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MODELLING HOUSING CHOICE AND DEMAND IN A SOCIAL HOUSING SYSTEM: THE CASE OF GLASGOW[1]

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MODELLING HOUSING CHOICE AND DEMAND IN A SOCIAL HOUSING SYSTEM: THE CASE OF GLASGOW[1]

First Draft – not for quotation without prior written approval of the author

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Abstract
This paper is concerned with the attempt to model and simulate an urban housing system dominated by non-market social housing, primarily to forecast demand for social housing under different scenarios. The urban system concerned is the city of Glasgow and its suburbs, a post-industrial city in West Central Scotland, a region now emerging from long-term structural economic decline.

There is an established literature concerned with the development of metropolitan housing market models in both the USA and the UK. The present model draws from these traditions but is heavily influenced by the work of Meen (1999). The Glasgow model is heavily demand-determined with only a limited supply-side but with a standard market-clearing set-up. Data for the model comes from the Scottish House Condition Survey 1996 and from extraneous housing, population and household estimates from local authority planners.

The focus of the core part of the paper is primarily on the demand-side. Demand in the model is composed of three elements: new household formation, net migration and the tenure and locational choices of existing households. It is this third element that poses the most difficulties and is modelled separately using a nested multinomial logit formulation. The paper discusses the modelling issues and results from a series of NMNL models that attempt to explain the locational, tenure and mobility decisions of existing households. The preferred results are then adopted as conditional probabilities in the simulation model. The paper sets out the structure of the basic model and reports some initial runs. The paper concludes by examining the academic and policy implications of the model and suggests future avenues for refinement and further work.

[1] The research was funded by Scottish Homes and Glasgow City Council. The project was carried out by a multi-centre team led by Kenneth Gibb, Geoff Meen (University of Reading) and John Quigley (University of California, Berkeley). Key contributions were made throughout by Daniel Mackay and Mark Andrew (Reading) with assistance from Margaret Keoghan. This work is in draft and this paper reports on-going work. It should be therefore treated as confidential. All errors and omissions in the current paper remain the sole responsibility of the author.

1. INTRODUCTION

This paper reports on-going work by a multi-Centre team to model and forecast the Glasgow housing system. The motivation for the work arose out of two research requirements. First, Glasgow City Council wished to estimate the future demand for social housing across the City under a range of plausible economic and policy intervention scenarios. Second, Scottish Homes, the national housing agency, wished to commission research aimed at the construction of metropolitan housing models that could be used for housing planning purposes. The research team viewed this coincidence of wants as a rare opportunity to construct a computer model of a UK city's housing system, building on work by Meen and Andrew (1999) which examined housing and labour markets in London and the South East, as well as the North American tradition of simulation models of metropolitan housing systems (Anas and Arnott, 1991, 1993a, 1993b, 1993c, 1997, McFadden, 1978, Quigley, 1985, Wheaton, 1979).

In this paper, we set out the housing and economic context for the model. Second, the paper examines the issues involved in the construction of such a model: its structure, its data and modelling requirements, its strengths and weaknesses. In particular, the paper focuses on a separate modelling exercise required for the model, namely, the need to construct a discrete choice model that explains the location, tenure and mobility decisions of existing households. The results of such a nested multinomial logit model are reported and appraised. Finally, the full computer model is implemented and initial results are reported, along with their chief implications. The concluding section considers refinements and future possibilities and applications of the model.

2. THE GLASGOW HOUSING SYSTEM

Glasgow

Glasgow is Scotland's largest city, located to the west of the country's Central belt, forty miles from Edinburgh, the capital city of Scotland. Glasgow is situated on the River Clyde and that fact plus strong canal links with the east of Scotland allowed the City to grow in the 18th and 19th Centuries through manufacturing trade west to North America and East to Northern Europe. The City experienced rapid urbanisation in order to fuel the development of key industrialisation industries: coal and steel, shipbuilding, engineering, chemicals and related industries. Urban population grew rapidly with large-scale in-migration from both the Scottish Highlands and from rural Ireland. The City quickly became the hub of a much larger industrial conurbation across west-central Scotland. Population peaked in the inter-war period at just over one million before falling back steadily to its present levels of around 650,000. Between 1951 and 1991, the annual average population loss was 12,000 – primarily sub urbanisation through public policy slum clearance and new town developments and more recently through the private choices of moving households.

A major reason for the City's contraction has, of course, been the economic decline of the City that has been well-documented elsewhere (e.g. Maclennan and Gibb, 1988; Bailey, et al, 1999) and can be briefly summarised. The primary reason for decline was de-industrialisation – Glasgow had a relatively high share of manufacturing jobs and lost 70% of them between 1971 and 1997. Construction, Transport and communications jobs were also disproportionately lost in Glasgow. At the same time, services growth has been relatively modest in Glasgow – although Glasgow has improved in the most recent period 1993-7 (Bailey et al, 1999, p.13). These broad trends have also been associated with shifts in employment location with repeated patterns of decentralisation of jobs away from Glasgow in the 1950s and again in the 1980s.

From around 1980, there has been a concerted effort to improve both the image and the economic base of the City, pursuing many of the policies and initiatives that will be familiar from North America. The main elements of this period were: image-building, attracting inward investment and massive reinvestment in the existing tenemental housing stock (typically transferring stock to the voluntary sector) and through the regeneration of neighbourhoods (central, inner city and peripheral). At the same time, the City succeeded in promoting Glasgow and some of its more attractive neighbourhoods as successful, dynamic and cosmopolitan places to live and work (Maclennan and Gibb, 1988).

Despite these initiatives, Glasgow retains profound problems of economic non-activity, massive levels of social or multiple deprivation, and relative economic decline compared with its suburbs and particularly when contrasted with the east of Scotland and booming Edinburgh. More than half of the multiple deprived small areas in Scotland are found within Glasgow. Unemployment is stubbornly high (as is economic inactivity and benefit-dependence) and Glaswegians suffer from a range of health problems associated with poverty, bad housing and disadvantage. There is considerable public policy debate about the future economic strategy for the city, not all of which is coherent or agreed by the main players. However, at the heart of all of the discussions about Glasgow's possible futures is the key problem of tackling several, related housing problems.

Social Housing

The UK is unique in the way that it provides social housing. The vast majority is council housing – owned and managed by local authorities, funded by long term debt with pooled rents set below market levels - often with crude flat relativities varied by property type and neighbourhood according to managerial beliefs about rent relativities. Housing is allocated by waiting list rationing with points being awarded on the basis of 'need'. Since the mid-1970s, new investment in council housing has been eroded to virtually nothing. At the same time, more than 1.5 million council tenants have bought their council homes in the best areas at discounts averaging 50% of market value. This has left a residual of benefit-dependent poor tenants, usually in the worst housing in otherwise socially disadvantaged peripheral and inner city housing estates. Small improvements have been made neighbourhood by neighbourhood through transfers of stock to community-based non-profit housing associations. These associations have been entitled to receive grants to improve and redevelop ex-council housing. Typically, the new social housing providers are popular and effective managers (although their subsidy levels are much higher). However, more recently, there is clear evidence of pockets of low and falling demand even among these providers (Glasgow City Council, 1998; Chartered Institute of Housing in Scotland, 1998).

Glasgow has many of the housing problems shared by other parts of urban Britain: polarisation of housing outcomes between owners and tenants; poor quality and badly maintained public housing saddled with large debt repayments; pockets of very high value housing; a combination of both market failure and state failure in certain aspects of the organisation of housing in the City, and, an increasing problem of low demand for social housing characterised by surpluses of social housing and declining demand measured by waiting lists. What makes Glasgow unique is the scale of the problem: the City council owns and manages more than 117,000 units.

The tenure structure in 1997 broke down as 44% owner-occupied, 4% privately rented, 10% rented by non-profit housing associations and co-operatives and the remainder, 42%, rented by the City council. In relation to Scotland, this implies a relatively small owner-occupied

sector and a relatively large social rented sector. House prices are lower than the Scottish average (but there are some very hot spots). The recent national house condition survey suggests that Glasgow exhibits particular housing problems: bad housing conditions, particularly problems of dampness and condensation, the benefit dependency of tenants, high vacancy rates in certain areas, major backlogs of disrepair, growing homelessness (and the highest levels in Scotland) and associated management problems in letting property. Evidence suggests that demand for social rented housing is declining in aggregate terms and in specific neighbourhoods (Glasgow City Council, 1998). The council has responded by undertaking large-scale demolition of its own stock, often fairly new units for which there is no visible demand. The freed land is then used for a mix of non-council social and private housing development.

Presently, there are two key housing policies underway in Glasgow. The first is to create new private neighbourhoods for families in an attempt to reverse the out-migration of couples and families. This is part of a wider inter-agency attempt to tackle the physical, economic and social aspects of exclusion in the City. The major social housing policy for the Council (and all social landlords) is the on-going investigation of transferring *all* of the existing council stock to a new Trust or series of social landlords, thereby unlocking private finance to fund the massive backlog of repairs and improvements required to be carried out to the stock. Public spending rules means that local authority housing investment, even though it is repaid by rental income, counts as public spending in the year of borrowing and is thus controlled (and prevented) by Government. Changing ownership and effectively shifting to the voluntary sector opens up the opportunity to borrow from the private sector. This is now seen as the only realistic way of improving the stock to a reasonable standard in a politically acceptable timeframe. A critical concern for those lenders who might fund the £1-1.5 billion syndicated loan thought to be involved is a defensible estimate of future demand for social housing in the City.

The Research

However, the policy-level or practical case for a computer simulation model of the wider Glasgow housing system rests on a number of reasons, not just the central forecast required by the Council to give the lenders' comfort:

1. A wider understanding of the housing choices and preferences of households in the Greater Glasgow area is required to feed into the economic and physical planning strategy of the City and its suburbs.
2. A need by the Council to forecast demand for social rented housing under a range of plausible economic and policy environment scenarios (for instance, the Council has been pursuing a policy of large-scale demolition of its own stock for several years).
3. A wider requirement to understand the private market processes governing the housing market of the city and its suburbs. This would facilitate housing planning both in terms of social provision but also land release for private house-building (seen to be critical to re-attract commuters back to the City).
4. An interest by Scotland's housing agency in the feasibility of a replicable model of urban housing systems – with the possibility of building a similar housing planning tool or model in other Scottish cities.

These prerogatives coincided with a desire, academically, to develop a comprehensive picture of the wider Glasgow housing system, building on the local knowledge of economists at the University of Glasgow. It was also facilitated by the model-building skills of Geoff Meen and Mark Andrew at Reading University. Consequently, a feasibility study was commissioned in

the Spring of 1999, followed by the full simulation model, the initial construction of which was completed by the end of 1999.

3. AN ECONOMIC MODEL OF THE HOUSING GLASGOW SYSTEM

In this section, a brief description of the model is outlined. The purpose of the model is to construct, on economic principles, a coherent simulation of the Greater Glasgow housing system, such that forecasts and scenarios can be developed for future levels of housing demand.

There is a long tradition of urban housing market models in the United States (Anas and Arnott, 1993) and more recently, similar techniques have been deployed in the UK (Meen, 1999). A key feature of these models is that they are able to incorporate in a consistent manner both the demand and supply sides of the market and can show how each responds to changes in economic and demographic conditions, including appropriate feedback effects. For instance, a policy measure may be adopted on the supply-side that increases demolitions. By thus tightening the housing market, prices might be expected to rise and this will impact on affordability, tenure choice and demand. Simulation models allow us to trace through these impacts. This allows the economist to understand better market dynamics and provide policymakers with information about the possible consequences of policy interventions and environmental changes.

Of course, it is not possible to model all of the elements thought to explain these dynamic relationships and interactions. Economists are constrained in their modelling strategy by the lack of suitable data (particularly across space) and by the conceptual complexity of many of the relationships themselves. Instead, the model develops by focusing on a number of key relationships or equations and by combining new econometric modelling with imposed values for other relationships taken from the literature and/or based on the modeller's judgement. This is why sensitivity analysis and continual testing is important to the evolution of any of these models. The simplest way to explain these issues further is to describe the elements of the Glasgow model itself.

The Greater Glasgow model

The Glasgow model has three main elements: a demand-side, a supply-side and a market-clearing relationship. Of these, the demand-side is the most complex and consists of three main parts: new household formation, net migration and the housing choices of existing households within greater Glasgow. Again, it is the existing households who pose the most problems for the model's development (and this is the main subject of the next section of the paper). However, at the relatively small spatial scale with which we are concerned, these flows by existing households are crucial. At larger spatial scales, e.g. regions, they become less central. Unfortunately, few studies in Britain exist in the literature from which we can draw experience. The appendix to this paper diagrammatically describes the moving options of owners and renters and provides the reader with an idea of the scope of the modelling framework.

New household formation is based on Planning data that provide zero migration population forecasts and headship rates. From this and an assumption about the future age distribution of the propensity to form households, new household projections in each of the three sectors of our Glasgow model (North, South and Outwith the City) can be obtained. Net migration from the rest of Scotland is based on a model used previously by Meen and calculates net migration as a function of relative employment growth, relative house prices (both with respect to Scotland) and previous net migration. This provides information on population flows that

have to be converted into households again based on assumptions about the propensity to form certain household types.

The existing households component (internal tenure and dwelling mobility) is the largest part of the model and makes extensive use of the conditional probabilities derived from the econometric model discussed in the next section of the paper. Essentially, the equations in this part of the model determine the proportion of existing households who move in each period across the three areas within Greater Glasgow, how many change tenure and how many do not move or otherwise alter their housing requirements.

The three elements of the demand-side are constructed in a series of equations that allocate seven household types to three different areas, two dwelling types (house or flat) and two (owning and renting) tenures. Data is collected for the 1996 values for all of the households that go into each type/area/tenure/dwelling type box and these are calibrated to change through time as a result of the cumulative effect of the probabilities derived from the various modelled and imposed relationships (and its interaction with supply).

Housing supply is constructed by adding owner-occupied supply (net of demolitions) and rented supply (net of demolitions). A construction price elasticity is imposed on the owner supply-side and account is taken of the impact of RTB transfers from renting to owning. The market is 'cleared' in two basic ways: through price adjustment that brings demand equal to supply but also alternatively by quantity adjustment as supply expands to close any gaps between demand and supply. In the first case, prices are market-clearing; in the second, prices are constant in real terms. The model can be solved under both methodologies, Once again, data is collected for 1996 for all of these variables.

This project is about the demand for social housing in Glasgow. It is therefore important to clarify the role of *private renting* in this model. The two tenures used in this model are 'owning' and 'renting'. Renting encompasses both social and private renting. This means that an estimate of the private rented component has to be deducted from our renting projections in order to arrive at the level of social rented housing demand. Why has the model been constructed in this way? First, the private rented sector (PRS) is small in Glasgow and this means that it is not possible to derive meaningful sample scores for private renting households in the econometric model, and, as a small share of all households, the size of cells in the computer model would themselves be very small. Second, there are grounds for treating the PRS in Scotland as a residual part of the social rented sector – evidence of this can be found in Peter Kemp's analysis of the composition of private tenants in the Scottish House Condition Survey. In short, the PRS is a small residual sector and its households have characteristics that are more like social renters than owner-occupiers. In our results, we use the 1996 and 2005 estimates of tenure share provided by the City planning team to calculate the residual share of social renting that needs to be deducted to account for the PRS.

There are a number of key assumptions required of the model that arise because it is necessary to make judgements about the size of certain parameters. Below, we use sensitivity analysis to begin to explore several of these assumptions. We 'shock' these key variables and examine what impact this has on the central estimates. In this paper, the following sensitivity exercises are reported:

- Increased rate of new household formation
- Increased and decreased net migration into Greater Glasgow
- Increased probabilities of separation and household splitting (couples becoming singles and families splitting) and of single pensioners dying.

All models simplify reality. Assumptions have to be made in place of either the direct information required or that which is capable of being modelled. Simulations do however allow the analyst to relax and vary assumptions to test their accuracy. This is only an interim stage and work is continuing to conduct many more of these sensitivity exercises and experiment further with the econometric model at the core of the existing households section. This will lead to a refined central estimate and a range of values around that estimate as well as a limited set of policy scenario simulations.

Data for the Model

The model requires (1996) starting values for the number and composition of households (disaggregated by tenure, location, household type, age band of household head) as well as the housing stock (disaggregated by tenure, location and property type). There are also starting values required for house prices and rents (again, disaggregated by tenure, location and property type). Most of this data has been collected from official Planning sources but with missing data grossed up from survey data (see below).

A second source of data is wholly extraneous: where no information is readily available or no model exists or can be constructed at the relevant spatial scale, values or models have been imposed. This was the case for the price elasticity of supply and a model of long distance migration – both of which were developed from regional models used elsewhere by Meen. A third data source used was the recently developed area deprivation index for Scotland (Gibb, et al, 1998). This small area (post code sector) index of multiple deprivation (based on six domains of disadvantage) is a helpful proxy for neighbourhood conditions.

Fourth, extensive use, both within the computer model and the econometric model (see below), was made of the Greater Glasgow component of the 1996 Scottish House Condition Survey (SHCS). The SHCS is an extensive household and physical survey of 18,000 households and homes. Data is collected on households, their economic position, their housing histories, intentions and experiences, as well as property characteristics and finances. The sample basis is mixed, including a random component, a longitudinal component (the earlier wave was also random) and two boosts, one to increase particular property types and one bought by various local authorities to increase the statistical strength of samples within their boundaries. The sample size for the SCHS as a whole was 18,158. The sample data used for the Greater Glasgow modelling involved more than 5,391 households.

The Greater Glasgow area which is the subject of the model is defined in three parts: within the present City boundaries and North of the River Clyde; within the present City boundaries south of the River Clyde; and, all of the remaining six contiguous to Glasgow local authorities (West Dunbarton, East Dunbarton, North Lanarkshire, South Lanarkshire, East Renfrew and Renfrew). Both Glasgow and South Lanarkshire had boosts to their sample within the SHCS. In terms of relative sizes, the planning data reported in Table 1 indicates that the relative sizes of the three areas are very different. In 1996, there were 170,686 households in the North but only 99,247 in South Glasgow. In 1996, there were 438,501 outwith Glasgow. The respective percentage shares were 14:24:62. The tenure pattern across the three areas is also distinctive with 60% home ownership outwith the city but between 39-49% within the City boundaries.

Table 1 Households in 1996

Tenure	**South**	**North**	**Outer**	**Total**
Owners				
1996	47642 (48)	67284 (39)	262230 (60)	377156 (53)

Private rent				
1996	5046 (5)	7839 (5)	7776 (2)	20661 (3)
Social rent				
1996	46559 (47)	95563 (56)	168495 (38)	310617 (44)
All households				
1996	99247 (100)	170686 (100)	438501 (100)	708434 (100)

Source: City Council Planning Data
Note: percentage figures (in brackets) are rounded.

In Section 5 of the paper, the initial results and sensitivity analysis are considered. First, in Section 4, we examine the econometric modelling required to construct the parameters (conditional probabilities) for existing households within Greater Glasgow for their moving, location and tenure decisions.

4. THE NMNL CHOICE MODEL

Method

The approach adopted is analogous to that of the field of transport economics where one often wants to model the mode of transport chosen by different individuals in order to identify those factors that induce specific choice of travel (rail, air, car or bus). It is straightforward to see how this is relevant to the area of housing choice since the options faced by the household are just as complex: for instance, the choices to own or rent, to select location A or B, to move or to stay, or to choose a house or a flat.

Imagine that households only concerned themselves with their tenure choice: owning or renting. If this were the case then modelling the household's decision would be fairly straightforward and would require little more than a simple discrete choice of owner occupation versus renting. However, to do so would be to oversimplify the choice faced by the household. Most importantly, it ignores the role of *location* in the decision. It is perfectly feasible that if the household cannot move to the location that they prefer then they may not move at all. The problem is that the decision to move may be *conditional* on finding the 'right' location. In effect, the two decisions are simultaneous and cannot be disentangled. The diagram (Appendix 2 Figure 3) illustrates succinctly the complexity of the housing choice problem.

In the figure, called a decision tree, the choice of private housing versus public housing is clearly conditional on location and the decision to move or not. Of course, it is perfectly feasible that the choice may not end at one of tenure. The ultimate choice could be between a house and a flat (not illustrated in the figure). There are many permutations of such trees. The main point to take, however, is that the housing choice decision is a complex one *conditional on other factors* as well as the ultimate choice of owner occupation versus public renting.

This conclusion has consequences for the modelling of residential choice. Instead of modelling tenure choice using a discrete choice procedure such as a logit regression, one must now explicitly take into account the other decision levels. In effect, the 'ultimate' choice of owner occupation versus renting is now *nested* within these other decision levels. As a result, modellers use a procedure called *nested multinomial logit* to model the likelihood of individuals choosing to move to a specific location and tenure. In other words, each level of the decision tree is modelled. There is also a technical reason to support this approach – in seeking to overcome the problem of the Irrelevance of Independent Alternatives (IIA). In

other words, the non-nested model assumes that providing an extra alternative, for instance, a new location, will not affect the choice made. This is implausible in the context of housing choice – a new development creating effectively a new location alternative will impact on wider housing choices - and the nested model allows explicit account to be taken of alternatives (McFadden, 1978; Quigley, 1985). However, the statistical and computational requirements to make the NMNL model work are onerous and can lead to the researcher having to artificially force the model to work (see below).

The model operates by stacking data – one row for each possible choice. This means that if a household has seven choices (three locations, two tenures and one non-moving option), then each observation involves seven rows – factoring up the statistical and computational complexities of the model. The data is drawn primarily from the SHCS and this is also the key constraint. We may feel for instance that previous location is an important factor in determining present location – we evidently need to be able to construct such a variable from the data set. This is particularly a problem because in moving and decisions we are interested in push factors that involves change at the margin for instance, household splitting. The SHCS data set only really allows us to estimate household type and size, not recent changes in the household. At the same time, one can plausibly argue that location choices are driven be wider non-housing factors. Following this argument, we have made extensive use of multiple deprivation indicators as a measure of neighbourhood quality, drawing on earlier work by members of the research team (Gibb, et al, 1998)

There are a number of ways in which one could construct the household choice decision tree. Initially, the research team wanted to distinguish between flats and houses but it quickly became apparent that the data would not support a fourth level in the tree with too few observations being observed in this lowest level of the tree to make estimation feasible. For example, there were only 4 households who decided to move north, into private tenure and into a house. Consequently, the research team opted to try a three level tree as illustrated in appendix 2 (figure 3).

The decision to try a three level tree did resolve the problem of too few observations in the choice categories but unfortunately resulted in an equally frustrating problem of counter-intuitive and unstable results. These counter intuitive results occurred as a result of a lack of variation in the data used to model the *locational* choice level of the tree. Basically, the values of the deprivation index and housing costs terms, the factors we were using to model the locational choice level, were more or less identical for the North and South of Glasgow. Consequently the study team decided to adopt a two level tree structure - as shown in appendix 2 (figure 4).

As can be seen from figure 4, the location level is now omitted in the structure. In other words, it is not explicitly modelled. Instead, it is modelled indirectly by being estimated along with the tenure choice level. This is readily achieved by interacting the location choice variables/factors (such as the deprivation index and the housing cost term) with constants for North, South and Outwith Glasgow.

Results

The results for the two level model which were ultimately used to construct conditional probabilities at this stage of the project are illustrated in table 2 below and are presented in two parts. The first part consists of the results for tenure choice i.e. owning (Private) versus renting (Public) and the second part consists of the results for the move decision. The results have been deliberately simplified to ease interpretation. Standard results and diagnostics are

presented in Appendix 3. The full variable description is given as well as the sign on its coefficient and an indicator of its significance or importance, represented by a *. One * means that the variable is important at the 10% level of significance. Two ** represents 5% significance and three *** 1% significance. This is the highest level of significance.

Table 2 Econometric Model Results

A. Tenure Choice Decision (Bottom level of decision tree)

Variable	Sign	Significance
Housing cost	_	ins
Public sector rationing (interacted with NORTH and PUBLIC)	+	***
Public sector rationing (interacted with SOUTH and PUBLIC)	+	***
Public sector rationing (interacted with OUTWITH and PUBLIC)	+	***
Household permanent income (interacted with NORTH and PUBLIC)	_	***
Household permanent income (interacted with SOUTH and PUBLIC)	_	***
Household permanent income (interacted with OUTWITH and PUBLIC)	_	***
Deprivation score (interacted with NORTH and PRIVATE)	_	***
Deprivation score (interacted with NORTH and PRIVATE)	_	***
Deprivation score (interacted with NORTH and PRIVATE)	_	***
Household's previous location is NORTH	+	***
Household's previous location is SOUTH	+	***

B. Move-stay Decision (Top level of decision tree)

Variable	Sign	Significance
Household permanent income	_	*
Head of household is married or co-habiting	_	***
Number of children aged below 16	+	ins
Head of household is aged 16-24	_	***
Head of household is aged 25-29	_	***
Head of household is aged 30-34	_	***
Head of household is aged 35-44	_	***
Head of household is aged 45-54	_	***
Head of household is aged 55-59	_	***

Looking at part A of Table 2 the results suggest that housing costs play a statistically insignificant role in the tenure choice decision of households (but see below). Instead, the greater the availability of social housing (i.e. the less binding are rationing effects in the public sector) then the more likely is the household to move into rented (public sector) housing in the north of Glasgow. This is also true for SOUTH and OUTWITH. The three * indicate that these variables are highly significant. Household permanent income is also a highly significant factor in housing choice. The results also say that low income households tend to choose rented (public sector) housing, in all locations. (NORTH, SOUTH and OUTWITH). As expected, the level of deprivation in an area impacts strongly on location choice. Households who choose low deprivation areas tend to be in owner occupied housing - again this holds true across all locations. The final significant factor in tenure choice is previous location with those households who moved from the North and those households who moved from the South more likely to remain in those areas.

Part B of table 2 illustrates the factors that influence the move-stay decision of households. The lower a household's income then the significantly more likely they are to stay. This is also the case if the head of the household is married or co-habiting. The number of children under 16 would appear to have no significant effect. The most significant factor in the move-stay decision is the head of household's age. Compared with heads of households over 60 years of age, every younger head of household is significantly less likely to stay.

The results are *largely* plausible but far from conclusive. Income and demographics seem to determine moving decisions while neighbourhood quality, locational attachment, availability and income seem to shape tenure/location decisions. The research team is continuing to re-estimate the model and to adjust its specification in order to improve the model's outcomes. It is clear that the model is not particularly robust in that its results are sensitive to small re-calibrations. Other particular concerns remain with the sign on the housing cost term. We expected this to be negative (this can, perhaps be explained, by the fact that most tenants receive substantial housing benefits which insulate them form the cost of housing and marginal changes thereof). It may be that housing costs only affect the decisions of households in the private sector – initial evidence (not reported here in detail) suggests that the housing cost term does become negative if it is interacted with the private sector (i.e. we ignore the housing cost term for the renters). This has wide policy ramifications. The other main issues concern the absence of an explicit role for previous tenure within the model and the continuing need to force the overall model to work by imposing inclusive values of around 1.0. The latter point suggests a case could be made for reverting to some form of non-nested model.

5. INITIAL APPLICATIONS OF THE FULL MODEL

The Base Position

The estimates discussed above were next applied to the computer model of the Glasgow housing system (as conditional probabilities that explain housing choices by existing households within the Glasgow area). In order to report the results from that model in a sensible fashion we first set out the base position in 1996.

The model has a base of 1996 and uses data primarily from the 1996 Scottish House Condition Survey for the Greater Glasgow area and demographic numbers for households and population provided by the City Planners for 1996 and projections they provided for 2005 based on their assumptions about migration (part of the model was also calibrated assuming no migration)[2]. The geography of the model works on Unitary Local Authority boundaries with the GCC split north and south of the River Clyde and the area outwith the city defined as the contiguous ULAs (North and South Lanarkshire, East Renfrew, Renfrew, East Dunbarton and Clydebank and West Dunbarton).[3]

Table 3 sets out the basic household and stock position in 1996 along with the 'official' City projections for 2005 (including an 'optimistic' assumption for migration). This table should be interpreted carefully. The first figure shows the number of households for the given year, followed by the column percentage for that year i.e. the tenure share for that year. The figure in italics indicates the percentage change in households in that tenure between 1996 and 2005. Thus owners in the south of Glasgow between the two years grew by 18.9% but as a share of all tenures grew from 48% to 56%.

The main messages from Table 3 are:

- The relative sizes of the three areas are very different. In 1996, there were 170,686 households in the North but only 99,247 in South Glasgow. In 1996, there were 438,501 outwith Glasgow. The respective percentage shares in 1996 were 14:24:62. All three areas grew in the period until 2005 but the Outer area grew at more than three times the Glasgow components. The respective shares consequently changed in the 2005 projection to 14:23:63.
- Tenure will change considerably – increasing owner-occupied households by 22% and reducing social renting households by 14%. The biggest owning increase is estimated to be in North Glasgow (which also has the smallest proportionate reduction in social renting households). South Glasgow has a bigger reduction in social renting households and a smaller increase in owning households.
- The private renting shares are static although the numbers increase in all three areas, with the biggest increase in households (3.9%) in North Glasgow.

Table 3 Households 1996 and 2005 – 'Official' City Estimates

Tenure	South	North	Outer	Total
Owners				
1996	47642 (48)	67284 (39)	262230 (60)	377156 (53)
2005	56647 (56)	83164 (47)	321568 (68)	461379 (61)
% Change in households	*18.9*	*23.6*	*22.6*	*22.3*

[2] On inspection, we found that the City Planners provided us with three slightly differing estimates of the stock of households in 1996. We used the figures that could be disaggregated by tenure for the base.

[3] The main exception to this involved the calculation of net migration from the rest of Scotland which involved the use of Health Board data weighted by population shares of each authority.

Private rent				
1996	5046 (5)	7839 (5)	7776 (2)	20661 (3)
2005	5085 (5)	8146 (5)	7884 (2)	21115 (3)
% Change in households	*.08*	*3.9*	*1.4*	*2.2*
Social rent				
1996	46559 (47)	95563 (56)	168495 (38)	310617 (44)
2005	39941(39)	83508 (48)	143621 (30)	267070 (36)
% Change in households	*-14.2*	*-12.6*	*-14.8*	*-14.0*
All households				
1996	99247 (100)	170686 (100)	438501 (100)	708434 (100)
2005	101673 (100)	174818 (100)	473073 (100)	749564 (100)
% Change in households	*2.4*	*2.4*	*7.9*	*5.8*

Note: percentage figures (in brackets) are rounded.

The same household information in terms of owning versus renting can be described in terms of the stock estimates and projections also provided by the Council. This demonstrates that rented housing will fall most from 1996 to 2005 outside of the City but will, nonetheless fall by between 11.4% and 12.7% within Glasgow.

Central Model Estimates

After testing the model and making some initial refinements, the following central estimates were generated. Starting from a base of 1996, results are reported for 2005 (to compare with the official projection) and for 2009. Comparing the model-generated estimates for 2005 with the 'official' projections, it is clear that they are close together (Table 4). In fact, all of the figures are within one per cent apart from the figures for South Owners that are 2.6% apart. Three of the model figures for 2005 exceed the official estimates but both numbers for South Glasgow and the number for Outwith Owners are below those of the official estimates.

Table 4 Central Estimates for 1996, 2005 and 2009 (Household numbers)

Location/tenure	1996 Base	2005 (official)	2005 (model)	2009 (model)
North Owners	67284	83164	83862	90580
North Renters	103402	91654	92395	89270
South Owners	47642	56647	55312	58872
South Renters	51605	45026	44677	42834
Outwith Owners	262230	321568	320494	343850
Outwith Renters	176271	151505	152876	144006

What messages are there for social housing demand from these central projections to 2009? First, of all total demand for housing in the city of Glasgow will rise from 269,933 households in 1996 to 281,556 households in 2009 – an increase of 4.3 per cent. Second, demand for owning rises sharply, from 114,926 households in 1996 to 149,452 households in 2009. This is equivalent to a percentage increase of 30%. This means therefore that there is a corresponding decline in rented housing. The Table suggests that rented housing in Glasgow will decline from 155,007 households in 1996 to 132,104 in 2009. This represents a percentage reduction in demand of 14.8%.

However, third, as was pointed out above, these estimates are for the demand for rented housing as a whole and we, therefore, have to remove the private renting residual from the total. Table 3 suggests that between 1996 and 2005, private renting as a proportion of social renting rose from 9.0% to 10.7% - this is roughly equivalent to a 0.2% annual increase in share. If this is extrapolated forward to 2009, it implies that private renting will be approximately 11.5% of the total in 2009 (note that the increase in this ratio is primarily due to the decline in social rented households and that private renting households are fairly constant in terms of households).[4] This suggests that the demand for social rented housing will be 88.5% of the total renting households' figure. Therefore, by extension, social rented housing in Glasgow will fall from (91% of 155,007) 141,056 households in 1996 to (88.5% of 132,104) 116,912 households. This is a fall of 17.1%.

Sensitivity Analysis

The final stage of the interim work was to undertake some sensitivity analysis of these results. Certain key variables are 'shocked' by arbitrarily changing their values in a certain direction and we see what this does to the model's central results, in particular, does it move in the predicted direction and what impact does it have on the overall level of demand. Clearly, there are a near infinite number of sensitivity tests that can be undertaken in such a model. Presently, we restrict ourselves to a limited number of issues namely assumptions about household formation, migration and the transitional probabilities of household types changing (in this case household splitting and increased deaths among single pensioners). Note, also, that the scale of these shocks is relatively arbitrary. Part of the discussion of further work should revisit the sensitivity testing and the scales employed. Table 5 shows the cumulative deviation from the central estimate. It focuses on the City of Glasgow alone and compares deviations from the 2009 central forecast using the forecast period 2000-2009.

Table 5 indicates that the rather arbitrary shocks applied have the expected impact on overall demand. For instance, increasing net in-migration from the rest of Scotland increases the number of households, as does higher levels of households splitting or new household additional formation. On the other hand, we would expect to see falls in household numbers from decreased net migration and from higher death rates among single pensioners. The proportionate changes involved are a function of the size of the 'shock' to the variable but it is worth noting the relatively small impact of quite large changes to net migration – we think this may be due to a downward bias imparted by the model into headship rates fro migrating households. It is interesting to note that the model implies that when households split they initially boost the rented sector but as time goes on, more and more of these households switch to owner-occupation.

Table 5 Sensitivity Analysis (Cumulative Deviation in Numbers of Households; Glasgow City, 2009)

Sensitivity test	Deviation from Central Estimate (No. of h'holds)	% Deviation from central estimate
10% increase in new household formation	2388	0.8
25% increase in net in-migration	435	0.001
25% decrease in net in-	-437	-0.001

[4] However, one should remember that initially, many newly forming households and migrants will reside in the private rented sector. In other words, the marginal effects will be different from the average. We could argue that the private rented sector share should in fact be larger.

migration		
Doubling of transition from couple/family to single or lone parents	8541	3.0
Doubling of death rate of single pensioners	-9056	-3.2

Implications

If we assume that these results are relatively robust, and mindful that extensive further work remains to be done, what are the implications of these findings for Glasgow, the disaggregated parts of Glasgow, tenure structure and related questions?

First, the number of households are increasing and this is consistent with official household projections, although the rate of increase is at the low end of the projections for other parts of Scotland such as Edinburgh. It is well-known that this demand is increasingly for smaller households and, consequently, for different, smaller housing requirements. At the same time, there is a belief that housing demand in Glasgow is increasingly shifting away from flats towards houses. We will address these compositional questions in the next stage of the research. We also intend to consider the supply implications of this increased demand. Second, Glasgow City's increase in households is smaller than the increase in households in the surrounding conurbation (Outwith Glasgow). The central projection is that between 1996 and 2009, households in the contiguous local authorities will experience an increase in households of more than 11.2%, from 438,501 to 487,856 households. Thus, the relative growth, and corresponding demand pressures in the suburbs relative to the city core, will continue. Third, there is differential growth between the North and South of the City. The larger North Glasgow area is expected to grow in total households by 5.3% to 179,850 households by 2009; whereas South Glasgow only grows by 2.5% to 101,706.

If the attention shifts to household numbers for owning and social renting, the following implications are apparent. For Glasgow City, the number of owning households is expected to rise by 30%. For the surrounding conurbation (Outwith Glasgow), the equivalent increase is 31.1%, a broadly equivalent increase but, in absolute terms a much more significant scale (increasing from 262,230 in 1996 to 343,800 in 2009). Thus, Greater Glasgow can expect a broadly similar increase in the demand for owner-occupation. This has important implications for new supply and land release and future work on the model will seek to relate this to simulations that vary supply conditions. It should be borne in mind here that a critical environmental variable driving home ownership is the assumed level of RTB sales. We have followed the projections used by the City Planning team but clearly this is something can be examined further.

The number of social renting households in Glasgow is expected to fall by more than 17% from 141,056 households in 1996 to 116,912 households in 2009. This compares with the equivalent figures for Outwith Glasgow for social renting. Private renting's share of all renting in Outwith Glasgow rose from 4.4% in 1996 to 5.2% in 2005. This is approximately equal to 0.09% per annum relative growth. If this extrapolated forward to 2009, this in turn implies that private renting as a share of all renting should be approximately 5.6%. This means that social renting households in 1996 approximates to (95.6% of 176,271) 168,515 households. In 2009, social renting households outwith Glasgow approximates to (94.4% of 144,006 households) 135,941 households. This implies a reduction of 19.3% between 1996 and 2009 – a larger proportionate reduction than in the City of Glasgow.

6. SOME WIDER CONCLUSIONS

This paper reports the construction and initial results of a new simulation model of the Greater Glasgow housing system. The development of the model involved the application of work conducted by Meen in the South East of England to the different context of West Central Scotland. The model is particularly elaborate on the demand-side involving new household formation, migration and the internal housing choices of existing households. This latter sub-group require separate econometric modelling in order to measure their conditional probabilities. The model essentially allocates owning and renting households into tenure, location and moving decision boxes, split by household type and age. The market is cleared by two potential routes – by prices or by supply equalling demand. Supply is more mechanistic but the overall framework provides for a rich diversity of possible scenarios to test and simulate (e.g. increased investment, more demolitions, rent policies, income change, etc.).

Continuing work with the model seeks to test and refine both the econometric model and the wider simulation model. Scenario testing will be undertaken as will the feasibility of developing the model in other Scottish urban areas (including developing more rigorous boundaries for metropolitan housing markets). The model can evidently produce future estimates of demand under different assumptions about economic and demographic drivers. When the model is suitably refined and robust, we hope that it can be offered up as a useful policy intervention model teasing out the impacts and chains of cause and effect following on from various housing policies.

From an academic point of view, the model is a first for the UK in that it connects the social and private sectors of the housing system across space. However, the model is, in many ways, rudimentary and highly-data contingent. Advances in modelling, software, better data and with improved local contextualisation, the overall model is bound to improve in future versions.

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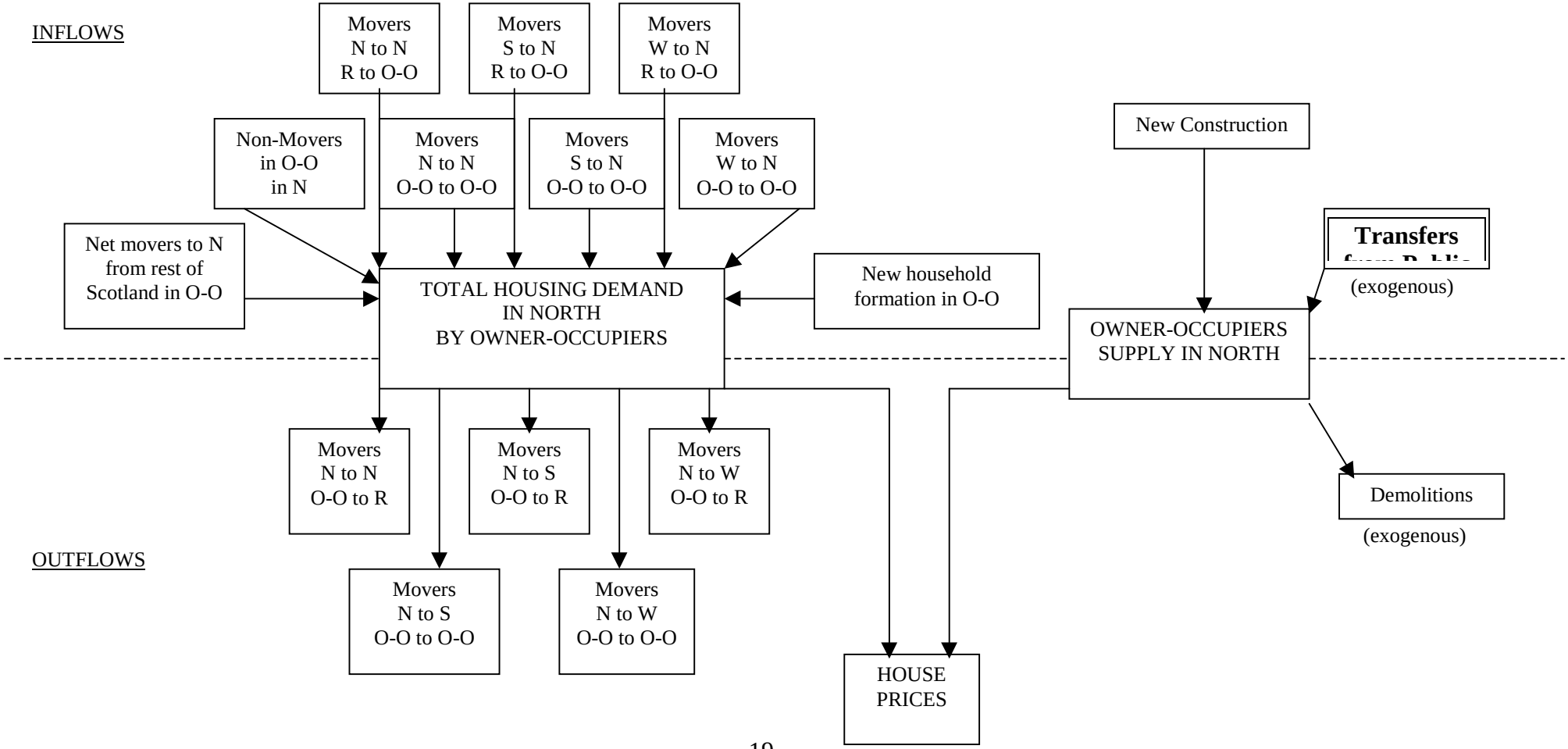
APPENDIX: MODEL OVERVIEW

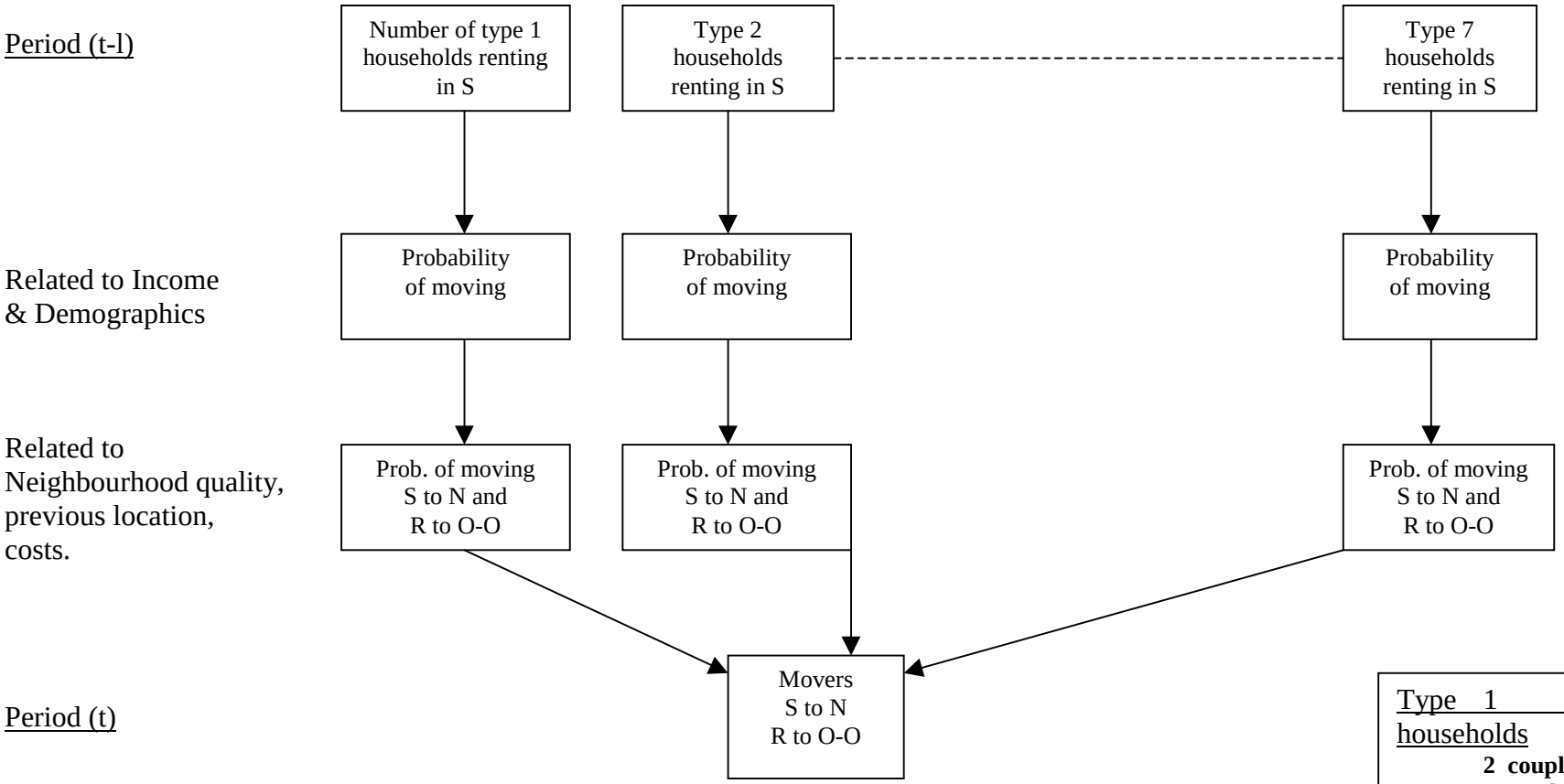
This demonstrates the model for owner-occupiers in North Glasgow. Similar diagrams exist for the other 2 areas and for renters.

Key
R = renting
O-O = owner-occupation
N = North
S = South
W = West



THE NUMBER OF MOVERS

e.g.1 renters previously living in South moving to owner-occupation in the North.



Type 1 single person households

2 couple, no children
3 single parent
4 couple with children
5 single pensioner
6 couple pensioner
7 Other

OTHER MODEL FEATURES

(i) Supply

New construction is determined:

either: as a function of house price changes,
or: as the necessary level of meeting demand, given prices.

This implies that prices are:

either: market clearing (in the long term),
or: constant in real terms.

(ii) New Household Formation

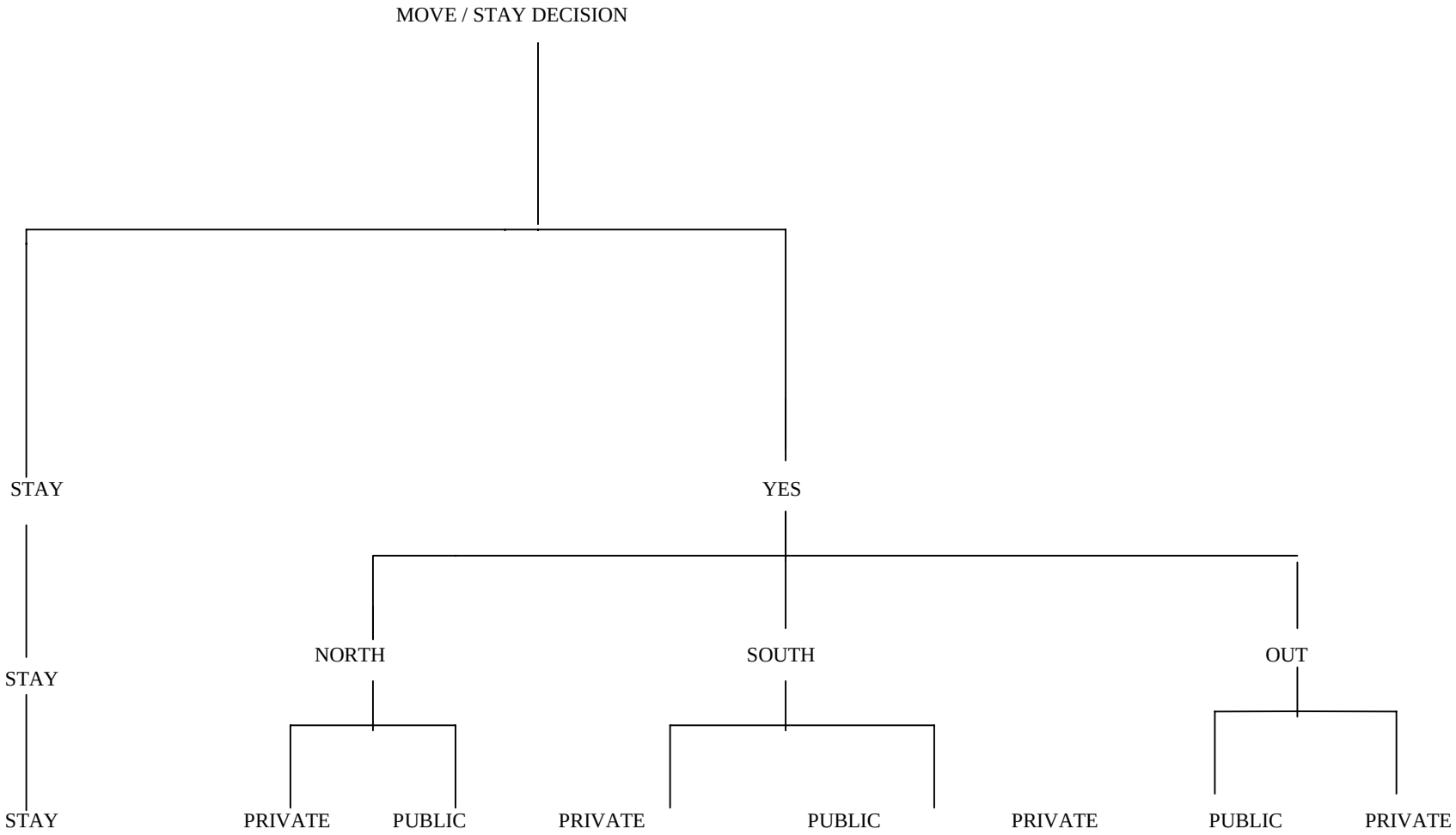
This is based on official headship rate projections (which are taken to be exogenous).

(iii) Migration

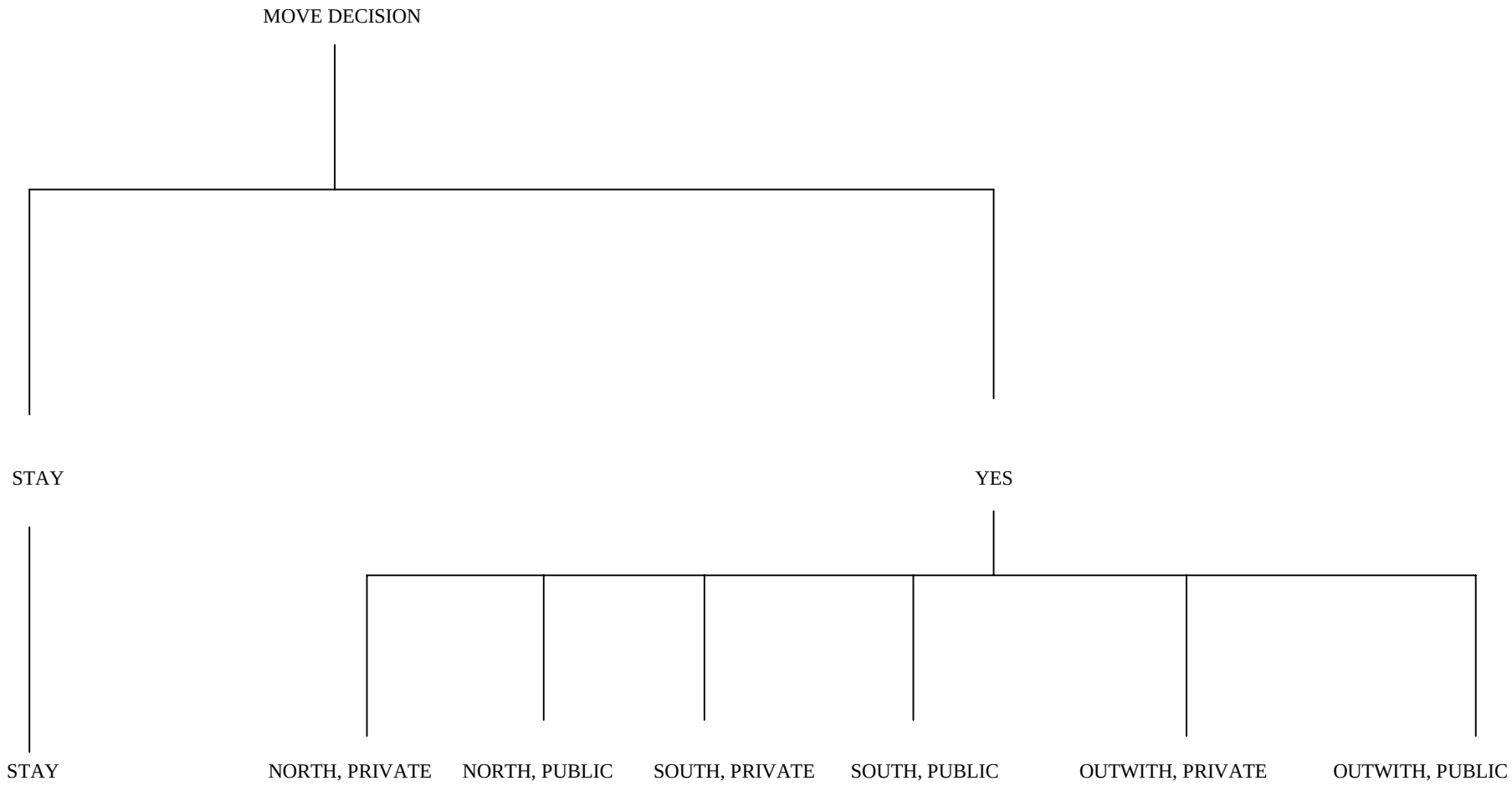
- The model endogenously determines flows between the 3 areas.

- Net flows to each of the 3 areas from the rest of Scotland are partly based on official projections, but equations also exist based on earlier work related to employment growth and house price differentials.

APPENDIX 2 Figure 3



APPENDIX 2 Figure 4



APPENDIX 3
Econometric Results: Two Level decision Model

```
+--------------------------------------------+
| FIML: Nested Multinomial Logit Model       |
| Maximum Likelihood Estimates               |
| Dependent variable              ACHOICE    |
| Weighting variable                  ONE    |
| Number of observations            26719    |
| Iterations completed                 30    |
| Log likelihood function       -1366.029    |
| Restricted log likelihood     -3265.692    |
| Chi-squared                    3799.326    |
| Degrees of freedom                   21    |
| Significance level             .0000000    |
| R2=1-LogL/LogL*  Log-L fncn  R-sqrd  RsqAdj |
| No coefficients  -3265.6916  .58170  .58132 |
| Constants only   -1712.3937  .20227  .20154 |
| At start values  -6911.1491  .80234  .80216 |
| Response data are given as ind. choice.    |
+--------------------------------------------+
```

NMNL MODEL FOR THE CITYWIDE SURVEY DATA SHCS

```
+--------------------------------------------+
| FIML: Nested Multinomial Logit Model       |
| The model has 2 levels.                    |
| Coefs. for branch level begin with I1      |
| Number of obs.=  3817, skipped   0 bad obs. |
+--------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
Attributes in the Utility Functions (TENURE CHOICE EQUATION)					
A25	.1134627624E-02	.90414509E-03	1.255	.2095	
C1	12.92586561	4.3566197	2.967	.0030	
C2	19.22213134	7.0945842	2.709	.0067	
C3	24.30001594	5.4143598	4.488	.0000	
C4	-2.470813494	.39398810	-6.271	.0000	
C5	-2.799819984	.54676066	-5.121	.0000	
C6	-2.436946264	.32134790	-7.584	.0000	
C9	-.8315789055	.63808887E-01	-13.032	.0000	
C10	-.8873725672	.70122205E-01	-12.655	.0000	
C11	-.9447035888	.96286889E-01	-9.811	.0000	
C12	2.894515739	.30588976	9.463	.0000	
C13	2.698320668	.32840588	8.216	.0000	
Attributes of Branch Choice Equations (MOVE-STAY EQUATION)					
I1	-3.201553573	.23604809	-13.563	.0000	
I2	-2.262798433	.22818272	-9.917	.0000	
I3	-1.878722562	.23186567	-8.103	.0000	
I4	-.9331817255	.23254940	-4.013	.0001	
I5	-.6905933462	.22814375	-3.027	.0025	
I6	-.8732926894	.25968495	-3.363	.0008	
I12	.9952857431E-01	.74982760E-01	1.327	.1844	
I28	-.6341078189	.18228246	-3.479	.0005	
I49	-.1844564118	.10175273	-1.813	.0699	
Inclusive Value Parameters					
NOMOVE	1.000000000	.....(Fixed Parameter).....			
MOVEYES	.9000000000	.....(Fixed Parameter).....			

Variable List

Variables appearing in the tenure choice equation (lowest level)

A25 housing cost by tenure and location (per month)

C1 rationing variable interacted with alternative specific constant for PUBLIC and NORTH
C2 rationing variable interacted with alternative specific constant for PUBLIC and SOUTH
C3 rationing variable interacted with alternative specific constant for PUBLIC and OUTWITH

C4 permanent income interacted with alternative specific constant for PUBLIC and NORTH
C5 permanent income interacted with alternative specific constant for PUBLIC and SOUTH
C6 permanent income interacted with alternative specific constant for PUBLIC and OUTWITH

C9 deprivation index score interacted with alternative specific constant for PRIVATE and NORTH
C10 deprivation index score interacted with alternative specific constant for PRIVATE and SOUTH
C11 deprivation index score interacted with alternative specific constant for PRIVATE and OUTWITH

C12 dummy variable for previous location is NORTH
C13 dummy variable for previous location is SOUTH

Variables appearing in the mobility equation (top level)

I1 dummy variable for head of household is aged between 16 and 24 years
I2 dummy variable for head of household is aged between 25 and 29 years
I3 dummy variable for head of household is aged between 30 and 34 years
I4 dummy variable for head of household is aged between 35 and 44 years
I5 dummy variable for head of household is aged between 45 and 54 years
I6 dummy variable for head of household is aged between 55 and 59 years

I12 number of children under 16 years of age
I28 dummy variable for head of household is married/living together

I49 permanent income of household (monthly)