A SPATIAL ECONOMETRIC MODEL OF THE SCOTTISH HOUSING MARKET, 1980-81

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I hereby declare that this thesis has not been submitted, either in the same or different form, to this or any other University for a degree.

Signature:

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SUMMARY

This thesis formulates a spatial econometric model of the Scottish housing market over the period 1980-81. The study is concerned with the role of space in the dynamic operation of an owner-occupier housing market, particularly as applied at the regional level. These four considerations - space, dynamics, tenure, and level of aggregation - are selected for attention after an examination of the approaches to housing market models in a number of disciplines, but in particular within economic and econometric models. It is found that the approaches used in other disciplines can be treated as alternative forms of, or special cases of, those based on the utility maximisation premise of economic theory. Existing utility maximisation housing models are generally specified at the urban level of aggregation, with private rental as the dominant form of tenure. Dynamics are an integral part of urban simulation models but in general the attainability of equilibrium is assumed. The aggregate counterpart to an urban model is a macroeconometric model, which is purely dynamic in specification, and the results from this approach are contrasted with those of microeconomic theories. It is shown that assumptions about the spatial structure of the housing market are implicit in macroeconometric models. Three housing market dimensions or analytical categories - space, time, and house type - are identified, and this provides a basis for the classification of existing models. A matrix formulation is used to specify the theoretical structure of a dynamic regional owner-occupier model, and the spatial econometric technique of the weights matrix is introduced as a parsimonious method for operationalising the theoretical structure. Empirical estimation of demand and supply equations gives an indication of the nature and scale of spatial interaction effects at the regional level. These indicate that there are grounds for including regional level analysis in any discussion of the operation of the housing market. The results are compared with those of the existing housing market literature, and possible extensions of the matrix formulation show that it is a useful framework for urban level analysis as well. The policy implications which follow from this thesis are then discussed and current policy is examined in the light of these findings.

INTRODUCTION

(I) INTRODUCTION

This thesis is concerned with the development of a regional housing market model. This level of aggregation is a relatively neglected area of a literature which includes urban cross section and macroeconometric time series models. A regional model provides a link between the two scales of aggregation, and may help to resolve some of the conflicting views of the operation of the housing market which arise from these different approaches. The notion of a regional model as a link between the urban and national scales of aggregation implies the existence of a continuum of models across each aggregation level. This thesis will propose the use of three housing market dimensions, namely space, time and house type or quality level. A regional model can be specified in any of these dimensions but ideally should take account of all three. The reason for this is that urban and national models tend to differ in terms of their dimension of specification as well as in their level of aggregation.

Urban models are primarily concerned with the roles of space and house types, with particular reference to the impact of spatial considerations on location decisions. The paradigm which dominates this approach is that of utility maximisation, which can be a powerful and flexible way of formulating models of housing market behaviour. Such urban models develop the notion of space as a source of transport costs, and modify it in a number of ways to take into account social stratification and house-type heterogeneity. These models generally deal in terms of long run equilibrium, and with the exception of simulation models, eschew dynamic considerations altogether. The notion of a long run equilibrium is based on housing stock equilibrium, and for this to be valid in all time periods presupposes system behaviour as if the entire housing stock is transacted every time period. Although this approach has had some notable empirical successes, the range of questions which can be addressed is limited by the relatively superficial treatment of the temporal dimension.

A second form of urban approach abstracts from the idea of the housing system as a market, and focuses upon the movement of volumes of persons and vacancies. The "gravity" and "entropy" models use concepts from the natural sciences to model flows of persons. These models have encountered some specific drawbacks, but nevertheless represent a flexible and parsimonious representation of spatial structure and spatial dynamics. The gravity approach is used in the model developed here to represent spatial interaction via the spatial econometric technique of the weights matrix.

Vacancy and mobility models use the Markov transition matrix approach. This assumes that the process of household mobility can be represented by a matrix of transition probabilities linking spatial areas or different house types. This requires some strong assumptions about the urban area as a self contained unit, rather than as a part of a larger system. The vacancy model illustrates the flexibility of a matrix formulation in representing interaction between spatial units or different house types, and can incorporate a temporal dimension. It abstracts from the market process on the grounds that the existing housing stock exerts such a powerful influence on the housing system that the flows into and out of the system are unlikely to influence house prices. It thus demonstrates the importance of volumes to housing markets and this provides a useful basis for the model developed here.

Macroeconometric time series models use concepts from mainstream macroeconomics and are particularly concerned with the notion of asset market equilibrium. With recently developed econometric techniques, it is possible to use the notion of a long run, steady state equilibrium and to model short run dynamic fluctuations around this trend. The long run steady state corresponds to the stock equilibrium of the microeconomic urban models discussed previously. Macroeconometric models are primarily concerned with the temporal dimension, and implicitly incorporate highly restrictive assumptions about the spatial operation of the housing market, and about the role of the quality dimension. Such models are almost completely aspatial and aggregative, but are nevertheless used to make policy statements which have an explicitly spatial dimension.

The main contention of this thesis is that a regional model of the housing market is a useful construct but one for which there currently exists no readily applicable framework. The urban models discussed above have been developed primarily in the U.S. and are more readily applicable to the form of housing market prevailing there, with a high degree of private rental tenure and car ownership. Time series models are more common in the U.K. where the owner occupier tenure dominates. A regional model of any part of the U.K. has to take account of the tenure form and resultant spatial impacts. Scotland, in particular, is interesting as an area in transition from public rental tenure to owner occupier tenure dominance.

A regional model is a useful construct because it provides a synthesis between the microeconomic and macroeconomic perspectives and in consequence highlights the inherent assumptions in each type of model. For this to be possible, the basic criteria for the construction of a regional framework are that it contains most other models as special cases. As such, it must be capable of making statements in a number of dimensions and of determining values for certain key variables. As discussed previously, the dimensions of time, space, and quality are central to the housing market and the framework to be developed is capable, given suitable data, of modelling in these three dimensions using the matrix format and giving specific interpretations to the matrix elements. The key variables are prices, volumes, and tenure, although the latter could equally be argued to be a dimension. Tenure affects the model in that owner occupiers who buy a house will also, in general, be sellers of their original house. This duality has implications for the way in which prices are determined and for the way in which owner occupiers time their market transactions. It will be argued that as a result of this duality, an owner occupier market may be more sensitive to volumes of demand and supply, or to prices, depending on the state of the market.

The discussion of price determination suggests that a probabilistic definition of equilibrium is necessary. This means that observed prices will be distributed about some mean, with the mean representing the long run equilibrium. In this thesis, a deterministic model is specified but this represents the expected rather than actual equilibrium.

The concepts of stock and flow equilibria are central to the discussion of the definition of housing market equilibrium. The stock formulation views the existing stock as exerting a powerful influence over the actual, transacted market, whereas the flow formulation ignores the existing stock on the grounds that only a relatively small proportion is transacted at any one time. This study focuses on a flow specification for a number of reasons. First, macroeconometric studies have tended to indicate that the adjustment to stock equilibrium is slow; hence in a short run model it can be ignored. Second, this study argues that the modern housebuilding industry is more flexible than has historically been the case which will tend to favour the short run, flow based equilibrium. Third, and perhaps most important, it is possible to argue that the concept of a stock equilibrium is irrelevant without some discussion of the process by which such an equilibrium is achieved. This study focuses on the process of adjustment within the housing market, and on the reasoning that the long run stock equilibrium is the result of a series of short run flow adjustments, the study of the flow adjustment process is logically prior. Fourth, given that a regional model focuses on the importance of space, the influence of the existing stock is reduced by spatial separation of sub sectors of the housing market. Fifth, mobility studies show that households often utilise long planning horizons and their capacity to alter their plans in response to short run market pressures may be limited. This will be asymmetric, however, in that the decision to move can be delayed if short term market pressures are too great, whereas it will tend to take time for mobility plans to be formulated and implemented. This process may be compounded by imperfect information on the part of incumbent households.

For empirical purposes, this study will assume either that the influence of the existing stock is negligible or that the market is initially in stock equilibrium; however, a formulation which incorporates a stock equilibrium is also discussed (in the appendix to Chapter Five) and the empirical results are interpreted with the proviso that specific assumptions have been made about the nature of equilibrium.

(II) THESIS STRUCTURE

This thesis is in nine chapters. The first three chapters contain a detailed review of the literature outlined above, indicating specific strengths and shortcomings in each approach. The next two chapters respectively outline the key concepts relevant to the development of a regional model, and present the formal and operational structures of the model. The next chapter discusses the data and the study area, and the following chapter reports the estimated equations of the model. This chapter also discusses the implications for model dynamics of the estimates. The penultimate chapter indicates possible extensions to the model structure and draws out the policy implications, and in addition discusses current policy in the light of model findings. The last chapter summarises the conclusions.

Chapter One discusses a range of urban models based upon the premise that individuals maximise utility. This notion can be employed in a number of ways, depending on the specific form given to the maximand and constraint functions. It has been used in uni-dimensional access-space models with highly stylised and restrictive utility functions to give a reasonable approximation to the observed density profile. This chapter goes on to examine simulation models which attempt more detailed examination of urban structure, and of changes in that structure through time. One of the key criticisms of access-space models is the reliance on long run equilibrium, and in response simulation models use a number of techniques to incorporate dynamics. Apart from disaggregation of the housing stock and households, to allow for heterogeneity, the processes of mobility and location are seen to be central to the operation of the urban housing market. It is seen that a key of the housing market model "problem" is the allocation of households to dwellings and the various ways in which this can be achieved. The last section of this chapter discusses the discrete choice modelling approach, which is a technique used both in simulation models and in studies of specific housing choice processes. This technique can be used for forecasting most housing related decisions, such as mobility, tenure choice and household formation.

Chapter Two examines geographic models, in particular the "gravity" model, the related "entropy" model, and Markov chain mobility models. All of these models focus on the volumes of flows of persons or vacancies, based on notions of locationally specific characteristics which repel and attract individuals. It can be shown that all of these models are special cases of a general formulation and that they can all be derived under the assumption of utility maximisation as readily as under their own rather more *ad hoc* paradigms. These models generally ignore market considerations, since they treat demand and supply volume flows as being independent of one another. The Markov model, in particular, imposes constant transition probabilities on specific classes of movers, spatial units, or house types, and this is equivalent to assuming that the housing market is always in long run equilibrium. With some adaptations, it is possible to state the Markov model as a special case of the model developed here. The general formulation which contains all geographic models as special cases takes the form of a set of logistic gravity interactions; specific restrictions on coefficients of the general form yield specific models. The model developed here uses the weights matrix technique and the general formulation can be nested within this.

Chapter Three discusses macroeconometric models. It is observed that there are definite relationships between the activity in the economy generally and that of the housing market, but that the form of these relationships differs between the U.S. and the U.K.. The credit market is seen to be influential but two of the most important elements in the behaviour of housing market variables over time appear to be real incomes and house price expectations. It is shown that macroeconometric models make restrictive assumptions about the homogeneity of housing and hence about the interactions between the markets for new and existing houses. In particular, the implicit view of the building industry may be inaccurate. The discussion of macroeconometric models highlights the stock and flow equilibrium approaches, with flow equilibrium models tending to show a much more rapid process of adjustment than stock equilibrium formulations.

Chapter Four sets out the key concepts behind the regional model, and in particular discusses the role of space and tenure in the behaviour of owner occupiers; it is shown that in an environment of imperfect information, the owner occupier has a number of search and bidding strategies available which are dependent on the prevailing state of the market. Owner occupation implies that many market participants are both suppliers and demanders with the spatial impact of each role differing. This discussion also illustrates that to be fully specified, a model of the housing market needs to determine both prices and volumes, in contrast to many of the macroeconometric models discussed in Chapter Three which only deal in one of these. The introduction of an environment of imperfect information demonstrates one of the reasons why a short run flow equilibrium and long run stock equilibrium may diverge, since the long run stock equilibrium position can be stated as one of perfect information and frequent mobility. A discussion of the current structure of the building industry shows that a rapid response by housebuilders to market conditions is possible. The chapter also discusses the likely interaction of the markets for new and existing houses along with the implications for house price determination. This discussion demonstrates that the generalised geographical formulation may not be flexible enough to model a housing market characterised by imperfect information and joint determination of prices and volumes.

Chapter Five brings together the review and analysis of the preceding four chapters and sets out the formal regional model in matrix form. This formulation is stated in flow equilibrium terms, but a chapter appendix shows that a stock equilibrium formulation is also feasible, and subsequent empirical work must be interpreted with this in mind.. It is shown that the matrix framework is highly flexible and is capable of making statements about all three housing market dimensions. The systems of equations are specified per time period, with the basic elements of the matrices representing spatial units; no a priori limitations are placed on the extent to which all spatial areas interact. The matrices of price coefficients represent own price and cross price elasticities of demand and supply; these will partly reflect quality differences between the housing stock in different spatial areas. In addition, the weights matrix technique provides an operational version of the model and permits detailed hypotheses about spatial structure. The system of equations is then solved and its dynamics are analysed; this analysis can be contrasted with the discussions of prices and volumes in Chapter Two and with the differing views of stock and flow equilibria in Chapter Three. It is also possible to make specific statements about the dynamic implications of estimated coefficients. The regional model is then used to demonstrate the specific spatial assumptions inherent within a macroeconometric model, and is further used to illustrate that the general geographic model form of Chapter Two can be stated as a special case. It is shown that although the operationalisation of the regional model poses some problems, these are partially resolved by the use of the weights matrix.

Chapter Six discusses the relevant history of Scotland's economy and housing market, and the recent changes which have been occurring as a result of Government policy. The data to be used in model estimation are discussed and transformed to yield the exogenous and endogenous variables for the model. Expectations of empirical results are then set out along with the implications which particular results have for the models discussed in previous chapters.

Chapter Seven gives regression results for the model and indicates that while exogenous factors are important, the operation of the housing market is highly sensitive to changes in volumes, and market failure is possible. The spatial scale of operation confirms the validity of the regional concept, and the market dynamics results suggest that the view of market dynamics promulgated by macroeconometric models should be treated with some caution. In particular, the results appear to indicate that the Scottish housing market is dynamically stable but oscillatory, implying a degree of price overshooting; this may reconcile the fact that macroeconometric flow equilibrium models show rapid price adjustment, with the finding from stock equilibrium models that adjustment to equilibrium is slow.

Chapter Eight demonstrates that the regional model form used here is only one of a number of potential more complex forms, and investigation of these is likely to be a fruitful avenue for future research. The other forms focus upon more sophisticated price adjustment processes, and on the possiblity of building in longer price adjustment lags. This chapter also expands on the policy implications of the model findings, with ramifications for, in particular, Local Authority attempts to measure demand and the current controversy over land release. It is also shown that the current government policy of promoting owner occupation is desirable provided the preconditions of an orderly market are satisfied. In particular, the spatial concentration of unemployment blackspots is likely to contribute to housing market failure.

Chapter Nine draws together the conclusions to the thesis and relates the work done here to the literature discussed in the first three chapters.

CHAPTER ONE

UTILITY MAXIMISING MODELS

1.1 INTRODUCTION

There exist a large number of housing models based upon the premise that individuals maximise utility. Model forms range from neoclassical long-run equilibrium land use models to complex short-run simulation models and discrete choice models covering particular aspects of the housing demand process. Many of these theoretical forms have been subjected to empirical testing, with a variety of results.

Recent work, notably Porell (1982) and Van Lierop (1985), has devoted considerable effort to classification of previous theoretical and empirical studies. The taxonomies which have emerged are detailed and go some way towards making sense of a voluminous literature. Van Lierop stresses the importance of intended use as a determinant of model form but such a caveat still leaves some considerable variation in approach. The categories of analysis which have emerged take into account whether "housing" is treated as a homogeneous or heterogeneous good, whether a micro- or macro- approach is employed, and whether the model solution is one of short- or long- run equilibrium. Further distinctions cover the labour-housing market relationship and the treatment of mobility transaction costs. These categories collectively exhaust the kind of assumptions which can be made in constructing a utility maximising model.

1.2 LAND-USE MODELS

Land use models are the earliest economic models of urban spatial structure and the best-known examples of work in this field are Wingo (1961), Alonso (1964), Muth (1969) and Solow (1973).

The essence of these models is that all employment is located in the Central Business District (CBD) and that work place position dominates the household's choice of location.

Each household is assumed to have a utility function of the form:

$$U = U\ (q(d),\ X) \qquad (1.1)$$

where q(d) is the quantity of homogeneous housing service consumed at some distance, d, from the CBD.

X is a composite good representing all other goods.

The household's budget constraint is represented by:

$$Y = P_h(d)q(d) + P_x X + T(d,Y) \qquad (1.2)$$

where $P_h(d)$ is the price per unit of housing services, P_x is the price of the composite good, and T(d,Y) is generalised transport costs, reflecting the fact that such costs have a fixed, distance-dependent component but are also a function of the individual's income, which measures the value to him of time spent commuting.

From this a Lagrangean function can be constructed to yield the first order condition:

$$- \frac{\delta P_h}{\delta d} = \frac{\delta T(d,Y)}{\delta d} \qquad (1.1.3)$$

That is the household will locate where the saving in transport costs from locating marginally closer to the centre is just balanced by the additional housing expenditure which will be incurred.[1]

In most of these models housing is produced by a neoclassical production function exhibiting a constant elasticity of substitution between land and non-land inputs.[2]
Mills (1972) used a Cobb-Douglas production function whilst Sirmans, Kau and Lee (1980) employed a variable elasticity of substitution. The main thrust of such refinements has been to achieve better empirical performance - Solow (1972), for example, introduced congestion costs and finds a significant improvement in statistical fit over models which lack this feature.

Whilst early models assumed uniformity of demand functions, Solow introduced the idea of differing preferences for space between different income groups. This, the first step towards disaggregation, was undertaken with respect to households rather than the housing stock which was still assumed homogeneous. Mills (1972) included a non-housing sector competing with households for space, and a transportation sector to move goods and workers to the Central Business District. The interesting feature of this work is its explicit account of the "economic base" underlying the housing market; this is a point which will be discussed more fully later in this chapter.

Underlying these models are the interdependent assumptions of a "unit of housing service" and long run equilibrium. In the long run, arbitrage permits the use of one price for the homogeneous good, housing. This is facilitated by the assumption that the choice set is continuous, such that the number of households in any one annulus, n(d), can be given by the total quantity of housing available in that annulus, Q(d), divided by the quantity demanded by each household, q(d):

$$n(d) = \frac{Q(d)}{q(d)} \qquad (1.1.4)$$

This approach continues to be employed e.g. Altmann & De Salvo (1981). Porrell has pointed out that these models all contain the implicit assumption that the locating households are immigrants to the urban area and can costlessly locate anywhere; this entails the further assumption that the locating household's decision is in no way dependent on its prior residence.

The response from advocates of the neoclassical approach is well summed up in Solow's comment that "Existing patterns of location must have been determined in large part by decisions that were made and events that happened under conditions that ruled long ago... Nevertheless it turns out that the equilibrium states of simple models of urban location do actually reproduce some of the important characteristics of real cities" (Solow, (1973) P.1.). However, Whitehead and Odling-Smee (1975) attribute the empirical success of long run equilibrium models to the slowness of adjustment of all variables which tends to generate observed significance, in cross-sectional data, without yielding information about causality. More specifically, they point out that model calibration based on the assumption that the data are from a long run equilibrium state will yield biased estimates, if adjustment is still occurring. There are a variety of reasons why the long run equilibrium position is unlikely to be satisfied at any one point in time. Kain & Quigley (1975) have both argued that the extreme durability of the housing stock, the high costs of physical transformation, construction lags, and mobility costs or transactions costs all weigh against the attainment of long-run equilibrium. As Ingram et al (1972) put it: "In effect, in existing theories of location it is assumed that either cities are destroyed every night and rebuilt the next morning or that households live in house trailers that are relocated daily". (P.16)

More seriously, in the absence of long run equilibrium, the concept of homogeneous units of housing service is weakened. Straszheim suggests: "...households regard housing services as multidimensional, with some of their attributes directly associated with particular characteristics of the capital stock (the housing stock)". (P.21) But whilst through time, there will be spatial variation in the demand for housing, and consequently its price, "...these price variations are not likely to be sufficient to make it worthwhile to tear down the existing stock". (P.21) There have been attempts to handle such considerations within a neoclassical framework, notably the model developed by Muth (1973), and applied empirically by Brueckner (1981), which generated explicit predictions about the age structure of the existing stock. The most important development to arise out of dissatisfaction with the long run equilibrium housing service concept is the introduction into the basic access-space model of heterogeneous housing.

1.3 SEGMENTED MARKET MODELS

In models which depart from the long-run equilibrium assumption, it becomes necessary to deal with housing stock heterogeneity. The simplest way to do so is to define:

$$U = U(A_1 \ldots\ldots\ldots\ldots A_k, X, d) \qquad (1.5)$$

where A_i = quantity of the i^{th} attribute which can be present in a house $i = 1 \ldots\ldots\ldots k$

This is maximised subject to: $PxX + \sum_{i=1}^{k} P_{hi}A_i + T(d) = Y$

$P_{hi}A_i$ is the implicit price of the i^{th} attribute.

Following Lancaster's (1966) presentation of consumer choice in the characteristics or attributes domain, utility can be described as deriving from fundamental attributes which the individual chooses by constructing convex combinations of available goods so as to maximise utility. The drawback in applying this approach to urban analysis is that housing is available in discrete structures which will tend to be prohibitively expensive so as to disallow most individuals from owning and consuming more than one unit.

Straszheim (1975) circumvents this by suggesting that the individual chooses the discrete bundle closest to the optimum. Once heterogeneity of the housing stock is admitted, in conjunction with the previous attempts to disaggregate consumers, there is a veritable explosion in the number of subcategories which can be dealt with: e.g. race, tenure, house type and age, spatial location, transportation and accessibility to the workplace. Straszheim takes a number of these aspects into account. He studies the correlations between a variety of housing characteristics, and finds the strongest negative correlation between access (travel time to employment) and space (average lot size), and the strongest positive correlation between average structure age in an area and the percentage of pre-1950 units (as might be expected). This last variable acts as a measure of neighbourhood homogeneity.

Straszheim also finds that areas of concentration of owner occupiers in very low density housing have the highest mean income, although surprisingly central city older housing of high density also shows a high mean income. On this basis he is able to construct a standardised price per dwelling unit in each submarket, by looking at the "premiums" paid, in a variety of submarkets, for particular housing attributes.

Straszheim's data, which deals with multiple employment locations, supports the conclusion of land use models that households tend to commute in order to secure lower unit housing expenditures.

Straszheim's conclusion is that employment location and life cycle stage, as well as income, are important determinants of residential location choice as well as the amount of housing consumed and the particular attributes preferred - suggesting that analysis of housing market changes needs to disaggregate by house type as well as household type. (e.g. households with more children will demand greater house sizes).

Straszheim finally constructs and estimates a model where average neighbourhood incomes and house prices are endogenous, because households will relocate in response to the prices of housing "bundles", but this will in itself influence overall house prices. To simplify estimation, he ignores spatial interdependencies between submarkets and rules out substitute relationships with other submarkets. Market equilibrium is given by stock equilibrium, since data on stock utilisation (i.e. on vacancy rates) are unavailable.

Endogeneity of income is, to an extent, desirable given the relatively small spatial units used. It may also, however, have proxy peer group effects which, in conjunction with a heterogeneous stock, contributes to submarket price differentials through time.

Goodman (1981) has extended the submarket notion to study the optimum submarket grouping, using Cliff, Haggett and Ord's (1975) criteria of simplicity, and compactness; in essence these state that the best grouping has as few submarkets as possible, maintains within-submarket homogeneity, and only groups contiguous zones.[3]

The studies which have been examined so far all focus primarily on location, and would be classed as "micro behavioural" in Van Lierop's or Porell's taxonomy. The micro-macro distinction will be discussed shortly, but it should be borne in mind that location is only one aspect of housing choice; tenure is another important element. There also exist a number of "micro" models which deal with the decision to move (e.g.Rossi (1955), Wolpert (1965), Brown and Moore (1970), Hanushek and Quigley (1978), and Cronin (1978)). The basic hypothesis underlying these approaches is that the household has some notion of the utility it derives from its current residence and this utility is continually re-assessed; the household is likely to be in disequilibrium at any given point in time and the probability that it will move is a positive function of the extent of the disequilibrium.

The importance of mobility models lies in their attention, albeit partial, to the process of movement from one micro equilibrium to another; in long run equilibrium models such a transition (associated with, say, an exogenous change in transport costs) generates, for each household, an instantaneous and costless adjustment to the new equilibrium (a macro equilibrium).

The boundaries between micro and macro are not distinct but Porell points primarily to differences in the treatment of the allocative role of price, especially with respect to mobility models. Prices are endogenous in Straszheim's model but he does not deal in changes over time.

Many location and mobility models, and their syntheses, relocation models, are rooted in the discrete choice framework which results from McFadden's (1973) random utility theory.
This will be dealt with at a later stage in this chapter, but first it will be instructive to examine how some models have dealt with the macro effects of micro behaviour and which combine mobility and location. Forrester (1969) states that "...it is almost an act of faith.....that large, complex systems give rise to counter-intuitive consequences". With this in mind, attention can be turned to simulation models.

1.4 SIMULATION MODELS

The two most famous simulation models are those developed by the National Bureau of Economic Research (NBER) and the Urban Institute (UI). A variety of writers have dealt with these models as they have evolved over the years, but the names most closely associated with them are; Ingram, Kain and Ginn (1972) and Kain and Apgar (1985) (NBER-HUDS); and de Leeuw and Struyk(1976) and Macrae (1982) (UI). These models both incorporate an explicit model of supply, which takes a variety of forms from newbuild to existing stock conversion.

In terms of purpose, simulation models are firmly in the sphere of policy and planning analysis. A variety of simulation models were developed in the 1960's, notably the Penn-Jersey Transportation Model of Herbert and Stevens (1960) which suggested the use of a linear programming algorithm. Such models were based on observed statistical regularities rather than any theoretical framework, although Herbert and

Steven viewed the linear programming solution as a direct analog to the utility maximisation process.

The NBER model is described by those who developed it as a hybrid of empirically based simulation models and economic theories of location. Both the models under consideration view the essence of the housing market "problem" as the allocation of households to dwellings, and effect a solution within an explicitly temporal framework. In terms of complexity, the NBER model is much larger, so the UI model will be considered first.

1.4.1 The Urban Institute Model

The UI model developed by de Leeuw and Struyk (1976) is based on a set of "model" households (differentiated by race and age (elderly/non-elderly), and further by household income [4]). The model invokes the housing service assumption and household choice is made with respect to the available price-quantity configurations, as well as the characteristics of the zone in which a dwelling is located. The characteristics are accessibility, race, and average net rent per dwelling; the latter two are endogenous.

There are four groups - owners of existing dwellings, the government, construction companies, and households seeking a dwelling. The "model" dwellings are characterised by the quantity of housing services supplied.

Owners aim to maximise profit by choosing a point on their supply curve, which refers to supply over a ten year period, and depends on the depreciation rate and the price elasticity of supply. If the price per unit service falls below the operating cost level, the dwelling is withdrawn from the stock (it is demolished or becomes long term vacant). Builders have perfectly elastic supply functions and respond passively to changes in the price of the existing stock. Government is primarily important due to tax and transfer activity, and also zoning (the imposition of a minimum amount of housing service per dwelling in the "newbuild zone").

The model searches for an equilibrium solution; in the process of doing so it is possible that some households will move very frequently although de Leeuw & Struyk suggest that the means of achievement of equilibrium is unimportant. This is in direct contrast with the NBER model where it is suggested that the final equilibrium may be path-dependent.

The UI model consumer choice framework posits a quasi-Cobb-Douglas utility function for the household:

$$U_{ij} = H \; X \; \Pi_k Z_k \qquad (1.6)$$

In a linear expenditure system, utility is a function of quantity over and above some minimum threshold level. In the UI model, this minimum threshold, in the case of housing, is a function of income. Thus we have:

U_{ij} = Utility to the i^{th} household of the j^{th} dwelling

Z_k = Utility of Zonal characteristic k

H = Utility of housing services

$$= [Q_j - \alpha_i \omega \ (Y_i / P_n)]^{\alpha i} \qquad (1.7)$$

Q_j = Quantity of housing services offered by dwelling j

α_i = Strength of household type i's preference for housing

Y_i = Household i's income after taxes and transfers.

P_n = Price per unit of housing service of newly constructed dwellings.

ω = Parameter expressing degree to which households alter their choice on receipt of a price discount. If $\omega = 0$, then the utility function is properly Cobb-Douglas.

X = Utility of non-housing goods.

The supply function for existing dwellings is given as:

$$Q_j = \left[\beta_1 + \beta_2 \frac{P_j - P_o}{P_c} \right] Q_o \qquad (1.8)$$

where Q_j = level of housing services currently provided by dwelling j

Q_o = level of housing services provided by dwelling j ten years ago

P_j = price per unit of services offered by dwelling j

P_o = operating costs per unit of service

P_c = capital costs per unit of service for a new dwelling.

β_1, β_2, are parameters

In application, hedonic regressions are employed to construct rent deflators for each zone and are then used to generate housing service distributions for each zone, by applying the deflators to zonal rent levels.

The model generates a series of prices giving the distribution of prices per unit of housing services for a variety of structures representing quantity of housing services. Such a distribution is termed a price-structure curve.

It is quite possible for zoning restrictions, in conjunction with the income distribution, to generate higher prices per unit of housing service for houses supplying quantities of service below the legal newbuild limit, due to excess demand in that sector. Meanwhile real income and population growth , plus depreciation, create continual excess demand for housing at the higher end of the value spectrum; sufficiently high as to be equal to the threshold level just sufficient to introduce new building. In this scheme, then, new building will be clustered at the top end of the market.

The model is used to simulate exogenous effects such as an increase in construction costs, a decline in population growth, a housing allowance programme, and a new construction subsidy (see Ingram (1977)).

The most important feature of the UI model is its separate treatment of households and house owners. Whilst this is a conceptual separation only it is not clear how different the results would be if modelled as an explicitly owner-occupied market. A key drawback from the point of view of short-term forecasting is the 10-year perspective and the broad aggregative groupings used. As an indicator of long term trends, however, the UI model remains an important contribution to the study of housing market dynamics.

Macrae (1982) has modified the algorithm employed in the UI model such that households should, in equilibrium, be indifferent between their current dwelling and the next best alternative. (He also points to the inconsistency in supplier behaviour implied in the original UI formulation where the supplier is simultaneously a price taker and a price setter). There is no restriction, however on the mobility rates required to attain equilibrium although allocation of households in descending order of income should mean that this is not too unrealistic.

1.4.2 The National Bureau Model.

Although the NBER model is considerably more detailed in input and output than the UI model, its structure is, paradoxically, much more simple. It consists of a series of submodels, summarised in Table 1.1

TABLE 1.1 COMPONENTS OF THE NBER MODEL

Employment Location Submodel

↓

Movers Submodel

↓

Vacancy Submodel

↓

Demand Allocation Submodel

↓

Filtering Submodel

↓

Supply Submodel

↓

Market Clearing Submodel

↓

Model Simulation

Source: Ingram et al (1972)

The first and most noticeable difference between this and the UI model is the treatment of the economic "base". The assumption of workplace dominance which pervades the literature in this area suggests that employment location is a fundamental constraint on residential location [5] and this is included in the choice process of moving households. By contrast, the UI model imposes exogenous travel costs for each zone (the implication being that all the residents in one zone work in the same place). The need to take explicit account of employment location means that household details include occupational attainments, employing industry, and labour market status (i.e. whether currently unemployed). One worker per household is assumed.

A further major difference is in the simulation period. Although the NBER model aims at 10-50 year projections, each iteration of the model refers to one year so there exists potential for short term forecasting. Moreover, the NBER model contains more specific spatial detail. This is partly in terms of the number of alternatives (19 workplaces, 44 residence zones compared with the UI model's 6 zones) and partly in the operation of zoning and land markets. The UI model has one "newbuild" zone in its original formulation, whilst the NBER model deals explicitly with the amount of vacant land available in each zone.

The two models also differ in their price formation processes. In the UI model, prices are set by suppliers with the intention of maximising profit - although as Macrae (1982) points out, this is inconsistent supplier behaviour in a perfectly competitive market.. . Macrae's response is to alter the allocation algorithm, which it should be remembered is not intended to be realistic. The NBER modellers tackle the issue more directly, although stating:

"The difficulty of devising an operational, yet theoretically defensible, technique of forming prices in a dynamic context may have been the greatest single obstacle to the development of a market model of housing choice and residence location". (P.51)

The NBER model employs shadow prices from the linear programming solution; for any given house type these are interpreted as the "location rents" accruing to a particular zone. These are then used to adjust expected price rises, via an adaptive expectations formula, which influence demand decisions. However, the model does not calculate a transaction price for each period. The coefficient of expectations in the adaptive expectations formula is determined experimentally.

On the demand side, movers are generated by application of historical mobility rates to household classes, [6] and this is subsequently modified by workplace-specific alterations. These movers are then allocated to submarkets, which they choose by minimising gross prices (gross prices include travel-to-work costs, and as usual include fixed and income-dependent elements).

Assignment is to house type (via household demand functions) and then to residential location on the basis of minimisation of travel-to-work costs; since higher income groups value commuting time more highly they choose accessible locations within any submarket. Since this process is carried out for each house type, it is equivalent to minimisation of aggregate costs. Ingram et al (1972) claim that evidence suggests that gross price effects (i.e. travel-to-work cost effects) are large.

On the supply side, vacancies are created by movers, out migrants, and income/household-type specific changes in occupancy rates. To this is added new supply by house type either from newbuild or from transformation of units. The supply function for new houses uses the Dow Jones Building Cost Calculator, to compute the costs associated with the production or transformation of units, in the form of an input-output array and includes some consideration of the quality[7] of any given house type.

Supply can also change by change in the quality level ("filtering") which any unit occupies. This can happen via (costless) downgrading (i.e. natural depreciation) or by conscious upgrading by the owner who perceives the quality "premium" as exceeding the upgrading costs.

The last stage in the process, the market clearing submodel, carries out a variety of accounting procedures (e.g. updating the pattern of work trips). For the purposes of achieving market clearing, households can substitute locations, according to previous period prices, but not house types. In practice there is no one-to-one allocation of households to houses, rather a tally of net numbers is kept. [8] Excess demands (unallocated households) are carried forward to the next period, and shadow and expected prices are updated for the next iteration. Thus the "equilibrium" to which the model tends is a moving target.

The choice process, then, is sequential, and the mobility, house type, and location choices occur independently. At the market clearing stage, substitution is in terms of spatial units rather than house types.

The Kain and Apgar (1985) HUDS simulation model expands the NBER model. The most important new features which it contains are population-serving employment (which is endogenous) and a tenure choice submodel. Tenure choice occurs after the demand equations have allocated households to house types and locations, and is dependent on a variety of factors such as past tenure, current income, previous dwelling, and the age/race of household head.

Simulation models have been considered here at some length to illustrate the complexity with which it is possible to model housing markets, and the specific assumptions involved when using a more aggregative modelling approach. The most important aspect of simulation models is the treatment of time. Introduction of dynamic elements do, however, pose problems - not least the decision as to what is endogenous, as opposed to exogenous - in the longer period. Forecasts and simulations of any kind require projections of exogenous variables and in the NBER - HUDS models this is mainly achieved by use of state-space transition matrices. The merits and demerits of this technique will be discussed in the next chapter but it can be stated here that it is clearly a powerful accounting procedure in the handling of large numbers of subcategories.

One of the main reasons that simulation models were initially developed was the considerable observed complexity of urban systems. But disaggregation alone does not automatically solve the problems arising from such complexity; it generates its own dilemmas of model calibration, partly due to data volume considerations and partly from the more fundamental problem of the exogeneity/endogeneity dichotomy.

In the HUDS version of the NBER model, demand equations are estimated by multinomial logit and tenure choice by binomial logit. These decisions still occur sequentially and are assumed independent. Kain and Apgar claim the evidence does not suggest otherwise, but this raises the calibration and model design problem. Whilst it might be felt that many factors are important at each choice level, and indeed that there exists interdependency between choices, only empirical applications and evidence can ultimately suggest the best form.[9] The alternative is to be faced with so many variables, and "imposed" parameters, as to render the model incapable of meaningful detailed predictions, turning it instead into a "black box" even for the researcher.

With this in mind, attention can now turn to examine the theory and practice of discrete choice models as applied to housing.

1.5 DISCRETE CHOICE MODELS

1.5.1 Theory

Underlying discrete choice models is the assumption that whilst a variety of factors may be important in determining the likelihood of any one individual making a particular choice, the relationship between the explanatory variables and the choice probability is non-linear. In the case of the logit model, the function is cumulative logistic, and in the case of probit it is cumulative normal.

The random utility framework is given in McFadden (1973), and its essence is as follows: Let U_i be the utility attached to the i^{th} alternative and let X_i be a vector of attributes associated with an individual, or broadly homogeneous group of individuals, which influence choice. Let V_1 and V_2 denote functions, and let ϵ_{1i} be an independent, identically distributed (but not necessarily normal) disturbance associated with the i^{th} alternative. Finally let β be a vector of coefficients and let ψ be a coefficient vector which varies from one individual to another even within the same group.[10] So for one individual, this gives:

$$U_i = V_1(X_i^T\beta) + V_2(X_i^T\psi) + \epsilon_{1i} \quad (1.9)$$

with $\quad E(U_i) = V_1(X_i^T\beta)$

ψ, the individual taste variation parameter, is not assigned any systematic pattern so it is assumed that its influence can be subsumed into a composite disturbance, ϵ_{2i}.
Thus the utility expression becomes:

$$U_i = V_1(X_i^T\beta) + \epsilon_{2i} \qquad (1.10)$$

The probability that the i^{th} alternative is chosen, Pr_i, is taken to be the probability that the utility associated with the i^{th} alternative is greater than all other alternatives' utilities.

This yields the fundamental equation of the random utility approach:

$$Pr_i = Pr[V_1(X_i^T\beta) + \epsilon_{2i} \geq V_1(X_j^T\beta) + \epsilon_{2j}] \qquad (1.11)$$

$$= Pr[\epsilon_{2j} \leq V_1(X_i^T\beta) + \epsilon_{2i} - V_1(X_j^T\beta)] \qquad (1.12)$$

where $\Sigma_i Pr_i = 1$.

The use of normally distributed disturances is undesirable because in this framework they are heteroskedastic. The commonest form employed for multinomial logit purposes is a Wiebull distributed disturbance. The exact form is not relevant but does satisfy independence and identical distribution.

Under the Wiebull distribution, the basic model becomes:

$$Pr_i = \frac{\exp^{V_i(X_i{}^T\beta)}}{\Sigma_j \exp^{V_i(X_j{}^T\beta)}} \qquad (1.13)$$

The individual's ranking of all the alternatives can be given by a series of paired comparisons - this is the "independence of irrelevant alternatives" property.

The binary logit case is given as:

$$\ln \frac{P_1}{P_2} = \ln \frac{P_1}{1 - P_1} = V_1(X_1{}^T\beta) - V_1(X_2{}^T\beta) = V_1(X^T\beta) \qquad (1.14)$$

Hence in the binary model, relative probabilities are a function of the set of all explanatory variables, X.

Since the joint probability of an event's occurence is the product of the marginal and conditional probabilities, the logit model can be extended to deal with sequential choice. The random utility function is assumed to be linearly seperable into those attributes that vary across both levels of the choice procedure (the conditional choice probabilities) and those that vary across only one (the marginal choice probabilities).

McFadden's (1978) nested logit model generalises the sequential logit procedure to allow for some correlation between disturbances; he goes on to show that all of these logit models are members of the family of general extreme value choice models.

In applying these models, there are a number of considerations to be borne in mind. Firstly, estimation of model parameters requires software with non-linear estimation routines and appropriate disturbance distributions. Secondly, the models are "micro" in the truest sense and require individual-level data. It is possible, especially in the binary case, to use the least-squares approximation applied to aggregate data. Such an approach is, however, only valid if there are likely to be large proportions choosing the appropriate alternative [11] (i.e. where the relevant behaviour is on the approximately linear portion of the cumulative logistic function).

1.5.2 Practice

1.5.2.1 Tenure and Housing choice

The more straighforward applications of discrete choice models pertain to the choice of tenure and the mobility decision. Applications to spatial choice or relocation are more complex.

In the models reviewed thus far, the implied tenure form is rental. This is primarily because it is assumed that there exists a straightforward relationship between rents and capital values; capital values are the present discounted value of the future net benefit stream arising from rental income.

In a perfect market this will be valid, but if there exists any form of market segmentation, imposed by an institutional framework of rent controls and other subsidies, the relationship between rents and capital values may not be maintained.

Struyk (1976) examines the tenure choice process. He eschews the notion of a segmented housing market on the evidence of an earlier study (Schnare and Struyk (1976)) and invokes the housing service assumption; that is, housing is homogeneous and the only difference between structures is the quantity of services supplied. This can be viewed "as if" it is the case by the choice of suitable hedonic indices as weights to transform the multi-dimensional housing bundle into a uni-dimensional good. In the absence of market segmentation and false trading, this is valid.

Struyk points out that most studies which attempt to evaluate the price elasticity (e.g. de Leeuw (1971)) and income elasticity (Wilkinson (1973)) of demand for housing separate results for owners and renters. Struyk suggests that tenure is important in housing analysis because of housing's dual role as an investment and consumption good. There will exist interdependence between the owner and rental markets because both compete for housing services, whilst only owners demand for investment purposes.

Struyk's theory of tenure choice is not cast in terms of utility functions although these are implicit - renters desire to avoid maintenance and transaction costs, and so it should be theoretically possible to deal in risk aversion as a key determinant. (This has been proven to be the case in a study by Ioannides (1979)) But Struyk also suggests that owners and renters have different house structure preferences; the single unit (detached) structure is the dominant form available to owners, and is desirable as such when the owner has a family. In addition, inelasticity of supply in the short run will mean that at any point in time there will be a mismatch between the supply and demand of structures demanded by owners and renters; this mismatch partly accounts for differences in the price per unit of services facing owners and renters.

In conjunction with this, the tax subsidy to owner-occupiers acts as a very obvious incentive to own but is one which is dependent on income. These considerations lead Struyk to estimate a model in which tenure, housing consumption and subsidy received are simultaneously determined for each household.[12] Prior to this he estimates a binary choice model[13] for tenure choice alone, with probability of ownership a function of permanent income, life cycle and marital status, number of persons in the household, the value of subsidy received and the tenure chosen by the household's peer group. This effect is also suggested for location behaviour by Ingram et al (1972).

Struyk splits the sample by age and household type, and finds almost all variables are significant [14] for husband-wife families with the age of head of household in the ranges 30-44 and 45-65. He achieves similar results for the under 30's with the exception of the peer group effect.

Struyk criticises Kain and Quigley (1972) (amongst others who have studied tenure choice) for aggregation across households and for concentrating on newly formed or relocating households. This criticism is made because it is suggested that viewing recent movers as being in equilibrium represents substantial myopia on the part of the relocators; if they have a view to <u>future</u> housing requirements, their new residence may still represent a short term disequilibrium position. Struyk also points out that current income may affect the <u>timing</u> of the mobility decision. Kain and Quigley experiment with current and permanent income, but not in the same equation, as Struyk does. He goes on to suggest that by using aggregate probabilities of owning and renting, (presumably derived from relative frequencies) it should be possible to construct an aggregate tenure choice, housing consumption and supply model.

Quigley (1976) has estimated a conditional multinomial logit model to analyse housing choices. He first of all points out the distinction between service price and gross price, determined by travel to work costs (as in the NBER - HUDS models). He then estimates the model with the sample split by income and family size, with the relative likelihood of choice of any one housing type as a function of density, size (rooms), quality (age), availability and effective (gross) relative price of each house type. To satisfy the conditions of negative own-price elasticity and positive cross-price elasticity, the coefficient on relative prices should be negative. Invoking Sweeney's (1974) commodity "heirarchy" notion, it is to be expected that households prefer more to less quality, ceteris paribus, so one expects the age coefficient to be negative also. By the same reasoning the size coefficient should be positive. The results bear out these hypotheses fairly closely although size tends to show perverse signs for small families (as might be expected) and relative price effects become unimportant at high income levels. The availability variables are nearly all significant. Quigley's work shows that it is unwise to ignore house types and the effects of travel to work costs on choice. This would suggest that Struyk's model may be mis-specified in that travel costs are ignored; his peer group variable may go some way towards proxying this, however.

Boehm (1982) has suggested that house type choice and tenure choice cannot be treated independently. Quigley's samples are all recently relocated renters and Struyk's work would suggest that results for them cannot be generalised, or are mis-specified because they treat the tenure decision as independent. Boehm views the tenure, size and quality choices as occurring within a "hierarchy" The consumer is viewed as making the tenure choice first.[15] The order in which the subsequent choices are made, conditional on the tenure choice, is varied experimentally. If hierarchy level is unimportant, it would be expected that (for example):

$$\Pr(HQt \mid Ot, Lt) = \Pr(Lt \mid Ot, HQt) \qquad \text{for all t (time periods)}$$

where HQ denotes "high quality" ownership (proxied by neighbourhood income)

O denotes ownership tenure

L denotes "large" (definition varies by tenure)

Pr denotes choice probability

Boehm estimates equations with first quality and then size at the lowest level of the hierarchy. Some of the parameters vary considerably,[16] although Boehm does not discuss this. The regressors used in the first hierarchy are family size age of head of household, marital status, race, one of three "wealth" variables (prior house value, estimated permanent income, and actual wealth), average price of owner-occupied dwellings, relative costs of owning versus renting, expected mobility, and expected house price changes. The latter two variables are given directly by survey data. The results show expected signs for all variables except house price changes, with wealth, family size and marital status showing a strong positive effect, whilst average price, owning costs, and expected mobility are strongly negative. The equations at the lower level of the hierarchy[17] include relative price terms although the results tend to be insignificant, especially with respect to quality choice.

This gives eight possible housing choices. Given that the joint probability of any one of these choices is the product of the marginal and conditional probabilities, it is possible to construct a matrix showing the change in the probability of making any one housing choice due to a change in any one explanatory variable. This has the advantage of ease of interpretation. Also, since each decision in the hierarchy is treated as dichotomous (binary logit) the independence of irrelevant alternatives assumption can be avoided. There is the disadvantage, however, of rapidly diminishing sample size the more hierarchy levels are estimated.

1.5.2.2 Mobility and Housing Choice.

The discrete choice models reviewed so far have highlighted the difficulties involved in modelling complex choices in a framework which does not take account of the heterogeneity of households, house types, and the institutional environment. They demonstrate that "feedback" effects from one choice to another may be strong. Underlying this is the tension which exists between two schools of thought on the mobility decision. One such view is that households move in response to disequilibrium, and thus recent movers, being in equilibrium , are the only ones to give a true picture of their preferences. This is the rationale used by Quigley for studying only recent movers. Struyk rejects such a notion and would probably reject the possibility of modelling mobility at all, on the grounds that current residence choice reflects all the information about future circumstances available to the household at any one point in time. Weinberg (1979) has suggested that mobility is due to unexpected disequilibrium.

Rejection of the disequilibrium - mobility hypothesis outright is too harsh without investigation of the evidence. Mobility is a major means of adjusting housing consumption (although the NBER - HUDS model and

Struyk suggest maintenance and upgrading expenditures are equally important; this is especially so in Struyk's analysis where the asset demand for housing is stressed. The force of Struyk's argument depends on disequilibrium costs in relation to mobility and search costs.)

The earliest studies of mobility aim at discovering empirical regularities, and the strongest associations found are between socio-demographic factors, tenure, and movement propensities. Pickvance (1974)[18] uses path analysis to disentangle causal relationships in the mobility decision. He finds that life cycle position and age have a positive impact on tenure (ie choice of owner-occupation) which affects desired mobility negatively. By contrast Boehm reverses the causality and employs expected mobility in his tenure choice equation, yielding the result that higher expected mobility lowers the probability of choosing owner-occupation. Since both techniques aim to show causality this leaves the question "Do renters avoid owner-occupation because they are more mobile (avoiding some transactions costs) or are renters expecting to move to owner-occupation because they view renting as inferior to owning?" This demonstrates the problems inherent in mixing temporal data (expectations) with data on the household's position which effectively reveals previous choices (although not necessarily previous preferences).

The conceptual causal model employed in early mobility studies suggests that over time, life cycle changes generate a mismatch between housing needs and a household's current housing situation, resulting in a move. The subsequent choice is viewed as more or less independent of the decision to move itself, but important linking factors are life cycle stage and permanent income.

The unification of the mobility - location decision is achieved by the introduction of the notion of search, especially by Clark & Cadwaller (1973), Speare et al (1974) and Goodman (1976). The household is viewed as continually re-evaluating the "place utility" of its dwelling. Either an alteration of its needs or of the immediate environment will generate "locational stress". This initiates search, which is in effect an information gathering process. Of all the opportunities available, the household only has sufficient information to assign "place utilities" to some. This defines the household's "awareness space". The household is also assumed to have defined its "aspiration region" - the upper and lower bounds of dwelling and neighbourhood attributes which the household deems acceptable. The intersection of the "aspiration region" and the "awareness space" gives the "search space".

This sets the framework within which search operates, but constructing and testing a model raises a number of questions. The first point is that search involves a variety of costs and is subject to constraints (eg time). McCall (1970) suggests treating search as a sequential sampling procedure, whilst Rothschild (1973) (among others) suggests that "learning" effects will also operate.

The literature on search is vast and much of it is not directly pertinent to housing, but is rather aimed at macro theories of the labour market. Nevertheless, many of the concepts translate well:

Stigler (1962) viewed search as sampling from a vacancy distribution, whilst the learning effects mentioned above refer to a probability distribution of prices.

Hanushek and Quigley (1978) formulate a mobility model which implicitly incorporates search by assuming that search and moving costs are randomly distributed. Their model postulates that household disequilibrium can be decomposed into two components; first is the expected change in the equilibrium demands of the household over the forthcoming time period, second is the extent of current disequilibrium. Deviations of this kind can be positive or negative. Equilibrium demand is a linear function of a household's income, its size, and the age of the head. Hanushek and Quigley employ probit estimation[19] on the differences between the actual and desired demands. The desired demands are calculated using equations estimated in Hanushek and Quigley (1979) - since these apply to recent relocations they are taken as representing equilibrium (Struyk's criticisms notwithstanding). They find that disaggregation of "stress" into two component yields superior statistical fit; and since their data consists of longitudinal interviews, they are able to suggest that at any point in time a large number of households are in disequilibrium.[20]

Although in the "stress" model of search and mobility it is suggested that the household is unaware of external opportunities until it reaches a threshold level of dissatisfaction there is at least the possibility that consequent upon search the household may decide not to relocate. This can be contrasted with the mechanical view held in, say, the NBER - HUDS model where excess demand is carried forward from one period to the next, and mobility is automatically "triggered" (as in e.g. Jones (1981)). Speare et al (1984) points out that selection of a new residence may occur prior to the decision to move, whilst Cronin (1978) found in survey data that 31% of respondents expressing very great dissatisfaction with their current housing situation did not search, whilst 33% of those claiming to be satisfied did search.

Cronin (1979) estimates the probability of search in any one year as a logit function of cost and benefit factors, including dissatisfaction with current housing circumstances, search and mobility costs, social ties with the current neighbourhood, past mobility, and race. He also suggests that different household characteristics will result in different information sources or information gathering activities (and hence differing search costs). For those restricted to public transport, or who make infrequent use of newspapers, search will be more costly for any given expected benefit. Cronin uses the income equivalent variation (the amount necessary to render the household in equilibrium again) and finds that as this value rises, the search period falls whilst search intensity rises. He finds inconsistencies in the signs of mobility cost variables. Previous mobility is insignificant when household demographic characteristics are included. In a subsequent study, Weinberg et al (1981) found previous mobility and age of household head, as well as dissatisfaction, to be important in explaining the probability of search.

Whilst the evidence suggests that search is important for gathering information and will be sensitive to a variety of factors, household disequilibrium amongst them, in practice a household needs to have some notion of its desired housing consumption given current constraints prior to initiating search. The basis of this is that some information about housing is available at very low cost in newspapers, so that all households will have some knowledge of the external market situation, and the distinctions between "searching" and "not-searching" are likely to be blurred. "Search" then takes on the characteristics of "fine-tuning" of information. MacLennan (1977) defines the search-mobility process as occurring in conjunction with an "aspiration set redefinition circuit". In the process of redefining the aspiration set (i.e. completing the preference map), the awareness space and consequently the search space are also redefined.

The micro-level models discussed so far implicitly utilise the notion of revealed preference; that is, at any one point in time a household's situation reflects its preferred position subject to constraints.[22] This is valid provided the household is known to have possessed perfect information at the time of the choice.[23] Empirical refutation of this would require demonstration that a strictly preferred alternative had not been chosen (assuming rationality) or alternatively the ability to read minds!

In the absence of this, there is always the danger that the need to take into account important constraints will have been ignored (e.g. "gatekeeper" effects, operating especially in the rental sector, where public and private landlords may impose their own criteria for acceptance of tenants.) Longley (1985) suggests that in analysing housing choice, separation of the sample into tenure groups is a pre-requisite given that a free tenure-choice environment cannot be assumed. He also suggests that, in the case of spatial choice (of, say, housing alternatives) information or market entry constraints represent a breakdown of the fundamental discrete choice modelling assumption, of a universal choice set faced by all decision makers.

MacLennan and Williams (1980) have investigated revealed preference in a spatial context when preferences are of the neoclassical (that is, constraint - independent) type. In the case of the homogeneous-housing location models, preferences for space in terms of density determine spatial choices; in heterogeneous discrete structure housing, house type choice is determined by life cycle factors as well as attribute preferences, whilst location is chosen by transport - cost minimisation (so choice of peripheral location due to low density is viewed as conceptually part of the house type choice). This reflects the traditional role of space in neoclassical economics as a source of transport costs alone.[24] To this might be added the potential for spatial clustering via peer group effects and stock durability, either as a social phenomenon or as a reflection of information networks. MacLennan and Williams also suggest that in the absence of an optimal stopping rule (e.g. Flowerdew (1976)) in cases of spatial choice, changes in knowledge due to continued search will create problems in specifying demand or more generally will result in a breakdown of the traditional choice axioms. Van Lierop (1985) suggests the use of stated and revealed preference data in combination.

1.5.2.3 Household Formation

All of the models examined so far contain the assumption that the household is the basic decision-making unit. The market size may change through population growth (a change in the absolute size of the various categories to which headship rates are applied) or through a long term change in population age structure affecting the relative size of the headship categories (given by life cycle factors in temporal comparisons). It will also obviously change through real income growth. A much neglected possibility, however, is that of systematic changes in headship rates; that is, in the actual propensity to form households.

The conventional treatment of demand in housing is in terms of household expenditure, either on housing services or their equivalent scaled into one dimension using hedonic indices. As has been seen however, such an approach implicitly assumes long run equilibrium and apart from the factors likely to prevent this discussed in Whitehead and Odling-Smee in Section 1.1, the failure of perceived and non-perceived feasible sets to coincide will also militate against it. The NBER-HUDS and UI models at least deal in actual numbers of households but even in the NBER model, which requires household projections, headship rates are used. Struyk (1976) in his suggested form for an aggregate simultaneous equation model treats the number of households as exogenous, since: "...to make it endogenous would involve incorporating central place or differential regional growth theory in the model" (P.178) This is a crucial statement, but discussion of it will be left until Chapter Four where regional factors will be analysed.

Ermisch (1981) has suggested a utility maximising framework for the analysis of the household formation process. He suggests that the decision to form a separate household is a special case of the more general choice of optimal household grouping. The suggestion is, in effect, that household members engage in "home production" and that there exist economies of scale in this respect, notably deriving from quasi-public goods (consumer durables in the house and the house itself).

More formally, let X be services yielded per capita by a <u>market</u> good (i.e. housing) and let Z be the quantity of housing available. Let q be the number of members of the household, giving

$$X = X(q, Z) \qquad (1.16)$$

Ermisch suggests that:

$$-1 < \frac{\delta X}{\delta q} \frac{q}{X} \leqslant 0$$

and imposes $X = q^{-\phi} Z$

$0 \leqslant \phi \leqslant 1$ (Scale economies)

i.e. the elasticity of output of housing service per capita with respect to numbers of persons in the household demonstrates economies of scale. If the elasticity is -1, no economies of scale operate, whilst if it is zero, the house is a pure public good.

In order to benefit from owning a house it is suggested that household members have to combine the purchased goods (housing and consumer durables) with time spent in the home (at the expense of time spent supplying labour to the market).

Thus there is the (concave) "home-produced commodity" production function:

$$C = C\ (X\ L\ q) \tag{1.17}$$

where L = hours of time spent in the home.

Lastly there is the utility function:

$$U = U\ (\underset{+}{C}\ \underset{-}{q}) \tag{1.18}$$

where signs denote expected signs of first-order derivatives.

Letting T be the total time available and N be the hours of time spent supplying labour to the market the time constraint is :

$$N + L = T \tag{1.19}$$

Letting w be the hourly wage rate and V be non-labour income, and p the price of "housing services", the budget constraint is:

$$wN + V = \frac{pZ}{q} \tag{1.20}$$

for any individual.

The individual chooses Z, L and q so as to maximise (1.18) subject to (1.19) and (1.20).

The model allows for corner solutions (e.g. L = T) such that some houshold members may not work at all, and empirical results[25] suggest that $\delta q/\delta W$ is negative. (The elasticity of household size with repect to income is approximately -0.2; Hickman (1974) found it to be -0.18 using numbers of households).

Ermisch and Overton (1980; 1985) have applied these ideas to explain two housing-related demographic phenomena: the decrease in marriages and the actual household formation decision. With regard to the first, given that female earnings have risen relative to male earnings in the post-war years, Ermisch's model predicts a decrease in marriages (or at least an increase in the average age at marriage) and empirical work appears to support this. Marriage is not, however, the only source of new households and is becoming less important in this respect.

Ermisch and Overton (1985) use the notion of "minimal household units" (MHU's) to analyse household formation. There are four kinds of MHU's:

U_1 : Single adults without children

U_2 : Lone parent families

U_3 : Married couples without children

U_4 : Married couples with dependent children

It is possible for individuals to move from one type to another via marriage, divorce, illegitimate birth, and so on. The MHU's are regarded as the basic economic decision taking unit. Households, on the other hand, may be "simple" (one MHU) or "complex" (more than one MHU). The optimal MHU grouping for any set of individuals will be determined, as in Ermisch's household formation model, by earnings, desire for privacy, and economies of scale in "home production".

Using General Household Survey data, Ermisch and Overton estimate a probit model which predicts the probability of being a separate household for a variety of categories (classified by age and previous marital status) of non-married individuals, one-parent families, and for couples (with husband aged over 65) categorised by whether or not the wife works.

Amongst single people, the biggest differences are for "never-married" compared with those widowed or divorced. The presence of children considerably increases the probability of living alone when all other factors are controlled (i.e. age, marital status, income and place of residence).

This approach is superior to the traditional "headship rate" method which employs age, sex, and marital status categories, especially for the younger sections of the adult population. By paying specific attention to economic factors, the approach has the potential for extension to take into account the possible simultaneous determination of household formation and house availability. This raises some key issues: the first is that in a single-equation probit framework, there is the implicit assumption of the congruence of revealed and actual preferences, whilst this in turn presupposes perfectly elastic supply.

1.6 CONCLUSIONS

In this chapter the intention has been to illustrate a variety of points which will be pertinent to subsequent discussion. It has been seen that the utility maximisation premise is a powerful one which can handle a variety of situations, assumptions, and levels of detail. It has been shown how the assumption of revealed preference can be employed to generate quantitive predictions concerning choice probabilities in a number of different contexts relevant to housing, and that there exist many ways in which multi-level choice can be modelled.

Further, it is clear from the above that space is, initially, treated as a source of transport costs alone in utility maximising models and this is its only path of influence on the housing market. In the polycentric workplace case, households which are identical in all other respects may face spatially different gross prices for housing in a given system, by virtue of their employment locations. In the NBER-HUDS model, households may substitute across space according to transportation cost minimisation criteria in order to achieve an equilibrium position.

Space may also enter indirectly in the form of externalities, (which generate location rents for particular areas) which may have a systematic spatial pattern - for example, the East-West dichotomy in urban areas in the UK where the prevailing wind is from the West; clean air becomes a non-traded good, reflected in location rents.

Space is only one dimension of the market. Many of the studies discussed here employ the "expenditure on housing services" concept as a measure of demand, but at the aggregate level this takes the form of a volume of expenditure distributed (non-uniformly) over a number of households. That number will be variable (and possibly endogenous) as seen in Ermisch's household formation studies, and its distribution by tenure will also depend on a variety of factors, including past building and demolition activity and government policy, reflected in rent regulations and the tax treatment of owner-occupation.

The bulk of discrete choice models deal with individual level data, and transferring these to an aggregate level (for the purpose, say, of constructing a simulation model) requires explicit aggregation assumptions; for example about the shape of the income distribution. The naive approach integrates individual level relationships across all individuals, employing some income distribution (e.g. lognormal) to do so. The discussion of simulation models, however, has illustrated the interdependency that exists between individual choices. This implies the possibility of multiple equilibria for the individual particularly if the model incorporates false trading. If any one individual's choice is frustrated, the individual has to decide whether to keep searching and remain in disequilibrium or break off search and revert to equilibrium.

The apparent need for multiple equilibria to reconcile macro and micro models is false, however. The process of search by the individual has been seen to be one which alters the individual's information set in an uncertain environment. The time constraint (possibly self-imposed) is the "slack" for any one individual, and in practice the housing system will "grope" towards a possibly unique equilibrium which would exist in a world of perfect information.[26] In practice there will be some number of individuals in disequilibrium at any one time (as suggested by Hanushek and Quigley) and an equilibrium to which the system tends. The allocative role of price over and above location and quality premia is one which operates slowly (as reflected in the NBER-HUDS model where it takes some time for shadow price changes to affect decisions significantly).

The NBER-HUDS model is non-Walrasian by construction,[27] although the UI model (by allowing unlimited mobility for some households) is likely to attain a unique equilibrium. It seems intuitively unlikely, however, that the NBER-HUDS model will have a unique equilibrium given that spatial substitution is possible and excess demands are carried forward from one time period to the next. In the next chapter some of the methods employed to model vacancies more formally (in a non-utility maximisation framework) will be investigated, as opposed to the ad hoc algorithms used in simulation models. A feature which is common to most of the studies discussed here is that they treat the core of the housing market "problem" as being the allocation of households to houses, where such an allocation takes time to happen and is of a speed such that changes in both dimensions, households and houses, can also occur.

Overlaying this is the strong spatial component which means that the "housing market" is the result of interconnections between desires, opportunities, and information, where all three are simultaneously determined.

Some researchers have tackled these aspects, either on a theoretical (Gale and Moore (1973)) or an empirical level (Van Lierop (1985)). Both begin at the micro scale and imply considerable expense in data gathering. For this reason, this study will be restricted to a more "macro" oriented approach.

CHAPTER TWO

GEOGRAPHIC MODELS

2.1 INTRODUCTION

The models discussed in the last chapter possess the common feature of assuming utility maximisation or its supply side counterpart, profit maximisation. By contrast the models examined here employ a variety of approaches, although they all address similar questions. Consequently the classification adopted is one of technique, since all the models address mobility, location, or relocation at the macro or micro level of aggregation. The boundaries between these latter categories tend to be diffuse and will not be adhered to here in a rigid manner. The Porell (1985) and Van Lierop (1985) taxonomy draws a distinction between "statistical" models based on empirical regularities and "analogue/heuristic" models which employ concepts developed in the natural sciences. Such a classification is useful, but the broad headings predominately used here are threefold: firstly, the "gravity" model of spatial interaction will be examined; then the "entropy" model which derives from it; thirdly, those models which employ variants of the Markov Chain stochastic processes will be evaluated. The first two forms are broadly of the analogue type, the latter is statistical. These categories are not, however, mutually exclusive.

The models to be reviewed have developed from the disciplines of sociology and economic geography. They have a strongly spatial bias although the form of such "space" varies - from "social space" (between, say, social classes with applications of a geographic nature) to "economic space" (however defined). Space is the motive force, in contrast to the last chapter where behaviour flows from utility functions. As will be shown, however, a number of the model forms to be discussed can be arrived at by some form of constrained optimisation process, with benefits (such as "attractiveness") maximised subject to costs (such as "congestion"). It will also be shown that most of the models discussed in this chapter can be analysed within the common framework developed by Alonso (1978).

The earliest form of spatial interaction posited is the "gravity" model, which has a number of housing market applications, and this will be discussed first.

2.2 GRAVITY MODELS OF SPATIAL INTERACTION

The notion that analogues to the laws of Newtonian physics can explain human behaviour is first set out in Carey (1858), who suggests that the attractive force of a geographic area will be greater the higher the population concentration. In the Newtonian formulation, the amount of "interaction" between two bodies is directly proportional to the mass of the two bodies, and inversely proportional to the square of the distance between them. Zipf (1947) points out that although the exponent on distance in a three-dimensional system (e.g planetary motion) is 2, in a two dimensional system it should be 1. An exponent of 1 does imply that interaction is an inverse linear function of distance, which seems intuitively difficult to accept.

The model presented by Zipf is:

$$I_{ij} = \frac{AP_iP_j}{d_{ij}} \qquad (2.1)$$

where I_{ij} is the "interaction" (usually flows of persons or goods) between areas i and j

P_i is the population of area i

d_{ij} is the distance (however defined) between i and j

A is a constant

This formulation has been applied in two main ways, depending on the "interaction" being examined. The first application (used by Zipf) models interurban migration flows, which in effect is an aggregate, long distance, housing relocation model. The formula in (2.1) aims at modelling two-way flows. For unidirectional predictions, only the destination "attractiveness" is required. Zipf suggests that population adequately proxies "attractiveness" when income and unemployment are uniformly distributed. Stouffer (1940) suggests that "attractiveness" should be replaced by "opportunities", proxied by the total number of immigrants to an area (implicitly invoking revealed preference). Stouffer's measure of distance is the number of "intervening opportunities" between i and j, whereas Zipf's is geographic (transportation distance).

Anderson (1955) compares Zipf's and Stouffer's hypotheses and finds that, in aggregate, there is little difference between the two in terms of predictive capacity, although for any one source area, predictive power varies. Anderson also finds that using higher exponents for the distance figure does not yield statistically superior results. He suggests that in Zipf's formulation, raising distance by an exponent which itself is a positive function of the size of source area will improve results, and that amending the destination population figure to take account of unemployment will do likewise, probably because it is closer to Stouffer's notion of opportunities. He does not find Stouffer's intervening opportunities distance measure to be superior.

The implicit hypothesis in these models is that employment "drives" the migration process, or at least is the major source of relocation. Use of population is intended, however, to proxy a variety of factors, including housing and recreational opportunities. The second usage of the gravity formulation is an extension of this, which suggests that residential location around a workplace can be similarly modelled. This is used by e.g. Lowry (1960) as a component of a general urban model. After workplaces (and hence the number of jobs in any one area) are generated, individuals are allocated subject to the constraint:

$$\Sigma_i T_{ij} = E_j \qquad (2.2)$$

where T_{ij} is the number if people working in j who live in i, and E_j is the number of jobs in j. Since the origin of trips is generated first and constrains the location activity, models of this form are termed "origin-constrained" or "production-constrained". Within the context of an urban model, the employment "base" will consist of industrial (exogenous) employment. The location of primary workers results in a derived demand for secondary and tertiary employment. Apart from the origin constraint, location is subject to a constraint resulting from "spatial deterrence", and commonly in these models this is some function of commuting time. The parallels with the neoclassical land use models are clear, although the solution process varies from iterative algorithms to linear programming (see Batty (1978)). This usage of the gravity model will be examined in more detail later in the discussion of the entropy approach.

Both the gravity formulations outlined above use the workplace-dominance assumption, but employ different definitions of "space" according to usage. In application, gravity models have shown some empirical success, but one of the major criticisms has been the lack of theoretical underpinnings; Niedercorn and Bechdolt (1969) employ utility maximisation [1] to provide a vigorous framework which can be applied to gravity models in general. (They also provide a comprehensive account of previous work on the gravity formulation). They suggest that individuals derive utility by "interacting" with others, and this is realised by making trips. In the origin constrained case, the k^{th} individual's "total net utility of interaction" is

$$U_{ik} = A \, \Sigma_j P_j \; U(T_{ij})_k \qquad (2.3.1)$$

where $U(T_{ij})$ is the utility derived from the trip from i to j

P_j is the population at j which proxies "attractors" inviting interaction

A is a constant

The formulation suggests the utility function is additive (in destination utilities). The individual is assumed to allocate some set proportion of his time and income for the purpose of deriving utility in this way, and the budget and time constraints are:

$$r \Sigma_j d_{ij} \; T_{ijk} \leqslant M_{ik} \qquad (2.3.2)$$

$$1/s \; \Sigma_j d_{ij} \; T_{ijk} \leqslant H_{ik} \qquad (2.3.3)$$

where M_{ik} and H_{ik} are the proportions of income and time allocated, respectively, and

r is the cost per mile of distance travelled

1/s is the average speed of travel in the area

d_{ij} is the distance from i to j, as before.

Maximisation of (2.3.1) subject to (2.3.2) and (2.3.3) when there are n destinations yields n-1 equations (excluding the constraint derivative). The precise solutions depend on the form of utility function chosen, and Neidercorn and Bechdolt experiment with logarithmic and power functions.

If the general form of the gravity model is

$$I_{ij} = A\, P_i^{\beta}\, P_j^{\gamma}\, d_{ij}^{-\delta} \qquad (2.4)$$

(where in (2.1) $\beta = \gamma = \delta = 1$), then (2.4) can be shown to follow by manipulation of the n-1 equations under each functional form for utility.

Taking logarithms gives:

$$\ln I_{ij} = \ln A + \beta \ln P_i + \gamma \ln P_j - \delta \ln d_{ij} \qquad (2.5)$$

Niedercorn and Bechdolt show that if, in a regression of (2.5), $\gamma = \delta \simeq 1$, then a logarithmic utility function can be inferred, whilst if $\delta > 1$, a power function is suggested. (Here, I_{ij} and T_{ij} are identical.) This model generated a series of comments and replies (Mathur (1970)), Niedercorn & Bechdolt (1970), Allen (1972) resulting in a reformulation Neidercorn and Bechdolt (1972).

Mathur suggested that trips are the means of achieving utility by accessing "characteristics" (cf. Lancaster 1966) associated with trips - therefore trips represent a form of consumption technology; subsequent debate centered around the minimum number of trips that it is necessary for the individual to make in order to maximise utility.

This model is interesting because it indirectly raises a number of important issues. The first is that it employs a micro perspective which is subsequently aggregated. It thus becomes necessary to deal with behavioural consistency at the micro level, a point ignored in the earlier macro formulations. More specifically, the constraints relevant to any one individual (time and money) must be made explicit. Secondly, it could be argued that the Neidercorn and Bechdolt model is unrealistic in as much as the individual is allocating a fixed time and money budget to the trip-making process; this assumes independence between the utility attached to the products of trip-making and those available elsewhere (see Strotz (1957)), or else the much stronger assumption that it is possible to abstract from the price changes of all other goods. Since the model does not specify the nature of the goods acquired when tripmaking occurs, and does not detail a production side (even though some trips will be for the purposes of supplying labour) the latter assumption is difficult to maintain. Applied to shopping and recreation however this model is probably not too unrealistic. The last point concerns a more housing-specific consideration - whilst the model represents a general framework for (implicitly return) trips, it does not accommodate migration (inter-urban relocation) at the micro level; yet if the individual is concerned with maximising utility, the option of centering one's activities elsewhere should be included.

Black (1972) applies the gravity model to inter-regional commodity flows. He suggests as a general form:

$$T_{ij} = \frac{P_i \; A_j \; F_{ij} \; D_{ij}}{\Sigma_j (A_j \; F_{ij} \; D_{ij})} \qquad (2.6)$$

where A_j measures "attractiveness" (eg the demand for the product) at j

F_{ij} is a general "friction of distance" measure between i and j

D_{ij} is a measure of the demographic similarity of i and j (to proxy demand factors)

P_i is the level of production of commodity i

The denominator represents all possible destinations. He uses an unconstrained approach, that is, the T_{ij} figures generated do not need to sum to observed totals leaving i or entering j. Black sets $F_{ij} = d_{ij}^{-\delta}$ where dij is Euclidean distance. In common with Mera (1971) he finds the unconstrained gravity model to be adequate. Mera finds that the unconstrained gravity model fits best at the aggregate level; as disaggregation increases linear programming is to be preferred. This mirrors the empirical success of the gravity model in the absence of theoretical underpinnings; the use of the model at the individual level normally requires explicit hypotheses (e.g utility maximisation).

It has already been shown that the gravity model can be estimated in the specification of (2.5). Ewing (1974) generalises this to suggest:

$$\log I_{ij} = \log A + \Sigma_k k \log V_{kj} + \beta \log P_i + \gamma_{k+1} \log P_j - \delta \log d_{ij} \quad (2.7)$$

where V_{kj} is the k^{th} attractor variable's value in j.

He criticises the gravity model for its "independence of flows" property; that is, the introduction of a third location will not change the flows between the first two locations. In an extension of Stouffer's intervening opportunities model, Ewing suggests the inclusion of $\delta_j \log O_{ij}$ in place of $\delta \log d_{ij}$, where O_{ij} is the number of alternative destinations of similar distance or closer. To relax the assumption that δ is homogeneous for all destinations, this would become:

$$\Sigma_j \delta_j \log O_{ij} \qquad (2.8)$$

Stouffer (1960) has amended the intervening opportunities model to take account of competition for the intervening destinations with migrants from other origins. Alonso (1978) provides the most general statement of the gravity model in a form which incorporates intervening opportunities, competition, and flow interdependence. He suggests:

$$I_{ij} = V_i D_i^{\alpha i - 1} W_j C_j^{\beta j - 1} t_{ij} \qquad (2.9)$$

where:

V_i is a function of the characteristics of the population in i, or the population of i itself

W_j is a function of the characteristics of the population in j, or the population of j itself

t_{ij} is some linking factor <u>specific to</u> i and j (for example, a transport network) and in effect, a weight

D_i is the "draw" of the <u>entire system</u> generating movers leaving i, per unit of V_i

$D_i^{\alpha i}$ is the actual numbers leaving i

C_j is the "pool" of movers available to j per unit of Wj

$C_i^{\beta j}$ is the actual number who choose j

So $D_i^{\alpha_i-1}$ and $C_j^{\beta_j-1}$ give the proportions of actual to potential movers (out from i and in to j respectively). These variables are determined by the entire system and hence are termed "systemic"[2]. The marginal totals used to derive (2.9) are given by:

$$\Sigma_i I_{ij} = W_j C_j^{\beta_j} \qquad (2.10)$$

and

$$\Sigma_j I_{ij} = V_i D_i^{\alpha_i} \qquad (2.11)$$

Summing (2.9) across i, setting the result equal to (2.10), and re-arranging, gives

$$C_j = \Sigma_i V_i D_i^{\alpha_i-1} t_{ij} \qquad (2.12)$$

That is, potential arrivals per unit of W_j are the total opportunities (outmovers) in the system outweighted from j's point of view. Summing (2.9) across j , setting it equal to (2.11) and rearranging gives:

$$D_i = \Sigma_j W_j C_j^{\beta_j-1} t_{ij} \qquad (2.13)$$

and (2.10) and (2.11) give:

$$\Sigma_i \Sigma_j I_{ij} = \Sigma_i V_i D_i^{\alpha_i} = \Sigma_j W_j C_j^{\beta_j} \qquad (2.14)$$

Alonso does not apply this model, but the theoretical formulation demonstrates the interdependency which exists between pairwise comparisons and system-wide factors. Alonso provides a table which enumerates all possible interregional migration as special cases of (2.9) (see Table 2.1 in Section 2.5) and it will be useful to review this at a later stage in this chapter, after the entropy and Markov models have been presented.

The majority of the models discussed so far pertain to interregional flows, either of goods or of individuals. With the exception of Lowry (1964), these models, as applied, bear only a tangential relationship to the housing market; one of the reasons for this is their relatively aggregate spatial perspective, compared with most studies of housing which posit an individual-orientated, locally based form of spatial interaction. This question can be examined in more detail in Chapter 4. In the meantime, attention can be focussed on a derivative of the gravity model which deals more explicitly with housing and which takes into account the "systemic" factors mentioned by Alonso; this is the entropy-maximisation model.

2.3 ENTROPY MAXIMISATION MODELS OF SPATIAL INTERACTION

Regressions of the form (2.4) and (2.7) require data on O_{ij} before model calibration can be achieved; one possible interpretation of the entropy model is as a means of estimating these flows. The method employed is set out in Wilson (1970) and consists of an objective function ("entropy") which is maximised subject to a variety of origin, destination, travel cost and housing-specific constraints. In the simplest model, the distribution of workplaces is given and the problem is to allocate households around the workplaces. A worker living in a house in i and working in j generates a commuting trip, and the sum of all such workers gives the commuting flow i to j, T_{ij}. The matrix T = $[T_{ij}]$ is termed a trip distribution. Residential location is given by:

$$H_i = \Sigma_j T_{ij} \qquad (2.15)$$

that is, the total number of workers living in i (H_i). Any particular assignment of workers to workplaces is termed a microlevel state, this being the case where there is differentiation between the identity of otherwise homogeneous workers. Without regard to their identities, an assignment gives an intermediate representation of flows of individuals (a "mesolevel distribution"); any one mesolevel distribution can correspond to a number of microlevel states (it is assumed that all microlevel states are equiprobable). In the thermodynamic analogy from which the entropy approach is derived, the subject matter is gas molecules in a closed system. Under such circumstances, it is possible to supply a fixed amount of energy to the system (for example, by heating). The social equivalent is the commuting budget, and consequently total transport cost is imposed as a macrolevel constraint:

$$\Sigma_{ij}{}^{2} T_{ij}c_{ij} = C \qquad (2.16)$$

Two other macrolevel constraints which guarantee logical consistency are the familiar origin and destination constraints; that is, (2.15) and

$$\Sigma_j T_{ij} = E_j \qquad (2.17)$$

These ensure that the estimated T_{ij} and the resultant E_j and H_i are consistant when totalled.

The aim is to find the most probable mesolevel distribution conditional on the three macrolevel constraints. This is achieved by developing a combinational formula for the assignments of microlevel states to mesolevel distributions and is given as[3]

$$S = \frac{\Sigma_i \Sigma_j \; T_{ij} \; !}{\Pi_{ij} \; T_{ij} \; !} \tag{2.18}$$

The logarithm of this is defined as the "entropy" of the system. Maximisation of the log of (2.18) subject to (2.15), (2.16) and (2.17) gives:

$$T_{ij} = A_i B_j H_i E_j \; (e^{-\beta c_{ij}}) \tag{2.19.1}$$

where $$A_i = [\Sigma_j B_j E_j (e^{-\beta c_{ij}})]^{-1} \tag{2.19.2}$$

and $$B_j = [\Sigma_i A_i H_i (e^{-\beta c_{ij}})]^{-1} \tag{2.19.3}$$

β is the Lagrangean multiplier associated with (2.16) [4].

(2.19.2) and (2.19.3) are directly analogous to the "balancing factors" (2.12) and (2.13) in Alonso's model.

"Entropy" can be interpreted as uncertainty, and the opposite of information (c.f. Theil (1967)); consequently the entropy model is maximising the uncertainty as to the particular microlevel state prevailing, by choosing the mesolevel distribution consistent with the largest number of such microlevel states. The imposition of further constraints represents additional information and a reduction in entropy.

In applying this model to the analysis of residential location, Wilson identifies four kinds of location behaviour, depending on the constraints facing the locators. These are:

n = 1 Unconstrained (not tied to a particular residence or workplace)

n = 2 Origin constrained (fixed residences)

n = 3 Destination constrained (fixed workplaces)

n = 4 Doubly constrained (hence non-movers)

This categorisation provides a counter to the suggestion that the entropy model is unrealistic or orientated to long run equilibrium. By changing the proportion of the population with type 4 location behaviour, the implicit time scale in the model can be altered, and the corresponding solution can be deemed "short-run" or "long-run" as appropriate. Type 2 location behaviour might be appropriate to those resident in council housing or in private rental under rent control, whilst type 3 are the classic "workplace-dominated" locators. Type 1 may be immigrants or the independently active elderly. For simulation and solution purposes some form of estimate of the proportions in each location category is required, as well as their travel cost expenditure;

Wilson suggests a variety of methods for this, dependent on data availability.

Disaggregation of the model to take account of different income classes (or social groups) and house types is possible; Wilson assumes that the average proportion of income devoted to housing varies by income class. Given exogenously imposed prices for each house type, it is assumed that the within income class variance of actual housing expenditure around each house type price is normally distributed for each income class. This is then imposed as a constraint before re-solution of the model[5]

Neoclassical economic theorists might object to these assumptions concerning the exogeneity of prices, total travel costs , and average housing expenditure. Wilson does suggest that in practice prices will be determined by market forces, such that:

$$P^k_i = h^k_i + l^k_i \qquad (2.20)$$

This states that the price of the k^{th} house type in the i^{th} zone is made up of construction costs specific to that house type (h^k_i) and a location premium specific to the house type and zone (l^k_i). Wilson does not however , elaborate on how the location premium is arrived at in practice.

Removal of the simplifying assumption of one worker per household, and the introduction of new supply allows re-solution under household formation with the constraint that new household formation and new supply be equal in magnitude. There is, however, no interdependence between the two and the means of estimating them is not elaborated. In a sense this is because the entropy model is a framework and technique, not a theory per se. It would be possible, for example, to have a "market sub-model" which would estimate supply and demand in each zone for each house type as a function of price, and a household formation model based on demographic characteristics and house availability. This would, however, compound the calibration problem, when the number of simulation possibilities is already large.

Baxter (1975) applies the entropy model to Road Research Laboratory data on trip-making in Reading, together with small area housing and employment data, using three socio-economic groups; manual, professional/managerial, and non-manual/non-managerial.

Baxter hypothesises that β in (2.19.1) has a different value for each socio-economic group (that is, there exists β^n where n=1,2,3). The intention is to estimate the "housing attractor" terms, Z^n_j which represent the different housing preferences of each socio-economic group (SEG, hereafter). The $Z^n j$ are constrained such that $\Sigma_n Z^n_j = 1$, and it should be noted that the subscripts here are reversed - i denotes workplace and j denotes residence.

Initially, the β^n are set arbitrarily and the values of $T_{ij}{}^n$ are calculated. This allows calculation of total travel costs by SEG, which can then be compared with observed costs; the process continues until observed and modelled costs converge. The first such procedure is carried out with housing floorspace as the sole "attractor" at j, and uniformly so for all SEG's. This process then outputs values of β^n and W^n_j (where $W^n_j = \Sigma_i T_{ij}{}^n$) under the assumption of housing stock homogeneity. Comparison of the W^n_j estimated by the model and the observed W^n_j show discrepancies and it is assumed that these can be accounted for by inter-SEG differences in "preferences" for housing in particular small areas. Z^n_j are calculated by the formula

$$Z^n_j = \frac{W^n_j\,(obs)}{W^n_j} \left[\Sigma_n \frac{W^n_j\ (obs)}{W^n_j} \right]^{-1} \qquad (2.21)$$

In the extreme case, where, for example, $W^n_j = W^n_j$ (obs) and W^nj (obs) > 0 for n=1 only, Z^n_j would be 1.0 for SEG 1, and 0.0 for SEG's 2 and 3, suggesting that this zone would be very attractive to SEG 1, but not at all attractive to SEG's 2 and 3.

As a final step, Baxter uses regression equations to model the Z^n_j as a function of housing-relevant variables for each zone. These variables are house age (proportions pre/post 1914), house condition (proportions good/medium/poor), residential plot area, and accessibility (to shopping/public and private open spaces/job opportunities). For all SEG's he finds no significant results for the spatial variables (plot area and accessibility). The remaining coefficients are used to predict residential location (with an assumed participation rate to convert employees to total residents). On goodness of fit criteria they achieve some success.

The abstraction from market forces which this model involves leaves some grounds for criticism - the term "attractor" has causal connotations which may be misplaced, although the disaggregation by SEG means that SEG - specific regression coefficients could be interpreted as hedonic prices in the presence of an income constraint. The other potential source of criticism is the statement of the entropy maximisation process as a behavioural hypothesis: "The premise adopted is that individuals behave collectively so as to maximise entropy....." (Baxter, P. 144) This is potentially misleading because it confuses technique with behaviour. In practice, however, it should not make any difference to the final result, since Wilson (1970) has demonstrated the formal eqivalence of the entropy maximisation process with the behavioural utility maximisation process. An alternative interpretation of the entropy maximisation process is given in Nijkamp (1975). He demonstrates the formal equivalence between the entropy model and a non-linear programming problem, which leads to his describing the entropy model as one which "attempts to maximise the net surplus of total push and pull effects with respect to total loss of interaction owing to cost frictions" (Nijkamp, P214). The "net surplus" notion corresponds to a form of collective utility.

It is worthwhile considering the gravity and entropy approaches *qua* housing market models. Both forms deal with location or relocation, treating mobility as a side issue or else as a process inseparable from location. In the gravity model of migration flows, the timing of a move (which gives the flow magnitude per unit of time in aggregate) and the direction of a move are simultaneously determined. The intervening opportunities hypothesis is a form of assumption about search behaviour which suggests that the moving household looks at areas closest to its point of origin first, then searches further afield if no closer opportunities are available. The additivity constraints are introduced to ensure logical consistency of departures and arrivals, rather than paying explicit attention to housing availability.

This suggests a very long run perspective, when housing supply is perfectly elastic, and this is reinforced by the universal neglect of the allocative role of prices in the housing market. Transport cost is, in effect, the only "economic" factor systematically included. Given the implicit long run perspective, it is questionable to what extent such models would be of use in short-term forecasting, in their present form. Gravity models are also very general in form: for example the "flow generators" and "flow attractors" relevant to a migration model may differ considerably from those of an inter-regional commodity flow model, and may even vary for differing aggregation levels of the same process.[6] The model form as given does not provide any guidance in this respect. The entropy model suffers from similar drawbacks but the location behaviour distinction allows some variation in the time horizon used. It is possible to incorporate mobility into these models by having some households move, supplying one form of house and demanding another. As presented, however, it is possible for households to move between identical house types with no apparent reason for doing so, and again the researcher has no guidelines as to what factors are or are not relevant. Calibration of such models relies heavily on the existing, historical distribution of the housing stock and employment location, and these are unlikely to change in the short run. The entropy model is probably better suited to simulating the long run results of exogenous shocks (e.g. a sudden increase in travel costs) on location; as a local, short run indicator of housing market activity it has a number of disadvantages. The treatment of mobility in the location-based entropy model is cursory and restrictive, whilst in the gravity model it has been suggested that it is too general. Consequently it is appropriate to review more direct approaches to mobility.

2.4 GEOGRAPHIC MOBILITY MODELS

This discussion is in three sections. The first is concerned with the theory and matrix representation of Markov Chains. The second examines the Markov Chain approach to mobility, which can be viewed as a macro-flows approach; as will be seen, however, subsequent work has been fundamentally micro in orientation. The third section deals with the macro-flows Markov Chain approach to vacancy chains.

2.4.1 Markov Chain Models [7] (I): Theory

Consider a system where there are a finite number of "states", $S_1 \ldots\ldots\ldots\ldots S_n$, such as quality levels in a housing hierarchy. Let the conditional probability of moving from the i^{th} to the j^{th} state be P_{ij}[8]. This gives the n×n transition matrix:

$$P = [P_{ij}] \qquad (2.22)$$

This gives, in the housing example, the probability that the individual moves to i conditional upon their most recent place of residence being in state j.

Let π_t be the n * 1 vector of probabilities of being in each state at time t. Then the vector of probabilities of being in each state at time t + 1 is given by:

$$\pi_{t+1} = P^T \pi_t \qquad (2.23)$$

$$\text{with } \Sigma_i \pi_{it} = 1 \qquad (2.24)$$

(2.24) simply states that the system must be in at least one state at any one time. This is an example of a first-order Markov Process. If such a process is allowed to continue indefinitely, the values of π_t for all t will normally settle down to a perpetually repeating sequence of values (periodic case) or else to a single, repeated value (aperiodic case). In the latter instance, this gives

$$\pi_\infty = P^T \pi_\infty \qquad (2.25)$$

A first-order Markov Chain possesses the property of "forgetfulness"; that is, that the present system state probabilities (π_t) are completely determined by the previous period's system state probabilities. It is possible to allow for a "longer memory" by using higher order processes:

$$\pi_t = P^T \pi_{t-1} + Q^T \pi_{t-2} + \ldots \qquad (2.26)$$

with as many transition probability matrices as the order of the process requires. It is difficult, however, to intuitively interpret high-order Markov Chains and in practice they are infrequently used. Three assumptions are made about the matrix P. These are:

(1) That the P_{ij} do not change through time (Stationarity)

(2) That the population being dealt with is homogeneous (Homogeneity)

(3) That the length of time in one state does not influence the transition probability (No Duration - of - Stay effects or no Cumulative Inertia)

(3) is a special case of (1)

If a population is considered which is homogeneous, except that any one individual can be in one state whilst another individual can simultaneously occupy a different state, then the transition matrix (which is assumed to satisfy (1) - (3)) can be used for population forecasting. The system state probabilities become relative frequencies and the state-space transition matrix maps a population into itself with a one-period time lag. A variant of this approach which relies heavily on assumption (1) maps a population into sub-classes (e.g. households, employees) and this assumption in effect is that of constant headship rates. This method is used in the NBER - HUDS model.

2.4.2 Markov Chain Models (II): Residential Mobility Models

The model presented in the last section appears to be suited for application to a variety of social processes and has been employed in the basic form by Blumen et al (1955) to labour mobility. This and similar studies uncovered a problem. McGinnis (1968) describes it thus: "The failure of the Markov model shows up in a peculiar and characteristic way that might be called 'lumping on the diagonals'. That is, observed transition matrices often display markedly higher diagonal values, than are predicted from the model". (McGinnis, P715)

McGinnis suggests an explanation for this and gives an amended model form to deal with it. Essentially, he points out that the simple Markov model ignores the "identity" of individual elements (in much the same way as the entropy model does.) "Identity" refers, in McGinnis' analysis, to the individual's past history. This is ignored in the simple Markov model, due to the "no memory" property which states that:

$$Pr(s_i \overset{t}{\rightarrow} s_j \mid \overset{t-1}{s_r}) = Pr(s_i \overset{t}{\rightarrow} s_j \mid \overset{t-1}{s_k}) \qquad (2.27)$$

That is, the probablility of moving from state i to state j in time t is idependent of the state left at time t - 1.

McGinnis suggests that in the case of mobility, especially residential mobility , the "no-memory" property will not operate, and cumulative inertia will be exhibited. The *cumulative inertia hypothesis* can be stated as follows: "The probability of remaining in any one state of nature increases as a strict monotone function of duration of prior residence in that state". (McGinnis P716)

The observed result will be a violation of assumption (3), cumulative inertia. The hypothesis is based on the empirical work of Myers et al (1967) who find evidence of a prior residence effect using survey data. Morrison (1967) regresses migration probabilities on the logarithm of prior residence duration and finds that a quadratic specification fits best. Land (1969) finds similar evidence of non-linearity for the inertia effects. McGinnis constructs a "duration - specific" transition matrix with monotonically higher inertia probabilities as residence duration rises.

As constructed, the decision to move is independent of the choice of destination, [9] and if allowed to continue indefinitely mobility will cease altogether. Morrison finds that age interacts with prior residence history suggesting that McGinnis' model fails to take account of the counteracting effect of household life cycles on transition probabilities. Recalling the last chapter, Porell suggests:

"In fact, the strong empirical associations of household size, age of head of household, and housing tenure status with mobility rates have made the life cycle explanation of mobility...a cornerstone in the literature" (Porell (1982) P.17)) This suggests that an alternative, or additional explanation for observed effects is violation of (2), the homogeneity of the population. McFarland (1970) states the heterogeneity problem as follows:

Let m be the population and let No(m) be a matrix with 1's on the diagonal elements corresponding to person m's initial state and define

$$No = \Sigma_m No(m) \qquad (2.28)$$

Hence the diagonal elements of No contain population counts in each category. Let each member of the population have their own transition matrix, P(m). Define the k-step population transition matrix as

$$Q^k = No^{-1} \Sigma_m No(m) [P(m)]^k \qquad (2.29)$$

for a sufficiently high k, (2.29) gives the long run individual and population transition matrices:

$$Q^* = No^{-1} \Sigma_m No(m) P^*(m) \qquad (2.30)$$

In this amended form, Q^* gives the long run population flows between any two states.

Spilerman (1972a) points out that even if P(m) is stable, shifts in the distribution of population between states through time will generate observed changes in the " aggregate transition matrix", Q^*. This implies that stationarity is not necessarily violated at the individual level. For the purposes of operationalisation, sub-group homogeneity can be assumed where sub-group characteristics explain inter-group differences in transition matrices. (For example, Taurer and Gurley (1965) disaggregate population by age and race to analyse migration in a Markovian context). Spilerman suggests using regression to model the origin-destination flows for all sub-groups (as in the empirical work on the gravity model discussed previously). If there are m sub-groups, this gives m^2 equations, and simultaneous zero coefficients on all regressors means that the null hypothesis of "no heterogeneity" cannot be rejected.

Ginsberg (1971) claims that in the work of Land and Morrison it is not possible to distinguish between heterogeneity and cumulative inertia, and the latter may result from the former. In the simplest case, the population consists of only two groups, "movers" and "stayers". As the duration of residence for any one cohort rises, fewer movers are left leading to apparent cumulative inertia. A similar process applies in the work of McFarland and Spilerman. Spilerman (1972b) suggests uniformity of transition matrices for all members of the population; heterogeneity arises because mobility rates vary across individuals. In the special case of "movers" and "stayers", stayers have a mobility rate of zero, whilst movers will have some finite probability of mobility in any one time period.

Clark and Huff (1977) attempt empirical replication of the work of Myers et al, Morrison and Land in the light of such theoretical considerations. They aim to disentangle the observed effects of non-stationarity, non-homogeneity, and cumulative inertia. They use paired comparisons of proportions of the population experiencing the same number of moves in different sequences, and reject an independent trials model controlled for heterogeneity on this basis. By similar methods they reject an independent trials model after controlling for heterogeneity and mobility rate variation through time. Significant differences remaining in paired comparisons are assumed to be due to prior residence or inertia effects. Further subdivision is carried out by age and tenure; this results in the conclusion that for owners and renters in the 45 - 65 age group, cumulative inertia does not operate,, but is also important for renters in the 25 - 44 age group. Lastly they investigate the effect of different waiting times since the last move, and these do not tend to support the cumulative inertia hypothesis.

Ginsberg (1979a) sets all of these notions - heterogeneity with respect to mobility propensity, mobility rate differences through time, and waiting time differences, in a theoretical framework with a variety of waiting - time distributions. He states the residence history of an individual as a sequence of places in which the individual lives and a sequence of times at which he moves. He demonstrates that depending on the duration specific move rate assumed, a variety of mobility hypotheses can be incorporated. In a further paper (Ginsberg (1979b)) these hypotheses are applied to longitudinal mobility data, with the main conclusion being that waiting time between moves and selection of subsequent destination are broadly independent.

Huff and Clark (1978) explain mobility as the result of interaction between cumulative inertia and the "residential stress" notion mentioned in the last chapter. Individuals with a high stress - to - inertia ratio will have a higher probability of mobility; stress in this case represents the process whereby life cycle factors generate a mismatch between household and house characteristics. Their theoretical model predicts that, through time, mobility rates for any one household will follow a "sawtooth" pattern of the form where "peaks" in mobility rates correspond to life cycle events. One spatial prediction which flows from this model is that households moving in the same neighbourhood will have less inertia since social ties are not being ruptured. The corollary to this is that after a long period of time in one residence, any move which does occur will tend to be within the immediate neighbourhood.

Huff and Clark's work is a precursor to the developments in the field of search and mobility which use the notion of utility (for example Smith et al (1979)). The line of development of mobility models described in this chapter has demonstrated that approaches based on statistical regularities alone (as is the simple Markov model) will tend to require some form of underlying causal mechanism in order to be successfully applied. The alternative, detailed in Ginsberg (1979a) is to employ somewhat cumbersome operations - research based methods which necessitate making a variety of assumptions about behaviour without clear grounds (other than empirical) for doing so. The Markov model and its extensions demonstrate the need to control for heterogeneity; in contrast to the gravity model where such heterogeneity is included as a causal factor in explaining flows, albeit in the very general form of "attractive" and "generative" indices. The elements in Markov models which relate to the timing of moves will tend to be determined by the external market environment. The models discussed in this section bear only a tangential relationship to the housing market per se; they ignore house prices and essentially take a mechanical view of mobility which assumes away market factors.

In the first chapter, the models reviewed employ demand and prices as central to household decision taking. The allocation of households to houses is achieved using somewhat ad hoc algorithms. An extension to the Markov Chain approach models the household - house allocation procedure more formally, although continuing to abstract from other market factors. This is the vacancy chain approach to mobility analysis.

2.4.3 Markov Chain Models (III): Vacancy Chains

White (1971) draws on the work of Kristoff (1965) to argue that the housing system demonstrates behaviour which violates the classical axioms used by Koopmans (1957) to define a "market". White states: "Net yearly increments to houses and to families in a metropolitan area cannot be seen as real flows to be matched to each other in a market. A different view is required, a model of continuing realignment between huge existing stocks of houses and families. In this model, price levels are no longer the dynamic element in the housing 'market'. Moves fit together in chains of cause and effect identified by careers of vacancies" (White p.88)

White suggests that financial and fiscal factors dominate suppliers of new housing, and consequently: "The stream of new houses can be treated as a flow relatively independent of the exact state of any current 'housing market' in one area" ((White P88). Similarly, he suggests that flows out of the system (death of head of household, interuban migration) can be viewed as exogenous. Each move into a dwelling is conditional upon its prior occupants leaving, and the sequence of moves generated has one unifying feature, namely that a vacancy changes its location. It will be recalled that the first-order Markov Chain possesses the "no-memory" property and the fact that this is unrealistic with respect to a heterogeneous population resulted in the series of amendments proposed in the last section. By contrast there are stronger grounds for supposing that the mobility of vacancies can be approximated by a simple first-order process.[10] In White's model, vacancies are created by the (exogenous) flows of out-migrants, deaths, and new construction, and are terminated by being filled by a household from outside the system or else by demolition. From this it follows that:

"Once the vacancy jumps and extinctions can be predicted, then mobility and change in the housing system can be predicted from the rates of creation of vacancies" (White, P90)

White cites evidence which estimates the vacancy "multiplier" as 4; i.e. every new unit built results in four moves, with the vacancy "filtering" down through price bands in a relatively short space of time (compared with the rates of depreciation of a house). The process can be illustrated as the following:

Let V denote a k x k (where there are k "strata"(for example, house types or submarkets)) transition matrix for vacancies, such that v_{ij} is the probability that a vacancy created in price band i attracts a family from price band j, thus creating a vacancy there. Note that $\Sigma_j v_{ij} \leqslant 1$, in contrast to (2.24). Define $d_i = 1 - \Sigma_j v_{ij}$; this denotes the probability that a vacancy created in i will attract a mover external to the system, or leave due to demolition.

Let F(t) be the total number of vacancies in each strata arriving from outside the system at time t, and let M(t) be the <u>cumulative</u> number of vacancy arrivals to each strata of the housing market. Hence: [11]:

$$M(t) = M(t)V + F(t) \qquad (2.31)$$

$$\Rightarrow \quad M(t) = (I-V)^{-1}F(t) \qquad (2.32)$$

This model is analogous to Leontief's (1951) input-output model. Sands (1976) cites evidence which puts the new housing unit multiplier (average first row element of $(I-V)^{-1}$) in the interval 2 - 2.5. However, the differences in incomes between the families exchanging dwellings tends to be small, with correspondingly questionable effects on low-income families. This is contrary to the conclusions of White, who suggests that the vacancy multiplier can be used to indirectly benefit low income families by building high quality new units.

Porell (1981) analyses the spatial impact of a Markov vacancy chain model, as part of the policy question about the optimal spatial distribution of housing programmes. He states (following Anderson and

Goodman (1957)) that the maximum likelihood estimators of household and vacancy transition probabilities will be given by:

$$\hat{p}_{ij} = \frac{I_{ij}}{\Sigma_j I_{ij}} \quad \text{(Households)} \qquad (2.33)$$

$$\hat{v}_{ij} = \frac{I_{ij}}{\Sigma_i I_{ij}} \quad \text{(Vacancies)} \qquad (2.34)$$

This latter is defined as the probability that a vacancy in j moves to i. Generally, $p_{ij} \neq v_{ij}$ since $\Sigma_j I_{ij} \neq \Sigma_i I_{ij}$
Both White's and Povell's models use the vector d, which gives the probability for each state that a vacancy will leave the system. For proper specification, this implies that if a vacancy leaves, it does not return. In this case d is termed an "absorbing" state. The validity of this assumption depends on the level of aggregation used, that is, in the boundaries which are set up for the system. It seems likely that there will exist some "distance", either geographic or in terms of housing quality, beyond which the absorbing state assumption is valid. Finding this will be termed the "system boundary problem".

It has already been demonstrated that the simple gravity model implicitly assumes perfectly elastic housing supply. Housing market assumptions become more relevant in a vacancy transfer model, and it is illuminating to examine the asumptions which underlie the present approach. Consider an element of the matrix V*, v^*_{ij}. This gives the probability that a vacancy created in j moves to i, by virtue of a household moving in the opposite direction. Such a move is conditional upon the existence of a vacancy in j. But is it unconditional upon the uptake of the vacancy in i ? If it is, then the vacancy model is valid as presented. If not, the notions of ownership, holding costs, and uncertainty become relevant, and the "vacancy chain" becomes an infinite regress until some exogenous form of vacancy closure is found. Barring Acts of God, this takes the form of household formation and truly exogenous inmigration. As constructed, the vacancy model has as its driving force new vacancies entering the system; hence the need for exogenous vacancy creation, either through outmigration (with attendant system boundary problems) or through household "deaths" and exogenous new supply. This last assumption, stated by White, can be compared with the supply elasticity assumption commonly made in other models. It is questionable whether the vacancy chain model adequately describes the housing system. By casting new vacancies as the motive force, it can be argued that the housing market process is completely inverted. In Leontief's open output-input model there is an exogenous final demand vector, and new vacancies are the vacancy chain analogue. But approaching from this direction generates system boundary problems of a form not encountered by Leontief. These points will be developed more fully later.

2.5 SYNTHESIS

It has already been stated that the models discussed in this chapter fall into two broad categories - analogue models and statistical models. As mentioned previously, Alonso (1978) has developed a general framework

TABLE 2.1 ALONSO'S TYPOLOGY OF SPATIAL INTERACTION MODELS

	General	Push (Markov)	Pull (Economic Base)	Elastic (Gravity)	Inelastic (Entropy)
Flow from i to j	$v_i w_j t_{ij} D_i^{\alpha-1} C_j^{\beta-1}$	$v_i w_j t_{ij} D_i^{-1} C_j^{0}$	$v_i w_j t_{ij} D_i^{0} C_j^{-1}$	$v_i w_j t_{ij} D_i^{0} C_j^{-1}$	$v_i w_j t_{ij} D_i^{-1} C_j^{-1}$
Departures	$v_i D_i^{\alpha}$	$v_i D_i^{0}$	$v_i D_i^{1}$	$v_i D_i^{1}$	$v_i D_i^{0}$
Arrivals	$w_j C_j^{\beta}$	$w_j C_j^{1}$	$w_j C_j^{0}$	$w_j C_j^{1}$	$w_j C_j^{0}$
Opportunity	$\Sigma_j w_j t_{ij} C_j^{\beta-1}$	$\Sigma_i w_j t_{ij} C_j^{0}$	$\Sigma_j w_j t_{ij} C_j^{-1}$	$\Sigma_i w_j t_{ij} C_j^{0}$	$\Sigma_j w_j t_{ij} C_j^{-1}$
Competition	$\Sigma_i v_i t_{ij} D_i^{\alpha-1}$	$\Sigma_i v_i t_{ij} D_i^{-1}$	$\Sigma_i v_i t_{ij} D_i^{0}$	$\Sigma_i v_i t_{ij} D_i^{0}$	$\Sigma_j v_i t_{ij} D_i^{-1}$
α	$0 \leqslant \alpha \leqslant 1$	0	1	1	0
β	$0 \leqslant \beta \leqslant 1$	1	0	1	0

for all the models examined here, and his presentation forms the basis of this section.

Alonso's taxonomic table is given in Table 2.1. There are six rows and five model types. The first row gives the equation for flows, I_{ij} (M_{ij} in the table), and the subsequent two rows detail departure and arrival terms respectively. The next two rows are concerned with the systemic terms in each model - the opportunities which "draw" persons into the system from any one origin, and the competition for any one destination by persons in the system. All of the model types nest within Alonso's general model with suitable restrictions on the "elasticities" associated with each systemic term, α and β, and these are detailed in the last row. In the first entry in the fourth row (equivalent to (2.13)), the system draws migrants depending on the attractiveness of all destinations, but flows are attenuated by "congestion" at various destinations. The degree of attenuation is given by $C_j^{\beta j}/C_j = C_j^{\beta j-1}$ so that β_j is the elasticity of in-migrants to "congestion" or "competition" at destination j. If $\beta_j = 1$, no congeston occurs.

Similarly, the first entry in the fifth row (equivalent to (2.12)) demonstrates the extent to which entry to destination j is attenuated by changes in the "draw" from any one origin. α_i may differ from 1 because as more people leave any one origin, the incentive to leave simultaneously falls - e.g., if there is regional unemployment, relative opportunities rise when out-migration occurs; in this case α_i is less than 1. If out-migration is completely insensitive to system opportunities, $\alpha_i = 0$. If "bandwagon" effects occur, α_i may be greater than 1.

The models reviewed in this chapter can be summarised by the values assumed for α amd β. These will, for simplicity, be assumed the same for all i and j.

In the simple Markov Chain, $\alpha = 0$ and $\beta = 1$.

The system is completely determined by the pair-specific relation tij; $w_j = 1$, and $V_i = P_i$ (the population in i)[12] The C_j term drops out;

D_i is given by :

$$D_i = \Sigma_j \; w_j \; C_j^{\beta-1} \; t_{ij} \tag{2.35}$$

$$= \Sigma_j \; (1) \; C_j^{0} \; t_{ij}$$

$$= \Sigma_j \; t_{ij} = 1$$ by definition in the simple Markov model.

Consequently $I_{ij} = t_{ij} \; P_i$

Thus the perfectly elastic supply at destination j is made explicit, as is the complete inelasticity of outmigrants from i to general systemic factors.

The second type is the workplace - dominant gravity - location model. (Alonso terms this a "pull" model). Here $\alpha = 1$ so that the "draw" into the system is completely responsive to (and not constrained by) opportunities; $\beta = 0$, so a fixed number of jobs are made available and the supply of opportunities is perfectly inelastic, and the inflow is unresponsive with respect to opportunities elsewhere in the system. (This can be regarded as pertaining to either the competition (other opportunities) or congestion (fixed number of jobs) effect).

The next model is the unconstrained gravity formulation with $\alpha = \beta = 1$. There are no constraints on the numer of individuals leaving one destination and arriving at another; systemic factors are irrelevant. By contrast the doubly constrained entropy model sets $\alpha = \beta = 0$ such that binding constraints operate on original and destination zones. The probability of successful entry by a migrant is $C_j^{\beta-1} = C_j^{-1}$; that is, a linear inverse function of the number of competing migrants.

In models where $\alpha = \beta = 1$ the exponents on D_i and C_j become zero; consequently these terms are implicit and can be suppressed under these assumptions.

Alonso's general formulation sets $0 \leqslant \alpha \leqslant 1$ and $0 \leqslant \beta \leqslant 1$. These are theoretically estimable if values are given for D_i and C_j; their values may alter over time depending on circumstances.

In White's version of the vacancy chain model, there is inelasticity in the vacancies drawn into the system ($\alpha = 0$) but perfect elasticity at the vacancy destination ($\beta = 1$). Given that vacancy moves are the opposite of household mobility, is this assumption ($\alpha = 0$, $\beta = 1$ in the vacancy model) compatible with $\alpha = 0$ and $\beta = 1$ for the mobility model? In practice the two should be modelled as interdependent - a household move is conditional upon a vacancy existing and vice-versa. Estimation of transition probabilities from ex post flows will yield logically consistent results by default; the ex ante theoretical parameters may not, however, even though the <u>aggregate</u> flows (total vacancies and total movers) are compatible. Consequently this inconsistency problem is <u>not</u> the same as that of the gravity model, whereby interzonal flow totals are incompatible with opportunities due to simplifications in construction. The two problems are similar in so far as in each case, the mechanism used to resolve the potential inconsistencies takes the form of systemic terms which do not have exponents constrained to be zero or one. These points will be developed more fully in Chapter 5, where the general problem of system interdependency is discussed..

It is clear, then, that most of the models in this chapter can be analysed in a common framework. At the heart of this framework, the notions of benefits (utility, attractiveness) and costs (distance, congestion) are fundamental. Markov Chain models are special cases of gravity models; these in turn nest within the entropy formulation, and the gravity and entropy results can be achieved by some utility maximisation process.

It is appropriate to ask why such models should be used in a non-utility framework at all. The most pressing reason is their relative simplicity in terms of parameters. Wilson (1970) suggests that the entropy model is superior to a utility based approach because to achieve similar results the entropy model is less tedious algebraically, and can have a-priori information imposed as additional constraints. From the point of view of economic theory, it is reassuring to know that if techniques of this kind are to be "borrowed" their derivation is possible through utility maximisation.

2.6 CONCLUSIONS

This chapter has shown the ways in which spatial interaction can be modelled from a theoretical and partly empirical point of view. The main results can be summarised as follows:

1) Gravity flow models perform best at a relatively aggregate level.

2) Implicit in each model sub-group are assumptions about supply and demand elasticities.

3) The Markov Chain stationarity assumption is relatively robust and _apparent_ violations can often be traced to inadequate disaggregation of the relevant population into homogeneous groups.

4) Whilst the long run market equilibrium models of the last chapter focus on location and prices to the exclusion of mobility, there exists a literature which deals explicitly with the mobility process (of households and vacancies) and implicitly with location as a _system_ to the exclusion of other market factors.

5) The household-vacancy mobility model may be viewed as a form of input-output, giving a more parsimonious representation of the essentials of dynamics than the cumbersome allocation algorithms of simulation models.

These results will all be employed in the development of the regional model in Chapter 5.

CHAPTER THREE

MACROECONOMETRIC MODELS

3.1 INTRODUCTION

This chapter focusses on studies which attempt to formulate national housing market models. The model specification depends on the intended purpose, and is broadly of two types. The first is as a means of forecasting, either for the housing market *per se* or as an input to a more general macroeconomic model; in each case, a reduced form equation is likely to be used. The second approach aims at establishing causality and consequently attempts to estimate structural form equations. Some reduced form equations have been employed in an explanatory role, so the boundaries are not distinct.

The data used are time series data at the aggregate (and hence aspatial) level. An inseparable element of this approach is the use of macroeconomic theories to guide econometric work; theories of economic cycles, investment behaviour, and sectoral versions of simple macroeconomic theory which focus on the demand for housing as an asset (as in Struyk's work in Chapter 1). In recent years, it has been possible to subject the resultant specifications to the battery of econometric tests developed for time series data and this has resulted in some consensus concerning the "best" model form.

The sectoral models constitute the bulk of this chapter but it will first be illuminating to review their antecedents in the form of analyses of construction cycles and residential investment behaviour.

3.2 RESIDENTIAL CONSTRUCTION CYCLES

One of the earliest established features of economic data is its tendency to follow cyclical fluctuations. From quarterly and seasonal variation to the much disputed fifty-year Kondratieff waves, attempts to quantify and predict such cycles have been numerous. The role of construction generally as a provider of infrastructure necessary to any economic upturn has been examined in Matthews (1955). Gottlieb (1976) has analysed the details of construction cycles, especially urban building, citing work which estimates the long cycle period as fifteen to twenty years. He focuses on two sets of questions, the first pertaining to the overall pervasiveness of cycles in time and space and their similarity with the trade cycle and cycles in other countries; the second to links with land markets, labour and raw materials markets, property values, and migration and demographic trends. He also investigates the interconnections between local and national cycles, arguing local cycles to be:

"..simply a local phase of a national movement, while the national movement is in turn mainly a coalescence of local cycles" (Gottlieb. P9)

He finds that long swings in migration and household formation, especially rural to urban migration, and the marriage rate, explain, in part, residential building cycles. Property vacancies tend to follow a similar but leading pattern to building rates, with a lead of about 5 years, with the suggestion that building tends to overshoot demand.

Building materials costs exhibit long cycles similar to building activity, with a lag, although building labour costs do not. Turning points in the rents of vacant properties lead building cycles by about two years. This suggests a market cycle whereby vacancy rate changes are the earliest indication of a demand upturn, followed by rent levels, followed by an upswing in building activity which generates derived cost inflation amongst building raw materials and reduces profit margins. Eventuallly building activity declines, but has a tendency to overshoot thus creating the vacancies for the next cycle. This mirrors the housing market dynamics described in Blank and Winnick (1953).

Gottlieb's work draws on a long tradition of analysis of the residential construction long cycle although he also discusses shorter waves. Analysis of the short cycle is relatively recent. Guttentag (1961) used time series data on non-farm housing starts, non-farm mortgage recordings, and residential contract awards. To qualify as a "cycle" in Guttentag's analysis, all three series have to exhibit the same behaviour. Guttentag finds evidence of a five-year cycle (as Gottlieb does) for short term dynamics and suggests that (in the USA) the frequency of construction is countercyclical with respect to the rest of economic activity. Guttentag suggests that it is possible to distinguish betwen demand-led and supply determined construction activity by the behaviour of mortgage yields; if they move together, demand determinants are paramount whereas a negative relationship suggests supply of credit drives the market. If demand for funds rises, mortgage rates and construction rates rise. If supply increases mortgage rates are driven down but construction rises or stays the same, depending on how elastic demand is with respect to mortgage credit costs. Guttentag traces a variety of other routes by which mortgage credit affects the market, and suggests that:

"Demographic factors and the relative price of housing which must be crucially important determinants of housing demand and construction in the long run, ordinarily do not change very much in the short run." (Guttentag. P286)

One of the suggested reasons for this is that households take a long term view of their future income and this dampens any tendency to short-run fluctuations in demand - in effect invoking the permanent income hypothesis.

Guttentag suggests, then, that the supply of mortgage credit dominates construction, and such supply will be inversely related to the overall level of economic activity; when other sectors are slack, surplus or residual credit is channelled into the housing market.

Vipond (1969) analyses UK data in this way, although extending the explanatory role to include building costs and incomes; she also uses completions as a building activity indicator since she suggests that starts reflect future output, not current activity. Vipond distinguishes between credit conditions facing builders (bank credit) and those facing buyers (mortgage credit), but suggests that the bank rate adequately proxies credit conditions in both markets. Although building costs and income growth have some effect on the housing market, the author concludes that credit availability is central and downturns in the supply of credit will have an effect on completions with a year's lag. Consequently there is a tendency in the UK for building activity to be pro-cyclical.

Both studies of short waves mentioned here employ relatively informal techniques for estimating cycles and inferring causality. Both suggest that the rhythm of residential building is directly determined by financial markets and that financial factors appear to dominate other determinants of demand and supply. Both studies use a volume-based approach to building activity - either starts or completions - and consequently assume that housing is either homogeneous or supplied in fixed proportions of each heterogeneous grouping. Some models have used more formal relationships; work of this kind is reviewed in Fromm (1971). Fromm concludes that the explanatory variables used are ad hoc and do not derive from economic theory. However, recent developments in the theory of investment and the empirical testing of theoretical predictions indicate it to be a relatively short step to suggest that housing is a form of investment like any other and can be modelled as such.

3.3 INVESTMENT MODELS

In its simplest form, the theory of investment suggests that the volume of investment is a declining function of the "interest rate" because fluctuations in the unitary market rate render more or less projects profitable, given their own internal rates of return. Analysts of housing cycles tend to observe inverse relationships between interest rates and housebuilding, and simultaneously positive relationships between the supply of mortgage credit and housebuilding. However, Arcelus and Meltzer state:

"This consensus or near-consensus on the importance of mortgage credit appears to rest on nothing more substantial than a blend of conjecture and casual empiricism" (Arcelus and Meltzer (1973) P.79)

They suggest that with respect to mortgage rates, previous models show a:

"....failure to distinguish between high rates and rising rates, actual rates and anticipated rates, market rates and real rates." (P.80)

They point out that rising market interest rates will result in consumers deferring the purchase of durables, including housing. In an integrated financial market, the effect of market rates on demand and on the supply of finance should be almost simultaneous. Arcelus and Meltzer also specify a supply function for housing which compares the rate of return on new housing (rental price relative to costs) with the market rate of interest, which proxies the opportunity cost of investing in housing. (In addition, they find no evidence that the demand for or supply of housing increases with changes in the stock or flow of mortgage credit.)

Arcelus and Metzler's work is more orientated to traditional investment theory; construction cycle analysts tend in effect to adopt an accelerator theory of housing investment.

Questions surrounding the effect of the supply of mortgage credit with respect to housing market activity continue to appear in housing market analysis. In the UK, O'Herlihy and Spencer (1972) have formulated a model of Building Society behaviour. They model mortgage lending and receipts of funds as functions of the mortgage rate and personal disposable income respectively. The mortgage rate is a lagged function of the share deposit rate which in turn is determined by the balance between the supply of and demand for funds reflected in the liquidity ratio and reserve ratio. In the UK, mortgage rates have shown considerable inflexibility and credit has been rationed by non-price means. O'Herlihy and Spencer include dummy variables for strict, mild, and zero rationing; these dummies are constructed ex post from the financial press and are significant in explaining the "demand" for mortgages, (although this is not surprising with ex post constructed variables).

The importance of Building Societies in the Net Acquisition of Financial Assets by the Personal Sector is demonstrated in Table 3.1. This role has resulted in a number of attempts to model their behaviour for its own sake. The O'Herlihy and Spencer study is a case in point. Hendry and Anderson (1977) specify a model which aims at a more theoretical statement of UK Building Society behaviour than can be expressed in ex post dummy variables. The behaviour of the sector in

TABLE 3.1 BUILDING SOCIETIES AND FINANCIAL ASSETS

PERSONAL SECTOR SELECTED LIQUID ASSETS 1985, £m

Certificates Bonds and SAYE	Ordinary and Investment Accounts	Bank Sight Deposits	Bank Time Deposits	Building Society Deposits	Total*
24.6	7.5	38.3	31.3	111.4	215.8

PERSONAL SECTOR LIABILITIES 1985, £m

Personal Bank Loans	Credit Companies	Public Sector Loans for House Purchase	Banking Sector Loans for House Purchase	Building Society Loans for House Purchase	Accounts and Creditors Payable	Other Long Term Loans	Total*
40.6	5.0	5.1	20.9	97.2	22.5	5.2	203.0

* Minor categories have been excluded so that the individual elements will sum to less than the total.

Source: Financial Statisitics, HMSO.

itself is not central to the discussion here although it frequently appears in some form or another in the market models which will be discussed in the next section.

3.4 MARKET MODELS

To formulate a market model requires, at the very least, implicit demand and supply functions. The general form can be cast as follows:

$$D_h^i = f_1 (P_h, P_{AOG}, \Delta P_h, \Delta P_{AOG}, IY, Z_1) \qquad (3.1.1)$$

$$S_h = f_2 (P_h, \Delta P_h, C, Z_2) \qquad (3.1.2)$$

where D_h^i is the i^{th} individual's demand for housing (cast at the individual level due to the variety of ways of aggregating), as a function of the price of housing (P_h), the price of all other goods (P_{AOG}), the changes in these prices, the individuals' income level (IY) and a vector of preference shifters and factors such as finance availability (Z_1). S_h, the total supply of housing, is a function of the price of housing and its price change, of costs (C) and of factors such as climate and finance availability (Z_2). Empirical representation of these theoretical determinants requires a number of assumptions and these are discussed in the next section.

3.4.1 Explanatory variables

3.4.1.1 Prices

The first differences in prices are included to capture the effect of expectations. If elasticity of demand with respect to ΔP_h is positive, then a higher rate of house price inflation results in increased demand due to expectations that the boom will continue, either to avoid paying more than necessary or to acquire an investment asset. In applying this, Whitehead (1974) finds the demand for housing to be speculative with respect to house price inflation but precautionary with respect to general price inflation. That is, expectations can act in an opposite direction to the allocative role of price in the case of housing. Expectations are an important, but complex, area and will be discussed more fully in Section 3.5.

Price changes apart, the "price of housing" variable can vary considerably in application. In the first chapter, it was seen that the two basic approaches to house prices are to assume homogeneity and a uniform price of housing services, or a series of hedonic indices to allow transformation of the value of a heterogeneous dwelling to a unidimensional scale. There are, it was seen, conceptual problems in applying the latter technique. In the case of the former, published price data gives:

$$\bar{P}_h = \frac{\Sigma_i p_i q_i}{n} \qquad (3.2.1)$$

where pi is the price and qi the quantity of housing services. If n is sufficiently large, $\Delta\bar{P}_h$ can be interpreted as showing a change in p_i, the price of housing services. This is assumed the same for all properties (the long run equilibrium assumption) and consequently (3.2.1) becomes:

$$\bar{P}h = \frac{p\Sigma_i q_i}{n} \qquad (3.2.2)$$

Provided $\frac{\Sigma_i q_i}{n}$ remains constant through time, $\bar{P}_h$ will be an adequate measure of the price of housing services. Whitehead (1974) suggests that in practice "quality" (in a homogeneous market, q can be interpreted as this) will increase by about 4% per annum due to new supply, demolitions, and improvements to the existing stock. Most writers abstract from quality change of this kind although recent developments in house price index calculation aim to take it into account. This issue will be taken up in the conclusion to this chapter.

Two main considerations remain concerning house prices. The first is whether to use price series for new or existing dwellings, or some average of the two; the second is whether financial and fiscal elements in house prices should be incorporated. In the first case, the choice of price series depends on the view held of the market. Whitehead states:

"One of the most relevant variables in a market for durable goods, where new building only accounts for a maximum of 2% of the total available, must be the existing stock" (Whitehead P.53)

Consequently the interactions between the two might suggest that some average measure is required. Nellis and Longbottom state:

"...attention is focussed on new houses, since it is implicitly assumed that the average price of these is a good indicator of average house prices in general". (Nellis and Longbottom (1981) P.10)

The apparently high substitutability between new and existing houses is the reason for supposing that price changes in one sector will be reflected in price changes in the other. Different writers disagree, however, as to the direction and extent of causality; if indeed causality is unidirectional at all. To some extent, the price series chosen will also depend on how "demand" is specified. Whitehead, for example, uses new house prices as an explanatory variable, and the importance or otherwise of the existing stock is tested by inclusion of a lagged housing stock term as part of a stock-adjustment model.

Straightforward application of house prices may be misleading. The true cost of a house includes mortgage interest (if bought with a loan) and is also affected by tax relief on mortgage interest payments. Whitehead creates a composite price variable which takes mortgage costs into account, but subsequent evidence suggests that too many different reactions are bound up in this one variable. The fact that the two elements may simultaneously move in different directions has resulted in two amendments. The first is simply to separate out these variables in a regression while the second is to model the building society sector separately in an attempt to account for discrepancies in directions of change. A number of models (Treasury (1977), Buckley and Ermisch (1982)) also make some adjustment for mortgage interest tax relief. Kearl(1979) argues that nominal, not real, mortgage rate should be used since if there is any degree of capital market disequilibrium, nominal mortgage commitments impose cash flow constraints.

3.4.1.2 Incomes

Studies in the USA (Reid (1962) Muth (1960)) suggest that permanent income is the appropriate theoretical measure for estimating housing demand. In the UK macroeconometric studies this is often proxied by a 4-quarter moving average of personal disposable income (Hadjimatheou (1976), Mayes (1979)); although Buckley and Ermisch (1982) use a more sophisticated stochastic approach. Whitehead used nominal, current income on the grounds that Building Societies view this as a basis for lending. The corollary to this is that pre-tax income is to be preferred, but like other analysts Whitehead uses disposable income. All except Buckley & Ermisch use volume which does not distinguish between changes in income per capita and changes in numbers employed,each of which may be different with respect to housing market effects.

Hall (1978) demonstrates that under the permanent income hypothesis, optimisation by an individual will result in a household's income following a Markov process random walk. By dealing in first differences of real permanent incomes, the income element in a demand equation drops out and only affects demand in a random fashion. This is the approach adopted by Buckley and Ermisch, although they include a term in current income on the basis of work by Daly and Hadjimatheou (1981) which suggests that the "efficient" permanent income hypothesis of Hall cannot be maintained by UK data.

3.4.1.3 Prices of other goods

This can include the price of rented housing and existing housing stock prices if new house prices are used as the main price variable.. In theory, demand for any one good is a function of prices for all goods, and this can generally be proxied by the retail price index or the GDP deflator. An alternative way of including relative price effects is to cast all variables in real terms by deflating them; this also applies to nominal interest rates. Once again, however, the asset role of housing can be responsible for counter-intuitive results. In times of generally high inflation, housing (which tends to inflate faster than average) becomes a good investment; thus the allocative role of price is apparently counteracted because it is dominated by expectations. Under these circumstances, the key constraint on the market becomes finance. Buckley and Ermisch stress the effect of inflation in conjunction with the tax treatment of owner-occupation as affecting the equilibrium level of house prices. This issue will be returned to in Section 3.5.

3.4.1.4 Other factors

Preferences and finance availability will affect any one individuals' demand for housing. Finance availability, as has been seen, is the primary determinant of demand in early studies; a scarcity of finance imposed, say, by a general upturn in the rest of the economy will necessitate rationing (in the UK environment) although this has now been replaced by variations in the terms of mortgage lending (for example, the loan to income or the loan to value ratio). This may be viewed as an alteration in the effective price of housing to the individual, in the case of loan to value variations; it is a pure income effect in the case of loan to income variations.

3.4.1.5 Costs

All of the factors discussed above have been of importance to demand. Theoretical considerations suggest that house prices will be of relevance to supply as well, on the reasoning that increased prices, ceteris paribus, imply increased profitability. Costs can be disaggregated into four basic elements : raw material cost, labour cost, land cost, and the cost of credit. It has been argued however, that any attempt to move up the supply curve will generate land price increases and hence eradicate profits. If the proportion of costs accounted for by land is relatively small, this should be a minor effect; but expectation of continued house price increases will mean that some or all of the supplier's potential profit is capitalised into higher land prices. By contrast, the labour market for housebuilders is still dominated by labour-only subcontracting which means that supply is highly elastic. Raw materials are partly sourced from highly monopolised industries (glass, bricks) and partly from internationally competitive ones (timber). The land market is highly unstable and shows considerable geographic variations in behaviour; in practice land is not a homogeneous good and substitutability between residential and other land uses varies. Rather than model the land market, most writers ignore it, invoking a Ricardian rent approach such that land prices become a "residual". Analytical difficulties are compounded by the lack of suitable data, so that land costs are usually excluded from the catch-all "construction costs index". This index includes elements for profit so the ratio of prices to building costs is an inadequate measure of profits; as the proportion of total profit in the building cost index increases, so does the inadequacy of the measure.

Most building, in the period covered by UK models, was financed by short term loans from banks, and the relative costs of such credit is the interest rate (e.g the Bank Rate). However, building is a high risk activity. Amongst the "other factors" affecting supply are climate and the unpredictability of this in conjunction with low capitalisation, high gearing, and few opportunities for economies of scale means that banks will be more wary of investing in housebuilding firms than elsewhere. The corollary to this is that during a credit famine, builders are the first to be affected. Consequently finance availability rather than cost *per se* may be the key factor, although the two tend to be highly collinear.

3.4.2 Dependent variables

3.4.2.1 Demand

In the general functional form (3.1.1), demand is given per individual. This raises a number of questions, similar to those mentioned in Chapter One. Under the homogeneous market assumption, the units in which demand is denominated are housing services, or expenditure thereon. Transformation of this into aggregate demand is achieved by multiplying the quantity per individual by the population. This implies that any population change will, ceteris paribus, increase the demand for housing services by a constant amount. This does not seem likely given heterogeneity of the population; an increase in the number of births with constant headship rates will not change the quantity of households. However it may result in enlarged households requiring more space, and the inference is that by a series of adjustments (in mobility) this is achieved and manifests itself as an increased demand by other displaced households for new houses. This is the "black box" approach to the existing stock, and can be contrasted with the simulation models of Chapter One (which allocate households to houses) and with the Markov transition model of White in Chapter Two.

A related issue is the specification of stock and flow adjustment models. By the above calculation, there exists a desired stock for any given population. In any one time period, the actual stock will be somewhat less than desired if adjustment occurs with a lag. (Griliches (1967) shows that lagged adjustment is consistent wih cost minimisation if there are quadratic costs of adjustment as well as costs of disequilibrium). In the flow adjustment model, desired changes in the flow are not achieved. In each case, the implication for econometric specification is that when demand is measured by the actual flow (e.g. completions) a lagged stock or lagged completions term should be included as an explanatory variable. In the stock adjustment case, regardless of how large the discrepancy is, it still has an effect on behaviour; the discrepancy may be very large if the stock-adjustment parameter is low whilst the rate of growth of factors explaining desired stock is high. In the flow-adjustment case, the absolute size of the stock discrepancy is assumed to be important, and adjustment is more myopic. In practice there seems little difference between the two if housing units are assumed homogeneous; the distinction becomes vitally important if the housing stock is heterogeneous and only some proportion of the population moves each time period.

In the NBER-HUDS model discussed in Chapter One, demand is measured as a particular number of households which have to be allocated to the housing stock; different households have different housing requirements and the mix of discrete structures required is "demand". In this model, only some households move in any one time period in order to adjust their housing consumption; it is this subset of the population who "demand". The characteristics of this sub-population will vary through time and it therefore seems unlikely that the desired flow into the system will vary in a simple, proportionate fashion with aggregate demand determinants. For example, the "baby boom" generation will have generated excess demand for the type of houses which are suitable for families with young children, such as suburban properties. The more recent ageing of the UK population is creating demand for sheltered and retirement homes, which do not need to be located close to urban centres and will have unusual internal characteristics. These are examples of long term changes induced by demographic factors, but the mix of houses offered by builders will vary through shorter market cycles as well. (This is discussed extensively in Ball (1984)). One possible way of circumventing this is to use values instead of volumes as the dependent variable, as in Artis et al (1975) and Hadjimatheou. There are a number of distinct but closely related issues here. The first is that, as Buckley and Ermisch state, treating population as the aggregative variable:

"...implicitly assumes a unitary elasticity of demand for housing with respect to population, an assumption that is rejected by the data". (Buckley and Ermisch (1982) p.276)

The second issue is that even if the non-unitary elasticity of <u>household formation</u> with respect to population is corrected for, there still remains a non-unitary elasticity of demand for housing with respect to <u>households</u>. The above quote compresses the two into one issue. Ermisch's (1981) work discussed in Chapter One suggests that a desire for privacy in conjunction with higher incomes will, through time, increase the rate of household formation with respect to any given population. As detailed above, variations in the proportion of the population at a given life cycle stage will alter the elasticity of demand for "housing" (q per household) with respect to households.

Use of a value dependent variable rather than a volume one will allow variation in a less restrictive fashion; treating values as the correct dependent variable will necessitate modelling the extent to which demographic and other changes alter the required housing stock mix. It is possible that some proxy measures could be used; if, for example, there exists a crucial life cycle stage when housing requirements alter drastically then the proportion of the population around this stage may capture the bulk of such effects. Buckley and Ermisch go some way towards modelling this effect by using the "demographically induced" (using constant headship rates) number of households adjusted for council houses whilst Hadjimatheou uses endogenous marriages ; the latter study employs a value-based dependent variable. Value-orientated dependent variables do not distinguish between volume and price increases; this may be undesirable at least from a planner's point of view, and consequently there are drawbacks to both approaches. A third approach, which employs an inverse demand function (the demand function being rearranged so that price becomes the dependent variable) is used by Mayes (1979) and by Buckley and Ermisch, and will be discussed in section 3.5.3, which examines empirical results.

This review of the choice of dependent demand variable measure has raised some important questions which illustrate the relevance of the issues discussed in Chapters One and Two. In Chapter Two, the Markov process mobility model postulates constant (on the Markov process assumption) transition probabilities which tie the entire housing stock together. This in effect, models the "black box" discussed here, suggesting that a given system input (e.g. increased incomes) will generate a predictable output in the form of excess demands after the filtering process has occurred. Consequently, after a period of learning, it can be assumed that suppliers provide fixed proportions of the required house types until some form of structural change occurs. The "Black-Box (existing stock)-as-a-Classical-Markovian-transition-matrix" assumption is never made explicit in the literature. It is implicitly assumed that a single coefficient can capture the variations in terms of spatial location and housing quality that are constantly occurring in the pattern of "demand".

Chapter One illustrated the heterogeneous nature of demand in the context of simulation models, and the fact that "aggregate demand" can have a spatial component by virtue of the way in which transport costs alter location decisions. Both categories of model are heavily biased towards the treatment of housing as a consumption good with a use value only; this is apparent in the houshold-house allocation algorithms. Discrete choice models similarly deal in "real",consumption oriented factors; the one exception is Struyk (1976) who stresses the asset demand for housing as a feature in tenure choice. By contrast all macroeconometric models are concerned with the demand for housing as an asset, although with varying degrees of importance; consumption features are viewed as secondary, proxied by demographic variables.

3.4.2.2 Supply

The measurement of supply poses fewer problems than demand. In terms of input to the closed system, it is a number of houses, which are more or less homogeneous. Some supply will come from conversion and improvement of the stock. Muth (1971) estimates the long run elasticity of supply from this source as only 0.17 and macroeconometric models tend to ignore it (although Buckley and Ermisch include a term for improvement grants to capture some of this effect). The bulk of supply can be measured by starts which become the relevant behavioural variable and feed through to the market in a technically determined fashion; it is, however, possible to include other "market" variables which might result in producers reducing or increasing the mean start-completion lag.

The main difficulty is knowing the appropriate explanatory variables to use; in the case of demand, it can normally be assumed that for new houses the new house price is most relevant. For supply, however, it has not been established whether price changes in the existing housing stock provoke a supply response or whether price signals within the new housing market predominate. If the former, a number of points arise - if it is possible to represent price changes in the existing stock by a single price change figure, does there always exist a one-to-one correspondence between this figure and the mix of new housing types supplied ? In the case of the latter the problem for econometric specification becomes that of finding the appropriate dynamic simultaneous structure. In the period covered by most macro-economic models, housing supply is represented as being close to a perfectly competitive industry; for example, Whitehead states:

"The general picture is one of a large number of small firms with rapidly changing composition grouping together and separating again in response to changes in demand. The whole structure of the housebuilding industry is thus extremely fluid" (Whitehead (1974))

There are theoretical problems involved when attempting to model price changes in a perfectly competitive industry where all firms are price takers. It is possible (as a number of writers do) to specify an implicit inverse supply function such that price becomes the dependent variable, and to suppress modelling of the causal mechanism which changes price. This in effect assumes price setting behaviour, as a function of other supply determinants and supply itself - consequently supply is undetermined. It will be illuminating, in the next chapter, to review econometric evidence on general industrial pricing in the context of a detailed examination of house price determination. This is especially important in the light of the "new view" of the housebuilding industry expounded by Ball (1984) which suggests that the perfectly competitive view is inappropriate.

3.5 ECONOMETRIC SPECIFICATION

3.5.1 General Issues

The formulations given in (3.1.1) and (3.1.2) are very general, and translation of them into practice requires a series of assumptions to be made. The simplest would be to assume a linear, (additive) form without behavioural lags where price adjusts instantly to clear the market each period. This gives the three-equation reduced form model:

$$Y = X\Pi + V \tag{3.3}$$

where $\Pi = -B\Gamma^{-1}$ and $V = \phi U\Gamma^{-1}$.

Π is the matrix of jointly dependent variable coefficients, B is the matrix of exogenous and, in the case of lags, predetermined variable coefficients, U is the vector of disturbance terms, and ϕ is a matrix of disturbance term coefficients. In the simplest case:

$$Y = \begin{bmatrix} P_h \\ D_{ih} \\ S_h \end{bmatrix} \equiv \begin{bmatrix} \text{Prices} \\ \text{Completions per capita} \\ \text{Starts} \end{bmatrix} \tag{3.4}$$

Prices are exogenous in Whitehead's model and she assumes identification, (and it is satisfied on rank and order conditions). The structural equations are estimated using Ordinary Least Squares; Two Stage Least Squares' is used to test for simultaneity (and seems to show little evidence of it). Mayes' and Hadjimatheou's models are similar with respect to the housing sector but are truer to (3.4) in that prices are endogenous. A disproportionate amount of attention has focussed on the first of these three equations, the reduced form for prices. Specification of this particular equation has become the essence of a macroeconomic housing market model throughout recent literature. In traditional economic theory, the role of price as a disseminator of information is crucial. The assumption embedded in simple models, that the market clears each time period, and that prices adjust instantaneously to achieve this relies, in practice, on prices being very flexible relative to other variables i.e. there exists a perfect Walrasian auctioneer. The alternative is to make explicit some form of disequilibrium adjustment mechanism for prices (recall the quote from Ingram et al (1972) in Chapter One). Samuelson (1947) sets out the details of a non-Walrasian adjustment process, of the discrete-time form:

$$\Delta P_t = \gamma (D_t - S_t) \qquad (3.5)$$

assuming the adjustment process is linear. If a reduced form for prices is used, the inclusion of a lagged price term renders it a disequilibrium model, with an estimated coefficient value close to 1 indicating that some lagged adjustment towards equilibrium is occurring[2] Mayes interprets the coefficient value differently, stating:

"the high value of the coefficient for lagged prices shows that long run effects will be much greater than short run effects" (Mayes (1979))

It is possible to separate out the effects of equilibrium and disequilibrium by use of the error - correction mechanism employed by, for example, Davidson et al (1978). Here it is assumed that all system behaviour can be represented by the <u>long run</u> relationship:

$$P = K\, Z^{\tau} \qquad (3.6)$$

Maintenance of steady state equilbrium in the long run requires that Z and P grow at rates g(P) and g(Z) such that $g(P) = \tau\, g(Z)$ and τ is the long run elasticity of P with respect to Z.

Let the general model be:

$$\log P_t = \alpha \log P_{t-1} + \delta + \beta o \log Z_t + B_1 \log Z_{t-1} \qquad (3.7)$$

ignoring disturbances for the moment, and assuming $\alpha < 1$.

$$\Delta \log P_t = \delta + \beta o \,\Delta \log Z_t + (\alpha-1) \left[\log P_{t-1} - \frac{(\beta o + \beta_1)}{(1-\alpha)} \log Z_{t-1}\right] \qquad (3.8)$$

In equilibrium, $\Delta \log P_t = \Delta \log Z_t = 0$ and (3.8) becomes

$$\log \bar{P} = \frac{\delta}{(1-\alpha)} + \frac{(\beta o + \beta_1)}{(1-\alpha)} \log \bar{Z} \qquad (3.9)$$

(3.9) is equivalent to (3.6) when written in logarithmic form, with

$$\frac{\delta}{(1-\alpha)} = \log K \text{ and } \tau = \left[\frac{\beta o + \beta_1}{(1-\alpha)}\right] \qquad (3.10)$$

In many applications, τ is assumed equal to one (since otherwise, through time, the ratios between the aggregate quantities would be observed to change). Any tendency for the values of $\log P_t$ and $\log Z_t$ to differ from each other will result in the expression in square brackets, in (3.8) taking a non-zero value. Since α is assumed to be less than one, $(\alpha-1)$ is negative, so any discrepancy between the $\log P_t$ and $\log Z_t$ alters $\Delta \log P_t$ in the direction necessary to bring them back into equality. In this way it is possible to reconcile long-run and short-run estimated parameters. Short-term system dynamics are captured in $(\alpha-1)$; if in practice they have little effect, $(\alpha-1) = 0 \Rightarrow \alpha = 1$ as estimated by Mayes for levels variables. This reconciles Mayes' quote, above, with the work of Artis et al (1975) who found that the speed of adjustment is rapid enough to ensure equilibrium each time period; in each case (and both are really statements of the same feature) short-term system dynamics are of relatively little importance compared with long term determinants.

This discussion illustrates that, implicit in reduced form equations which model house prices are demand and supply functions and system dynamics. The error-correction presentation draws a distinction between equilibrium and disequilibrium effects; Buckley and Ermisch employ this technique, and by stating that in long run equilibrium the stock of housing is unchanging, their "reduced-form" for prices can be interpreted as an inverse demand function. The same result follows by treating price as a direct measure of demand using an expenditure based view of the demand variable.

3.5.2 Housing Sector Macroeconomic Theory

The notion of a housing sector "theory" is relatively new. Such a theory is implicit in most macroeconomic models, but is presented more formally by Buckley(1982). In Section 3.4 of this chapter, the cost of credit was discussed as an adjunct to the price of housing. An alternative approach which recalls investment-based theories of the housing market is the capital asset pricing model, where in equilibrium:

$$P_H = R/r \qquad (3.11)$$

where P_H is the real price of housing, R is the rental value of housing services, and r is the real mortgage rate (which is assumed to move in perfect step with other costs of capital). Consequently given R, the "demand for housing" will be an inverse function of the real mortgage interest rate; the mortgage rate alters the relative rate of return on housing and has a consequent inverse effect on the real price of housing (which can therefore be taken as an indicator of "demand" especially if it is assumed that in the short run supply is unchanging). It is assumed, following the work of Feldstein and Eckstein (1970) that the nominal interest rate, i, is the sum of the real rate of interest, r, and the expected rate of inflation, θ; hence $i = r + \theta$; capital markets are perfect so that i = nominal mortgage rate = cost of capital. Returns on all other goods are taxed, so that the real return to investment will, in equilibrium, equal the exogenous cost of capital, C;

$$C = (r + \theta)(1 - t) - \theta \tag{3.12}$$

which is equivalent to the real, after tax, rate of interest facing borrowers for home purchase. Returns to housing and mortgage interest costs are tax free for owner occupiers and this is the source of some important effects. Buckley casts the housing sector in a manner analogous to the IS-LM income determination model. Relation (3.11) provides a speculative demand for housing and the size of the housing stock provides a positive transactions demand for mortages (due to e.g. mobility). The supply of mortgage credit has exogenous and interest-sensitive components; the latter is a function of any differential between the mortgage saving rate (and housing's cost of capital) and the exogenous market determined cost of capital. The demand for mortgage credit is an inverse function of the real mortgage rate, and the stock demand for housing is a function of real disposable income, net household formation (after allowing for local authority provision), the real after tax housing borrowing rate, and the real price of housing. For any given demand for mortgage credit, a particular real mortgage market-clearing interest rate is implied, as is a volume of mortgage lending. The interest rate implies an equilibrium real price of housing via (3.11) and the volume of mortgage lending implies a particular housing stock (through the transactions demand). This gives a locus of points in real house price/housing stock space for any given combination of mortgage demand/mortgage supply schedules. Housing market equilibrium then involves simultaneous clearing of the interdependent housing and mortgage markets. Two conclusions follow: the first is that the effect of a change in tax rates on the demand for housing is ambiguous; disposable incomes will fall when taxes rise, but the relative rate of return to housing rises. The interplay between income and substitution effects determines the overall result. Secondly, higher anticipated inflation increases the demand for (and real equilibrium price of) housing, because of the tax subsidy. A further conclusion is that increased production of council houses does not <u>necessarily</u> reduce the demand for owner occupation; it reduces the demand for mortgage credit, which lowers the mortgage rate and the asset demand for housing increases. By similar reasoning, increased supply of mortgages also increases the demand for housing, whilst council house sales, via the mortgage market , reduce the overall demand for housing (a "crowding out" argument).

In practice, the nominal mortgage rate does not follow the capital market rate, and this factor has prompted Hadjimatheou's and Mayes' analysis of Building Society behaviour using "managerialist" theories. If, for reasons of policy or political pressure, Building Societies cannot adjust their mortgage rates, then they become relatively exposed in terms of their savings inflow, necessitating the familiar rationing process. In the absence of a profit maximisation motive, an alternative explanation is required as to why Societies react at all. Hadjimatheou suggests that Societies' liquidity ratios feature in managerial utility functions, whilst Ghosh and Parkin (1972) suggest that reserves or their rate of growth are important. Mayes work is similar in spirit to that of Hadjimatheou, although different in detail. The upshot is that the mortgage and housing markets may exhibit some "stickiness".

The inclusion of the anticipated inflation rate as a factor which affects the asset demand for housing raises the issue of how, in practice, it is to be modelled. Essentially there are three generally proposed forms for expectations formation: naive, adaptive and rational. In the most naive model:

$$P_t^{e} = P_{t-1}$$

$$\Rightarrow \quad P_t^{e} - P_{t-1}^{e} = P_{t-1} - P_{t-2} \tag{3.13}$$

where P_t^{e} is the price expected to prevail at time t.

Mayes suggests $P_t^* = (1 + \lambda) P_{t-1}$ which is an amended version of (3.13). Under adaptive expectations:

$$P_t^* - P_{t-1}^* = \delta (P_t - P_{t-1}^*) \quad (3.14)$$

This is the form used by Ingram et al, with δ determined experimentally. Inclusion in a structural equation with application of the Koyck transformation yields the result, for specification purposes, that a lagged dependent variable should be included as a regressor. Whitehead and Hadjimatheou use price change and rate of change respectively to model expectations; this implies an expectations model which is a hybrid of (3.13) and (3.14).

$$\Delta P_t^* = \delta \Delta P_t \quad (3.15)$$

Hadjimatheou finds it to be insignificant but suggests this is due to the inadequacy of the variable as a proxy for expectations rather than as evidence against the effect of expectations per se; Whitehead finds it to be positive and significant. Friedman's (1968) adaptive expectations model is:

$$P_{t+1}^* - P_t^* = \delta (P_t - P_{t-1}^*) \quad (3.16)$$

which again implies the inclusion of a lagged dependent variable. One drawback of any adaptive expectations model is its tendency, in a generally inflationary environment, to systematically underpredict inflation. This feature was first pointed out in Muth (1960, 1961) who proposed rational expectations instead. Here it is suggested that individuals will always make optimal use of the information available to them; systematic mistakes will not be continued, so that forecast errors between actual and expected series will be random. This is normally applied in macroeconomics where some "datum" such as the money supply is available to influence expectations. Even if most individuals do not monitor economic events closely, their advisors (economists, politicians, and trade unionists) will, and the system will behave "as if" rational expectations are operating. The lack of direct analogue in the housing sector has meant that rational expectations have not been used in housing models, although Buckley and Ermisch's permanent income variable implicitly uses them. This question will be discussed more fully in the next chapter.

3.5.3 Empirical Results

A number of empirical results have already been reported but in this section a more systematic analysis will be presented. Only models using UK/GB data will be analysed, although similar work has been carried out in the US e.g. Kearl and Mishkin (1977), Kearl (1978), Jaffee and Rosen (1979), and Rosen (1979). For reasons of space, models are not presented in full.

Whitehead's final demand equation includes a lagged, population deflated stock variable, which is unusual considering that the model is supposed to be a flow equilibrium. Whitehead includes it to assess the

"...interaction between the market for existing stock and that for new housing" (Whitehead (1974) P.89). Variables are in per capita terms and on statistical criteria the equation fits well. The starts-completions relation includes a 3 period lagged starts variable (using the Koyck transformation) assuming housebuilding takes at least 6 months and a lagged dependent variable is included since this is a flow adjustment model.

The supply elasticities (Prices 0.62, Construction Costs - 5.02), imply perverse results with respect to profits (or considerable diseconomies of scale). One possible source of inaccuracy is the construction cost index, which ignores productivity changes, and assumes that land prices grow at 2% per annum. There is a substantial trend component, and this with the nominal values on prices and interest rates might produce multicollinearity, and hence coefficient instability.

Artis et al use an investment-oriented approach, and the coefficient on the lagged stock term in their model reflects depreciation as well as lagged stock adjustment. They also suggest that there will not be a technical, one-to-one relationship between starts and investment; so their supply function uses investment itself as the dependent variable. Thus the first equation is a straightforward equilibrium investment stock adjustment model. In the demand functions they use a real price/real mortgage rate adjusted for taxes composite variable, and the four period change in real house prices to proxy expectations, permanent income (a distributed lag) and real local authority rents to proxy the effects of the other tenures. Their supply function includes building costs and credit costs separately, the relative price of housing, a time trend and a term to reflect tender-approval/construction lags. This shows positive autocorrelation; removal of this by means of instrumental variables renders the time trend insignificant. Their elasticity on costs is, like that of Whitehead, much larger than on prices.

For the demand equation, the composite price variable performs best, as does the income measure. The success of local authority rents is reduced by removal of autocorrelation. The expectations variable generally performs badly. A variety of dummies are employed to reflect rationing by Building Societies; in general rationing is not a maintained hypothesis. Artis et al also formulate a disequilibrium model, as discussed previously. In neither the supply nor the demand formulations does the disequilibrium variable (the change in real prices) show significance.

Hadjimatheou's flow equilibrium model employs both investment and starts as dependent variables in the supply function. There is some similarity with the equilibrium supply equation of Artis et al, but the problem of perverse elasticities on prices and costs is solved by using the ratio of the two. As discussed above, this has some difficulties in itself since published building cost indices include an element for profit. It will be an adequate proxy provided the profit element is not too large. The supply of starts equation achieves very similar results; it is marginally less successful than the investment supply equation in terms of R^2 but in practice there is little to choose between the two. The starts-completions relation is a purely mechanical one, estimated by instrumental variables. It shows a pattern similar to the coefficients estimated by Whitehead when deciding on an equation structure - that is, that few coefficients on lagged starts variables are particularly large, with some being insignificant, and the most important regressor tends to be current starts. It is common for high (6,7 or 8 quarter) lags to also be significant and this may reflect a short building cycle rather than a technical phenomenon. Hadjimatheou's demand equation is deflated by population and is similar to Whitehead's apart from the exclusion of a lagged stock term and the inclusion of a variable to reflect rationing by Building Societies in the face of pressure on liquidity ratios In terms of R^2 and Durban Watson statistics, there is little difference between them.

Mayes' model is ostensibly a stock equilibrium model but the stock term is dropped. The starts-completions relationship shows variation in the patterns of significance on lagged starts variables compared with Whitehead and Hadjimatheou, but the overall pattern of one-period and six-period lag significance with low explanatory power for intervening periods is maintained. A four-period difference is insignificant. The supply of starts equation is similar to Hadjimatheou's except that a term for total lending, from Building Societies and other financial institutions, is included, to capture builder's expectations (who, it is supposed, monitor events in capital markets). Mayes' reduced form for house prices is not explicitly defined as such; it includes terms for public and private completions (theoretically supply variables) and for the nominal mortgage rate. There is also a term for gross mortgage advances by Building Societies. The lagged dependent variable is intended to capture expectations although equivalence with a dynamic adjustment model has already been discussed.

Whitehead, Hadjimatheou and Mayes find little to choose between linear and log-linear specifications. Recent work has tended to use log-linear because the elasticities are more tractable. Another point which emerges from these models is the difficulty in modelling expectations, and the observational equivalence, in terms of econometric specification, of a variety of theories which suggest the inclusion of lagged dependent variables. A further problem which occurs especially when using a price reduced form is that all the data tend to be heavily trended, particularly nominal values; spurious correlations and multicollinearity will result.

Nellis and Longbottom (1981) estimate a reduced form with first differences in logarithms as the dependent variable. The theoretical underpinnings of the equation are not clear, but seem to be an amalgam of a stock adjustment model with Mayes' reduced form. There is some mixing of logarithmic and level variables, and the coefficients on the effects of new private and public supply are constrained to be equal. They also present a "steady-state" equation which appears to consist of the first equation with lagged terms dropped and supply and demand prices assumed unchanging. They also have a coefficient on consumer's expenditure deflator of 1.0 which suggests perfect and instantaneous (within any one quarter) adjustment of the differentials in prices between houses and all other goods.

Buckley and Ermisch (1983) point out that amongst other things, Nellis and Longbottom's model can, under certain assumptions, imply an income elasticity of demand for housing of 4.4, which is much higher than any other estimates. They present short-run and long-run price reduced forms which use the error correction mechanism of (3.8). This model, derived from Buckley and Ermisch (1982), is important for three reasons. Firstly, it employs a variant of the capital asset pricing model detailed by Buckley (1982); secondly it differentiates between equilibrium and disequilibrium, and finally it addresses the questions of endogeneity of permanent incomes (since they can include housing wealth) the effect of building society variables, and the tax advantage to owner-occupiers.

On the basis of the capital asset pricing model, changes in the anticipated rate of inflation (i.e. in nominal interest rates when real rates are constant) will change the equilibrium price of housing as will Building Societies' acquisition of assets adjusted by the prevailing loan to value ratio. The results show some support for the housing market sectoral theory, although it is notable that council house production , local authority rents, and household changes do not show a strong impact. Improvement grants have a positive impact. A cubed term in first differences of logarithms of house prices is intended to capture Hendry's (1979) suggestion that expectations of capital gains from housing may be disproportionately influenced by very large changes in house prices. The levels variables give error-correction or short-term dynamic behaviour, and they are all significant suggesting that short-term mismatches between the subsidy to owner-occupiers and the price of housing, between the volume of funds available for loans and the price of housing, and between the total number of new households relative to council house population, will all have positive impacts on prices. The equilibrium effect of household formation is weaker, especially under instrumental variable estimation; but instrumental variable estimation also shows changes in the coefficients of a number of variables, including households on levels form. This suggests that house prices and households are simultaneously determined, a point which will be discussed in more detail in the next chapter. Buckley and Ermisch's reduced form for prices in long run equilibrium has household formation, income growth, the tax advantage to owner-occupiers, and funds available for lending by Building Societies. This is interpreted by Buckley & Ermisch as a demand function, since supply is assumed unimportant in the long-run steady state. As an approximation this is acceptable, but seems to render the definition of "steady-state" somewhat arbitrary.

The models reviewed so far are the most important, but other examples include Duffy (1970), who stresses the role of net Building Society advances and general inflation; this is one of the first of the house price reduced forms. The London Business School (1979) model is of house price changes with real incomes, the nominal mortgage rate, and an eight-period moving average on starts as explanatory variables. It is probably an adequate reduced form for its purpose, which is as an input to an economy wide model. The Awan (1980) model never reached completion, but is novel in the use of four period changes. Most. Most writers use seasonal dummies to filter out seasonal effects, which are especially important in an externally constructed product such as housing. Buckley and Ermisch use data which are seasonally adjusted, and note that this may lead to inconsistent estimates. A further hypothesis embedded within a four-period difference model is that it is more reasonable to expect agents (especially producers) to base their behaviour on "subjectively deseasonalised" variable values; for this reason this method of deseasonalising is to be preferred to dummy variables.

3.6 CONCLUSIONS

A number of observations can be made at this stage. At the empirical level, all of the models discussed here have shown strong autoregression in the starts and completions data series and this has tended to result in problems in the behavioural modelling of these quantities. In general, success in modelling starts and completions has not been as marked as that of modelling prices. This is one reason for focussing on prices as a dependent variable, but as has been seen, the other is that prices are viewed as the sole housing market datum of any importance in the long run, and indeed are taken as conceptually equivalent with "demand". A related point is that later work shows some confusion over the definition of structural versus reduced form equations and this is reflected in the difficulty in distinguishing supply and demand (e.g. the inclusion of supply variables (public and private completions)) in the "demand" equaions presented in Mayes, Nellis and Longbottom, and Buckley and Ermisch. It is possible to argue that the reason for this is that all the models reviewed so far only deal with a subsection of the housing sector; the price of a new houses reflects the behaviour of the new housing market, but this is likely to be closely linked to the existing sector. As has been seen the existing sector is commonly implicitly viewed as a classical Markovian transition matrix, which is not explicitly analysed. It does appear as a lagged stock term, but with the heavy trend element in this variable it is unlikely to accurately reflect new/existing interactions. By invoking an asset demand approach, Buckley and Ermisch suggest that changes within the existing stock will generate flows into the market and have corresponding effects on new house prices. This is implicit within most models, which use as explanatory variables, terms such as net mortgage advances, total income change, total improvement grants, etc. But some of these changes must impact on the existing stock. Is it always valid to suggest that the effect on the new housing market will be identical every time ?

Artis et al mention this point with respect to the supply response, suggesting that there will not be a one-to-one relationship between starts and investment, due to conscious variation of the value to new housing unit ratio by builders in the face of altered market conditions.

A related point is the adequacy of available price data (when, in practice, housing is heterogeneous) as a measure of price changes or as an expenditure measure of demand. A crude average of all house prices in any one period presupposes that the relative quantites in each house type (and value) category are unchanging through time. Crude averages have been replaced by "mix adjusted" price indices in later studies.

The details of calculation of these are given in the Department of the Environment Paper (1982). The basic problem is to find broadly homogeneous groupings of houses and of using the relative proportions of such groups within the stock or transacted in some base period to weight price changes. The Department of the Environment method uses 156 size, age, type, and region cells.

Fleming and Nellis (1981) have surveyed all the house price data available, and have concluded that because most of the sources of price data only cover a proportion of the market (namely that funded by loan institutions) there is a tendency to overstate the "true" house price level. This may not, in itself, be a serious source of bias provided that the relationship between the observed and unobserved sectors is fairly constant and/or that the two are independent. Fleming and Nellis (1984) suggest that in tackling heterogeneity, the hedonic price approach, detailed in Chapter One, be used, as do Wilkinson and Archer (1976). This allows much more standardisation although the difficulties with this technique, discussed in the first chapter, should be borne in mind.

Rosenthal (1984) suggests that hedonic prices should be interpreted as minimum error weights. Comparing results from crude averages, mix-adjusted indices, hedonic-based indices, and indices weighted by rateable values, he finds that crude averages are biased below the adjusted indices, counter to what is expected. In general, however, he finds the correlation between the series to be very high even after removal of the time trend element; he concludes that

".....little is to be gained from the use of the more sophisticated approaches to the estimation of national owner-occupied per unit house price indices presented here than are already available". Rosenthal (1984) P.281

The issue of heterogeneity highlights a fundamental shortcoming, or at least assumption which pervades the macroeconomic housing modelling literature. In order to ensure that the theoretical approaches used are valid, it is necessary to assume homogeneity of housing. In stock-adjustment models, such homogeneity extends to the existing stock (where this is measured in terms of existing units) and the flow volumes of housing units. Focus on the heterogeneity issue with respect to prices alone is, therefore, somewhat restrictive (although in the Buckley and Ermisch steady-state case, it is the only variable where this is of relevance).

If heterogeneity is admitted, the theoretical points raised in Chapter One become important. These points concern the existence and stability of a long run housing market equilibrium when stock is heterogeneous. On the strong assumption that equilibrium conditions are satisfied, (and that in effect, the existing stock is a classical Markovian transition matrix) a macroeconometric approach will be valid in so far as residuals' randomness are satisfied. The question of whether anything could be achieved by taking heterogeneity into account then becomes the question of whether overall residual variance can be reduced.

One of the reasons for adopting a homogeneous market asset pricing model is the emphasis on financial factors as explanatory variables. The implicit suggestion is that housing market activity is dominated by financial rather than real variables.

Given such dominance, the effects of capital market changes will be similar in terms of direction and magnitude throughout the country, and faster than locationally specific "volume" responses; ultimately, this is the rationale for treating housing markets as one homogeneous entity. This issue will be discussed more fully in the next chapter.

Apart from the desire, for its own sake, to determine causal factors, macro-econometric models have also been employed in the analysis of policy. This is especially so with respect to financial variables, in the case of Building Society and taxation structure reform. It is also seen as a valid activity where spatial variables are concerned; for example, council house sales (Buckley) and land release (Nellis and Longbottom suggest that their model implies that local authorities should zone more land for housebuilding). It will be argued that some of these issues can only be properly analysed by using an explicitly spatial approach. Another reason for doing so is that it introduces an additional dimension to analysis. This is desirable because as has been seen, a number of housing market theories are observationally equivalent as far as tests with time series data are concerned.

In this chapter I have suggested that a major potential drawback of macroeconometric models is their limited treatment of interactions between the new and existing housing stock. It has also been pointed out that, in the heterogeneous/homogeneous housing market framework presented in Chapter One, macroeconometric models "work" more easily, in theoretical terms, if homogeneity is assumed and the asset role of housing is stressed. Considering such an apparently unrealistic approach, macroeconomic models achieve a surprisingly high degree of success, and this must be due at least in part to the battery of econometric tests which are now available for specification analysis. There can be no dispute that work such as that of Buckley and Ermisch represents a parsimonious representation of "broad brush" (short run) equilibrium and its determining factors. The question is whether such work contributes to an understanding of the housing market for the purposes of planning and policy design. Answering this involves examination of the planning process as applied to housing, but a few general points can be made here; namely the failure of any researchers to find local authority rent levels to be an important explanatory variable, and the fact that attempts to incorporate demographic components, culminating in Buckley and Ermisch's "household formation" variable have demonstrated their importance and even endogeneity with other market indicators. Both results will be seen to be of key importance to the discussion of the next chapter.

CHAPTER FOUR

A REGIONAL MODEL (I): KEY CONCEPTS

4.1 INTRODUCTION

The previous three chapters have reviewed a broad area of theory and practice. Urban models stemming from the utility maximisation premise have been shown to be classifiable according to, amongst other criteria, their view of the housing market in terms of homo- or hetero- geneity. It has been shown that macroeconometric models largely rest on the former assumption, homogeneity, and that they model only a portion of the housing market, namely that for new housing. The market for existing housing is generally ignored and is implicitly assumed to exhibit regularities of behaviour of the kind which feature in the Markov models discussed in Chapter Two. Tests for homogeneity have been applied extensively at the urban level and this work has been reviewed in Chapter One, with mixed conclusions.

This chapter begins the development of a regional housing market model, drawing on the insights provided by the analysis of the preceding chapters. It will be argued here that the behaviour of the housing market can be classified in three dimensions: time, space, and quality. Of these, the spatial aspect is the most important for a regional model, but all three interact. It will be shown that analysis of the role of space and its interaction with time in the housing market will require examination of household search processes. It then becomes equally important to treat the mobility decision as interdependent with the overall market. This leads to a discussion of house price determination generally, in the markets for new and existing houses. The notion of a market evolving through time with imperfect information requires a more probabilistic definition of equilibrium than that used in models discussed so far.

4.2 THE RATIONALE FOR A REGIONAL MODEL

There are two distinct potential outputs of a regional model and these are dependent on the purpose of the model. From the point of view of local authorities, the ability to make regional forecasts of housing market variables (especially demand) is desirable for the purposes of planning. From the causal modelling point of view, a regional model permits examination of a particular aspect of heterogeneity; space. Paelinck and Nijkamp have defined "regional economics" as follows:

"Regional economics is concerned with an explicit consideration of spatial elements in general (theoretical) economics: it studies the spatial dispersion and spatial coherence of activities from an economic point of view"

(Paelinck and Nijkamp (1977))

On this definition, "regional" and "spatial" models are conceptually equivalent. The treatment of space in urban housing models varies, but it primarily appears as a source of transport costs (constant and/or income related). In simulation models the treatment is similar. Although these models address heterogeneity by using disrete zones, interactions between such zones are ignored.

In the entropy model, distance is of the Euclidean form, although it is adjusted by transport cost rates and is thus equivalent to urban model "space". In the gravity model, distance is directly Euclidean although the intervening opportunities model allows for different definitions of space. The Markov model treats interactions between spatial units (however defined, i.e. social and housing quality "space" as well as geographic) as constant, provided the initial classifications are internally homogenous.

Macroeconometric models have no explicit spatial element. In part this arises from the logically prior (and unproven) assumption of housing market homogeneity, but in practice these models employ two distinct sets of variables. Tax and interest rates and financial flows are aspatial variables (that is, a fully accurate description of such variables does not require a spatial co-ordinate). In contrast, house completions and stock, house prices, demographic variables, local authority rents, and incomes or income changes, all posess a spatial component. Bennett (1979) terms models which ignore this kind of spatial component "lumped systems". Assessing the extent to which a spatial system can be approximated by a "lumped system" requires detailed examination of the manifestation of space *per se* in the housing market.

4.3 SPACE AND THE HOUSING MARKET

4.3.1 Housing Market Dimensions

The "commodity hierarchy" model of Sweeney (1974) consists of two related hypotheses. The first is that housing heterogeneity can be adequately represented by classifying housing into a series of distinct, internally homogeneous groups; the second is that the relationships between these groups in terms of consumer substitutability can be represented by a quality hierarchy This framework has been subsequently restated by Gerber (1985) to permit more general substitutability between groups. It will be argued here that a full description of the housing market requires analysis in three dimensions: space, time, and house quality. This last dimension is further decomposable such that houses are represented by points in characteristics space, but for the moment it will be supposed that such representations can be simplified, without loss of generality, into groupings of the kind proposed by Sweeney and Gerber.

The time dimension is analysed in considerable detail in macroeconometric models where the (static) long run solution is derived in conjunction with short term disequilibrium dynamics. More generally, all macroeconometric models use time series data and hence focus on intertemporal behaviour. "Costs of Adjustment" are usually invoked to justify dynamic approaches, in the same way that costs of movement "create" space in purely spatial models.

It is possible to argue that at least some of the debate about the nature of housing markets stems from a confusion of the quality dimension with the spatial. It is common for urban analysts to refer to "submarkets" although the definition of these varies. The NBER-HUDS model draws a distinction between spatial zones and submarkets associated with particular house types. In contrast, Goodman (1981) uses a purely spatial definition by employing the Cliff, Haggett, and Ord (1975) criteria, which only groups contiguous zones. It will be remembered that a further criterion is that of simplicity - that a definition which results in fewer submarkets is to be preferred to one which results in a proliferation. A macroeconometric model in effect assumes that one zone is an adequate assumption for the housing market; in conjunction with the Markov assumption about the existing stock, the analysis then reduces to the temporal sphere.

Urban models do incorporate all these dimensions but in varying proportions; land use models, for example, generally use a long run solution. Simulation models use a "medium run" temporal perspective. What is apparent in urban models is that it is difficult to disentangle house type "submarket" effects from spatial submarket effects on observed housing market behaviour at the urban level of analysis. Grouping by spatial units alone tends to inadequately describe housing submarket interdependencies, whilst grouping by house type alone can disguise the role of space. It will be argued that in order to examine spatial effects in isolation, it will be necessary to operate at a much higher level of aggregation of spatial units than is implied by urban models. At this higher level of aggregation spatial interaction will be argued to arise not just from distance effects but also from the joint activities of search and information transmission. Search behaviour will be hypothesised to be the main source of spatial links within the housing market especially at the regional level. The gravity model has been shown to represent a parsimonious method of modelling spatial interaction, and is one which can be applied to commodities as well as individuals. As a commodity housing is peculiar since demand adjustment usually takes the form of consumer mobility rather than commodity mobility. It is a locationally specific good both in production and consumption, which means that migration and mobility are not always observationally separable. It is common to define migration as movement in response to a change of work place, particularly inter-regional changes: mobility is usually viewed as a housing market adjustment in response to, say, life cycle changes. Graves and Linneman (1979) have argued that ownership of a house involves the simultaneous consumption of locationally specific "non-traded goods". Such goods (environment, amenities) may prompt housing consumption adjustment over considerable distances and may be treated by the household as more important than job choice. There is a direct analogue here with Wilson's (1970) four types of locational behaviour. Linneman and Graves (1982) provide a taxonomy of these kinds of mobility and location behaviour.

It follows that the distinctions between mobility and migration are unclear. Both are the outcome of adjustment to housing consumption disequilibrium, but as was seen in Chapter One, the search process is logically prior to mobility. The actual move is only one of a potential number of outcomes and the use of observations of mobility behaviour as evidence of desire means invoking the revealed preference assumption. In practice, any actual move is "shadowed" by a series of "dummy" moves in the form of search patterns.

4.3.2 Search Processes

Some research has been conducted on the role of information in influencing search patterns (e.g. MacLennan and Wood (1982)) but less attention has been focussed on the role of search patterns as disseminators of information. Search models were initially developed as additions to macroeconomic theory and focussed on the labour market. The intention was to explain sluggishness in labour market adjustment and more generally to model uncertainty with its attendant disequilibrium macroeconomic solutions. It has been pointed out that search involves the acquisition of information and hence the process is anathema to a neoclassical framework of perfect information. Beginning with Stigler (1961), however, it has been suggested that at the individual level it is possible to incorporate imperfect information without compromising the principles of utility maximisation, and it is worthwhile examining models incorporating this perspective in more detail. The central hypothesis is that information acquisition incurs costs, so that the acquiring economic agent has to decide at what stage it is optimum to stop searching. It is generally assumed that the individual faces a series of opportunities, such as job offers or housing vacancies, and must decide after each one whether to accept or to continue searching. The individual seeks to maximise the net gain from such a process and this involves assessing whether the expected gain associated with the next offer outweighs the additional search costs, conditional upon satisfaction of some reservation value for the net gain.

It can be shown (e.g. Hey (1981)) that the reservation price is an increasing function of search costs, and consequently search will cease earlier as search becomes more expensive. It can also be shown that the optimal reservation price is just equal to the expected net cost (purchase price plus search costs). If the searcher comes upon an observed price equal to this optimal reservation price he will be indifferent between continuing or stopping his search.

There are two forms of search, active and passive, and these can be examined in a static or dynamic framework. The essential features of any search model are the shape of the utility function of the searcher and the expected distribution function of the set of prospects. It is clear that problems arise when the searcher's subjective perception of this distribution is at variance with the actual distribution. In order to incorporate this, search models which include learning have been developed. One such model, detailed in Hey, includes an updating scheme for the probability of an event's occurrence, such that if the process is allowed to continue for a sufficiently large number of time periods, the actual and expected distributions will coincide. In the housing market, the problem for most households is the infrequency with which they transact compared with housing market professionals and housebuilders. The models which incorporate learning do not usually give explicit predictions about the intensity of search because the range of possible subjective distributions is so large; nevertheless, some general observations are appropriate. Firstly, the marginal opportunity cost of an individual's time will be a crucial determinant of the intensity of search even in an adaptive situation. Secondly, the cost of acquiring information will include a monotonically increasing spatial component so that long-distance migrants will have higher optimal reservation prices. Thirdly, the initial information set will be more complete for prospective purchases that are associated with the household's peer group; hence there will be a subset of all possible moves about which the household has more perfect knowledge.

Huff (1982) has analysed the residential search process in a spatial context, where the household searches over house vacancies offered for sale in a series of discrete spatial areas. Given that it is possible to represent housing as a heterogeneous good composed of attributes, Huff employs a "minimum requirements" decision rule of the form developed by Tversky (1972) in the Elimination by Aspects Model.[1] Huff defines the subset of vacancies, n, as those which cannot be rejected without direct investigation on the part of the household. He then states:

"If the spatial distribution of vacancies in the choice set, n, does not correspond to the spatial distribution of a similar number of vacancies randomly sampled from the set of all existing vacancies then the decision to investigate only those vacancies which are members of n will necessarily result in a spatially biased search pattern".

(Huff (1982), P.116)

Huff analyses the spatial search process in a Markovian framework such that the probability of searching in a given area is a function of the location of the last vacancy seen by the household, and of the relative concentration of possible vacancies.

It follows that the spatial search process will, like any other, involve comparison of the reservation price with the expected cost of continued search, and that the way to minimise this cost is to concentrate the field of active search. This principle, applied by Huff to two-dimensional Euclidean space, is equally applicable to any form of space, including that which separates housing market strata.

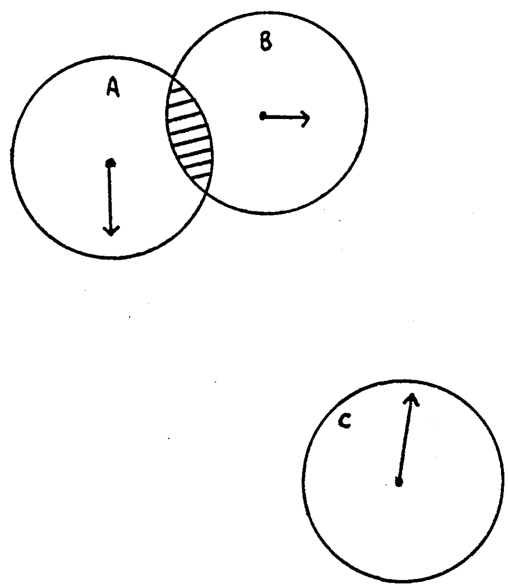
The spatial relationship between the household's current location and their area of search will depend on their motive for moving; job-related moves will result in search in the environs of the new employment location, whereas a housing-related move such as a birth in the family will result in search in the same area as the current housing situation. The differences in scale between the move distances of the two groups will vary with the spatial distribution of the housing stock varieties compared with employment locations. In general, the housing adjustment move will be shorter.

The primary purpose of search models is as an amended micro-behavioural foundation for macroeconomic theory, where the economy may not be in Walrasian equilibrium. Such aggregation to investigate the macroeconomic effects of micro search behaviour is a relatively neglected area in residential search analysis, but it is one which is vital if the regional (i.e. spatial) nature of the housing market is to be explored. It was seen in the first two chapters that models which deal with the simultaneous behaviour of a large number of individuals often contain implicit views of search. For example, the NBER-HUDS model assumes perfect information whilst the intervening opportunities model implies a radiating search pattern. The way in which search is conducted can also vary considerably, and within the context of the housing market, it can consist of any activity from perusal of the local newspaper to physically visiting a property. This latter form will convey information to sellers and their agents about demand, and hence provides a link between the current location of a household and some or all of that household's potential new locations.

It was seen in Chapter One that the intersection between the aspiration and awareness sets provides the search space, and Huff's analytical categories distinguish between those properties which are effectively searched without being physically visited, and those which must be physically inspected. This subset of the search space is the information about demand available to suppliers of housing.

Within two-dimensional Euclidean space, it is possible to equate the search space with a physical area, at least within any one stratum of the housing market. Such a restricted form of search space will be termed a "search field". This set of vacancies, within which physical inspection occurs, need not be continuous.

FIGURE 4.1 SEARCH AND MIGRATION FIELDS



At the aggregate level, mobility or migration decisions can be represented by "migration fields"; that is, by arrows representing the direction of migration from the point of origin. Figure 4.1 gives hypothetical search and migration fields for three individuals, A,B, and C. The determinants of any particular search field may be tempered by uncertainty and ignorance or may be the result of a rational economic calculus. Behavioural geographers (Golledge and Rushton (1975)) have employed the notion of "mental maps" and have demonstrated that perceptions of space can vary considerably across individuals. It is problematic, however, to translate such a behaviourally based method of determination into a neoclassical economic framework.

Hägerstrand (1954) suggests that individuals possess "private information fields" and that these can be proxied by migration fields. The reasoning is that, in rural areas, individuals will rely on personal contacts to furnish information about job opportunities or residential vacancies, and migration flows will reflect this. He finds evidence to suggest that migration fields (and, by implication, private information fields) are stable over long periods of time, with a direct analogue with the Markov stationarity assumption. The introduction of search processes suggests that the particular migration field chosen is only one possible outcome; ceteris paribus, it can be viewed in the aggregate as the <u>expected</u> outcome. Information possessed will place a restriction on possible migration fields, although as has already been seen, Maclennan and Williams (1979) have argued that the awareness set, and consequently the search space, may alter as search progresses; hence the learning effect already referred to may be operating.

Two features are central to the search-based view of the modern housing market. The first such feature is the duality of the market, given that both buyers and sellers are searching for one another, with each facing an uncertain environment and hence the need to acquire information about the other side of the market. The second feature is that as owner occupiers, the majority of transacting households are acting simultaneously as buyers and sellers, albeit in different areas or housing market strata.

4.3.3 Owner Occupier Search Processes

It follows that the existing owner-occupier has a series of directly relevant choice variables, namely his reservation price as a buyer, his reservation price as a seller, and the relative timing of the two transactions. To illustrate this latter point, consider Table 4.1.

TABLE 4.1 OWNER OCCUPIER TRANSACTION TIMING STRATEGIES

STRATEGY	COST	BENEFIT
(1)	Storage Psychic Cost Foregone Cheaper Buy	$I(B)\rightarrow\infty$ $Max(\pi(s))$
(2)	Bridging Loan Foregone Higher Sell	$I(S)\rightarrow\infty$ $Min(-\pi(p))$

The two strategies in Table 4.1 represent:

(1) Sell own house, and only attempt purchase when sale complete.

(2) Buy desired house, and only attempt to sell own property when purchase complete.

The expressions I(B) and I(S) refer to the owner-occupier's knowledge of the distribution of buyers and sellers respectively. The financial sector implications of these two strategies are not symmetric, given the posible need for bridging loan finance; it follows that such a choice may not, in practice, exist. Following either strategy will maximise the owner-occupier's knowledge of one of these distributions,: in the absence of perfect knowledge the distributions will be of a subset of all buyers and sellers, and this subset may not be a representative sample. This tendency towards perfect knowledge on the part of the owner-occupier will be offset by the large number of potential buyers who will judge quality not by price (as in the Veblen effect) but by the length of time that a property is on the market. This further constraint will only affect sellers; its counterpart in buyers is the gradual increase in the psychic costs of search and the possibly bounded nature of rationality, which precludes effective decision making over a large number of alternatives. Further to this, the distribution of buyers and sellers will be changing, possibly randomly, through time. It follows that the household can never completely eliminate uncertainty in either of its roles.

Which strategy is to be preferred will depend upon the relative costs of storage, bridging loans, and the likely direction of movement of house prices in the immediate future. If there is chronically strong demand and rising prices, strategy (2) is probably to be preferred to strategy (1), since the probability of maximising expected profit from the sale is higher than the probability of minimising expected loss on purchase. Storage costs will be more or less fixed, but bridging loan costs will be a function of the interest rate and house price. In general, for a given spatial area, as the number of buyers and sellers increases, the rate of acquisition of knowledge about both sides of the market will also rise. It follows that the market actor can pursue the strategy of initiating both sides of the transaction simultaneously when in a generally buoyant market, particularly an urban area; Similarly the relatively constant mobility rates for all household types will mean that a house transaction is easier to accomplish in the lower strata of the housing market, where the overall market size is larger. This will vary, however, according to the supply/demand balance.

The foregoing discussion demonstrates that transaction timing can be reduced to one dimension, namely the cost of the difference between the times of the two halves of the market transaction. Consider the following utility function:

$$U=U(\pi(s),\pi(p),C(td),q) \quad (4.1)$$

where:

where P^{r} is the household's reservation price and the expression is positive or negative depending on whether the household is selling or purchasing. For an existing owner occupier trading up who has already sold his own property, the maximum reservation price that he can bid is given by:

$$P^{r}(p) = [P_{1s} - P_{1s}(1+i)^{n} + tm_{o} + nm_{t}] \qquad (4.4.1)$$

where:

P_{1s} = price received on sale

$P_{1s}(1+i)^{n}$ = mortgage originally transacted

tm_{o} = proportion of mortgage paid off after t periods

nm_{t} = new mortgage amount (ex mortgage interest)

Obviously the household may choose to add savings (a function of income, length of working life completed, and wealth), but wealth stock equilibrium will be assumed here. For the individual who has already purchased his new house, the minimum reservation price that he can set for his old house is given as:

$$P^{r}(s) = [P_{1s}(1+i)^{n} - tm_{o} + C(bl)] \qquad (4.4.2)$$

where C(bl) is the cost of any bridging loan (i.e. $C(bl) = P_{2s}(1+i)^{td}$, where P_{2s} is the price of the new dwelling). It should be clear that not all of the elements in these expressions will vary proportionately for all housing market actors. In particular, n will be shorter as the mortgagee ages, whilst i may vary considerably over the lifetime of a mortgage. The mortgage given will be partly a function of the individual's income and partly of the quality of the house being bid for; its relationship to both of these will depend on the competition for credit generally. Variations in these Building Society rules across the three dimensions of the housing market will be responsible for local fluctuations in market conditions. This will be especially evident in the case of spatial or strata-based differences, which will result in the possibility of local housing market failure or overheating. The household's search and reservation bid price strategy is intended to locate and secure a property which minimises $-\pi(p)$. Apart from choice of advertising medium, the household is passive as a seller and sets the reservation offer price to maximise $\pi(s)$.

It is possible for individual's search fields to overlap even though their migration fields display divergent directions. Vacancies located in the intersection of two or more search fields will experience more intensive search than those elsewhere, such that in any given time period, they will be visited by more searching households and are more likely to be sold. It follows that the information set of sellers located within such intersections will differ from those located elsewhere to the extent that such sellers rely upon the number of searchers as a guide to the magnitude and spatial location of demand. Through a variety of processes, the final transacted price will be higher, for any given vacancy, as the number of search fields that include it increases. These processes are:

(1) Prospective purchasers are made aware of the existence of competition and submit higher offers than would otherwise be the case.

(2) Housing market professionals are aware of the spatial pattern of demand and advise the seller to set a higher offer (i.e. reservation) price.

It should be noted that there is no suggestion that the areas where search fields intersect have any differential worth. They are differently priced only because of the pattern of search fields. For any such effect to persist, it is necessary that the search fields represent the market long run positions, and this will be determined by the relationship between the sources of mobility and search fields. This in turn raises the issue of the mode of determination of search fields and their stability.

4.3.4 The Determination of Search Fields

The search field of any given market actor will be determined by two factors: his preferences and his information set. The two will not be independent if the information set is incomplete. The cost of additional information will be a function of the distance separating origin and potential destination, but this function will not necessarily be monotonically positive, although it should at least approximate such a form. The information set will also be affected by the frequency of transaction of the market actor, hence there will be an asymmetry of information between households contemplating a one-off move and specialist market agents; this is the reason for the use of such specialists in the majority of cases. It follows that when migration fields have stabilised, the search fields will tend to coincide, in aggregate, with them. It is only when there is a necessity for migration fields to alter that search fields will adjust at different speeds for different individuals. The catalyst for change will be that properties on a selling agent's books will attract a higher price than was thought appropriate for a given area, due to the efforts of "pioneer" searchers. The information will gradually filter through to other agents and hence to subsequent market actors. It follows that the processes operating are (1), above, followed by (2) until equilibrium is restored. It is by no means clear that the time taken from the tension emerging in the pattern of migration fields to the full re-adjustment of search fields is short, and it will almost certainly be greater than the time taken for one typical housing market transaction to be completed. Evidence is lacking, but the period may even be longer than the average frequency of the underlying changes; consequently equilibrium may never be achieved. In most of the models reviewed so far, it is assumed that the employment locations are given and fixed, and that search has sufficient time to adjust; in the simulation models discussed in the first chapter, it is assumed that the effect of demand on prices is the same for all houses of a given type and is instantaneously transmitted to all sellers of such houses. In contrast, it is suggested here that in the transition to a new equilibrium it will be necessary for sellers to rely upon the numbers of searching households as a guide to the magnitude of demand, and that the rate at which this process occurs may be sufficiently slow that a mismatch between migration fields and search fields is a general feature of the housing market. Depending upon the speed of adjustment relative to the transaction time, (and the latter will vary with a number of local and global parameters) there is a possibility of false trading given spatial search patterns of the form described by Huff. Ioannides (1975) has analysed the dynamic search process for a dual market, where both buyers and sellers experience uncertainty. He demonstrates that for successful exchange to occur, buyer's and seller's reservation prices must coincide and the market tends towards a stochastic version of exchange equilibrium. This is valid provided no structural change occurs in the spatial configuration of the searching households; any change in this configuration alters the pattern of search costs and hence of effective house prices. A further complication arises if the housing market professionals base their own expectations of price levels on past transacted prices; any price discrepancies will tend to persist. These propositions are based on the fact that housing is peculiar in three ways: it is a spatial good, it is infrequently transacted, and it is problematic to assess its quality. All of these features are responsible for the existence of housing market agents who attempt to neutralise these features; such an attempt will be imperfect to some degree. Quantification of this degree will determine which of the two views of the housing market, stochastically perfect or chronically imperfect, is correct. The implication is that equilibrium may not exist *per se*, but only as a state towards which the market tends. The role of the housing market professional is akin to that of the entrepreneur in the literature of the Austrian school.

It will consequently be necessary to examine in more detail the process of housing price determination and adjustment, both for new and existing houses, and this will be discussed in the next section. Two empirical comments are appropriate at this stage. The first is that it is not possible to determine, from migration fields alone, whether search fields overlap. The second is that whilst most macroeconometric models use house price reduced forms, they contain no explicit mechanism for altering prices; it is assumed that excess demand and supply are immediately apparent and prices are adjusted accordingly. This observation leads to the core proposition of this thesis: the macroeconomic effect on housing market activity of any given macroeconomic stimulus depends on the relative spatial configuration of the stimuli's points of initial impact. In effect, this proposition is always true but its relevance is doubtful for highly aspatial systems. As the spatial element of the system being modelled increases, so does the importance of the proposition.

4.4 HOUSE PRICE DETERMINATION

4.4.1 The Existing House Market

In the UK (including, now, in Scotland) the dominant form of tenure is owner occupation. The primary source of second-hand houses offered for sale is households who are simultaneously attempting to purchase another property, either new or second hand. The price asked or the selling household's reservation price will usually be based upon a surveyor's valuation; the price offered for a property will also bear some relationship to this. Galt(1982) suggests that the price asked by an owner-occupier will be a function of the prices of new houses, the prices of other second hand houses, the price of the house which the household intends to purchase, the valuation given by a housing market professional, and the mortgage outstanding, as well as "other" demand factors. He also points out that the price offered for a given property will reflect the individual's desire for it. It follows that it is in the interest of the seller to let it be known to all prospective purchasers that there are other interested parties. It is also in the interest of the prospective purchasers to know of such interest, so that they can bid accordingly. It follows that the Scottish sealed bid system, where closing dates for offers are set and once accepted are legally binding, is an effective way of appropriating consumer's surplus; this can be contrasted with the English system where "gazumping" is common. It is possible for consumer's surplus to be appropriated in the English system but it will be a more imperfect method of achieving this. The Scottish system resembles a multi-person game, with a payoff matrix as shown in Table 4.2. Given the constraint on the time of the seller's move in the English system, "gazumping" is far from certain whereas in the Scottish system there is only, usually, one chance to bid; hence there is more certainty of each bidder optimizing. In general, the more individuals there are competing, the higher will be the eventual successful bid.

TABLE 4.2 OWNER OCCUPIER BIDDING STRATEGIES

	Household A	
	Bid High	Bid Low
Others Bid High	?	Lose House Incur Extra Search Costs Save Excess Over Bid
Others Bid Low	Win House Lose Extra Bid	?

In the last section, the search effect on prices was analysed, whilst the process described here refers to the households who actually submit formal offers. Provided the information sets of searchers are complete, the sealed bid procedure should ensure an efficient allocation of houses to demanders. It has already been suggested that in the long run, the notional price distribution arising because of the search effect and the actual price distribution should coincide. It is likely that as the number of transactions per unit of area decreases, the divergence between the notional (asking) prices and the actual transacted prices, will increase. Hence the variance of outcomes increases as the density of agents decreases, and the urban areas will be the most efficient markets. The corollary to these propositions is that in equilibrium, the selling agent's valuation (V) and the transacted price (P) should coincide. Galt (1982) has drawn a distinction between $(P - V) > 0$ due to a particular individual's desire for a property and one which reflects a general scarcity premium.

Ignoring structural considerations, a housing market professional will, in valuing a property, look at the transacted prices relative to valuations of comparable properties in the same area. For example: "There are also examples of houses going well over the top, (sic) such as an example in Edinburgh, valued at £33,000, and going for £41,000" RICS News, 8th April 1982

The valuer has to assess whether a transacted price greater than or less than the consensus valuation is due to random fluctuations (i.e. a particular individual's preference), or a general change in the pattern of demand; the foregoing discussion suggests that prediction errors by valuers will be lower in urban areas than elsewhere. The valuer will also have to distinguish between upturns which are spatially specific and broadly-based upturns in demand due to, say, a downturn in the mortgage rate.

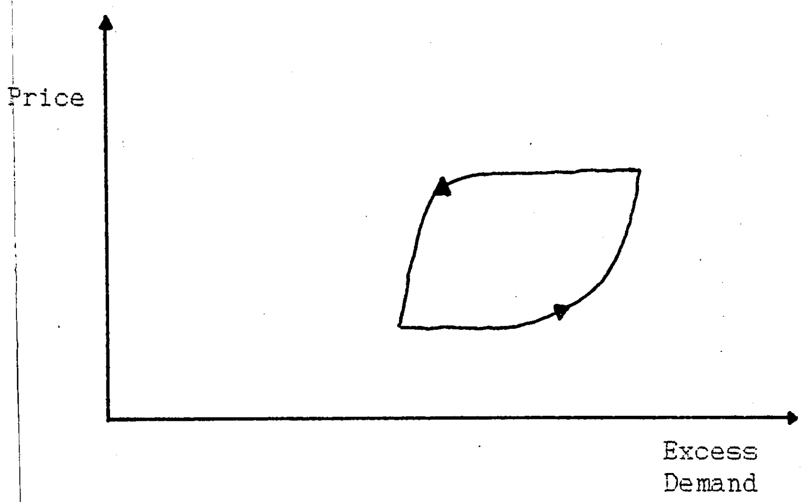
The role of the housing market professional is therefore that of an imperfect Walrasian auctioneer. Valuations are, however, usually based upon the ex post transaction prices of "comparable" properties, rather than on beliefs about future housing market activity based on mortgage rate changes, inflow of funds to Building Societies and other proxy measures which are used to capture expectations in macroeconometric models. It would appear that the mechanism whereby excess demand feeds through to house price changes has two components; the first is successful bids in excess of valuations, the second is a revision of valuations on this basis. Whilst this process is fairly straightforward in the case of excess demand, the corollary is that in a falling market prices will be offered below valuations. It seems that there will be resistance to this by sellers, such that either the house will stay on the market longer than normal, or the households will decide not to move at all in the short term; hence local turnover will be reduced until the supply/demand balance has been restored. There are two reasons for this, the first being that the marginal cost of privacy rises and that of overcrowding falls as the sale price decreases, the second being that households do not face the same constraints operating on firms; it is feasible for them not to sell at all without incurring fixed costs, other than the psychic ones mentioned above. It also implies that in a falling market, the optimum strategy is to sell the existing property first.

Hua (1972) suggests that prices will be set by individual sellers so as to maximise expected return. Any given price influences the expected selling time, so the expected return has to be discounted by the time lag. Cubbin (1974) also finds a positive relationship between price and selling time, although Galt (1982) draws attention to the Veblen role of price as an indicator of quality in a market where such knowledge is costly to obtain. In practice, either the asking price or the selling time may be viewed as a quality indicator; hence for the selling household, there is a fine balance to be achieved between asking a price that is too high and one that is too low.

It follows that the first sign of a spatially or sectorally falling market will be increased selling times, fewer houses on the market, and reduced mobility. The situation when the entire market is falling will be more complex, depending on the differential rates of depreciation in each strata, which may make mobility <u>more</u> attractive to some households.

For falling house prices to reduce mobility generally, it is necessary for the upper strata to depreciate more slowly; it is to be expected that mobility rates will adjust in all strata such as to eliminate such differences.

FIGURE 4.2 HYSTERESIS LOOP PRICE ADJUSTMENT



This implies that the pattern of house price adjustment will follow a hysteresis loop, with the possibility of a discontinuity, as shown in Figure 4.2. This form is first suggested in Blank and Winnick (1953) with vacancies as the excess demand indicator. It is possible, albeit problematic, for it to be statistically estimated. It has already been seen in Chapter Three that price equations contain implicit assumptions about price adjustment processes; the linear or log-linear specifications chosen suggest that the embedded adjustment mechanism is also linear or log-linear. If hysteresis effects do operate, it follows that the standard adjustment mechanisms are inadequate in that they assume that the effects of excess supply and demand on the market are symmetric. As will be seen, however, it is possible for hysteresis-type adjustments to occur within a linear framework

The problems of judging the state of the market when transactions are relatively infrequent has already been stated. There is a further implication that when the absolute level of vacancies is very low, it will take longer for excess demand to become apparent. In the limiting case, the only way in which concrete demand will be manifest is through increased purchases of speculatively built houses, and it will be appropriate to turn to the supply and pricing of new houses.

4.4.2 The Housebuilding Industry

The standard view of the housebuilding industry is that of a perfectly competitive structure, and over the sample period of most macroeconometric models this is an adequate assumption. Ball (1984) has argued that 1973 was a watershed year for the industry with a number of important changes occurring. The general downturn in house prices, which had been built up in a speculative process, resulted in a wave of bankruptcies with a consequent centralization and concentration of the remaining firms. As a result, housing is no longer used as a residual activity engaged in by construction firms when their main markets are slack; another reason for this is: "It is not possible to expand output rapidly in private housebuilding; the most obvious limitation being the acquisition of a land bank" (Ball, p.49)

The tendency is for large construction firms to set up semi-autonomous housebuilding subsidiaries. Ball states: "The whole essence of speculation is to profit by spotting opportunities which have not already been discounted and incorporated by the market into price."

This applies in particular to land. Ball has suggested that net starts (starts minus completions) are the indicator of commitments of new capital, and that the rate of net starts will be determined by the profitability of housebuilding, which will be heavily influenced by the land cost of a particular site. This implies that non-profit constraints, such as land release, do not affect building rates unless they indirectly reduce profitability. The modern housebuilder holds a substantial land bank, which acts as a hedge against land price increases. The fact that demand increases are capitalized into land price increases means that ideal sites may not be profitable, and hence the builder will have to extract profit from apparently sub-optimal sites, through skilful marketing. Builders will also engage in counter-cyclical land dealing to minimise the impact of land prices.

The speculative nature of the industry means that the central problem for housebuilding firms is the management of a portfolio of risky assets. The risk associated with such assets is defined over the three housing market dimensions described previously, such that it can arise from temporal, spatial or stratum fluctuations in demand. The need to maintain flexibility means that the golden rule is to minimise the working capital committed to any given plot of land, and consequently sales rates, not prices, are the key concern. Small downturns in rates can have a significant impact on profitability.

The need for flexibility has been facilitated by the technological advance represented by timber frame construction. The locationally specific nature of housing is such that factory type production runs are impossible, which precludes economies of scale. With prefabricated timber frame housing, internal plumbing and wiring can be installed before the brick walls are constructed, which permits minimisation of idle time for members of any one trade. This is further helped by vertical as opposed to horizontal building; construction follows a quasi-production line process, with trades moving from one house to the next. The result is that in technical terms, a house can built "from slab" in six to eight weeks. This has important implications for macroeconometric models which use distributed lags on starts of up to six quarters to explain building rates.

Most of the industries which supply housebuilders are highly monopolised with the result that cost increases are passed on. In an attempt to circumvent this, builders will clear extensive areas and lay the slabs well in advance of production, which has the advantage of reducing response time to demand upturns, by letting the labour force (generally employed via labour-only sub-contracting) know that more work is available for future contracts, which minimises re-hiring costs. These practices further undermine an aggregate starts-completions relationship.

At the margin therefore, housebuilders can respond very rapidly to increases in demand and it is the firm's speed of response rather than its pricing strategy which determines its overall profitability. Rapid response reduces the costs incurred (general building costs and interest costs on borrowings tied up in land and buildings) and also reduces opportunity costs arising when particular house types or spatial sectors show strong demand. It follows that pricing will not necessarily follow the perfectly competitive model.

4.4.3 The Price of New Houses

Most empirical work on industrial pricing has suggested that firms use some variant of the average cost pricing rule detailed in Hall and Hitch (1939), although Smyth (1967) suggests that some firms accept the market determined price and use their desired profit margin to set a target unit cost; this will tend to prevail in near-perfectly competitive markets. In the former case, the only way in which prices can respond to increased demand is if derived demand in the input goods industries creates bottlenecks and hence pushes up costs. This requires input producers to follow a different pricing strategy, relying on order book length as an indicator of excess demand. This description is valid for the housebuilding industry where input producers are monopolists or members of an oligarchy, whilst housebuilders have a more competitive structure. Hay and Morris (1979) have suggested that pricing behaviour by producers can be classified according to a continuum from purely supply-based to purely-demand based. They argue that supply-based pricing will predominate for new products, with demand-based pricing for subsequent price changes. For the housebuilder, locational specificity means that each site is a new product.

Macroeconometric housing models effectively assume demand-based price setting; if prices were set on a cost-plus margin basis, then the model of Whitehead (1974), which has new house prices and building costs entered as separate regressors, will show near-perfect multicollinearity, whilst those of Mayes (1979) and Hadjimatheou (1976), which use the ratio between the two, would find little variation in the series. In practice there is some variation, so that a purely cost-based pricing strategy is unlikely.

The literature on industrial pricing is extensive. Econometric work (e.g. Eckstein and Fromm (1968), Brownlie (1965), McFetridge (1973), and Ripley and Segal (1973)) has attempted to distinguish between supply and demand based determinants. The indicators of demand include the ratio of unfilled orders to average sales volume, the ratio of inventory to sales, an inventory change dummy and the degree of capacity utilisation. In one ingenious model, McCallum (1970) uses present and future period labour market excess demand on the reasoning that this will lag behind product market excess demand; hence the current value proxies cost increases whilst the future value proxies demand increases. These models have achieved mixed results with the main conclusion being that demand influences are difficult to identify. The reason for this is that a variety of non-price responses are possible in the short run, primarily in the form of changes in the length of order books and changes in inventories. These act as buffers against demand fluctuations and so reduce costs. Price changes may also be disguised by product changes or marketing techniques, such as discounts.

It follows that the pricing and marketing strategy will vary for different markets and products, and in the housing market three features are critical: The spatial dimension creates extreme product heterogeneity (supply based pricing), the level of demand is highly uncertain in all three housing market dimensions, and the cost of holding inventories is prohibitively high. These latter two factors will tend to militate against aggressive supply based pricing. There is, further, the large existing stock whose price is outwith the control of firms.

This combination of factors implies that the optimum pricing strategy is one which aims for a fixed minimum price-cost margin, with the response to excess demand or supply being variation in the package marketed (i.e. manipulation of costs); the firm has to choose between longer delivery times or higher prices, each of which has attendant risks of alienating potential customers. Ball (1984) has suggested that housebuilding firms will shift the emphasis of their production depending on the state of the market, moving into higher market strata in booms and lower in slumps, with consequent effects on pricing. In booms, the higher market strata will offer higher margins, partly because the apparent quality of the dwelling can be altered at little additional cost. Ball states: "What is important are features that create an image for a dwelling and so fix the subsector in which it will sell. There need be no relation between the production costs of these image features and the additional prices at which the houses are sold. Some, in fact, cost less than the lower market alternative." (Ball, p.141)

Ball also suggests that marketability is little influenced by plot size (within obvious limits). Therefore the goal of profit maximisation is served by maximising sales per time period and dwellings per unit of land. Higher prices in upmarket sectors are therefore part of the marketing package. To an extent, the institutionalised relationship between major builders and Building Societies allows the builder to ease the impact of prices on the consumer by varying credit terms. Pricing will be constrained by the need to ride out demand downturns; in such circumstances, explicit price cuts are unlikely and will instead be represented by inducements, such as furniture, at a negligible cost to the builder. This strategy minimises the "regret" felt by previous customers, particularly those on the same site. The more common technique is that suggested by Marris (1978), where low prices are used as a means of inducing "pioneers" into the new product market (i.e. the new housing development). Subsequent movers-in may be charged higher prices once the new development has been accepted.

4.4.4 Interactions Between The New And Existing Markets

The foregoing discussion suggests that the prices of new houses may be an inadequate guide to short term market pressure. The existence of a large stock of secondhand housing will act as a regulator on new house prices. This does, however, have to be reconciled with Ball's evidence that since 1973, new house prices have led those of existing properties. Buckley and Ermisch (1983) argue that new supply will occur provided the prices of existing dwellings are above building costs. This view has two corollaries: firstly that the prices of the existing stock leads new house prices, and secondly that a fall in the average level of existing house prices below the new building cost level will result in new supply falling to zero. Clearly these writer's views are diametrically opposed, although each draws on sound evidence. In practice the question of which series leads and which lags probably varies across the space and market strata, depending on the similarity of the new and existing house types in each. It is possible to argue that the relative increase in concentration in the housebuilding industry after 1973 implies the coexistence of two different types of price setting. The numerous small builders, with output of about ten dwellings per annum, will have to be aware of the overall market state when pricing their product,and market prices are outwith their control. The few large builders will have a view to long term profit maximisation and pricing will be only one element of their marketing strategy. Indeed, Ball has argued that the factors which influence housing market activity in general need not lead to house price changes at all; whether they do or not will depend on their impact on housing market interlinkages. Ball also points to the flow of funds into and out of the system; for example, a given injection of funds into the system may facilitate a large number of transactions but will only affect prices if funds leak elsewhere, as in the case of a purchase of a new property. Not all of the funds leaving the system will necessarily re-enter. Also, if a household is trading down to a lower market stratum, the re-injection of funds will not necessarily be as large as the withdrawal.

4.5 CONCLUSIONS

In Chapter Two, the analysis of the vacancy model showed that it effectively inverts the market process, such that the creation of vacancies drives the market. What has been shown in this chapter is that depending on market conditions, it can be optimal for households to only buy when they have sold their existing dwelling, or vice versa and consequently the key determinant of housing market activity may be the number of first time buyers willing and able to initiate chains of moves, or the number of new properties made available for sale by housebuilders. The following table summarises these propositions:

TABLE 4.3 MARKET DETERMINANTS

	MARKET TYPE	STRATEGY	KEY DETERMINANT
Seller in i	Pi > Pj	(1)	new houses in j
moving to j	Pi < Pj	(2)	new households in i

This demonstrates the inadequacy of the vacancy model in a market environment.

The next chapter formalises the notions of spatial market segregation, temporal lags, and volume based (as opposed to price based) behaviour into a regional model.

CHAPTER FIVE

A REGIONAL MODEL (II): THE FORMAL STRUCTURE

5.1 INTRODUCTION

The previous chapters have reviewed the existing literature on housing market models, which have been seen to differ in aggregation level, methodology and underlying assumptions. It has also been shown that space is important to housing markets because of gross price (transport cost) and search effects. As the NBER-HUDS model has demonstrated, there does not appear to be an easy solution to capturing the complexity of urban market phenomena; that model represents the state-of-the-art in modelling a metropolitan area. By contrast, the Buckley and Ermisch model is the state-of-the-art for macroeconometric housing models. In constructing a regional model, the form used will borrow from each of these approaches, but this leaves the question of the point of departure: "top-down" or "bottom-up". On the premise that simplicity is always to be preferred to complexity, the macro approach will be taken as the benchmark.

5.2 FUNCTIONAL FORM OF THE MODEL

The general form to be used is:

$$Q_{dt} = f_d (P_t , Z_{1t}) \qquad (5.1)$$

$$Q_{st} = f_s (P_t , Z_{2t}) \qquad (5.2)$$

$$\Delta P_{t+1} = f_x (Q_{dt} , Q_{st}) \qquad (5.3)$$

An alternative form is to write (5.1) and (5.2) as:

$$Q_{dt} = f_d (P_t , Z_{1t} , Q_{st}) \tag{5.1.1}$$

$$Q_{st} = f_s (P_t , Z_{2t} , Q_{dt}) \tag{5.2.1}$$

This reflects the possibility of quantity rationing not reflected in price; this latter form only really becomes relevant upon further disaggregation.

As demonstrated in Chapter Three, a macro model might estimate (5.1) and (5.2) with a technical link between the two. For the model used here, this technical link is eschewed on the grounds that, as argued in the last chapter, the modern building industry suffers from few such technical lags. Some macro models estimate a version of (5.3), which removes the need for structural estimation. Although general functional forms are given here, the usual specification is linear or log-linear, and obviously other forms such as semi-log are possible. In order to fix ideas, the model will be analysed in linear form, although the results hold for log-linear equations. To yield the regional model, the three structural market equations are re-written in matrix form:

$$Q_{dt} = -AP_t + Z_{1t}M_1 \tag{5.4}$$

$$Q_{st} = BP_t + Z_{2t}M_2 \tag{5.5}$$

$$\Delta P_{t+1} = -\Gamma [Q_{st} - Q_{dt}] \tag{5.6}$$

where Qdt and Qst are n*1 vectors of quantities demanded and supplied, respectively, at the prevailing n*1 price vector, P_t. A and B are n*n matrices of slope coefficients (elasticities in the log-linear model). Z_{1t} and Z_{2t} are n*k vectors of exogenous variables and Γ is an n*n matrix of market adjustment speeds. M_1 and M_2 are k*1 vectors of exogenous variable coefficients

5.2.1 The A Matrix

The matrix A captures the way in which demand substitution occurs in response to price changes; hence if utility functions are well-behaved and housing is a normal good, it will follow that:

$$a_{ii} \geqslant 0$$

$$a_{ij} \leqslant 0 \quad \forall \quad i \neq j$$

It should be noted that unlike a linear expenditure system, where Slutsky symmetry is imposed, it will generally be the case that:

$$a_{ij} \neq a_{ji}$$

This means that if the product categories {1...n} can be used as the basic units of analysis, then the effect of an increase in the price of product i on demand for j is not necessarily the same as the effect of an increase in the price of product j on the demand for i. This might occur if, for example, there exist a number of substitutes for j of which only one is i, whilst j is the only substitute for i.

This inequality only holds when the goods in question are consumed in discrete quantities and consumption of one category implies non-consumption of the other, as is the case with housing markets. In particular, it holds when the products are distinguished by their spatial location and the a_{ij} coefficients reflect, in part, distances. These n elements represent spatial areas and the a_{ij} reflect not only distance but also similarity (and hence substitutability) of house types. In the absence of a Walrasian auctioneer, numbers demanding must be interpreted as the number of households searching.

5.2.2 The B Matrix

The b_{ii} and b_{ij} elements capture the substitution in production of houses in different areas in response to price changes throughout the system. Whilst this applies primarily to housebuilders, it also includes existing owner-occupiers who may be prompted to move because local house prices provide a profitable opportunity to "trade up" to a preferred house type. This latter process will imply links between areas which offer such similar products. For housebuilders, spatial substitutability will depend on the amount of land currently available and on local authority policies on planning permission, as well as on housebuilders' own views of market structure.

It follows that these coefficients will take the form:

$$b_{ii} \geqslant 0$$

$$b_{ij} \leqslant 0$$

This latter, the cross-elasticity in a loglinear formulation, is ambiguous as to sign since rising prices in one area may signal potential demand in similar areas elsewhere. For this study it will be assumed that builders do not attempt to second guess the market in this way. It is arguable, in the light of the discussion in the last chapter, that builders will show little supply response to price; hence these coefficients primarily capture the behaviour of existing owner-occupiers who can only supply one area at a time.

5.2.3 The Γ Matrix

This matrix is of crucial importance to the operation of the regional housing system. It reflects the way in which prices respond to market conditions, and in particular the behaviour of housing market professionals acting as Walrasian auctioneers. It assumes that the housing market professional can correctly assess the degree of excess demand and supply mismatch prevailing in his own area or product line, and adjusts price recommendations and valuations as appropriate. If Γ is indeed diagonal, this is equivalent to suggesting that each area or product group has its own speed of adjustment independent of other areas. This will be invalid if any valuers look at other areas as a basis for valuing their own, and to some extent this must occur if price changes are to be diffused throughout a region; effectively it is a sufficient but not a necessary condition for such diffusion. In the Artis et al (1975) model discussed in Chapter Three it was assumed that there is one γ parameter for the entire national housing market. Given the absence of one co-ordinator, this is a restrictive assumption especially when applied to such a large spatial area containing a variety of house types. As the spatial area reduces, or the homogeneity of house types increases, the suitability of a single γ parameter is increased.

5.3 MARKET DYNAMICS

The equation system (5.4) - (5.6) can be solved by writing:

$$\Delta P_{t+1} = -\Gamma[\ BP_t + Z_{2t}M_2 + AP_t - Z_{1t}M_1\ ]$$

$$\Rightarrow \quad P_{t+1} = -\Gamma[\ (B+A)P_t + Z_{2t}M_2 - Z_{1t}M_1\ ] + IP_t \tag{5.7}$$

In equilibrium:

$$(B+A)^{-1}\ [Z_{1t}M_1 - Z_{2t}M_2] = \bar{P} \tag{5.8}$$

which exists non-trivially iff $(B+A)^{-1}$ exists.[1]
(5.7) is a system of simultaneous difference equations with solution :

$$P_t = \bar{P} + [\ I - \Gamma(B+A)\ ]^t\ [\ P_o - \bar{P}] \tag{5.9}$$

To simplify matters consider the polar case where B = [0] and there is a single γ parameter. The elements of the A matrix represent the deterrent effect of price changes on the two components of demand, new households and relocating households.

It will be seen that for stability it is necessary that:

$$|a_{jj}| > \Sigma i \neq j \; |a_{ij}| \text{ for all } j \qquad (5.10)$$

That is, if the price of i rises, at least some households are dissuaded from demanding at all, and only a subset spatially substitute their demand. This in turn implies that no perfect substitutes for j exist. Consequently the dissuaded households decide not to change their residence, and either do not form a new household or else do not move from their existing owner-occupied house.

This model has a direct analogue with that of Alonso (1981). In the Alonso theory of movements, the actual number of in-movers to any area compared with the potential number is given by:

$$\frac{C_j^{\beta j}}{C_j} \qquad (5.11)$$

$$\Rightarrow \quad \frac{\Delta \text{ actual in-movers}}{\Delta \text{ potential in-movers}} = \beta j$$

where βj is the elasticity of inmovers to j with respect to congestion at j. A similar notion in the model presented here is given by:

$$\beta j = \frac{\Delta Q_{dj}}{\Delta P_j} \; \frac{\Delta P_j}{\Delta (Q_{dj} - Q_{sj})} = \frac{a_{jj}}{(a_{jj} - b_{jj})} \qquad (5.12)$$

Hence Alonso's model subsumes the market process in the single parameter, βj.

The model presented here has some important implications for the Blank and Winnick (1957) model, the Artis et al (1975) model, and for macroeconometric models in general. The implications for macroeconometric models are central to this thesis, but the other two considerations are closely related. As already discussed, Blank and Winnick (1957) suggested that housing market adjustment follows a hysteresis loop. The reasoning is that rents only adjust to excess demand or supply with a lag, after a corresponding fall or rise in the vacancy rate.

In a simple one product, one region model, the market difference equation solution is given as:

$$P_t = [\ 1 - \gamma(b+a)\ ]^t\ [P_0 - \bar{P}] + \bar{P} \qquad (5.13)$$

In order for a difference equation with this solution to yield the pattern in price/excess demand space shown in Figure 5.1, it is both a necessary and sufficient condition that:[2]

$$\gamma = \frac{2}{b+a} \qquad (5.14)$$

The pattern is not a hysteresis loop with the sharp points of Blank and Winnick, but will tend to be circular.

The skewed appearance would result if price adjustments were only carried out infrequently (e.g. estate agent valuations) such that γ alternates in value between γ and 0. A number of other well known cases are possible and are set out in Figure 5.2

FIGURE 5.1 CYCLICAL MARKET ADJUSTMENT

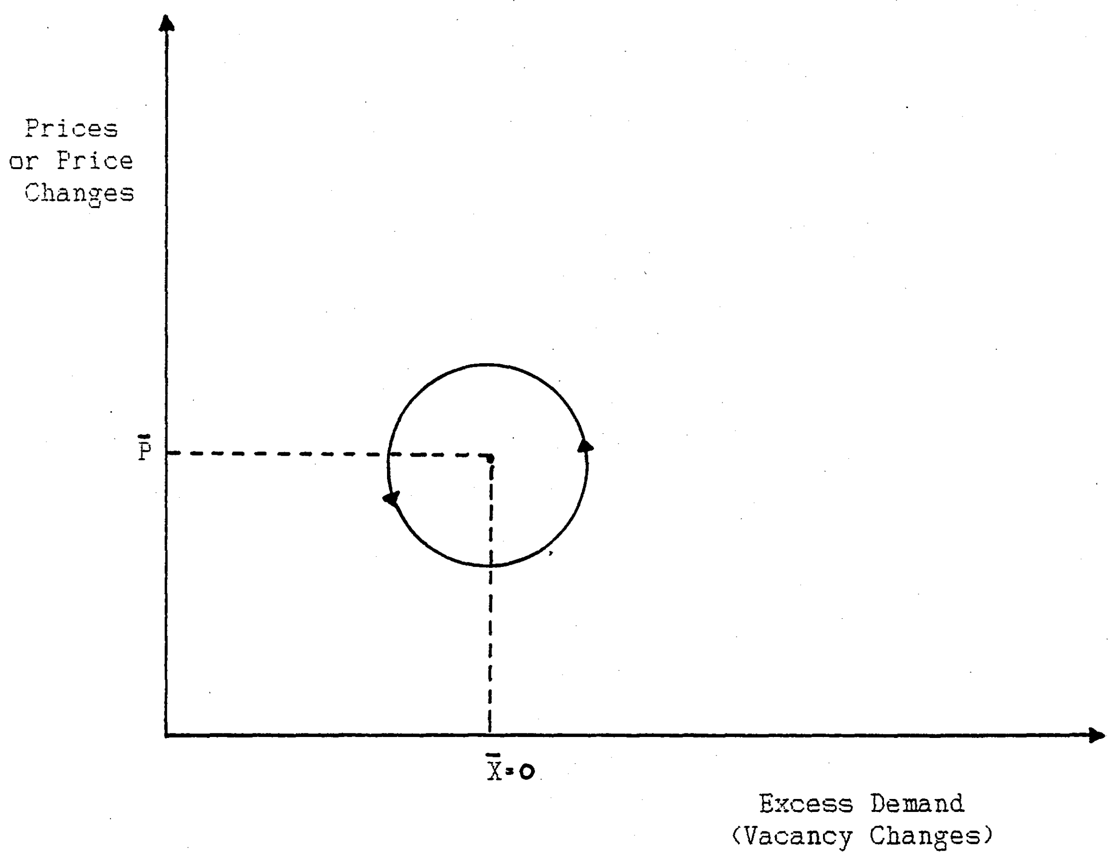
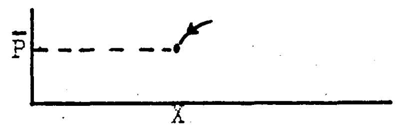
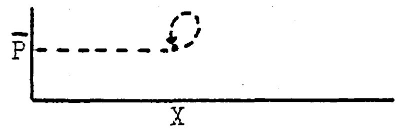
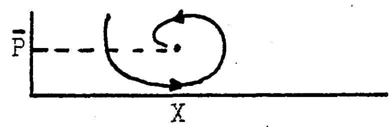
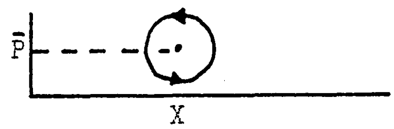
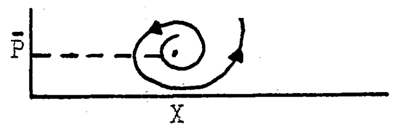


FIGURE 5.2 DYNAMIC PRICE BEHAVIOUR

γ value	Price Time Path	Price/Excess Demand Pattern
$0 < \gamma < \frac{1}{b+a}$	Nonoscillatory Convergent Sluggish	
$\gamma = \frac{1}{b+a}$	Remaining in equilibrium	
$\frac{1}{b+a} < \gamma < \frac{2}{b+a}$	Oscillatory Convergent Tatonnement	
$\gamma = \frac{2}{b+a}$	Uniform Oscillation Non-convergent	
$\gamma > \frac{2}{b+a}$	Oscillatory Explosive Price overreacts	

Source: Chiang (1974)

The Blank and Winnick model is thus one of a family which can be classified according to the value of γ relative to a and b. It is curious that of the three parameters which together describe the nature of the housing market, the greatest research effort has been devoted to evaluating a, with less attention focused on b, and only two models (Fair and Jafee (1972) and Artis et al (1975)) attempting to measure γ. These two models contain an error in construction; both correctly take the upper value of γ to be infinity, and both calculate the speed of adjustment by calculating the parameter $-1/\gamma$, arguing that as it tends towards zero, γ tends towards infinity and hence prices adjust faster. Both models extrapolate from here, however, to suggest that a value of $1/\gamma$ not significantly different from zero (i.e. a value of γ tending to infinity) implies that equilibrium is attained within the time period. The correct test of this hypothesis requires $1/(b+a) = \gamma$. Values of γ which are greater than or equal to $2/(b+a)$ imply some degree of instability and oscillation; as γ increases relative to $2/(b+a)$, the implication is that equilibrium is not attained, due to explosive oscillation. This problem arises because it is the value of γ relative to $1/b+a$ which is important, not the absolute value of γ. It follows that even if the Artis et al results are correct, their interpretation (that the UK housing market adjusts to clear the market within one quarter) is not.

The two models mentioned above assume a uniform γ, but if speeds of adjustment vary across markets, then stability conditions become more complex. It is necessary for the matrix $[\ I - \Gamma(B+A)\ ]^t$ to tend towards zero as t tends towards infinity; if the eigenvalues of this matrix lie within the unit circle then the system will be stable. This will in general be the case if the matrix $\Gamma(B+A)$ has a dominant diagonal, such that:

$$|d_{jj}| > \Sigma_{i \neq j} |d_{ij}| \quad \text{for all } j$$

where d_{ij} is an element of the matrix $\Gamma(B+A)$. In this case, $\Gamma(B+A)$ is a form of Metzler matrix (Takayama (1985, p.366, note 3)).

It can also be shown that macroeconometric models in general place important restrictions on the multi-product or multi-region model described here. To illustrate this, consider the n*1 vector ΔZ as representative of the distribution of some source of additive exogenous change. Let i be an n*1 vector of units. It follows that the total exogenous change in the system is $i^T \Delta Z$. The average house price prevailing after the exogenous change (assuming homogenous structures) is $i^T P/n$. A macroeconometric model is spatially invariant iff $i^T P/n$ is the same for all ΔZ conditional upon $i^T \Delta Z$ being unchanged.

As a specific example, consider the employment vector:

$$z_i = E\theta(I - G)^{-1} f \qquad (5.15)$$

where f is a vector of final demand changes, θ is labour intensity, G is a matrix of input-output coefficients, and E is the matrix of relative proportions of persons employed in each area. In the absence of formal housing submarket linkages it is still possible for apparent links to exist due to a high correlation of G and E.

As will be seen, the property of spatial invariance with respect to exogenous change places a number of restrictions on the (B+A) matrix. These restrictions are one of the following:[3]

1) (B+A) is diagonal and $\theta_{ii} = \theta_{jj}$ for all i,j, where

$$\theta_{ii} = \frac{1}{b_{ii}+a_{ii}}$$

2) (B+A) is such that all of the following are simultaneously true:

i) $\theta_{ii} = \theta_{jj}$;

ii) $\theta_{ij} = \theta_{ji} = \theta_{i+k\,j+l}$ conditional on $i+k \neq j+l$, $i \neq j$ for all k,l;

iii) $\theta_{ij} \neq \theta_{ii}$;

iv) $\theta_{ii}, \theta_{ij} > 0$

3) (B+A) is a block diagonal form of 2), above.

In these latter cases, each diagonal element or block is a submarket and is linked to all other submarkets by identical parameters. Each of these conditions ensures that the average price will be spatially invariant with respect to any given exogenous change. In the case of 1) and 2) it also ensures that the equilibrium price vector, if it exists, will be spatially invariant. If it is not possible to choose n so as to diagonalise or block diagonalise the matrix, then there are no independent submarkets and the off-diagonal elements represent submarket linkages.

5.4 TRANSLATION TO PRACTICE: THE 'W' MATRIX

The submarket linkages represented by the off-diagonal elements of (B+A) may arise for a number of reasons such as:

1) Proximity of i and j

2) Similarity between i and j in terms of house type

3) Similarity between i and j in terms of employment structure

4) Some other form of socio-economic similarity between i and j

5) Some combination of 1)-4).

Provided the nature of the linkages is known, or can be hypothesised, then under some restrictive assumptions it is possible to represent (B+A) by a matrix of weights, W, which is determined by the spatial structure of the system. In the weights matrix representation, it is assumed that:

$$a_{ij} = \alpha w_{ij} \quad \text{for all } i \neq j, \quad \Sigma_i \; w_{ij} = 1 \qquad (5.16.1)$$

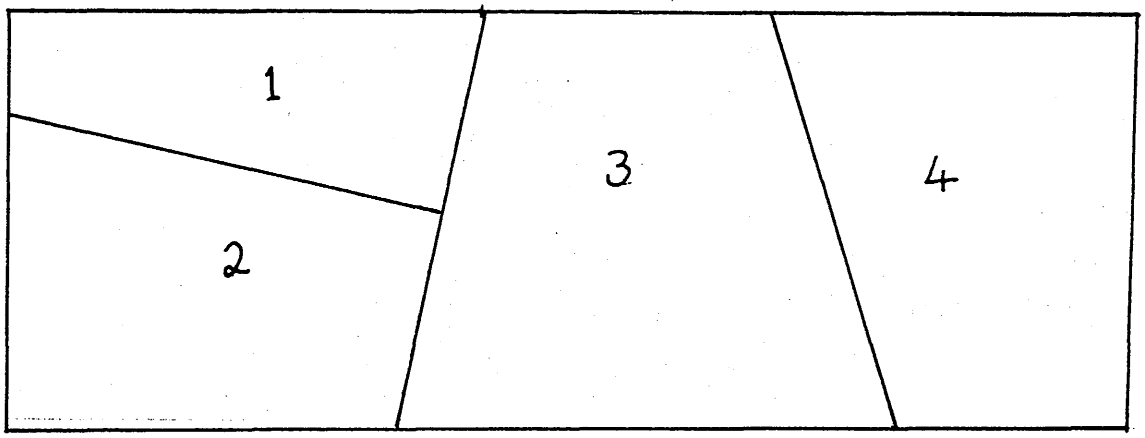
If housing is homogeneous, w_{ij} represents friction of distance between discrete spatial areas, whilst α represents the slope coefficient on prices or the price elasticity of demand, depending on whether a linear or log-linear formulation is used. It is possible for the weights to be highly flexible in construction; they can for example correct for heterogeneity between spatial units using the gravity formulation reviewed in Chapter Two. A key problem in applying a weights matrix simplification is not the social heterogeneity of spatial units per se, but rather their topological heterogeneity. This is not a problem when using temporal data, which relate to regular intervals and hence different orders of lag are comparable. When considering a spatial system it is not always feasible to distinguish between two orders of spatial lag; Figure 5.3 gives an example.

Here it is not clear whether areas 1 and 3 are first order or second order lagged; they are, effectively, both. The solution to this problem proposed by Blommestein (1985) is to represent higher order lags by powering the W matrix and setting its diagonals to zero. Hence the a_{ij} coefficients would be related as:

$$\left.\begin{aligned} a_{ij} &= \alpha w_{ij} \\ a_{ij-1} &= \alpha \Sigma_j \; w_{ij} \; w_{ji} \end{aligned}\right\} \qquad (5.16.2)$$

Provided that the initial W matrix represents first order contiguities, this approach yields the appropriate higher order weights. It does, however, incorporate two crucial and related assumptions about the spatial process which is operating. The first assumption is that as distance increases, any effect diminishes so that the closest areas are the most important. The second assumption is that the spatial process is continuous, acting across the plane without any discontinuity. This means that areas which are first and second order lagged have their

FIGURE 5.3 IRREGULAR SPATIAL UNITS



Source: Bennett (1979)

effects double counted to some extent. This is inappropriate if some effects at higher orders of lags are direct or nonexistent, rather than gradually declining. This is particularly a problem if contiguous districts display extreme heterogeneity since such districts are unlikely to interact, but appropriately specified weights should correct for such heterogeneity. In practical applications, the effect of differing weights is often outweighed by the simple presence or absence of contiguity. This is, however, an econometric point and will be discussed later. It is possible to use the W matrix to test a number of hypotheses simply by varying its structure and this is a separate class of hypotheses to those which take the spatial structure as given and assess the significance of different members of the regressor set. In practice, these hypothesis tests are not independent. A distinction will be made here between general and specific spatial hypotheses; one applying to spatial structure, the other to particular regressors. The latter will be discussed in detail in the next chapter, whilst attention here will focus on general effects, and three areas are of interest:

1) The magnitude of spatial effects (the order of the spatial process)

2) The extent to which housing is homogeneous, and the degree of congruence between such homogeneity and the homogeneity of spatial areas

3) The division of the housing market into independent or quasi-independent spatial submarkets, and the relationship between this and the heterogeneity problem.

5.4.1 The Magnitude of Spatial Effects

In the last chapter, it was suggested that four types of searchers operate in the housing market: active (newly formed households), passive (housebuilders or absentee owners), and those who are both (existing owner occupiers who wish to move). It is the spatial search fields of these market actors which will determine the magnitude of spatial effects. Housebuilders are most likely to take a national perspective, although there will be a major difference between local and national companies. Despite the existence of such a perspective, many builders will face land zoning or land bank constraints on their cross price elasticity of supply. In the short run, therefore, B is likely to be diagonal or block diagonal depending on the units chosen.

New households and existing owner occupiers will demonstrate considerable variety in their search field sizes depending on the reasons for their move; thus for an existing owner occupier who is changing jobs to a new location active search will occur around the new location and passive search at the old, providing a form of spatial interaction between the two locations. In order to classify the different scales of spatial activity depending on each market actor and their motives, the taxonomy in Table 5.1 is proposed.

It follows from this that each market actor will have a different scale of operation between and within areas depending on the opportunity cost of search, which in turn implies a separate A matrix for each set of market actors based on variation in both of the constituent elements of

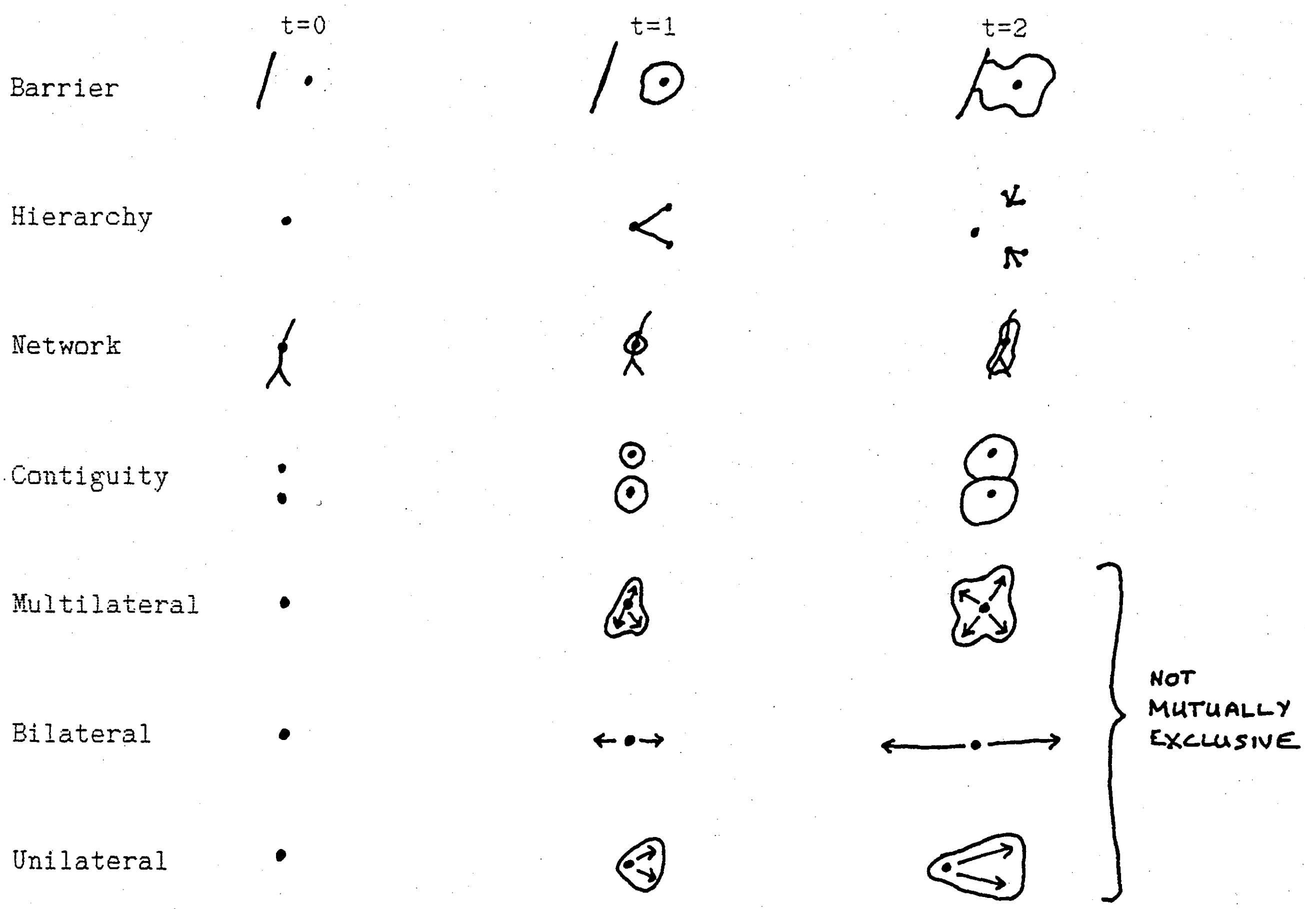
TABLE 5.1 SPATIAL BEHAVIOUR OF MARKET ACTORS

	Determinants of Spatial Behaviour	Form of Spatial Interaction
New Households	Proximity to existing employment Low price	Contiguous - within travel-to-work area
Local Movers (Housing Related)	Proximity to existing employment Suitable for trading up	Contiguous - within travel-to-work area
Non-local Movers (Employment Related)	Proximity to new employment Similar house ?	Similar SEG profile
Housebuilders	Land availability Size of firm Intended market	Depends on market and size of firm

the right hand side of (5.16.1). At any given destination, the density of housing will, ceteris paribus, determine opportunities for substitution. Separation between job locations will vary depending on the occupation of the householder, assuming that the move does not coincide with a radical change in occupational status. In general, the higher up the occupational scale, the higher the spatial scale of job related moves. This is severely affected by the status of particular labour markets and by the macroeconomic environment prevailing.

Figure 5.4 (from Bennett(1979)) shows the variety of spatial processes which can exist. Spatial processes may be time-like or space-like; the more unidirectional the process, the more time-like (hierarchy, unilateral) whilst space-like follow contiguity or multidirectional patterns. Between these polar cases are barrier processes and network or bilateral processes. It seems likely that all of these processes are operating in the housing market simultaneously which is one of the main reasons for its formidable complexity, as evidenced by the variety of approaches adopted in the models reviewed in the first three chapters. Rosenthal (1984b) investigates the hypothesis that the behaviour of house prices in Great Britain follows a unilateral process with London and the South East as the only source generating dissemination of price behaviour as a wave throughout the British planning regions. He uses time series data on prices and employs spectral analysis to assess the gain, phase, and coherence properties of the time series for each region. The results do not support a unilateral process on such a macro scale. From the point of view of this thesis, the important result is that Scotland appears to be distinct from the rest of Britain in terms

FIGURE 5.4 SPATIAL PROCESSES



• represent sources of spatial effects.

Source: Bennett (1979)

of phase and coherence[4], suggesting that Scotland's housing market is largely independent of the rest of Britain. Some of the reasons for this will be discussed in the next chapter. The Rosenthal study does not offer any explanation for why a unilateral contiguity process is expected rather than any other. In the light of the discussion of valuation practices in the last chapter, it might be supposed that the South East being the area of highest per capita income acts as a house price leader and provides a benchmark for other surveyors and valuers. This in turn implies that information dissemination is also a unilateral process. It is possible that a wave can be set up by very high demand for housing in the London area; this would be associated with the financial community, raising prices to the point where those earning incomes which are low by London standards but high relative to other parts of the country substitute commuting time for housing costs, thus bidding up prices elsewhere. Such a scenario links housing markets in Britain indirectly with those of other countries through a hierarchy process. It seems likely that hierarchy processes will particularly be associated with employment based housing market activity, especially to the extent that the economic influences on the spatial location of companies are strong. This is the counterpart to the employment change matrices described earlier in the chapter.

It is possible that the South East represents a "growth pole" which sets up a diffusing wave of economic activity with the housing market responding passively to changes in employment and real incomes. It will tend to be the case that large spatial units cannot distinguish between hierarchy and unilateral processes or indeed between any of the processes shown in Figure 5.4

In the last chapter, it was suggested that workplace dominance will link most housing market activity to employment nodes; hence any stimulus to the economy will generate housing market activity as a hierarchy spatial process albeit with an additional random component. It follows that different local economic stimuli will be occurring simultaneously depending on the form of macroeconomic stimulus applied. Search activity associated with relocation will provide links between affected nodes and transport costs will mean that location decisions are constrained by transport networks. In general therefore, the diffusion of housing market activity will approximate a hierarchy process at the regional level, and an imperfect network process at the local level. Barrier processes will operate on coastlines and against rivers and mountains, to the extent that these topographical features also hinder transport network development.

All of these processes can be approximated by a contiguity process, particularly if lags of greater than first order are used. The approximation will be more valid the greater the size of spatial units used relative to the spatial scale of the hierarchy and network processes, and the more that the boundaries of spatial units correspond to economic units or to physical barriers. The contiguity process is particularly amenable to the weights matrix formulation, which will be used extensively in the empirical section of this study.

5.4.2 Housing Homogeneity

In Chapter One, it was seen that the homogeneity or heterogeneity of housing could be addressed according to the existence of single "units of housing service" or multiple characteristics. The characteristics approach can be represented by an n*k binary matrix C of house types by characteristics. A specific house consists of varying proportions of each characteristic. The hedonic price approach assumes that there exists a vector of characteristic prices, v, which yields house prices through multiplication by the appropriate quantities of each characteristic. Such an approach assumes that a single v exists due to arbitrage across house types. This requires the existence of suitable opportunities for trading up to occur, but as has been demonstrated in the last chapter, the structure of households compared with the structure of available housing may obstruct the necessary arbitrage. Maclennan (1985) uses factor analysis to split the housing stock into internally homogeneous product groups, and examines variation in characteristic prices within product groups when there exists more than one spatial location for such a product group. Clustering to create internally homogeneous areas is inevitable, given peer group effects and historical evolution. This will in addition be responsible for the segmentation of particular annuli into smaller areas as the pattern of urban development and economic activity changes through time. At the highly local scale, builders will prefer to have identical house types within one development, in part to capture economies of scale discussed in Chapter Four. The congruence between homogeneous house types and the market homogeneity of spatial areas rests upon the force of arbitrage to smooth the apparent discontinuities which exist between the prices of different house types and create, instead, a unified market.

5.4.3 Spatial Submarkets

5.4.3.1 Horizontal Classification

Heterogeneity and vertically fragmented markets imply that there exist a number of strata which are independent unless interaction occurs in the form of a household move from one strata to another. Hence there is a low degree of inter-house type interaction, but a high degrree of spatial interaction. The validity of this classification can be investigated by comparing the explanatory power of employment related variables with that of housing related.

5.4.3.2 Vertical Classification

Employment centres are surrounded by various house types which together provide a network capable of supporting a housing "career". Hence there is a high degree of inter-house type interaction, and a low degree of spatial interaction. The validity of this classification can be tested by examining the significance of spatial lags, provided that the spatial units used are sufficiently large.

In practice the relevant split in importance between inter-house type effects and spatial interaction will depend on the zonal boundaries chosen; this effect is analogous to the process of attempting to diagonalise the (B+A) matrix. To illustrate this, consider an arbitrary number of spatial areas, n1, with arbitrarily chosen boundaries. Let the specific set chosen be designated S1={s1...sn1}. The problem of diagonalising the (B+A) matrix consists of finding a set S*, such that each and every element of S* is an independent submarket. In practice the choice of sets is constrained by the data available; for example, census enumeration areas which can be built up into fewer, larger spatial units. Maclennan's approach employs the weak assumption that for any given product group, the minimum spatial market size is greater than the census enumeration area size. Consider the case where each spatial unit corresponds with an internally homogeneous product group. The number of submarkets will be greater than, less than, or equal to this number, and each relation yields a particular form for the W matrix. Let S be the set of submarkets with elements representing spatial areas and let P be the set of product groups with elements representing spatial areas. The three cases are as follows:

1) S > P ; limiting case : $W \equiv [0] \Rightarrow$ No interaction.

2) S < P ; limiting case : $W \equiv \begin{bmatrix} 0 & 1 & \cdots & 1 \\ 1 & 0 & 1 \cdots & 1 \\ \vdots & 1 & 0 & 1 . 1 \\ 1 & \cdots 1 & 0 & 1 \\ 1 \cdots & & 1 & 0 \end{bmatrix}$ Perfect interaction across space and product groups

A subset of 2) is the macroeconometric assumption which uses the true vertical classification; interaction is high across spatially contiguous areas even with different product groups, but low across non-contiguous areas.

3) $S \equiv P$; limiting case: W structure determined by spatial contiguity of product groups (Horizontal classification).

It is possible, however, that the data used are so constrained that $\{n\}$, the set of observations is such that $\{n\} > P$, $\{n\} > S$, $\{n\} < P$, $\{n\} < S$, $\{n\} \equiv P$ and $\{n\} \equiv S$, are all possible. Given such constraints, it is only possible to test a subset of hypotheses about spatial structure, by making assumptions about P relative to S . Consider case 3), $S \equiv P \equiv \{n^*\}$. It is possible to test:

$$\{n^*\} > \{n\} \text{ (spatial model)}$$
$$\{n^*\} \leqslant \{n\} \text{ (aspatial model)} \qquad (5.17)$$

by comparing spatial and non aspatial models. Such a comparison would need to assume correct regression specification and test for lags alone. It is possible, however, to investigate hypotheses about S relative to P by experimenting with different regressors or splitting dependent variables into groups. This results in the now familiar problem of which step comes first - choice of lags or of regressors ? Without any obvious rule, experimentation must be broad based whilst conclusions are tentative.

5.5 SPECIFICATION, METHODOLOGY AND TECHNIQUE

Thus far, three related specification problems have emerged. These are:

1) Interdependence of W choice with other aspects of specification

2) Interdependence of lag length choice with other aspects of specification

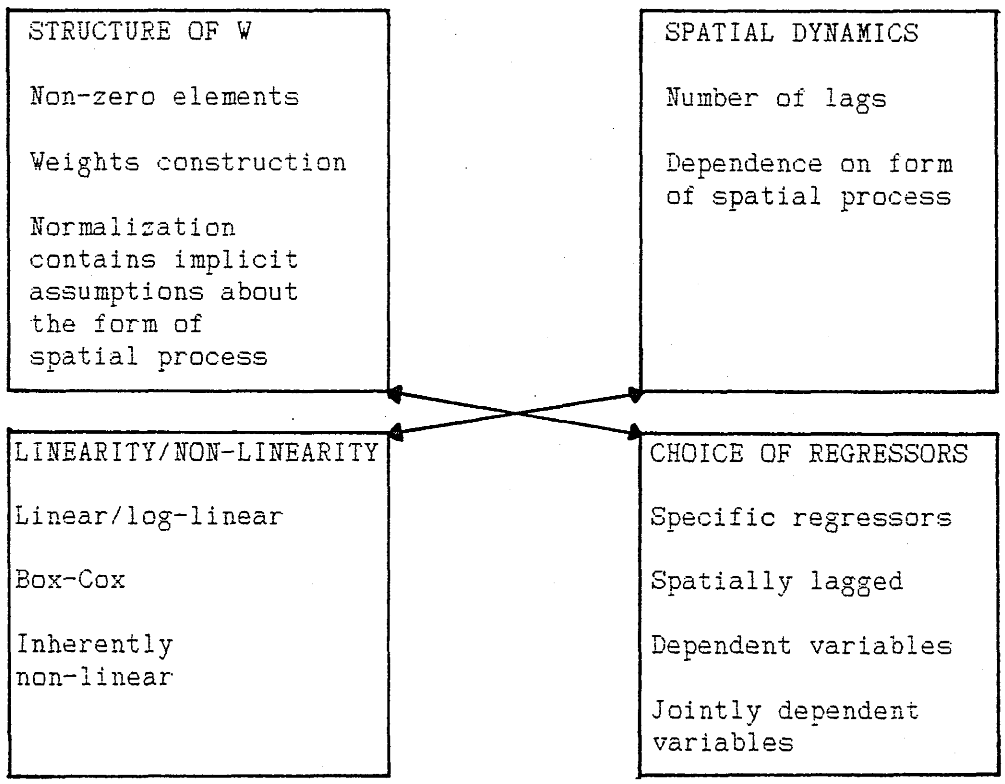
3) Linearity against non-linearity.

The first problem arose in the discussion of specific spatial hypotheses, the second concerns general spatial hypotheses. As has been seen, however, constraints on data availability render these hypotheses interdependent. A fourth problem is the possibility of simultaneity of determination if, in response to data constraints or absence of knowledge about S relative to P, the model uses a number of dependent variables. Table 5.2 summarises the questions of specification, where bi-directional arrows indicate that no order of priority can be assigned to the choice of each aspect of specification.

5.5.1 Spatial Lags

Blommestein (1985) has utilised the general-to-specific methodology of Sargan (1964) and Hendry and Mizon (1978) and applied it to spatial specification questions.

TABLE 5.2 SPECIFICATION CONSIDERATIONS



This method involves estimating a model with as many lags as degrees of freedom will allow:

$$Y = X_{B1} + WX_{B2} + W2X_{B3} + \ldots + WnX_{Bn-1} \qquad (5.18)$$

Likelihood-ratios are used to sequentiallly test the hypotheses $\beta_n = 0$, $\beta_n = \beta_{n-1} = 0, \ldots\ldots = \beta_1 = 0$.

This is the Universally Most Powerful (UMP) technique. In applications, the present author has found the technique to be too powerful with strong collinearity between the W_iX_{Bi} terms precluding any meaningful interpretation. It seems that in practice. spatial lags of order greater than 2 cannot be used. A formulation of the type given in (5.18) contains a spatial first-difference model as a special case, if lagged dependent variables are included as a regressor. If dependent and independent variable lags can be represented by lag polynomials A(L) and B(L), then if:

$$A(L)Y = B(L)X + U \qquad (5.19)$$

and

$$A(L)^{-1}B(L) \qquad (5.20)$$

has a common factor polynomial $\gamma(L)$, autocorrelation of the system's disturbances represents a simplication. This is the general spatial lag version of the specific time series case discussed in Chapter Three. The advantage in using a formulation such as (5.19) is that, provided the equation is specified correctly (sufficient lags and regressors, suitable linearity/non-linearity) OLS or 2SLS can be used without inconsistency. The fundamental but linked problem with spatial data is one of simultaneity of determination between data points, rather than between variables. This bidirectional autocorrelation can be detected by a variety of means (Cliff and Ord (1981)) either informally (e.g. visual) or formal (the Moran I-statistic or Geary C-statistic). Distribution theory for these statistics is complex, since the distribution of the test statistic under the null hypothesis is not necessarily normal. Blommestein suggests informal use of the I-statistic to compare specifications as a compromise. The relevant I-statistic for regression residuals is given by: (where k is the number of regressors and e is an n*1 vector of residuals)

$$I = \frac{e^T W e}{e^T e} \frac{n-k}{k-1} \tag{5.21}$$

If there is no first-order spatial autocorrelation then $e^T We$ will tend towards zero. It follows that in comparing specifications, larger absolute values for I indicate autocorrelation. A family of such values is possible, by powering W, although it should be noted that the efficacy of this statistic depends on the validity of the W matrix used. Formal hypothesis tests can be conducted by evaluating

$$Z = \frac{I - E(I)}{\sigma(I)} \tag{5.22.1}$$

This necessitates calculation of the variance of I, which is given as:

$$\sigma(I) = \frac{n^2}{S_0^2 (n-k)(n-k+2)} \left[S_1 + 2tr(A^2) - tr(B) - \frac{2[tr(A)]^2}{n-k} \right] \tag{5.22.2}$$

assuming normality of the disturbance terms. In this expression:

$$A = (X^TX)^{-1} X^TZ \qquad \text{where } Z = ½(W+W^T)X \tag{5.22.3}$$

$$B = (X^TX)^{-1} X^T(½(W+W^T))^2X \tag{5.22.4}$$

$$S_1 = ½ \Sigma_{ij} (w_{ij} + w_{ji})^2 \tag{5.22.5}$$

$$S_0 = \Sigma_{ij} (w_{ij}) \tag{5.22.6}$$

Evaluation of this for each regression is computationally expensive, and its use in (5.22.1) assumes that I is distributed normally. In practice use will be made of the ratio:

$$I^* = \frac{e^TWe}{e^Te} \tag{5.23}$$

as a guide to the spatial patterns amongst the residuals. In experiments with this ratio, approximately 85% of all resultant values are in the range [-2,+2]. Other aspects of specification such as goodness of fit and regressor choice can be tested by comparisons of R^2 statistics and Breutsch - Pagan (1979) tests for heteroskedasticity.

5.5.2 Choice of Regressors

This topic will be discussed more fully in chapter Six, but some general principles can be mentioned here. A regressor may be present in an equation in spatially lagged or unlagged form, or both, as appropriate. For example, factors which affect mobility decisions will be present in unlagged form as causal elements in turnover rates, whilst in-migration rates will be determined by mobility decisions outside the area of interest. There is a case, therefore, for including only specific lags of this type. In the general-to-specific methodology all regressors are lagged. In practice this can give rise to considerable difficulties of interpretation (for example, the role of spatially lagged local authority rents on owner-occupiers leaving the area; in theory this effect should be insignificant, but this depends on the degree of correlation between jointly dependent variables).

Jointly dependent variables can, within limitations imposed by data availability, be chosen so as to approximate submarkets and, in consequence, more closely identify spatial effects. This involves splitting "demand" and "supply" for any one area into sub-groups with the hypothesis of homogeneity between groups being maintained if suitable results are obtained in estimations of the j.d.v. coefficient matrix.

5.5.3 Structure of W

The W matrix represents the basic spatial structure of the system, and most commonly consists of non-zero elements where first order contiguity exists. These non-zero elements may be used to account for inter-zonal differences, by giving them a gravity-type formulation:

$$w_{ij} = S_i^{\alpha_0} S_j^{\alpha_1} c_{ij}^{\alpha_2} \quad \alpha_2 < 0 \qquad (5.24)$$

The restriction

$$\Sigma_j w_{ij} = 1 \qquad (5.25)$$

is usually imposed to guarantee stationarity. It does, however, imply that the spatial process is "apportioned" from each contiguous district so that if the effect from one district is strong, the effect from other districts is weakened. This is not readily justifiable, and there is a case for using unnormalisd weights, especially when using a straightforward contiguity relationship. Normalised weights deal only with the relative importance of each contiguous district to its neighbour and ignore absolute effects. Normalised weights provide greater standardisation of coefficient magnitudes.

The $c_{ij}^{\alpha_2}$, $S_i^{\alpha_0}$ and $S_j^{\alpha_1}$ terms may take any form, since weights are subsequently normalised; the problem is to determine α_0, α_1, α_2, and in use within a regression framework these would have to be determined experimentally

5.5.4 Linearity and non-linearity

The polar cases for linear and quasi-linear models are;

Linear: $$Y_i = \beta_0 + X_{1i}\beta_1 + X_{2i}\beta_2 + \ldots + X_{ki}\beta_k + U_i \qquad (5.26)$$

$$U_i \sim N(0, \sigma^2 I_n)$$

Log-linear: $$Y_i = \beta_0 X_{1i}^{\beta_1} X_{2i}^{\beta_2} \ldots X_{ki}^{\beta_k} U_i \qquad (5.27)$$

$$U_i \sim LN(0, \sigma^2 I_n)$$

A family of models between these extremes can be generated using the

Box-Cox(1962) transformation:

$$Y_i^{\lambda} = \beta_0 + X_{1i}^{\beta_1} + X_{2i}^{\beta_2} + \ldots + U_i \qquad (5.29)$$

This can in practice, lead to problems with different λ values for each equation (in a multi-equation model) or for sub-samples of the data set. (Maclennan (1985))

None of these problems is as severe, however, as the choice when spatial lags are involved. Whilst it is possible to write, for example,

$$\log Y_i = \log\beta_0 + \beta_1 \log X_{1i} + \gamma_1 \Sigma_j w_{ij} \log X_{1j} + \ldots + \log U_i \qquad (5.29)$$

there is no a priori reason for doing so. In particular, if the underlying model and weights are specified multiplicatively, why should normalised linearly constructed weights be entered linearly ?
It is equally possible to take the expression

$$\log \Sigma_j w_{ij} X_{1j} \qquad (5.30)$$

as the appropriate lagged value, which implies a <u>linear</u> spatial process interacting <u>multiplicatively</u> with adjoining districts.

In the absence of any clear decision rule, the lag form given in (5.29) will be used for the log-linear-model, since that formulation implies that the W_{ij} are indices and components of the composite coefficient, $w_{ij}\beta_k$. This is the power to which the k^{th} variable is raised in the multiplicative model. This is more consistent and easier to interpret than (5.30)

5.5.5 Regression Strategy

In the light of the foregoing discussion, the regression strategy to be used will contain some a priori constraints. After some experimentation it is clear that there are few differences between some of the gravity specification W matrices (i.e. between those which approximate social space), whilst there can be considerable differences in the performance of W matrices where only the number of non-zero elements is varied. In practice the W matrix to be used consists of:

$$w_{ij} = 1/d_{ij}^2 \qquad (5.31)$$

where d_{ij} is the Euclidean distance between the approximate district centroids. This formulation corrects for the irregular shape of districts whilst incorporating a very simple friction of distance effect such that the degree of spatial interaction varies inversely with the square of the inter-district distance. It is assumed a priori that there is only one W matrix applicable to all the sub-groups of movers, but in a sense this is not restrictive because there does not exist a single correct W matrix; use of the same form for all equations provides comparability. It follows that correction is being made for Euclidean rather than social space, but in experimentation it has been found that unusual results are possible when a social space formulation is used. This is because the regressors to be used fall into three categories; there are demographic variables which broadly correspond with the forces prompting housing related moves, there are socio-economic variables which equate with employment related moves, and there are market determined variables which influence the short term patterns of such moves. All these variables display some degree of collinearity, and given the discussion previously on the fundamental interconnectedness of the entire housing market, such that a pure vertical or horizontal classification is inadequate, it is likely that attempts to replicate social space will introduce distortions.

The W matrix to be used will consist of first order contiguity only since strong collinearity between regressors of higher than first order lagged renders them ambiguous. Given the average district size compared with average move distances, this is not restrictive in most cases except for suburbs which lie on each side of a city; such areas are assumed to be unconnected with one another but in practice may show interdependence. This loss of information is almost certainly outweighed by the simplicity of the formulation as applied to most areas.

There are four possible types of regression:

1) Exogenous Unlagged Regressors: This will determine the basic importance of the three categories of regressors mentioned above: demographic, socio-economic, and market influences.

2) Endogenous Unlagged Regressors: This will determine the likely dynamic operation of the housing market, comparing volume influences with market pressure indicators.

3) Exogenous Lagged Regressors: Lag significance indicates that the average size of spatial submarkets is large compared with the size of spatial data units, conditional upon limited congruence between the boundaries of each. This is an imperfect test, since it can only allow qualitative statements and only gives an indication of the average position. A detailed study of spatial submarkets would require spatial versions of Chow tests with a very large number of permutations; equivalent, in effect, to diagonalising the A matrix. This is computationally beyond the scope of this study.

4) Endogenous Lagged Regressors: This is the most general model, and corrects for spurious exogenous lag significance arising from strong dependence on the volumes of moves originating or terminating elsewhere.

If the model detailed previously is rewritten as:

$$Q_{di} = f_d(\Delta P, Z_1) \tag{5.32}$$

$$Q_{si} = f_s(\Delta P, Z_2) \tag{5.33}$$

$$\Delta P = \gamma(Q_d - Q_s) \tag{5.34}$$

$$\Rightarrow Q_{di} = f_d(\ \gamma(Q_d - Q_s),\ Z_1) \tag{5.35}$$

$$Q_{si} = f_s(\gamma(Q_d - Q_s), Z_2) \quad (5.36)$$

where Q_{di} and Q_{si} are the demand and supplies of the i^{th} sub-group, then it is possible to directly relate elements of demand and supply with all other elements of demand and supply. In the empirical work of Chapter Seven, only the "opposite side" of the market will be included to avoid excessive multicollinearity.

5.6 CONCLUSION

This chapter has presented and analysed a framework for a regional housing model and suggested how such a framework can be applied in practice. It has been shown that although the underlying specification is based on demand and supply volumes as functions of price levels, with individual relationships between each district, it is possible to make assumptions which reduce the spatial specification problem to that of a weights matrix. As specified, it is possible to substitute out prices altogether and deal, instead with a volume based model. This results in a loss of information as to price elasticities, but permits construction of a regional model with existing data. The limitations, mainly imposed by the available data or by computational expense, have also been described, as have the interpretations which can be placed on results. The next chapter will detail the regressors and dependent variables to be used and provide some of the background for the study area.

CHAPTER SIX

THE SAMPLE DATA AND VARIABLES

6.1 INTRODUCTION

The first three chapters have demonstrated that there are a wide variety of approaches to modelling the housing market. To some extent, the differences arise because of specific local variations in housing market structures, either in terms of race or tenure. It would be intuitively unacceptable to pool data from U.S. and U.K. sources, but most U.K. macroeconometric models include Scottish data for the purposes of equation estimation. The validity of this practice is debatable when the Scottish institutional framework demonstrates marked differences from that of the rest of the U.K..

The purpose of this chapter is to detail such differences, and to evaluate the sources of data which are available for the purposes of constructing a spatial econometric model.

6.1 THE SCOTTISH ECONOMY AND HOUSING MARKET

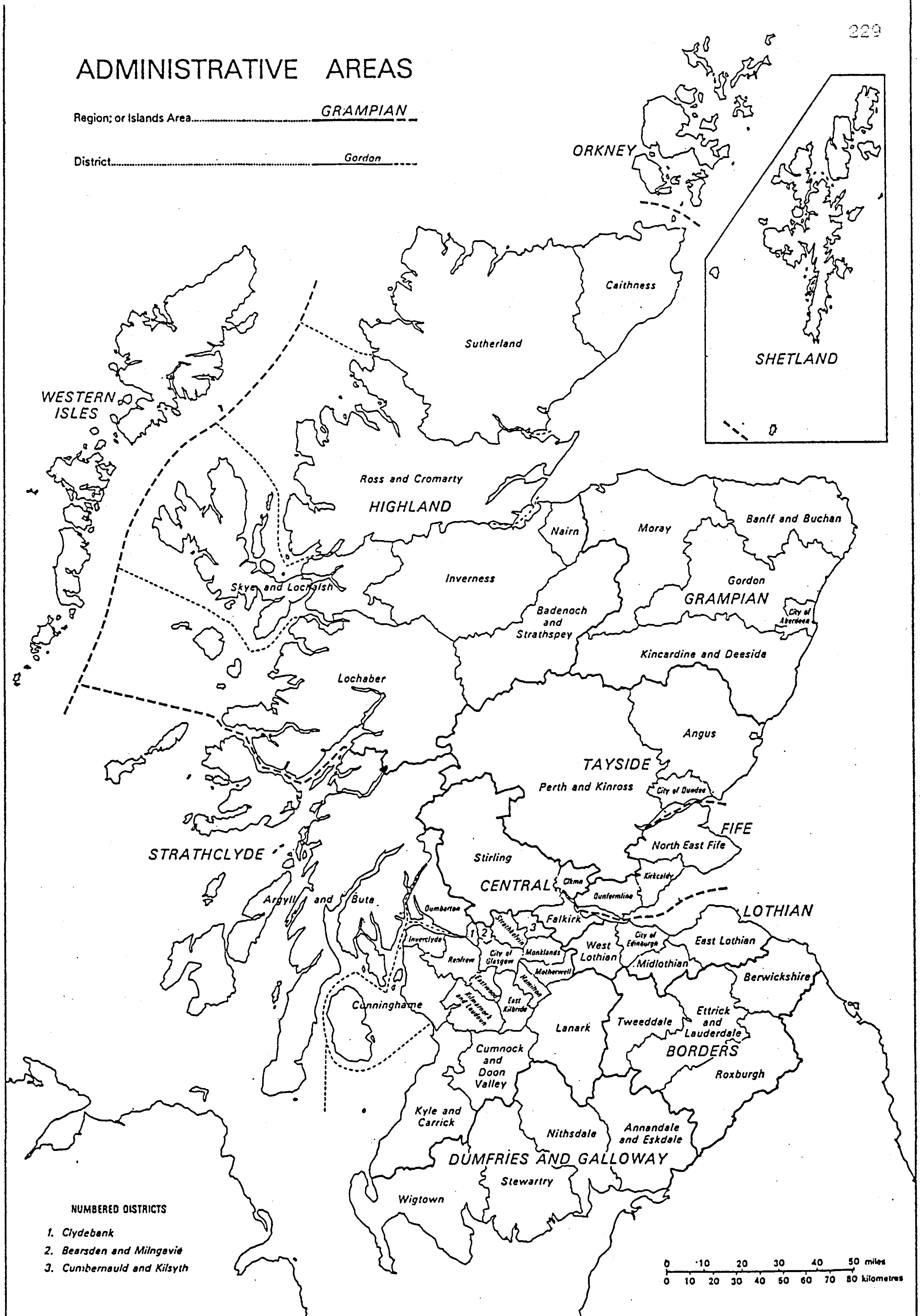
Until 1707, Scotland was a separate nation. It retained its independent religious, educational and legal systems, and the latter continues to exert an influence on the housing market in the form of the sealed bid process. Its banks have some degree of autonomy from their English counterparts, although only one, the Bank of Scotland, is truly independent. These banks can issue their own notes but this is a symbolic rather than a real difference, since each note issued must be backed by an English equivalent. Hence Scotland's monetary system is effectively integrated with the rest of the U.K.

Geographically, Scotland has three distinct areas: the Southern Uplands, the Highlands and Islands, and the Central Lowlands. Only two railway lines and three main roads connect it with England, and the Cheviot Hills provide a physical barrier between the two. It has a population of about five million, but over half of these are concentrated in the Strathclyde administrative region (see Figure 6.1). Topography and geological accident have combined to make the Central Lowlands the main initial centre of industry, with coal and iron reserves located there. More recently the discovery of North Sea Oil has had a major impact throughout the Highlands, although Grampian Region has been the main beneficiary of oil-related employment changes. Oil production continues but the slowdown in exploration and drilling has had corresponding impacts on areas with platform construction yards. These changes are documented in Lythe and Majmudar(1982).

Other factors have contributed to a shift in economic activity towards Eastern Scotland, reflecting a U.K. trend. In the face of competition from other countries, especially Japan, traditional shipbuilding and related industries around Clydeside and in the West generally have declined; this has been reinforced by rationalisation of the steel industry which has closed a number of traditional Scottish steelworks (e.g.Dalziel).

The activities of the Scottish Development Agency have contributed towards persuading multinationals to locate in Scotland, with an emphasis on microprocessor technology. The focus of this has been "Silicon Glen" around Glenrothes, again in the East. Entry to the EEC

FIGURE 6.1 SCOTTISH ADMINISTRATIVE REGIONS AND DISTRICTS 1980



Source: Scottish Development Department.

has further reinforced the Eastward shift of economic activity and the importance of Edinburgh as a financial centre has been boosted in the aftermath of financial deregulation.

There are, then, structural changes occuring in Scotland's economy: but whether Scotland's economy is in decline is more debatable. Lythe and Majmudar point out that the majority of Scottish "foreign" trade is with the U.K., linking it closely to the economic performance of the rest of the country. They argue that any sustained recovery will benefit Scotland more than most U.K. regions due to specialisation in microelectronics and bio-engineering.

Scotland's separate legal system immediately sets Scottish housing apart from the rest of the U.K., and this is reinforced by its different tenure structure. Gibb and Maclennan (1985) trace the evolution of this tenure structure to the Scottish political scene in the early decades of this century; they also note that Scottish local authorities have tended to show a preference for low rents, making owner-occupation less attractive. This has been compounded by rivalry between private builders and local authorities over land appropriation. In addition, design mistakes and design obsolescence have had an adverse impact on public sector housing, leading Gibb and Maclennan to state: "Tenants may like the concept of subsidised council housing, [but] many do not like their council houses and the estates they live in." (Gibb and Maclennan (1985), p.283)) This has contributed to the growing popularity of owner-occupation as an alternative tenure. The Housing Support Grant system, introduced in 1978, was intended to supplement the Rate Support Grant and was explicitly linked to the specific housing committments of individual Local Authorities. However, it rapidly became an instrument of central government control, with corresponding increases in local authority rent levels and decreases in local authority building rates.

It has already been shown in Chapter Three that in an asset-pricing model, inflation makes owner-occupation an attractive proposition, and this process has been responsible for a sizeable element of U.K. private housing demand. Gibb and Maclennan suggest that in Scotland, tenure change is particularly associated with new household formation. They also state that in contrast to the rest of the U.K., Scottish council housing

"...contains a relatively large proportion of 'higher' socio-economic groups. The Scottish council sector is far from being 'residualised'..." (ibid.,p.285)

The net result of a relatively recent move to owner-occupation has been to put pressure on the lower end of the market, effectively raising the relative price of housing services. This parallels the Urban Institute model simulation of an arbitrary cut-off point for structure "quality", which generates a similar pattern. In Scotland, the effect is more likely to arise from an inadequately structured private sector stock. Cullingworth (1966) argues that Scottish privately owned housing contains a gap in the trading-up chain which generates excessive price pressure at the low end of the market; consequently housing market careers become impacted. This quality gap is most likely to consist of

FIGURE 6.2 HYPOTHETICAL PRICE STRUCTURE CURVE FOR SCOTLAND

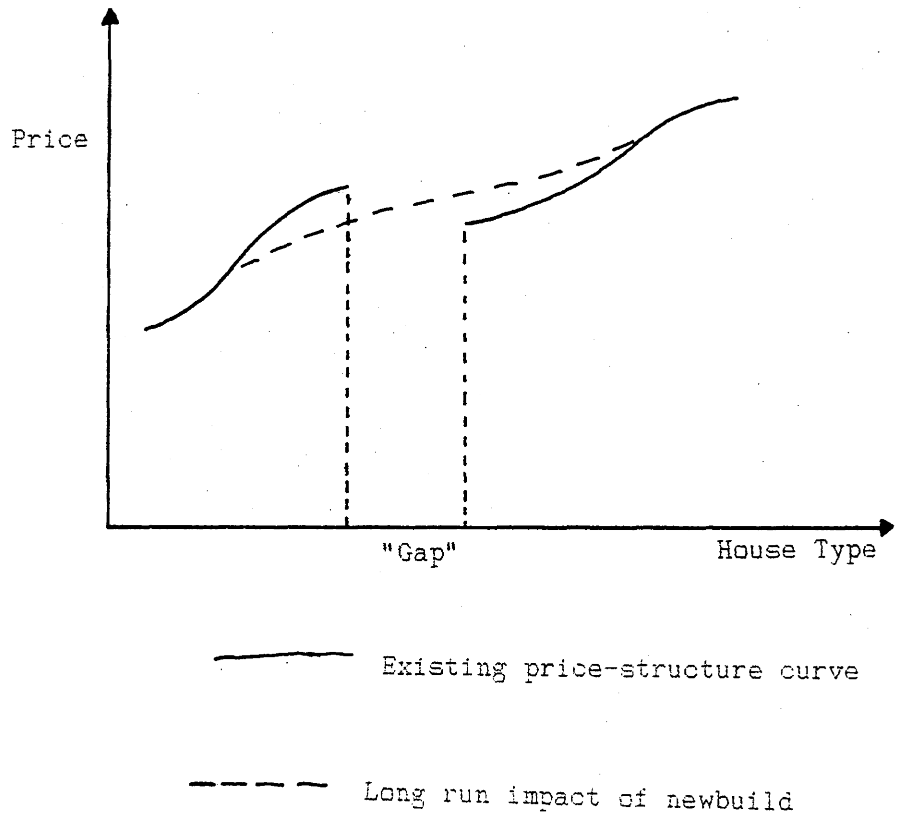


TABLE 6.1 SCOTTISH AND U.K. PRIVATE HOUSE COMPLETIONS

YEAR	SCOTLAND	U.K.	%
1971	11614	196313	5.9
1972	11835	200755	5.9
1973	12215	191080	6.4
1974	11239	145177	7.7
1975	10371	154528	6.7
1976	13704	155229	8.8
1977	12132	143344	8.5
1978	14443	151730	9.5
1979	15069	136454	11.0
1980	12187	130132	9.4
1981	11021	116381	9.5
1982	11532	123781	9.3
1983	13067	142979	9.1
1984	13992	158420	8.8
1985	14151	153650	9.2

Source: Housing and Construction Statistics semi-detached and small detached houses. The existence of such a gap, coupled with the move to owner-occupation means that the building industry has found Scotland a profitable area in recent years, compared with the building slump, mirroring recession, elsewhere in the U.K. (see Table 6.1). The long run impact of newbuild on the "price-structure curve" is shown in Figure 6.2

6.3 THE SAMPLE DATA

The data used in this study consist of 56 cross-sectional observations on a variety of socio-economic and housing-related variables. These are taken from the 1981 Census of Population and from a variety of Government and Local Authority publications, and generally represent 100% enumeration. The 56 data points correspond to the Scottish Districts shown in Figure 6.1, and it is these units which make up the larger Administrative Regions. The average size of each district is 100,000 people (about 30,000 households) although this is much higher in the four cities Glasgow, Edinburgh, Dundee and Aberdeen. Some of the data used is in first-difference form i.e. changes over the period 1980-81 for each cross-sectional unit, although this information is not available for all variables.

6.4 THE DEPENDENT VARIABLES

The model has seven jointly dependent variables, representing demand and supply for each spatial unit. These are:

Demand: IN In-migrant households from a district within the same region.

INN In-migrant households from a district outside the region.

HHFR Newly-formed households; constructed from Census data this variable measures new households who also leave the district, (and is consequently a form of "negative" demand but should at least proxy the behaviour of all new household formation.)

Supply: OUT Households leaving a district who move to another district within the same region

OUTN Households leaving a district who move to a district outside the region.

RCM Newly built houses

TVR Turnover; that is, households who relocate within the same district and who simultaneously demand and supply houses in that district.

A number of remarks about these variables are necessary. Of the above, IN, INN, OUT, OUTN, and TVR are taken from the Census and are classified by

<u>current</u> tenure, so that not all those designated as owner-occupiers will have been in this tenure prior to relocating. If this were not the case, it would be possible to write vacancy changes as

$$\Delta VAC=OUT+OUTN+RCM-IN-INN-HHFR+DTH+SALES-PURCHASES \quad (6.1)$$

where DTH is the number of owner occupiers whose death results in the sale of their house, and where SALES and PURCHASES are included separately to allow for transactions involving second homes. The Census classification means that this expression is amended to read

$$\Delta VAC=OUT_1 \pm \Delta VAC^* \quad (6.2)$$

In this formulation, OUT_1 represents only out-migrant households whose relocation results in the sale of their house, and ΔVAC^* represents the other elements of (6.1). Hence

$$OUT^*+OUTN^*-OUT_1=OUT+OUTN \quad (6.3)$$

The first two elements of this expression are the Census definitions. This means that Census data will overstate the magnitude of vacancy changes unless adjusted for classification difference, which is achieved by subtracting the third element of the left hand side. Similarly, the IN^* and INN^* values from Census data will include new households whose relocation has not left a vacancy elsewhere. It follows that with appropriate assumptions about DTH, SALES, PURCHASES, and RCM, and with suitable exogenous data on vacancy changes, it is possible to estimate the magnitude of OUT_1, which is the outmigrating counterpart to HHFR. Consequently any equation which models in- and out-migration will tend to include the effect of the exogenous variables on new households, but the characteristics of the "pure" household formation equation, OUT_1, should give some indication of the differences between the two subgroups.

Second home transactions have been ignored in this study. Other than in the Highlands and Islands, they do not constitute a significant part of the housing market. (Table 6.2) Deaths are included by multiplying the number of deaths recorded in the district by that district's average propensity for living alone (i.e. by the proportion of Type 1 Minimal Household Units). This requires the assumption that death rates are constant across tenure.
Exogenous data on vacancy rates is available from local authority rating returns, but this refers to domestic rateable units rather than transactable houses; this data is, therefore, adjusted by the district's tenure split and by its ratio of rateable units to separate houses. This procedure requires the assumption that this ratio is constant across tenures; this assumption is probably valid in most districts but is somewhat heroic in cities with multiple occupancy and high rise dwellings. In the absence of any alternative adjustment, this method will be used but its shortcomings should be borne in mind.

By splitting demand and supply as far as available data will allow, it is possible to attempt to model the spatial interaction of each level of the housing market hierarchy separately. A common "house price"

TABLE 6.2 SECOND HOMES IN SCOTLAND

REGION	%
Scotland	0.68
Borders	1.70
Central	0.25
Dumfries and Galloway	0.01
Fife	0.70
Grampian	0.63
Highland	2.70
Lothian	0.29
Strathclyde	0.53
Tayside	0.69
Islands	2.30

Source: 1981 Census, Housing and Household Report variable is used in the form of ΔVAC; at first sight, this appears to deny the existence of independent hierarchy levels. In fact it is a necessary simplification given that the Census classifications preclude complete separation of these markets, and because this separation will not necessarily coincide with that of the market. The "within region/outside region" classification provides a crude split between local and non-local movers, which in turn will approximate those who move because of employment relocation and those who move for house-related reasons. Each will respond to different exogenous stimuli, or respond to the same stimulus differently. Hence the point at issue in using this separation is whether the enhanced predictive power that it offers more than outweighs coefficient bias due to inadequate classification.

In using this data for the jointly dependent variables it is tacitly assumed that sufficient inventory exists for excess demand or supply to be realised and reflected in vacancy rate changes. Using vacancy rates as proxies for house prices assumes the linear or loglinear price adjustment mechanism discussed in previous chapters. All the variables relating to flows of households are deflated by the total number of owner-occupied houses to adjust for district size and tenure differences.

6.5 THE INDEPENDENT VARIABLES

6.5.1 Local Authority Rents (LAR)

This variable measures the average annual unrebated local authority rent level prevailing in the district and proxies the cost of public sector housing services. It is to be expected that, ceteris paribus, a higher local authority rent level will push households into owner-occupation, either directly or through the medium of council house sales. Unfortunately the data on such sales is incomplete.

6.5.2 Rateable Value (RV)

Rateable value has frequently been used as a measue of housing quality, but a number of criticisms have been levelled at this practice, particularly for English data, due to anomalies and slow updating. In Scotland, rateable value is reassessed regularly and structural changes to dwellings should be registered with the Regional Assessor within one year of execution. Despite its shortcomings, average rateable value is a fairly accurate indicator of the quality of housing in a district and will serve the purpose of correcting for any quality-based effects which might obscure the spatial behaviour of interest here.

6.5.3 North Sea Oil Dummy (OIL)

This dummy variable adjusts for any exceptional effects consequent upon the oil-related housing market boom in and around Aberdeen. It takes the form of a 1 for the Aberdeen district and the two surrounding districts, and a 0 elsewhere. In particular, this variable captures the extent to which the inventory model of price adjustment is inadequate when vacancy rates are already squeezed and prices are the only means of reflecting demand pressure. This intercept adjustment is the simplest way in which the oil boom might affect the housing market, but other means are obviously possible, such as estimation of separate equations for the areas affected by the oil boom. Data limitations preclude the latter in this study.

6.5.4 Urban-Rural Dummy (URD)

This dummy variable takes a value between 5 (highly urban) and 1 (highly rural) and is based on a Scottish Office study[1] which conducts a factor analysis of the 1981 Census Data on a number of variables including the structure of the economic base and the population density. It is included because it captures some of the search effects, discussed in Chapter Four, which may be inadequately captured by the other variables. It also provides a proxy for employment location.

6.5.5 Birth Rate (BRTH)

In accordance with the discussion in Chapter Two, births in the family are one of the two key "life events" which generate mobility. The conclusion of work previously reviewed is that only unexpected events will cause mobility, although in an imperfect capital market inability to perfectly adjust housing consumption to future requirements may arise because of income constraints. Given that most households plan ahead, but that some will adjust with a lag, the birth rate variable is a three-year moving average centred on 1981, with equal weight given to each year. Rather than constrain the coefficients in this way, it might be desirable to enter each year separately but this generates unnecessary complexity when spatial lags are introduced.

6.5.6 Household Formation Potential (MHU)

This variable derives from Ermisch's (1985) work on Minimal Household Units and is constructed from Census analyses of households, which give information about the number of adults and dependents within complex household units. It is possible to calculate an approximate ratio of potential to actual households, and obviously the higher is this ratio, the greater, ceteris paribus, is the potential demand for additional houses, especially if the potential households have only recently become adults and are not constrained in some other way (e.g. incapacity). This also has implications for the number of households searching even if they do not "demand".

6.5.7 Average Income Level (SEG)

Accurate data on per capita wealth and earnings is not collected for individual districts and some form of proxy is required. The approach used in this study is to take a weighted average of the proportions of households in each socio-economic grouping to provide an index of earnings. The weights used are the average weekly wages of males in that group, before tax and overtime. The latter is used because Building Societies will take this measure (or annual equivalent) as relevant in determining eligibility for mortgage finance, although mortgage interest tax relief will distort effective incomes to some extent. It is not possible to adjust for this with published data. This variable also ignores wealth, either inherited or accumulated in the form of unrealised appreciation in the value of the household's dwelling. By focusing on male earnings there will be a slight distortion, and the SEG classification conceals large within-group earnings differences. Despite these problems it is the best measure available and seems to serve as an adequate proxy in practice.

6.5.8 The Unemployment Rate (U)

Employment classifications based upon the most recent occupation are meaningless without some indication of employment status, but systematic unemployment statistics with SEG breakdowns are only provided periodically and use employment office areas rather than districts. The unemployment data used here is from the Census and will include those individuals who choose not to work. It will be a misleading variable in areas where most unemployment is concentrated in public sector housing estates, since the impact on the private housing market will be limited. It will also obscure the effect of current owner-occupiers who have become unemployed and sell their house in order to realise their capital gain. Lastly it does not distinguish current owners from those who merely live with a current owner. Some of the other complexities of interpretation in using this variable are discussed below.

6.5.9 Composite Potential Demand Variable (HHSEG)

It is conceivable that neither the SEG nor the MHU variables will be capable of influencing housing market activity in isolation; rather it is only when both are high that demand will be strong. The reason for this is that whilst a high number of potential households is a necessary condition for volume-based housing demand, it may signify the existence of a constraint on household formation, such as low per capita income. Similarly, high per capita income will not lead to a flow of demand for housing units if the residents are satisfied with their existing location and if few potential households exist. The HHSEG variable takes the product of the two as the most likely form of interaction.

6.5.10 Land Availability (LAND)

This variable measures the ratio of land without planning permission, held by housebuilders, to land held with planning permission. The discussion in Chapter Four concluded that for the modern speculative housebuilding industry, the land portfolio can be crucial to profitability, and this includes land with planning permission to allow a flexible response to demand changes. Local Authority land release policies then become the key factor in determining the supply elasticity of the housing market.

6.5.11 Rate of Vacancy Change (DV)

The construction of this variable has already been detailed, but its use as an exogenous regressor requires some justification. It is intended to proxy price changes to give some indication of price elasticities of demand and supply. The use of changes, rather than levels, arises because the year-on-year vacancy rate level data shows high collinearity, probably because a large proportion of the stock of vacancies are inadequate as dwellings, being semi-derelict, and hence are not transacted. It is the marginal vacancies which are of interest. This specification is not, then, strictly in accord with the analytical demand and supply functional forms given in the last chapter, but should serve as an approximation for the price level.

The second qualification concerns the inventory formulation which assumes that the existing stock of vacancies consists of adequate substitutes for the dwellings in the market. This will be valid if there are sufficient vacancies being redeveloped or due to come on to the market as the result of the death of the occupant. If the useful elements of the stock of vacancies are used up due to sustained and excessive demand, such as during the oil boom, this formulation will be invalid. The oil dummy attempts to capture this structural change.

The third qualification concerns the excess demand-price adjustment mechanism generally. As has already been discussed, this assumes that Walrasian auctioneers, or some form of automatic bidding process, will compare the relative volumes of demand and supply and adjust prices accordingly. As employed here, the implicit basic market period is one year which is four times as long as in macroeconometric models. Since the data spans May 1980 to May 1981, there will be some lack of comparability between supply and demand figures. Informal conversation with estate agents suggests that there are two, and possibly three, market periods within any one year; between these there is considerable overlap. The first period is in spring, when housing market activity begins to surge; the second is in late summer, so as to execute mobility plans before school terms begin; and the third relates particularly to new houses, just after Christmas, when households seeking a morale boost contemplate "trading in" their existing house for a new model. This anecdotal evidence suggests three overlapping waves of activity, where those households who bought but were unable to sell in one wave will find a buyer in the later upturn. Consequently these annual cycles are probably not independent and the yearly approximation is valid. From a pricing viewpoint, the rate of vacancy change ("price change") prevailing at the year-end is a proxy for the average rate through the year and used by housing market participants as a input to decision making. Thus the market is assumed to clear within one year, with prices and vacancy rates adjusting during this period. As used, there will be a lagged element in the vacancy rate variable.

The last qualification relates to the relative time frames and consequent danger of spurious correlations. This is potentially the most serious criticism, since it relates to the speed of adjustment within the market. As detailed above, the model used here assumes that a) the inventory model and b) the price adjustment formulation are valid. This latter is embodied in most demand elasticity studies and its failure can result in perverse coefficient estimates. As embodied here, the assumption of annual adjustment is not as strong as that of quarterly adjustment contained in the Artis et al (1975) model. In general, standard demand and supply equations presuppose that volumes and prices do not overshoot. In practice, relative adjustment speeds may vary, with slow volume adjustment and hence price allocation taking time to operate and the short term behaviour of the market may show considerable price volatility. It follows that the use of vacancy rates circumvents this problem by avoiding empirical price data altogether, but spurious correlations are still possible if one element of vacancy change dominates the overall total; this will produce perverse coefficient signs. As a more concrete example, if in-migrating households are treated as an element of demand then the expected price effect is negative and the coefficient on vacancy change will be positive. If the in-migration class used dominates the sources of vacancy change, then the actual coefficient may be negative (since in-migrants reduce vacancies). Either of the effects mentioned here can be responsible for counter-intuitive results, with no apparent method of distinguishing between the two. Some idea of the degree of dominance of any one element of the vacancy change variable can be gained from the following regression:

$$DV = -2.26IN + 0.12INN + 0.91OUT - 2.87OUTN + 0.07RCM$$
$$(-2.91) \quad (1.06) \quad (0.73) \quad (-2.14) \quad (0.13)$$
$$R^2 = 0.18$$

where HHFR is excluded in order to avoid perfect collinearity. This suggests that local in-migrants and non-local out-migrants dominate vacancy changes (although the overall level of explanatory power is low, perhaps because demolitions are a major source of vacancy change). This is not unreasonable given that housebuilders will not pay rates on new houses, and are unlikely to hold large stocks of empty dwellings for long. Long distance movers will be more constrained by the need to find a new dwelling and may face delays in the sale of their own house. On a similar argument, however, the dominance of local over non-local in-migrants is surprising.

It is possible that the flows of households will not have adjusted to price changes, in which case coefficient signs will be incorrect. This would arise in the event that households are locationally price-insensitive generally; they are not deterred spatially by higher prices, but instead purchase a house lower down the "quality hierarchy" in the same broad spatial area. This would imply that spatial location has a low elasticity of substitution with other elements of housing characteristics. In the model used here, where space is assumed to be the major housing market dimension, any insensitivity of volumes to price movements implies that γ outweighs a and b in the short run. It follows that use of vacancy rates has its own empirical drawback in that it tests for the joint significance of the values of γ, a, and b. This does mean that by examining the coefficient sign obtained for DV in estimation, it is possible to decide which of these parameters is dominating and consequently to make inferences about the dynamic behaviour of the market. For example, if γ is greater than $1/(b+a)$, then prices are highly responsive to changes in excess demand, but supply and demand are relatively unresponsive to changes in price. As shown in Chapter Five, this will yield oscillatory behaviour in prices through time, but such oscillation will be damped, stable, or explosive depending on the magnitude of γ relative to $1/(b+a)$ and $2/(b+a)$.

The problems discussed so far generally refer to the inadequacy of the temporal sampling frame, but the spatial sampling frame may also be a source of error. For example, the number of potential households in contiguous districts is a factor determining one element of demand in those districts. For an out-migrant household, strong demand is beneficial in that it increases the probability of successful search for sellers, but it decreases the probability of successful search for a new property in surrounding districts. Different levels of the hierarchy may be affected in each area, but the possible ambiguities remain.

6.6 EXPECTED RESULTS

In order that these considerations can be seen in more detail, and to set the scene for the empirical results of the next chapter, the expected signs given in Table 6.3 will be used as a basis for discussion.

TABLE 6.3 EXPECTED RESULTS

	IN	INN	OUT	OUTN	RCM	HHFR	TVR
LAR			+	+		+	
LARL	+	+					+
OIL	–	+	+	–	+	+	
OILL	?	?	?	?	+	?	
URD	+	+	+	+	–	–	+
URDL	+	+	+	+	+	+	+
RV	+	+	–	–	+	–	–
RVL	+	+	–	–	+	–	+
SEG	+	+	–	–	+	+	–
SEGL							
U	–	–	+	+		+	–
UL							
BRTH			+	+			+
BRTHL	+	+					+
MHU						+	
MHUL	+	+					
DV	+	+	–	–	–	–	?
DVL	–	–	+	+	+	+	?
LAND					+		
LANDL							
HHSEG						+	
HHSEGL	+	+					

N.B. L suffix indicates a spatial lag

6.6.1 Local Authority Rents

The effect of local authority rents on each variable will depend on the profile of the households in the public sector. If they have a high level of household income, either due to a large family or sufficiently well-paid employment, then the level of rents compared with mortgage payments becomes operational as an input to decision-making. This will be more important in Scotland, where the public sector has a more diffuse socio-economic profile. Given that there will be an owner occupation risk premium which will vary for each household, it is not possible to quantify the threshold level of rent and mortgage payments at which households will be indifferent as to tenure; hence the variable is entered separately.

In general, the impact of local authority rents is thought to be direct, either pushing out out-movers (in the unlagged case) or generating in-migration to adjoining districts in the spatial form. There is assumed to be no effect on newbuild and the impact on turnover is to increase within-district movers. As has already been stated, the bulk of the rent level effect will probably be to increase owner-occupation through council house purchase, rather than through market transactions, so that it is possible that as constructed, no effect will be detected.

6.6.2 The Oil Dummy

The oil dummy is intended to represent the unusual market environment prevailing as a result of the oil boom. This will have a number of effects; employment-related movers who are entering the oil industry may receive some assistance with housing cost, so that the net effect will be positive on non-local in-movers (due to the distinct lack of such opportunities elsewhere in Scotland) and negative on non-local out-movers. It is assumed that housing related movers will be displaced, hence there will be negative and positive impacts on local in- and out-movers respectively. It is likely that there will be a positive effect on new housebuilding, but this will be tempered by the availability of land, its cost, and the likelihood of obtaining planning permission. Newly-formed households are likely to be displaced, whilst the effect on turnover is unclear; either moves are increased as existing owners realise windfall profits, or decreased due to the increased difficulty of successfully purchasing a property in the next strata. This will depend on the balance of housing market pressure across the various market strata.

The effect of the oil dummy lagged is more ambiguous, since the spatial impact of the oil boom itself is unclear and probably does not have strong spatial effects at this kind of distance; rather a diffuse impact is felt throughout the Highlands. Consequently no a priori expectation is imposed on this variable.

6.6.3 Urban-Rural, Socio-Economic, and Rateable Value Variables

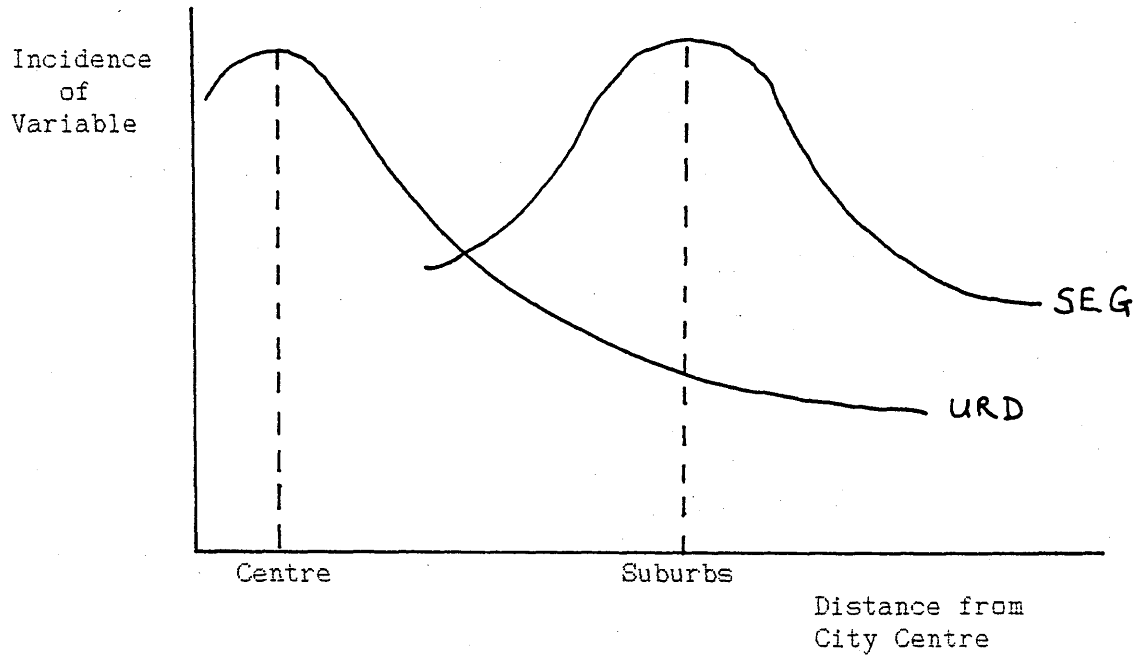
The RV, SEG and URD variables can be dealt with as a single group, since, as will be seen in the next chapter, they are strongly collinear. Within the context of the model set out in the last two chapters, the essence of an urban area is its high density of dwellings, with a corresponding impact on search strategies. It follows that the more urban is any given area, the greater the intensity of housing market activity associated with any particular level of owner-occupation. It follows that the expected effect is universally positive, with the exception of new housebuilding and new household formation. In the case of the first, there will be a shortage of suitable sites due to the high demand for land, particularly commercial property. This is a similar effect to that of the LAND variable discussed below, but reflects a different aspect of the impact of land availability. In the case of the latter, it is assumed that whilst the urban areas will be more crowded, which stimulates household formation, the generally higher level of market activity will increase price levels, which will reduce household formation. The overall effect on new households is unclear, since the price effect of the urban area may extend a greater distance than the search space of the newly forming households.

The urban-rural dummy, therefore, demonstrates two problems. The first relates to the way in which this dummy serves as a proxy for too many conflicting effects, but also represents a separate influence (i.e. density). The second problem is more pervasive and relates to the spatial nature of the model; namely that each regressor will have a spatial effect which may not be adequately represented by its proxy; this results in difficulty in determining the a priori expected sign for a variable. This is illustrated in the lag of the urban-rural dummy, where the expectation is again universally positive, this time including the newbuild and new household variables; in each case, the elements of the city which might give rise to ambiguous signs are assumed to be more than outweighed by the original effect. Hence it is assumed that an adequate supply of land is available in the suburban areas, and that there are sufficient latent households with sufficient income for their aspirations to be realised, either moving further away from, or closer in to, the city.

The SEG and rateable value variables will almost certainly serve as proxies for one another, given that housing rateable values are a function of size and amenities, which is also positively correlated with price. Further to this, there is a concentration of professional and middle class households in cities and suburbs, so the reason for the collinearity between these two variables and the urban-rural dummy should be clear. It will also be likely, however, that the spatial distribution of these variables will show subtle differences, as shown in Figure 6.3.

Whilst the urban-rural dummy is expected to be associated with a generally higher level of housing market activity, it is assumed that higher rateable values will have a dampening effect on housing-related migrants. Although negative signs appear on the lag of the out-mover variables, this is only because there is a positive sign expected for the in-mover regressors; it is equally possible that the presence of higher rateable values in an adjoining district will increase the rate of out-migration and reduce the rate of in-migration, due to the presence of a substitute. This is another example of the ambiguity inherent in the use of spatial variables, where there is no a priori

FIGURE 6.3 SOCIO ECONOMIC GROUPINGS AND URBAN DENSITY



guidance as to whether a "contagion" or substitution effect will operate. In the first case the impact of an exogenous variable, such as prices, across the boundaries of a spatial unit will be smooth. In the latter case, the spatial limits to the direct impact of an exogenous variable approximate the boundaries of the spatial unit. On the assumption of the contagion dominating, the newbuild effect of lagged rateable values will be positive, to the extent that housebuilders use the image of surrounding areas to fix the strata of their own product. The impact on turnover is assumed to be negative given that those already in the area will be reluctant to move. Although a negative sign is given for the lag, this will again depend on the contagion/substitution effects.

The signs given for socio-economic status are identical to those given for rateable values, but it is assumed that there is no direct lagged effect, other than a peer effect equivalent to the contagion process assumed to operate through rateable values.

6.6.4 Demographic Variables

The birth rate, MHU, and HHSEG variables can be treated as a related group since all are demographic. All these variables are expected to increase mobility because all increase overcrowding and hence the demand for housing, although this will only apply to effective demand, hence the use of the HHSEG variable. The expected signs are identical for all three variables and their lags, with a positive impact on out-migrants and a positive lagged effect on in-migrants. There is no impact expected for newbuild although housebuilding firms may show a speculative response to perceived high demographic demand; any such link is probably too tenuous to be acted upon as a guide to short-term investment decisions. The effect on turnover is expected to be positive, since trading up will be stimulated by all of these regressors.

6.6.5 The Unemployment Variable

The unemployment variable is assumed to operate as a mirror image to rateable values but the emphasis will be on non-local movers. If an area is depressed it will tend to push out all households and fail to attract replacements. It is possible that speculative builders will take the depression of an area as a sign that properties will not sell, but factors such as land release will also be important. The relationship between unemployment and turnover is not clear, since some trading down will occur but may be frustrated by lack of demand for the sellers' houses.

6.6.6 The Land Variable

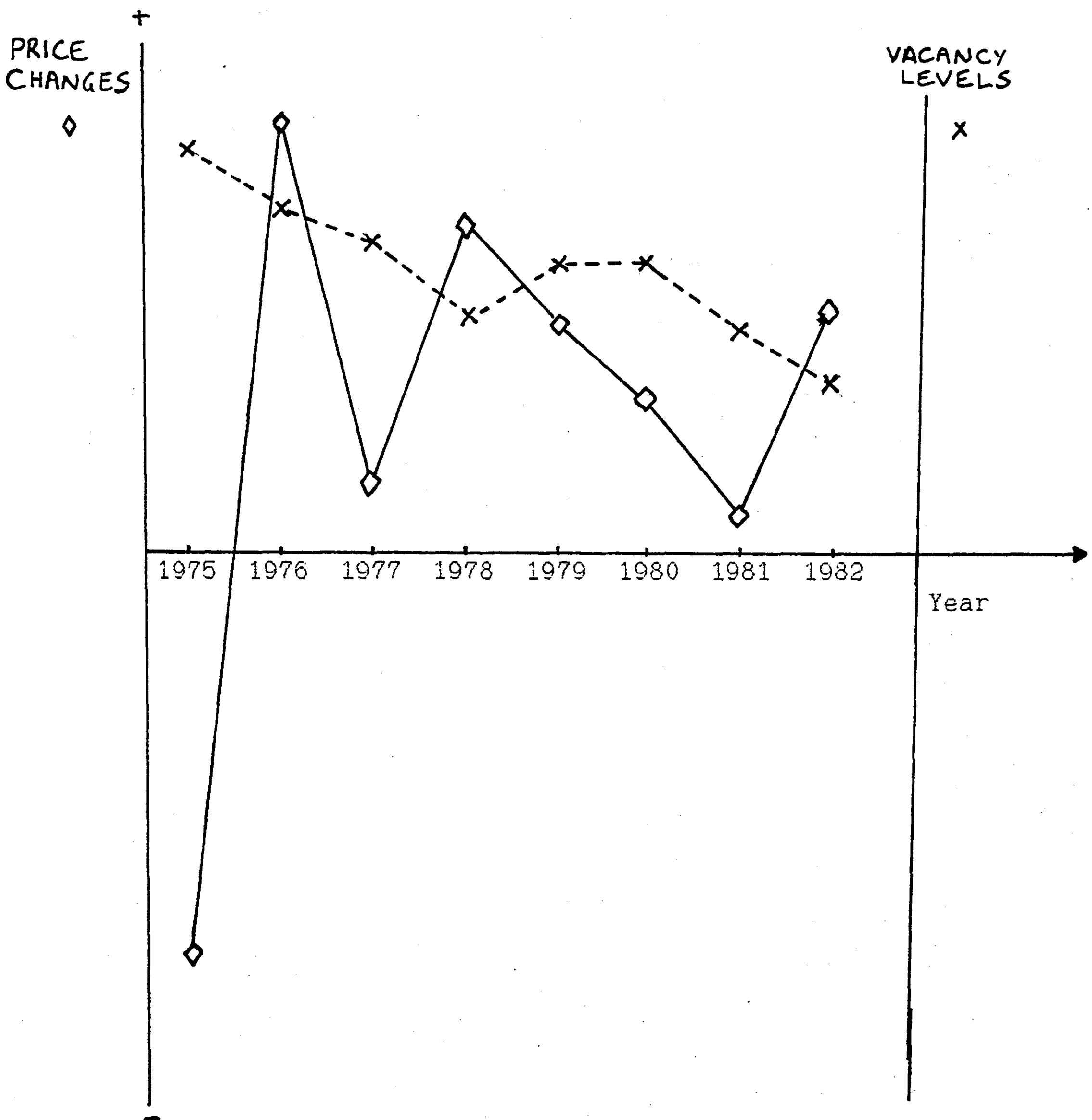
The last variable is the ratio of land held without planning permission to land held with planning permission; whilst this is a crude measure of builder's perceptions of the attractions of an area, it is subject to some inaccuracies if, for example, there is a high proportion of land held without planning permission because expected demand has failed to materialise It follows that this variable is effectively a "snapshot" of the two elements of a stock. These elements will be changing through time as builders attempt to acquire land in desirable areas and reduce their holdings of land in undesirable areas. Its use in this model assumes that there have been no major recent alterations to builders' desired land portfolio as a result of structural shifts in demand. For a housing market as relatively stable as that of Scotland this assumption is probably robust. This variable is expected to have a positive impact.

6.7 CONCLUSIONS

A number of the expected results which have been discussed here show some ambiguity because there is a pure effect, and one which is dependent upon the availability of demand or supply. Hence the model was also run with endogenous variables. A related consideration is the expected sign of the vacancy change variable. It has already been demonstrated that the sign achieved for this variable will, within a broad variety of specifications for the underlying model, yield qualitative information about the relative magnitudes of γ, a and b for each of the dependent variables. The expected signs given here are based on the assumption that the demand and supply elasticities dominate the vacancy rate-dependent variable relationship. This ambiguity arises from the lack of suitable price data, although the qualitative information is intrinsically useful.

It is possible to gain some idea of the nature of the relationship between vacancy rates and house prices in the Scottish case during the

FIGURE 6.4 REAL PRICE AND VACANCY CHANGES, SCOTLAND 1975-82



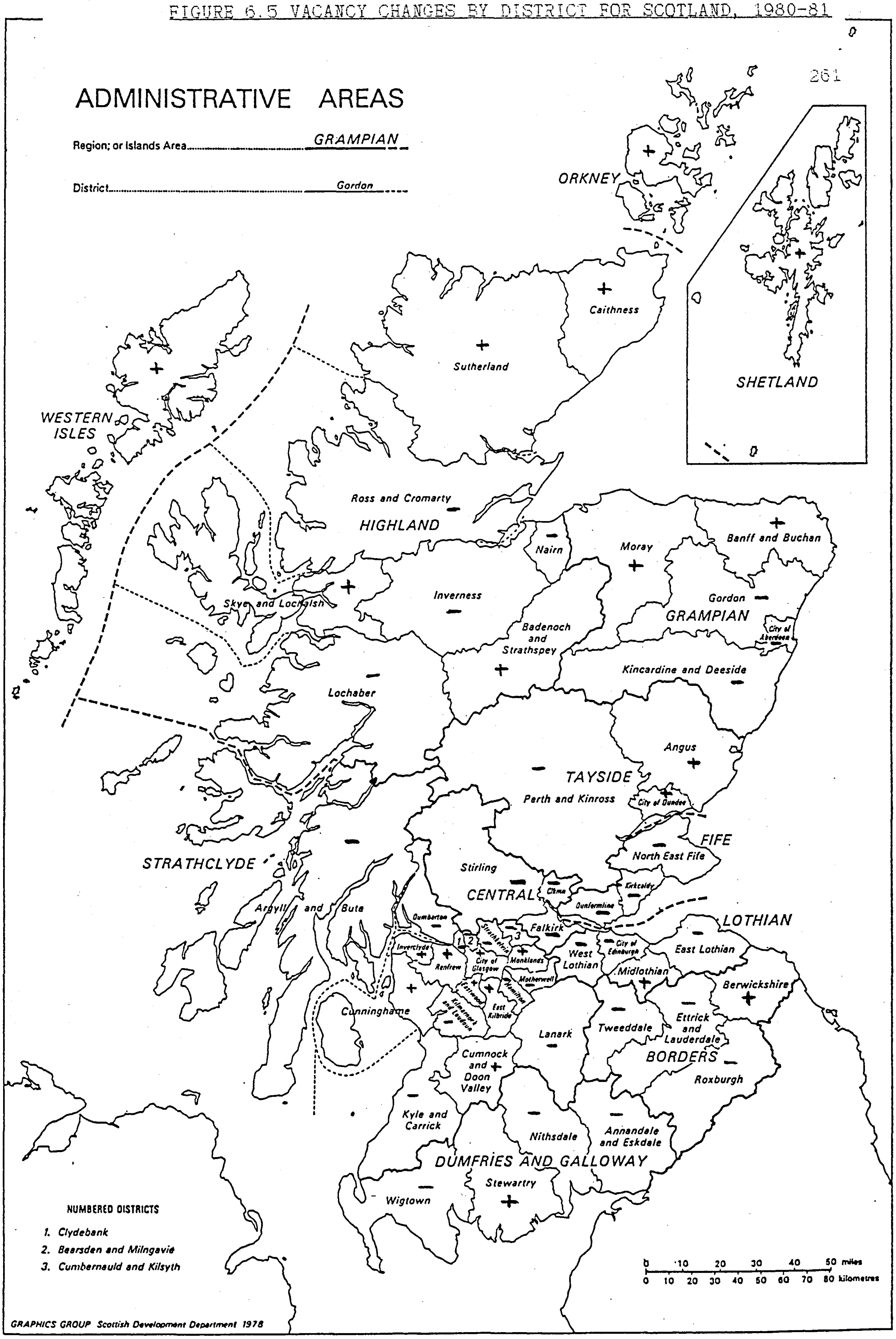
Sources: Scottish Housing Statistics
Registrar General for Scotland

period of this study by examining aggregate data (the criticisms of Chapter Three notwithstanding). In Figure 6.4, vacancy changes and real house price changes (adjusted by the GDP deflator) are shown for the whole of Scotland over the period 1975-1982; this demonstrates that perverse movements are possible and that prices tend to overshoot, although the small sample means that this is only indicative.

It also shows that in the period of this study, the bulk of the Scottish housing market was in a position of excess supply. However, this was not uniformly spread as can be seen from Figure 6.5 which shows the vacancy change status of Scottish districts for the period 1980-81. Whilst negative changes predominate, there are some notable exceptions. This reinforces the view that for a spatial commodity such as housing, aggregate data can be inadequate.

The expected signs for lagged vacancy changes are based on the assumption that the substitution effect dominates the contagion process, in contrast with the view taken for rateable values, above. This is based on the assumption that no perception process is involved and that consequently prices communicate information about the state of the market swiftly and accurately. It is possible for the reverse to be the case, but this would be another form of imperfect price-setting behaviour by housing market professionals, with respect to the spatial boundaries of a market rather than to its excess supply/excess demand status.

FIGURE 6.5 VACANCY CHANGES BY DISTRICT FOR SCOTLAND, 1980-81



Source: Registrar General for Scotland.

It is expected that vacancy rate changes will be positively associated with in-migrants, and negatively associated with the out-migrant and supply variables. Given the substitution effect, the signs for lagged vacancy changes are reversed. The signs for turnover are undetermined, because they depend on the structure of the existing market. If there are a large number of households attempting to sell their properties and trade up when excess demand exists at higher levels in the market hierarchy, then the net impact of the excess demand will be to depress turnover; with the position reversed, it will be facilitated.

This chapter has indicated some of the qualifications which have to be made when applying the spatial model to imperfect data. These caveats will be returned to on a number of occasions in the next chapter, which reports on regressions and other statistical analyses which have been applied to this data set.

CHAPTER SEVEN

EMPIRICAL RESULTS

7.1 INTRODUCTION

The purpose of this chapter is to present estimated forms for structural supply and demand equations of the Scottish housing market. These are based on the theoretical model discussed in Chapters Four and Five, and on the variables described in Chapter Six. The latter chapter also showed how the specific variables to be used reflect the four issues addressed in this thesis. The results reported here will indicate which of the spatial effects dominate for each class of movers and at what scale, and what the impact, if any, is of the public sector on the owner occupier market. Assessing the system dynamic behaviour is more problematic, because the high degree of collinearity between some of the independent variables, and with some of the dependent variables. The magnitude of these effects can be more clearly assessed by transforming the exogenous regressors into principal components and comparing the coefficients with those of equations which include endogenous variables.

The chapter is structured as follows. A preliminary section discusses an independent regressor correlations matrix, to give some indication of the reliability of coefficient estimates and of the likely extent of any collinearity problems. The subsequent sections discuss results for the seven dependent variables in turn. As discussed in Chapter Five, regressions can be of four types, depending upon the inclusion or exclusion of endogenous variables and spatial lags respectively. Each section is then split into two subsections, the first reporting results for aspatial regressions, the second for spatial. Principal components estimates are reported based on equations with principal components only, and on equations which include endogenous variables' All equations are estimated in linear and log-linear form. In each reported set of equations, the following statistics are given:

R^2 The ratio of explained to unexplained variation in the dependent variable, in each case adjusted for degrees of freedom.

I^* The adjusted Moran spatial autocorrelation statistic, defined in equation 5.23

BP The Breutsch-Pagan test for heteroskedasticity; this involves regressing the residuals on the regressors and indicates if there are grounds for higher disturbance variance being associated with any particular regressor or regressor combination. It is either present (H) or absent (-).

Throughout this chapter, t-statistics are given in brackets.

7.2 REGRESSOR CORRELATIONS

The discussion in this section is based on Table 7.1 which gives simple correlation coefficients between the exogenous regressor data series. As can be seen, the SEG, RV and URD variables are strongly intercorrelated which has implications for the income and quality based coefficient estimates. It should not be a problem if the equation R^2 is greater than the largest regressor correlation. This result suggests

TABLE 7.1 REGRESSOR CORRELATIONS

	LAR	OIL	URD	RV	SEG	U	BRTH	MHU	DV	LAND	HHSEG
LAR	1										
OIL	-0.16	1									
URD	-0.38	0.03	1								
RV	-0.11	0.07	0.57	1							
SEG	0.02	0.09	0.40	0.72	1						
U	0.16	-0.16	-0.45	-0.49	-0.23	1					
BRTH	-0.08	0.17	-0.13	-0.03	-0.02	-0.03	1				
MHU	0.01	-0.18	0.13	0.13	-0.07	0.25	0.13	1			
DV	0.23	-0.27	-0.28	-0.24	-0.16	0.15	-0.10	0.16	1		
LAND	-0.02	0.12	-0.03	0.01	0.12	0.20	-0.02	0.12	0.15	1	
HHSEG	-0.02	-0.17	0.18	-0.11	0.19	0.15	0.17	0.97	0.12	0.15	1

that higher income groups have adjusted to the available housing stock and that this result is detected at the regional data level. This is also associated with the degree of urbanisation which serves as a proxy for the concentration of higher income employment and more extensive amenities; the latter arising from the agglomerative force of consumption on service sectors. The matrix also demonstrates that the unemployment rate is negatively correlated with these variables; this is in contrast to expectations and may reflect a difference between registered and actual (i.e. non-economically active males) unemployment being highest in rural areas. This is corroborated by the much lower correlation between MHU and the three "urban" variables; in terms of the Ermisch household formation model it is economic for average household sizes to be greater in rural areas (perhaps from lower marginal costs of additional household members due to lower land costs, and lower marginal utility of privacy). It follows that casual labour can be more prevalent without inducing a high degree of residential stress. The main feature of this table is the way in which the urban-rural dummy has some form of significant correlation with most variables, which suggests that it is a key aspect of this study.

7.3.1 ASPATIAL LOCAL IN-MOVERS EQUATION

The exogenous regressor equation results are given in Table 7.2. Explanatory power is significantly increased by the inclusion of the endogenous variables OUT, OUTN, RCM, and TVR. The oil dummy is only significant in one equation and this falls with the addition of the endogenous regressors which arises, in part, from the collinearity between OUT and OIL. There are valid reasons for this relationship which will be discussed in more detail for the OUT equation.

The results also demonstrate the RV-SEG collinearity and the RV coefficient seems to be unstable particularly on inclusion of the endogenous variables. This indicates that movement throughout the region (in and out migration) has a definite spatial pattern, predicated on housing-related factors. The generally significantly positive coefficient suggests that housing-related movers are attracted to high quality housing. Further evidence of this appears in the other equations.

TABLE 7.2 ASPATIAL LOCAL IN-MOVERS EQUATION (OLS)

	(1)	(2)	(3)	(4) (LOGS)	(5) (LOGS)	(6) (LOGS)
C	-0.077	-0.03	-0.02	-56.5	-4.3	-6.05
	(-1.76)	(-3.3)	(-2.8)	(-1.63)	(-1.05)	(-2.88)
OIL		0.011	0.003		0.48	0.04
		(2.42)	(1.06)		(0.58)	(0.14)
URD	0.0006	-0.0006		0.44	-0.34	
	(0.54)	(0.58)		(0.91)	(-0.67)	
RV	0.00008	0.00011	0.00007	-2.35	-0.43	0.65
	(3.2)	(5.87)	(7.17)	(-2.78)	(-0.57)	(3.23)
SEG	0.0006			14.5		
	(0.97)			(1.99)		
U	0.022	-0.0067		-0.16	-0.36	
	(0.12)	(-0.038)		(-0.64)	(-1.35)	
BRTH	0.91		0.56	2.31		-0.04
	(3.04)		(2.60)	(1.80)		(-0.81)
MHU		0.017			5.3	
		(2.23)			(3.5)	
DV	0.001			0.17		
	(0.15)			(0.18)		
OUT			0.6			1.02
			(7.6)			(22.4)
OUTN			-0.15			-0.44
			(-1.4)			(-0.27)
RCM			0.01			-0.26
			(0.26)			(-0.28)
TVR			-0.2			-0.68
			(-3.1)			(-2.97)
R^2	0.48	0.48	0.81	0.09	0.18	0.92
I*	0.11	-5.99	0.04	0.25	0.81	-1.37
BP	-	-	-	-	-	-

The MHU and BRTH variables, both indicative of the age profile of an area (but also of lower per capita income in the case of MHU) show positive and significant coefficients in the linear form. In so far as peer effects on location operate, this result is to be expected, since young families relocating for housing-related reasons will tend to cluster with similar types of household. It is counterintuitive as far as potential competition is concerned since complex households and births will generate demand for additional housing; these competing influences can be seen in the fact that inclusion of the turnover variable results in a significantly negative coefficient and reduces the significance of BRTH, so that attractant and repellant forces both operate.

The endogenous variable results show a one-for-one relationship between OUT and IN (logarithmic coefficient value of 1.02) and a substantial negative impact from TVR which suggests that most within-district movers are competing with local in-movers. Each group may be first time buyers, or they may be existing owners trading up. This does imply an element of excess demand in these groups' markets.

The DV, URD, and U variables are always insignificant. As has been indicated previously, URD is strongly collinear with SEG and RV and hence URD is redundant in this equation. The insignificance of U will also result from collinearity with URD although some of this can be attributed to the oil dummy, whose inclusion reverses the sign of the U variable. It follows that the attractant force of low unemployment on local movers is weak. It is likely that housing-related movers will already be located in areas of employment levels similar to those of their destination anyway. The DV variable suggests that the response to short term market pressures is also weak, in keeping with the model set out in Chapters Four and Five where for an existing owner occupier, price differentials are more important than generally rising prices.

The logarithmic equations tend to have superior goodness of fit with some differences in patterns of coefficient significance. Overall, then, there appear to be non-linearities although the I-statistics show no consistent pattern as to the preferred equation; in the limiting case, this would imply spatial autocorrelation of the residuals when logs are used as opposed to the linear form, or vice-versa, depending on the equation. There is no evidence of heteroskedasticity.

7.3.2 SPATIAL LOCAL IN-MOVERS EQUATION

The spatial equations, given in Table 7.3, show improved I-statistics and increased explanatory power, although for the equations which include the endogenous variables the differences are negligible. Coefficient significance falls generally with URD, U, and DV remaining insignificant. The lagged regressors are more significant than some of their unlagged counterparts, such as DVL (intermittently and with an unstable coefficient depending on the presence of endogenous variables) URDL and UL, which have positive and negative impacts respectively. The first result demonstrates a preference for the suburbs and this is reinforced by the dependence of the spatially lagged coefficient significance on the exclusion of the RV variable. The latter may reflect the fact that areas of high unemployment will be a source of fewer housing-related moves, an effect which was not detected in the aspatial equations.

The endogenous regressors again lower the oil dummy significance (Table 7.4) but the lagged variables tend to reduce the significance of the endogenous variables themselves. This arises in part from the joint causality of lagged exogenous and unlagged endogenous variables.

As such, there are direct and indirect effects on the variable of interest, and these may be conflicting or reinforcing. This kind of collinearity is one reason for excluding lagged endogenous regressors even though such an inclusion is econometrically more correct, within the Sargan-Hendry methodology.

Local Authority rent levels are not significant which strengthens the view that the bulk of local movers are existing owners or their offspring.

The logarithmic equations again show superior fit whilst the I-statistics show no obviously preferred spatial fit. There is no evidence of heteroskedasticity.

The conclusions which can be drawn from these results are that the local in-movers variable is a reasonable proxy for housing-related moves. Spatial influences are apparent in the choice of area with a

TABLE 7.3 SPATIAL LOCAL IN-MOVERS EQUATION (I)(OLS)

	(1)	(2)	(3)	(4) (LOGS)	(5) (LOGS)	(6) (LOGS)
C	-0.03	-0.03	-0.03	-1.9	-3.4	-2.3
	(-2.7)	(-3.6)	(-3.3)	(-0.5)	(-0.98)	(0.68)
OIL		0.006			1.11	
		(0.81)			(2.16)	
LARL			-0.00003			-0.68
			(-0.83)			(-0.91)
URD	-0.0002	-0.001	-0.0005	-0.14	-0.11	-0.13
	(-0.17)	(0.07)	(-0.44)	(-0.5)	(-0.47)	(-0.48)
URDL	0.003	0.0002	0.023	0.74	0.98	0.8
	(1.57)	(0.07)	(1.1)	(1.76)	(2.24)	(2.2)
RV	0.00007	0.00007	0.00007	1.2	1.23	1.4
	(3.12)	(3.23)	(3.48)	(2.3)	(2.59)	(2.8)
RVL			0.00001			-0.8
			(0.41)			(-1.3)
U	0.04		0.09	-0.12		0.0006
	(0.24)		(0.56)	(-0.86)		(0.004)
UL		-0.71	-0.91		-0.13	-0.44
		(-1.97)	(-2.06)		(-0.5)	(-1.88)
BRTH	0.75	0.90	0.97	0.83	0.64	1.2
	(2.48)	(3.1)	(3.1)	(1.12)	(0.94)	(1.84)
BRTHL	-0.28	-1.46	-0.14	1.14	1.93	1.2
	(-0.66)	(-2.7)	(-0.51)	(1.53)	(5.63)	(1.63)
MHUL	0.012	0.04		1.26	1.37	
	(0.8)	(2.6)		(0.8)	(0.94)	
DV	-0.003	0.0011	-0.0013	-0.38	0.07	-0.09
	(-0.39)	(0.16)	(-0.18)	(-0.75)	(0.15)	(-0.18)
DVL	0.0008	-0.004	0.7	1.3	2.2	1.67
	(0.05)	(-0.26)	(0.42)	(0.95)	(1.8)	(1.35)
R^2	0.51	0.62	0.53	0.77	0.80	0.78
I^*	0.28	0.31	-1.49	0.12	0.18	0.2
BP	-	-	-	-	-	-

TABLE 7.4 SPATIAL LOCAL IN-MOVERS EQUATION (II)(OLS)

	(1)	(2)	(3)	(4) (LOGS)	(5) (LOGS)	(6) (LOGS)
C	-0.02	-0.02	-0.02	3.27	3.8	-6.6
	(-1.97)	(-3.4)	(-3.3)	(1.3)	(1.5)	(-3.0)
INL	0.6	-0.04	-0.1	0.34	0.29	-0.09
	(2.9)	(-0.3)	(-0.8)	(1.62)	(1.3)	(-0.57)
OIL	0.01	0.005	0.002	1.34	1.04	0.13
	(1.75)	(1.04)	(0.44)	(2.4)	(1.7)	(0.47)
URD	-0.001			-0.01		
	(-0.86)			(0.35)		
URDL	0.005			1.6	1.3	
	(3.34)			(4.3)	(3.1)	
U	0.002	0.2	0.1	-0.04	-0.02	0.14
	(0.13)	(1.57)	(1.5)	(-0.32)	(-0.16)	(1.73)
UL	-0.07	-0.03	-0.3	0.06	0.01	-0.25
	(-0.2)	(-0.16)	(-1.24)	(0.26)	(0.06)	(-1.6)
BRTH	0.75	0.75	0.7	0.96	1.1	0.67
	(2.36)	(3.0)	(2.9)	(1.44)	(1.6)	(1.38)
BRTHL	-0.24	-0.37	-1.0	1.52	1.14	0.12
	(-0.77)	(-1.39)	(-2.4)	(4.9)	(2.68)	(0.21)
DV	-0.004			-0.07		
	(-0.5)			(-0.14)		
DVL	0.02	-0.01	-0.02	2.75	2.24	-1.31
	(0.7)	(-1.1)	(-1.5)	(2.12)	(1.67)	(-1.6)
OUT		0.52	0.45		0.64	0.73
		(4.9)	(4.2)		(6.8)	(7.12)
OUTN		-0.36	-0.36		-0.51	-0.53
		(-2.8)	(-2.9)		(-2.8)	(-2.9)
RCM		-0.04	-0.02		-0.2	-0.18
		(-0.65)	(-0.4)		(-1.74)	(-1.66)
HHSEGL			0.0002			0.03
			(1.95)			(1.84)
R^2	0.53	0.78	0.80	0.77	0.77	0.92
I*	0.11	0.19	0.26	0.08	-0.04	0.18
BP	-	-	-	-	-	-

particularly strong effect for movement from the cities to the suburbs, where local movers compete with those trading up (and presumably local, newly formed households) in the destination area. Local in-movers are heavily dependent on a supply of second-hand houses from local out-movers, rather than from non-local out-movers or new houses. These results are not inconsistent with the theoretical model which predicts a relationship between the distance of the move and the house price bid. For this result to be valid, it must be the case that the local in-movers are unsuccessfully competing with non-local in-movers and this is confirmed in later equations.

Local in-movers are attracted to high quality housing in neighbourhoods with young families (i.e. with high birth rates) and are not moving to escape unemployment. Any market pressure effect yields counter intuitive coefficients, which suggests that $\gamma > 1/b+a$. The importance of spatial variables means that the number of submarkets is fewer than the number of districts with a minimum average distance for housing market interaction being 15 miles. Lastly, districts interact multiplicatively as do own district variables.

7.4.1 ASPATIAL NON-LOCAL IN-MOVERS EQUATION

The results for this group of movers are given in Table 7.5. The URD variable is negative and significant, except for the linear endogenous form. The logarithmic coefficient rises from -0.61 to -0.49 when the

TABLE 7.5 ASPATIAL NON-LOCAL IN-MOVERS EQUATION (OLS)

	(1)	(2)	(3) (LOGS)	(4) (LOGS)
C	0.005	0.015	-12.6	-1.5
	(0.17)	(4.64)	(-1.1)	(-2.1)
URD	-0.004	-0.001	-0.61	-0.49
	(-4.4)	(-1.44)	(-4.35)	(-4.66)
SEG	0.0001		1.78	
	(0.62)		(0.77)	
OIL	0.006	0.79	0.14	0.27
	(1.31)	(2.27)	(0.47)	(1.35)
DV	-0.01	-0.5	-0.81	-0.29
	(-2.21)	(-0.92)	(-2.2)	(-1.19)
OUT		-0.33		-0.19
		(-3.77)		(-6.2)
OUTN		0.46		0.55
		(3.7)		(4.6)
RCM		0.18		0.23
		(2.94)		(3.23)
TVR		-0.04		-0.02
		(-0.47)		(-0.11)
R^2	0.29	0.60	0.27	0.71
I*	0.18	0.02	-0.03	-1.04
BP	-	-	-	-

SEG variable is excluded and the endogenous included, so that the pattern of non-local moves has an urban-rural bias and depends, to some extent, on the other endogenous variables. The positive significance of the oil-dummy rises on inclusion of the endogenous variables as does the overall equation fit. The DV variable is negative and significant in both the linear and logarithmic forms but becomes insignificant on inclusion of the endogenous regressors. The negative coefficient implies that γ is high relative to 1/b+a as with the local in-movers equation, although the only endogenous variable with a significantly negative coefficient is OUT, so that it is not possible to separate out the effects of repulsion of potential in-movers due to unsuitable housing (for reasons of size or quality) and sluggish price adjustment to excess supply.

The pattern of significance on the endogenous variables implies that local outmovers have a moderately (in elasticity terms) negative effect on non-local in-movers, whilst non-local out-movers and newbuild have, respectively, strongly and moderately positive effects. This is not inconsistent with employment-related long distance movers reducing search costs by either purchasing new properties or those sold by other long distance movers. In keeping with the theoretical model, these latter households will offer any given quality of property at a proportionately lower asking price. As has already been demonstrated, however, all the dependent variables have an urban-rural bias so it is difficult to distinguish between the spurious and systematic effects; Equation 4 of Table 7.5 shows URD maintaining its significance ficance despite the presence of the supply availability variables. The turnover variable is negative but insignificant which suggests that intra-district movers and employment-related movers rarely compete. Overall, the logarithmic endogenous equation has superior goodness of fit so non-linearities appear to be present; this may indicate the presence of structural breaks or spatial trend surfaces, either of which could occur if the non-local in-movers category actually contains at least two distinct categories of relocator. This will be investigated further later in this chapter. There is no evidence of heteroskedasticity.

7.4.2 SPATIAL NON-LOCAL IN-MOVERS

The results for this group of movers when spatial variables are included are given in Table 7.6. The overall goodness-of-fit of the spatial equations yields little improvement over the aspatial but spatial autocorrelation is reduced in most cases. Two factors account for this; one is the increased ability of the long-distance mover to be successful in search, hence the reduced spatial search area; the other is that, being non-local, first order lag influences will not usually be generating moves; both processes will tend to reduce spatial interaction. There is no evidence of heteroskedasticity.

The negative significance of the URD variable rises when spatial lags are included, and URDL itself has a strong negative effect. The obvious implication is that non-local in-movers have a strong aversion to urban locations; this is in addition to the assumed attractive force of low unemployment. However, the unemployment variable is insignificant and

TABLE 7.6 SPATIAL NON-LOCAL IN-MOVERS EQUATION (OLS)

	(1)	(2)	(3)	(4) (LOGS)	(5) (LOGS)	(6) (LOGS)
C	0.01	0.015	0.02	-1.57	-7.56	-3.94
	(4.3)	(3.15)	(11.5)	(-2.2)	(-5.36)	(-3.52)
U		0.17			-0.017	
		(1.11)			(-0.15)	
UL		0.28			-0.16	
		(1.35)			(-0.96)	
DV		-0.008			-0.53	
		(-1.16)			(-1.66)	
DVL1	-0.01	-0.04	-0.05	-1.12	-3.0	-2.52
	(-1.3)	(-3.0)	(-3.49)	(-1.76)	(-3.88)	(-3.2)
OIL	0.01	0.007	0.006	0.22	-0.49	0.16
	(2.25)	(1.57)	(1.59)	(1.14)	(-1.48)	(0.59)
URD	-0.002	-0.0036	-0.004	-0.37	-0.67	-0.54
	(-2.47)	(-3.75)	(-4.89)	(-3.35)	(-4.16)	(-4.7)
URDL	-0.003	-0.0009		-0.25	-0.75	
	(-3.6)	(-0.48)		(-1.9)	(-3.14)	
RV		0.00001			0.66	
		(0.68)			(2.09)	
RVL		0.00002			-0.04	
		(0.90)			(-0.25)	
OUT	-0.54			-0.19		
	(-5.86)			(-6.21)		
OUTN	0.39			0.55		
	(3.6)			(4.6)		
RCM	0.18			0.19		
	(3.3)			(2.4)		
TVR	-0.08			0.00007		
	(-1.0)			(0.0004)		
R^2	0.70	0.4	0.37	0.47	0.50	0.72
I*	0.13	-0.26	0.31	0.37	0.64	-0.19
BP	-	-	-	-	-	-

the coefficient is unstable; this is probably due to collinearity with the urban-rural dummy.

The DVL variable is significant in the exogenous equations but this falls on inclusion of the endogenous variables as regressors, so that any apparent vacancy (i.e. price or market pressure) effects are probably operating on non-local in-movers indirectly, through the effect on out-movers. A reverse effect operates via URDL, since its significance rises when the dependent variables are included. This reinforces the view that non-local in-movers have a distinct non-urban location preference whilst URDL is having a positive effect on OUTN or RCM. The negative coefficient on DVL is, once more, perverse and implies price overshooting.

The endogenous variable coefficients tend to be highly stable, with the exception of turnover. The pattern of significance is identical to the aspatial model. It seems clear, therefore, that non-local in-movers are dependent on a supply of housing from non-local out-movers and housebuilders, whilst local out-movers have a negative impact. This latter may arise from opposing responses to some common third factor, such as the urban-rural dummy or local in-movers with whom non-local in-movers compete.

The oil dummy is positively significant in the linear equation when the dependent variables are present which underlines the employment-driven nature of long distance mobility. Rateable values are insignificant but collinearity with URD is strong.

The logarithmic fit is again superior to the linear form, and this indicates the possible presence of two classes of movers creating apparent non-linearity. There appears to be one employment-related element of the non-local in-movers, particularly due to the oil boom, and one element who are anti-urban but otherwise undirected in their relocation behaviour; possibly households with a retiring head.

There are important differences between local and non-local in-movers, most obviously the degree of aversion to urban location, but also the employment and housing related motives for mobility. In both cases there is evidence that there are fewer submarkets than districts, but this is more obvious for the local movers. Both classes of relocaters are more sensitive to the availability of supply than they are to short term market pressures, which suggests that first-time buyers are only a small proportion of in-movers; they are the only category who do not possess an imperfectly "index-linked" asset to finance their purchase.

7.5.1 ASPATIAL LOCAL OUT-MOVERS EQUATION

The results for this class of movers are given in Table 7.7. These equations exhibit some unusual characteristics, notably that the success of the linear version compared with the logarithmic reverses depending upon the inclusion of the endogenous variables. Unemployment rates, vacancy changes, and local authority rents are all insignificant, although in the logarithmic form the unemployment rate approaches significance. The negative sign probably reflects the dominating effect of a lack of buyers over the desire to leave a depressed area. The rent

TABLE 7.7 ASPATIAL LOCAL OUT-MOVERS EQUATION

	(1)	(2)	(3)	(4) (LOGS)	(5) (LOGS)	(6) (LOGS)
C	0.015	-0.04	-0.009	-17.3	3.02	4.8
	(0.34)	(-2.57)	(-0.79)	(-0.6)	(0.32)	(1.8)
DV	0.002	0.045		-0.28	0.11	
	(0.26)	(0.66)		(-0.36)	(0.13)	
IN			0.82			0.81
			(6.98)			(21.9)
INN			0.0026			-0.1
			(0.02)			(-0.93)
TVR			0.13			0.75
			(1.36)			(3.7)
LAR		-0.000007	-0.000002		0.7	-0.01
		(-0.29)	(-0.1)		(0.5)	(-0.02)
OIL		0.008	0.0007		1.0	0.3
		(1.65)	(0.19)		(1.4)	(1.52)
U	0.05			-0.38		
	(0.27)			(-1.77)		
MHU	0.014	0.016		5.27	4.97	
	(1.74)	(2.11)		(3.7)	(3.57)	
URD	0.003	0.003	0.002	0.007	0.51	0.001
	(2.54)	(2.34)	(1.75)	(0.014)	(1.12)	(0.008)
RV	0.00006	0.00004	-0.00004	-1.5	-1.17	-0.64
	(2.31)	(2.22)	(-2.34)	(-1.92)	(-1.70)	(-3.3)
BRTH	0.83	0.72	-0.004	1.59	1.67	0.07
	(2.63)	(2.27)	(-0.02)	(1.44)	(1.47)	(0.2)
SEG	-0.0004			4.9		
	(-1.29)			(0.80)		
R^2	0.38	0.40	0.73	0.35	0.32	0.95
I*	0.3	-1.2	0.04	-0.05	0.27	0.13
BP	-	-	-	-	-	-

level result indicates that those currently in public housing constitute a negligible proportion of local moves. The oil dummy is positive but below the threshold for significance, which implies a weak displacement of local households either due to lack of vacancies for trading up, or due to existing households extracting their equity from rising house prices and moving elsewhere.

The MHU variable is positive and generally significant, as are births and the urban-rural dummy. This means that despite collinearity, there are two related generators of local moves; one is the effect of potential demographic demand, the other is the repellent impact of urban locations. Taken together, this means that the strongest force acting on local out movers is pressure on living space, particularly in urban areas. (The significance of the births variable falls when the endogenous regressors are entered which is consistent with the attractant effect of births on in-movers).Rateable values are always negative but only significant in the linear equations when the endogenous variables are included. It follows that households in areas of high quality housing are less likely to move (probably due to lack of suitable alternatives). SEG is insignificant for the linear and logarithmic equations; collinearity with RV and URD is highly likely.

The inclusion of the endogenous variables results in a substantial increase in explanatory power, but this is due to local in-movers and, in the logarithmic form, turnover. Both are positive so that at least some of the intra-district movers are trading up and purchasing the houses of local out-movers; this suggests that the local out-movers are already existing owners and are moving beyond the district for housing-related reasons rather than because of short term market pressure. In the logarithmic model, the coefficients on turnover and local in-movers (0.81 and 0.75) sum to greater than unity, implying instability; this probably results from collinearity between the two variables. Non-local in-movers have an insignificant coefficient, and whilst this will result in part from differing spatial distributions of these classes of movers, it will also be due to their operation in different strata of house type submarkets. None of the equations show evidence of heteroskedasticity.

7.5.2 SPATIAL LOCAL OUT-MOVERS EQUATION

The spatial results for this group of movers are given in Table 7.8. The spatial exogenous equations provide a superior fit over the aspatial, but there is little difference as regards the endogenous, so that much of the apparent spatial effect is due to simultaneity. Nevertheless, the I statistics show some improvement. There is no evidence of heteroskedasticity.

The unemployment level and its lag are insignificant so no systematic effect, repellent or otherwise, is operating, probably because local movers are already in suitable employment and are relocating because of changes in their vertical location in the labour market, rather than altering their chosen labour market. This is consistent with the findings for local in-movers. As in the aspatial case, the positive significance of births and, now, the negative near-significance of lagged births falls when the endogenous variables are included; this

TABLE 7.8 SPATIAL LOCAL OUT-MOVERS EQUATION

	(1)	(2)	(3)	(4) (LOGS)	(5) (LOGS)	(6) (LOGS)
C	-0.048	-0.027	-0.022	4.59	0.94	-6.34
	(-4.13)	(-2.3)	(-1.84)	(1.76)	(0.58)	(-2.08)
OUTL	-0.055	-0.35	-0.36	0.19	-0.25	-0.18
	(-0.25)	(-2.03)	(-1.98)	(0.72)	(-1.58)	(-1.18)
OIL	0.011	0.011	0.012	1.26	0.78	0.72
	(2.42)	(2.69)	(2.77)	(2.45)	(2.7)	(2.5)
U	-0.055	0.14	0.17	-0.009	0.06	0.1
	(-0.32)	(0.96)	(1.18)	(-0.07)	(0.83)	(1.44)
UL	-0.56	-0.08	-0.16	0.1	0.03	-0.04
	(-1.51)	(-0.26)	(-0.49)	(0.48)	(0.83)	(-0.36)
BRTH	0.63	-0.05	0.02	1.42	0.05	0.34
	(2.15)	(-0.19)	(0.08)	(2.21)	(0.12)	(0.85)
BRTHL	-0.77	-0.18	-0.36	1.01	0.72	0.04
	(-1.76)	(-0.52)	(-0.98)	(1.97)	(2.39)	(0.08)
MHU	0.022	0.018		1.64	1.61	
	(2.65)	(2.49)		(1.84)	(2.94)	
MHUL	0.031	0.014		-0.93	0.017	
	(2.10)	(1.13)		(-0.54)	(0.02)	
HHSEG			0.00009			1.7
			(1.76)			(3.17)
HHSEGL			0.00013			-0.5
			(1.48)			(-1.6)
IN		0.47	0.41		0.63	0.58
		(3.87)	(3.34)		(8.4)	(7.83)
INN		-0.37	-0.44		-0.34	-0.39
		(-2.42)	(-2.88)		(-2.5)	(-3.04)
TVR		0.18	0.19		0.72	0.77
		(1.80)	(1.77)		(3.19)	(3.34)
URD	0.001	-0.00007	-0.00013	0.26	-0.04	-0.05
	(1.21)	(-0.07)	(-0.11)	(1.01)	(-0.27)	(-0.35)
URDL	0.002	0.002	0.0016	1.11	0.27	0.16
	(0.81)	(1.16)	(0.81)	(2.9)	(1.18)	(0.67)
DV	0.0001			0.08		
	(0.15)			(0.17)		
DVL	0.003	-0.009	-0.013	2.2	0.19	-0.09
	(0.16)	(-0.75)	(-1.03)	(2.0)	(0.28)	(-0.13)
R^2	0.58	0.75	0.74	0.84	0.95	0.95
I*	-1.28	-0.7	-0.08	-4.3	-1.7	-1.5
BP	-	-	-	-	-	-

underlines the fact that any impact on out-movers is through the availability of demand rather than direct movement generation or attraction. The oil dummy is always positive and significant in the spatial form, which reinforces the response of local out-movers to oil market induced pressure. Obviously this will include a shortage of suitably priced vacancies for households who would otherwise trade up.

The MHU variable is positively significant but the lagged version becomes insignificant when the endogenous variables are included. The situation here is similar to that for births, in that any spatial impact is indirect and indistinguishable from that of the dependent variables.

The urban-rural dummy and its lag are insignificant in most equations, unlike the aspatial version. This may arise from collinearity between this dummy and some of the spatially lagged regressors which means that housing-related moves, such as those from the city to the suburbs, are being decomposed into their components; that is, the attractive forces of peer-group areas with increased lot size acting as the "draw" to families with children.

The negative impact of non-local in-movers is increased in the spatial equations. The implication is that any desired move out of an area is prevented by competition from long-distance movers searching over a number of contiguous districts. This is in direct opposition to the findings for the behaviour of long distance movers discussed earlier which suggested search within a localised area. It is possible for this latter to be the case whilst finding general out-mover and in-mover competition if the spatial incidence of these two classes of mover happens to be coincident, and this will only in general be the case in the oil-related areas. The fall in significance of the urban-rural dummy, partly to the benefit of long distance migrants, is also indicative of the very different spatial distribution of these classes of mover. It follows that inference of causality in this particular case may be inappropriate. The spatial equation yields more stable estimates of the IN and TVR coefficients.

The process which emerges is of young families, primarily existing owner-occupiers, currently located in cities, moving to suburbs in order to locate with similar households and presumably to gain access to desirable suburban facilities and space. Such relocators are not always successful due to competition from employment related long distance movers but are dependent on in-migrant and trading up households to purchase their previous residences. The dependence of out-movers on in-movers is not as great as that of in-movers on out-movers; suggesting that in this market segment, there is excess demand. The generally weak impact of spatial variables indicates that push factors predominate. The primary driving force is demographic rather than earnings-related, and there is little impact from short term market effects, with the possible exception of those persuaded to relocate in order to realise windfall profits.

7.6.1 ASPATIAL NON-LOCAL OUT-MOVERS EQUATION

The results for this class of mover are given in Table 7.9. In general, the fit of these equations is very poor. There is a large increase in explanatory power when the endogenous variables are included and there is no evidence of heteroskedasticity. It seems a priori likely that this variable will be the most difficult to model given that long-distance out-movers will be attracted by employment opportunities in other areas, rather than responding to effects operating in their district of residence. As in the local out-movers equations, whether logarithmic or linear forms fit better depends on whether the endogenous variables are present.

The only significant regressor in the exogenous equations is DV in the linear formulation, with a negative coefficient. The oil dummy is negative but falls short of significance, whilst the unemployment rate, the urban-rural dummy, rateable values, SEG and MHU are all insignificant. This indicates, in particular, that any urban or rural bias in long distance out-migrants is not apparent.

The endogenous variables show non-local in-movers and turnover to be significant and positive in the linear case, suggesting that long distance out-movers are in the upper echelons of the housing market and sell their houses to intra-district movers trading up or to non-local in-movers. This latter result is consistent with the predictive model in Chapters Four and Five which implies that all long distance movers will favour reduced search periods and will bid or offer house prices

TABLE 7.9 ASPATIAL NON-LOCAL OUT-MOVERS EQUATION

	(1)	(2)	(3) (LOGS)	(4) (LOGS)
C	0.03	-0.01	-5.5	-1.75
	(0.77)	(-1.0)	(-0.56)	(-1.39)
U	-0.0046		0.04	
	(-0.03)		(0.52)	
DV	-0.014		-0.50	
	(-2.17)		(-1.73)	
IN		0.085		0.05
		(0.70)		(1.38)
INN		0.52		0.50
		(3.79)		(4.42)
TVR		0.23		0.34
		(2.36)		(1.77)
OIL	-0.0056	-0.007	-0.26	-0.32
	(-1.3)	(-1.85)	(-0.97)	(-1.67)
URD	-0.0006	0.00001	-0.04	0.13
	(-0.56)	(0.01)	(-0.22)	(0.90)
RV	0.000008	0.000003	0.21	0.15
	(0.34)	(0.18)	(0.79)	(0.77)
SEG	-0.00005		0.09	
	(-0.17)		(0.04)	
MHU	-0.007	0.057	-0.67	0.27
	(-1.04)	(0.88)	(-1.43)	(0.58)
R^2	0.02	0.37	0.05	0.32
I^*	0.1	-0.03	1.17	0.62
BP	-	-	-	-

appropriately. Conversely, local in-movers operate in a different market. Turnover is not significant in the logarithmic form.

7.6.2 SPATIAL NON-LOCAL OUT-MOVERS EQUATION

The spatial results for these movers are reported in Tables 7.10 and 7.11. A larger number of equations than usual are reported due to the relatively low explanatory power which results. The equations which show most improvement in overall fit are the linear and logarithmic ones which include births and the urban-rural dummy as positively significant regressors. This is interesting given the lack of relationship that exists with local in-movers, because it indicates that this is not purely due to the spatial distribution.

In most of the equations the DV variable is insignificant whilst its lagged value is sometimes significant and negative; this falls on inclusion of the births variable so there is a possibility of collinearity amongst some of the lagged variables. This negative coefficient implies that a shortage of vacancies in an adjoining district will increase the number of non-local out-movers. This is consistent with a number of processes, such as high competition in the district of residence and its neighbours either preventing would-be local migrants from relocating nearby or providing a more buoyant market for the sale of properties. The result for DV in the exogenous model is also consistent with these processes. Either way, there does appear to be some price and market pressure sensitivity amongst this class of movers, but this is overshadowed by the impact of demand availability.

TABLE 7.10 SPATIAL NON-LOCAL OUT-MOVERS EQUATION (I)

	(1)	(2)	(3)	(4) (LOGS)	(5) (LOGS)	(6) (LOGS)
C	0.03	0.02	-0.007	-5.44	0.71	-0.6
	(3.84)	(1.96)	(-0.7)	(-4.06)	(0.52)	(-0.58)
OUTNL		0.3			0.46	
		(1.18)			(1.66)	
U	0.21	0.18	-0.07	0.12	0.11	0.08
	(1.34)	(1.22)	(-0.45)	(1.44)	(1.57)	(1.18)
UL	0.84	0.45		0.13	0.23	-0.02
	(2.55)	(1.44)		(0.76)	(1.82)	(-0.4)
DV	-0.009	-0.006		-0.36	-0.20	
	(-1.44)	(-0.99)		(-1.26)	(-0.74)	
DVL	-0.025	-0.02	-0.005	-1.61	-0.91	-0.8
	(-1.87)	(-1.39)	(-0.37)	(-2.34)	(-1.41)	(-1.27)
URD	0.0005	0.001		0.05	0.24	
	(0.51)	(1.46)		(0.32)	(1.64)	
URDL	0.004	0.001		0.07	0.16	
	(2.06)	(0.60)		(0.30)	(0.76)	
RV	0.00001			0.42		
	(0.81)			(1.49)		
RVL	0.00001			0.03		
	(0.01)			(0.16)		
BRTH		0.72			1.16	
		(2.77)			(3.4)	
BRTHL		-0.56			-0.79	
		(-1.3)			(-2.33)	
MHU	-0.015	-0.018	0.6	-0.82	-0.84	0.08
	(-2.3)	(-2.47)	(0.9)	(-1.42)	(-1.65)	(0.17)
MHUL	-0.02	-0.005		-0.64	-0.81	
	(-2.33)	(-0.42)		(-0.66)	(-0.79)	
OIL	-0.002	-0.003	-0.009	-0.17	0.07	-0.37
	(-0.47)	(-0.60)	(-2.26)	(-0.56)	(0.25)	(-1.66)
IN			0.06			0.05
			(0.6)			(0.94)
INN			0.48			0.34
			(3.1)			(2.64)
TVR			0.18			0.52
			(2.0)			(2.67)
R^2	0.22	0.32	0.28	0.15	0.16	0.30
I*	0.08	-0.12	-0.02	2.1	1.64	0.87
BP	-	-	-	-	-	-

TABLE 7.11 SPATIAL NON-LOCAL OUT-MOVERS EQUATION (II)

C	-0.007	-0.01	3.1	1.03
	(-0.66)	(-1.67)	(1.17)	(0.82)
OUTNL	0.16		0.16	
	(0.64)		(0.65)	
OIL	-0.007	-0.008	0.06	-0.44
	(-1.73)	(-2.57)	(0.22)	(-2.28)
U	-0.008		0.1	
	(-0.58)		(1.68)	
UL	-0.06		0.09	
	(-0.2)		(0.84)	
BRTH	1.02	0.59	1.24	0.68
	(3.87)	(2.91)	(3.62)	(2.21)
BRTHL	-0.8	-0.25	-0.83	-0.03
	(-2.1)	(-2.1)	(-2.04)	(-0.3)
HHSEG	-0.00005		-0.06	
	(-1.16)		(-0.13)	
HHSEGL	0.00007		-0.52	
	(0.82)		(-1.63)	
URD	0.003		0.4	
	(2.87)		(2.9)	
URDL	-0.001		0.28	
	(0.54)		(1.5)	
IN	-0.02	0.06	-0.05	0.03
	(-0.17)	(0.69)	(-0.8)	(0.55)
INN	0.56	0.46	0.4	0.36
	(3.76)	(4.2)	(3.5)	(3.74)
TVR	-0.024	0.2	0.06	0.37
	(-0.22)	(2.86)	(0.3)	(2.43)
DVL	-0.008	-0.01	-0.16	-0.76
	(-0.58)	(-1.04)	(-0.26)	(-1.35)
R^2	0.47	0.44	0.48	0.37
I*	-0.04	-0.07	0.94	1.28
BP	-	-	-	-

Demographic factors seem to play a role particularly in mobility arising from births. The measure of overcrowding has a negative impact which is unusual, since MHU tends to be positively associated with births, but births and minimal household units represent different stages of the family life cycle in that a high number of potential households will be the result of older children and young adults living with parents. It follows that this result implies that non-local out-movers are younger than other migrants, a conclusion which contradicts the hypothesis that this group are higher per capita income households; unless they are both young and high income which implies a higher socio-economic group. This is in accordance with the long distance migration pattern but the only evidence for it is the positively significant coefficient for URD in the later equations, where RV does not appear and SEG has been entered as an element of the composite HHSEG variable.

The unemployment level is insignificant in all equations but the lag does have an important effect if births and lagged births are excluded; again this indicates some correlation between the lags. The unemployment coefficients suggest some movement to avoid job scarcity, but this effect is not strong, and is unstable. The oil dummy is negative and significant in some equations, which underlines the view of long-distance movers as respondng primarily to employment opportunities.

The conclusion is that the spatial formulation has only a limited impact on long distance out-movers, and this is also seen in the I-statistics which are almost unchanged compared with the aspatial. The equations show the continued strength of the oil market and the effect that this has on mobility. There are some demographic determinants but these suggest that the long distance migrants are younger than average. It follows that the main determinants of long distance out-moves are pull factors in other areas, and effective modelling of this would require higher order lags; these are precluded by collinearity of higher order lags due to the smoothing effect of the lagging process. There does not seem to be any particular spatial pattern for out-movers, and whilst their destinations may be spatially focused (as non-local in-movers) this will be the only category of households which may leave the system entirely.

7.7.1 ASPATIAL OUT-MIGRANT NEW HOUSEHOLDS EQUATION

The group of migrants whose behaviour is modelled in Table 7.12 are all newly formed households who are leaving a district. This is the only identifiable subset of all newly formed households. Any differences which exist between the out-moving newly formed households and new households in general will be similar to the differences between turnover and local or non-local outmovers.

Overall, the level of explanatory power is reasonable and rises, as usual, on inclusion of the endogenous variables. There is no evidence of heteroskedasticity. The demographic variables, births and minimal household units, are positive and generally significant which is in keeping with expectations given that any form of overcrowding will prompt the creation of a new household if this is feasible. The result

TABLE 7.12 ASPATIAL OUT-MIGRANT NEW HOUSEHOLD EQUATION

	(1)	(2)	(3)	(4) (LOGS)	(5) (LOGS)	(6) (LOGS)
C	0.13	-0.05	-0.1	58.9	11.3	6.4
	(1.59)	(-1.83)	(-5.3)	(3.61)	(2.16)	(2.24)
U	0.19	0.15		-0.11	-0.1	
	(0.58)	(0.48)		(-0.95)	(-0.74)	
OIL		-0.008	-0.06		-0.63	-0.67
		(-1.0)	(-0.9)		(-1.44)	(-1.58)
BRTH		1.78	0.95		2.47	2.39
		(3.28)	(1.75)		(3.88)	(3.47)
DV	0.018			0.86		
	(1.39)			(1.9)		
LAR	-0.000002	0.00001		-0.25	-0.20	
	(-0.06)	(0.32)		(-0.32)	(-0.25)	
URD	0.002	0.003	-0.003	0.08	0.16	0.17
	(1.02)	(1.55)	(-1.55)	(0.31)	(0.57)	(0.60)
RV	0.18	-0.00007		-0.04	-1.03	
	(0.03)	(-2.09)		(-0.09)	(-2.68)	
SEG	-0.001			-12.5		
	(-1.7)			(-3.53)		
MHU	0.04	0.03	0.07	1.96	0.89	2.07
	(2.64)	(2.03)	(5.2)	(2.50)	(1.12)	(2.04)
IN			-0.05			0.02
			(-0.3)			(0.29)
INN			0.4			-0.04
			(1.55)			(-0.2)
TVR			0.8			0.49
			(3.85)			(1.44)
R^2	0.22	0.30	0.47	0.34	0.33	0.51
I*	0.1	-0.31	0.06	0.2	0.84	-1.4
BP	-	-	-	-	-	-

for births should be assessed taking into account the fact that it is a moving average. The assumption is that during the model sample period, expected births were those which actually occurred (in general!) in 1982. Inclusion of the births variable is based on the hypothesis that mobility is a function of expected and actual births, and in particular that a significant proportion of newly formed households only leave their existing residence because of an imminent birth, or in order to marry with a birth shortly afterwards.

The RV and SEG variables can be seen to be acting as perfect substitutes for one another, in that their significances vary strongly when one or other is added to the equation. The strongly negative coefficient on each of these variables indicates that the newly formed households are more constrained in their choice than all other migrant groups. There will be some overlap in the composition of local out-movers and newly-formed out-migrant households, as can be seen in the similar reactions to demographic influences. The urban-rural dummy also shows some effect but never reaches significance, partly due to the presence of RV or SEG. The oil dummy has a negative but insignificant impact; this is compatible with fewer newly forming households in the Aberdeen City area but with a reduced proportion of new households forming in the two outlying districts, who subsequently are compelled to leave the area to find a residence. This would indicate that the newly formed household's search process is a highly localised one, imposed by a strong budget constraint which impacts both on search and on bids in excess of valuations.

The local authority rents variable is insignificant in every equation, so that very few of the new households are public sector tenants induced to seek owner occupation because of high rent levels. It is still feasible that this effect operates but only on those who purchase their own council houses, a scheme which at the time of preparing this thesis was not fully implemented. No such effect is detectable in the turnover equation either, but this will be discussed later in this chapter when estimates for this variable are reported.

The DV variable yields positive coefficients which borders on significance in the logarithmic form. This is, as in other equations, a perverse result which implies price overshooting; the only circumstances under which it is not perverse are if out-migrant and intra-district new households occur in stable proportions. Given the result here for the oil dummy and the general incidence of counter-intuitive, but significant, coefficients on the DV variable this appears to be unlikely and consequently the price overshooting phenomenon appears to be pervasive.

The unemployment regressor is insignificant which may indicate that those new households with the financial capacity to purchase a dwelling are spatially distributed independently of areas of high and low unemployment; this in turn implies that they are of a higher socio-economic group than most households in the area; this is in keeping with the model developed earlier which posits that higher SEG groups will have a higher spatial scale of operation. Newly forming households located randomly (say) will gravitate towards their own SEG types.

It is questionable which, if any, of the endogenous variables should be included but in the interests of avoiding excessive multicollinearity, only the in-movers and turnover figures are included. Of these the non-local in-movers have a positive but insignificant effect; the sign is as expected but so is the insignificance given that competition between these two classes of movers is unlikely. The turnover variable is positive and significant with the implication that new households face competition from intra-district movers, both existing owners and new households, and leave the district due to such displacing forces. The insignificance of local in-movers is surprising but may reflect the absence of existing out-mover owners from the dependent variable; nevertheless the implication is that new households and local in-movers do not compete which indicates that they operate in different strata of the market.

There is little difference in explanatory power between the linear and logarithmic formulations.

7.7.2 SPATIAL OUT-MIGRANT NEW HOUSEHOLD EQUATION

The spatial equations are reported in Table 7.13 and show little improvement in explanatory power apart from the linear endogenous form, which has an R^2 more than double that of the logarithmic. The I-statistics generally show little change, but these are only indicative. In general the patterns of significance are similar, but it is worth noting that URDL and DVL are close to significance (positive and negative respectively) The former indicates a suburban attractive force

TABLE 7.13 SPATIAL OUT-MIGRANT NEW HOUSEHOLD EQUATION

	(1)	(2)	(3) (LOGS)	(4) (LOGS)
C	0.02	-0.07	8.68	9.8
	(0.63)	(-2.8)	(1.47)	(2.33)
U	0.25	0.1	-0.07	0.08
	(0.58)	(0.46)	(-0.47)	(0.57)
UL	1.07	0.005	0.09	-0.013
	(1.50)	(0.01)	(0.31)	(-0.06)
DV	0.03		0.95	
	(1.89)		(1.77)	
DVL	-0.06	0.04	-2.03	0.29
	(-1.88)	(2.1)	(-1.56)	(0.28)
LAR	-0.00004	0.00005	-1.16	0.57
	(-0.10)	(1.73)	(-1.31)	(0.87)
LARL	-0.00002	0.00001	0.37	0.50
	(-0.30)	(0.46)	(0.52)	(0.96)
URD	0.002	0.00006	-0.11	-0.3
	(0.79)	(0.03)	(-0.34)	(-1.18)
URDL	0.006	0.002	0.74	0.38
	(1.42)	(0.9)	(1.33)	(1.1)
RV	-0.00007	-0.00008	-1.29	-1.86
	(-1.72)	(-3.01)	(-2.40)	(-4.4)
RVL	-0.00001	-0.00003	-0.24	-0.11
	(-0.18)	(-0.68)	(-0.27)	(-0.16)
MHU	0.03	0.04	2.29	2.1
	(1.68)	(3.1)	(2.05)	(2.4)
MHUL	-0.01		-1.44	
	(-0.38)		(-0.76)	
IN		-0.04		-0.07
		(-1.93)		(-0.4)
INN		-0.25		-0.02
		(-0.85)		(-0.07)
TVR		0.34		1.67
		(1.79)		(4.24)
R^2	0.24	0.74	0.23	0.33
I^*	0.15	-0.11	0.24	0.17
BP	-	-	-	-

despite the significantly negative RV coefficient, whilst the DVL result suggests, as usual, price overshooting. This coefficient becomes significant when the endogenous variables are included, but also changes sign; this means that some of the lagged vacancy effect is spurious and that in fact, at the lower end of the market, there may be fairly rapid price response to excess supply. The local authority rents variable is positive and almost significant in the endogenous equation but generally this effect is not important.

The local in-movers regressor is negative (as opposed to expectations) and almost significant but this is not repeated in the logarithmic form and seems to be at the expense of the turnover variable, so the analysis for the aspatial equations is probably still valid. The urban-rural dummy is not significant whilst the rateable value coefficient remains negative and usually significant. Births are excluded since the MHU variable seems, in this case, to act as an adequate proxy for both.

The general conclusion is that spatial effects are weak, implying that it is primarily push factors that operate on new households. They appear to face considerable competition from other market actors and want to locate close to cities (presumably for employment reasons) but are barred from locating in areas of high rateable values. They are responsive to the attractant effect of slack markets which implies that for the lower end of the market (where they have no competitors) prices adjust more rapidly than is generally the case. Further to this, newly-formed households tend to have a smaller scale of spatial search and there is evidence that a small proportion are dissuaded from entering or

TABLE 7.14 ASPATIAL NEW BUILDING EQUATION

	(1)	(2)	(3) (LOGS)	(4) (LOGS)
C	0.024	-0.005	-4.2	0.8
	(3.72)	(-0.67)	(-2.28)	(0.6)
DV	-0.004		-3.8	
	(-0.34)		(-0.75)	
OIL	0.013	0.006	0.70	0.5
	(1.59)	(0.8)	(1.75)	(1.43)
URD	-0.002	-0.004	-0.24	-0.15
	(-1.30)	(-2.03)	(-1.1)	(-0.73)
RV	-0.000006		0.03	
	(-0.20)		(0.08)	
LAND	0.0025	0.002	-0.008	-0.007
	(1.30)	(1.5)	(-0.1)	(-0.11)
IN		0.3		0.13
		(1.7)		(2.07)
INN		0.6		0.5
		(2.4)		(2.65)
TVR		0.5		0.67
		(2.5)		(1.97)
R^2	0.08	0.33	0.04	0.23
I*	-1.6	-1.25	0.2	0.17
BP	-	-	-	-

(more realistically) are persuaded to leave the council sector due to high rent levels.

7.8.1 ASPATIAL BUILDING EQUATION

The aspatial results for the rate of new building are reported in Table 7.14. The overall fit of the new building equations is poor, and significantly enhanced by the addition of the endogenous variables. There is no evidence of heteroskedasticity. The linear form seems to be preferred to the logarithmic.

The oil and urban-rural dummies are most affected by the inclusion of the endogenous variables. In the case of the oil dummy, the coefficient is positive but never attains significance even in the exogenous form, so that builders are either unwilling or unable to respond to the manifest demand pressure in these areas. The urban-rural dummy result indicates an aversion to urban sites generally, but the t-ratio varies depending on whether the form is linear or logarithmic, being significant only in the endogenous linear case. The apparent effect of either of these two variables may arise from constraints operating on builders, such as zoning controls (i.e. lack of planning permission) or lack of suitable brownfield sites to purchase for redevelopment. The LAND variable (the ratio of land held but without planning permission to land held with planning permission) tests the former hypothesis subject to the provisos discussed in Chapter Six, and whilst it has a positive coefficient, it is insignificant. It tends to approach significance in the linear form. Collinearity with the urban-rural dummy cannot be ruled out, and there are other land-related effects possible which this variable will fail to detect.

The rateable values coefficient is insignificant and this is the case even in equations (not reported) which exclude the urban-rural dummy; the implication being that housebuilders are not dependent on existing neighbourhood housing quality in order to "fix" the image of their product, and housebuilders supply all strata of the market as far as these strata have a clear spatial distribution.

The vacancy rate variable is negative but insignificant, implying that housebuilders do not react to localised short-term market pressure. This is not necessarily inconsistent with the literature discussed in Chapter Four which suggested that builders provide upmarket properties in boom times and aim for volume when the market is depressed, since the statement here is of the spatial distribution of building. It follows that housebuilders are confident of creating their own market in terms of the spatial location of the product; this is consistent with the result for rateable values, above.

All three endogenous variables have a positive impact on the rate of newbuilding, particularly non-local in-movers. The elasticities which are estimated in the logarithmic model imply instability if the spatial destinations of all three were to coincide, but this is unlikely. The strong result for these three endogenous variables is in accordance with the suggestion above that builders are addressing all housing market strata, and is also the pattern expected if builders are following a completion to order strategy. This in turn implies either that builders make no major errors in spatial targetting of their output, or that they possess sufficient market power viz-a-viz those offering second hand houses that they can guarantee occupancy of a property once built. Nevertheless it also highlights the dependence of the builder on the availability of short-term demand.

7.8.2 SPATIAL NEW BUILDING EQUATION

The spatial equation estimates are given in Table 7.15 and show some improvement in explanatory power over the aspatial forms in the exogenous case, and this is underlined by the reduction in the absolute value of the I-statistics; this is also apparent in the endogenous equations. As before, the linear equations demonstrate superior fit over the logarithmic.

The main points to notice concerning the spatial equations are the negative significance of the lagged vacancies regressor and the reduction in significance of the urban-rural dummy. Given that the t-ratio of DVL falls on inclusion of the dependent variables, the apparent importance of DVL may be spurious, but the coefficient still approaches significance in the logarithmic endogenous form. If there is a residual attractive effect from neighbouring high vacancy rates, then this is another example of perverse signs and hence of price overshooting.

TABLE 7.15 SPATIAL NEW BUILDING EQUATION

	(1)	(2)	(3) (LOGS)	(4) (LOGS)
C	0.02	0.001	-5.03	-1.4
	(3.80)	(0.14)	(-2.55)	(-0.4)
RCML		0.1		0.2
		(0.63)		(1.3)
OIL	0.01		0.32	
	(1.17)		(0.78)	
DV	0.006		-0.07	
	(0.46)		(-0.14)	
DVL	-0.07	-0.01	-3.29	-1.9
	(-2.49)	(-0.4)	(-2.84)	(-1.8)
URD	-0.003		-0.15	
	(-1.42)		(-0.70)	
URDL	-0.00002		-0.46	
	(-0.01)		(-1.48)	
RV	-0.00001	-0.00009	0.22	0.3
	(-0.42)	(-3.1)	(0.55)	(1.34)
IN		0.66		0.015
		(2.9)		(0.14)
INN		0.84		0.3
		(3.5)		(1.34)
TVR		0.35		0.63
		(2.2)		(1.85)
LAND	0.004	0.002	0.03	0.02
	(1.89)	(1.63)	(0.39)	(0.33)
R^2	0.16	0.33	0.15	0.24
I*	-2.1	-1.14	0.16	-0.44
BP	-	-	-	-

As indicated in the aspatial equations, there does not seem to be any particular spatial bias in the pattern of building, with rateable values still showing no significance although in the linear formulation, the lagged variable has a positive impact so that there is a need, albeit spatially weak, for builders to use a neighbourhood image to sell their product. The oil dummy is now insignificant but the LAND variable t-ratio rises slightly, so collinearity may still be a problem.

As for the aspatial equations, the endogenous variables dominate in terms of explanatory power in the linear case, although t-ratios are lower in the logarithmic form. Given the higher significance for DVL in this latter case, there may be some collinearity. This may imply that builders can effectively manipulate vacancy levels in adjoining districts which is consistent with the suggestion that the builder can create a market, drawing demand away from other areas. The coefficient for turnover remains positive, indicating that those households trading up have, on average, found the market to be in a state of excess demand.

In conclusion, it would appear that builders are effective at spatially targetting demand and that (presumably through effective marketing) are capable of drawing migrants away from other locations. They supply houses in a broad range of spatial areas and to a number of different housing market strata, but particularly appeal to non-local migrants, who will wish to minimise search time. Builders are capable of operating with the minimum of dependence on the local housing market, both in terms of the state of local market pressure and local market quality. In practice, there are probably two classes of builders, as has already been described in Chapter Four. National builders will possess considerable market power and can manipulate location decisions, but local builders will passively accept demand location and market price. Ambiguity in results may arise if the spatial distribution of activity of local and national builders varies.

7.9.1 ASPATIAL TURNOVER EQUATION

In the equations discussed thus far, it has become apparent that turnover can play a key role in the migrant behaviour of a number of household groups. As constructed, this variable consists of a heterogeneous series of migrant groups. Turnover will include newly formed households moving within the district and all households trading up; it follows that the degree of heterogeneity of the latter group will depend on the number of housing market strata that exist. It has been estimated that the average UK household moves once every seven years, and assuming a housing career lifetime of similar duration to that of employment, a figure of five or six moves in a household's lifetime is implied. Of these, only a subset will be intra-district within the context of the data used here; further only a subset will involve a move between housing market strata. It follows that perhaps two or three behaviourally distinct intra-district migrant groups are represented by the turnover variable.

The aspatial turnover equations are reported in Table 7.16 and show a high degree of explanatory power which is further improved by the addition of the endogenous regressors. The exogenous equations show that

TABLE 7.16 ASPATIAL TURNOVER EQUATION

	(1)	(2)	(3)	(4) (LOGS)	(5) (LOGS)	(6) (LOGS)
C	0.03	0.04	0.06	-1.97	0.43	-0.76
	(2.95)	(2.70)	(3.6)	(-2.41)	(0.26)	(-0.5)
U	-0.30	-0.33	-0.48	-0.08	-0.12	-0.1
	(-1.69)	(-1.86)	(3.21)	(-2.01)	(-2.73)	(-2.43)
LAR		-0.00002	-0.00001		-0.42	-0.3
		(-0.93)	(-0.75)		(-1.63)	(-1.3)
OIL		-0.005	-0.006		-0.25	-0.3
		(-1.11)	(-1.4)		(-1.76)	(-2.24)
URD	0.005	0.004	0.004	0.25	0.16	0.16
	(4.80)	(3.99)	(4.1)	(3.86)	(2.15)	(1.83)
BRTH	0.72	0.74	0.36	0.50	0.50	0.14
	(2.34)	(2.32)	(1.1)	(2.42)	(2.43)	(0.56)
MHU	-0.01	-0.02	-0.02	-0.56	-0.57	-1.11
	(-2.05)	(-2.09)	(-3.2)	(-2.35)	(-2.42)	(-3.5)
IN			-0.52			-0.18
			(-3.7)			(-2.9)
INN			-0.31			-0.09
			(-1.4)			(-0.8)
RCM			0.34			0.12
			(3.89)			(2.0)
OUT			0.28			0.21
			(1.7)			(2.8)
OUTN			0.27			0.11
			(1.54)			(1.1)
R^2	0.47	0.47	0.67	0.48	0.50	0.62
I*	0.6	0.87	-1.2	0.12	0.74	0.02
BP	H	H	H	H	H	H

H: Heteroskedasticity

the linear form yields the preferred fit, but the reverse holds for the endogenous. There is some evidence of heteroskedasticity, especially for the exogenous forms, associated with the urban-rural dummy in particular.

The urban-rural dummy is positive and highly significant in all equations except the logarithmic endogenous form. This indicates that urban households move more frequently but are dependent on a stream of in-migrants to purchase their houses or out-migrants to supply them with houses. Hence those in urban areas are most successful. This effect fails to capture the probable importance of first time buyers, originating in the same district, in purchasing the properties of those trading up. The birth rate is also significantly positive, but this disappears in the endogenous form. Hence although some households might be expected to trade up in response to overcrowding, there is also an effect on out-movers who have positive impact on turnover; thus it is difficult to distinguish between these two effects.

The minimal household units variable is always negative and significant, so that despite houses being relatively overcrowded, local turnover is low. The negative significance of the unemployment variable is increased by exclusion of the minimal household units variable. This would appear to indicate that low turnover and high household formation potential coincide in affluent areas. Two explanations are possible, both of which arise from the Ermisch (1981) model discussed in Chapter One. The first is that average house size is greater, so that the marginal privacy cost to existing household members of additional members is low. The other explanation is that for a given house, individuals in more affluent areas tend to have a lower propensity to form households, perhaps because of the high average product of the household production function.

The oil dummy tends to be insignificant except in the logarithmic endogenous form, where it has a significantly negative coefficient. It is not surprising to find some negative impact given that households wanting to trade up will find strong competition from non-local in-movers, but bearing in mind the fact that such households will also be experiencing windfall profits due to the appreciation of their own property, the generally weak impact of this variable is also to be expected.

The unemployment level is usually significant and negative, a result which is to be expected given that areas of high unemployment will not be experiencing house price inflation at the same rate as most areas, and consequently windfall profits will be fewer. However, this should not necessarily militate against mobility within the district unless there exist diferential house price inflation rates within different market strata. This latter possibility is not inconsistent with the view of different spatial scales of operation for different strata. The main reason for the reduced turnover in areas of high unemployment, however, is the difficulty in selling the existing property.

The local authority rents variable is generally insignificant although it approaches the critical level in the logarithmic form. A negative effect would be puzzling unless it implied that those attempting to move from the public sector compete with other new households and by doing so reduce the total number of intra-district moves. (Bear in mind that the turnover figures are classified by tenure at destination).

The endogenous variable results are generally consistent with the MHU result which has indicated excess supply as being a constraint on intra-district mobility; these endogenous coefficients suggest that intra-district migrants are short of properties to purchase. The MHU variable is still significantly negative in the endogenous forms. It follows that, by creating a demand for properties in higher strata than the first, large numbers of MHU's compound the shortage; hence large numbers of potential household units may be more associated with trading up households than with newly forming households. There is some evidence of heteroskedasticity, particularly associated with the URD variable; this implies that there is more "noise" in highly urban areas, and that estimates are not minimum variance (although still unbiased).

7.9.2 SPATIAL TURNOVER EQUATION

The spatial equations are reported in Table 7.17 and show an inferior explanatory power in the exogenous case and only a limited improvement in the endogenous case. There is also little change in the I-statistics. Once again, the goodness of fit of the linear and logarithmic forms varies according to the presence of endogenous variables. The incidence of heteroskedasticity is somewhat reduced.

TABLE 7.17 SPATIAL TURNOVER EQUATION

	(1)	(2)	(3) (LOGS)	(4) (LOGS)
C	0.04	0.05	-1.19	-2.1
	(3.45)	(3.62)	(-1.37)	(-1.68)
U	-0.2	-0.38	-0.08	-0.11
	(-1.02)	(-2.55)	(-1.98)	(-2.93)
UL	0.51	-0.06	0.16	0.09
	(1.28)	(-0.17)	(2.48)	(1.56)
IN		-0.53		-0.15
		(-3.87)		(-2.33)
INN		-0.46		-0.10
		(-2.33)		(-0.9)
OUT		0.12		0.14
		(0.69)		(1.67)
OUTN		0.20		0.12
		(1.13)		(1.15)
RCM		0.41		0.13
		(4.81)		(2.04)
URD	0.0056	0.005	0.29	0.19
	(4.30)	(4.27)	(3.58)	(2.32)
URDL	0.003	-0.001	0.20	0.14
	(1.03)	(-0.52)	(1.81)	(1.39)
BRTH	0.67	0.55	0.70	-0.02
	(1.98)	(1.65)	(3.20)	(-0.8)
BRTHL	0.29	-1.1	-0.20	-0.25
	(0.59)	(-2.2)	(-2.09)	(-0.99)
MHU	-0.22		-0.44	
	(-2.4)		(-1.37)	
MHUL	-0.02		-1.12	
	(-1.41)		(-2.05)	
HHSEG		-0.0002		-0.68
		(-3.4)		(-3.99)
HHSEGL		0.00001		-0.12
		(1.0)		(-0.58)
R^2	0.47	0.72	0.52	0.61
I*	-1.68	-1.52	0.28	-0.04
BP	H	H	H	H

The lagged versions of the birth and MHU variables are negative and significant in some cases, which reinforces the view that these determinants create migrant households who compete with those trading up in the district of interest. Both the births and lagged births variables fall in significance when the dependent regressors are entered, so there is no evidence of a direct births effect on turnover. Replacement of MHU with HHSEG in the endogenous equations shows an increase in the significance of the own-district variable but a fall in that of the lagged version. This endorses the conclusion that the MHU effect arises from those trading up rather than from first time buyers, who would tend to be of lower SEG.

The urban-rural dummy continues to be positive and significant, whilst its lagged version is insignificant, hence the decline in turnover rates from the city to the suburbs is very steep.

The unemployment variable continues to be significantly negative in the endogenous forms, but its lag is only significant in the logarithmic exogenous version; if households in areas of high unemployment have a high number of employment-related movers, then potential competitors for moving into an adjoining district will find more vacancies in the low employment areas, hence facilitating turnover where excess demand in higher market strata is dominant. This is a form of "gentrification" process, with housing-related movers of one quality strata displacing employment-related movers in another.

Whilst the overall pattern of significance for the exogenous variables is unaltered from that of the aspatial form, the importance of OUT and OUTN falls, due to the presence of the exogenous spatial regressors. It follows that there is a limited spatial impact, but one which it is difficult to separate out from the direct effect (exogenous lagged on endogenous) and the indirect (exogenous on endogenous on further endogenous). This has proved to be a common problem and one which, arising as it does from multicollinearity, is difficult to resolve. The significance of IN and INN rises.

The results for the turnover equations highlight a number of points. Firstly, there is a noticeable multicollinearity problem when all the endogenous variables are included, a result which is not surprising given the results achieved for other variables. Secondly, households trading up seem to have encountered excess demand as more of a problem than excess supply, hence the optimum strategy is to buy the new property and then sell the old one; this does not hold true for all classes of movers. This also means that in the urban areas (where turnover is highest) there is a sufficient supply of new households to complete the mobility chains. It also follows from these results that most of the in-movers, at least to urban areas, are not first time buyers (given the negative coefficients). The heteroskedasticity and the mixed experience with the logarithmic and linear forms implies that these results hold true more for highly urban areas than for others, where the turnover variable will have a more heterogeneous composition.

7.10 SUMMARY OF INDIVIDUAL REGRESSOR EQUATION RESULTS

This section draws together the results for each endogenous variable to arrive at a coherent picture of the Scottish housing market. A few general observations can be made: for most equations, the inclusion of endogenous variables and/or spatially lagged variables considerably increases explanatory power and in a number of cases eliminates spatial autocorrelation of the residuals. It is common, although not universal, for spatially lagged exogenous regressors to be more significant than their unlagged counterparts. On the assumption that each district approximates a submarket and that the district level is the maximum scale of spatial interaction, this class of results appears to indicate "location by default" whereby a household selects its destination by rejection of other locations, because of those locations' undesirable qualities.

A large number of the coefficient signs are ambiguous with those for the urban-rural dummy and the vacancy change variables giving the clearest results. Of these, the urban-rural dummy generally conforms with expectations although the vacancy change variable tends to show perverse signs, as has already been noted. The sign for the rate of completions is consistent with the vacancy change variable proxying prices, but if prices are generally sluggish it seems to imply that housebuilders are sensitive to vacancy rates rather than to prices, reflecting their extended information set. This agrees with the discussion in Chapter Four.

There is a substantial increase in explanatory power when spatial variables are included, but specific effects are not clear. It seems that the phenomenon of spatial interaction within the housing market can be said to be associated with the density of housing (i.e. the presence or absence of the urban-rural dummy) which is as predicted in Chapter Four, and with the related effect of price movements even although such movements seem to only sluggishly adjust to demand. This raises the question of the dynamics of the housing market. This has already been touched upon as far as the speed of price adjustment is concerned, where it has been suggested that for the Scottish housing market, the speed of adjustment of prices to excess demand or supply differs from the speed of adjustment of market actors to those prices.

The local in-mover and out-mover variables both show some degree of housing-related motivation in their behaviour. In-movers respond locationally to attractants at their destinations, such as "peer" variables, but out-movers respond to locational stress factors such as overcrowding. Both are positively impacted by the oil dummy, and both are relatively unresponsive to short-term market pressures. Out-movers appear to be leaving urban areas, and in-movers (the same households) are migrating from urban to suburban areas. Local out-movers are highly dependent on local turnover and on local in-movers as purchasers of their dwellings, whilst local in-movers compete with those moving within the district and with newly-formed households. Local out-movers seem to be reluctant to move once they are living in high quality housing. These results imply that local in- and out- movers are younger households, many with or expecting children. They are living in or close to urban areas and are constrained in their relocation behaviour by their workplaces. There is a considerable amount of two-way mobility between suburbs and urban areas, but some insensitivity to the local market environment.

The non-local in- and out- mover variables show less homogeneity. Non-local in-movers do not appear to be responding to employment related stimuli, and show a strong anti-urban bias. They compete with local in-movers to some extent. Out-movers who relocate some distance away are dependent on long-distance in-movers or local movers to buy their properties and are unable or unwilling to leave areas with depressed housing markets. There have also been fewer such moves from the oil-related areas. There is little urban or rural bias in the location behaviour of this group. It would appear that non-local in-movers are primarily elderly households moving to retirement properties, and that long-distance out-movers are a heterogeneous group, some of whom are "opportunistic", but generally constrained in their relocation behaviour, and responding to distant employment-based attractants at dispersed locations.

Newly-formed out-migrant households are also choice constrained, and compete with local movers. Provided the out-migrant subset of newly-formed households is a reasonable approximation of the behaviour of all newly-formed households, the results also indicate a tendency to avoid suburban areas. It is, however, possible that out-migrant new households are not representative and this result actually reflects the preference for higher quality (and possibly larger) houses of minimal household units located in complex households in suburban areas. There is weak evidence of responsiveness to short term market pressure, but the coefficient is perverse.

Housebuilders avoid urban areas and areas of high quality housing. They show no reaction to short term market pressure but are heavily dependent on the presence of volume demand. However, it is possible that builders spatially manipulate demand and can profitably build in areas where the housing market is depressed. This reinforces the view of the building industry as entrepreneurs who seek profitable opportunities to arbitrage between low land prices and potential but spatially remote demand. There is some support for this from the land variable results but a number of conflicting effects are present in this regressor.

Turnover is the least spatially sensitive variable and is associated primarily with urban areas, with a very steep decline in turnover towards the suburbs. There is some dependence on the presence of new supply and on local in-movers, so that the overall impression is of movers who have limited resources and move frequently, who require purchasers for their existing dwelling and who are in strong competition with one another.

Taken together, these results seem to support the notion of the region as a meaningful unit of analysis. Broad flows of households are discernable with some correlation between mobility "triggers", life-cycle stage, and relocation behaviour. Inter-district spatial influences have effects on most households but the precise impacts are not clear. The supply of vacancies and the existence of purchasers are essential elements for mobility to occur, far more than the "overall" state of the market. There is no evidence of high Local Authority rents having any impact on the housing market. The "housing market" seems to be far from homogeneous with a number of different but interacting levels. Given the relative weakness of overall market pressures, it is the interaction between housing market levels which will determine the dynamic behaviour of the system.

The results for the equations discussed here have to be qualified in a number of ways but the most important consideration is multicollinearity, to which some of the other qualifications are related. In addition, no single reliable set of elasticities for the endogenous variables has been given, again in part because of multicollinearity and in part because for each equation, although explanatory power is high, there is no single preferred specification. Apart from some collinearity between regressors, the dependent variable divisions may be rather too crude for specific effects to be clear. It simplifies specification considerably if the regressor data set can be reduced to a limited number of components. In addition to reducing mulitcollinearity and simplifying independent regressor specification, any discussion of dynamics requires a set of internally consistent elasticities which will determine the stability of the system.

In the light of these considerations, the next section undertakes a principal components analysis of the exogenous regressors and conducts some regressions on the resultant components. In addition to the considerations detailed above, this will provide a cross check on the interpretation of the results given here.

7.11 PRINCIPAL COMPONENTS ANALYSIS OF THE REGRESSORS

The principal components are constructed with five as a maximum in each group and a limiting criterion that the extracted components explain 95% of the variation in the data. Hence if a 95% level of explanation is achieved with fewer components, only that number will be extracted. The components in any one group will be approximately orthogonal. Two groups are used, the aspatial and the spatial exogenous regressors. As will become apparent, this results in some remaining redundancy but this has to be set against the aspatial/spatial separation. Five aspatial and three spatial components are extracted, with the factor loadings given in Tables 7.18 and 7.19

7.11.1 Aspatial Components

(1) The regressors which load most highly on this factor are the urban-rural dummy, rateable values, and socio-economic groups. It follows that this is primarily a city and suburban factor; this will also include some element of the oil dummy.

(2) This factor is most strongly associated with moderate socio-economic status, fairly low unemployment, and a low potential demographic demand. Whilst this suggests suburban areas as far as social status is concerned, the lower association with rateable values

TABLE 7.18 PRINCIPAL COMPONENT FACTOR LOADINGS (LINEAR)

	1	2	3	4	5
URD	0.75	0.26	0.40	0.07	0.21
RV	0.82	0.39	-0.10	-0.01	-0.20
SEG	0.70	0.27	-0.11	-0.34	-0.37
MHU	-0.21	0.13	0.83	-0.24	-0.21
U	-0.61	-0.15	0.21	-0.51	0.03
OIL	0.27	-0.74	-0.22	0.01	-0.11
LAR	-0.37	0.29	-0.45	-0.44	-0.39
DV	-0.53	0.48	-0.03	0.07	-0.11
LAND	0.47	-0.44	0.08	-0.60	0.09
BRTH	-0.03	-0.37	0.24	0.38	-0.76
URDL	0.71	0.56	0.18		
RVL	0.90	0.31	0.19		
SEGL	0.98	-0.14	0.02		
MHUL	0.97	-0.15	0.04		
UL	0.18	-0.88	-0.28		
LARL	0.94	-0.25	-0.03		
DVL	-0.27	-0.53	0.79		
BRTHL	0.91	-0.18	-0.07		

TABLE 7.19 PRINCIPAL COMPONENT FACTOR LOADINGS (LOGS)

	1	2	3	4	5
URD	0.81	0.24	0.35	0.14	0.19
RV	0.84	0.26	0.01	-0.14	-0.13
SEG	0.67	0.19	0.08	-0.34	-0.44
MHU	-0.25	0.03	0.80	0.18	-0.19
U	-0.75	-0.08	0.25	-0.27	0.12
OIL	0.24	-0.70	-0.42	0.06	-0.20
LAR	-0.40	0.35	-0.28	-0.42	-0.48
DV	-0.48	0.57	-0.05	0.17	-0.24
LAND	0.03	-0.45	0.40	-0.69	-0.01
BRTH	-0.04	-0.40	0.20	0.45	-0.64
URDL	0.62	0.63	0.04		
RVL	0.98	-0.10	-0.03		
SEGL	0.98	-0.17	-0.05		
MHUL	0.28	0.65	-0.64		
UL	-0.96	0.06	-0.12		
LARL	0.97	-0.19	-0.05		
DVL	-0.28	-0.48	-0.78		
BRTHL	-0.97	0.19	0.04		

and the low demographic demand implies areas with households which are either at the very beginning or the very end of the household life cycle, and possibly both. Hence it represents transitional areas which are not properly suburban and may include some rural areas in the early stages of urbanisation.

(3) This factor shows high potential demographic demand, high unemployment and low socio-economic status. This almost certainly represents depressed areas, demonstrating the tendency for unemployment to primarily affect those in the lower status vocations. The household formation model predicts that low per capita income will be associated with larger household size, so this result is not surprising.

(4) The fourth factor is associated with high birth rates, low unemployment rates, and does not score highly on the urban-rural dummy. Consequently, this represents high-growth rural areas; that is, areas where there is a higher and growing proportion of young households, and most moves are employment-driven.

(5) The last aspatial factor is strongly urban, but shows low birth rates and low socio-economic status, suggesting that it represents elderly people in cities and adjacent areas.

7.11.2 Spatial Components

(1) The first spatial factor scores highly on the lagged versions of the urban-rural dummy, and the other regressors that load highly on

the first aspatial component. It also shows an association with low unemployment levels, and with low vacancy increases. It represents adjacency to areas of higher employment growth and higher demand for housing, so that it is a more diffuse element of the data than a suburban component would be.

(2) The second component scores moderately highly on the urban-rural dummy, but is not associated strongly with rateable values, or with unemployment levels and vacancy increases. This suggests suburbs and also adjacency to fast growing areas with pressure both in labour and housing markets, so that it corresponds to transitional areas.

(3) The last spatial component scores weakly on the urban-rural dummy and on rateable values, whilst scoring highly on vacancy increases. This implies association with rural and depressed areas.

It follows that the spatial regressors are reducible to three elements depending upon the characteristics of adjacent areas, but that each of these is primarily associated with the urban-rural dummy or housing market pressure. Given the smoothing effect of the spatial lagging process, the smaller number of components is not surprising.

7.12 PRINCIPAL COMPONENT REGRESSIONS

The next step is to use these components in regressions, bearing in mind that there will be a degree of collinearity between some of the aspatial and spatial variables. Six tables of regressions for linear and logarithmic forms are reported. These consist of two exogenous (Tables 7.20 and 7.21) and four endogenous (Tables 7.22 to 7.25), with the last two Tables showing endogenous variables taking the form of a "control" by including all dependent variables and comparing the coefficients with those of the first set. These control regressions are only carried out for five of the dependent variables, since the turnover equation already includes all of the endogenous regressors and the new household equation has interpretability problems. For the other five variables, this process provides a check on the robustness of estimates in the presence of dependent variable collinearity and hence on the interpretability of the coefficients. Given that the same regressors are common to all equations, and that the dependent variables are related, the Seemingly Unrelated Regressions technique (SURE)[2] is used for the exogenous equations.

7.12.1 Exogenous Principal Component Results

Unlike the individual regressor results, there are considerable, almost symmetric, differences between the linear and logarithmic patterns of significance, and in terms of which shows superior goodness of fit. The main reason for this derives from the fact that each component can be associated with a particular subset of areas; given that there is evidence for spatial interaction and non-linearity, it is possible for there to be two classes of regressor for each dependent variable, each of which is important, but the elements of one enter linearly and those of the other interactively.

TABLE 7.20 PRINCIPAL COMPONENT EXOGENOUS REGRESSIONS (SURE)

	IN	INN	OUT	OUTN	HHFR	RCM	TVR
C	0.01	0.02	0.01	0.02	0.02	0.02	0.04
	(14.1)	(21.4)	(13.3)	(18.2)	(13.9)	(12.7)	(37.0)
PC1	0.003	-0.002	0.0007	0.001	-0.005	-0.001	0.004
	(2.9)	(-1.6)	(0.65)	(1.1)	(-2.43)	(-0.76)	(2.8)
PC2	-0.0004	-0.002	-0.001	-0.0001	-0.0004	-0.005	0.00004
	(-0.47)	(-2.69)	(-2.0)	(-0.14)	(-0.22)	(-2.95)	(0.03)
PC3	0.001	-0.004	-0.003	-0.0002	0.008	0.002	0.002
	(1.13)	(-4.53)	(-3.71)	(-0.27)	(4.47)	(1.2)	(1.43)
PC4	0.0002	-0.001	0.0009	0.001	0.001	-0.002	0.004
	(0.18)	(-1.26)	(1.0)	(1.14)	(0.77)	(-1.04)	(3.7)
PC5	-0.004	0.0007	-0.002	-0.0008	-0.003	-0.003	0.002
	(-4.98)	(0.9)	(-2.8)	(-0.9)	(-1.7)	(-1.99)	(1.64)
PCL1	0.003	0.001	0.004	-0.0007	0.001	0.001	0.0006
	(2.7)	(1.21)	(4.16)	(-0.65)	(0.51)	(0.80)	(0.45)
PCL2	0.003	-0.0002	0.003	0.0003	0.002	0.001	0.001
	(3.28)	(-0.3)	(3.67)	(0.34)	(0.92)	(0.52)	(1.1)
PCL3	0.002	-0.003	0.002	-0.002	-0.002	-0.004	-0.001
	(2.1)	(-3.4)	(2.1)	(-2.41)	(-1.4)	(-2.3)	(-0.99)
R^2	0.58	0.56	0.55	0.05	0.32	0.26	0.36
I*	2.4	-3.7	1.62	-0.6	0.2	0.74	1.47
BP	-	-	-	-	-	-	H

TABLE 7.21 PRINCIPAL COMPONENT EXOGENOUS REGRESSIONS (LOGS)(SURE)

	IN	INN	OUT	OUTN	HHFR	RCM	TVR
C	-4.4	-4.2	-4.4	-4.2	-3.9	-4.1	-3.2
	(-4.6)	(-7.7)	(-5.3)	(-8.6)	(-5.7)	(-5.4)	(-10.3)
PC1	0.47	-0.14	0.35	0.02	-0.4	-0.06	0.13
	(3.83)	(-2.0)	(3.3)	(0.34)	(-4.7)	(-0.7)	(3.2)
PC2	-0.07	-0.1	-0.11	-0.03	-0.04	-0.19	-0.006
	(-0.7)	(-1.76)	(-1.3)	(-0.53)	(-0.5)	(-2.51)	(-0.2)
PC3	-0.14	-0.11	0.03	0.08	0.3	0.2	0.0006
	(-0.94)	(-1.34)	(0.28)	(1.05)	(2.9)	(1.7)	(0.01)
PC4	0.1	-0.16	0.24	-0.04	0.4	0.09	0.08
	(0.98)	(-2.92)	(2.8)	(-0.74)	(5.3)	(1.2)	(2.6)
PC5	-0.1	-0.05	-0.07	-0.05	-0.12	-0.28	0.06
	(-0.93)	(-0.82)	(-0.7)	(-0.81)	(-1.44)	(-3.22)	(1.5)
PCL1	-1.19	0.08	-1.1	0.04	0.18	0.03	-1.2
	(-9.6)	(1.2)	(-10.1)	(0.68)	(1.97)	(0.33)	(-9.6)
PCL2	0.57	-0.13	0.50	-0.004	0.04	-0.09	0.04
	(4.1)	(-1.6)	(4.2)	(-0.57)	(0.4)	(-0.8)	(0.85)
PCL3	-0.2	0.2	-0.13	0.16	0.23	0.28	0.02
	(-1.3)	(3.0)	(-1.16)	(2.4)	(2.5)	(2.75)	(0.47)
R^2	0.73	0.46	0.78	0.03	0.52	0.29	0.33
I*	3.1	-1.38	2.1	-0.42	0.22	0.68	-0.91
BP	-	-	-	-	-	-	H

Without regard to linearity or loglinearity, the urban/suburban component is significant for all dependent variables except non-local out-movers. It is positive for local in- and out- movers, and for newbuild and turnover; it is negative for non-local in-movers and newly formed out-migrant households. The only unexpected result here is the newbuild positive effect, which might be expected to be the reverse due to land constraints. As in the individual regressor equations, this component shows some evidence of heteroskedasticity in the turnover equation.

The suburban/transitional component has a negative impact on local out-movers and non-local in-movers; the first result is as expected, since having left the city, it is unlikely that housing-related migrants will make any spatially specific moves. The second implies that long-distance movers will avoid urban and suburban destinations; this is partly due to some rural areas being growth nodes, it is also due to this category of mover including retiring couples moving to rural locations.

The depressed area component has a significantly negative effect on local out-movers and non-local in-movers, as for the previous component. This implies that these areas are (not surprisingly) avoided by employment-related migrants, and show <u>low</u> levels of housing-related moves, which reflects the difficulty involved in selling houses in depressed areas. There is a positive impact on the out-migration rate of new households, which implies that the desire to relocate exists but can be frustrated if the household is forced to act as a dual searcher in a depressed market.

The fourth component which represents high growth rural areas has a positive effect on local out-movers, new household out-migrants, turnover and new housebuilding, but a negative impact on non-local in-movers. These results are puzzling and only, in the main, arise in the logarithmic form. However they are not inconsistent with housing market pressure displacing new households, but facilitating trading up by existing owners; the excess demand for housing also stimulating newbuilding. Whilst growth of earnings might be responsible for some of the shortage, it is not clear where the additional numbers of households come from, given the negative effect on long-distance in-migrants (who may be elderly and of limited resources). It follows that much of the additional volume of households comes from local household formation, as evidenced in the turnover variable.

The component which is associated with elderly households in cities is negatively significant in the local in- and out- mover equations, and insignificant elsewhere. This implies that most elderly households move long-distances; of those that remain, a number may be in public sector housing.

The high status, urban adjacency variable is negative in the case of local in-movers and turnover; it is positive in the case of new household out-migrants and the sign varies in the local out-mover equation. The results for the first two variables are as expected and the new household effect is consistent with the children of middle-class families moving back to cities.

The adjacency to suburban and related areas is positively significant in the local in- and out- mover equations, and insignificant elsewhere. This indicates the high degree of housing-related moves in outlying areas, with some moves closer to the city (the out-movers), perhaps older households wanting more central and compact accomodation.

The adjacency to depressed areas variable shows some important differences compared with the direct, aspatial equivalent. There is a negative effect on non-local out-movers and on housebuilding, whilst the local out-mover effect is positive. The impact on non-local in-movers varies. These results seem to be indicative of a "contagion" effect but one which operates imperfectly. Existing households can observe the possibility of their area declining and sell their properties; there are still some purchasers, especially non-locals, but the direct impact on employment does not operate, so few households become long distance out-movers because they are still in employment. Housebuilders also see the problem emerging, perhaps due to falling house prices, and do not invest.

7.12.2 Endogenous Variable Principal Component Results

The main difference which emerges in the endogenous forms is the reduction in importance of the spatial components, indicating that at least some of the apparent exogenous variable effects arise, instead,

TABLE 7.22 PRINCIPAL COMPONENT AND JDV REGRESSIONS (I)

	IN	INN	OUT	OUTN	HHFR	RCM	TVR
C	0.02	0.015	0.003	0.002	-0.03	-0.03	0.04
	(4.26)	(4.82)	(0.47)	(0.31)	(-2.1)	(-2.95)	(9.3)
PC1	0.004	-0.0008	-0.002	0.002	-0.01	-0.005	0.005
	(4.7)	(-1.1)	(-2.1)	(1.48)	(-4.1)	(-2.3)	(3.6)
PC2	0.0006	-0.001	-0.001	0.001	0.0006	-0.002	-0.0001
	(0.36)	(-2.1)	(-1.9)	(1.17)	(0.37)	(-1.6)	(0.34)
PC3	-0.001	-0.003	0.002	0.0015	0.007	0.004	-0.001
	(-1.4)	(-3.9)	(2.8)	(1.63)	(4.24)	(2.3)	(-1.12)
PC4	0.001	0.00006	0.0001	0.001	-0.002	-0.003	0.004
	(1.2)	(0.9)	(0.2)	(1.06)	(-1.35)	(-2.3)	(3.9)
PC5	-0.002	0.002	0.0003	-0.002	-0.004	-0.002	0.0015
	(-3.17)	(2.45)	(0.4)	(-1.97)	(-2.12)	(-1.3)	(1.25)
PCL1	0.0002	0.003	0.003	-0.001	-0.001	-0.02	0.0025
	(0.2)	(3.5)	(3.0)	(-1.1)	(-0.4)	(-1.08)	(1.86)
PCL2	0.0014	0.0008	0.001	0.0005	-0.0004	-0.025	0.002
	(1.77)	(1.13)	(1.5)	(0.5)	(-0.2)	(-1.25)	(2.1)
PCL3	0.0005	-0.0004	0.0002	-0.0004	-0.001	-0.015	0.0006
	(0.67)	(-0.61)	(0.3)	(-0.47)	(-0.5)	(-1.01)	(0.54)
IN			0.63	-0.08	0.27	0.66	-0.64
			(5.2)	(-0.6)	(1.01)	(2.68)	(-3.24)
INN			-0.21	0.5	0.41	0.98	-0.72
			(-1.64)	(3.5)	(1.44)	(3.8)	(-3.04)
OUT	0.62	-0.3					0.11
	(5.8)	(-3.5)					(0.53)
OUTN	-0.11	0.5					0.52
	(-1.02)	(5.3)					(2.81)
RCM	0.07	0.27					0.42
	(1.03)	(5.02)					(4.4)
TVR	-0.26	-0.20	0.11	0.14	0.91	0.65	
	(-2.86)	(-2.64)	(1.22)	(1.4)	(4.73)	(3.6)	
R^2	0.8	0.79	0.78	0.32	0.54	0.50	0.61
I*	0.94	-0.06	1.10	-0.73	-0.18	-0.56	0.21
BP	-	-	-	-	-	-	-

TABLE 7.23 PRINCIPAL COMPONENT AND JDV REGRESSIONS (I)(LOGS)

	IN	INN	OUT	OUTN	HHFR	RCM	TVR
C	-2.57	-2.48	-1.65	-1.3	0.62	0.91	-2.2
	(-2.3)	(-3.7)	(-1.6)	(-1.2)	(0.45)	(0.59)	(-3.42)
PC1	0.21	-0.003	-0.06	0.04	-0.6	-0.07	0.13
	(2.55)	(-0.05)	(-0.9)	(0.65)	(-6.6)	(-0.71)	(2.9)
PC2	0.02	-0.05	-0.1	0.02	-0.03	-0.1	0.02
	(0.37)	(-1.3)	(-2.2)	(0.36)	(-0.45)	(-1.56)	(0.56)
PC3	-0.15	-0.22	0.08	0.12	0.31	0.28	-0.1
	(-1.8)	(-4.3)	(1.2)	(1.84)	(3.4)	(2.76)	(-1.8)
PC4	-0.1	-0.1	0.07	0.004	0.26	0.15	0.03
	(-1.4)	(-2.6)	(1.6)	(0.82)	(3.9)	(2.05)	(0.86)
PC5	-0.03	0.07	-0.04	-0.05	-0.2	-0.26	0.1
	(-0.46)	(1.65)	(-0.81)	(-0.95)	(-2.81)	(-3.26)	(2.57)
PCL1	-0.15	-0.23	-0.3	-0.03	0.2	0.08	-0.002
	(-1.21)	(-3.1)	(-3.1)	(-0.32)	(1.33)	(0.51)	(-0.24)
PCL2	0.12	0.05	0.07	0.05	-0.03	-0.07	0.04
	(1.35)	(0.9)	(0.93)	(0.7)	(-0.33)	(-0.67)	(0.88)
PCL3	-0.007	0.01	0.05	0.05	0.2	0.13	-0.03
	(-0.1)	(0.2)	(0.8)	(0.8)	(2.5)	(1.3)	(-0.79)
IN			0.65	-0.03	0.02	0.1	-0.12
			(8.5)	(-0.34)	(0.24)	(0.9)	(-1.51)
INN			-0.36	0.43	-0.01	0.7	-0.19
			(-2.7)	(3.36)	(-0.63)	(3.6)	(-1.38)
OUT	0.93	-0.26					0.11
	(9.58)	(-4.5)					(1.1)
OUTN	-0.12	0.53					0.28
	(-0.72)	(5.3)					(2.49)
RCM	-0.05	0.37					0.17
	(-0.42)	(5.7)					(2.23)
TVR	-0.5	-0.27	0.45	0.38	1.4	0.5	
	(-1.38)	(-1.7)	(2.25)	(1.95)	(5.3)	(1.65)	
R^2	0.92	0.83	0.94	0.32	0.69	0.46	0.44
I*	0.94	-0.06	1.1	-0.73	-0.18	-0.56	0.21
BP	-	-	-	-	-	-	-

TABLE 7.24 PRINCIPAL COMPONENT AND JDV REGRESSIONS (II)

	IN	INN	OUT	OUTN	RCM
C	0.02	0.02	0.004	-0.007	-0.03
	(4.35)	(4.9)	(0.65)	(-1.1)	(-3.1)
PC1	0.004	-0.00002	-0.002	0.0007	-0.003
	(4.5)	(-0.03)	(-1.93)	(0.65)	(-1.5)
PC2	0.0003	-0.001	-0.001	0.0006	-0.001
	(0.38)	(-1.9)	(-1.83)	(0.66)	(-0.93)
PC3	-0.002	-0.003	0.002	0.002	0.004
	(-1.97)	(-4.2)	(2.04)	(2.35)	(2.85)
PC4	0.001	0.0002	0.0002	-0.000003	-0.003
	(1.22)	(0.35)	(0.26)	(-0.004)	(-1.98)
PC5	-0.002	0.001	0.0006	-0.002	-0.003
	(-2.5)	(1.6)	(0.71)	(-2.8)	(-2.43)
PCL1	0.0009	0.003	0.002	-0.002	-0.003
	(0.86)	(3.6)	(3.1)	(-1.89)	(-1.81)
PCL2	0.0016	0.001	0.001	-0.0001	-0.002
	(2.0)	(1.48)	(1.54)	(-0.16)	(-1.1)
PCL3	0.0004	-0.0003	0.0003	-0.0008	-0.002
	(0.5)	(-0.47)	(0.4)	(-1.0)	(-1.37)
IN		-0.19	0.61	0.02	0.49
		(-1.47)	(4.5)	(0.11)	(1.72)
INN	-0.26		-0.32	0.79	1.43
	(-1.47)		(-1.67)	(5.0)	(5.25)
OUT	0.54	-0.2		0.12	0.16
	(4.5)	(-1.67)		(0.74)	(0.59)
OUTN	0.02	0.48	0.11		-0.8
	(0.11)	(5.05)	(0.74)		(-3.35)
RCM	0.13	0.28	0.05	-0.26	
	(1.72)	(5.3)	(0.59)	(-3.34)	
TVR	-0.31	-0.25	0.06	0.3	0.74
	(-3.24)	(-3.04)	(0.53)	(2.81)	(4.4)
R^2	0.81	0.79	0.75	0.44	0.59
I*	0.94	-1.12	0.37	0.23	-1.7
	–	–	–	–	–

TABLE 7.25 PRINCIPAL COMPONENT AND JDV REGRESSIONS (II) (LOGS)

	IN	INN	OUT	OUTN	RCM
C	-1.92	-2.24	-1.5	-0.65	0.5
	(-1.5)	(-3.2)	(-1.4)	(-0.71)	(0.36)
PC1	0.21	-0.02	-0.06	0.03	-0.02
	(2.6)	(-0.42)	(-0.85)	(0.53)	(-0.2)
PC2	0.04	-0.05	-0.08	0.0004	-0.06
	(0.56)	(-1.35)	(-1.77)	(0.01)	(-0.93)
PC3	-0.1	-0.2	-0.01	0.2	0.35
	(-0.95)	(-3.88)	(-0.11)	(3.2)	(3.75)
PC4	-0.06	-0.08	0.04	0.04	0.13
	(-0.9)	(-2.3)	(0.87)	(0.88)	(1.93)
PC5	-0.05	0.08	0.02	-0.13	-0.28
	(-0.7)	(1.7)	(0.4)	(-2.55)	(-4.05)
PCL 1	-0.09	-0.2	-0.32	0.06	0.17
	(-0.66)	(-2.87)	(-3.21)	(0.62)	(1.15)
PCL2	0.11	0.036	0.07	0.01	-0.06
	(1.2)	(0.67)	(0.97)	(0.19)	(-0.61)
PCL3	-0.009	0.01	0.01	0.08	0.15
	(-0.11)	(0.19)	(0.16)	(1.5)	(1.77)
IN		0.1	0.63	-0.13	-0.16
		(1.01)	(8.46)	(-1.19)	(-0.98)
INN	0.26		-0.63	0.75	1.18
	(1.0)		(-3.4)	(5.33)	(5.74)
OUT	1.01	-0.34		0.21	0.36
	(8.5)	(-3.4)		(1.59)	(1.86)
OUTN	-0.26	0.54	0.27		-0.78
	(-1.19)	(5.33)	(1.6)		(-3.89)
RCM	-0.14	0.37	0.21	-0.34	
	(-0.98)	(5.74)	(1.86)	(-3.89)	
TVR	-0.42	-0.23	0.25	0.46	0.63
	(-1.5)	(-1.38)	(1.1)	(2.49)	(2.23)
R^2	0.92	0.83	0.94	0.48	0.60
I*	2.1	-1.84	0.72	-0.54	-1.24

from dependence on volume variables. I^{F}-statistics are generally higher and this is taken to indicate that principal component regressions result in some loss of information, particularly concerning spatial interaction patterns. The aspatial regressor results show few differences compared with the exogenous forms, although some coefficient significances are accentuated or diminished. In a number of cases, the sign on the depressed areas component alters, for example in the local out-movers equation; this implies that aside from the dependence on purchasers to permit a move, even housing-related movers wish to avoid depressed areas. In this context, the strengthened positive impact on newbuild is surprising. It should, however, be borne in mind that the results in previous equations demonstrated that housebuilders have the power to create their own spatial markets more or less independent of local housing market conditions.

7.13 HOUSING MARKET DYNAMICS

The most important new results concern the estimates of the endogenous variable coefficients, both in the specific form (i.e. a supply-type equation contains demand-type variables and vice-versa) and in the general unrestricted form. The estimates do not yield any major departures from those which have been made previously, and seem to be robust with respect to the inclusion of additional endogenous variables. Taking insignificant results as coefficient values of zero, the dynamic elasticities matrix from the logarithmic, specific form regressions is given in Table 7.26. This is as close a representation as it is possible to achieve, given existing data, of the dynamics of volume changes in the Scottish housing market.

TABLE 7.26 DYNAMIC ELASTICITIES

	IN	INN	OUT	OUTN	RCM	TVR
IN	0	0	0.65	0	0	0
INN	0	0	-0.36	0.43	0.7	0
OUT	0.93	-0.26	0	0	0	0
OUTN	0	0.53	0	0	0	0.28
RCM	0	0.37	0	0	0	0.17
TVR	0	0	0.45	0	0	0

The new household variable is omitted since it is recursively determined by the rest of the system. This is inaccurate to the extent that new households leaving one district appear as in-movers to another district, but the new/existing split is not known for the migration variables and for the model as a whole, the inclusion of the out-mover variables and the new household variable simultaneously would involve an element of double counting.

The coefficient matrix can be treated as a Markovian transition matrix, M. Taking a unit change in any particular variable to be given by the vector i, it follows that state of the system after t time intervals have elapsed is given by:

$$i(t) = [M^T]^t i(0) \qquad (7.1)$$

For stability it is necessary that $i(t) \to 0$ as $t \to \infty$. It can be seen in Table 7.27 that this is the case for all the jointly dependent variables but happens rapidly in the case of IN, and OUT, but for INN, OUTN, RCM, and TVR, the adjustment is much slower.

TABLE 7.27 HOUSING MARKET DYNAMICS

		System dynamic behaviour:
	IN	Dampens quickly
	INN	Oscillatory and dampens slowly
Unit Change In:	OUT	Dampens quickly
	OUTN	Oscillatory and dampens slowly
	RCM	Oscillatory and dampens slowly
	TVR	Oscillatory and dampens slowly

It follows that any change in these variables can have a prolonged effect on the housing market particularly if the change follows the causal path of high long distance in-migration rendering increased building and long distance out-migration feasible, leading to generally increased turnover. IN and OUT seem to function almost independently of the rest of the housing market. If it is possible to argue that long distance in-migration is primarily associated with a change in the employment structure, either due to there being more jobs or because of increased rates of retirement, then the general housing market effect can be destabilising; this gives an erroneous impression, however, since it applies to volumes and at some point prices will reach a level where unstable volume changes are checked. In summary, the housing market appears to be a finely balanced web where a small change in an employment related variable can lead to a multiplied series of moves and new bulding. Housing related moves seem to be self contained and only impact on employment related moves indirectly, through local turnover. It is interesting to compare the volume based dynamics with the sensitivities to the vacancy change variable and its spatial lag. Average values for these are set out in Table 7.28. In general, the market sensitivity results do not conform to those expected. There are a number of possible reasons for this. The results with respect to the lagged variables will appear perverse if the average spatial submarket size is greater than the average district size, such that the lag effectively measures the same effect as the own district variable. If the district and submarket boundaries correspond, then the perverse signs can imply one of two possibilities. Either the demand for housing follows Veblen considerations such that price levels, and by implication price changes, are treated as indicators of quality or the explanation lies in the housing market dynamics, encompassed in the a,b, and γ coefficients.

TABLE 7.28 MARKET SENSITIVITIES

	DV	DVL	Implied dynamics
IN	0	1.8	No reaction to general market pressure Spatial sensitivity is Veblen?
INN	-0.55	-2.2	Veblen sensitive Spatial sensitivity may reinforce this
OUT	0	1.1	No reaction to general market pressure Spatial sensitivity correct
OUTN	-0.35	-1.2	Correctly signed as a supply variable Spatial result valid if submarkets are large
RCM	0	-2.6	No reaction to general market pressure Spatial result valid if submarkets are large
HHFR	0.9	-0.8	Veblen sensitive

As estimated, the DV coefficient is given as:

$$D_t = a\gamma\ DV - aP_{t-1} + Z \qquad (8.2)$$

Here, Z represents all exogenous influences, spatial lags and the intercept. Since data on prices is not available, it is possible for coefficient bias to appear if vacancy changes and prices are correlated, with the effect outweighing that of γ. If vacancies as a whole tend to lead the behaviour of prices, then it is possible for individual components of demand and supply to be reacting to past vacancy rates reflected in current prices. It is not possible to settle this issue without more detailed price data.

As far as the Veblen effect is concerned, this proxies a series of motives, particularly the fact that housing is an investment as well as a consumption good, and demand will be conditional upon the expectation of a higher future realised price. Hence the fear of contagion of decline from contiguous areas may serve to negate the price allocation procedure.

It follows that on the basis of published data it is not possible to distinguish between Veblen behaviour and long lags in vacancy-price change relationship. This is discussed further in the section on possible model expansions in Chapter Eight.

7.14 LIMITATIONS OF THE MODEL

There are a number of important limitations to this study which must be borne in mind. These are:

(1) The implied dynamic adjustment mechanism or its empirical proxy may be invalid. This latter depends upon equating (S-D) and vacancy changes; efforts have been made to render this proxy as accurate as possible.

(2) The results may also be affected by the housing homogeneity assumption (attempts to circumvent this failed because spatial structure proved to dominate). This is probably not crucial except for some particularly unusual contiguous districts (e.g. Bearsden and Clydebank)

(3) This study can only distinguish between aspatial models (assuming the district to be the basic spatial unit) and some form of spatial model. Distinguishing between spatial models would require a longer time series of data for each district to remove spurious correlations due to movements in some third, time-dependent variable (e.g. tax and interest rates). This would also provide guidance as to the suitable form for a W-matrix viz-a-viz higher-order lags.

(4) The tendency for the spatial lagging process to smooth the data results in multicollinearity if lags of greater than first order are used. This places further restrictions on the spatial hypotheses that

can be tested and has important implications for the spatial econometric literature in general.

(5) The use of ordinary least squares as an estimation technique. Given the strong importance of the endogenous variables with a degree of orthogonality with respect to some of the exogenous regressors, instrumental variables is inadequate as a technique, whilst as discussed previously, the more esoteric spatial econometric estimation methods are not yet suitably developed for this form of problem. The regressions reported do permit the more robust relationships in the data to be detected and it is questionable whether the data are sufficiently "clean" for more sophisticated methods to be used.

It follows that the main limitations of the model presented here refer to the data used. All the data available have been employed, but this only yields a quasi-dynamic set of cross sectional observations. It is possible to span more time periods but only for the whole of Scotland; the availability of time series is limited anyway. The Census data are available for smaller spatial units but some of the data used, such as new building, are not readily available at sub-district level. Price data is available in the Register of Sasines but has not been categorised by Local Authority District. It follows that this study has compromised between the various partially complete data sets. The availability of more disaggregate spatial data would permit investigation of the particular types of spatial process operating, subsumed here within the contiguity spatial interaction process. The network and hierarchy processes are the most likely to be operating in housing markets and smaller spatial units would allow discrimination between these. This would be further served by a longer run of time series on the spatial units, and by disaggregation of the jointly dependent variables into more strata. If such runs of data were to be made available, the econometric issues to be addressed would be formidable since spatial and temporal dynamics are being simultaneously modelled. The other main limitation is the W-matrix; this has had the first order contiguity process imposed, but the structure would have to be more complex for hierarchy or network processes and finding the appropriate matrix would be largely a matter of trial and error. The solution employed here has been to use a simple assumed spatial structure which allows OLS to be used as approximately consistent. A more detailed empirical investigation of space in the housing market would require:

1) Econometric software capable of solving the joint problems of simultaneity of determination between variables and observations. At present, no analytical solution for this exists (Bennett (1979))

2) Software, preferably within the same package, which is capable of handling large matrices for carrying out data transformations with the possibility of searching for structural breaks.

3) A facility for readily calculating spatial autocorrelation statistics under the assumptions of normality and randomisation, preferably as part of the same package for the requirements set out above.

Such software is not currently available but would be a prerequisite to a more detailed spatial study of the housing market.

7.15 CONCLUSIONS

It is not possible to test all parameter restrictions with the available data but some results are fairly clear and the main conclusions are as follows:

(1) Spatially lagged variables in general add more explanatory power than additional own-district variables, but this can only be tested for first order lags.

(2) Endogenous variables add more explanatory power than additional own-district variables.

(3) Variables representing socio-economic profiles tend to have more success than those representing market conditions, such as local authority rents, land release and vacancy rates (latter more mixed).

(4) Principal components analysis of the explanatory variables yields some readily interpretable components primarily associated with spatial characteristics of sub-groups of districts.

(5) The basic spatial structure of the W matrix (in terms of value/zero) is much more important in determining the fit of spatially lagged equations than the detail of the non-zero W matrix elements.

(6) Log-linear and linear specifications show no consistent best fit.

(7) Although general trends dominate the data and lead to some fairly conclusive results, a number of the estimated parameters are unstable and leave considerable ambiguity, so that the issues raised here have by no means been settled.

Taken together, these conclusions indicate that local housing market volume conditions seem to be crucial in determining the rate and direction of intra-regional mobility (i.e. relocation behaviour). On the basis of the significance of vacancy rates, short term market pressure has only a limited rationing effect since much of the rationing has already taken place via socio-economic stratification. Hence within each socio-economic "submarket" demand functions are highly price-inelastic and may even be Veblen. Supply response within any small area will depend primarily on newbuild which in turn will be hampered by land availability and the existence of a suitable portfolio of land. In terms of A, B, and Γ, the values of A and B are probably low relative to Γ, so that prices will oscillate through long periods of time as they find their equilibrium level. (If the investment demand for housing is strong then expectations can become self-feeding.) The results only indicate the relative temporal responsiveness, not the long run equilibrium elasticity values. There are good reasons for this, in that it takes time for searching households to put mobility plans into reverse and for an apparently local phenomenon to be recognised as widespread. The implied dynamic for the housing market is one of ultimate stability although there is the possibility of a long damping time for some oscillations. There seems to be a difference between local and long distance movers in their reaction to price as suppliers, with long distance movers acting more as classical suppliers, presumably withdrawing their equity from areas of rising house prices. On the basis of these results it is also possible that, for similar profit-related reasons, mobility will fall in depressed areas from a combination of lack of demand and low house prices.

With these conclusions in mind, the next chapter will outline some possible extensions and areas for future research.

CHAPTER EIGHT

EXTENSIONS AND POLICY IMPLICATIONS

8.1 INTRODUCTION

This chapter discusses possible expansions and adaptations of the spatial housing model. As constructed, the model is designed for use at a relatively high level of spatial aggregation, using first order spatial lags and one year changes in the dependent variable data series. The level of spatial aggregation reflects the horizontal classification but the matrix format can be extended to the vertical classification. This is discussed in Section 8.2.1. The use of first order spatial lags reflects, in part, the limitations of the spatial lagging process, where the W matrix is powered before being used to transform the data. If it was possible to specify *a priori* the likely pattern of interaction between non-contiguous spatial units, then an alternative to the powering technique could be used to lag the data. This would appear to involve a large element of "trial and error", so it is probably more suitable for use in testing the strength of particular spatial links, such as between cities or between areas with similar or related employment structures. This is discussed in Section 8.2.2. The use of one year changes in the dependent variables primarily reflects the availability of data at this particular spatial scale. It would only be feasible to collect spatial time series data for a small area but the regional effects discussed in this thesis might not be detected at a smaller spatial scale. It would be more realistic to collect price data and to combine it with vacancy data held by Local Authorities, and estimate dynamic reduced forms for longer time periods. Possible formulations for this are discussed in Section 8.2.3.

8.2 EXPANSIONS TO THE BASIC MODEL

8.2.1 Vertical Classification Models

It is possible to apply the model developed here to interactions between house types within a given submarket, effectively using the vertical classification rather than the horizontal employed throughout this study. This is very close to the model developed by Sweeney (1974) and Gerber (1985). The model in log-linear form uses the A and B matrices of elasticities as employed throughout this thesis, but instead of spatial units the rows and columns of the matrices refer to house types. In an owner occupier market, the decision to demand is simultaneously a decision to supply, so it would be reasonable to expect some relationship between the cross elasticities. For example, if the price of house type j falls, there is an incentive for all non-type j house owners to demand houses of type j in preference to their own and hence for them to supply houses of type $i \neq j$. In a pure owner occupier market with one household per dwelling and no newbuild or household formation, it follows that:

$$\Sigma_{i \neq j} b_{ij} = a_{jj} \qquad (8.1)$$

$$\Sigma_{i \neq j} a_{ij} = b_{jj} \qquad (8.2)$$

Equation (8.1) states that all those who demand houses of type j must be selling their own houses of type $i \neq j$. Equation (8.2) states that all those selling houses of type j must be demanding houses of type $i \neq j$.

This assumes a high degree of substitutability between all house types. In practice, if there exists some form of commodity hierarchy, it is likely that many of the cross elasticities will be zero. This would be the case if market price movements were within a narrow range of the equilibrium price level for a particular type of dwelling, and the household's expectation of capital gain prevents house prices moving too far from their equilibrium values (although the equilibrium price levels may themselves be appreciating through time). The price gaps separating quality levels would place restrictions on the scope for trading up. In the limiting case, where households only trade up and only to the next hierarchy level, the A matrix is diagonal with the last diagonal element equal to zero, and the B matrix has the non-zero diagonal elements of A on the next diagonal to the right. The fact that those at the top of the hierarchy have no further level to which they can move will tend to create excess demand for the upper end of the quality hierarchy and hence, ceteris paribus, for house prices to inflate faster there. This is in keeping with the vacancy transition models where a common conclusion is that newbuild at the upper end of the market will help all households by aiding the filtering process (and by reducing the cost of housing generally).

In practice, households trade down as well as up, new households are always forming, and newbuild occurs at a number of different quality levels. This renders it unlikely that the pure commodity hierarchy model will be valid, and also that the coefficient restrictions in (8.1) and (8.2) will not hold. Instead, there may be a mismatch in elasticities such that at the upper end of the hierarchy, demand is relatively insensitive to price changes (which seems to be borne out by this thesis) but supply may be more responsive as households realise their investment or households break up through death. At the lower end of the hierarchy, demand may be very price sensitive (again borne out in this study). Supply will be less price sensitive, with it being uneconomical for households to realise their investment and unprofitable for builders, particularly during times of low volume. Such a presentation sheds considerable light on the supply/demand driven debate; this study has indicated that the housing market can probably be divided into groups each of whom is subject to one or other of the demand and supply constraints (and some will be subject to both). Comparison of estimated A and B matrices would indicate the points of separation of such groups.

8.2.2 Higher Order Spatial Lags

Instead of powering the W matrix, it is possible to impose an assumed network. In the case of a regional housing market based around employment nodes, it is likely that the response to any given employment stimulus will diffuse through the nodal pattern over time.

Hence the higher order W matrices would reflect the secondary and tertiary nodal structures and would affect the model response in time t+1, t+2, to the point where no further exogenous input changes were occurring as in the following reduced form:

$$P_t = \theta_0 + \theta_1 W_1 E_1 + \theta_2 W_2 E_2 + \theta_3 W_3 E_3 + \ldots \qquad \ldots + \psi_1 P_{t-1} \tag{8.3}$$

where θ_0 is all constant influences

W_t is the weights matrix representing the spatial areas affected at time t by the exogenous stimulus to employment

E_t is the employment change vector at time t

θ_t are the reduced form coefficients

ψ_1 is the lagged price coefficient

For this form of model to be operational, it would be necessary to have a large number of smaller spatial units and time series observations on those units. It would also require that the periodicity of the price data conform at least approximately to the speed of transmission of the employment changes. This formulation would be useful given that the zero/non-zero structure of the W matrix has been found to be important, since it would give a clearer indication of the fundamental spatial structure.

8.2.3 Price and Vacancy Equation Forms

Throughout this study the assumed price adjustment process, linear or log-linear, is of the form:

$$\Delta P = -\Gamma(S - D) \quad (8.4)$$

with $\Gamma = \gamma\ [I]$ and excess demand $(S - D)$ = vacancy changes. A variety of other forms could have been used, such as:

$$\Delta P/P = -\Gamma(S - D) \quad (8.5)$$

Equation (8.5) states that rates of change, not absolute changes in the price level, is a function of absolute excess demand or supply. This could reflect builders operating a fixed profit margin and reacting to land cost increases. Over short time periods, it is not possible to distinguish between (8.4) and (8.5), and difference is irrelevant if demand and supply are also sensitive to the same form of price term.

$$\Delta P = -\Gamma((S - D)/D) \quad (8.6)$$

Equation (8.6) normalises the excess demand term on demand volume It is also possible to normalise on supply or on an average of the two, provided it is possible for each volume to be separately distinguished. In this study, the vacancy change term is normalised on the previous period vacancy level, to eliminate the effect of different sizes of spatial units.

$$\Delta P = -\Gamma_1[S - D] - \Gamma_2[\Delta S - \Delta D] - \Gamma_3[\Delta^2 S - \Delta^2 D] - \ldots \qquad (8.7)$$

Equation (8.7) assumes price setters are responsive to changes in the supply/demand balance and hence to changing trends rather than to chronic excess supply or demand.

$$\Delta P = -\Gamma[(S_t - D_t) - (S_{t-1} - D_{t-1})] - \ldots \qquad (8.8)$$

Equation (8.8) assumes price setters are equally responsive to previous period excess supply and demand as well as current levels, which suggests very slow adaptation to market conditions.

$$\Delta P = -\Gamma_1[S_t - D_t] - \Gamma_2[S_{t-1} - D_{t-1}] - \ldots \qquad (8.9)$$

Equation (8.9) assumes the price setter's historical information can be extended indefinitely, but has a different responsiveness to the market environment prevailing in each time period. Obviously, forms as complex as the latter two require considerably more data than is available here but would be a useful topic for further study. The important point is that this class of functional forms represents the core of a housing market model. It can be expanded, as it has been in this study, to capture spatial effects, although this study has also shown that the simplest form leaves a number of unanswered questions. It can be condensed by making the "lumped system" assumption as in a macro model, where the number of submarkets is assumed to be one. The determinants of demand and supply can be included if direct observations of these variables are unavailable, again as used in macro models. With sufficient data, combining cross section and time series, it can be used to test a wide variety of hypotheses about housing market phenomena whilst making the assumptions underlying those hypotheses explicit.

As a further extension, it is clear from the results discussed here that there is a possibility of non-zero off-diagonal elements in the Γ matrix. This effectively means that price setters will take the degree of apparent excess supply or demand in adjoining submarkets into account. This considerably complicates the dynamics of the spatial housing model and for it to be operationalised would require the longer runs of data discussed above. An alternative form of spatial submarket classification is the diagonalisation of the Γ matrix which will correspond to the structure of housing market professionals' information fields. This is essentially another version of the structural breaks problem, which in the spatial case is intensive of computing time.

8.3 SIGNIFICANCE FOR THE HOUSING MARKET LITERATURE

This study has implications for a number of the papers discussed in the first three chapters, and it is worth summarising the main points of the literature review.

(1) The majority of models deal in terms of long-run equilibrium, assuming that such an equilibrium exists and is stable (i.e. attainable)

(2) The dominant assumed tenure is private rental, this being one of the main reasons for the long-run equilibrium assumption.

(3) Space is assumed to be a source of transport costs only, and the market operates under perfect spatial information.

(4) In vacancy transition models, the market process is assumed to be irrelevant due to volume constraints and over long periods of time the operation of the housing market can be represented by a set of constant transition probabilities.

(5) The housebuilding industry is sluggish to respond to the demands of the housing market and this is responsible, in part, for the tendency for house price inflation to exceed general price inflation.

These points are discussed in turn below:

(1) The indications are that the dynamic behaviour of the Scottish housing market does not correspond either to the pure oscillatory form of Blank and Winnick, or to the perfect one quarter adjustment of Artis et al. Instead, each strata of the housing market has its own form of damped or oscillatory damped behaviour with varying time periods to return to equilibrium. This result holds for Scotland but in housing markets which have a more substantial speculative element such as that of the South-East of England, less stable oscillation is possible over longer time periods.

(2) The explicit owner-occupier tenure implies that Veblen effects, where quality is judged by price, cannot be rejected. For similar reasons (and the two views may be observationally equivalent in many cases) the investment role of housing appears to dominate the timing of many mobility decisions. This is directly relevant to the large range of studies based on rental tenure which find a negative signed price elasticity of housing demand. The suggestion is not that demand does not respond to market pressures at all, but that the expectation of continued house price increases may dominate the demand for housing. The fact that most of those who demand are already owners means that house prices have a built-in source of inflationary pressure since the sale of one property can be used to finance the purchase of the other. The housing system can accommodate rising prices with a given inflow of funds if the rate of transactions (i.e. mobility) adjusts downwards.

(3) Spatial effects operate at a higher scale than might be expected if transport costs alone were the source of friction of distance, and the general level of spatial interaction implied by this study gives some support to the notion of information fields and search effects at the regional level. These effects operate in addition to those of the urban and metropolitan levels.

(4) It is necessary to draw a distinction between the volume and value approaches to conceptualising the demand for and supply of housing; each has its own characteristics with volume being associated with links between submarkets and value being associated with variations within submarkets. Between submarkets, the volumes of households trading up

will be the most important feature, since all mobility chains are dependent on the existence of buyers from the next level. Within house type submarkets, households may be sensitive to very small house price variations. Overall, it is not valid for a macroeconometric model to assume that there exists a stable relationship between say, per capita incomes or the flow of funds into Building Societies and house prices, without standardising for the number and type of transactions, with regard to hierarchies and spatial units. The conclusions of the Markov chain models are that either vacancies or first time buyers drive the housing market. According to this study, vacancies are more important further down the hierarchy, whilst the existence of demand to allow trading up is important further up the hierarchy. This may reflect the state of the market during the sample period of the study; these findings may be reversed in other time periods. Nevertheless, it is clear that it is unrealistic to expect one side of the market, supply or demand, to dominate all levels in all time periods.

(5) It is by no means clear that the building industry is sluggish to respond to markets. It may be sluggish with respect to prices, which could reflect land shortages, although the apparent insignificance of local authority land release behaviour suggests that the land constraint is in the cost of land which may rapidly be bid up so as to discount price increases. It follows that the builder is more heavily dependent on the existence of demand in locations which are profitable, and there is some evidence that the builder can influence the spatial location of demand. It follows that the builder has every incentive to reinforce high price levels through, for example, product differentiation.

8.4 POLICY IMPLICATIONS

Current U.K. Government policy is aimed at encouraging owner occupation by a number of specific means. These include the manipulation of the system of Local Authority finance to effect higher real rent levels in the council sector than has been the norm. For those tenants not in receipt of subsidy, there is an incentive to move towards owner occupation, particularly given the extension of the "Right-to-Buy" legislation. Owner-occupation has also been encouraged by some deregulation of land release policy, although this has led, on occasions, to conflict between housebuilders and planners. Some Local Authorities and builders have attempted to quantify household demand, and one of the techniques which has been suggested is that of the minimal household units approach. Differential rates of house price inflation in the UK have been blamed for reducing labour mobility, and it has been suggested that policy should be directed to minimising the impact of this effect.

On the basis of the findings in this study, it is possible to comment on these aspects of policy:

(1) Local Authority rent increases may increase owner occupation levels. However, the council house sales programme has been intended to "create" a new set of owner-occupiers who possess an investment, and assessing the true effectiveness of the council house sales programme will require a period of years when there has been sufficient mobility within that sub-sector to indicate that those who buy their council houses find that marketability is identical with the housing market in

general. On the evidence collected here, there is a slight tendency for movers to avoid areas of high council rents, and by implication to avoid those areas where council house sales have been highest. Other explanations such as lack of supply are possible, but it is not yet proven that ex-council tenants will be able to realise their investment.

(2) Land release may be an inefficient way of reducing the real cost of housing if land prices are bid up to reflect market demand. This is probably one reason why housebuilders acquire considerable land banks with limited or even with no planning permission, with the intention of exploiting profitable market opportunities as they arise in the longer term. This can be contrasted with the study by Nellis and Longbottom (1981) which concluded on the basis of a nationwide macroeconometric model, with no spatial elements and no land release regressors, that Local Authorities in the U.K. should zone more land for housebuilding in order to reduce the real cost of housing. This study has indicated the severe limitations and implicit spatial submarket assumptions which macroeconometric modellers must address when they attempt to make spatial prescriptions.

(3) A high ratio of potential to actual households is more likely to indicate an inability to demand for economic reasons, rather than the existence of latent demand' The recurring finding that an area with a large number of complex households is less likely be a source of demand and less likely to have high numbers of mobile households may confirm Ermisch's suggestion that the relationship between utility and household size may not be monotonically decreasing, and implies that the turning

point in the relationship is a function of other variables such as socio-economic grouping, urban/rural location, and the employment prospects in an area. It is to be expected that optimal household size will increase as the cost of space falls (i.e. rural areas) and that when employment prospects are poor or per capita incomes are low, it is optimal to spread the fixed costs of housing.

(4) A flat housing market may be damaging to the operation of the labour market, not because of notional price differentials but because of the lack of volume demand for houses in depressed areas. The fear of "contagion" of low prices or slack demand leads to a bandwagon effect on supply in adjoining districts. A classic example of this is the South Bronx in New York. There is a tendency for such effects to spread, until they meet a barrier in the form of a housing market with employment related buoyancy, where demand may spill over into the depressed areas, bringing windfall gains to the incumbent households. This has been a noteable feature of the London housing market in recent years. Hence an owner occupier housing market can be a useful vehicle for the redistribution of wealth. Under such circumstances, "gentrification" may be a desirable effect.

8.5 CONCLUSIONS

This chapter has discussed possible extensions to the regional housing matrix model and has indicated how the findings of this study contrast with those of the existing literature. A number of policy implications follow and these indicate that whilst the present policy of expansion of owner occupation can be desirable under certain circumstances, there are a number of aspects of the specific means used to encourage owner occupation which may have undesirable side-effects. The next chapter summarises the study.

CHAPTER NINE

SUMMARY AND CONCLUSIONS

9.1 SUMMARY AND CONCLUSIONS

This chapter summarises the main conclusions of this thesis and relates them to the literature reviewed in the first three chapters. This thesis has developed a framework for the theoretical analysis and empirical estimation of a dynamic regional owner occupier housing market model. These aspects have been selected as mutually interdependent but relatively neglected areas of the existing housing market literature.

A more detailed examination of this literature shows, in Chapter One, that the utility maximising concept is a powerful one, and has been applied in a broad variety of housing market models which progressively reduce the level of analytical abstraction and introduce notions of heterogeneity, both of houses and households. In addition, they incorporate the idea of mobility and hence of the process of change within the housing market.

In Chapter Two, it was seen that geographic models which do not explicitly employ the utility maximising paradigm can be shown to nest within it. Geographic models are generally based on ideas originating in the natural sciences, but it is possible to state most such formulations as special cases of a general gravity type model. It follows from these two chapters that the twin notions of spatial structure representation and utility maximisation prove to be recurring in the attempt to represent the operation of the housing market, and this reflects the essence of the housing market as a spatial system consisting of competing individuals.

This system is one which evolves through time, and this aspect, although studied in detail in Chapters One and Two, is abstracted from price movements. By contrast, in Chapter Three it was shown that the dynamic evolution of prices and volumes is the central premise of macroeconometric models. The dynamic behaviour of the housing market is a crucial issue, but one which cannot be properly defined without some form of disaggregation, particularly with respect to space and when an owner occupier tenure dominates.

Although there are a number of studies of tenure choice, these do not generally reflect the market implications of the fact that for most households, the decision to buy is simultaneously a decision to sell. This idea is examined in Chapter Four where it is argued that the dual role places a time constraint on decision making and hence raises questions about the flow of information to the owner of an existing house. It also means that owners of existing houses compete more or less directly with the builders of new houses. This is particularly important given that the building industry in the U.K. has been transformed in the last 15 years and is now capable of a much more rapid response to market trends than has been assumed in most existing models. It follows that an information asymmetry exists between owner occupiers and builders, with corresponding impacts on the determination of prices. It is possible that each set of market actors will respond to market signals other than prices. This is particularly the case for owner occupiers, who themselves own an appreciating asset, and hence for whom price rises may have only a limited rationing effect. Another aspect of housing market analysis discussed in Chapter Four is the concept of housing market dimensions. It is argued that there are three key dimensions: space, time, and house type. It is not possible for any model of the housing market to be complete without at least a crude incorporation of all three dimensions, and in retrospect it is explicit lack of account of at least one of these dimensions that characterises most of the models discussed in the literature review of the first three chapters.

Chapter Five constructs a theoretical model of a regional housing market on the premise that market actors display some responsiveness to prices, and that prices may not adjust perfectly within any given time period. The model is specified in matrix form and can be linear or log-linear, although the log-linear form gives price elasticities directly. The matrix dimensions correspond to the different categories of house type and/or spatial unit. The A and B matrices represent the response of demand and supply sides respectively to prices, and the Γ matrix gives the response of prices to the demand/supply imbalance prevailing.

A detailed comparison of the theoretical framework of the regional matrix model with existing housing models is given in Carruthers (1988), but the salient features are summarised here.

Within this framework, it is possible to classify the utility maximising models of Chapter One according to the assumptions made about the forms of the A, B and Γ matrices. It is usual to assume that $\Gamma = [A+B]^{-1}$; that is, that equilibrium is achieved within one time period of any exogenous change. Simulation models place zero restrictions on the A matrix, such that interactions between areas may only occur if they are of similar house type or socio-econcmic profile.

The gravity, entropy and vacancy formulations of Chapter Two model the flows of persons independent of the level of house prices, which implies zero restrictions on the A, B and/or the Γ matrices. The housing system in these models is, to a greater or lesser extent, a function of the exogenous variables which represent attractor and repellant forces. In the context of vacancy and mobility models, zero coefficients are implied for almost all variables except those which determine vacancy and new household generation respectively.

The macroeconometric models of Chapter Three effectively assume a regular structure for the A, B and Γ matrices relative to the spatial distribution of any variable which is a source of exogenous shocks to the system. If this condition is not satisfied, the spatial invariance of macroeconometric models rests on each submarket, or spatial zone, interacting identically (including zero interaction) with all other zones. For most spatial systems this implies no friction of distance beyond a certain point. Most macroeconometric models assume rapid and even instantaneous movements to equilibrium, which implies that $\Gamma = [A + B]^{-1}$.

Chapter Five also demonstrates how the weights matrix developed in spatial econometrics can be used to operationalise the model. This does involve placing certain restrictions on the extent of spatial interaction, in particular assuming that for the data set used in this study, one spatial lag is generally sufficient to capture all spatial interaction effects. It is further necessary to assume that the A, B and Γ matrices can be reduced to $[a_1 I + a_2 W]$, $[b_1 I + b_2 W]$, and γI; this corresponds to uniform elasticities and cross-elasticities of demand and supply, and uniform price response to supply and demand imbalances. It follows that W represents the friction of distance and can further be used to correct for heterogeneity of house types between spatial zones.

Due to lack of explicit price data, the model is cast in vacancy change form. This obscures the dynamic response since it is not possible to separate out the effects of a, b, and γ, but it is possible to make statements about the dynamics of the system as a whole.

After examining the insitutional and economic background in Chapter Six, which also discusses the specific data series used, Chapter Seven gives detailed estimates for the spatial model. These estimates indicate the following main conclusions:

(1) The sensitivity to market pressure varies for different classes of movers and is higher for those who are newcomers to the housing market. (Rejection of uniform a). In addition, each social stratum acts as a quasi-autonomous submarket.

(2) Spatial effects are strong and the spatial location process can be characterised by the rejection of alternative locations as much as the selection of the actual destination. The significance of the market pressure variable in own district and spatially lagged form, and the

common occurrence of perverse coefficients for this variable, implies that either the investment role (that is, inflationary expectations) of housing dominates or the off-diagonal elements of Γ are non-zero.

(3) The successful operation of the market when the predominant tenure is owner occupation depends more on the presence or absence of volume supply and demand, rather than prices, for the reasons outlined in (2). However, the dynamic response of such volumes is stable, albeit oscillatory, and this permits a more precise statement about house price dynamics in the Scottish housing market:

$$\frac{1}{a+b} < \gamma < \frac{2}{a+b} \qquad (9.1)$$

(4) Although in volume terms the rapid response of the building industry is confirmed, there appears to be a significant degree of insulation from short term market pressures, with some evidence of an ability to spatially manipulate demand and tentative evidence that the land zoning constraint is not binding. (B non-uniform)

(5) Local authority rents have little impact on the mainstream housing market, and those council tenants who have chosen owner occupation due to rising rent levels have probably purchased their own council house rather than joining the housing market. For new households, the key factor will probably be the non-availability of council housing rather than its rent.

It is not possible, within the scope of this thesis, to collect and analyse price data to permit quantitative statements to be made about the A, B and Γ matrices, but this study has shown the likely route that such an exercise could take and has indicated that it would be a fruitful project.

The major conclusion of this work is that the spatial scale of operation of the housing market is sufficiently high in Scotland (and probably in the U.K.) to render the region the appropriate level of analysis, rather than the individual urban unit. In addition it has shown that questions of dynamic stability are of paramount importance in a spatial owner occupier market, and that in Scotland, the housing market is dynamically stable.

NOTES TO CHAPTERS

NOTES TO CHAPTER ONE

1. In Alonso's model the household chooses land price, whilst in Muth's the house price is exogenous and entry to the market by suppliers eliminates excess profit by bidding up land prices.

2. Muth explicitly introduces supply with perfectly competitive factor markets.

3. Strazheim's submarket groupings satisfy similarity and compactness. It is not clear whether simplicity is also satisfied.

4. In practice two income measures are used - one is actual income which is affected by policy, the other is a permanent income measure.

5. Graves and Linneman (1978) have suggested that "non-traded goods" may be crucial in the mobility/migration decision.

6. There are 72 household types and 27 house types.

7. There are three possible quality levels, defined ad hoc.

8. For this reason Porell describes the NBER model as an equilibrium model even though it eschews the long-run equilibrium concept.

9. c.f. Struyk, below.

10. This term captures measurement errors as well as individual taste variations, and also covers bounded rationality.

11. In this case Tobit estimation is to be preferred

12. Two-stage least squares is used. Simultaneity is not apparent for the 30-44 age group and for the over 65's.

13. Generalised least squares to remove heteroskedasticity does not significantly alter coefficient values.

14. This includes quadratics to approximate the various portions of the S-curve.

15. By contrast, in the HUDS model tenure is the last aspect chosen.

16. The coefficients on permanent income and prior house value are the most stable.

17. These effectively employ a sub-sample.

18. Strictly speaking, this is not a utility maximising model.

19. This is valid because random deviations from the expected pattern are assumed to be due to search costs which are assigned a random

normal distribution.

20. They find households to be more sensitive to under consumption.

21. It might be argued that for a "satisfied" household, actual and desired demand coincide, although "satisficed" might be a more appropriate term.

22. Maclennan (1982) suggests inclusion of finance search.

23. Maclennan (1977) suggests a further division of choice space into perceived and non-perceived, as well as the usual feasible and non-feasible.

24. Anas (1981) estimates an "aggregate equivalent" to the multinomial logit model in which commuting mode as well as zone and dwelling are chosen.

25. The size of the data set precludes use of logit or probit estimation of the limited dependent variable "household size" but the instrumental variables technique is used to allow for simultaneity.

26. The NBER-HUDS model in effect assumes perfect information.

27. Analysis to determine the existence, stability and uniqueness properties of a model of this size is likely to be infeasible.

NOTES TO CHAPTER TWO

1. This model is not, strictly speaking, the subject matter of this chapter, but it provides a link between utility maximising and geographic approaches.

2. If $\alpha_i = \beta_j = 1$ and tij = 1/dij then the Alonso form yields the gravity model.

3. The derivation of this formula is given in the appendix to this chapter

4. It is possible to have a decay function which is not exponential, such as an inverse power function.

5. The housing-specific expenditure proportion is applied to income net of travel costs, so there is some "gross price" effect (c.f. Chapter One)

6. For example, within a city relocators are likely to be following a housing "career" whereas interurban migrants are more likely to be changing jobs.

7. The terms "Markov Chain" and "Markov Process" are used interchangeably here, although strictly speaking there are differences. These differences are not significant for the purposes of this discussion.

8. That is, p_{ij} is the probability of moving to the jth state conditional on having been in the ith state immediately prior to moving.

9. Some writers use the phrase "Time Homogeneous" to refer to stationarity. This usage will not be employed here.

10. Ginsberg (1972a) points out that this feature renders McGinnis' model semi-Markov.

11. This will be the case provided life-cycle and house choice relationships are not too strong.

12. The derivation of this model is given in the appendix to this chapter.

13. In the more complex versions considered in this chapter, heterogeneity could be incorporated by making v_i an "average" of characteristics.

NOTES TO CHAPTER THREE

1. Whitehead makes some modifications to variables for two-stage least squares estimation, such as separating out the house price and cost of capital components; hence prices entered in the demand and supply equations are compatible.

2. Neuberger and Nichol (1976) find that in some cases the estimated coefficients on lagged prices is greater than 1, implying instability.

NOTE TO CHAPTER FOUR

1. In the Elimination By Aspects model, the individual makes a series of choices from a set of different aspects (characteristics) and either accepts or rejects such aspects outright. Hence the notion of degrees of substitutability is ignored.

NOTES TO CHAPTER FIVE

1. The equilibrium price may be a static or moving equilibrium. A more general version of this model which includes a definition of stock equilibrium is given in the appendix to this chapter.

2. For proof see Chiang (1979) p.189

3. Proof: Consider two different vectors of exogenous variables values distributed randomly within the spatial system. The aggregate value of each vector is identical, and hence:

$$i^T X_1 = i^T X_2$$

where i is a column vector of units and X_1 and X_2 are the vectors of exogenous change (such as employment). From the equilibrium condition in (5.8), spatial invariance requires:

$$i^{-1}(A+B)^{-1}X_1 = i^{-1}(A+B)^{-1}X_2$$

By the rules of matrix algebra, if (A+B) is diagonal, then so is $(A+B)^{-1}$, and if all diagonal elements of (A+B) are identical, then all the elements of the exogenous change vectors are given equal weight. It follows that the spatial invariance condition given above must hold, but only as applied to average values (of, say, house prices). By a similar argument, if in addition all the off-diagonal elements are identical, but not equal to the diagonal elements, all the elements of the

exogenous change vectors are again given equal weight, once each row of the $(A+B)^{-1}$ matrix has been multiplied out. Further aggregation by the vector of units results in an identical aggregate figure. Taking these two arguments together, the block diagonal form of the latter type of matrix also yields a spatially invariant result.
A simple example is given below:

It is assumed that $x_1 + x_2 = y_1 + y_2$ where x_1, x_2, y_1, and y_2 are elements of the vectors x and y respectively. It is necessary to prove that $i^TAx = i^TAy$, where A is given by:

$$A = \begin{matrix} a_1 & a_2 \\ a_2 & a_1 \end{matrix}$$

$$i^TAx = a_1x_1 + a_2x_2 + a_2x_1 + a_1x_2$$

$$= a_1(x_1 + x_2) + a_2(x_1 + x_2)$$

$$= a_1(y_1 + y_2) + a_2(y_1 + y_2) \qquad \text{Q.E.D.}$$

4. Phase and Coherence are the measures used in spectral analysis which correspond, respectively, to the degree of temporal coincidence of cycles, and the degree of overall correlation between two cyclical series.

NOTE TO CHAPTER SIX

1. Scottish Office (1983). Given that some of the variables used in the factor analysis and some of the variables used in this study will coincide, some collinearity is inevitable.

NOTES TO CHAPTER SEVEN

1. Inclusion of endogenous variables as regressors will almost certainly result in simultaneous equation bias, and instrumental variables should be used in the estimation process. However, the data set used here did not yield a good set of instruments, and the explanatory power of any instrumental variable regressions was very low. This is likely to result from the endogenous variables being highly correlated with one another, whilst the exogenous regressors alone do not predict the endogenous variables well. Hence replacement of the endogenous regressors with variables constructed from the exogenous regressors will result in low explanatory power due to the highly simultaneous nature of the model.

2. Seemingly Unrelated Regressions refers to the technique used when the model is not simultaneous, but there are reasons to believe that disturbance terms are correlated across equations. In this case, the common regressor set and the correlation between the dependent variable of each equation renders it probable that the SURE technique is necessary. This involves adjusting the standard errors to take account of the disturbance term correlation.

3. The Veblen effect is one where individuals judge quality by relative price, and assume that a positive relationship exists between the two. It follows that positive own price elasticities can arise if Veblen effects are operating.

NOTE TO CHAPTER EIGHT

1. The difference being that a high ratio of potential to actual may indicate that a large number of households are searching (i.e. demanding); the results of this study seem to indicate that households which are relatively overcrowded are not searching and hence are not active in the market.

APPENDICES TO CHAPTERS 2,5 AND 7

APPENDIX TO CHAPTER TWO: DERIVATION OF THE ENTROPY FORMULA AND THE MARKOV CHAIN MODEL

A2.1 Derivation of the Entropy Formula

The problem is stated as: how many assignments of individual workers to origin-destination routes are possible?

Given that, where T are the number of trips in the whole system, and T_{ij} are the number of trips from i to j:

$$T = \Sigma_i \Sigma_j \ T_{ij} \qquad \text{(A2.1.1)}$$

the question becomes: how many ways can T_{11} be selected from T ? Denoting the number of ways by $N(T_{11})$, combinatorial theory states:

$$N(T_{11}) = \frac{T!}{T_{11}! \ (T-T_{11})!} \qquad \text{(A2.1.2)}$$

Selection of T_{12} has to be made from the remaining $T-T_{11}$, giving:

$$N(T_{12}) = \frac{(T-T_{11})!}{T_{12}! \ (T-T_{11}-T_{12})!} \qquad \text{(A2.1.3)}$$

and so on for all T_{ij}.

The total number of assignments is the product of $N(T_{ij})$ for all T_{ij}, given by:

$$S = \frac{T!}{\prod_{ij} T_{ij} \ !} \qquad \text{(A2.1.4)}$$

Substitution of (A2.1.1) into (A2.1.4) gives the entropy formula.

A2.2 Derivation of the Markov Chain Model

Defining v_{ij} as the probability that a vacancy in i moves to j, the total number of vacancies arriving in j by virtue of the operation of the system alone is given as:

$$m_j = \Sigma_i \; m_i \; v_{ij} \qquad (A.2.2.1)$$

where v_{ij} are the transition probabilities.
In matrix form this is:

$$M = M \; V \qquad (A.2.2.2)$$

where M is a 1*k vector and V is a k*k matrix, and k is the number of sub-categories (house-quality ranges in White's model, zones in Porell's model). If it is assumed that the system is not a closed one, i.e. that $\Sigma_j v_{ij} \neq 1$, then a vector of new vacancies arriving from outside the system is included:

$$M = MV + F \qquad (A.2.2.3)$$

$$\Rightarrow \qquad M = (I - V)-1 \; F \qquad (A.2.2.4)$$

Q.E.D.

APPENDIX TO CHAPTER FIVE: A STOCK EQUILIBRIUM VERSION OF THE REGIONAL MODEL

The stock equilibrium version of the regional model is a more generalised form and can be represented as follows:

$$\Delta P_t = -\Gamma_1(\Delta H_{st} - \Delta H_{dt}) - \Gamma_2(H_{st} - H_{dt}) \qquad (A.5.1)$$

where H_{st} and H_{dt} refer to n * 1 vectors of the stock supply of and demand for housing, respectively, at time t, and all other vectors and matrices are of the same dimensionality as the main model. In addition:

$$\Delta H_{st} = Q_{st} \qquad (A.5.2)$$

$$\Delta H_{dt} = Q_{dt} \qquad (A.5.3)$$

Q_{dt}, Q_{st} and P_t are as defined in equations (5.4) to (5.6). Γ_1 and Γ_2 are the n * n matrices of price adjustment parameters corresponding to the flow and stock positions respectively. As in the main model, these can be reduced to $\gamma_1 I_n$ and $\gamma_2 I_n$. The main difference with respect to the flow model is that even if the market is in flow equilibrium, stock disequilibrium will result in price changes up or down, depending on whether the stock postion is one of excess demand or excess supply. The stock demand may be chronically above the stock supply if prices do not move at sufficient speed so as to clear the market in each time period. As the stock disequilibrium increases, prices will change more rapidly until it is possible that the flow position will be one of excess supply. Eventually, this process should bring about a return to equilibrium, although the speed with which it does so will be a function of the sensitivity of demand and supply to prices. The attainability of equilibrium will depend on the signs of the price elasticities.

The formulation given in this appendix implies that the underlying demand and supply functions are specified in stock terms. There is no particular reason why the specification of stock demand and supply functions should significantly differ from that of the flow functions used in this thesis, although given the long run nature of the stock equlibrium the asset demand for housing may become more important. This will include the response of all households to a once and for all alteration to the price of housing as a result of a spatially specific tax or subsidy being imposed. The effects of such a "one off" event may not be detected in a one time period flow model.

In practice, the model estimated in this study aggregates the stock and flow demands together, and estimates which allow inferences to be made about the single γ parameter actually pertain to the two price adjustment parameters, γ_1 and γ_2. In a short run model, it is likely that γ_2 is small relative to γ_1, so this aggregation is unlikely to have a significant impact.

APPENDIX TO CHAPTER SEVEN: DATA SOURCES, TRANSFORMATIONS, VARIABLE DEFINITIONS, AND DATA LISTINGS

Listed below are the primary data sources, along with any adjustments which have been made for estimation purposes. For Census data, the OPCS cell number is given.

VARIABLE	DEFINITION	SOURCE
U*	Male unemployment rate	1981 Census, OPCS 860
LAR	Average unrebated Local Authority rent level	Scottish Housing Statistics
OIL	Oil dummy	Imposed *a priori*
URD	Urban-rural dummy	Scottish Office
BRTH*	Birth rate	Registrar General for Scotland
RV	Average rateable value	Scottish Housing Statistics
SEG	$w^T s$ where w is a vector of average pre-tax wage rates for adult males by socio-economic group, and s is a vector of the proportions of adult males in each socio-economic group.	Family Income Survey and 1981 Census OPCS 4877-4895
LAND	Ratio of land held without planning permission to land held with planning permission; measured in terms of "potential dwellings".	Scottish Office HSIU No 20 Table 6
MHU*	Potential household units Assumes 3 adults to be maximum per household.	1981 Census OPCS 2253-2260 16+ only
DTH*	Death rate per head of population	Registrar General for Scotland

IN*	In-movers to a District in the past year who are now in owner-occupation and whose move originates outside the District but from the same Region.	1981 Census
INN*	In-movers to a District in the past year who are now in owner-occupation and whose move originates outside the District and from another Region.	1981 Census
OUT*	Out-movers from a District in the past year who are now in owner-occupation and whose move terminates outside the District but in the same Region.	1981 Census
OUTN*	Out-movers from a District in the past year who are now in owner-occupation and whose move terminates outside the District and outside the Region.	1981 Census
HHFR*	An estimated subset of all out-movers, being those who have formed new households: HHFR = ESTVAC - DV where ESTVAC = OUT+OUTN+RCM +DTH-IN-INN	Composite of other variables
RCM*	Rate of completions of new private sector houses	Scottish Housing Statistics
TVR*	Movers within a District during the past year	1981 Census

DV*	Change in vacancies 1980-81, calculated as $\theta \times \%OO \times VRU$, where for any given District, θ is the average ratio of dwellings to rateable units, %OO is the proportion in owner occupation, and VRU is the number of vacant rateable units.	Registrar General for Scotland

* : Variable is deflated by the number of owner occupiers, or adjusted by the proportion of owner occupiers, as appropriate.

DATA LISTINGS

The following pages list the data used in regressions. The data for each district are listed in the following (Region) order.

1. Berwickshire
2. Ettrick and Lauderdale
3. Roxburgh
4. Tweedale
5. Clackmannan
6. Falkirk
7. Stirling
8. Annandale and Eskdale
9. Nithsdale
10. Stewartry
11. Wigtown
12. Dunfermline
13. Kirkcaldy
14. North East Fife
15. Aberdeen City
16. Banff and Buchan
17. Gordon
18. Kincardine and Deeside
19. Moray
20. Badenoch and Strathspey
21. Caithness
22. Inverness
23. Lochaber
24. Nairn
25. Ross and Cromarty
26. Skye and Lochalsh
27. Sutherland
28. East Lothian
29. Edinburgh City
30. Midlothian
31. West Lothian
32. Argyll and Bute
33. Bearsden and Milngavie
34. Clydebank
35. Clydesdale (Lanark)
36. Cumbernauld and Kilsyth
37. Cumnock and Doon Valley
38. Cunninghame
39. Dumbarton
40. East Kilbride
41. Eastwood
42. Glasgow City
43. Hamilton
44. Inverclyde
45. Kilmarnock and Loudon
46. Kyle and Carrick
47. Monklands
48. Motherwell
49. Renfrew
50. Strathkelvin
51. Angus
52. Dundee City
53. Perth and Kinross
54. Orkney Islands
55. Shetland Islands
56. Western Isles

The unnormalised inter-district distance matrix used for weights construction is also given. The numerals in brackets correspond with the district numbers given above, and for each district there are 56 entries corresponding to its potential neighbours. Only contiguous districts (including those connected by road bridges) are given non-zero values. Distances are in miles and measure the straight line between estimated centroids.

	U	LAR	OIL	URD	BRTH	RV	SEG
(0001)	0.00959	463.54004	0.00000	1.00000	0.01820	207.00000	139.79814
(0002)	0.00500	334.65991	0.00000	2.00000	0.02121	205.00000	144.13226
(0003)	0.00544	491.87012	0.00000	2.00000	0.01996	199.00000	142.22142
(0004)	0.01300	432.97998	0.00000	2.00000	0.02003	213.00000	144.22685
(0005)	0.00585	373.62988	0.00000	3.00000	0.02617	279.00000	145.00703
(0006)	0.00215	347.59009	0.00000	4.00000	0.02407	267.00000	143.84248
(0007)	0.00321	357.52002	0.00000	3.00000	0.02238	307.00000	149.35222
(0008)	0.00653	444.81006	0.00000	2.00000	0.01950	226.00000	140.86218
(0009)	0.00420	369.51001	0.00000	2.00000	0.02376	251.00000	144.55856
(0010)	0.00731	497.84009	0.00000	1.00000	0.02064	244.00000	142.31802
(0011)	0.01009	443.50000	0.00000	1.00000	0.02335	215.00000	140.27275
(0012)	0.00164	440.62012	0.00000	3.00000	0.02739	287.00000	144.13361
(0013)	0.00215	420.27002	0.00000	3.00000	0.02566	265.00000	143.20839
(0014)	0.00300	496.97998	0.00000	2.00000	0.02166	293.00000	146.21563
(0015)	0.00073	310.45996	1.00000	5.00000	0.02112	242.00000	146.70663
(0016)	0.00240	401.54004	0.00000	2.00000	0.02688	213.00000	140.60493
(0017)	0.00137	427.76001	1.00000	1.00000	0.03330	229.00000	147.53896
(0018)	0.00240	391.92993	1.00000	1.00000	0.02734	245.00000	147.17671
(0019)	0.00257	403.73999	0.00000	2.00000	0.02726	219.00000	141.46768
(0020)	0.01958	438.71997	0.00000	1.00000	0.02413	215.00000	144.08228
(0021)	0.00764	358.10010	0.00000	1.00000	0.02780	150.00000	144.49261
(0022)	0.00354	447.03003	0.00000	2.00000	0.02643	256.00000	149.74297
(0023)	0.01503	427.96997	0.00000	2.00000	0.02940	188.00000	144.55504
(0024)	0.02293	390.25000	0.00000	2.00000	0.02527	248.00000	146.49553

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	U	LAR	OIL	URD	BRTH	RV	SEG
(0025)	0.00362	429.09009	0.00000	1.00000	0.03181	188.00000	142.71907
(0026)	0.04239	419.73999	0.00000	1.00000	0.02631	119.00000	145.30655
(0027)	0.01799	453.35010	0.00000	1.00000	0.02265	126.00000	141.47760
(0028)	0.00257	379.68994	0.00000	2.00000	0.02136	328.00000	146.57187
(0029)	0.00049	476.10010	0.00000	5.00000	0.01942	286.00000	150.50772
(0030)	0.00196	373.98999	0.00000	3.00000	0.02620	298.00000	147.02620
(0031)	0.00240	425.32007	0.00000	3.00000	0.02949	287.00000	143.39334
(0032)	0.00390	506.20996	0.00000	1.00000	0.02527	211.00000	144.30237
(0033)	0.00272	460.10010	0.00000	4.00000	0.02043	455.00000	162.59709
(0034)	0.00927	366.11011	0.00000	4.00000	0.02346	213.00000	145.44090
(0035)	0.00506	390.28003	0.00000	2.00000	0.02621	296.00000	145.99686
(0036)	0.00483	464.20996	0.00000	3.00000	0.03113	340.00000	148.69606
(0037)	0.00974	387.85010	0.00000	2.00000	0.02411	229.00000	138.76390
(0038)	0.00346	371.50000	0.00000	3.00000	0.02642	266.00000	144.12276
(0039)	0.00448	389.59009	0.00000	3.00000	0.02863	334.00000	146.01933
(0040)	0.00289	433.88989	0.00000	3.00000	0.02441	383.00000	150.04916
(0041)	0.00202	441.87988	0.00000	4.00000	0.02312	424.00000	163.68718
(0042)	0.00074	436.25000	0.00000	5.00000	0.02253	205.00000	143.09367
(0043)	0.00383	325.39990	0.00000	4.00000	0.02838	306.00000	147.98804
(0044)	0.00441	379.63989	0.00000	4.00000	0.02485	285.00000	142.93542
(0045)	0.00445	413.83008	0.00000	3.00000	0.02483	271.00000	144.15005
(0046)	0.00273	325.07007	0.00000	3.00000	0.02116	350.00000	148.54399
(0047)	0.00483	379.63989	0.00000	4.00000	0.02877	297.00000	142.54849
(0048)	0.00321	364.60010	0.00000	4.00000	0.02599	280.00000	142.87540

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	U	LAR	OIL	URD	BRTH	RV	SEG
(0049)	0.00148	373.93994	0.00000	4.00000	0.02415	281.00000	146.78798
(0050)	0.00225	444.33008	0.00000	3.00000	0.03000	328.00000	154.06857
(0051)	0.00231	417.52002	0.00000	2.00000	0.02338	216.00000	145.27055
(0052)	0.00211	307.12012	0.00000	5.00000	0.02168	245.00000	145.63243
(0053)	0.00174	398.18994	0.00000	2.00000	0.02112	239.00000	146.30754
(0054)	0.00978	412.50000	0.00000	1.00000	0.02419	110.00000	140.02242
(0055)	0.00451	415.87012	0.00000	1.00000	0.02981	114.00000	142.13799
(0056)	0.01601	492.97998	0.00000	1.00000	0.02343	85.00000	140.19656

	LAND	MHU	DTH	IN	INN	OUT	OUTN
(0057)	0.25828	0.92528	0.00930	0.00415	0.02281	0.00332	0.01867
(0058)	0.48079	0.92029	0.00970	0.00315	0.02048	0.00495	0.01643
(0059)	0.48975	0.91535	0.01040	0.00368	0.01399	0.00368	0.00933
(0060)	1.07273	0.90189	0.01080	0.00408	0.03179	0.00163	0.01834
(0061)	0.00000	0.96459	0.00570	0.01248	0.02666	0.00868	0.02920
(0062)	0.50918	1.05793	0.00620	0.00262	0.01960	0.00501	0.02500
(0063)	0.50538	1.11063	0.00750	0.00712	0.03192	0.00592	0.02266
(0064)	0.00000	1.08021	0.00730	0.00561	0.01905	0.00381	0.01303
(0065)	0.00000	1.08950	0.00810	0.00440	0.02062	0.00490	0.01144
(0066)	0.00000	1.07910	0.00890	0.00571	0.02258	0.00596	0.01365
(0067)	0.00000	1.22965	0.00910	0.00128	0.02053	0.00231	0.01412
(0068)	0.28960	1.02685	0.00640	0.00412	0.03335	0.00459	0.03042
(0069)	0.03480	0.99340	0.00710	0.00604	0.01498	0.00633	0.01483
(0070)	0.06680	0.91553	0.00930	0.00492	0.02623	0.00401	0.01649
(0071)	5.83012	1.09637	0.00800	0.00999	0.01621	0.01493	0.01101
(0072)	0.00546	1.07124	0.00640	0.00835	0.01200	0.00782	0.00826
(0073)	0.78119	0.92480	0.00500	0.02896	0.02924	0.02131	0.01282
(0074)	0.27683	0.95166	0.00600	0.02067	0.03144	0.01550	0.01609
(0075)	0.00000	1.04587	0.00660	0.00430	0.01616	0.00334	0.01405
(0076)	2.14061	1.08475	0.00910	0.00388	0.03568	0.00776	0.01396
(0077)	0.25000	1.16658	0.00800	0.00259	0.01132	0.00356	0.01423
(0078)	0.57385	1.15483	0.00690	0.00595	0.02295	0.00401	0.01615
(0079)	0.95692	1.15290	0.00750	0.00190	0.02792	0.00698	0.03426
(0080)	1.77000	1.02609	0.01200	0.00770	0.02439	0.00513	0.01797

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(0081)	1.55556	1.08172	0.00650	0.00439	0.01872	0.00553	0.01042
(0082)	0.63054	1.27833	0.00910	0.00379	0.02413	0.00331	0.01230
(0083)	0.85714	1.09122	0.01040	0.00592	0.01731	0.00501	0.00775
(0084)	1.73370	1.05274	0.00710	0.02608	0.01878	0.01948	0.01484
(0085)	0.06180	1.05962	0.00950	0.00537	0.01423	0.00668	0.01284
(0086)	0.03134	1.09721	0.00460	0.03255	0.01463	0.02886	0.02029
(0087)	1.83495	1.02815	0.00470	0.02165	0.02297	0.01870	0.02968
(0088)	0.76857	0.98838	0.01080	0.01173	0.01397	0.00693	0.01066
(0089)	4.21106	1.18671	0.00460	0.03093	0.01034	0.01307	0.01532
(0090)	0.00000	1.33819	0.00730	0.02665	0.00300	0.04504	0.01276
(0091)	0.00000	1.01307	0.00690	0.02689	0.01579	0.01209	0.01437
(0092)	1.48193	1.08326	0.00350	0.02534	0.00845	0.02920	0.02479
(0093)	0.31670	1.17752	0.00710	0.01883	0.00899	0.02182	0.01027
(0094)	1.96639	1.04433	0.00680	0.01796	0.00948	0.01388	0.01030
(0095)	1.05831	1.06188	0.00650	0.01504	0.01569	0.01257	0.02815
(0096)	0.00000	1.26024	0.00390	0.02485	0.00808	0.02620	0.01322
(0097)	0.63434	1.05805	0.00470	0.02987	0.00673	0.01616	0.00968
(0098)	0.77344	1.31418	0.01110	0.01221	0.00530	0.02667	0.00982
(0099)	0.26573	1.18354	0.00580	0.02436	0.00779	0.02217	0.01246
(0100)	1.53701	1.30083	0.00850	0.01039	0.00492	0.01285	0.01140
(0101)	0.00000	0.98344	0.00730	0.02112	0.00639	0.01655	0.01267
(0102)	0.30294	1.09324	0.00830	0.01693	0.01294	0.00922	0.01019
(0103)	0.22568	1.37795	0.00590	0.01607	0.00600	0.03055	0.01236
(0104)	0.48639	1.27877	0.00710	0.03028	0.00661	0.02767	0.00885

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(0105)	0.84714	1.14530	0.00700	0.02041	0.01249	0.01951	0.01141
(0106)	0.53233	1.19763	0.00410	0.03683	0.01116	0.01739	0.01485
(0107)	0.15077	0.88258	0.00750	0.00897	0.01677	0.00656	0.01486
(0108)	0.44465	1.02116	0.00830	0.00508	0.01072	0.00787	0.01591
(0109)	2.09091	0.99155	0.00890	0.00460	0.02474	0.00344	0.01470
(0110)	0.00000	1.17147	0.00830	0.00000	0.01270	0.00000	0.00847
(0111)	0.61696	1.27505	0.00610	0.00000	0.01253	0.00000	0.03298
(0112)	0.73643	1.73011	0.01040	0.00000	0.00919	0.00000	0.00763

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	RCM	HHFR	TVR	DV
(0113)	0.00782	0.01454	0.03277	0.03161
(0114)	0.01328	0.01534	0.03849	-0.10789
(0115)	0.00736	0.01158	0.04001	-0.02268
(0116)	0.00530	-0.00417	0.03016	-0.12069
(0117)	0.02116	0.01142	0.04655	-0.59811
(0118)	0.02461	0.03805	0.05979	-0.05222
(0119)	0.02368	0.02014	0.04440	-0.03105
(0120)	0.01143	0.01042	0.03729	-0.02266
(0121)	0.01308	0.01191	0.04061	-0.05372
(0122)	0.00893	0.01251	0.02928	0.19876
(0123)	0.00390	0.01252	0.02977	-0.01395
(0124)	0.02598	0.02774	0.05727	-0.20037
(0125)	0.01440	0.02010	0.04901	-0.09694
(0126)	0.01284	0.00969	0.03388	-0.05861
(0127)	0.03052	0.00472	0.05493	-0.57541
(0128)	0.01804	0.02088	0.03608	0.01363
(0129)	0.04667	0.02594	0.04187	-0.03666
(0130)	0.03410	0.01787	0.02672	-0.04161
(0131)	0.01677	0.02154	0.04013	0.03354
(0132)	0.08843	0.08081	0.04577	0.02137
(0133)	0.01359	0.02716	0.02879	0.04067
(0134)	0.03278	0.02987	0.04699	-0.04521
(0135)	0.02982	0.04753	0.03870	-0.05181
(0136)	0.00898	0.01030	0.03016	-0.05785

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(0137)	0.02214	0.01735	0.03434	-0.07580
(0138)	0.03454	0.03276	0.02271	0.03196
(0139)	0.01822	0.01947	0.01914	0.02395
(0140)	0.02631	0.02140	0.04533	-0.07547
(0141)	0.01342	0.01849	0.05361	-0.14072
(0142)	0.01766	0.02460	0.04428	0.03061
(0143)	0.03862	0.04271	0.05793	-0.31758
(0144)	0.01301	0.01494	0.04501	-0.02513
(0145)	0.01062	0.00157	0.02689	-0.17742
(0146)	0.00150	0.03181	0.03565	-0.15601
(0147)	0.02020	0.00801	0.03855	-0.21127
(0148)	0.00955	0.03131	0.04096	-0.13312
(0149)	0.01883	0.03176	0.04022	0.10435
(0150)	0.00741	0.01113	0.04967	0.00692
(0151)	0.01784	0.03405	0.05823	-0.01240
(0152)	0.01873	0.02920	0.03722	0.03030
(0153)	0.00861	0.00303	0.02867	0.06122
(0154)	0.01610	0.04835	0.05652	0.07033
(0155)	0.01667	0.02022	0.04067	-0.32374
(0156)	0.01732	0.03630	0.05608	0.13692
(0157)	0.00719	0.01373	0.04817	-0.14085
(0158)	0.00804	0.00498	0.04255	-0.07800
(0159)	0.02808	0.05489	0.05298	0.00000
(0160)	0.03963	0.04571	0.04150	-0.08929

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(0161)	0.01448	0.02077	0.05725	0.09432
(0162)	0.02546	0.01354	0.03710	-0.03516
(0163)	0.00930	0.02552	0.04301	0.31322
(0164)	0.00893	0.02998	0.05197	0.15635
(0165)	0.01803	0.01353	0.03650	-0.05505
(0166)	0.02142	0.02771	0.04085	0.03778
(0167)	0.02374	0.05142	0.04287	0.03629
(0168)	0.02088	0.03678	0.01465	0.08749

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	UL	LARL	OILL	URDL	BRTHL	RVL	SEGL'
(0169)	0.00416	397.23157	0.00000	2.00000	0.02092	252.21591	144.55971
(0170)	0.00661	434.55804	0.00000	2.03515	0.02097	241.45899	143.57439
(0171)	0.00658	396.93664	0.00000	1.74383	0.01998	211.09108	142.15329
(0172)	0.00339	405.75914	0.00000	2.86235	0.02394	268.84023	145.63601
(0173)	0.00210	387.22856	0.00000	3.24302	0.02455	276.61503	145.15284
(0174)	0.00402	412.30773	0.00000	3.21838	0.02834	300.63868	145.14947
(0175)	0.00429	416.40704	0.00000	3.07146	0.02582	302.69463	148.82137
(0176)	0.00643	404.52730	0.00000	2.00000	0.02218	231.58859	144.15625
(0177)	0.00790	439.79322	0.00000	1.65601	0.02223	246.61174	141.91033
(0178)	0.00626	378.84355	0.00000	2.02029	0.02310	262.70688	143.42260
(0179)	0.00602	411.45508	0.00000	2.00000	0.02090	297.00000	145.43101
(0180)	0.00268	407.63684	0.00000	3.55970	0.02377	271.25000	145.58499
(0181)	0.00219	457.11388	0.00000	2.46358	0.02424	282.56954	145.26326
(0182)	0.00207	367.11247	0.00000	3.73013	0.02322	252.12417	144.74306
(0183)	0.00182	412.14177	1.00000	1.00000	0.03070	235.97436	147.38106
(0184)	0.00151	418.95267	0.63333	1.36667	0.03109	225.33333	145.31282
(0185)	0.00193	371.81343	0.58492	2.61834	0.02535	231.91069	144.46503
(0186)	0.00345	395.73257	0.47862	2.28208	0.02591	227.25781	145.63335
(0187)	0.01059	408.83858	0.39903	1.43322	0.02749	232.00297	145.48069
(0188)	0.00864	411.78981	0.11844	1.88156	0.02595	236.75511	146.35248
(0189)	0.01799	453.35010	0.00000	1.00000	0.02265	126.00000	141.47760
(0190)	0.02010	421.45969	0.00000	1.38844	0.02704	197.85478	144.62878
(0191)	0.01987	427.11294	0.00000	1.44973	0.02495	197.25261	146.42664
(0192)	0.00857	428.45019	0.00000	1.66441	0.02596	228.74414	144.82469

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(0193)	0.02072	439.79446	0.00000	1.37347	0.02528	172.21918	145.83985
(0194)	0.00814	433.82798	0.00000	1.68758	0.02929	207.65096	145.48069
(0195)	0.00568	392.72936	0.00000	1.00000	0.02976	168.53659	143.62747
(0196)	0.00416	416.70060	0.00000	2.75201	0.02161	253.46728	145.41518
(0197)	0.00358	408.23813	0.00000	2.74125	0.02581	285.33522	145.13548
(0198)	0.00447	428.66947	0.00000	3.16505	0.02029	265.07282	147.16175
(0199)	0.00404	416.52904	0.00000	3.53509	0.02247	270.67836	146.43569
(0200)	0.00359	380.38368	0.00000	2.83099	0.02528	308.80000	147.17588
(0201)	0.00487	403.57622	0.00000	3.88551	0.02496	249.85510	147.55736
(0202)	0.00238	422.57917	0.00000	3.98105	0.02273	348.80072	152.84117
(0203)	0.00529	398.01264	0.00000	2.95139	0.02514	280.95718	144.58057
(0204)	0.00316	390.35666	0.00000	3.57680	0.02735	300.47492	147.28458
(0205)	0.00451	402.93028	0.00000	2.46947	0.02361	303.77649	146.14089
(0206)	0.00329	380.42356	0.00000	3.60716	0.02417	287.89245	145.16593
(0207)	0.00600	402.60531	0.00000	2.87148	0.02365	239.99662	146.27035
(0208)	0.00384	395.49923	0.00000	3.53950	0.02512	303.47349	148.99225
(0209)	0.00304	409.59711	0.00000	3.28571	0.02449	313.85714	147.01057
(0210)	0.00379	401.27235	0.00000	3.73357	0.02560	324.17837	150.26163
(0211)	0.00284	412.41969	0.00000	3.61053	0.02476	298.30526	145.64905
(0212)	0.00229	372.94178	0.00000	3.59091	0.02508	274.86364	145.69766
(0213)	0.00349	402.42100	0.00000	3.27518	0.02404	336.33212	150.55895
(0214)	0.00781	424.93772	0.00000	1.91473	0.02369	242.62171	141.61862
(0215)	0.00303	407.54752	0.00000	3.88189	0.02645	281.74016	144.77466
(0216)	0.00387	373.88737	0.00000	3.85600	0.02720	284.19600	144.87317

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(0217)	0.00422	400.12067	0.00000	3.88756	0.02413	278.03379	147.43213
(0218)	0.00280	445.41844	0.00000	3.91232	0.02429	336.86639	151.81192
(0219)	0.00211	355.54630	0.31628	3.02326	0.02334	243.33953	146.28100
(0220)	0.00252	450.19026	0.00000	2.00000	0.02216	255.47958	145.90240
(0221)	0.00462	396.78918	0.06513	2.69972	0.02442	266.13306	146.69370
(0222)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
(0223)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
(0224)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

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	LANDL	MHUL	DTHL.	INL	INNL	OUTL	OUTNL
(0225)	0.98155	0.97157	0.00886	0.01242	0.01796	0.01037	0.01378
(0226)	0.60966	0.98409	0.00849	0.01227	0.02007	0.00989	0.01552
(0227)	0.29607	0.96405	0.00896	0.00406	0.02070	0.00423	0.01610
(0228)	0.39497	1.03093	0.00707	0.01694	0.01765	0.01348	0.01799
(0229)	0.83904	1.04752	0.00682	0.00411	0.02693	0.00482	0.02515
(0230)	0.85876	1.11044	0.00530	0.01619	0.01860	0.01897	0.02439
(0231)	1.20142	1.10638	0.00621	0.01963	0.01423	0.01678	0.01981
(0232)	0.39734	0.97302	0.00920	0.00763	0.02053	0.00520	0.01371
(0233)	0.06972	1.08805	0.00773	0.01274	0.01741	0.01014	0.01290
(0234)	0.13661	1.13516	0.00817	0.00962	0.01642	0.00873	0.01150
(0235)	0.15147	1.08617	0.00860	0.01132	0.01776	0.00759	0.01192
(0236)	0.29391	1.01392	0.00721	0.00666	0.01947	0.00648	0.02013
(0237)	0.72973	0.97771	0.00790	0.00450	0.02932	0.00420	0.02270
(0238)	0.52508	1.00535	0.00790	0.00540	0.01457	0.00657	0.01529
(0239)	0.56134	0.93651	0.00544	0.02535	0.03020	0.01878	0.01425
(0240)	0.49475	0.96919	0.00559	0.01992	0.02444	0.01472	0.01327
(0241)	1.83370	1.04019	0.00680	0.01160	0.01955	0.01132	0.01237
(0242)	1.89038	0.99179	0.00711	0.01292	0.02246	0.01166	0.01328
(0243)	1.05994	1.00765	0.00798	0.01418	0.02659	0.01144	0.01424
(0244)	0.99134	1.06092	0.00825	0.00716	0.02410	0.00578	0.01811
(0245)	0.85714	1.09122	0.01040	0.00592	0.01731	0.00501	0.00775
(0246)	1.51712	1.11253	0.00899	0.00448	0.02692	0.00594	0.01732
(0247)	1.19239	1.15314	0.00847	0.00454	0.02632	0.00444	0.01411
(0248)	0.89032	1.09157	0.00753	0.00465	0.02475	0.00502	0.01465

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(0249)	0.67586	1.17730	0.00866	0.00522	0.02169	0.00407	0.01240
(0250)	1.03324	1.13122	0.00701	0.00385	0.02361	0.00567	0.02158
(0251)	0.88686	1.12518	0.00727	0.00347	0.01493	0.00452	0.01237
(0252)	0.18647	1.00940	0.00794	0.01319	0.01779	0.01248	0.01739
(0253)	0.99289	1.03462	0.00612	0.01970	0.02315	0.01681	0.02363
(0254)	0.72108	0.99931	0.00929	0.00922	0.02015	0.00807	0.01511
(0255)	0.34782	1.02325	0.00811	0.00916	0.01905	0.00657	0.01780
(0256)	1.04904	1.06620	0.00724	0.01064	0.02261	0.00882	0.02405
(0257)	0.36726	1.27670	0.00733	0.02458	0.00796	0.03015	0.01339
(0258)	2.24892	1.18083	0.00673	0.02159	0.01214	0.01620	0.01578
(0259)	0.57402	1.13623	0.00661	0.01902	0.01493	0.01789	0.01513
(0260)	0.42433	1.21229	0.00555	0.01853	0.01367	0.01740	0.01737
(0261)	0.05431	1.08624	0.00709	0.01767	0.01320	0.01351	0.01253
(0262)	0.75243	1.14046	0.00768	0.01726	0.00869	0.01551	0.01160
(0263)	0.36216	1.17408	0.00833	0.01677	0.01453	0.02296	0.01508
(0264)	0.34529	1.11845	0.00680	0.02308	0.00797	0.01930	0.01152
(0265)	0.24204	1.12854	0.00600	0.02225	0.00874	0.02084	0.01251
(0266)	1.01518	1.23882	0.00559	0.02729	0.00842	0.02429	0.01302
(0267)	0.32457	1.24159	0.00694	0.02407	0.00814	0.02469	0.01126
(0268)	1.30502	1.10399	0.00692	0.01941	0.01126	0.01721	0.01096
(0269)	0.66239	1.13172	0.00582	0.02299	0.00911	0.01871	0.01091
(0270)	0.38317	1.11157	0.00788	0.01275	0.01386	0.01232	0.01220
(0271)	0.82108	1.18052	0.00654	0.01979	0.00978	0.02294	0.01709
(0272)	0.29499	1.24966	0.00690	0.01970	0.00797	0.02440	0.01228

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(0273)	0.82479	1.13997	0.00761	0.01975	0.00578	0.02256	0.01111
(0274)	2.10949	1.18696	0.00641	0.02184	0.01024	0.02101	0.01711
(0275)	0.78208	0.99215	0.00771	0.00990	0.02060	0.00923	0.01568
(0276)	0.48484	0.91859	0.00859	0.00628	0.02263	0.00479	0.01558
(0277)	0.62017	1.01733	0.00749	0.00901	0.02163	0.00703	0.01925
(0278)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
(0279)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
(0280)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

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	RCML	HHFRL	TVRL	DVL
(0281)	0.01678	0.01668	0.04164	-0.07072
(0282)	0.01197	0.01246	0.03826	-0.03224
(0283)	0.01141	0.01383	0.03671	-0.04942
(0284)	0.01921	0.02028	0.04514	-0.12633
(0285)	0.02409	0.02851	0.05346	-0.09942
(0286)	0.02410	0.03371	0.05013	-0.22284
(0287)	0.01541	0.02146	0.04288	-0.13938
(0288)	0.01158	0.00877	0.03776	-0.09565
(0289)	0.01392	0.01536	0.03543	0.04439
(0290)	0.01208	0.01430	0.03859	-0.01939
(0291)	0.00848	0.00875	0.03592	0.06038
(0292)	0.01832	0.02091	0.05069	-0.21782
(0293)	0.01965	0.01859	0.04509	-0.12383
(0294)	0.01254	0.02346	0.04843	0.02092
(0295)	0.04119	0.02242	0.03527	-0.03882
(0296)	0.03571	0.02433	0.04123	-0.01092
(0297)	0.02612	0.01528	0.03983	-0.17562
(0298)	0.03346	0.02513	0.04459	-0.06988
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(0300)	0.02267	0.02243	0.03727	-0.03800
(0301)	0.01822	0.01947	0.01914	0.02395
(0302)	0.04028	0.04031	0.03542	-0.02498
(0303)	0.04225	0.03846	0.03651	-0.00672
(0304)	0.04562	0.04393	0.04408	0.00586

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(0305)	0.02909	0.02778	0.03073	0.00079
(0306)	0.02828	0.03300	0.03973	-0.05740
(0307)	0.01776	0.02237	0.03150	-0.01614
(0308)	0.01333	0.01878	0.04235	-0.03642
(0309)	0.02383	0.02538	0.04837	-0.13350
(0310)	0.01444	0.01363	0.04404	-0.11632
(0311)	0.01708	0.01849	0.04835	-0.12621
(0312)	0.01981	0.02596	0.04996	-0.02581
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(0316)	0.02592	0.03379	0.04870	-0.02765
(0317)	0.01240	0.01388	0.04031	-0.05247
(0318)	0.01255	0.02146	0.05266	0.02203
(0319)	0.01121	0.02369	0.04082	-0.08294
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(0326)	0.01089	0.01736	0.03863	0.04282
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(0329)	0.00977	0.02496	0.04539	0.00160
(0330)	0.01304	0.02524	0.04102	-0.08045
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(0332)	0.01260	0.01597	0.03758	0.07226
(0333)	0.01654	0.01941	0.04138	-0.06260
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(0335)	0.00000	0.00000	0.00000	0.00000
(0336)	0.00000	0.00000	0.00000	0.00000

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DISTANCES MATRIX

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