, these scores being the determining variables in a regression with households' expenditure for each residential characteristic in turn, as the dependent variable.

In essence the view taken is that any multicolinearity is not so much an obstacle for the estimation of parameters as representative of the underlying forces which together determine household consumption. Indeed the interdependence of household variables serves to provide variables (factors) which might represent in some sense the behavioural determinants of residential choice.[2]

This approach has two main advantages over the alternatives suggested. In the first place the notion of specific equivalence scales, is not explicitly required yet factors representing the interdependent existence of household variables could be derived. Secondly, in utilizing relevant information on household socio-economic characteristics there is no necessity to hold constant any variables so as to obtain parameter estimates of others.

However, in handling the problem of multicolinearity the approach of factor analysis raises the separate problem of 'errors in variables'. This problem arises whenever errors affect the measurement of independent variables. In such cases, it is well known that regression analysis does not provide consistent parameter estimates as the independent variables are not distributed independently of the error terms (KENDALL and STUART, p.377). In the regression of factor scores for residential attributes on factor scores for household attributes, the variables represent estimates of the true but unknown variables, whose functional relation we wish to parameterize.

Without information or 'a priori' assumptions concerning the error variances, estimates of the parameters cannot be obtained. However the least squares method of estimating the factor scores provides estimates of the residuals and their variances. This information might be used

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1 These 'variables' can be, the income, asset worth, social class, and number of persons in each age/sex group defined.

2 Multicolinearity may not be present in which case the possibility of using ordinary least squares to estimate individual parameters, exists. In the absence of multicolinearity of course, a factor structure is unlikely to exist. This was in fact the case for this study.

to provide therefore, maximum likelihood estimates of the parameters.

4.4. APPENDIX

House Prices and the Measurement of Externalities : A Comment

In a recent article in the Economic Journal, R.K. Wilkinson provided by means of a 'factor analysis',

> "an approach to the explanation of the price structure of a set of dwellings and to the assessment of the effect of specific environmental attributes on the structure of house prices." 1

It is the purpose of this note to comment on both the theoretical foundation and statistical methodology employed in Wilkinson's paper and to suggest possible alternatives. The fundamental assumption of Wilkinson's paper that the prices of a given stock of dwellings can be said to reflect the relative desirability of those dwellings to consumers, is not questioned.

In postulating that the price structure of houses reflects the influence of dwelling and locational attributes which may be grouped into a herarchy of residential services Wilkinson utilizes a utility function of the form

$$U = f\,[\,V, (x, x_2 \ldots x_\alpha), V_2\,(x_{\alpha+1} \ldots x_3) \ldots]$$

where the x's represent individual attributes and the V's represent service groups. Such functions, which imply that the marginal rate of substitution between any two attributes within a group is independent of the quantity of any attribute outside the group, are generally employed to illustrate the situation where consumers first allocate sums of money to the separate groups before allocating expenditure within groups. Further it is clear that consumers are supposed to derive their utility directly from the bundle of residential attributes, rather than from any residential services or wants that they satisfy.

There are two points to be made here. Firstly if residential consumers do behave in the manner suggested then a factor analysis is not the appropriate statistical analogue of such behaviour as described here. This is so quite simply because the values of the attributes, the variables in a Factor Analysis, are 'explained' in

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1 Economic Journal, March 1973, pps. 72-86.

terms of <u>all</u> the Factors, while the V's in the Utility function are functions of exclusive subsets of the variables. Of course this is not to say that separability of the variables cannot exist. In the event that zero loading of variables on certain factors are observed it may be possible to observe separability. This is not the case however in Wilkinson's analysis of fourteen variables and it is unnecessary to assume that it will be the case in general. The confusion may arise as a result of the interpretation of the factors,

> "Each factor may be defined as a linear combination of all the variables analysed but mainly comprises those variables on which it loads most strongly"
>
> (WILKINSON, p.78)

Strictly speaking it is the other way around with the variables being explained by all factors, which together are smaller in number than the original variables set, without any inverse existing. Only in principal components analysis where it is desired to find a linear combination of the elements of x having maximal variance can the problem be expressed in this way. Secondly it would appear a priori more reasonable to suppose that "

> "both the market and individual households evaluate residential quality in terms of fewer broader aggregates" 1

than the individual attributes separately considered. By this it is meant that households, rather than having a sharp awareness of the individual residential attributes, form an aggregate perception of their residential environment in terms of say its physical, aesthetic and accessibility characteristics. This would suggest that utility is not directly obtained from attributes but from the characteristics.

A theoretical formulation which describes such behaviour and is consistent with a Factor analysis can be illustrated by considering the utility function

$$U = U[(w),(\alpha)], \quad (w = w, w_2 \ldots w_m), \ \alpha \text{ is a scalar quantity}$$

where w represents a vector of residential characteristics, and the consumers' budget constraint,[2]

---

1 KAIN and QUIGLEY (1970)

2 It is assumed that expenditure upon non-residential goods is separable from residential expenditure. There is no need to assume that residential expenditure itself is separable.

$$M - \alpha = p'x$$

where M is money income, α is non-residential expenditure and p' a vector of prices corresponding to x a vector of residential goods. Money is spent on goods but utility is derived from characteristics.[1] The relationship between goods and characteristics may be described as

$$x = Aw$$

where A is a matrix of order n x m, m $<$ n. This relationship, which provides the means of reconciling utility with money spent, corresponds to the statistical model of factor analysis, with the addition of a stochastic term,

$$x = \Lambda f + u$$

where f and u are mutually independent m and n dimensional random variables respectively, distributed as

$$f \sim N(0,I) \quad u \sim N(0,\Delta)$$

and Λ is a matrix of constants (factor loadings) of order n x m. Σ is the population variance-covariance matrix and is given by

$$\Sigma = \Lambda\Lambda' + \Delta$$

where Δ is the diagonal matrix in the diagonal entries of δ_i (i=1,2,...n) representing the residual variances. When C is the observed variance-covariance matrix then in general it can be shown (KENDALL and STUART (1966), LAWLEY and MAXWELL (1963)) that Maximum Likelihood estimates of Λ and Δ satisfy

$$\text{diag}\ (C - \Sigma) = 0$$

and $$\Sigma^{-1}\Lambda = C^{-1}\Lambda$$

1 This is Lancaster's approach to consumer theory given its most recent exposition in LANCASTER (1972).

when $\Sigma = \Lambda\Lambda' + \Delta$

Least squares estimates of the f's, which may be interpreted as the w residential characteristics, are given by

$$\hat{f} = (\Delta'\Delta^{-1}\Lambda)^{-1}\Lambda'\Delta^{-1}x$$

Shadow prices of the residential characteristics are obtained by a least squares solution to the regression of house price (the px's) on the estimated residential characteristics (the f's), given above.

It is interesting to note that the procedure adopted by Wilkinson for estimating the matrix of factor loadings was that of 'principal components' rather than factor analysis as described above. It is not an uncommon mistake for these procedures to be called by the same name but it is an unfortunate one. The two procedures are not designed for the same purpose and can give quite different results as will be shown below.[1] At best the principal components method is that procedure which gives a maximum likelihood solution for the factors restricted to the case where the residual variance of the variables are assumed to be equal.[2] In so far as this is an unnecessary restriction the Full Maximum Likelihood method is to be preferred. In order to illustrate the operational significance of the different approaches the correlation matrix for Wilkinson's 14 variable case was used as input for a Full Maximum Likelihood factor analysis. The results for the rotated factor loadings which demonstrate different results from his case are given below in Table One, Wilkinson's corresponding Table being reprinted for convenience.

The first observation to make on comparing the F.M.L. solution with the P.C. solution is that the former provides factors which are easier to interpret than the latter. Factor One is seen to be a 'size' factor. It is quite similar to Factor Two of the P.C.

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1 The Principal Components model of Factor Analysis is given by Harman as

$$x_i = \sum_i \alpha_i f_i \quad (i = 1,2,\ldots n)$$

the Classical Factor Analysis model is given by $x_i = \sum_j \alpha_j f_j + u_i$

$(i = 1,2,\ldots n)\ (j = 1,2,\ldots m)$

(see HARMAN (1967) pp.15-18).

2 See DHRYMES (1970) pp.80-82 for an illustration of this relation between principal component and restricted maximum likelihood factor analysis. For a useful reference to the essential differences of the two methods see RAO (1955).

TABLE ONE F.M.L. Factor Analysis of Fourteen Variables, Four Factor Case

Maximum Likelihood Solution

Variable	Factor Loadings 1	2	3	4	Communality	Uniquity
1 House Type	0.19213	0.57153 *	-0.00042	0.57491 *	0.694159	0.305841
2 Construction Date	-0.11590	0.40295	-0.10784	0.69524 *	0.670794	0.329206
3 Soc.-Econ.Class	-0.14826	-0.78540 *	-0.02292	-0.14762	0.661146	0.338854
4 Gr.Res.Density	0.18315	0.76458 *	0.00243	0.22516	0.668958	0.331042
5 Distance, centre	0.07106	-0.62860 *	0.03112	-0.36507	0.534656	0.465344
6 No. Rms	-0.88737 *	-0.16319	-0.14519	-0.30514	0.928254	0.071746
7 No. Bdrms.	-0.77922 *	-0.16361	-0.13810	-0.32714	0.760043	0.239957
8 Garage	-0.32677	-0.18967	-0.81078 *	-0.18117	0.833050	0.166950
9 Garage Space	-0.15931	0.26057	-0.78508 *	0.38169	0.855322	0.144678
10 Dwelling Area	-0.68106 *	-0.18841	-0.13692	0.14697	0.539688	0.460312
11 Fixed Bath	-0.15676	-0.30072	0.03975	-0.25123	0.179703	0.820297
12 Inside Toilet	-0.16993	-0.32637	0.04757	-0.39981	0.297500	0.702500
13 No. Attics	0.12230	0.22587	0.00997	0.73614 *	0.608417	0.391583
14 Schools Ratio	0.23391	-0.06433	0.12225	-0.18124	0.106645	0.893355
Proportion Variance	15.89045	18.07465	0.74801	15.84643	59.55954	

Principal Components Factor Analysis of Fourteen Variables (reprinted from WILINSON p.77)

	Variables	Rotated factor loadings				Communality
		F_1	F_2	F_3	F_4	
x_1	House type	-0.6953	-0.2883	-0.2657	0.2518	0.7005
x_2	Construction Date	-0.6346	0.0280	-0.2626	0.4803 *	0.7032
x_3	Socio-economic class	0.8505	0.1674	0.0218	0.1450	0.7729
x_4	Gross residential	-0.8209	-0.1677	-0.2393	-0.1780	0.7909
x_5	Distance from city centre	0.7297	0.0039	0.1231	-0.3034	0.6397
x_6	No. of rooms	0.2029	0.8249	0.2851	0.0185	0.8032
x_7	No. of bedrooms	0.2104	0.7969	0.2224	-0.0919	0.7372
x_8	Garage	0.1446	0.8065	-0.1715	-0.0206	0.7013
x_9	Garage space	-0.4137	0.5233	-0.4277 *	0.2376	0.6844
x_{10}	Area of dwelling	0.0187	0.6553	0.2453	0.3620 *	0.6210
x_{11}	Fixed bath	0.1453	0.1140	0.8148	0.0110	0.6982
x_{12}	Inside toilet	0.2505	0.1652	0.7621	-0.1518	0.6939
x_{13}	No. of attics	-0.4879 *	-0.2591	-0.1861	0.5207	0.6109
x_{14}	Schools ratio	-0.0125	-0.1390	0.0316	0.7293	0.5524
	Eigenvalues	3.4157	2.9359	1.8961	1.4618	9.7095
	% total variance	24.40	20.97	13.54	10.44	69.35

solution with the omission of garage and garage space. This is convenient in that it is more likely that 'garageness' is not a dimension of size or of the dwelling so much as one of mobility. Factor Two of the F.M.I. solution, is quite clearly a locational factor with a ready interpretation in that as distance from the centre increases, households become increasingly of a higher socio-economic class living in lower density suburbs. This is perhaps characteristic of most British towns and cities.

The third factor, (F.M.L.) is indicative of some notion of 'garageness' reflecting perhaps the need for mobility. It is notable that this factor is not a locational one as it is not highly correlated with distance from the city centre. This would suggest that the desire for mobility is not necessarily stronger in a suburban context, where 'accessibility' might be thought to be least. The fourth factor (F.M.L.) can be related to the Type and Age of the housing stock. This is reasonable in that older houses are seen to be of a type, usually terraced, which have attics and more modern houses, usually semi-detached or detached are of a type which do not.[1]

It is apparent that Factors 4 and 2 of the F.M.L. solution are similar to Factor 1 of the P.C. solution, while Factors 1 and 3 (F.M.L.), are similar to Factor 2 (P.C.). In both cases it would appear easier to rationalise the F.M.L. solution, in terms of meaningful dimensions of the housing stock. In the F.M.L. solution no equivalent Factors to 3 and 4 of the P.C. solution are derived. In the case of 'Fixed Bath' and 'Inside Toilet' both variables load on the locational and type/age factors. This is not unreasonable. Given the signs of these loadings we expect suburban houses to be newer and to have fixed baths and inside toilets.

Table Two, shown below, illustrates the F.M.L. solution for five factors while Tables Three and Four, respectively illustrate the R.M.L. (restricted maximum likelihood) solution for the four factor and the F.M.L. solution for the six factor case. Table Three thus represents the P.C. solution where the condition of equal residual variance is imposed, i.e.

$$\Delta = \sigma^2 I$$

1 Wilkinson had intended 'no. of attics' to be a measure of dwelling characteristics rather than as a dimension of locality as it is in his case, with the then attendant problem of interpretation.

TABLE TWO F.M.L. Factor Analysis of Fourteen Variables Five Factor Case

Maximum Likelihood Solution

Variable	Factor Loadings 1	2	3	4	5	Communality	Uniquity
1 House Type	-0.11437	-0.20382	-0.46543 *	-0.70842 *	0.17727	0.004770	0.195347
2 Construction Date	0.09363	0.04518	-0.36886	-0.57298 *	0.28907	0.558778	0.441250
3 Soci-Econ. Class	0.03047	0.17916	0.82840 *	0.18074	-0.04358	0.754413	0.245869
4 Gr.Res. Density	-0.01748	-0.19865	-0.72219 *	-0.20395	0.27710	0.680460	0.319921
5 Distance, centre	-0.02405	-0.03058	0.58609 *	0.32106	-0.25157	0.511632	0.488492
6 No. Rms.	0.13192	0.91385 *	0.11709	0.20619	-0.17418	0.930885	0.060512
7 No. Bdrms.	0.12453	0.80614 *	0.13170	0.24270	-0.11803	0.756679	0.243882
8 Garage	0.91690 *	0.34097	0.13486	0.14186	-0.06890	0.999976	0.000000
9 Garage space	0.67684 *	0.17941	-0.19745	-0.54231 *	0.11687	0.836705	0.163127
10 Dwelling Area	0.14780	0.63749 *	0.13125	-0.12329	-0.09976	0.470665	0.529362
11 Fixed Bath	0.00740	0.10815	0.16832	0.18124	-0.65184 *	0.482264	0.517766
12 Inside Toilet	-0.00650	0.13061	0.17776	0.25463	-0.74558 *	0.660446	0.330568
13 No. Attics	-0.01672	-0.20261	-0.21624	-0.57502	0.21120	0.463594	0.536535
14 Schools Ratio	-0.09967	-0.22600	0.03240	0.20580	-0.07731	0.110617	0.889497
Proportion Variance	9.91096	16.26277	15.12275	13.52487	9.72104	64.54187	

1 Communalities and uniquities should properly sum to unity. The small discrepancies, none higher than 0.0006, reflect the extent to which the maximum of the likelihood has not yet been reached.

Table Two shows that the Five Factor solution corresponds to the Four Factor F.M.L. solution with the addition of a factor for 'Fixed Bath' and 'Inside Toilet'.

Table Three illustrates a Factor structure which resembles both Wilkinson's solution and the F.M.L. solution of Table One. Factor One combines the Age/Type and Locational Factors, including 'No. of Attics', while the size factor, garage factor and 'Fixed Bath' and 'Inside Toilet' factor make up the other three. An interesting comparison is given by the variability of the 'uniquity' (the elements of Δ) for the F.M.L. solution of Table One and the lack of such variability for the R.M.L. solution of Table Three. The range of variation of the uniquity in the former case is from 0.89 to 0.07 which would suggest that the assumption of constant residual variance in the latter case is not justified.

The six factor case, while being readily interpretable is somewhat different from the other solutions. It is apparent that again a size factor related to the number of rooms and bedrooms exists (no.3) along with a type factor (no.4) and a type locational factor (no.1). This latter factor is most interesting as it reflects that as distance from the centre increases houses become older rather than newer. In fact in Leeds suburban houses do tend to be older than newer redeveloped inner areas of the city. Factors 2, 5 and 6 indicate factors for 'garageness', hygiene and attics/age respectively.

In order to compare the relative performance of the F.M.L. and the R.M.L. solutions for a predetermined number of factors the criterion, $-2 \log . L_R$ can be used where L_R is the ratio of the maximum of the likelihood given the hypotheses to its unrestricted maximum. If the observed matrix is based upon N observations then for large N the criterion will be distributed approximately as χ^2 on $[(p-m)^2 - (p+m)]/2$ degrees of freedom if the null hypothesis that the m factors do explain the variability is observed. Table Five provides values of the criterion for the F.M.L. and R.M.L. solutions.

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TABLE THREE

R.M.L. Principal Component Solution, Factors Analysis, Four Factor Case

	Variable	Component 1	2	3	4	Communality	Uniquity
1	House Type	-0.703185 *	0.311735	-0.199105	0.072803	0.636590	0.426973
2	Construction Date	-0.706986 *	0.022271	-0.197531	0.254664	0.604198	0.426973
3	Socio-Econ. Class	0.685526 *	-0.230653	0.026025	0.082392	0.530612	0.426973
4	Gr.Res.Density	-0.659575 *	0.295253	-0.167742	0.006212	0.550390	0.426973
5	Distance Centre	0.745412 *	0.064101	0.213678	0.057916	0.608761	0.426973
6	No. rooms	0.222407	-0.778278 *	0.167175	0.139874	0.702694	0.426973
7	No. Bdrms.	0.248082	-0.754246 *	0.105188	0.098412	0.651182	0.426973
8	Garage	0.189148	-0.478484	0.021332	0.591424 *	0.614962	0.426973
9	Garage Space	-0.400010	-0.191043	-0.175351	0.652038 *	0.652407	0.426973
10	Dwelling Area	-0.047767	-0.621959 *	0.179728	0.274775	0.496918	0.426973
11	Fixed Bath	0.192887	-0.181583	0.689348 *	-0.055186	0.548423	0.426973
12	Inside Toilet	0.330245	-0.219857	0.630095 *	-0.100202	0.566343	0.426973
13	No. Attics	-0.590390 *	0.258583	-0.097810	0.207987	0.478938	0.426973
14	Schools Ratio	0.261089	0.471762	0.261791	0.138261	0.379953	0.426973
	Proportions	23.851981	17.426957	8.611088	7.109627	57.302652	42.697318

1 The differance between the estimated communality in this case and in Wilkinson's analysis is the result of using differing estimation procedures. In this case the difference between using an R.M.L. procedure and a non-maximum likelihood procedure.

TABLE FOUR

Maximum Likelihood Solution

Variable		Factor Loadings 1	2	3	4
1	House Type	-0.30239 *	-0.00239	-0.24556	-0.70069
2	Construction Date	-0.40072 *	0.12122	0.03350	-0.24105
3	Socio-Econ. Class	0.45408 *	0.01651	0.24052	0.38984
4	Gr.Res.Density	-0.46226 *	-0.00820	-0.25967	-0.31114
5	Distance,Centre	0.95483 *	-0.00322	0.06046	0.10983
6	No. Rooms	0.00831	0.14854	0.89652 *	0.11612
7	No.Bdrms.	0.04825	0.13038	0.81341 *	0.13052
8	Garage	0.02648	0.89978 *	0.31701	0.25636
9	Garage space	-0.20748	0.74027 *	0.13020	-0.33935
10	Dwelling Area	-0.00221	0.15558	0.67825 *	0.08929
11	Fixed Bath	0.10371	-0.00635	0.11722	0.07712
12	Inside Toilet	0.19035	-0.02874	0.16768	0.13868
13	No.Attics	-0.17643	0.00159	-0.17021	-0.16623
14	Schools Ratio	0.32468	-0.10780	-0.19390	0.04007
Proportion Variance		12.95206	10.34571	16.72592	8.58761

Variable	5	6	Communality	Uniquity
1	0.21983	0.34948	0.931626	0.068344
2	0.25371	0.61249 *	0.673916	0.326039
3	-0.13385	-0.12722	0.450437	0.549588
4	0.29706	0.18839	0.501655	0.498304
5	-0.16296	-0.21421	1.000122	0.000000
6	-0.16178	-0.22998	0.918377	0.081600
7	-0.09165	-0.26120	0.774576	0.225402
8	-0.08429	-0.12399	0.998987	0.001010
9	0.15328	0.25772	0.812956	0.186987
10	-0.14859	0.24502	0.574320	0.425680
11	-0.81216 *	-0.06038	0.693826	0.306192
12	-0.62499 *	-0.23746	0.531481	0.468557
13	0.15195	0.78535 *	0.727557	0.272424
14	-0.03222	-0.05521	0.160144	0.839763
Proportion Variance	10.05006	10.98318	69.64454	

TABLE FIVE Values of the Criterion for F.M.L. and R.M.L. solutions of Factor Analysis of 14 Variables (a), (b)

Estimation Procedure \ No. of Factors	4 Factors	5 Factors	6 Factors
F.M.L.	< 0.001% 93.80 (41)	0.1% 60.47 (31)	5% 34 (22)
R.M.L.	< 0.001% 203.89 (54)	< 0.001% 150.69 (44)	< 0.001% 85.86 (35)

(a) Nos. in brackets refer to the degrees of freedom associated with each value of the criterion.

(b) % values are p values for the criterion with the no. of observations = 100.

From Table Five we can evaluate both the performance of the estimating technique and whether the posited number of factors can represent the variability of the data. The F.M.L. procedure is in every case superior having a higher probability of satisfying the null hypothesis than the corresponding R.M.L. procedure. However the null hypothesis is substantially rejected in all cases save that for Six Factors under F.M.L. for which the null hypothesis appears acceptable at about 95 per cent.

While there are differences of interpretation such differences alone do not form a basis for preferring one approach to the other. Even in a F.M.L. approach it is true that the estimate of factor loadings is indeterminate to an orthogonal transform. The choice of a particular transform is essentially subjective depending upon that rotation which the analyst feels conforms most with his a priori expectations.

It must be stressed however that difficulties of interpretation of factors do not necessarily undermine the usefulness of the technique. The problem to which factor analysis addresses itself is that of determining the underlying structure of a data set, particularly by ascertaining new variables (factors), linear combinations of which explain the variance-covariance matrix. In the strict statistical sense any one rotation of the factors is as good as another.

In a utility sense it may be convenient to be able to extract some intuitively reasonable interpretation of the factors. In so far as the structure of the data of the housing stock is likely to reflect past and present preferences of households for residential attributes, it is unlikely that the inference problem of factor analysis will be intractable. However the extent to which factors cannot be interpreted may not be an indicator so much of the 'failure' of the technique as of the level of 'understanding' of the data structure and what it may represent. It is important therefore that the method used to estimate this structure be adequate in the first place.

The F.M.L. method does provide a maximum likelihood estimate of Δ without imposing the restriction of common variance of the residual variance of the variables in the unit of measurement chosen. As such the F.M.L. is 'scale' independent whereas P.C. gives a F.M.L. solution only under conditions where the units of measurement chosen are proportional to the square roots of the true 'uniquities'. This is the crucial difference between the two methods. It would be preferable for authors to make explicit which method is used so that questions of interpretation may be confined to those of an a priori rather than a methodological sort.

CHAPTER FIVE

Calibration and Analysis

5.1. Introduction

This chapter presents the results of the empirical analysis conducted to calibrate and test the residential model outlined in the previous chapter. In 5.2. the maximum likelihood factor analyses are illustrated. Here the data of the residential attributes are described in a parsimonious fashion and interpreted as residential characteristics. The regression analysis of 5.3. illustrates the relationship between house 'price', taken to be house 'value', and the residential characteristics. As such this analysis represents a test of the hypothesis that a goods-characteristics technology is suitable for 'explaining' house price and therefore representative of how households perceive amenity. The coefficients of the individual attributes and the characteristics (factors) with respect to house price are illustrated. These coefficients may be interpreted as 'amenity prices' and show the impact on house price of marginal amenity changes. In 5.4. the analysis of residential expenditure and household socio-economic variables is described while in 5.5. the confirmatory analysis or parallel experiment referred to in Chapter 3 is presented. This latter illustrates by an attitudinal survey of the households in the sample, the amenity preferences of households. While not in itself used to 'measure' amenity, it does provide an independent indication of relative amenity preferences and can usefully be compared with the relative amenity values derived from the regression analysis.

5.2. Factor Analysis and Amenity Characteristics.

The initial analysis was conducted for 28 variables pertaining to the residential attributes of the 114 sample houses. The variables are described in Table 5.1. along with the Factors for the 11 Factor case. In order to obtain the best factor structure consistent both with parsimony and a probable value for the criterion, several analyses were conducted starting initially with the maximum allowable number of factors. The maximum allowable number is simply that number of factors, in which for p variables gives degrees of freedom, $(p-m)^2 - (p + m) / 2 \not> 1$. The procedure is then to compare the probability value for the criterion, which it will be recalled is distributed as χ^2 for the calculated degrees of freedom (see chapter 4 above), for successive reductions of the number of factors. The least number of factors is that number which gives a structure that would occur not as a rare or improbable event i.e. for which the null hypothesis is not rejected.

For the maximum number of factors, in this case 20, the p value of the criterion was 17%, for the 15 factor case 88%, for the 12 factor case 50%, for the 11 factor case 22% and for the 10 factor case, 1%. The 11 factor case may be considered therefore the most parsimonious yet probable structure and is shown below in Table 5.1.

From Table 5.1. it is possible to 'interpret' the factors in terms of those variables which load relatively highly on them. Factor 1 is an industrial characteristic, while Factor 2 describes how open space and residential land within a $\frac{1}{4}$ and $\frac{1}{2}$ mile radius of the house are inversely related. This is only to show that industrial land can occur whether there is open space or not but that if open space occurs then housing land is reduced. The Factor 3 is indicative of residential land within $\frac{1}{4}$ mile radius. As this variable loads also on Factor 2 and 4 we expect it to be well explained by the Factor analysis and indeed it has a low uniquity on specific effect. Factor 3 in fact is almost a specific factor for this variable. Factor 4 is similar to Factor 2 i.e. an open space/housing factor but within a radius of 1/8 mile and $\frac{1}{4}$ mile of the house. Factor 5 is a general location factor which shows that Nottingham is a circular city. As distance from the centre increases, the green belt becomes closer. Furthermore travel expenditure is in part related to distance from the centre. This suggests that distance from the centre could be justified as a proxy for travel expenditure, albeit a poor one. Factor 6 indicates that when a view exists with hills then woodland is also likely to be present. Factor 7 is a house/quality factor illustrating that houses of a terraced type tend to be older, without central heating, on small plots with no garage and in high density areas. It is difficult to identify Factor 8 as it does not have any variables loading heavily on it. Factor 9 is a separable Factor in that the variable which loads highly on it, view, does not load on any other factor. It is therefore a specific factor for view and indeed view, given its separability, could be excluded from the factor structure and

Varimax after . d Iterations

TABLE 5.1. Factor Analysis of 28 Variables.

Factor Loadings

Variable	1	2	3	4	5
1	-0.24290	-0.01022	0.05972	0.00368	0.17925
2	-0.22727	0.16528	-0.08956	-0.04456	0.09584
3	-0.00571	0.28298	-0.06760	0.15947	0.14787
4	-0.13975	0.13490	0.02251	0.07184	0.12651
5	-0.01378	-0.03867	-0.08626	0.04699	0.00350
6	0.32082	0.03699	-0.19572	-0.04237	-0.28185
7	-0.39081	0.29107	0.07153	0.69940	0.18762
8	-0.29686	0.57652	0.29328	0.57047	0.08514
9	-0.34348	0.64740	-0.08210	0.17881	0.34445
10	-0.27010	-0.15781	0.06337	-0.93948	-0.06194
11	-0.26307	-0.59863	-0.41429	-0.50786	0.01736
12	-0.12282	-0.92985	0.04431	-0.14307	-0.15111
13	0.76785	-0.14040	-0.15621	0.31167	-0.14359
14	0.79633	0.03384	0.05879	0.08947	-0.19311
15	0.69130	0.22329	0.15148	-0.03788	-0.26385
16	0.44613	-0.17478	0.02860	-0.13975	-0.27411
17	-0.15183	-0.07333	0.10989	-0.00128	-0.17743
18	-0.09492	-0.06966	-0.05278	0.04658	0.05027
19	-0.06702	-0.05127	0.14356	-0.06157	-0.04394
20	-0.08642	0.22921	-0.11606	0.04171	0.05559
21	-0.17292	-0.10324	-0.02391	-0.08258	0.02328
22	0.11933	-0.02506	0.12600	0.09252	0.13078
23	-0.00462	0.04562	0.02207	0.19258	-0.10922
24	-0.07677	0.14031	-0.00047	0.10952	0.91215
25	-0.14026	0.09307	0.16180	-0.02148	0.19191
26	-0.21370	0.01939	-0.12803	0.14947	0.30068
27	0.30378	0.05381	0.02891	-0.09206	-0.71090
28	-0.07499	0.12258	-0.00341	-0.01503	0.48658
Proportion Variance	10.38356	8.35602	1.78149	8.12125	8.28349

Variable	6	7	8	9	10	11	Communality	Uniquity
1	0.04838	0.80339	0.00378	-0.00790	0.08163	-0.05995	0.752917	0.247078
2	-0.17061	0.59406	0.14809	0.20687	-0.26091	-0.14370	0.633482	0.366447
3	0.09914	0.51650	-0.10412	0.02535	-0.04636	-0.09355	0.430993	0.569024
4	0.36131	0.48319	0.01523	0.05343	0.30389	-0.32897	0.627061	0.372933
5	0.13520	0.03646	-0.01888	-0.13789	0.50640	0.00482	0.306851	0.693181
6	-0.24282	-0.57203	0.12068	0.09539	-0.23620	0.23319	0.743855	0.256148
7	-0.07486	0.26990	0.06633	0.22722	0.25485	-0.16902	0.994807	0.005135
8	0.19866	0.27973	-0.09318	-0.01749	-0.10450	-0.15225	0.999999	0.000001
9	0.23073	0.33923	0.04355	-0.13761	-0.05171	-0.25034	0.948952	0.051046
10	0.07172	0.00205	-0.01353	-0.05515	-0.04381	-0.00805	0.998682	0.001313
11	-0.15845	-0.02710	-0.12595	0.05660	0.14778	-0.07959	0.831000	0.169079
12	-0.00974	-0.05020	-0.02917	0.03423	0.05040	0.01166	0.932297	0.067707
13	0.00743	-0.31881	-0.04329	-0.20307	-0.24025	0.21448	0.999999	0.000000
14	-0.17149	-0.32645	0.22782	-0.0364	-0.10336	0.24653	0.944633	0.055333
15	-0.33150	-0.37119	-0.16266	0.14743	-0.00010	0.28699	0.999998	0.000001
16	-0.10393	-0.56502	0.00158	0.01360	-0.05925	0.16860	0.687216	0.312771
17	0.04734	0.01450	0.01916	0.10521	0.37513	-0.17006	0.255527	0.744477
18	0.22491	0.12463	-0.04037	0.74907	-0.09915	-0.14147	0.680090	0.319932
19	0.54771	0.00497	0.01771	0.15144	0.08660	0.04891	0.366741	0.633327
20	0.56847	0.12776	-0.03365	0.08546	0.11511	-0.01002	0.439523	0.560450
21	0.00796	0.24293	-0.21242	0.14599	0.00986	0.02628	0.174777	0.825215
22	0.07307	-0.09071	0.01289	0.31055	-0.07915	0.28882	0.256178	0.743777
23	0.09164	0.35743	-0.03849	0.29571	0.15343	-0.22131	0.349060	0.650867
24	-0.02989	0.06552	0.02295	0.07662	-0.09650	-0.19103	0.926983	0.073014
25	0.05668	0.17179	-0.01629	0.12814	0.02821	-0.52407	0.416810	0.583264
26	-0.11397	0.15208	0.03882	0.04464	0.07941	-0.71830	0.736979	0.262979
27	-0.22622	-0.32302	-0.11680	0.01336	0.23923	0.04267	0.838210	0.161766
28	-0.02865	0.15251	-0.07059	0.01388	0.04661	-0.07723	0.295060	0.704950
Proportion Variance	4.59550	11.33365	0.82591	3.74827	3.34015	5.54820		

Variable Key.

1 = Garage
2 = Construction Date
3 = central heating
4 = Plot size
5 = No Bedrooms
6 = House Type 0 = Detached.
7 = Open Space within 1/8 mile
8 = " " " 1/4 "
9 = " " " 1/2 "
10 = Residential land " 1/8 "
11 = " " " 1/4 "
12 = " " " 1/2 "
13 = Industrial land " 1/8 "
14 = " " " 1/4 "
15 = " " " 1/2 "
16 = Density, 0 = low
17 = Trees
18 = View
19 = Hills (view dummy)
20 = Woods (" ")
21 = industry (" ")
22 = parks (" ")
23 = houses (" ")
24 = distance c.b.d.
25 = " " main road
26 = " " railway
27 = " " green belt
28 = Travel Expenditure.

included in the regression analysis on its own. Factor 10 is a seperable factor for bedrooms although Factor 10 only accounts for approximately 30% of the variance of this variable which has also a high uniquity. Factor 11 can be identified as a 'seclusion' factor as it indicates housing at a distance from railway lines and main roads and their associated noise and dirt.

This factor analysis on 28 variables provides the means whereby a second analysis can be envisaged, with fewer variables. Those variables which have either separable factors, as described above and/or high uniquities (i.e. greater than .6) can be said not to be part of a common factor structure. Such variables are bedrooms, trees, view and all the dummy variables associated with view and travel expenditure. These variables are of course not omitted from the regression analysis on house price below as they are relevant a priori for residential location.

Table 5.2. illustrates the Factor analysis conducted on the reduced set of 19 variables. The p values for the criterion for the 7,8,9, and 10 Factor cases where less than .00001 for 7 and 8 factors, 11% for 9 factors and 70% for 10 factors. The 9 factor case was then chosen. Factors 1,2,3,5 and 7 are all descriptive factors of the land use about the houses. Factors 1,3 and 7 illustrate the inverse relationship between open space and residential land while Factor 2 is an industrial factor for land within $\frac{1}{4}$ mile of the house and Factor 5 indicates general absence of industry over the whole area about the house. Factor 4 is the general location factor obtained in 28 variable case and factors 8 and 9 the house/quality and seclusion factors as before. Factor 6 is not identifiable. An examination of the uniquities now reveals that the following variables have a strong specific as well as a common factor effect; construction date, central heating, plot size, and distance from the main road. It is reasonable therefore to include these variables in the regression with house price as well as the common factors in order to obtain both specific and common factor (characteristics) coefficients.[1]

It must be stressed that the factor strucutre does not represent

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1 An examination of the uniquities will also reveal how inappropriate the homogenous variance or principal component solution would have been (see appendix to Chapter 4). There are no less than 7 variables which have uniquities of value zero to two decimal places while 4 variables have uniquities greater than 0.5.

Maximum Likelihood Solution

TABLE 5.2. Factor Analysis of 19 Variables

Variable	Factor Loadings 1	2	3	4	5
1	0.02574	-0.13100	0.00204	0.10438	0.07108
2	0.01500	-0.18554	0.03341	0.15591	0.01175
3	0.15185	0.05403	-0.03981	0.14498	0.00515
4	0.10133	-0.12726	-0.06394	0.01230	0.20411
5	-0.03349	0.22119	0.07540	-0.18355	-0.19425
6	0.80593	-0.33327	-0.14895	0.11936	0.07587
7	0.48886	-0.18780	-0.46559	0.07036	0.15873
8	0.15296	-0.17390	-0.14965	0.26533	0.30395
9	-0.88457	-0.38831	0.20244	-0.05557	0.05800
10	-0.32483	-0.18437	0.85095	-0.00562	0.10189
11	-0.15433	-0.02653	0.21116	-0.06391	0.15301
12	0.12521	0.83068	-0.08692	-0.07345	-0.14894
13	0.01349	0.58823	-0.17683	-0.13549	-0.41710
14	-0.00942	0.32628	-0.10144	-0.23896	-0.71810
15	-0.16524	0.27310	0.03249	-0.20674	-0.25164
16	0.11764	-0.03459	0.00223	-0.73907	-0.03483
17	-0.00249	-0.17539	-0.03837	0.13766	0.01367
18	0.18631	-0.08565	0.09685	0.16657	0.17517
19	-0.02418	0.10423	0.02973	-0.88236	-0.25630
Proportion Variance	10.26607	9.20486	6.03853	8.99745	5.88431

Variable	6	7	8	9	Communality	Uniquity
1	0.00872	-0.03064	-0.86377	0.08638	0.788482	0.211527
2	-0.04453	0.15617	-0.52234	0.03611	0.366863	0.633151
3	0.11043	0.29159	-0.50187	0.04533	0.399782	0.600208
4	-0.04705	0.12378	-0.53384	0.30191	0.466027	0.533961
5	-0.12801	0.05524	0.64968	-0.29038	0.653143	0.346843
6	-0.02864	0.18887	-0.32274	0.23932	0.999854	0.000145
7	0.34291	0.47674	-0.32564	0.15815	0.997163	0.002837
8	0.07117	0.67175	-0.40907	0.27221	0.936574	0.063428
9	-0.02303	-0.13133	-0.03142	-0.01746	0.999988	0.000011
10	0.01549	-0.34674	0.01037	0.07234	0.999903	0.000097
11	0.03931	-0.92665	0.06054	-0.02419	0.961270	0.038729
12	0.03454	-0.05606	0.41306	-0.26958	0.992686	0.007346
13	-0.17581	0.01711	0.43503	-0.29412	0.876781	0.123232
14	0.00253	0.12753	0.45368	-0.24718	0.999954	0.000045
15	-0.01477	-0.16888	0.62744	-0.22165	0.680553	0.319445
16	-0.06381	0.21119	-0.13763	0.35949	0.766645	0.233379
17	0.12553	0.06397	-0.19031	0.53419	0.392803	0.607197
18	-0.11782	0.05563	-0.19943	0.70657	0.665866	0.334147
19	-0.09143	-0.02694	-0.35958	-0.06338	0.999929	0.000071
Proportion Variance	1.22607	10.20388	18.67445	8.15792	78.65347	

Variable Key.

1 = Garage
2 = Construction Date
3 = Central Heating
4 = Plot Size
5 = House Type, 0 = Detached
6 = Open Space within 1/8 ml.
7 = " " " 1/4 ml
8 = " " " 1/2 ml
9 = Residential land within 1/8 ml
10 = " " " 1/4 ml.
11 = " " " 1/2 ml
12 = Industrial land within 1/8 ml
13 = " " " 1/4 ml
14 = " " " 1/2 ml
15 = Density, 0 = Low
16 = Distance c.b.d.
17 = " main road
18 = " railway
19 = " green belt

necessarily the way that households perceive amenity but merely describes an underlying structure of the variables representing the stock of housing attributes in the case of one city. Whether the factors, both common and specific, can be regarded as characteristics of a 'consumers technology' can be tested by relating households expenditure on residential attributes to the measurements of the factors, through regression analysis.

5.3. Relationship of house value ('price') to amenity characteristics.

The first requirement in regressing house price on amenity factors is to obtain measurements of the hypothetical factors for each household. In chapter 4 least squares estimates of the factor scores were shown to be given, following BARTLETT (1938) by,

$$\hat{y} = (A'\Delta^{-1}A)^{-1}A'\Delta^{-1}z$$

where A is the factor loading matrix and Δ the diagonal matrix of the residual variances. In practice the variables, z are scaled such that

$C = S^{-1} A S^{-1}$ (s diagonal) so that C has unit diagonal, where C it will be recalled is the observed covariance matrix of the variables, in which case the estimates of the factors are given as[1]

$$\hat{y} = (\hat{A}'\hat{\Delta}^{-1}\hat{A})^{-1}\hat{A}'\Delta^{-1}S^{-1}(\underline{z} - \underline{\mu})$$

With measures of the factors, or factor scores, and with the variables excluded from the factor analysis on grounds of their specificity, as the independent variables in a regression with house price as the dependant variable, then coefficients of the amenity variables which may be interpreted as 'prices' are obtained by Ordinary Least Squares.

It will be recalled that the factors are orthogonal with mean zero and unit variance; being independent of one another the problem for estimation of multicolinearity is reduced. It does not however

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1 It should be remembered that the M.L. solution is scale independent while the homogenous variance solution is not, unless the scaling used were $S = \Delta^{-\frac{1}{2}}$ in which case the solutions coincide. Of course, however Δ is unknown.

disappear as the non-factor variables may be correlated. In this case the specific variables of the house which are also present in the factor structure are correlated with the factor for house/quality. However this correlation, of the order of 0.5 is not so high that a step-wise regression procedure is unable to give reasonable parameter estimates. The results of this regression analysis are illustrated in Table 5.3.

TABLE 5.3.

Var	Coeff.	Stnd.Error	Ratio	Cont.Limits	
CONST	1981.2216	329.8799	6.01	422.7021	
Z 1	-3.7235	2.4242	1.54	3.1064	Travel Expenditure
Z 2	226.1809	185.3366	2.15	134.9764	No. Bedrooms
Z 3	244.4566	88.4440	2.76	113.3306	Central Heat (none, part, full)
Z 4	159.3608	30.6149	5.31	38.4606	Plot size (75 sq.yds)
Z 5	201.5671	61.8999	3.26	79.3174	Factor 1 nearby open space
Z 6	-152.2909	68.3398	2.52	77.3183	Factor 2 " industrial land
Z 7	188.5704	62.8151	3.04	79.4650	Factor 5 Absence of 'nuisance'.
Z 8	-663.1272	78.5967	8.40	100.7124	Factor 8 Poor quality house
Z 9	155.4132	58.8349	2.64	75.3900	Factor 9 Seclusion.
Z12	-228.1056	161.7192	1.36	207.2241	Adjacency to main road

MULT.CORRLN 82.1187
Adjusted 80.3738

The order of the variables in terms of their explanatory power for house price variation are consecutively, plot size, house/quality characteristic, open space amenity characteristic, general absence of industrial nuisance, seclusion, industrial nuisance within $\frac{1}{4}$ mile, central heating (specific), number of bedrooms, inaccessibility (travel expenditure per annum) and presence of a main road. Plot size and house/quality together accounted for 74% of the variation of prices, with 82% being accounted for in all. Variables which were not significant, even at 20%, were trees, view, construction date and factors 3,4,6 and 7. The relationship illustrated in Table 5.3. corresponds to the linear rent, function of chapter 2. It also represents the 'best fit' after several linear transformations of the variables had been compared.[1]

1 It should be noted that household annual travel expenditure is a composite variable estimated from two non-linear relationships one for travel by bus and the other for travel by automobile. The distance - bus fare relationship for 1968 was derived from Nottingham Corporation and the mileage - car costs from a formula used by the Road Research Laboratory in 1968, including petrol tax. Travel expenditure represents the actual money cost to the household and does not include any evaluation of time and convenience.

It is interesting to consider those variables which do not enter the final relationship. Perhaps the most notable omission is Factor 4, the general location factor. As an accessibility measure travel expenditure is already available, distance from the centre represents some notion of urbanity (see chapter 3). Apparently urbanity is not, for Nottingham at least, a desired attribute. This result does not of course undermine the usefulness of distance from the centre as a measure of access it simply illustrates that in this case it would be a poor measure. A prior indication of this result was shown in Table 5.1 where distance to and from the centre was poorly correlated with travel expenditure and the distribution of work places (industrial land). While distance from the centre is not generally discredited on this evidence as an accessibility measure it is this author's belief that whenever possible actual travel costs should be used.

The omission from the 'rent' function of Factors 3 and 7 is reasonable in that they are descriptions of the land use about a house along with Factors 1,2 and 5. It is unlikely that a household's perception of land use is sufficient to accommodate as many as five separate factors. The three factors of land use which are significant are distinct enough to be perceived separately i.e. open space amenity, industrial nuisance near to the house and an overall lack of nuisance in the area about the house.

Turning our attention to the coefficients of the variables it is noted that all their signs are consistent with a priori expectations and except for variables Z1 (travel expenditure), Z2 (bedrooms) and Z12 (main road) these coefficients are significant at better than 2% level. Z2 is significant at 5% and Z1 and Z12 at better than 15%. It is encouraging that the values of the coefficients for bedrooms and central heating are reasonably close to actual cost at 1968 prices.

While the coefficients for specific variables are readily interpretable it is more difficult to grasp what is meant by a marginal change in a factor. Thus having established the pertinence of a goods-characteristics framework for residential location decisions of households it is useful now to estimate the marginal impact of the separate variables on house price through their effects on factors. These effects are illustrated in Table 5.4. and are calculated as the factor score for each variable on each relevant factor times the coefficient for each relevant factor with respect to house price. Thus for example, the factor score for construction date, -0.14 with respect to the house/quality factor is multiplied by the coefficient for that factor with respect to house price, i.e. -663.1272. The product 95.02 is in units of £s and indicates that ceteris paribus a house depreciates by £95.02 per annum due to age alone. It will be noted that marginal coefficients for each variable through the factors may be measured as the sum of the products of the factor score for each variable on each factor and the factor coefficients. This summation procedure has not been followed on the grounds that while the variables covariance are described by all the factors it does not follow that a change in one variable will effect all factors. It is reasonable to suppose that a local authority could alter the acreage of open space in an area without changing the 'type' of houses. Hence armed with prior knowledge of the physical changes contingent upon changes in one variable the relevant variable factor scores and factor coefficients for multiplication can be identified. The coefficients of Table 5.4. will be used in chapter 6 in an appraisal of land use change.

Before leaving the calculation of the rent function and amenity 'prices' there is one question which it will be useful to answer at this point. While it has been shown that a rent function in terms of environmental amenity characteristics and accessibility can be estimated utilizing factor analysis prior to least squares it may be felt that a sufficient procedure would be to estimate the rent function using least squares directly. Such an analysis is illustrated in Table 5.5. There are however two reasons why such an approach is unsatisfactory. The first and most important reason concerns the a priori rationalization of such a model. In the event that consumers do perceive their environment in an 'aggregated' manner then a goods-characteristics type consumption technology is relevant. Factor analysis is a direct statistical analogue of such a model and lends itself to the business of identifying characteristics. Subsequent interest in the technological relationship between individual attributes and factors (characteristics) and house price is not inconsistent with interest in the aggregated perception of amenity and is not the same as an interest in the direct relation between individual attributes and house price. This may be seen by comparing the coefficients in Table 5.5. with the coefficients for variables through factors of Table 5.4., for identical variables. The use of factor analysis allows the estimation of both

TABLE 5.4. Coefficients for individual variables with respect to house price via their effect upon factors. 1968 prices

Variable	Factor effect(£)	Specific effect(£)	Total(£)
Garage[1]	549.53	-	549.53
Date Built	95.02	-	95.02
Central heating	109.16	244.46	353.62
Plot size (per sq. yard)[2]	1.22	2.12	3.34
Type[3]	-163.03	-	-163.03
open space 1/8 ml radius	460.75	-	460.75
open space $\frac{1}{4}$ ml radius	269.79	-	269.79
open space $\frac{1}{2}$ mile radius	66.0	-	66.0
residential land 1/8	-81.0	-	-81.0
residential land $\frac{1}{4}$	-26.0	-	-26.0
residential land $\frac{1}{2}$	0.0	-	0.0
industrial land 1/8	-228.66	-	-228.66
industrial land $\frac{1}{4}$	-47.40	-	-47.40
industrial land $\frac{1}{2}$	-352.95	-	-352.95
Density	-7.58	-	-7.58
distance, main road	54.83	-	-54.83
distance, railway	121.32	-	-121.32
Travel Exp. p.a.	-	-3.72	-3.72
No. Bedrooms	-	226.18	226.18
Adjacency main road	-	228.11	228.11

1 'garage' is measured as none, space or garage, 0,1 or 2 respectively.

2 Plot size per acre is £14,984.25

3 'Type' is measured as detached, semi-detached, end-terrace, interterrace, 0,1,2,3 respectively.

common and specific effects of variables on house price, separately.

TABLE 5.5. Direct Least Squares Analysis of House Price on 19 Amenity Variables.

Var.	Coeff.	Stnd.Error	Ratio	Conf.Limits
CONST	2646.7583	541.8583	4.88	1061.5908
Z 1	453.5645	86.9111	5.22	170.2734
Z 3	255.2222	76.4110	3.34	149.7918
Z 4	191.7083	24.0744	7.96	47.1657
Z 5	246.6407	93.2264	2.67	182.6461
Z 9	2.3969	1.1577	2.07	2.2681
Z10	-31.3529	13.5164	2.32	26.4810
Z16	-200.5428	69.1065	2.90	135.3912
Z19	-258.6186	38.7251	6.68	75.8680
Z21	455.0880	132.4798	3.44	259.5301
Z22	-156.7447	59.1789	2.65	115.9113

MULT.CORRLN 86.1668
Adjusted 84.8238

Notes

Z 1 = Garage, Z 3 = central heating, Z 4 = plot size, Z 5 = No. Bedrooms, Z 9 = Open space within $\frac{1}{2}$ ml. radius, Z 10 = Residential land within 1/8 ml. radius, Z 16 = density, Z 19 = distance from the central business district, Z 21 = distance from railway, Z 22 = distance from the green belt.

As a result of the multicolinearity of the variables distance from c.b.d. and the green belt have absorbed the effect of house type, open space within 1/8 mile radius and industrial land nuisance.

The second reason is related to the first but is more pragmatic. While multicolinearity of the variables can make parameter estimation ambiguous in a direct least squares model it does not pose the same problem for an indirect approach through factor analysis. However it must be stressed that as a justification for the use of factor analysis this reason is hardly sufficient. Principal component analysis may be equally efficient in obtaining a subset of variables which are independent and have maximal variance in some sense. Only if multicolinearity is indicative of some underlying structure which it is desired for some a priori reason to estimate, is Factor analysis necessary. This is precisely the case in the model developed here.

5.4. The Relationship between residential expenditure and household Socio-Economic variables.

The analysis of residential consumption and household socio-economic variables is illustrated in Table 5.6. below where total residential expenditure (house price) is the dependent variable. These results indicate the 'best fit' of several linear transformations of the variables.[1]

TABLE 5.6. Residential Expenditure and Household Socio-Economic Relationships.

Equation One. Double-logarithmic (constant elasticity)

2 VARIABLES IN

Var.	Coeff.	Stnd.Error	T.Ratio	Conf.Limits
CONST	6.1493	.6749	9.11	1.3228
Z 1	.2931	.0855	3.43	.1676
Z 4	-.3096	.0966	3.20	.1894

MULT.CORRLN 24.5607
Adjusted 23.0367

Equation Two Linear

2 VARIABLES IN

Var.	Coeff.	Stnd.Error	T.Ratio	Conf.Limits
CONST	2860.6685	291.6333	9.81	570.8588
Z 1	.6259	.1087	5.76	.2128
Z 4	-247.4766	92.2434	2.68	180.5621

MULT.CORRLN 24.5982 Elasticity = .6259 x Average Income/Av.Exp.
Adjusted 23.2306 = .33

Equation Three Linear with Household Size

5 VARIABLES IN

Var.	Coeff.	Stnd.Error	T.Ratio	Conf.Limits
CONST	2689.1728	312.2826	8.61	611.4701
Z 1	2.0599	.9650	2.13	1.8896
Z 2	-2.2509	1.3436	1.68	2.6308
Z 3	-.2041	.1567	1.30	.3068
Z 4	-301.2263	95.4156	3.16	186.8301
Z 5	.4319	.2874	1.50	.5627

MULT.CORRLN 28.2107
Adjusted 24.8871

Note

Z 1 = Income (or log income in Equation One)
Z 2 = Income per capita (or log form in Equation One)
Z 3 = Income times household size (or log form in Equation One)
Z 4 = Social Class (1 = high) (" " ")
Z 5 = Asset index (or log Index + 1 in Equation One)

For the linear relationship the income coefficient or marginal propensity to consume, taking account of household size is given by

1 It should be noted that variables analysed included the age and sex of children, adolescents, adults and aged members of households. All data pertain to the year 1968.

equation 3 as;

M(2.06 - 2.25/n - .20(n))

where M is money income and n is household size. For households in the size range 2 - 5 the m.p.c. are given in Table 5.7 along with the income elasticity calculated as the m.p.c. times the ratio of average income to average expenditure for each size group.

TABLE 5.7. Marginal Propensities to Consume and Income Elasticities by Household Size.

(a) Size (persons)	(b) m.p.c.	(c) Average Income,£.	(d) Average Expenditure,£.	(e) Income Elasticity $b \times \frac{c}{d}$
2	.54	2151.0	3546	.33
3	.71	1787.0	3612	.35
4	.70	2006.0	3373	.42
5	.61	1869.0	3369	.34

Thus for example of two households of 5 persons, where one household is wealthier by £100, the richer household will spend £61 of its extra wealth on housing compared with the £70 were their sizes 4 persons. A comparison of the m.p.c. and income elasticities on different household sizes indicate the relationships shown in Fig.5.1.

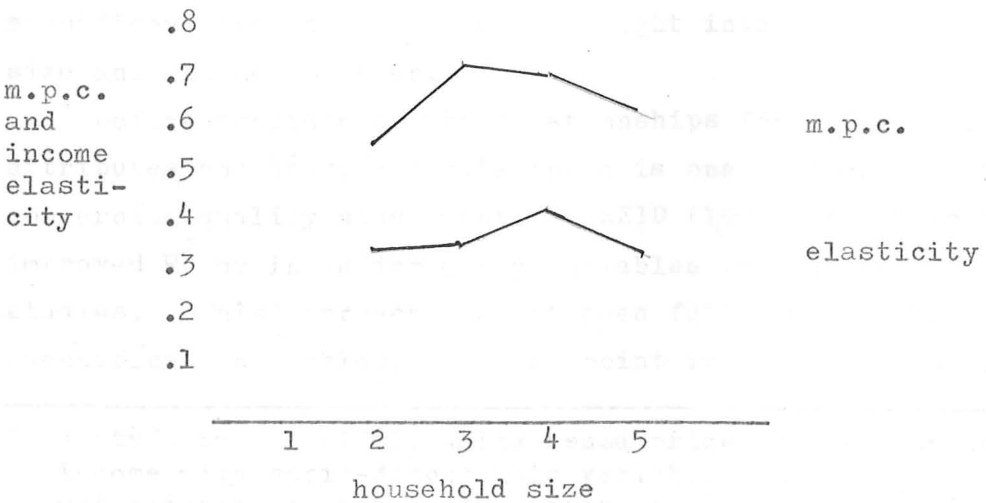

Figure 5.1.

This figure shows that for small to medium sized households relatively wealthier households spend more of their relative extra wealth on housing than is the case for medium to large households. This might indicate that expenditure on goods other than housing is relatively more important for large households. This is reasonable in that large households may face necessary expenditures such as for education and extra clothing which a small household may not.

The income elasticities on the other hand are less diverse and tentatively suggest a constant relation over household size, with the exception for household sizes of 4 person where the elasticity is higher than elsewhere. The results shown for the elasticities conform with 'Schwabes Law' which requires that articles of necessity such as housing have income elasticities less than unity.

The residential expenditure relationship has however to be considered from the point of view of its predictive power or 'goodness of fit'. Here it is seen that the relationship is very poor with an R^2 of only 28%.[1] This can be explained by the absence of relevant variables or by the lack of amenity choices that households have. Both explanations are probably pertinent. In the former case savings, wealth and the differential financial arrangements for house purchase, are variables which it would be desirable to include. In the latter case it is suggested that quite diverse households in terms of their age and sex composition may face similar residential options such that insufficient information exists to test the relevance of such household variables in determining the level of expenditure.

Notwithstanding the high unexplained residual variance it is worth bearing in mind that the variables which are included are highly significant and do provide some insight into the effects of household size and income together.

Before considering the relationships for individual residential attributes and household data there is one further remark to make concerning quality adjustment. REID (1962) and other authors have improved R^2 by including dummy variables for quality in cross sectional studies. This approach has not been followed here as it raises an identification problem. At one point in time with quality prices

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1 A study by LEE (1962) using house price as the dependent and current income with socio-demographic variables as the independent variates established an income elasticity of .89 and an R^2 of 0.3.

constant, expenditure variations, the dependent variable, already reflect quality variations. This is evident from the relation shown in Table 5.3. where R^2 was 0.8. To include them as independent variables with socio-economic variables is to confuse two functional relations; on the one hand the technological relation between house 'price' and amenity and on the other the behavioural relation between that amenity, either seperately considered or in total, and household variables. Only in time-series where house expenditure changes include the effects of both price, quantity and quality changes should an account be taken of all effects simultaneously.[1]

The relationships between individual residential attributes and household variables are illustrated in Table 5.8. These relations should be regarded rather more as descriptive than as indicators of cause and effect. It is possible however to make certain inferences concerning household preferences. In general though the high residual variance (low R^2) suggests that the dependent variables vary with respect to other variables in addition to those included. Furthermore while households may pay a higher price for amenity, as suggested by the relationship between house price and amenity, there may be insufficient amenity to accommodate the level of demand at the going price level. This would result in a low covariance of amenities and household incomes. Similarly household social characteristics may be quite diverse relative to the amenity opportunities available to them. In both instances poor relationships should result.

It might be argued that in this case why does not the price of amenity rise to cut off any excess demand and is not the market as observed simply in a disequilibrium situation? This view is however too simplistic a reading of the results. It is unlikely that equilibrium in the sense of market clearing at going prices is a useful concept in the second hand housing market. More likely is it the case that individual sellers have a probablistic distribution of offers that they expect to receive with higher offers increasing in probability as their time horizon increases. Thus the market is

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1 This would involve the simultaneous solution to a set of equations in terms of quality and quantity and price over time and space. A procedure for this has been established by KHAMIS and illustrated in chapter 3 above in the construction of a 'unique' hedonic index.

TABLE 5.8. Relationship between key residential attributes and a cross-section of households' socio-economic variables

Dependent Variables	Constant	Household Size	Social Class 1=High 5=Low	Income	Income Size	Income (size)	No. Children* M	No. Children* F	No. Adolescents* M	No. Adolescents* F	Asset Index	Dislike of Industry nearby	R^2 %age.
	Independent Variables - Coefficients and T-values (in brackets)												
Plot Size (units of 75 sq.yds.	3.83 (6.55)	-	-.52 (2.80)	.0013	-	-	-		-		-	-	25%
Bedrooms⌿	.98 (6.54) (1.10)	.51 ⌿ (2.78)	-	.20 ⌿ (1.67)	-	-	-	-.19 (2.0)	-	-	-	-	11%
Open Space ¼ ml. radius	32.26 (6.54)	3.44 (1.53)	-5.19 (2.85)	.05 (3.31)	-.06 (2.64)	-.01 (3.61)	-		-		-	-	17%
Industrial land ¼ ml. radius	18.83 (5.0)	2.40 (2.20)	3.31 (2.58)	-.002 (1.69)	-	-	-		-		-	-5.85 (4.48)	24%
Adjacent Main Rd.	0.31 (3.30)	-	.06 (1.99)	-.0001 (2.65)	-	-	-.07 (1.92)		-		-	-	11%
Travel ⌿ Expenditure	-86.67 (1.89)	-	-9.85 ⌿ (1.50)	17.1 ⌿	-	-	-		-		-	-	13%
Central Heating	.15 (1.02)	-	-	.0002 (3.39)	-	-	-		-		-	-	9%

* Sexual differentiation of children and adolescents is only used in the regression with 'Bedrooms'

⌿ Regressions for Bedrooms and Travel expenditure are semi-logarithmic with respect to variables of Household size, social class, and income.

characterized by sellers who decide first to enter the market and then to sell or withdraw at some future date determined by their expectations and the particular constraints by which they are conditioned, such as having to sell quickly in order to flee the country! In such a market disequilibria of the traditional sort may be consistent with "normal behaviour"[1] for that market.

From Table 5.8. it is observed that income and social class (defined as in the Classification of Occupations 1970, H.M.S.O.) are the most consistent contributors to the relationships. Moreover the correlation between these two variables of 0.16 illustrates that they are not separate measure for the same effect. The income coefficients, except for the 'open space' relation, are simple linear ones. In the case of open space, household size affects the coefficient in the following way;

income coefficient	household size
.015	2
.027	3
.033	4
.036	5

where the coefficient is calculated as,

$$(.05 - .06/n - .01(n))$$

where n is household size.

In all cases the signs of the coefficients conform with reasonable hypotheses, except in the case of female children whose number is inversely related to the number of bedrooms.

The relation for industrial land includes a variable of household attitude to industry, being high if the household felt a strong dislike for nearby industry and low if indifferent. This variable is in fact the most significant in that relationship and indicates that household choices for this variable are consistent with what they have said they prefer. Whether this indicates an <u>ex post</u> rationalization of their

1 Whether other equilibrium notions which may circumscribe this sort of 'normal behaviour', can be developed remains to be demonstrated, but an encouraging view is offered in "On the notion of equilibrium in economics" by F.H. HAHN, Cambridge University Press, 1973.

choice is of course hard to say. The 'open space' relationship, on the other hand was not significantly related to household expressions of amenity preference. These results may indicate that industrial nuisance is easily perceived so that whether households avoid it if they wish or ignore it if they are indifferent and whether this is an ex post rationalization or not they can identify it, at least as it is measured in this study. On the other hand it would seem that perceptions of amenity are less precise, at least as measured here. Households express a desire for amenity as an important consideration in choosing a house, yet do not necessarily consume it. Of course this may well represent a desire for a good that they cannot yet afford. However it is more likely that this is not the case and that households think they are getting amenity and then discover that they are not. Evidence for this view exists in so far as 55% of households explicitly cited amenity grounds for their main criteria of locational choice this being the most common criteria. Yet 32% of households cited amenity grounds for expressing ex post dissatisfaction with their choice, this being the most common criteria, when over half of this number had included amenity as their grounds for choice. Apparently a learning process has to be gone through to realize what 'amenity' is.

The importance of being relatively clear of traffic hazards is suggested by the relation between adjacency of main roads and the presence of children. Furthermore it might be argued that lower social classes are less safety conscious. Alternatively it could be argued that safety is not the consideration rather is it peace and quiet which is a 'middle class' value.

Social class may itself be considered by examining the sign of its coefficient with respect to the dependent variables. It would appear that low social classes have relatively small plots, little open space amenity, rather more industry nearby along with busy roads and spend little money on travelling, all of which may be expressions of taste and preference. 'Income' on the other hand has the opposite sign with respect to the same dependent variables. This suggests that lower classes would prefer a more 'middle class' environment if their incomes rose. This point may be obvious to some but is important to make as it has been argued that preference for amenity is simply a middle class value judgment which when imposed on lower classes by area improvement schemes is a misallocation of resources.[1]

1 As one American economist has remarked albeit tongue in cheek "why 'improve' the homes of the lower classes? Just spread the garbage in the better areas and secure equity that way, its cheaper."

While the results indicated in Table 5.8. are of some interest they are inadequate in sufficiently explaining the relationships between amenity and household characteristics. This is not surprising. These relationships will involve complex processes and interactions which cannot readily be resolved in terms of single equations or perhaps in terms of systems of equations. Man's relationship with his urban environment is an interactive one without any necessity to conform to simple relationships. Yet it has been possible to identify and evaluate the amenity which determines house prices or total residential expenditure. Further the relationships between the amounts of amenity and household variables which have been shown do not contradict a priori expectations. Considering that many relevant variables have not been included such as future and 'permanent' income measures and house finance arrangements, it would seem that further work with these measures would yield useful behavioural results. Notwithstanding these remarks it does appear that the economists' main contribution will be that of 'amenity measurement' in economic terms. A behavioural understanding will require in addition the cooperation of urban sociologists and psychologists.

5.5. Household Amenity Preferences - Analysis by Questionnaire

The household questionnaire was undertaken to provide an independent indication of amenity preferences from that suggested by the regression analysis. It can act therefore as a confirmatory analysis, or not as the case may be. Due to the difficulty of designing a questionnaire of the sort it is not always possible to infer relative values of amenities. However by using both structural and unstructural questions a ranking of amenity preferences can be devised. The results of this ranking are illustrated below in Table 5.10. Table 5.9. describes certain general information about the sample.

TABLE 5.9. General Statistics of the Sample of Households

1. Per cent inter and intra urban moves.

Inter urban	32.5%
of whom, from areas of cheaper housing	(29.8) %
and from areas of more expensive housing	(2.7) %
Intra urban	67.5%
of whom purchase was first home	(21.0) %

2. Mean values and standard deviations of key variables

Variable	Mean	S.D.	
House Price	3407.95	1444.93	
Built in	1938	30	
No. Bedrooms	3	0.6	
Type	1	1	0 = Detached, I = Semi, 2 = End Terrace, 3 = Inter Terrace.
Income	2012.30	974.14	
Household Size	3.27	1.09	
Travel Expenditure	32.49	26.68	

3. Travel Time to work compared with previous location

Same Time	52%
Less Time	23%
More Time	25%

TABLE 5.10. Ranking of Mean Values of Amenity Preferences

Scale = 1 - 5, 1 = Very Important, 2 = Important, 3 = Indifference
4 = Important to avoid, 5 = Very Important to avoid

Variable: Mean Values

Variable	Mean
Local Shops	1.72
Open Space	1.89
Access to Country	2.11
Access to Schools	2.17
Nearby Bus Stop	2.25
Access to Work	2.33
Local Social Facilities	2.63
Access to B.R. Station	3.14
Adjacent Traffic	4.0
Nearby Industry	4.25

Ranking by closeness to nearest extreme value i.e. by degree of importance

Variable	Distance from Extreme
1. Local Shops	0.72
2. Nearby Industry	0.75
3. Open space	0.89
4. Adjacent traffic	1.00
5. Access to country	1.11
6. Access to schools	1.17
7. Nearby Bus Stop	1.25
8. Access to work	1.33
9. Local social facilities	1.63
10. Access to B.R. station	1.86
Maximum distance from extreme value	2.00

From Table 5.10. it is clear that the two most important considerations other than house/quality and plot size from the regression analysis, that is industrial land and open space amenity are confirmed by the rankings shown. Further the presence of a main road which enters the regression equation is highly ranked in the questionnaire study.

The importance of local shops in the minds of householders is not inconsistent with its absence from the regression model. Local shops are available in all locales of Nottingham and are not therefore a variable although they are a consideration. Access to schools is more difficult to explain as Nottingham is only now starting comprehensive education schemes. In 1968 there were no locational constraints on choice of school. Households may well plan their locational choices with regard to likely future locational constraints on school choice.

The poor performance of 'access to work' casts doubt on the credibility of the 'journey to work' approach to residential location model building. This finding supports that of STEGMAN (1968) who established much the same result from a North American survey. However as a majority of respondents to the questionnaire were housewives this result is perhaps misleading. This result is consistent though with the relatively small impact on house price of travel expenditure (see Table 5.3.)

5.6. Summary of Findings.

1. The residential model incorporating a goods-characteristics consumption technology has been successfully calibrated revealing residential characteristics for: open space, house quality and density, industrial land use, seclusion, and the general absence of industrial activity. Specific residential characteristics have also been found for central heating, plot size, number of bedrooms, adjacency to main roads, and travel expenditure as a measure of inaccessibility. Of these characteristics, housing quality - density, plot size, industrial land and open space have been found to be the most important. The results further indicate that the model is pertinent for examining the interelated structure of environmental variables. Furthermore the underlying structure is interpretable in terms of meaningful variables which can relate to how households perceive their environment.

2. Relationships between the amounts of amenities consumed by households and their socio-economic characteristics were described. While these relationships were poor in terms of 'goodness of fit', the coefficients which were present were well determined and significant. Income and social class variables were common to most relations with signs suggesting that more open space and 'freedom' from 'industrial nuisance' was purchased by higher income groups. The lower social classes tended to lack these environmental attributes. The relationship between total residential expenditure and household variables indicated that while the socio-economic variables were not correlated two of them, income and household size, had combined effects

upon expenditure. It was possible to show the income elasticities with respect to total expenditure for various household sizes. A lack of information pertaining to relevant variables prevented a satisfactory explanation of the variance. Variables such as savings, future 'permanent' and past income and differential finance possibilities for house purchase, if included in future studies should reduce the residual variance.

3. The results further lend themselves to the view that traditional equilibrium notions of economics may be inadequate for housing markets. On the one hand a lack of amenity diversification relative to household diversity might indicate frustrated preferences which the relatively inelastic supply of housing may only with difficulty satisfy. On the other hand an amenity learning process may be at work suggesting that tastes and preferences are themselves interactive with the environment. Attempts to introduce a wider range of environmental layouts and choices combined with studies of households' interaction with them may yield more information on these matters. Here the contribution of other social scientists will be necessary.

4. An independent experiment designed to yield the relative importance of environmental attributes by means of a household questionnaire gave broad general support to the main findings.

5. It remains to comment that given the data sufficient to calibrate models such as that developed here then optimism regarding the evaluation of so-called 'environmental intangibles', would not be misplaced. The data it must be said could be collected by any local planning authority at a reasonably low cost.

CHAPTER SIX

Externalities, Resource Allocation and the Built Environment

6.1. External Effects and Resource Allocation

The urban environment is, as we have demonstrated, a complex of many interdependent items which can be structured using a technique such as factor analysis. This environment which urban man perceives is often however outwith his control. This is so because the goods and services that relate to the environment are frequently external to markets where the individual can decide his level of production and consumption of them. In determining an efficient allocation of environmental resources, these external factors must be taken into account in some way. In this chapter an overview of the usefulness of a factor analysis approach to evaluating the allocation of land to use is provided. The importance of the notion of environmental externalities in this context is also discussed.

Externalities, may be defined as positive or negative benefits incidental upon actions of agents of the economic system, for which no compensatory payments are made nor account taken of in exchange. The main issue with regard to externalities has been with the extent to which their existence affects an efficient allocation of resources.

The norm for efficient resource allocation has traditionally been the 'competitive model' of the economy, wherein the goods and services produced and consumed are done so at prices just sufficient to clear the market with producers and consumers acting as if their decisions had no influence on prices. Such a situation characterizes an 'equilibrium' where the resource allocation is 'optimal' in the sense that no other allocation, given the distribution of incomes, will make all the agents participating in the market better off.

The major conditions that must prevail to ensure an optimal state as defined are three; the existence of competitive equilibrium, the marketability of all utility generating goods and services and non-increasing returns to scale. The first two conditions ensure optimality in the sense used here and the third condition ensures that each initial distribution of purchasing power corresponds to an optimal state. (KOOPMANS (1957), DEBREU (1959). The question arises as to whether the existence of externalities necessarily prevents an optimal state from being achieved.

In the event that existing externalities be 'internalized' within the market, so that they are subsequently marketable, then they cease to be externalities and pose no problem for efficient resource allocation. There are however three main obstacles to such an eventuality. Firstly, the costs of establishing a market, obtaining information and carrying out transactions may be such as to 'prohibit' individual initiative or at least that of sufficient number of individuals such that prices are exogenous for each. Secondly, the costs of 'policing' rights of use for subsequently marketed external goods may be greater than the benefits derived. Thirdly, it may not be possible in practice to identify separate individual's production or consumption of external effects such that 'exclusive' charges may be levied. In these circumstances, collective intervention in the form of statutory and fiscal controls over the production and consumption of external factors will probably be necessary, as a first step towards incorporating their effects within societies accounting framework.

Externalities arise for several reasons. One reason is the lack of property rights in environmental resources, goods and services. Without such rights economic laws will not operate, for example the expected satisfaction to be obtained from purchasing a motor car is contingent upon the purchaser having exclusive rights of use. Only then will a price be paid reflecting the exclusive satisfaction obtained by the individual consumer.

In the case of the pedestrian who is able to consume less fresh air as a result of an increase in motor car sales an externality exists owing to the absence of property rights in fresh air. The car owner is not obliged to pay for his pollution as would be the case where explicit rights in fresh air exist.

The lack of adequate circumscription for goods by rights of use is itself related to the problem of identifying both the nature of the good in question and who the consumers and producers of it are. Environmental assets for city dwellers are not always readily recognized although their existence may not be in doubt. Is freedom from the physical presence of industrial and commercial buildings an asset and if so in what way is it distinct from freedom from noise, air and olifactory pollution that those buildings might be associated with? If we can recognize the nature of environmental assets can we equally observe who the recipients are so that charges may be levied?

Where the asset in question is one which is common to many if it is available to anyone at all, individual consumption may be difficult to distinguish. The provision of common property rights however may depend upon the distinction of fellow-commoners.

Another reason for market failure through externalities is the failure to <u>enforce</u> existing property rights. Generally this failure is related to the prohibitive costs of policing property rights. An example is the case of oceanic rights which can be identified, such as freedom from oil pollution, and possibly assigned to international parties but which cannot easily be enforced when unobserved ships discharge oil at sea.

A further reason is that the costs of organizing a possible market in environmental assets might be expected to exceed the benefits. Usually this reason is related to the costs of obtaining sufficient information about the goods to be traded and about the potential traders.

In the case of the urban environment information is relatively scarce and its value correspondingly high. For example knowledge of values of property on the market is itself a commodity which commands a high price such as the fees paid to professional valuers and estate agents who organize the market.

In the case of other environmental markets information and organization may be as yet too costly to provide in the market place. This would be the case for example with environmental health effects of pollution in cities. Here private benefits and costs may diverge from costs and benefits to the community as a whole leading to an underinvestment in the provision of environmental health by the market.

The traditional remedy, prescribed by PIGOU (1920), required that a system of taxes and subsidies imposed upon and received by the creators of external 'diseconomies' and 'economies', be established. It can be shown (for example NATH (1969)) that under certain conditions such taxes and subsidies lead to the optimal state described above. In practice however it is difficult, if not impossible, to levy the lump sum taxes required or to identify the marginal impact on individuals, of externalities.

The alternative remedy, apart from statutory control, is the asset utilization approach, KNIGHT (1924). Essentially this approach involves the explicit recognition of the assets contingent upon the existence of external effects and their circumscription with rights of use. For example the quantity of an asset 'fresh air' consumed by households adjacent to a factory chimney, is contingent upon the quantity of smoke emitted from that chimney. Rather than tax the factory for its smoke emission, both householders and factory would be charged in accordance with the 'fresh air' that they used up. The initial assignment of asset ownership to a third party such as a 'local authority' would avoid problems of assigning rights to other parties concerned in the first place.[1] In the event that charges levied by the authority were not optimal, bargaining between the parties concerned, factory and households, could secure an efficient allocation of fresh air.

However the explicit recognition of external assets and the establishment of suitable prices for them, apart from the problem of assigning initial rights and policing subsequent ownership, may not readily be achieved. The circumstances under which this can be achieved will now be discussed for the case of residential amenities which may be or might become associated with external effects.

6.2. External Effects and Residential Amenity

It is now well known that whenever external effects have a differential effect over space then the possibility exists that their value can be determined through their varying impact on land values. This applies equally to externalities which have joint consumption characteristics as to externalities exclusive to individuals. Thus for example in the case where several households suffer noise

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1 Such problems arise as 'distributional' value judgments have to be made as the distribution of incomes is not independent of the assignment of property rights. Furthermore unless the supply of producers themselves or of households is perfectly inelastic an initial assignment in favour of either will induce an expansion of these activities in order to enjoy the 'bounty' provided by the 'right' such that the pattern of production is changed. MOHRING and BOYD (1971).

'pollution' from a motorway, those adjacent to the noise source might be expected to have paid less for their housing, ceteris paribus, than households more distant.

It should be noted that such effects in themselves do not constitute externalities. This is so simply because the payments made on purchase of a residential location reflect all the amenities available at that site. In so far as trade takes place at all an externality cannot exist. However an externality is always likely to arise whenever rights of use or protection of consumer or producer interests are not adequately circumscribed in law. This is often the case with residential amenity. For example the household which purchases a house adjacent to a park may feel deprived when the park is subsequently redeveloped as a commercial precinct. Yet while the household may have paid more for the house given the presence of the park than it otherwise would have done, in the absence of any restricted covenant which pertains to the development of the park, the household has no proprietary rights nor the right to compensation.[1] At this point an externality may be deemed to have arisen not out of the lack of initial trade, but out of the non-existence of rights of ownership for the household in the traded asset. It is apparent that to obtain an efficient resource allocation such external costs should be evaluated.

This is not a question concerned with value judgments relating to the distribution of environmental costs and benefits such as whether compensation should actually be paid or not. In practice these matters would, one hopes, be settled out of political and ethical necessity. What is important in practice, is that agents concerned with overall efficiency of resource allocation should evaluate <u>all</u> land use development costs and benefits including those external to the development itself. For example where the discounted value of 'park' amenity is greater than that of the commercial precinct then on efficiency grounds it would be unwise to

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1 A right to compensation or a restricted covenant may be granted by the courts after an appeal made under the 'law of nuisance' but not 'compensation law' which refers strictly to the extent of the rights of ownership. However the provision made for compensation in accordance with the Land Compensation Act of 1973 will enable compensation to be made more readily for deprivation of amenity, although how this Act will operate in practice remains to be seen.

redevelop the open space in this way.

One conclusion of the empirical analysis has been that environmental amenity as perceived by households can be identified and 'priced', via the residential market. In the context of environmental 'externalities', so called, we are now in a position therefore to recognize them not as externalities but as integral parts of the assets traded in the residential property market. In so far however as property rights in environment are not precisely formulated, environmental effects of land use development may be overlooked or paid inadequate attention. Therefore it is suggested that the role of local authorities concerned about efficient use of land should incorporate a method of environmental appraisal.

6.3. An Approach to Environmental Appraisal

Project appraisal or cost benefit analysis in this context is an exercise in applied economics where a project is described in detail and its present and future consequences, including environmental ones, stated in money terms. Money costs represent 'benefits foregone' the appropriate measures of which are the subjective preferences of individual consumers as expressed in the market place or by the ballot box. In principle any development project that yields a net return, after including environmental considerations, should be undertaken (provided it does not exclude other more socially profitable projects). In practice such an evaluation of 'intangible' environmental effects has been difficult to achieve. The result has been that those aspects of urban development which are readily measurable have been given the most attention. This explains for example the emphasis of many planners upon 'journey to work' criteria in determining the residential layout of cities. It is relatively simple to measure time and cost savings of a transport project.

Yet an empirical conclusion of the present analysis has been that neighbourhood environment plays a more important part in determining a 'good' residential location than access to work places and services. Other attempts to include environmental considerations issue at a time, as for example where measures of the impact on house prices of 'noise' are sought. Inconclusive results are necessarily the result of such work which does not derive the fundamental insight from an appropriate theory, that the environmental milieu of cities is an interdependent one which should not be thought of in terms of separate parts.

An appropriate theory has however been demonstrated in this work (Chapter 2) and fortunately the practical application of it in terms of environmental factor analysis does appear feasible (Chapter 4). As a result an approach to the environmental appraisal of developments in the built environment can be outlined.

The essential insight is that the building blocks of the built environment and the attributes of urban land are perceived in complex and composite fashion by city dwellers. Only by revealing the complex structure of this environmental fabric can we begin to understand locational behaviour and evaluate environmental amenity. The environmental amenities because of their interdependence cannot be evaluated directly but only indirectly through the composite environmental factors relating to the land market. The essential requisites for this evaluation to take place are twofold. Firstly information concerning the urban environment should be collected. This information would include similar variables to those used in this study. The most important variables apart from those relating to the dwelling itself would appear to be related to open space, residential density and the proximity of industrial nuisance. It ought to be quite possible for local authorities to obtain more sophisticated data on these variables than was possible in this study. For example information on the different qualities of open space and of industrial buildings could be obtained. This information would be the basic data for a factor analysis.

The second requirement is that information relating to the value of amenities be collected. Here it is necessary to find some mechanism which relates in money terms to the preferences of city dwellers for environment. The land market provides such a mechanism. Subsequent analysis of the relationships between environmental factors and land values provides the basis for calculating the prices of the amenities which relate to the environmental factors. These prices in turn provide the necessary information for evaluating proposed changes to the environmental fabric of the city.

The major difficulty of this approach is that not all the environmental effects of development need be related to a land market mechanism even where the effects are unevenly distributed over space. This is the case where individuals are unaware of the transmission of any effect as for example when air pollution is causing lung disease and hence the resultant medi-care costs but the individual does not necessarily make any relocational decisions out of ignorance. Here the appropriate economic perspective is that of the costs of medicine and any productivity loss to society rather than the price of location.

In such circumstances the local authority can invest in projects designed to mitigate health damage or prevent productivity loss. The extent to which it is willing to do so will depend upon the value, relating to a greater or lesser extent to individual preferences, which it feels such projects will have. The mechanism by which such values are derived however is a political rather than an economic one. For example public participation in planning or public approval of local authority development control through some political process would reflect democratic values. The important point however is that even here an economic perspective in terms of the costs of action and the benefits foregone by not acting, is available to help formulate community decision making.

The procedure for a local authority would be to collect data in the first instance on the physical and built environment over the extent of its area. This data would be the input for a factor analysis which would output complex environmental factors. These in turn would be the input, along with data collected on land values over the same area, into a regression analysis of land values on environmental factors. The output would eventually be amenity prices which could in turn be applied to any quantitative changes in amenity resulting from development, in order to arrive at the amenity costs involved.

The factor analysis and amenity price calculations could in fact be conducted outwith the local authority on their behalf. This would mean that the local authority would simply be involved in collecting and maintaining a matrix of environmental variables over the extent of its area, and in defining the environmental impact of any development projects that it wishes to appraise.

Development projects as we mentioned above may however also have environmental and social effects which are not reflected in price signals from the land market. To accommodate such a contingency an auxiliary procedure can be used as described in the diagram.

Firstly these effects should be identified and then secondly the costs of mitigating or preventing them worked out. This in itself could require intensive analysis as for example where psychological stress is felt to be the result of building design but where the causal relationships are not proven nor the remedies immediately known. Without having a specific project in mind however speculation on these effects is fruitless as each project will have its own peculiarities that become evident only on study in each specific case.

Information regarding the costs of remedial action can be used in conjunction with the economic appraisal of other environmental costs derived from the land market. Essentially a development project should be accepted if after all costs including amenity costs have been calculated it has a net return greater than or equal to the costs of remedying other residual environmental effects. This simply means that the project should go ahead as if necessary it can provide a return sufficient to cover costs of remedying damage, whether or not these costs are actually incurred. The decision to remedy damage is then one of distributional value rather than of efficiency, that is to say it is a question of whether the project benefits should go to the developers of the project or to the persons benefiting from any shadow project.

In essence what we are saying is that in the absence of market prices to evaluate the benefits of not damaging the environment a first approximation to these benefits is the replacement cost of that environmental amenity. In the event that any development project has a return sufficient to cover such replacement costs then the project is efficient whatever the level of environmental benefits of a shadow or remedial project. Of course a decision in these circumstances actually to implement the shadow project requires now some indication of the level of environmental benefits relative to benefits from other uses for the money.

In the case where the net return of a project does <u>not</u> cover the costs of remedying residual damage the project may still be viable. This is because there are benefits in remedying damage as well as costs. These benefits may therefore be of sufficient magnitude along with the net return of the basic project to cover any remedial costs. What is important here is that the benefits of removing damage are only ascertained by a political rather than an economic mechanism.

An example would be a development project, on the outskirts of a town, of a shopping centre where an area of natural beauty is situated. As the project is outside of the city and the area of natural beauty does not influence residential prices in the city, the environmental damage caused by the project cannot be evaluated in the land market.

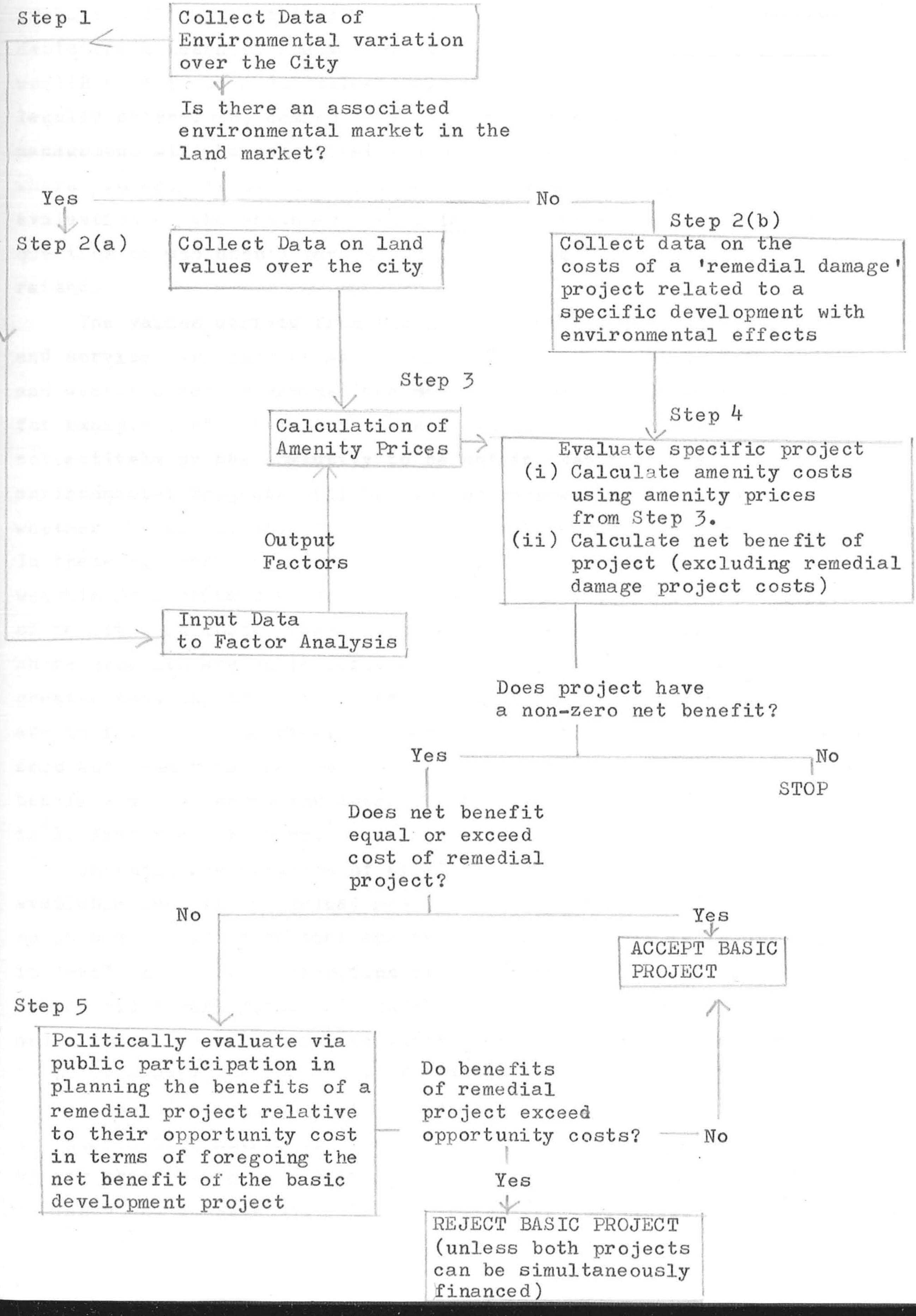
Here a 'shadow' project or as yet a hypothetical project designed to restore compensatory amenities (by landscaping, improved design of the shopping centre or provision of alternative recreational facilities) can be costed. If the net return of the shopping centre is sufficient to cover the costs of the shadow project, then the centre should be developed whether or not the shadow project is actually implemented. In the case where the net return to the shopping centre would not cover the costs of a shadow project the community would have to decide what level of <u>benefits</u> the shadow project would realize.

If there was a surplus of subjective benefits over the measurable costs of the shadow project then in principle the shadow project could be financially viable. In other words while the shopping project may have an insufficient net benefit to cover the costs of a shadow remedial damage project it may pay the community to find the extra finance elsewhere and have both projects. A diagrammatic description of the stages of this approach is shown in Diagram 6.1.

Alternatively if the only finance available is that secured by the net benefit of the commercial development it may yet be that a partial realization of the shadow project (which is now all that is possible) is sufficient to generate a level of benefits in excess of the total cost of the complete shadow project. Of course in this situation the commercial development is efficient, if undertaken with a partial realization of the shadow project.

The advantage of such a way of thinking is that it serves to place environmental projects in the perspective of the opportunities which they preclude and while the environmental project itself is not measurable in money terms the opportunity costs of it often are.

Diagram 6.1. Operational Schedule for Evaluating Development Projects with both Market and Non-Market Environmental Effects.



6.4. Environmental Appraisal and 'Distributional' Values

The role of public participation in environmental appraisal is relevant here even where environmental goods and services can be evaluated through the land market. This is so especially whenever decisions concerning the appropriate distribution of environmental wealth have to be made collectively. Where property rights have been legally determined, common or individual, then environmental management will be concentrated upon efficiency aspects. However where property rights have not been determined then after evaluation of the costs and benefits of environmental projects the question of who should pay and who should receive most benefit is raised.

The values derived from the land market for environmental goods and services are only as acceptable as the distribution of income and wealth which determined the market outcome. If it is the case for example that the distribution of income and wealth is considered collectively by the community to be unfair then benefits of environmental projects will be over or underestimated depending upon whether the recipients are high or low income and wealth classes. In these circumstances it would be desirable to adopt a set of weights reflecting the relative importance, felt by the community, of benefits on costs going to households of different income levels. Where benefits are an increasing function of income with elasticity greater than one then the distribution of benefits from a project are in favour of the rich. Where the elasticity is greater than zero and less than one the benefits mildly favour the rich. Where benefits are a decreasing function of income then a high elasticity is in favour of the poor.

Inconclusive evidence of strong distributional effects is available from the empirical results as Chapter 5. These results would seem to indicate that current income in itself is insufficient in 'explaining' the consumption of residential environment, as indeed are social class and household size. Data on wealth, savings and differential loan finance facilities for house purchase appear to be necessary for the study of the distribution of benefits.

Some indication of distributional effects can be derived from the correlation matrix of variables in Appendix A where it would appear that income is slightly negatively correlated with industrial nuisance and density and slightly positively correlated with open space.

On the basis of these slight correlations it is difficult conclusively to determine whether environmental amenity has a pro-rich distribution or not. All that can be said is that house price is significantly correlated with the environmental variables and the model of behaviour described in Chapter 2 is therefore relevant for describing how environmental benefits are distributed spatially.

Firstly individuals' utility is a function of environmental characteristics and other goods and services. Individuals, secondly, make choices from the environmental opportunities, described by sites and the set of prices corresponding to each, available to them over space. This choice is constrained by their income, wealth, borrowing power and household characteristics and by the availability of sites at a given moment in time. Individuals then adjust the pattern of their consumption to these constraints and so as to derive the most satisfaction from the characteristics of their location. Given that the availability of different environmental situations is relatively more diverse over different time periods than the diversity of household socio-economic types requiring locations then it will be difficult to observe strong relationships between socio-economic indicators and environmental consumption. However environmental values (house prices) are nevertheless strongly related to environmental characteristics so that the basis for both environmental project appraisal and the comparison of benefits over households exists.

There remains still the vexing question of what weighting system should be adopted by the community in bringing distributional values into environmental project appraisal. This however raises the more familiar problem of determining social values on the basis of collective choice. The most famous mechanism of social values is found in Kenneth Arrow's 'Social Choice and Individual Values'. Arrow set down certain minimal, but hardly sufficient, conditions which a collective choice mechanism should satisfy and found that in general it was impossible to derive such a mechanism. The conditions are firstly that of collective rationality: in any given set of individual preferences social preferences are derivable from the individual preferences; secondly the Pareto principle: if a preference for an alternative A is preferred by all individuals to an alternative B, then the social ordering ranks A above B. This has the effect of removing the 'intensity' of individuals' preferences from the choice mechanism. Thirdly, the condition that irrelevant alternatives are independent of the choice made from a set of relevant alternatives which amounts to a condition of sanity, and finally the ethical condition of non dictatorship which requires that no single individual's or group's preference is automatically society's preference.

It will be noted that these eminently reasonable conditions are hardly sufficient especially as they exclude any distributional values. The implication of this "impossibility theorem" is that systems of majority-rule cannot be guaranteed to provide collective choices whenever there are more than 2 alternatives to be considered. However what is more hopeful is the demonstration by E.T. Haefele in the American Economic Review of June 1971 that representative government can, through a system of vote trading, derive social choices without removing Arrow's conditions. The practical point of his demonstration especially relevant for environmental projects is however that legislatures mandated by the community to carry out programmes are more satisfactory, in terms of Arrow's conditions, than are committees of bureaucrats or experts carrying out executive responsibilities delegated by mandated authorities but not directly derived from the electorate. In the context of environmental projects this simply means that direct public involvement and voting is more consistent with social democratic values, in the non-pejurative sense, than executive action unconstrained by community participation. In order then to consider both efficient allocation of resources to environmental projects and their distributional impact appropriately weighted, public participation in the appraisal process is necessary.

6.5. Conclusion

In conclusion it would seem that factor analysis offers a method of reducing the complex of environmental variables to a smaller set of composite factors which can be seen as representative of the perception that urban man has of his environment. This is an important conclusion for it would then appear that the problem of resolving what is an optimal spatial configuration of locational attributes, amenity and the built environment is capable of solution in economic terms. An optimum spatial configuration of the built environment can be defined as one where no other areal rearrangement would secure a higher sum of site values. Furthermore if the concept of environment is extended to include psycho-social variables, such as health, anxiety, stress and cultural values, then the politico-economic rationale, of comparing the costs of preventing health damage or providing cultural benefits with the benefits to the community democratically expressed through the planning process, is useful.

Indeed the implication for physical planning would seem to be that it is quite compatible with the inherent value system of a market economy (emphasising individual preferences.) Physical planning would have two main functions; firstly it would be concerned with evaluating the development of the built environment using land market values to ensure that all environmental costs and benefits are accounted for and not just private ones. It would also be concerned here with instigating exchange of environmental assets between consumers and producers of environmental assets by establishing quasi markets with initial ownership of property rights vested in the local authority. Subsequent payments by polluters for rights to pollute and by consumers for rights to be pollution 'free' would establish the relative values of pollution to the individuals concerned. Where it is felt that initial ownership of environmental assets is already implicit such as for example where house owners 'pay', in the price of the house, for their neighbourhood environment, the local authority would ensure that compensation for loss of amenity be paid. This would include amenities over which the householders in the present situation held no property right in law.

Secondly, planning authorities would, where market values for environment do not exist, involve the public in participation in development planning in order to derive an expression of individual and community preferences. This process would not be a substitute for the market mechanism but an addition to it especially useful where market values are not comprehensive of all environmental effects.

The issues raised here particularly those relating to public participation in planning go beyond the scope of this present research. The fundamental idea however is germane throughout, that is, that man perceives his urban environment in a complex but structured fashion which we can measure and evaluate and hence plan for in the future. What is of paramount necessity is now not the techniques to implement that planning nor even the theory to base it on but the information, data and statistics for the implementation.

6.6. Further Research

To what extent then has this study achieved its objectives of providing a generalized residential location theory incorporating environmental effects; an operational framework for evaluating residential environments and an understanding of the nature of the socio-economic constraints on household residential expenditure?

The first objective has in large part been achieved. The essentially descriptive models of residential location behaviour which relate land prices and rent to density and distance both of which increase from the city centre have been in the past inadequately rationalized in terms of transport cost savings and site size alone. Such models are however compatible with other rationales. The structure of rents over space and the distribution of densities could be determined by a preference for low density itself. Alternatively density may only be one of many environmental factors which relate to households preferences.

The model used in this study has provided a framework wherein all these preferences can be accommodated. Moreover the empirical results have shown that accessibility is relatively unimportant compared with environmental factors. Further research should be less concerned with theoretical issues relating to descriptions of consumer equilibrium than with empirical refinements. These refinements should relate particularly to the quality of data on the environment and the collection of such data for all cities.

This should not be taken to mean that theoretical research is not useful. On the contrary theoretical developments especially on the supply side of residential models are very necessary. Such developments should look particularly for explanations of the processes of residential development and conversion of property for residential use with regard especially for the economic processes affecting the environmental quality of the stock of dwellings over time.

The second objective has also been achieved in large part. The evaluation of environmental amenity is necessary if urban development is to be measured as moving towards some efficiency goal or away from it. In this evaluation of development the spatial reorganization of land and its attributes is a key factor. Evaluation in the past has not been possible except in a piecemeal fashion such as where noise or other single dimensions of the environment have been stressed.

The key to providing an operational framework for evaluation is an understanding of the complexities of urban spatial organization in terms of consumer preference. The major contribution of this study is perhaps the provision of such an understanding both in terms of an appropriate theory and its statistical analogue.

Further research should concentrate here on methods of describing the spatial configuration of urban environments especially by computer mapping in terms of the information required for the analyses of environmental preferences via techniques such as factor analysis.

It should be understood however that there are still environmental phenomenon related to the way we order our urban land use which cannot be evaluated in terms of land prices. Such effects as stress, anxiety and physical illness are not necessarily perceived by households in the same way that the physical environment is. Yet they may be affected by spatial organization. Here the information requirements for our matrix of environmental interrelationships are simply made more extensive but evaluation now requires an analysis not in terms of land values but in terms of the values that the community puts on health. A first step towards identifying such values is the provision of estimates of the relationships between environment and health and the cost of avoiding health damage. Given that perspective decisions can be made on how much health damage should be tolerated. Further research here would include investigation of the feasibility of arriving at collective choices through the planning process.

As regards the third objective, that of understanding the nature of the socio-economic constraints on household residential expenditure, the study has in large part failed. At first sight the explanation of the failure is obvious. Lacking adequate information or data for key variables such as mortgage finance, savings and wealth, residential expenditure will hardly be explained especially in terms of simple single equation relationships. Given that the required data could not be collected for this study with sufficient accuracy or for sufficient numbers of households willing to part with this information then it is questionable whether any attempt should have been made to measure current income, social class and family type effects on expenditure. That view was not taken however on the grounds that some income and other effects ought to exist and would be of interest.

The fact that the income and social class effects on expenditure were significant but small and that family type characteristics were not significant suggests one important avenue for further research. This would be an investigation of the extent to which further variables of the sort already mentioned would improve the 'explanation' of residential expenditure. The extent to which improvements in the explanation of the variation of residential expenditure are small could then be related to the diverse needs of different socio-economic groups viz a viz the residential choices open to them. This would measure the extent to which the diversity of household types and needs was not matched by diversity of residential options at that particular time. In this research the question of 'indivisibility' of the bundle of locational goods associated with each house would be an important factor to introduce. Where a small household purchases a large dwelling because they want the open space that goes with this particular house the wrong conclusion might be drawn regarding the relationship between size of house and size of household. Given that a small dwelling be also available with the required open space at that time, then the choice is wider and residential expenditure should be easier to rationalize in terms of household characteristics.

It is the extent to which social factors are compatible with residential environmental factors in terms of reasonable expectations such as that large households buy large houses, income allowing, which is of interest. In this study the results might indicate that insufficient diversity of choice exists and that in itself is provocative and suggests an avenue for further work.

APPENDIX A The Data: A General and Statistical Description

This appendix provides a detailed description of the sample data and is organized in three parts. Firstly, a general description of the data and forms is provided. Secondly, the organization of the data in a form suitable for analysis is described. Thirdly, a statistical summary of the data is given in terms of sample statistics.

General Description

It will be recalled from Chapter 3 that the study required the collection of data on house prices, amenity and household socio-economic characteristics for each house. Each complete record in the sample includes therefore data for these categories of variable corresponding in each case to a particular house. The data was collected from the City of Nottingham by method of proportionate sampling where the proportions refer to the proportion of houses within a given price range. The proportions used were derived from an independent random sample of house prices maintained for each metropolitan district by the Department of the Environment. This procedure ensures that a non-random method of sampling, as used for this study, reproduces the sort of sample that would be obtained by true random sampling, where each population member has equal chance of being selected.

The first stage in data collection was the collection of actual selling prices of houses and of the sales particulars of each house which refer to the attributes of the dwelling itself. From two of the largest non-specialist estate agencies in Nottingham it was possible to obtain data of 210 transactions. Subsequently the household at each address was contacted with a view to securing their cooperation in the household survey required as a check on household amenity preferences and for information concerning their socio-economic status.

The second stage of the data collection was the collection of some of the data referring to the external neighbourhood amenities of each house. This data was collected in conjunction with the household social survey both being noted on the Residential Amenity Survey sheets for each house (see the enclosed data forms in APPENDIX B).

The third stage in the data collection was the collection of data from 25" - 1 inch Ordinance Survey Maps and referring to the land use within the area about each house at 1/8, $\frac{1}{4}$ and $\frac{1}{2}$ mile radius. Data on the distance of each house from the Central Business District and the green belt was obtained by measurement from 1" - 1 mile Ordinance Survey Maps. This data was collected from the Map Room at the University Library, Cambridge.

By these stages it was possible to obtain a sample of 114 complete records. It was not possible to complete each of the 210 records for which house price data was available as 30% households refused to answer the questionnaire completely and a further 16% of the remaining observations could not be utilized either because the households had moved or because land use changes had occurred which were not yet recorded on the latest Ordinance Survey Maps available for those locations.

The spatial distribution over the Nottingham housing market of the 114 records used in the analysis is given in Figure A.1. (see p. 121e)

Organization of the Data

The data from the survey sheets, maps and particulars of each dwelling was compiled on the Final Data Form (see Appendix B), each form representing a complete record for each observation in terms of 50 single or multi-dimensional variables. The data thus compiled were subsequently, reorganized to provide 67 single variables.

The Final Data Form variables are described as follows:-

1. Record Number:	An index
2. District:	An index referring to the district of Nottingham from which the observation is derived.
3. Price:	The selling price of the dwelling at 1968 prices. The prices were adjusted to 1968 levels by the Hedonic Index described in Chapter 3.
4. Garage:	Variable taking values 0, 1, or 2 depending upon whether neither a garage nor garage space is present; a garage

		space is present but not a garage and a garage is present.
5.	Age:	The construction date of the house.
6.	Central Heating:	A variable taking values 0, 1, or 2 depending upon whether the house has no, part or full central heating.
7.	Plot:	A variable measured for convenience in units of 75 sq. yds., derived from 25" - 1 mile Ordinance Survey Maps and referring to the Plot size upon which the dwelling is sited.
8.	Bedrooms:	The number of bedrooms (single or double) within the house.
9.	Type:	A variable taking the values 0, 1, 2, 3, 4 corresponding to a detached, semi-detached, end-terraced, inter-terraced house and inter-terraced without inside toilet respectively.
10.	Open space 1/8	The acreage of open space within the given area about the house.
11.	" " $\frac{1}{4}$	
12.	" " $\frac{1}{2}$	
13.	Residential space 1/8	The acreage of residential land within the given area about the house.
14.	" " $\frac{1}{4}$	
15.	" " $\frac{1}{2}$	
16.	Industrial and commercial land 1/8	The acreage of industrial and commercial land within the given area about the house.
17.	" " $\frac{1}{4}$	
18.	" " $\frac{1}{2}$	
19.	Density:	A variable taking the values 0, 1, 2, 3, 4, 5 depending upon whether the ratio of dwellings to residential land within an area of $\frac{1}{2}$ mile radius

		of the dwelling is approximately very low, low, medium, high or very high.
20.	Trees:	The number of trees within 100 yards of the dwelling.
21.	View:	Degrees of Panorama with 0 - 1 dummy variables representing features of the view.
22.	Hills:	0, 1 dummy variables for view features.
23.	Woodland:	" " " "
24.	Residential land:	" " " "
25.	Industrial and commercial land:	" " " "
26.	Parkland & Open space:	0 - 1. View dummy variable
27.	Distance from the Central Business District:	Measured in miles.
28.	Distance from the nearest main road:	Measured in miles
29.	Distance from railway:	Measured in miles.
30.	Distance from green belt:	Measured in miles.
31.	Travel Expenditure:	A composite variable representing the aggregate annual household travel expenditure for trips regularly made. Such trips include journeys to work, to shop, to school and to social activities. The journey distance is calculated for each trip and the mode of travel (bus or car) ascertained. The cash outlay per trip is calculated according to the Road Research Laboratory 1968 Formula for automobiles and including costs of wear, and fuel costs per mile. An average mileage per hour of 20 m.p.h. is assumed.

The Formula is:-

$$(2.4 + 19.8/20 \text{ m.p.h.} + .00019\ (20 \text{ m.p.h.})^2)$$

in units of old pence per mile. An addition of fuel tax of 0.8d per mile gives a total of 4.26d or 1.8p per mile. Bus fares are calculated according to the fare stages operating in 1968, the information being provided by Nottingham Corporation.

No allowance is made for psychic costs or benefits of travel nor time and convenience except perhaps the implicit assumption in the rent equation of Chapter 2 that they are a factor of proportion with respect to travel cost.

32. Household Size: The number of persons comprising the household (which in no case included non relatives).

33. Social Class: A variable derived directly from the Standard Classification of Occupations 1970, H.M.S.O. and measured from 1 (high) to 5 (low). This variable should be distinguished from Socio-Economic Grouping (S.E.G.) which includes a Social Classification weighted by income.

34. Income: A variable measuring the aggregate household income net of tax derived from the household questionnaire. In the case of persons in receipt of Pensions, the income is measured as the pension received as calculated by the standard rate of allowance. (See also income prompt sheet).

35. Males: A set of 5 variables, each taking the age of each male as a value or the value -1 for non-existent males making 5 variables in all.

36. Females: A set similar to that for males but with the ages of females indicated.

37. Travel Time: A variable derived from the household questionnaire taking the values 0, 1, or 2 indicating whether the main earner of the household spends the same, more or less time travelling to work now compared with the previous location.

38. Previous Location: A variable taking the index value of the appropriate district of Nottingham corresponding to the previous location of intra-urban movers or on the index value for the standard United Kingdom regions as classified by the Nationwide Building Society, for inter-urban movers.

39 - 47. Access: A set of variables the values of which are derived from the response to Question 13 of the Household Questionnaire. This question is a structured one requiring an indication of how important the household on moving considered access to work, a bus stop, a railway station, shops, social facilities, open space, the green belt (country-side), industrial land use, traffic and schools. The value ranges from 1, very important, through 3, indifference, to 5, very important to avoid. This variable provides

the data for the <u>confirmatory</u> analysis of Chapter 5.

48. A set of 4 variables derived from the unstructured response to Question 9 of the Household Questionnaire, coded according to the attached coding form and indicating reasons for moving. If less than 4 variables are obtained the set is made up of -1 variables.

49. A set similar to the above but referring to Question 10 of the Questionnaire and indicating reasons for the choice of house and neighbourhood.

50. A set similar to the above but referring to Question 11 of the Questionnaire and indicating dislikes concerning the chosen house and neighbourhood.

These 67 single variables on each Final Data form were put up on to magnetic tape and subsequently reanalysed to provide a final data set of 68 variables. The reanalysis of data which applied to the variables numbered 35, 36, 38, 48, 49 and 50 is described as follows:-

Variable 35: The ages of males becomes 4 single variables indicating the number of male children (less than 12 years of age); the number of male adolescents (12 18); the number of male adults (18 65); and the number of males older than 65 years.

Variable 36: A new set of 4 variables similar to the above but for female members of the household.

Variable 38: Previous location becomes a variable for 'asset worth' taking the value of regional house price index; where the region corresponds to the previous household location. New households are identified from Variable 48 where the reasons for moving are identified.

Marriage is the sole reason for the establishment of a new household and an asset worth value of zero is assigned to these households. This variable does not therefore measure savings but only the relative value of the households previous dwelling. (see enclosed Table of Index Numbers).

Variables 48, 49 and 50: These variables derived from the household questionnaire are converted to four 0 - 1 dummy variables indicating which of Amenity, Access, House quality and Social reasons are cited by the household for each of questions 9, 10 and 11 of the Questionnaire. In addition a 0 - 1 dummy variable indicating whether the household is a new one or not is derived from Variable 48.

Variables 3 - 30 are utilized in the Factor Analyses; while Variables 31 - 68 are utilized in the confirmatory analysis and also in the examination of any relationships between house amenity and type of household.

The Final Data set is stored on magnetic tape, paper tape and I.B.M. cards and is available from the author on request.

Statistical Summary

The final data set is further described below in terms of sample statistics. The following key is used and refers to the Tables of Histograms

VMU = Variable Mean

SIGMA = Standard Deviation

SKEW = Coefficient of Skewness

$$= \left[\frac{\frac{1}{N} \sum_{i=1}^{N} v_i^{3} - \frac{3}{N} \bar{v} \sum_{i=1}^{N} + 2(\bar{v})^{3}}{\sigma^{3}} \right]$$

VMIN = Minimum value of variable

VMAX = Maximum value of variable

NV = Number of Records

As well as these statistics the complete correlation matrix for variables 3 - 67 is constructed. It is worthwhile recalling that the reduced correlation matrix of variables 4 - 31 was the basic input for the factor analyses. The factor structure utilized for the construction of amenity prices through the regression with house price (variable 3) was derived from the correlation matrix of variables 4 - 7, 9 - 19, and 27 - 30. Of the remaining variables Bedrooms (variable 8) and Travel Expenditure (variable 31) were included in the regression analysis as specific factors not pertaining to any common factor structure (see Chapter 5). Variables 20 - 26 pertaining to trees and view were not included in the reduced factor analysis as clearly they did not belong to any common or specific factor structure (Chapter 5).

```
H I S T O G R A M     House Price
-----------------

VMU=  3407.94312     SIGMA=  16[illegible].58936     SKEW=     1.00800     VMIN=   750.00000     VMAX=  8888.00000     NV=  114

-----------------------------------------------------------------------------------------------------------------------
          RANGE                 FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
-----------------------------------------------------------------------------------------------------------------------
  1    750.0000   1136.8999     4  ****
  2   1136.8999   1523.7998     5  *****
  3   1523.7998   1910.6997     7  *******
  4   1910.6997   2297.5996    13  *************
  5   2297.5996   2684.4995     5  *****
  6   2684.4995   3071.3994     7  *******
  7   3071.3994   3458.2993    16  ****************
  8   3458.2993   3845.1992    24  ************************
  9   3845.1992   4232.0977    12  ************
 10   4232.0977   4618.9961     5  *****
 11   4618.9961   5005.8945     4  ****
 12   5005.8945   5392.7930     4  ****
 13   5392.7930   5779.6914     2  **
 14   5779.6914   6166.5898     0
 15   6166.5898   6553.4883     1  *
 16   6553.4883   6940.3867     1  *
 17   6940.3867   7327.2852     1  *
 18   7327.2852   7714.1836     0
 19   7714.1836   8101.0820     1  *
 20   8101.0820   8888.0000     2  **
-----------------------------------------------------------------------------------------------------------------------
      SCALING FACTOR = 1
-----------------------------------------------------------------------------------------------------------------------


H I S T O G R A M     Garage    0= None ;  1= Garage Space ;  2 = Garage
-----------------

VMU=     1.29629     SIGMA=     0.85769     SKEW=    -0.61254     VMIN=     0.0     VMAX=     2.00000     NV=   114

-----------------------------------------------------------------------------------------------------------------------
          RANGE                 FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
-----------------------------------------------------------------------------------------------------------------------
  1    -0.5000     0.5000    30  ******************************
  2     0.5000     1.5000    20  ********************
  3     1.5000     2.5000    64  ****************************************************************
-----------------------------------------------------------------------------------------------------------------------
      SCALING FACTOR = 1
-----------------------------------------------------------------------------------------------------------------------
```

```
H I S T O G R A M          Construction Date.
-----------------

VMU=  1938.05151     SIGMA=     29.86636     SKEW=     -4.15123     VMIN=  1714.00000     VMAX=  1969.00000     NV=   114

-----------------------------------------------------------------------------------------------------------------------
          RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
-----------------------------------------------------------------------------------------------------------------------
  1  1714.0000  1735.2500    1 *
  2  1735.2500  1756.5000    0
  3  1756.5000  1777.7500    0
  4  1777.7500  1799.0000    0
  5  1799.0000  1820.2500    0
  6  1820.2500  1841.5000    0
  7  1841.5000  1862.7500    0
  8  1862.7500  1884.0000    0
  9  1884.0000  1905.2500   12 ************
 10  1905.2500  1926.5000   15 ***************
 11  1926.5000  1947.7500   38 **************************************
 12  1947.7500  1969.0000   48 ************************************************
-----------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
-----------------------------------------------------------------------------------------------------------------------


H I S T O G R A M      Central Heating – 0= None;  1= Part;  2= Full
-----------------

VMU=      0.57017      SIGMA=      0.84780      SKEW=      0.94592     VMIN=      0.0          VMAX=      2.00000      NV=   114

-----------------------------------------------------------------------------------------------------------------------
           RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
-----------------------------------------------------------------------------------------------------------------------
  1     -0.5000      0.5000   76 ****************************************************************************
  2      0.5000      1.5000   11 ***********
  3      1.5000      2.5000   27 ***************************
-----------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
-----------------------------------------------------------------------------------------------------------------------


H I S T O G R A M            Bedrooms
-----------------

VMU=      2.99122      SIGMA=      0.59967      SKEW=      0.48931      VMIN=      2.00000      VMAX=      5.00000      NV=   114

-----------------------------------------------------------------------------------------------------------------------
           RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
-----------------------------------------------------------------------------------------------------------------------
  1      1.5000      2.5000   19 *******************
  2      2.5000      3.5000   79 *******************************************************************************
  3      3.5000      4.5000   14 **************
  4      4.5000      5.5000    2 **
-----------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
-----------------------------------------------------------------------------------------------------------------------
```

H I S T O G R A M   Plot size (units of 75 sq. yds)

```
VMU=   4.89472    SIGMA=   2.89558    SKEW=   1.50095    VMIN=   1.00000    VMAX=   16.00000    NV=   114
----------------------------------------------------------------------------------------------------------------
          RANGE             FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
----------------------------------------------------------------------------------------------------------------
  1      0.5000     1.5000   13 *************
  2      1.5000     2.5000    8 ********
  3      2.5000     3.5000   20 ********************
  4      3.5000     4.5000   22 **********************
  5      4.5000     5.5000   16 ****************
  6      5.5000     6.5000   15 ***************
  7      6.5000     7.5000    4 ****
  8      7.5000     8.5000    3 ***
  9      8.5000     9.5000    2 **
 10      9.5000    10.5000    6 ******
 11     10.5000    11.5000    0
 12     11.5000    12.5000    3 ***
 13     12.5000    13.5000    0
 14     13.5000    14.5000    0
 15     14.5000    15.5000    0
 16     15.5000    16.5000    2 **
----------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
----------------------------------------------------------------------------------------------------------------
```

H I S T O G R A M   Type   0: Detached ; 1: Semi-Detached ; 2: End Terraced ; 3: Inter Terraced   4: Inter Terraced (outside toilet)

```
VMU=   0.96491    SIGMA=   1.13114    SKEW=   1.23258    VMIN=   0.0    VMAX=   4.00000    NV=   114
----------------------------------------------------------------------------------------------------------------
          RANGE             FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
----------------------------------------------------------------------------------------------------------------
  1     -0.5000     0.5000   48 ************************************************
  2      0.5000     1.5000   44 ********************************************
  3      1.5000     2.5000    5 *****
  4      2.5000     3.5000   12 ************
  5      3.5000     4.5000    5 *****
----------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
----------------------------------------------------------------------------------------------------------------
```

H I S T O G R A M   Open Space 1/8 ml. (acres)

```
VMU=   4.75314    SIGMA=   4.02900    SKEW=   0.89965    VMIN=   0.0    VMAX=   17.00000    NV=   114
----------------------------------------------------------------------------------------------------------------
          RANGE             FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
----------------------------------------------------------------------------------------------------------------
  1      0.0        2.8333   44 ********************************************
  2      2.8333     5.6667   31 *******************************
  3      5.6667     8.5000   19 *******************
  4      8.5000    11.3333   12 ************
```

```
H I S T O G R A M        Open Space 1/4 mi (acres)

VMO=   25.72762    SIGMA=   17.39783    SKEW=    0.71258    VMIN=     0.0         VMAX=    71.00000      NV=   114

------------------------------------------------------------------------------------------------------------------------
           RANGE            FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
------------------------------------------------------------------------------------------------------------------------
  1      0.0          5.9167     9 *********
  2      5.9167      11.8333    21 *********************
  3     11.8333      17.7500    12 ************
  4     17.7500      23.6666    15 ***************
  5     23.6666      29.5833    15 ***************
  6     29.5833      35.5000    12 ************
  7     35.5000      41.4166    10 **********
  8     41.4166      47.3333     5 *****
  9     47.3333      53.2499     5 *****
 10     53.2499      59.1666     4 ****
 11     59.1666      65.0832     2 **
 12     65.0832      71.0000     4 ****
------------------------------------------------------------------------------------------------------------------------
    SCALING FACTOR = 1
------------------------------------------------------------------------------------------------------------------------

H I S T O G R A M        Open Space 1/2 mi (acres)

VMO=   135.06067    SIGMA=   69.22095    SKEW=    0.66173    VMIN=    40.00000      VMAX=   333.00000      NV=   114

------------------------------------------------------------------------------------------------------------------------
           RANGE            FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
------------------------------------------------------------------------------------------------------------------------
  1     40.0000      56.2778    13 *************
  2     56.2778      72.5555    12 ************
  3     72.5555      88.8333    11 ***********
  4     88.8333     105.1111     9 *********
  5    105.1111     121.3889    13 *************
  6    121.3889     137.6666     8 ********
  7    137.6666     153.9444     7 *******
  8    153.9444     170.2222     9 *********
  9    170.2222     186.4999     5 *****
 10    186.4999     202.7777     8 ********
 11    202.7777     219.0555     2 **
 12    219.0555     235.3333     2 **
 13    235.3333     251.6110     5 *****
 14    251.6110     267.8887     4 ****
 15    267.8887     284.1663     3 ***
 16    284.1663     300.4438     2 **
 17    300.4438     316.7214     0
 18    316.7214     333.0000     1 *
------------------------------------------------------------------------------------------------------------------------
    SCALING FACTOR = 1
------------------------------------------------------------------------------------------------------------------------
```

```
H I S T O G R A M          Residential land (1/8 ml) acres
-----------------

VMU=   18.23669     SIGMA=     4.14990     SKEW=    -0.40790     VMIN=     8.00000     VMAX=    25.00000     NV=   114

-------------------------------------------------------------------------------------------------------------------------------
              RANGE             FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
-------------------------------------------------------------------------------------------------------------------------------
   1      8.0000      10.8333     7 *******
   2     10.8333      13.6667    10 **********
   3     13.6667      16.5000    21 *********************
   4     16.5000      19.3333    23 ***********************
   5     19.3333      22.1666    35 ***********************************
   6     22.1666      25.0000    18 ******************
-------------------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
-------------------------------------------------------------------------------------------------------------------------------
```

```
H I S T O G R A M          Residential land 1/4 ml (acres)
-----------------

VMU=    63.36780     SIGMA=    19.23190     SKEW=    -0.82572     VMIN=     0.0          VMAX=    98.00000     NV=   114

-------------------------------------------------------------------------------------------------------------------------------
              RANGE             FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
-------------------------------------------------------------------------------------------------------------------------------
   1      0.0          8.1667     1 *
   2      8.1667      16.3333     2 **
   3     16.3333      24.5000     0
   4     24.5000      32.6666     7 *******
   5     32.6666      40.8333     5 *****
   6     40.8333      49.0000     9 *********
   7     49.0000      57.1666    11 ***********
   8     57.1666      65.3333    17 *****************
   9     65.3333      73.4999    26 **************************
  10     73.4999      81.6666    17 *****************
  11     81.6666      89.8332    14 **************
  12     89.8332      98.0000     5 *****
-------------------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
-------------------------------------------------------------------------------------------------------------------------------
```

```
H I S T O G R A M          Residential land 1/2 ml (acres)
-----------------

VMU=   218.77110     SIGMA=    62.38196     SKEW=    -0.32664     VMIN=    26.00000     VMAX=   352.00000     NV=   114

------------------------------------------------------------------------------------------------------------------------
            RANGE           FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
------------------------------------------------------------------------------------------------------------------------
  1     26.0000    44.1111    1 *
  2     44.1111    62.2222    0
  3     62.2222    80.3333    1 *
  4     80.3333    98.4444    1 *
  5     98.4444   116.5555    3 ***
  6    116.5555   134.6666    4 ****
  7    134.6666   152.7777   10 **********
  8    152.7777   170.8888    7 *******
  9    170.8888   188.9999    8 ********
 10    188.9999   207.1110   10 **********
 11    207.1110   225.2221   16 ****************
 12    225.2221   243.3332   10 **********
 13    243.3332   261.4441   11 ***********
 14    261.4441   279.5552   12 ************
 15    279.5552   297.6663    7 *******
 16    297.6663   315.7773    7 *******
 17    315.7773   333.8894    5 *****
 18    333.8884   352.0000    1 *
------------------------------------------------------------------------------------------------------------------------
      SCALING FACTOR = 1
------------------------------------------------------------------------------------------------------------------------


H I S T O G R A M          Industrial and Commercial land 1/8 ml (acres)
-----------------

VMU=     2.04385     SIGMA=     3.46762     SKEW=     1.91711     VMIN=     0.0        VMAX=    15.00000     NV=   114

------------------------------------------------------------------------------------------------------------------------
            RANGE           FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
------------------------------------------------------------------------------------------------------------------------
  1      0.0        2.5000   85 *************************************************************************************
  2      2.5000     5.0000   11 ***********
  3      5.0000     7.5000    7 *******
  4      7.5000    10.0000    6 ******
  5     10.0000    12.5000    1 *
  6     12.5000    15.0000    4 ****
------------------------------------------------------------------------------------------------------------------------
      SCALING FACTOR = 1
------------------------------------------------------------------------------------------------------------------------
```

```
H I S T O G R A M          Industrial and Commercial land 1/4 ml (acres)
-----------------
VMU=    9.86839    SIGMA=    12.54712    SKEW=    1.87266    VMIN=    0.0         VMAX=    64.00000    NV=   114

----------------------------------------------------------------------------------------------------------------------
          RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
----------------------------------------------------------------------------------------------------------------------
  1      0.0        5.3333   54 ******************************************************
  2     5.3333     10.6667   20 ********************
  3    10.6667     16.0000   12 ************
  4    16.0000     21.3333   11 ***********
  5    21.3333     26.6667    8 ********
  6    26.6667     32.0000    3 ***
  7    32.0000     37.3333    1 *
  8    37.3333     42.6666    1 *
  9    42.6666     48.0000    1 *
 10    48.0000     53.3333    1 *
 11    53.3333     58.6666    1 *
 12    58.6666     64.0000    1 *
----------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
----------------------------------------------------------------------------------------------------------------------


H I S T O G R A M          Industrial and Commercial land 1/2 ml (acres)
-----------------
VMU=    42.66628    SIGMA=    46.27774    SKEW=    1.35545    VMIN=    0.0         VMAX=    241.00000    NV=   114

----------------------------------------------------------------------------------------------------------------------
          RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
----------------------------------------------------------------------------------------------------------------------
  1      0.0       13.3889   38 **************************************
  2    13.3889     26.7778   25 *************************
  3    26.7778     40.1667   11 ***********
  4    40.1667     53.5555    3 ***
  5    53.5555     66.9444    6 ******
  6    66.9444     80.3333    4 ****
  7    80.3333     93.7222    6 ******
  8    93.7222    107.1111   11 ***********
  9   107.1111    120.5000    1 *
 10   120.5000    133.8889    4 ****
 11   133.8889    147.2777    3 ***
 12   147.2777    160.6666    1 *
 13   160.6666    174.0555    0
 14   174.0555    187.4444    0
 15   187.4444    200.8333    0
 16   200.8333    214.2222    0
 17   214.2222    227.6111    0
 18   227.6111    241.0000    1 *
----------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
----------------------------------------------------------------------------------------------------------------------
```

```
H I S T O G R A M
```

Density 0=V.Low, 1=Low, 2= Medium, 3= High, 4: Very High (See Appendix A for details of measure used)

```
VMU=     1.89473     SIGMA=     1.21661     SKEW=     0.17255     VMIN=     0.0          VMAX=     4.00000     NV=    114

----------------------------------------------------------------------------------------------------------------------------
            RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
----------------------------------------------------------------------------------------------------------------------------
  1     -0.5000      0.5000    16 ****************
  2      0.5000      1.5000    28 ****************************
  3      1.5000      2.5000    37 *************************************
  4      2.5000      3.5000    18 ******************
  5      3.5000      4.5000    15 ***************
----------------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
----------------------------------------------------------------------------------------------------------------------------
```

```
H I S T O G R A M
```

Trees (no. within 100yds radius)

```
VMU=     11.70173     SIGMA=     17.08769     SKEW=     3.12104     VMIN=     0.0          VMAX=    100.00000     NV=    114

----------------------------------------------------------------------------------------------------------------------------
            RANGE      .   FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
----------------------------------------------------------------------------------------------------------------------------
  1      0.0         5.0000    54 ******************************************************
  2      5.0000     10.0000    25 *************************
  3     10.0000     15.0000     7 *******
  4     15.0000     20.0000    10 **********
  5     20.0000     25.0000     3 ***
  6     25.0000     30.0000     8 ********
  7     30.0000     35.0000     1 *
  8     35.0000     40.0000     1 *
  9     40.0000     45.0000     0
 10     45.0000     50.0000     2 **
 11     50.0000     55.0000     0
 12     55.0000     60.0000     0
 13     60.0000     65.0000     0
 14     65.0000     70.0000     0
 15     70.0000     75.0000     1 *
 16     75.0000     80.0000     0
 17     80.0000     85.0000     0
 18     85.0000     90.0000     0
 19     90.0000     95.0000     0
 20     95.0000    100.0000     2 **
----------------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
----------------------------------------------------------------------------------------------------------------------------
```

```
H I S T O G R A M                    View.

VMU=    60.87656     SIGMA=    73.07405     SKEW=      1.26870     VMIN=     0.0          VMAX=    300.00000     NV=    114
------------------------------------------------------------------------------------------------------------------------
            RANGE            FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
------------------------------------------------------------------------------------------------------------------------
  1      0.0       16.6667   45 *********************************************
  2     16.6667    33.3333   18 ******************
  3     33.3333    50.0000    9 *********
  4     50.0000    66.6666    4 ****
  5     66.6665    83.3333    4 ****
  6     83.3333    99.9999    7 *******
  7     99.9999   116.6665    5 *****
  8    116.6666   133.3333    0
  9    133.3333   149.9999    0
 10    149.9999   166.6666    4 ****
 11    166.6666   183.3332    9 *********
 12    183.3332   199.9999    1 *
 13    199.9999   216.6665    4 ****
 14    216.6665   233.3332    2 **
 15    233.3332   249.9998    0
 16    249.9995   266.6655    0
 17    266.6665   283.3330    0
 18    283.3330   300.0000    2 **
------------------------------------------------------------------------------------------------------------------------
    SCALING FACTOR = 1
------------------------------------------------------------------------------------------------------------------------


H I S T O G R A M                    View Feature (Hills)   0 - 1 Dummy        1 indicates presence.

VMU=     0.14912     SIGMA=     0.35621     SKEW=      1.97007     VMIN=     0.0          VMAX=      1.00000     NV=    114
------------------------------------------------------------------------------------------------------------------------
            RANGE            FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
------------------------------------------------------------------------------------------------------------------------
  1     -0.5000     0.5000   97 *************************************************************************************************
  2      0.5000     1.5000   17 *****************
------------------------------------------------------------------------------------------------------------------------
    SCALING FACTOR = 1
------------------------------------------------------------------------------------------------------------------------


H I S T O G R A M                    View Feature - Woodland          0-1    1 indicates presence

VMU=     0.22807     SIGMA=     0.41959     SKEW=      1.29618     VMIN=     0.0          VMAX=      1.00000     NV=    114
------------------------------------------------------------------------------------------------------------------------
            RANGE            FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
------------------------------------------------------------------------------------------------------------------------
  1     -0.5000     0.5000   88 ****************************************************************************************
  2      0.5000     1.5000   26 **************************
------------------------------------------------------------------------------------------------------------------------
    SCALING FACTOR = 1
------------------------------------------------------------------------------------------------------------------------
```

```
H I S T O G R A M                View feature - Houses.      0-1   1 indicates presence
-----------------
VMU=     0.60526     SIGMA=     0.48879     SKEW=    -0.43069     VMIN=     0.0         VMAX=     1.00000     NV=   114
----------------------------------------------------------------------------------------------------------------------
            RANGE         FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
----------------------------------------------------------------------------------------------------------------------
  1    -0.5000     0.5000    45 *********************************************
  2     0.5000     1.5000    69 *********************************************************************
----------------------------------------------------------------------------------------------------------------------
      SCALING FACTOR = 1
----------------------------------------------------------------------------------------------------------------------

H I S T O G R A M                View feature - Industry             0-1    1 indicates presence
-----------------
VMU=     0.20175     SIGMA=     0.40131     SKEW=     1.48637     VMIN=     0.0         VMAX=     1.00000     NV=   114
----------------------------------------------------------------------------------------------------------------------
            RANGE         FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
----------------------------------------------------------------------------------------------------------------------
  1    -0.5000     0.5000    91 *******************************************************************************************
  2     0.5000     1.5000    23 ***********************
----------------------------------------------------------------------------------------------------------------------
      SCALING FACTOR = 1
----------------------------------------------------------------------------------------------------------------------

H I S T O G R A M                View feature - Parkland    0-1   Dummy    1 indicates Presence
-----------------
VMU=     0.28070     SIGMA=     0.44934     SKEW=     0.97609     VMIN=     0.0         VMAX=     1.00000     NV=   114
----------------------------------------------------------------------------------------------------------------------
            RANGE         FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
----------------------------------------------------------------------------------------------------------------------
  1    -0.5000     0.5000    82 **********************************************************************************
  2     0.5000     1.5000    32 ********************************
----------------------------------------------------------------------------------------------------------------------
      SCALING FACTOR = 1
----------------------------------------------------------------------------------------------------------------------
```

```
H I S T O G R A M
-----------------
```

Distance from city centre (miles)

```
VMU=     3.72486      SIGMA=      2.22851      SKEW=      1.00999      VMIN=      1.00000      VMAX=      9.00000      NV=   114
---------------------------------------------------------------------------------------------------------------------------------
          RANGE             FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
---------------------------------------------------------------------------------------------------------------------------------
   1      0.5000      1.5000    11 ***********
   2      1.5000      2.5000    37 *************************************
   3      2.5000      3.5000    36 ************************************
   4      3.5000      4.5000     0
   5      4.5000      5.5000     0
   6      5.5000      6.5000     7 *******
   7      6.5000      7.5000    15 ***************
   8      7.5000      8.5000     3 ***
   9      8.5000      9.5000     5 *****
---------------------------------------------------------------------------------------------------------------------------------
      SCALING FACTOR = 1
---------------------------------------------------------------------------------------------------------------------------------
```

```
H I S T O G R A M
-----------------
```

Distance from Main road (miles)

```
VMU=     0.18540      SIGMA=      0.16163      SKEW=      1.12906      VMIN=      0.0          VMAX=      0.80000      NV=   114
---------------------------------------------------------------------------------------------------------------------------------
          RANGE             FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
---------------------------------------------------------------------------------------------------------------------------------
   1      0.0         0.0533    25 *************************
   2      0.0533      0.1067    16 ****************
   3      0.1067      0.1600    19 *******************
   4      0.1600      0.2133    19 *******************
   5      0.2133      0.2667    10 **********
   6      0.2667      0.3200     4 ****
   7      0.3200      0.3733     4 ****
   8      0.3733      0.4267     3 ***
   9      0.4267      0.4800     0
  10      0.4800      0.5333    13 *************
  11      0.5323      0.5867     0
  12      0.5867      0.6400     0
  13      0.6400      0.6933     0
  14      0.6933      0.7467     0
  15      0.7467      0.8000     1 *
---------------------------------------------------------------------------------------------------------------------------------
      SCALING FACTOR = 1
---------------------------------------------------------------------------------------------------------------------------------
```

```
H I S T O G R A M
-----------------
```

Distance from Green Belt (miles)

```
VMU=     1.93157      SIGMA=      1.49144      SKEW= -    0.71125      VMIN=      0.0          VMAX=      5.25000      NV=   114
---------------------------------------------------------------------------------------------------------------------------------
          RANGE             FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
---------------------------------------------------------------------------------------------------------------------------------
   1     -0.5000      0.5000    19 *******************
   2      0.5000      1.5000    41 *****************************************
   3      1.5000      2.5000    27 ***************************
   4      2.5000      3.5000     5 *****
   5      3.5000      4.5000    11 ***********
   6      4.5000      5.7500    11 ***********
---------------------------------------------------------------------------------------------------------------------------------
```

HISTOGRAM

Distance from Railway (miles)

VMU= 0.52482 SIGMA= 0.48864 SKEW= 1.79920 VMIN= 0.0 VMAX= 2.50000 NV= 114

	RANGE		FREQ.	1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
1	0.0	0.1667	26	**************************
2	0.1667	0.3333	24	************************
3	0.3333	0.5000	12	************
4	0.5000	0.6667	22	**********************
5	0.6667	0.8333	8	********
6	0.8333	1.0000	3	***
7	1.0000	1.1667	11	***********
8	1.1667	1.3333	1	*
9	1.3333	1.5000	0	
10	1.5000	1.6667	1	*
11	1.6667	1.8333	0	
12	1.8333	2.0000	0	
13	2.0000	2.1667	5	*****
14	2.1667	2.3333	0	
15	2.3333	2.5000	1	*

SCALING FACTOR = 1

HISTOGRAM

Travel Expenditure (household p.a.) £.

VMU= 32.48738 SIGMA= 26.56647 SKEW= 1.41853 VMIN= 0.0 VMAX= 150.00000 NV= 114

	RANGE		FREQ.	T...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
1	0.0	5.0000	18	******************
2	5.0000	10.0000	9	*********
3	10.0000	15.0000	5	*****
4	15.0000	20.0000	7	*******
5	20.0000	25.0000	3	***
6	25.0000	30.0000	11	***********
7	30.0000	35.0000	21	*********************
8	35.0000	40.0000	9	*********
9	40.0000	45.0000	8	********
10	45.0000	50.0000	3	***
11	50.0000	55.0000	4	****
12	55.0000	60.0000	1	*
13	60.0000	65.0000	3	***
14	65.0000	70.0000	3	***
15	70.0000	75.0000	0	
16	75.0000	80.0000	1	*
17	80.0000	85.0000	2	**
18	85.0000	90.0000	2	**
19	90.0000	95.0000	0	
20	95.0000	100.0000	1	*
21	100.0000	105.0000	0	
22	105.0000	110.0000	2	**
23	110.0000	115.0000	0	
24	115.0000	120.0000	0	
25	120.0000	125.0000	0	
26	125.0000	130.0000	0	
27	130.0000	135.0000	0	
28	135.0000	140.0000	0	
29	140.0000	145.0000	0	
30	145.0000	150.0000	1	*

SCALING FACTOR = 1

```
H I S T O G R A M          Household Size.
-----------------

VMU=    3.29241      SIGMA=      1.09869      SKEW=      0.17075      VMIN=      1.00000      VMAX=      6.00000      NV=   105

------------------------------------------------------------------------------------------------------------------------------
         RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
------------------------------------------------------------------------------------------------------------------------------
  1      0.5000      1.5000    2 **
  2      1.5000      2.5000   28 ****************************
  3      2.5000      3.5000   31 *******************************
  4      3.5000      4.5000   28 ****************************
  5      4.5000      5.5000   16 ****************
  6      5.5000      6.5000    1 *
------------------------------------------------------------------------------------------------------------------------------
      SCALING FACTOR = 1
------------------------------------------------------------------------------------------------------------------------------

H I S T O G R A M               Social Class      1 = High
-----------------

VMU=    2.62854      SIGMA=      0.89722      SKEW=     -0.23044      VMIN=      1.00000      VMAX=      5.00000      NV=   105

------------------------------------------------------------------------------------------------------------------------------
         RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
------------------------------------------------------------------------------------------------------------------------------
  1      0.5000      1.5000   14 **************
  2      1.5000      2.5000   26 **************************
  3      2.5000      3.5000   51 ***************************************************
  4      3.5000      4.5000   13 *************
  5      4.5000      5.5000    1 *
------------------------------------------------------------------------------------------------------------------------------
      SCALING FACTOR = 1
------------------------------------------------------------------------------------------------------------------------------

H I S T O G R A M      Household Income (net per annum)
-----------------

VMU=  2012.29468      SIGMA=   969.34766      SKEW=      2.58982      VMIN=    150.00000      VMAX=   8000.00000      NV=   102

------------------------------------------------------------------------------------------------------------------------------
          RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
------------------------------------------------------------------------------------------------------------------------------
  1    150.0000     542.5000    1 *
  2    542.5000     935.0000    2 **
  3    935.0000    1327.5000   16 ****************
  4   1327.5000    1720.0000   23 ***********************
  5   1720.0000    2112.5000   26 **************************
  6   2112.5000    2505.0000   14 **************
  7   2505.0000    2897.5000    5 *****
  8   2897.5000    3290.0000    8 ********
  9   3290.0000    3682.5000    3 ***
 10   3682.5000    4075.0000    2 **
 11   4075.0000    4467.5000    0
 12   4467.5000    4860.0000    1 *
 13   4860.0000    5252.5000    0
 14   5252.5000    5645.0000    0
 15   5645.0000    6037.5000    0
 16   6037.5000    6430.0000    0
 17   6430.0000    6822.5000    0
 18   6822.5000    7215.0000    0
 19   7215.0000    7607.5000    0
 20   7607.5000    8000.0000    1 *
------------------------------------------------------------------------------------------------------------------------------
      SCALING FACTOR = 1
------------------------------------------------------------------------------------------------------------------------------
```

Male Children < 10 years of age

```
H I S T O G R A M

VMU=    0.53509     SIGMA=    0.76296     SKEW=     1.48154    VMIN=     0.0          VMAX=     3.00000     NV=   114

-------------------------------------------------------------------------------------------------------------------------
            RANGE            FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
-------------------------------------------------------------------------------------------------------------------------
  1    -0.5000     0.5000    68 ********************************************************************
  2     0.5000     1.5000    35 ***********************************
  3     1.5000     2.5000     7 *******
  4     2.5000     3.5000     4 ****
-------------------------------------------------------------------------------------------------------------------------
      SCALING FACTOR = 1
-------------------------------------------------------------------------------------------------------------------------
```

Male adolescents < 18 years of age

```
H I S T O G R A M

VMU=    0.13158     SIGMA=    0.36306     SKEW=     2.71454    VMIN=     0.0          VMAX=     2.00000     NV=   114

-------------------------------------------------------------------------------------------------------------------------
            RANGE            FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
-------------------------------------------------------------------------------------------------------------------------
  1    -0.5000     0.5000   100 ****************************************************************************************************
  2     0.5000     1.5000    13 *************
  3     1.5000     2.5000     1 *
-------------------------------------------------------------------------------------------------------------------------
      SCALING FACTOR = 1
-------------------------------------------------------------------------------------------------------------------------
```

Male adults ≥ 18yrs ≤ 65yrs.

```
H I S T O G R A M

VMU=    0.93859     SIGMA=    0.46425     SKEW=     0.83743    VMIN=     0.0          VMAX=     3.00000     NV=   114

-------------------------------------------------------------------------------------------------------------------------
            RANGE            FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
-------------------------------------------------------------------------------------------------------------------------
  1    -0.5000     0.5000    14 **************
  2     0.5000     1.5000    95 ***********************************************************************************************
  3     1.5000     2.5000     3 ***
  4     2.5000     3.5000     2 **
-------------------------------------------------------------------------------------------------------------------------
      SCALING FACTOR = 1
-------------------------------------------------------------------------------------------------------------------------
```

Male Aged > 65 years

```
H I S T O G R A M

VMU=    0.05263     SIGMA=    0.22330     SKEW=     4.00694    VMIN=     0.0          VMAX=     1.00000     NV=   114

-------------------------------------------------------------------------------------------------------------------------
            RANGE            FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
-------------------------------------------------------------------------------------------------------------------------
  1    -0.5000     0.5000   108 ******************************************************
  2     0.5000     1.5000     6 ***
-------------------------------------------------------------------------------------------------------------------------
      SCALING FACTOR = 2
-------------------------------------------------------------------------------------------------------------------------
```

Female Children < 10 years

```
H I S T O G R A M
-----------------

VMU=     0.39474     SIGMA=     0.65719     SKEW=     1.59717     VMIN=     0.0          VMAX=     3.00000     NV=   114

------------------------------------------------------------------------------------------------------------------------
           RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
------------------------------------------------------------------------------------------------------------------------
  1    -0.5000      0.5000    79  *******************************************************************************
  2     0.5000      1.5000    26  **************************
  3     1.5000      2.5000     8  ********
  4     2.5000      3.5000     1  *
------------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
------------------------------------------------------------------------------------------------------------------------
```

Female Adolescents < 18 years

```
H I S T O G R A M
-----------------

VMU=     0.03509     SIGMA=     0.18400     SKEW=     5.05336     VMIN=     0.0          VMAX=     1.00000     NV=   114

------------------------------------------------------------------------------------------------------------------------
           RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
------------------------------------------------------------------------------------------------------------------------
  1    -0.5000      0.5000   110  *******************************************************
  2     0.5000      1.5000     4  **
------------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 2
------------------------------------------------------------------------------------------------------------------------
```

Female Adults ≥ 18 years ≤ 60 years

```
H I S T O G R A M
-----------------

VMU=     0.90351     SIGMA=     0.37392     SKEW=    -1.05437     VMIN=     0.0          VMAX=     2.00000     NV=   114

------------------------------------------------------------------------------------------------------------------------
           RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
------------------------------------------------------------------------------------------------------------------------
  1    -0.5000      0.5000    14  **************
  2     0.5000      1.5000    97  *************************************************************************************************
  3     1.5000      2.5000     3  ***
------------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
------------------------------------------------------------------------------------------------------------------------
```

Female Aged > 60 years

```
H I S T O G R A M
-----------------

VMU=     0.07018     SIGMA=     0.28774     SKEW=     4.40873     VMIN=     0.0          VMAX=     2.00000     NV=   114

------------------------------------------------------------------------------------------------------------------------
           RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
------------------------------------------------------------------------------------------------------------------------
  1    -0.5000      0.5000   107  ******************************************************
  2     0.5000      1.5000     6  ***
  3     1.5000      2.5000     1
------------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 2
------------------------------------------------------------------------------------------------------------------------
```

Relative Travel Time   0 = Same   1 = More   2 = less   (compared with Previous location)

```
H I S T O G R A M
-----------------

VMU=     0.75472     SIGMA=     0.82200     SKEW=     0.48015     VMIN=     0.0     VMAX=     2.00000     NV=   106

---------------------------------------------------------------------------------------------------------------
          RANGE           FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
---------------------------------------------------------------------------------------------------------------
  1    -0.5000     0.5000   52 ****************************************************
  2     0.5000     1.5000   28 ****************************
  3     1.5000     2.5000   26 **************************
---------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
---------------------------------------------------------------------------------------------------------------
```

Asset Index (calculated from Regional Price Index of Houses, see Appendix B)
Value 0 indicates new households, which all appear in range 1.

```
H I S T O G R A M
-----------------

VMU=  745.71630     SIGMA=  437.62891     SKEW=     -1.09047     VMIN=     0.0     VMAX=  1389.00000     NV=   114

---------------------------------------------------------------------------------------------------------------
          RANGE           FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
---------------------------------------------------------------------------------------------------------------
  1       0.0       69.4500   29 *****************************
  2      69.4500   138.9000    0
  3     138.9000   208.3500    0
  4     208.3500   277.7998    0
  5     277.7998   347.2498    0
  6     347.2498   416.6997    0
  7     416.6997   486.1497    0
  8     486.1497   555.5996    0
  9     555.5996   625.0496    0
 10     625.0496   694.4995    0
 11     694.4995   763.9495    0
 12     763.9495   833.3994    0
 13     833.3994   902.8494    3 ***
 14     902.8494   972.2993    2 **
 15     972.2993  1041.7493   77 *****************************************************************************
 16    1041.7493  1111.1992    2 **
 17    1111.1992  1180.6492    0
 18    1180.6492  1250.0991    0
 19    1250.0991  1319.5491    0
 20    1319.5491  1389.0000    1 *
---------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
---------------------------------------------------------------------------------------------------------------
```

Importance on moving of:
Access to Work

See Household Questionnaire Q. 13.

1 = V. important   2 = important   3 = Indifference   4 = Important to avoid   5 = V. Important to avoid.

```
H I S T O G R A M
-----------------

VMU=     2.33959     SIGMA=     0.87839     SKEW=     -0.29930     VMIN=     1.00000     VMAX=     5.00000     NV=   106

---------------------------------------------------------------------------------------------------------------
          RANGE           FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
---------------------------------------------------------------------------------------------------------------
  1     0.5000     1.5000   25 *************************
  2     1.5000     2.5000   23 ***********************
  3     2.5000     3.5000   56 ********************************************************
  4     3.5000     4.5000    1 *
  5     4.5000     5.5000    1 *
---------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
---------------------------------------------------------------------------------------------------------------
```

```
                              Importance of a moving
H I S T O G R A M            Close Access to Bus stop                See Q.3 of Questionnaire
-----------------
VMU=      2.24528     SIGMA=      0.76252     SKEW=      -0.18994     VMIN=      1.00000     VMAX=      4.00000     NV=   106

------------------------------------------------------------------------------------------------------------------------
            RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
------------------------------------------------------------------------------------------------------------------------
  1     0.5000      1.5000    19 *******************
  2     1.5000      2.5000    44 ********************************************
  3     2.5000      3.5000    41 *****************************************
  4     3.5000      4.5000     2 **
------------------------------------------------------------------------------------------------------------------------
    SCALING FACTOR = 1
------------------------------------------------------------------------------------------------------------------------

                                   Importance of
H I S T O G R A M                  Access to Railway Station          See Q.13 of Questionnaire
-----------------
VMU=      3.11316     SIGMA=      0.50161     SKEW=       0.64667     VMIN=      1.00000     VMAX=      5.00000     NV=   106

------------------------------------------------------------------------------------------------------------------------
            RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
------------------------------------------------------------------------------------------------------------------------
  1     0.5000      1.5000     1 *
  2     1.5000      2.5000     3 ***
  3     2.5000      3.5000    87 ***************************************************************************************
  4     3.5000      4.5000    13 *************
  5     4.5000      5.5000     2 **
------------------------------------------------------------------------------------------------------------------------
    SCALING FACTOR = 1
------------------------------------------------------------------------------------------------------------------------

                                   Importance of:
H I S T O G R A M                        Access to Local Shops          See Q.13. of Questionnaire
-----------------
VMU=      1.70755     SIGMA=      0.75196     SKEW=       0.53776     VMIN=      1.00000     VMAX=      3.00000     NV=   106

------------------------------------------------------------------------------------------------------------------------
            RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
------------------------------------------------------------------------------------------------------------------------
  1     0.5000      1.5000    50 **************************************************
  2     1.5000      2.5000    37 *************************************
  3     2.5000      3.5000    19 *******************
------------------------------------------------------------------------------------------------------------------------
    SCALING FACTOR = 1
------------------------------------------------------------------------------------------------------------------------

                                        Importance of
H I S T O G R A M                            Access to Social Facilities          See Q.13 of Questionnaire
-----------------
VMU=      2.63204     SIGMA=      0.74397     SKEW=      -0.52823     VMIN=      1.00000     VMAX=      5.00000     NV=   106

------------------------------------------------------------------------------------------------------------------------
            RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
------------------------------------------------------------------------------------------------------------------------
  1     0.5000      1.5000    10 **********
  2     1.5000      2.5000    25 *************************
  3     2.5000      3.5000    66 ******************************************************************
  4     3.5000      4.5000     4 ****
  5     4.5000      5.5000     1 *
------------------------------------------------------------------------------------------------------------------------
    SCALING FACTOR = 1
------------------------------------------------------------------------------------------------------------------------
```

Importance of
Access to Parkland and Open Space   See Q.13 of Questionnaire

```
H I S T O G R A M
-----------------
VMU=    1.89620    SIGMA=    0.78825    SKEW=    0.18524    VMIN=    1.00000    VMAX=    3.00000    NV=   106

-------------------------------------------------------------------------------------------------------------------
            RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
-------------------------------------------------------------------------------------------------------------------
 1     0.5000     1.5000   39 ***************************************
 2     1.5000     2.5000   39 ***************************************
 3     2.5000     3.5000   28 ****************************
-------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
-------------------------------------------------------------------------------------------------------------------
```

Importance of
Access to the Countryside   See Q.13 of Questionnaire

```
H I S T O G R A M
-----------------
VMU=    2.12264    SIGMA=    0.82081    SKEW=    -0.23004    VMIN=    1.00000    VMAX=    3.00000    NV=   106

-------------------------------------------------------------------------------------------------------------------
            RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
-------------------------------------------------------------------------------------------------------------------
 1     0.5000     1.5000   30 ******************************
 2     1.5000     2.5000   33 *********************************
 3     2.5000     3.5000   43 *******************************************
-------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
-------------------------------------------------------------------------------------------------------------------
```

Importance of
~~Proximity to~~ Proximity to Industrial Premises   See Q.13 of Questionnaire.

```
H I S T O G R A M
-----------------
VMU=    4.20751    SIGMA=    0.83244    SKEW=    -0.60093    VMIN=    2.00000    VMAX=    5.00000    NV=   106

-------------------------------------------------------------------------------------------------------------------
            RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
-------------------------------------------------------------------------------------------------------------------
 1     1.5000     2.5000    2 **
 2     2.5000     3.5000   22 **********************
 3     3.5000     4.5000   34 **********************************
 4     4.5000     5.5000   48 ************************************************
-------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
-------------------------------------------------------------------------------------------------------------------
```

Importance of
Traffic on nearest road,   See Q.13 of Questionnaire.

```
H I S T O G R A M
-----------------
VMU=    3.62260    SIGMA=    0.91599    SKEW=    -0.29265    VMIN=    1.00000    VMAX=    5.00000    NV=   106

-------------------------------------------------------------------------------------------------------------------
            RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
-------------------------------------------------------------------------------------------------------------------
 1     0.5000     1.5000    3 ***
 2     1.5000     2.5000    3 ***
 3     2.5000     3.5000   45 *********************************************
 4     3.5000     4.5000   35 ***********************************
 5     4.5000     5.5000   20 ********************
-------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
-------------------------------------------------------------------------------------------------------------------
```

Importance of
Proximity of School — See Q.13 of Questionnaire

```
H I S T O G R A M
-----------------
VMU=    2.15978    SIGMA=    0.88464    SKEW=   -0.17430    VMIN=    1.00000    VMAX=    4.00000    NV=   106
---------------------------------------------------------------------------------------------------------------
          RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
---------------------------------------------------------------------------------------------------------------
 1     0.5000     1.5000   32 ********************************
 2     1.5000     2.5000   26 **************************
 3     2.5000     3.5000   46 **********************************************
 4     3.5000     4.5000    2 **
---------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
---------------------------------------------------------------------------------------------------------------
```

Reasons for Moving:
To do with Amenity (desire to improve amenity) 0-1, 1 indicates relevance.

```
H I S T O G R A M
-----------------
VMU=    0.19298    SIGMA=    0.39464    SKEW=    1.55594    VMIN=    0.0    VMAX=    1.00000    NV=   114
---------------------------------------------------------------------------------------------------------------
          RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
---------------------------------------------------------------------------------------------------------------
 1    -0.5000     0.5000   92 ********************************************************************************************
 2     0.5000     1.5000   22 **********************
---------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
---------------------------------------------------------------------------------------------------------------
```

Reasons for Moving
To do with Access (generally to seek improvement) 1 indicates relevance.

```
H I S T O G R A M
-----------------
VMU=    0.11403    SIGMA=    0.31785    SKEW=    2.42857    VMIN=    0.0    VMAX=    1.00000    NV=   114
---------------------------------------------------------------------------------------------------------------
          RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
---------------------------------------------------------------------------------------------------------------
 1    -0.5000     0.5000  101 **************************************************
 2     0.5000     1.5000   13 ******
---------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 2
---------------------------------------------------------------------------------------------------------------
```

Reasons for Moving
To do with Dwelling 1 indicates relevance

```
H I S T O G R A M
-----------------
VMU=    0.35088    SIGMA=    0.47724    SKEW=    0.62494    VMIN=    0.0    VMAX=    1.00000    NV=   114
---------------------------------------------------------------------------------------------------------------
          RANGE          FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
---------------------------------------------------------------------------------------------------------------
 1    -0.5000     0.5000   74 **************************************************************************
 2     0.5000     1.5000   40 ****************************************
---------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
---------------------------------------------------------------------------------------------------------------
```

Reasons for Moving

```
H I S T O G R A M
                                        For social reasons including marriage            1 indicates relevance
VMU=    0.39702     SIGMA=    0.46126     SKEW=    0.83677     VMIN=    0.0          VMAX=     1.00000     NV=   114
--------------------------------------------------------------------------------------------------------------------
          RANGE            FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
--------------------------------------------------------------------------------------------------------------------
 1    -0.5000     0.5000   79 *******************************************************************************
 2     0.5000     1.5000   35 ***********************************
--------------------------------------------------------------------------------------------------------------------
    SCALING FACTOR = 1
--------------------------------------------------------------------------------------------------------------------

H I S T O G R A M
                        Move occasioned by formation of new household (all by marriage)
                                                                          1 indicates marriage
VMU=    0.18421     SIGMA=    0.38766     SKEW=    1.62923     VMIN=    0.0          VMAX=     1.00000     NV=   114
--------------------------------------------------------------------------------------------------------------------
          RANGE            FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
--------------------------------------------------------------------------------------------------------------------
 1    -0.5000     0.5000   93 *********************************************************************************************
 2     0.5000     1.5000   21 *********************
--------------------------------------------------------------------------------------------------------------------
    SCALING FACTOR = 1
--------------------------------------------------------------------------------------------------------------------

H I S T O G R A M
                    Items indicated as 'Liked', concerning living conditions:
                                                         - Amenity -          1 indicates relevance.
VMU=    0.49123     SIGMA=    0.49992     SKEW=    0.03510     VMIN=    0.0          VMAX=     1.00000     NV=   114
--------------------------------------------------------------------------------------------------------------------
          RANGE            FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
--------------------------------------------------------------------------------------------------------------------
 1    -0.5000     0.5000   58 **********************************************************
 2     0.5000     1.5000   56 ********************************************************
--------------------------------------------------------------------------------------------------------------------
    SCALING FACTOR = 1
--------------------------------------------------------------------------------------------------------------------

H I S T O G R A M
                        Items indicated as 'Liked'
                                                - Access -              1 indicates relevance
VMU=    0.42105     SIGMA=    0.49373     SKEW=    0.31981     VMIN=    0.0          VMAX=     1.00000     NV=   114
--------------------------------------------------------------------------------------------------------------------
          RANGE            FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
--------------------------------------------------------------------------------------------------------------------
 1    -0.5000     0.5000   66 ******************************************************************
 2     0.5000     1.5000   48 ************************************************
--------------------------------------------------------------------------------------------------------------------
    SCALING FACTOR = 1
--------------------------------------------------------------------------------------------------------------------
```

Item indicated as liked

- Dwelling - 1 indicates relevance.

```
H I S T O G R A M
-----------------

VMU=     0.37719     SIGMA=     0.48468     SKEW=     0.50676     VMIN=     0.0          VMAX=     1.00000     NV=   114

----------------------------------------------------------------------------------------------------------------------
            RANGE             FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
----------------------------------------------------------------------------------------------------------------------
 1    -0.5000     0.5000    71 ***********************************************************************
 2     0.5000     1.5000    43 *******************************************
----------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
----------------------------------------------------------------------------------------------------------------------
```

Item indicated as liked

- Social Facilities - 1 indicates relevance

```
H I S T O G R A M
-----------------

VMU=     0.04386     SIGMA=     0.20478     SKEW=     4.45487     VMIN=     0.0          VMAX=     1.00000     NV=   114

----------------------------------------------------------------------------------------------------------------------
            RANGE             FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
----------------------------------------------------------------------------------------------------------------------
 1    -0.5000     0.5000   109 *******************************************************
 2     0.5000     1.5000     5 **
----------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 2
----------------------------------------------------------------------------------------------------------------------
```

Cause of Dissatisfaction, Dislikes - Amenity 1 indicates relevance

```
H I S T O G R A M
-----------------

VMU=     0.30702     SIGMA=     0.46126     SKEW=     0.83677     VMIN=     0.0          VMAX=     1.00000     NV=   114

----------------------------------------------------------------------------------------------------------------------
            RANGE             FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
----------------------------------------------------------------------------------------------------------------------
 1    -0.5000     0.5000    79 *******************************************************************************
 2     0.5000     1.5000    35 ***********************************
----------------------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 1
----------------------------------------------------------------------------------------------------------------------
```

```
H I S T O G R A M                    Dissatisfaction caused by or related to;
                                                      - Access -
                                                                          1 indicates relevance
VMU=    0.11404    SIGMA=    0.31785    SKEW=    2.42857    VMIN=    0.0    VMAX=    1.00000    NV=   114
---------------------------------------------------------------------------------------------------------
        RANGE              FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
---------------------------------------------------------------------------------------------------------
 1   -0.5000    0.5000   101 **************************************************
 2    0.5000    1.5000    13 ******
---------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 2
---------------------------------------------------------------------------------------------------------


H I S T O G R A M                    Dissatisfaction caused by or related to
                                                      - Dwelling -
                                                                          1 indicates relevance.
VMU=    0.04386    SIGMA=    0.20478    SKEW=    4.45087    VMIN=    0.0    VMAX=    1.00000    NV=   114
---------------------------------------------------------------------------------------------------------
        RANGE              FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
---------------------------------------------------------------------------------------------------------
 1   -0.5000    0.5000   109 ******************************************************
 2    0.5000    1.5000     5 **
---------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 2
---------------------------------------------------------------------------------------------------------


H I S T O G R A M                    Dissatisfaction related to
                                                      - Social Factors -
                                                                          1 indicates relevance.
VMU=    0.09649    SIGMA=    0.29526    SKEW=    2.73321    VMIN=    0.0    VMAX=    1.00000    NV=   114
---------------------------------------------------------------------------------------------------------
        RANGE              FREQ.1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80...85...90...95..100
---------------------------------------------------------------------------------------------------------
 1   -0.5000    0.5000   103 ***************************************************
 2    0.5000    1.5000    11 *****
---------------------------------------------------------------------------------------------------------
     SCALING FACTOR = 2
---------------------------------------------------------------------------------------------------------
```

Additional Analysis of Household Survey

As well as the ranking of environmental preferences which was detailed in Chapter 5 the social survey can be looked at through the inferences that can be made from the correlation analysis.

In the first place it would be of interest to establish whether the main household socio-economic indicators, household size, income and social class are in any way related to the rankings of environmental preference as measured by variables 39 - 47 i.e. variables Y42 - Y51 of the correlation matrix. This can be ascertained by examining the appropriate correlation coefficients i.e. the coefficients of variables Y39,30 and 31 with Y42 - Y51. In fact there is obviously no clear difference between household types and their amenity rankings, as is evident from the lack of any high correlations. This means in effect that environmental preferences are ordered independently of socio-economic characteristics which is consistent with the view that households of any type are as likely to emphasise any aspect of their residential environment as any other. In short there appears to be no environmentally conscious elite. There are three coefficients however significantly above zero which merit some discussion. Two are associated with household size and one with social class. The correlation between household size and emphasis on 'access to shops' in the amenity rankings of the order of -.23 indicates that for larger households accessibility to shops becomes more important (preferences being measured with 1 equal to very important and 5 very important to avoid). This suggests that larger families who have more children (size and children are correlated) are less willing to travel for their shopping requisites, preferring to have shops close at hand. Families with young children are of course more housebound and this correlation is quite reasonable on this interpretation.

Household size is also correlated with a preference for proximity to schools (-.63) and again this is reasonable given that education is a concern of households with children especially young ones. On the basis of this result although it is a rather obvious one, a concern with the provision of neighbourhood nursery schools would seem to be entirely justified especially as this preference was indicated at a time when there were no locational constraints on change of schools. The correlation between social class and Y48, preferences for proximity to the countryside (.34) , indicates that higher social classes are possibly more suburban in their environmental tastes. What exactly does this mean however?

By examining other variables correlated with Y48 we see that particularly travel expenditure (Y28) is correlated with preference for proximity to the countryside (-.45). This means in effect that as surburban preference increases so does travel expenditure. Such households are also able to satisfy their preference by living near the green belt as Y27 and Y48 are correlated (.41). This travel expense incurred as part of a preference for 'suburbia' and for 'access to the countryside', would indicate that for these households, distance from the centre of the town (inversely related with distance from the green belt) is an adequate proxy for some aspects of environmental amenity. This amenity includes seclusion as measured by distance from railways, low density and little industry (correlation Y15, Y16 and Y26). There are 26% of households who find it very important to be near the countryside and 29% who find it important. The remainder, under half are indifferent (see the appropriate histogram). What else can be determined from the correlations between aminity rankings and other variables? By examining the appropriate row of correlations between variables we find for example that those households who place importance on easy access to bus stop (Y43) do not live near the green belt are more centrally located (Y24) and living in high density areas (Y76). Such households are probably without alternative means of transport either for shopping in the case where the car is used for travelling to work or vice versa. 55% of households place some importance on access to bus stops.

In the case of the importance of local shops (Y45) it is interesting that not only do 76% of households place some importance on them but those households living nearer the city centre in busy areas (near main roads and railways) are more likely to favour local shops. This result is probably reflecting the fact that surburban dwellers have two choices for shopping places, local and central while central households have only one. Furthermore from the correlation with travel expenditure (Y28) it is apparent that households more indifferent to local shops also incur more travel expense. The inverse relationship between the importance of access to open space (Y47) and distance from the green belt deserves some comment especially given the importance of open space in the amenity rankings of the social survey (see Chapter 5.). Some 68% of households regard open space as important and by the relation with distance from the green belt are likely in fact to satisfy this preference. Conversely households nearer the centre of the city are more indifferent to open space which suggests that there is no strong sense of environmental deprivation as regards open space amenity for central locations.

As regards the importance of avoiding industrial nuisance (Y49) it is interesting to observe the relation with the amount of industrial land (Y13, Y14 and Y15). This diminishes as its importance as a disamenity increases. This of course suggests that households who are adjacent to industrial nuisance are more indifferent to it or perhaps more resigned to it.

Although the correlation coefficients referred to are small they are large relative to the other which generally are of the order of .01 to .09. Similarily we can examine the environmental preferences of households by the most commonly expressed broad expressions of environmental preference as indicated by variables Y53 - Y64. On this basis it is possible to describe 4 broad types of household types by examining variables correlated with these broad indicators.

The first type can be called the "amenity discontents". These are households who (on the basis of the correlation of Y61 with other variables) live in low valued, old terraced housing without gardens (large plots) and with heavy concentrations of industrial land in the area. To a lesser extent they also have inadequate open space. Some 31% of all households are in this group as seen from the histogram of variable Y61.

The second type can be called 'Garden lovers'. These are households who cite their dwelling as the main source of satisfaction (Y59) and this variable is in fact correlated with plot size (Y4), a variable which reflects garden size. These households are usually the better off ones as income is slightly positively correlated with (Y59). Some 38% of households cite dwellings as a cause of satisfaction while some 40% of households have above average sized plots as is seen from the relevant histogram.

The third type of household are "access orientated". These are households who stress accessibility as an attribute of their location; they appear to have relatively less open space as well (Y9 correlates with Y58). A majority of households, some 60%, do not however cite 'access' as a cause of satisfaction.

The fourth type of household is the "amenity conscious" one. Here households have avoided industrial land and high density neighbourhoods in preference for relatively more open space and better quality housing.

Of course these generalizations about household environmental tastes do not in themselves provide the foundation for understanding how environment is perceived. They are after all deduced from two dimensional views of amenity as given by the correlation matrix. However they do serve to highlight how the environmental amenity of residential location is a diverse bundle of goods which is perceived in a variety of ways. Such correlations provide in fact the first step towards a more multidimensional description of the environmental quality of housing.

Finally it can be said that these 4 broad groupings of household environmental taste do not appear to be at odds with the results of the regression analysis of Chapter 5. There, it will be recalled a house quality, and density associated factor was strongly related to house price along with plot size, a disamenity factor and an open space amenity factor. What is perhaps more worthy of comment is that no accessibility factor came out in the regression analysis, yet there is obviously a minority of households who feel that access to facilities is an important dimension of their environment. This could well mean that travel expenditure,, which was just significant in the regression analysis at the 20% level, is not the best proxy for access. Some measure of psychological distance as perceived by households might be more appropriate although how such a measure is to be devised is a task which remains for subsequent research.

Key to Figure A.1. (see back cover)

This Figure comprises an extract from the 1" to 1 mile O.S. map for Nottingham and indicates, in addition to the usual cartographic information, the distribution of the 114 sample houses used in the analyses. This distribution is given for each quadrant division of the city as follows:

N.E.	32%	of	houses
S.E.	28%	"	"
S.W.	28%	"	"
N.W.	12%	"	"

These figures are calculated from variable 2 of the final data form which indicates the district to which each observation pertains. A further perspective is given by the distribution of households from the city centre (see the appropriate histogram). Some 10% of the houses are within 2 miles of the city centre; a further 64% lie within 4 miles of the centre and the remainder are located up to 9 miles from the centre.

APPENDIX B Household Questionnaire, Location Survey Sheets, Coding Frames, Travel Cost Formulae, Regional House Price Index, Income Prompt Cards.

This appendix contains details of the questionnaire and survey sheets etc. utilised in obtaining the final data set.

Household questionnaire (enclosed)

Location survey sheets (enclosed)

Income prompt card (enclosed)

Travel Cost Formulae

Automobile, assuming an average speed of 20 m.p.h.

$$(2.4 + 19.8/20 \text{ m.p.h.} + .00019\ (20 \text{ m.p.h.})^2) \text{ old pence per mile}$$

The formula above is the 1968 formula used by the Road Research Laboratory for wear and tear and fuel costs per mile. No cost of time or convenience is included. In addition to this formula petrol tax of 0.8 old pence per mile was included giving a total per mile cost of 4.26 old pence or 1.8 pence. This cost represents the out of pocket costs of travel excluding road tax and depreciation which are not considered relevant for the locational study, being a constant with respect to location.

Bus Fares (1968 prices) derived from Nottingham Corporation

1/2 mile	1.25 new pence
1 "	3 " "
1.5 "	3.4 " "
2 "	3.8 " "
2.5 "	4.3 " "
3 "	4.8 " "
4 "	5.3 " "
5.5 "	5.8 " "
7 "	6.2 " "
8.5 "	6.7 " "

On the basis of the known regular travel of each household and the mode of travel (which in all cases except where no money costs were involved, was by car or bus), it is possible to construct an annual travel expenditure for each household.

House Price Index for Nationwide Building Society Regions (1968 Prices)

Region	Average Prices Old Houses	Modern	New	Index
Nottingham	3127	4322	4398	100
London & S.E.	5033	5033	5688	138.8
Southern	4167	5345	5484	126.5
Western	3400	4495	4482	104.4
Midland	3127	4332	4398	100
Eastern	2858	4688	4550	102
N. Western	2541	4213	4405	94.1
N. Eastern	2721	3688	3930	87.2
Scotland	3799	5145	4722	115.3
N. Ireland	2732	4037	3798	89.1

This index of regional house prices was used as a variable of assets pertaining to the differential advantages realized by households on sale of their previous house. As such this average price index gives only an approximate indication of this asset worth and is not adjusted for quality differences in houses.

UNIVERSITY OF CAMBRIDGE DEPARTMENT OF LAND ECONOMY
19 Silver Street, Cambridge *Telephone: Cambridge 55262/3*
Professor D. R. Denman

Dear Householder,

The University of Cambridge Department of Land Economy is making a study of Housing in Nottingham from the point of view of the location and quality of the residential areas in the City. The purpose of this study is to obtain a better understanding of residential facilities and needs and the effects on houses and householders of such things as heavy traffic noise or proximity of shops, schools and open spaces. This should provide essential information for improving existing housing areas and for the proper planning and development of new areas.

Of course, the people who know best what they like or dislike about their neighbourhood are the people who live there. We believe, therefore, that the best way to make our study is to ask householders themselves what they think. To ask every person in Nottingham about neighbourhood amenities would be an impossible task, so we have chosen a random sample of the population with addresses picked "out of a hat". This procedure greatly reduces the task of completing the survey but it does mean that we can only get the information we need if all those who have been selected will give some of their time to helping us. Your address has been selected and we very much hope that you will be prepared to help by giving us the answers, which only you can give, to a short list of questions. We will arrange for someone to call on you in the near future to ask for your answers to a short questionnaire.

I should like to assure you that all answers or opinions that you may give to us will be treated as strictly confidential and private. No information linked to any one name or address will be allowed to pass outside this Department.

Yours sincerely,

G. Davies, M.A.

Nottingham Residential Study

Final Data Form

Record No.		
1.District		31 hshold size
2.price		32 social class
3 garage		33 income
4 age		34 males
5 c/heat		35 females
6 plot		36 tr.time
7 bdrms		37 pr.loc
8 type		38 access work
9 o.sp.$\frac{1}{8}$		39 " bus stop
10 o.sp.$\frac{1}{4}$		40 " rwy st.
11 o.sp.$\frac{1}{2}$		41 " shops
12 res.$\frac{1}{8}$		42 " social
13 res. $\frac{1}{4}$		43 " o.sp
14 res.$\frac{1}{2}$		44 " gr.blt
15 ind $\frac{1}{8}$		45 " ind
16 ind $\frac{1}{4}$		46 " traffic
17 ind $\frac{1}{2}$		47 " schools
18 density		48 move reasons
19 trees		49 res.prefs.
20 view		50 dissats.
21 hills		
22 wdland		
23 res		
24 ind		
25 prkland		
26 d.cbd		
27 d.mrd		
28 d.rwy		
29 d.gr.blt		
30 tr.exp.		

STRICTLY CONFIDENTIAL.

INCOME RANGE CARD.

Please indicate which range your net income falls within.

WEEKLY INCOME.			ANNUAL INCOME.		
£1.00-£3.00	(1)	a	£1.00-£100.00	£4401.00-£4500.00	c1
£3.01-£5.00	(2)	b	£101.00-£200.00	£4501.00-£4600.00	c2
£5.01-£7.00	(3)	c	£201.00-£300.00	£4601.00-£4700.00	c3
£7.01-£9.00	(4)	d	£301.00-£400.00	£4701.00-£4800.00	c4
£9.01-£11.00	(5)	e	£401.00-£500.00	£4801.00-£4900.00	c5
£11.01-£13.00	(6)	f	£501.00-£600.00	£4901.00-£5000.00	c6
£13.01-£15.00	(7)	g	£601.00-£700.00	£5001.00-£5100.00	c7
£15.01-£17.00	(8)	h	£701.00-£800.00	£5101.00-£5200.00	c8
£17.01-£19.00	(9)	i	£801.00-£900.00	£5201.00-£5300.00	c9
£19.01-£21.00	(10)	j	£901.00-£1000.00	£5301.00-£5400.00	d1
£21.01-£23.00	(11)	k	£1001.00-£1100.00	£5401.00-£5500.00	d2
£23.01-£25.00	(12)	l	£1101.00-£1200.00	£5501.00-£5600.00	d3
£25.01-£27.00	(13)	m	£1201.00-£1300.00	£5601.00-£5700.00	d4
£27.01-£29.00	(14)	n	£1301.00-£1400.00	£5701.00-£5800.00	d5
£29.01-£31.00	(15)	o	£1401.00-£1500.00	£5801.00-£5900.00	d6
£31.01-£33.00	(16)	p	£1501.00-£1600.00	£5901.00-£6000.00	d7
£33.01-£35.00	(17)	q	£1601.00-£1700.00	£6001.00-£6100.00	d8
£35.01-£37.00	(18)	r	£1701.00-£1800.00	£6101.00-£6200.00	d9
£37.01-£39.00	(19)	s	£1801.00-£1900.00	£6201.00-£6300.00	e1
£39.01-£41.00	(20)	t	£1901.00-£2000.00	£6301-£6400.00	e2
£41.01-£43.00	(21)	u	£2001.00-£2100.00	£6401.00-£6500.00	e3
£43.01-£45.00	(22)	v	£2101.00-£2200.00	£6501.00-£6600.00	e4
£45.01-£47.00	(23)	w	£2201.00-£2300.00	£6601.00-£6700.00	e5
£47.01-£49.00	(24)	x	£2301.00-£2400.00	£6701.00-£6800.00	e6
£49.01-£51.00	(25)	y	£2401.00-£2500.00	£6801.00-£6900.00	e7
£51.01-£53.00	(26)	z	£2501.00-£2600.00	£6901.00-£7000.00	e8
£53.01-£55.00	(27)	a1	£2601.00-£2700.00	£7001.00-£7100.00	e9
£55.01-£57.00	(28)	a2	£2701.00-£2800.00	£7101.00-£7200.00	f1
£57.01-£59.00	(29)	a3	£2801.00-£2900.00	£7201.00-£7300.00	f2
£59.00-£61.00	(30)	a4	£2901.00-£3000.00	£7301.00-£7400.00	f3
£61.01-£63.00	(31)	a5	£3001.00-£3100.00	£7401.00-£7500.00	f4
£63.01-£65.00	(32)	a6	£3101.00-£3200.00	£7501.00-£7600.00	f5
£65.01-£67.00	(33)	a7	£3201.00-£3300.00	&7601.00-£7700.00	f6
£67.01-£69.00	(34)	a8	£3301.00-£3400.00	£7701.00-£7800.00	f7
£69.01-£71.00	(35)	a9	£3401.00-£3500.00	£7801.00-£7900.00	f8
£71.01-£73.00	(36)	b1	£3501.00-£3600.00	£7901.00-£8000.00	f9
£73.01-£75.00	(37)	b2	£3601.00-£3700.00	£8001.00-£8100.00	g1
£75.01-£77.00	(38)	b3	£3701.00-£3800.00	£8100.00-£8200.00	g2
£77.01-£79.00	(39)	b4	£3801.00-£3900.00	£8201.00-£8300.00	g3
£79.01-£81.00	(40)	b5	£3901.00-£4000.00	£8301.00-£8400.00	g4
£81.01-£83.00	(41)	b6	£4001.00-£4100.00	£8401.00-£8500.00	g5
		b7	£4101.00-£4200.00	£8501.00-£9000.00	g6
		b8	£4201.00-£4300.00	£9001.00-£10000.00	g7
		b9	£4301.00-£4400.00	£10000.00 and over.	g8

U N I V E R S I T Y O F C A M B R I D G E

D E P A R T M E N T O F L A N D E C O N O M Y

RESIDENTIAL AMENITY SURVEY - NOTTINGHAM

HOUSEHOLD QUESTIONNAIRE

Form Number				
Name of Respondent and Address				
Date and Time called				

RESPONSE

Interview Refused	1
Interview Accepted	2
No Contact	3

Recording Schedule

1. Some answers are to be coded as numbers, the interviewer circling the appropriate number.

2. Some answers are recorded verbatin in the spaces provided.

3. If there is no answer put Y.

4. If the answer is "don't know" put X.

PART I HOUSEHOLD INFORMATION

Could I please adk you some questions first of all about the members of the Household?

Q.1. Can you please tell me a) the relationship of each person living in the house to the head of the Household

b) the occupation of each person living in the house

c) the age of each person living in the the house?

(a) Relationship to Head	(b) Occupation	(c) Age
1. Head		
2.		
3.		
4.		
5.		
6.		
7.		
8.		

Q.2. Can you please tell me the number of children receiving a) Primary b) Secondary o) Higher Education

a) Primary . . . .

b) Secondary . . . .

c) Higher . . . .

PART II

Could you now tell me some information about the household's travel characteristics; for instance:

Q.3. How many cars does your household possess?

N.A.	Y
D.K.	X
One	1
Two	2
Three or more	3

Q.4. Can you please tell me a) where the working members of the household work (street of firm etc.) and
b) the usual means of travel to work.

a)	b)
1. Head	. . . .
2.	. . . .
3.	. . . .
4.	. . . .
5.	. . . .
6.	. . . .

Q.5. Does the main earner of the household spend more or less time travelling to work now, than in your previous home?

N.A.	Y
D.K.	X
Some Time	0
More Time	1
Less Time	2

Q.6. Can you please tell me a) about journeys made by members of the household last week <u>for purposes other than travel to school or work</u> and
b) the usual means of such travel

a) Frequency and Distance . . . .

. . . .

b)

N.A.	Y
D.K.	X
Bus	1
Bicycle	2
Car	3
Other	4

Q.7. Can you tell me for each member of the household undergoing full time education in Nottingham a) which school/college etc. he/she attends and b) the usual means of travel to school

a) b)

	a)	b)
1.	. . . .	. . . .
2.	. . . .	. . . .
3.	. . . .	. . . .
4.	. . . .	. . . .
5.	. . . .	. . . .

PART III ENVIRONMENTAL PREFERENCES

Can I now ask some questions about your attitude to your house and neighbourhood?

Q.8. Can you please tell me a) your previous address and
b) the type of house you lived in

a) . . . .

b) . . . .

Q.9. Can you tell me your reasons for changing houses?

. . . .

. . . .

Q.10. Can you please tell me what made you choose this particular house and neighbourhood . (then ask) Can you tell me if you have an outlook at the back of the house?

. . . .

. . . .

Q.11. Is there anything about your neighbourhood with which you are dissatisfied?

. . . .

. . . .

Q.12. Please can you tell me if the following shops are within walking distance?

Supermarket		Baker
Chemist		Grocer
Florist		Greengrocer
Ironmonger		Delicatessen
Butcher		Newsagent

Q.13. When thinking of the kind of area you wanted to move into how important did you consider the following? (Show prompt card)

	Very Important	Of some Importance	Doesn't Matter	Important to avoid	Very Important to avoid	N.A.	D.K.
a) Being near the chief earners place of work	1	2	3	4	5	Y	X
b) Being near a bus stop	1	2	3	4	5	Y	X
c) Being near a Railway Station	1	2	3	4	5	Y	X
d) Having local shops nearby	1	2	3	4	5	Y	X
e) Having social facilities e.g. pubs nearby	1	2	3	4	5	Y	X
f) Being near a park or some open space	1	2	3	4	5	Y	X
g) Being near the country	1	2	3	4	5	Y	X
h) Being near industrial premises	1	2	3	4	5	Y	X
i) Having traffic on the road outside	1	2	3	4	5	Y	X
j) Being near a School	1	2	3	4	5	Y	X

PART IV BUDGET DATA

Q.14. Can you please tell me the weekly/monthly/annual salary of working members of the household, (or if preferred in which income-group this income falls (show prompt card)

1. Head . . . .

2. . . . .

3. . . . .

4. . . . .

5. . . . .

U N I V E R S I T Y   O F   C A M B R I D G E

DEPARTMENT OF LAND ECONOMY

Residential Amenity Survey - Nottingham

LOCATION SURVEY SHEET

FORM NUMBER					
Name and Address of Household					
Date and Time of Survey					

Weather Conditions

RECORDING SCHEDULE:- See attached Notes for Compiler.

Coding: Leave Blank

Q.1 Description of Adjacent Land Use

Type	Left Side Description	Right Side Description
Commercial		
Industrial		
Residential		
Vacant		

Q.2 Condition of Adjacent Structures and Plot

Feature	Left Side	Right Side
Walls	-1 O +1 NA DK	-1 O +1 NA DK
Roof	-1 O +1 NA DK	-1 O +1 NA DK
Paintwork	-1 O +1 NA DK	-1 O +1 NA DK
Age	-1 O +1 NA DK	-1 O +1 NA DK
Lawn	-1 O +1 NA DK	-1 O +1 NA DK
Flower Bed	-1 O +1 NA DK	-1 O +1 NA DK
Fence (Wall)	-1 O +1 NA DK	-1 O +1 NA DK
Additional Remarks if		

Coding: Leave Blank

Q.3 Condition of Nearby Structures and Plot

% Same condition (as sample house) ... ...

% Worse condition ... ...

% Better condition ... ...

Additional Remarks

Q.4 Condition of Streets and Pavements

<u>Feature</u>

Trees (number within 100 yds. of house) ... ...

Grass (width of verge) ... ...

Litter (tick) Little ☐ [illegible] ☐ Very Untidy ☐

Road and Pavement — Cracks ☐ None ☐ — Holes ☐ None ☐ — Unevenness ☐ None ☐

Additional Remarks

Q.5 'View'

Degrees of Panorama

Features

Distance

Short (<100 yds.) ☐

Medium (100 yds.<>300 yds.) ☐

Long (>300 yds.) ☐

Additional Remarks

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