

WORKING PAPER 521

MICROANALYSIS AND SIMULATION OF HOUSING CAREERS:
SUBSIDY AND ACCUMULATION IN THE U.K. HOUSING MARKET

MARTIN CLARKE, PAUL LONGLEY AND HUW WILLIAMS

School of Geography
University of Leeds
Leeds LS2 9JT

January 1989

MICROANALYSIS AND SIMULATION OF HOUSING CAREERS: SUBSIDY AND ACCUMULATION IN THE U.K. HOUSING MARKET

* + +
MARTIN CLARKE, PAUL LONGLEY AND HUW WILLIAMS

CONTENTS:

- 1 INTRODUCTION: ISSUES IN HOUSING MARKET FINANCE AND POLICY
 - 2 DEVELOPING MODELS TO EXPLORE HETEROGENEITY IN HOUSING
EXPENDITURE AND SUBSIDY
 - 3 HOUSING FINANCE AND SUBSIDY TO OWNER OCCUPIERS
 - 4 A MICROSIMULATION MODEL OF HOUSING CAREERS
 - 5 SIMULATION RESULTS
 - 6 DIRECTIONS FOR FUTURE RESEARCH
- BIBLIOGRAPHY

PAPER PRESENTED TO THE EUROPEAN REGIONAL SCIENCE CONGRESS,
STOCKHOLM, SWEDEN, AUGUST 1988

* SCHOOL OF GEOGRAPHY, UNIVERSITY OF LEEDS, LEEDS LS2 9JT

+ DEPARTMENT OF TOWN PLANNING, UNIVERSITY OF WALES AT CARDIFF,
CARDIFF, CF1 3EU

ONE AUTHOR (MC) WISHES TO ACKNOWLEDGE THE SUPPORT OF ESRC UNDER
GRANT NUMBER R00022 0003

1 INTRODUCTION

Variations in the economic experience of different households in the housing system is a prominent and much discussed feature in many Western countries. One of the most notable features of this diversity is the very wide range of housing expenditure, from nothing up to approaching half of household income, for almost identical properties, whether these are in the same street or in different parts of the country.

Expressions of concern are particularly evident, and indeed often constitute newspaper headlines, at times of high house price inflation, when the implications for first time house buyers and the effects of regional disparities in prices on mobility may be graphically related in individual cases. Inflationary surges, such as those that occurred in the U.K. in the early and late seventies and within the last couple of years, have major implications for the relative economic positions of households entering and moving within the market at different times, and the subsidies which each receive.

A decade ago the British Labour Government undertook a major review of housing policy, the findings of which were published in a Green Paper (HMSO,1978). The Review was particularly concerned with assessing the expenditure and assistance received by different households in different tenure groups, and to consider policies to achieve a more equitable and balanced distribution of subsidy support. The technical reports accompanying the Green Paper made an initial exploration of the diversity in expenditure and subsidy by making use of a number of data sources including Building Society Mortgage Surveys, National Mover Surveys, the General Household Survey and the Family Expenditure Survey.

There have followed a number of attempts to refine the arguments in the Housing Policy Review, and particularly to clarify the issue of neutral treatment of the different tenures (Whitehead,1978; Grey et al.,1981; Atkinson and King, 1980) and to elaborate on the diversity of conditions in the housing system (Robinson et al.,1985).

For practical but mainly political reasons no radical reforms of housing finance resulted from the Housing Policy Review, and the subsidy arrangements which characterised the British housing system have remained essentially intact to this day. Indeed,

while various alternatives have been presented from time to time over the last two decades, major reform of housing finance has been rejected by the two main political parties. It is generally recognised that any policy which has significant adverse effects on the housing budget of families is likely to have potent electoral consequences. This is despite a large body of evidence that can now be assembled to demonstrate the social inequity and economic inefficiency of subsidy in the owner occupied sector (for an excellent general review see Balchin, 1985). The current Thatcher administration has consistently promoted a 'right to buy' policy by both retaining the subsidy arrangements for owner occupiers and encouraging the sale of publicly owned dwellings at large discounts. At the same time general subsidies to local authorities for public rented housing have been slashed and the private rented sector largely ignored. Many commentators suggest that Britain is currently in the throes of a housing crisis.

While the questions concerning the appropriate levels of support for different types of households can be addressed at a number of different levels, we would contend that the positive issues relating to the diversity of experience in the housing system and the distributional implications of current (and any alternative) arrangements are worthy of detailed **quantitative** analysis. Specifically, we note the need for a detailed account of the flows of exchequer subsidy to different household groups over time, and a corresponding identification of the processes of capital accumulation as a function of behaviour of households in the housing system.

In spite of the large number of qualitative studies of the impact of housing policy there have been very few attempts to systematically quantify the variations in housing subsidy and finance over space and time. Regional disparities in house prices, the effect on mobility and the differences between first time and exchange buyers, suggest that any quantitative approach to enumerating this variation must fully account for the heterogeneity to be found in the housing system. There must also be an explicit treatment of time so as to draw out the full implications of asset accumulation and the reserve purchasing power of exchange buyers, as well as to capture the appropriate relationship between asset holding and life cycle and inheritance. Approaches based on studying the housing system at the cross-section will fail to fully represent these important factors.

Examination of the heterogeneity of household experiences in social processes and the distributional implications of social policy has a long history in the social sciences and techniques were developed for this purpose in the early 1960s by Orcutt and his colleagues in the U.S.A. (Orcutt et al, 1961). His work was among the first that explored in a systematic way the dynamical interdependencies between the attributes of individual households

and their members and their relationship to other economic and social variables. Our own work lies within this tradition and the research reported in this paper builds on over a decade of involvement in the construction ,testing and application of microsimulation models in the transport, health, demographic and marketing sectors.

The major focus of this paper is therefore to explore, using microsimulation methods , the various dimensions of heterogeneity in housing market characteristics as experienced by individual households over time. Specifically we are concerned with:

- (i) the difference in housing careers between different households (characterised by age, income, household structure, etc) within a region.
- (ii) the same differences between households in different regions
- (iii) the differences between households which enter the owner occupier sector at different times and the budgets of the same household at different times.
- (iv) the flows of different types of government subsidies to different types of households over time and between regions.

The paper is organised as follows. In the next section we briefly review the different types of approaches to modelling aspects of the housing market, emphasising the need for an approach which will handle the underlying heterogeneity which we feel is necessary to address the issues identified above. In section 3 the essential features of housing finance and behaviour in the British housing system are outlined and an example is given which draws out the various factors which influence wealth accumulation and subsidy within the owner occupier sector. Section 4 presents the details of the model developed for this study together with a discussion of the data sources that we have used. Results of the simulation modelling are presented in section 5. Directions that we have identified for future research together with some concluding comments are given in section 6.

2 DEVELOPING MODELS TO EXPLORE HETEROGENEITY IN HOUSING EXPENDITURE AND SUBSIDY

2.1 EXISTING MODELS OF THE HOUSING MARKET

A large number of models have been developed to explore different characteristics of the housing system and the implications of policy. A central issue is the appropriate specification of the model to address the range of phenomena of interest, and whether alternative models exist for this purpose.

Because it will be necessary to return to the specification issue at different stages of the paper, and to relate our own to other work, we start with some brief comments on the general characteristics of housing models.

In the general characterisation of models distinctions are usually made between:

- a) the treatment of time and adjustment mechanisms (dynamic or comparative static)
- b) the detailed specification of the demand function
- c) the means by which behavioural relationships are estimated
- d) the level of aggregation and particularly the detailed classification of households and dwelling units
- e) the nature of the data used to estimate the model, and whether it is cross-sectional or longitudinal
- f) the interpretation and theories of association of households with dwelling units
- g) forecasting assumptions
- h) the representation of supply

Of the major classes of practical models we can identify a discrete number of categories. First there are those **aggregate econometric models**, either developed as isolated housing or part of more general macroeconomic models at regional or national level, which explore the interdependency of demand and supply and fiscal and monetary variables within lagged temporal frameworks. The second class comprises **comparative static models** which stratify the market and focus on the allocation of households to house types at the cross-section, either on the basis of prior probabilities or economic relationships. **Dynamic adjustment models** form a third broad class in which explicit consideration is given to the processes which contribute to the increments on the demand and supply sides and the transitions of households between states.

In both the latter categories the association between individual households and house types may be established through micro-economic relationships (specified and estimated at the individual level), and much emphasis has been directed at their development, particularly within a spatial context, to embrace the effects of housing and transportation policies.

The heterogeneity in the initial conditions on the demand or supply side and in the individual behaviour or transitions can be

modelled through the use of discrete or continuous probability distributions and the resultant models solved through the use of sampling. Such is the basis of microsimulation modelling, which we now discuss.

2.2 MICROSIMULATION MODELS OF THE HOUSING SYSTEM

The model of Orcutt et al (1961) and its various successors established the tradition for the dynamic investigation of demographic and economic processes. A review of this body of work can be found in Clarke and Holm (1987). The original model was not specifically concerned with the housing system, but DYNASIM (Orcutt, et al, 1976) did incorporate the accumulation of wealth within the housing market, and our present application attempts, within the British context, to address related effects.

Perhaps the most sophisticated stratified model of the housing market ever built is the NBER Housing Simulation model, which in its later stages of development incorporated microsimulation features for computational efficiency purposes, in order to cater for the degree of market segmentation on the demand and supply side. The history of the NBER model together with a description of its most recent manifestation is contained in Kain and Apgar (1985).

Our own work began by focusing on the interdependencies between demographic, labour market and housing systems in different parts of the U.K. (Clarke et al, 1981). In addition a considerable range of applications outside the housing system have also been developed - in health care (Clarke and Spowage, 1984), demography (Clarke, 1986), income modelling (Birkin and Clarke, 1988) and transportation (Williams, 1981).

3 HOUSING FINANCE AND SUBSIDY TO U.K. HOME OWNERS

3.1 INTRODUCTION

In this section we describe the ways by which central government assists the purchaser and owner of a house in the U.K. We outline the precise nature of the mechanisms involved and illustrate the implications of subsidy instruments by presenting a simple example of two households who begin with identical housing expenditure characteristics but who have different housing careers. The system-wide effects of differential subsidies are then examined in the next two sections.

3.2 SUBSIDY IN THE U.K. OWNER OCCUPIED SECTOR

Households purchasing a house with a mortgage in the U.K. are considered to enjoy favourable taxation benefits in three

respects:

- (i) they receive tax relief on mortgage interest payments
- (ii) they are exempt from tax on the capital gains received on the sale of their property
- (iii) they are exempt from tax on the imputed rental income from their property - in other words the benefit of being able to rent from themselves.

There is some debate as to the extent that owners are considered to be treated favourably, depending on whether owner occupied housing should be thought of for tax purposes as a consumption good, an investment good, or a financial asset. (Grey, Hepworth and Odling-Smee, 1981). However, as Balchin (1985) argues, the issue is really one of semantics. Whatever the argument, the Exchequer is foregoing income by the taxation policy surrounding owner occupation that has to be raised through other forms of taxation. For example, Balchin estimates that in 1983 8 billion pounds of revenue would have been raised through capital gains tax on housing, which would have allowed the Chancellor to cut the basic rate of income tax by 5p in the pound. It is also true to say that those households who perhaps view housing as a consumption good would not be quite as keen to commit such large proportions of their income to owner occupation if they did not expect to accumulate assets in the future.

It is the first two of the above tax advantages that have attracted most attention in studies of inter-household comparison, and it is on these which we shall concentrate in the rest of this paper. We shall also assume that, unless an owner occupied property is owned outright, it is in the process of purchase by means of an ordinary repayment mortgage.

We now describe algebraically how the process of repayment, subsidy and capital accumulation are determined. If:

$L(m)$ is the amount of the mortgage outstanding at the end of period m

$R(m)$ is the annual amount repaid in period m

$i(m)$ is the average interest rate in force during period m

P is the amount of mortgage taken out

N is the term of the mortgage

$V(m)$ is the current value of the house at end of period m

$V(0)$ is the house purchase price

$C(m)$ is the capital accumulated by time period m

$A(m)$ is the assets accumulated by time period m

$TXMI(m)$ is the tax relief on mortgage interest in period m

$tx(m,p)$ is the marginal rate of taxation for head of household with characteristics p in period m

then we may write recursively:

$$L(m) = L(m-1) [1 + i(m)] - R(m) \quad (1)$$

$R(m)$ is computed as

$$R(m) = L(m-1) \cdot \frac{i(m)}{[1 - (1 + i(m))^{-(N-m+1)}]} \quad (2)$$

Under fixed interest rates these reduce to the standard repayment schedules:

$$L(m) = P(1+i)^m \left\{ 1 - \frac{(1 - (1+i)^{-m})}{(1 - (1+i)^{-N})} \right\} \quad (3)$$

and :

$$R(m) = \frac{P i(m)}{(1 - (1+i)^{-N})} \quad (4)$$

The capital paid off in period m is $L(m-1) - L(m)$

The interest paid in period m is approximately $L(m-1) \cdot i(m)$ and the allowable tax relief is calculated as

$$TXMI(m) = L(m-1) \cdot i(m) \cdot tx(m,p) \quad (5)$$

where $tx(m,p)$ is the marginal tax rate for a person with characteristics p . There is currently a maximum ceiling on mortgage tax relief, set at the first 30000 of the mortgage.

If a household moves after year m , the capital gains can be simply calculated as the difference between the house sale price and the house purchase price.

$$C(m) = V(m) - V(0) \quad (6)$$

The asset accumulation is the difference between the house sale price and the amount of loan outstanding.

$$A(m) = V(m) - L(m) \quad (7)$$

Normally in the U.K. capital gains tax is calculated on the difference between the sale price of an asset and the purchase price at the highest rate of marginal income tax. If this was to be applied to capital gains in the housing system then it could be calculated as:

$$TCG(m) = C(m) \cdot tx(m) \quad (8)$$

There is a minor complication under current U.K. tax legislation in that the first 5000 of capital gains is exempt from tax. In the simulations performed below we ignore this allowance.

3.3 HOUSING FINANCE CHARACTERISTICS: A SIMPLE EXAMPLE

The temporal aspects of repayments, accumulation and subsidy, which are central to the computations to follow may be demonstrated simply with an example. We consider two households, identical with regard to socio-economic characteristics, the head of which earns (at time $t=0$) 4000 pa. Each buys a house at $t=0$ with a 100% mortgage for 2.5 times their income (10000) at a fixed interest rate of 12%. We can follow the economic fortune of these households over a ten year time period under the following assumptions: incomes and house prices inflate at constant rates of 10% and 13% respectively. The tax rates for these households is held at 30%. On subsequent moves, the trading behaviour of each household is summarised in the simple expression:

$$\text{mortgage advance} = 2.5 \cdot \text{income}$$

$$\text{price of house purchased} = \text{advance} + 0.9 \cdot \text{asset accumulation}$$

The only difference between the housing careers of the two households is that Household A moves twice (at the end of years 4 and 8) while B makes a single move at the end of year 8.

What is of interest are the following characteristics for both households: the total tax relief; the capital gains on moving; the relief from capital gains tax; repayments as a proportion of income; the mortgage liability as a proportion of the value of the house. Tables 3.1 and 3.2 summarise various features of the financial transactions and subsidy associated with owner-occupation, in this simple example. In the first table, the outstanding loans, the interest paid and the tax relief on that interest are presented for the two households. In the latter, the temporal behaviour of income, property values, repayments as a proportion of income, accumulated assets and accumulated

subsidies, are tabulated.

At the end of period $m=4$, when household A moves, it receives an accumulated asset saving of $\$16305 - \$9642 = \$6663$, which it uses to trade up into a house costing $\$20673$, for which an advance of $\$14640$ is sought. On the second move at the end of period $m=8$ the gain to A is $\$19535$, 90% of which is used to finance a house costing $\$39017$ for which a mortgage of $\$21435$ is obtained. Household B on the other hand, moves at the end of period $m=8$ and uses 90% of its assets ($\$17507$) towards a house costing $\$37191$ on which a mortgage of $\$21435$ is obtained.

year	Household A			Household B		
	L(m)	I(m)	T(m)	L(m)	I(m)	T(m)
1	9925	1200	360	9925	1200	360
2	9841	1191	357	9841	1191	357
3	9747	1181	354	9747	1181	354
4	9642	1170	351	9642	1170	351
5	14530	1757	527	9524	1157	347
6	14406	1744	523	9392	1143	343
7	14268	1729	519	9244	1127	338
8	14113	1712	514	9078	1109	333
9	21274	2572	772	21274	2572	772
10	21094	2553	766	21094	2553	766

TABLE 3.1 MORTGAGE CHARACTERISTICS AND TAX RELIEF ON INTEREST

year	Household A					Household B			
	Inc	R/I	V(m)	Accm	Sub	R/I	V(m)	Accm	Sub
1	4400	0.29	11300	1375	360	0.29	11300	1375	360
2	4840	0.26	12769	2928	717	0.26	12769	2928	717
3	5324	0.24	14429	4682	1071	0.24	14429	4682	1071
4	5856	0.22	16305	6663	1422	0.22	16305	6663	1422
5	6442	0.29	23320	8901	3948	0.20	18425	8790	1769
6	7086	0.26	26351	11945	4471	0.18	20820	11428	2112
7	7795	0.24	29777	15509	4990	0.16	23526	14282	2450
8	8547	0.22	33648	19535	5504	0.15	26585	17507	2783
9	9432	0.29	44089	22815		0.29	42026	20752	
10	10375	0.26	49821	28727		0.26	47489	26395	

TABLE 3.2 PAYMENTS AND ACCUMULATION IN OWNER OCCUPATION

On the two moves, household A is exempt from taxation on the capital gains of \$6305 and \$13011, respectively, household B is exempt from a gain of \$16585 from the single move. In arriving at the total subsidy to each household we have applied a standard tax rate of 30% to these gains and added them to the accumulated relief on mortgage interest. The results are shown in Table 3.2.

There are two features of the calculation worthy of note. First, table 3.2 shows the familiar 'front loading' of the debt liability, in which the repayment on a particular house, constant in money terms, becomes a decreasing proportion of income. This is particularly true of household B where, as a result of inflation, the ratio of repayment to income has decreased to half of the initial value by the time of the first move.

Secondly, it is clear that by moving and 'trading up' Household A has accumulated over \$2000 tax free more than household B over the four years till their next move at the end of year 8. This is of course associated with higher repayments (and tax relief) and will in the main be reinvested in property.

The most important comparison is with new entrants at any particular time. Under similar assumptions to those adopted in the calculation, the income of a new entrant (with no savings), at the end of period 8, would have to be \$13459 to purchase A's property. Alternatively, at the income of A and B (\$8574) a house of price \$21435 could be bought with a 100% mortgage. This can be compared with the house prices of A (\$33648) and B (\$26585).

3.4 GENERALISING THE ARGUMENT

It is clear from this example that the subsidy enjoyed by households will depend on a variety of factors, including: the purchase price of the house; the ratio of mortgage advance to price; the mortgage interest rate; the rate of taxation at which relief is given; and the frequency with which house moves are made.

The movement in exogenous factors, such as taxation and interest rates, house prices and incomes, will crucially influence the burden of housing expenditure (as a proportion of income), and interhousehold comparisons at different points in time and between regions. As Balchin (1985) notes, for much of the late 1970s households were effectively paying negative interest rates on their loans because of high inflation and tax relief.

The model we now describe associates such computations with the transitions made by any household in a sample of movers, and introduces variation between individual households in two basic ways. First, there will be differences due to the initial distributions of income, tenure, house value, mortgages and so

on. Secondly, variations will arise due to differences in the mobility and trading behaviour in the housing markets which are dependent on the attributes of individual households. Spatial variation will arise from differences in the initial conditions reflecting the distributions of demographic, social and housing characteristics of the populations in the 'North' and 'South' of Britain, and from any spatial differences in the movement of exogenous factors in these regions.

4 THE HOUSING SIMULATION MODEL - HOUSIM

4.1 INTRODUCTION

In this section we describe the main features of the housing simulation model developed to address the issues discussed above. HOUSIM is a dynamic microsimulation model that explores the processes of asset accumulation, mobility and subsidy effects in the owner occupied sector of the British housing system. A data base of households and their associated demographic, economic and housing attributes is specified from the 1976 Housing Conditions Survey undertaken by the Department of the Environment (DoE). The aim of the model is to successively update these attributes on an annual basis for a ten year time period 1976-86. In doing so we are particularly interested in examining the differential incidence of capital accumulation (through house price inflation) and of central government subsidy among different types of households and across different parts of the country.

The rest of this section is organised as follows. We first describe the micro-data base that has been used in the study. We then outline the structure of the model that has been developed so far, the assumptions underpinning the analysis and possible future extensions. The simulations that have been performed are described along with a commentary on the results obtained. Some concluding observations are presented, particularly in relation to the validity of the results obtained.

4.2 THE MICRO-DATA BASE

A prior requirement of micro-simulation models is a data base consisting of household/individuals with their associated attributes. These are stored in the form of lists on the computer. For many applications no micro-data base is available and the modeller has to resort to the synthetic generation of micro-data, a methodology described in detail in Birkin and Clarke (1988). In this study we were fortunate in being able to use a national micro-data base collected specifically in relation to housing and economic variables - the 1976 Housing Condition Survey. This survey, carried out by the Department of the Environment, is a detailed analysis of housing attributes among a

sample of 8700 dwellings in England. The variables identified in the survey and used in this study are shown along with the variable classification in table 4.1.

The national sample identifies a region of household residence ,the regions corresponding to the 10 English Standard Planning Regions. To enable us to investigate the differential spatial effects in terms of house prices and house price inflation we created two separate data bases. The first we term the 'Southern' data base and is composed of the following regions - Greater London and the Rest of the South East.The other is termed the 'Northern' data base and is composed of households resident in the Northern, North West and Yorkshire and Humberside regions.

A number of problems were identified in attempting to use the data base. First, there are a lot of missing data items in the survey data set. This is due to the respondents lack of knowledge (e.g.) amount of mortgage for an elderly owner occupier, or the respondents unwillingness to provide certain items of information. A discussion of both sampling and systematic errors can be found in O'Dell (1980)

VARIABLE	CLASSIFICATION
TENURE	1 OWN OUTRIGHT 2 MORTGAGE 3 RENTING LOCAL AUTHORITY 4 RENTING HOUSING ASSOCIATION 5,6 RENTING PRIVATE 8,9 OTHER
AGE OF HEAD	CONTINUOUS 0-99
SEX OF HEAD	1 MALE 2 FEMALE
MARITAL STATUS OF HEAD	1 MARRIED 2 SINGLE 3 SWD
HOUSEHOLD SIZE	CONTINUOUS
SEG OF HEAD	OCCUPATION GROUP 1 3,4 2 1,2,13 3 5,6 4 8,9,12,14 5 7,10,15 6 11

7 OTHERS

HOUSE PURCHASE PRICE	AMOUNT IN POUNDS
LOAN	AMOUNT IN POUNDS
YEAR MORTGAGE TAKEN OUT	YEAR
YEAR OF FINAL MORTGAGE PAYMENT	YEAR
HEAD'S ANNUAL INCOME	AMOUNT IN POUNDS
HOUSEHOLD INCOME	AMOUNT IN POUNDS

TABLE 4.1 VARIABLES AND CLASSIFICATION USED IN BASE POPULATION

Secondly, there is no information on house purchase price and other variables for owner occupiers who purchased before 1960. To attempt to get round some of these problems in the first instance we created a sub-sample of households that included only owner occupiers who purchased their house post-1960. Our analysis to date concerns this sub-population, although it is our intention to extend the analysis to a full sample population at a later stage. Removal of those who had not moved during the 17 year period left samples of 1454 (74.4%) and 1427 (72.6%) for 'North' and 'South' respectively. Screening for bad values of tenure, age and sex of head and household size cause negligible attrition, although when house purchase price, loan amount, year of first and last mortgage payments, head of household income, and household income are screened only 1007 (51.2%) and 1033 (52.9%) observations are left. Given that we are interested in the effects of mobility, notably the 'trading up' effect, we have increased the sample size by simple successive duplication of the population, to allow for the relatively small number of movers each year to be fully captured in the modelling process. The inflated sample sizes are 3021 and 3099 respectively. A priori reasoning might suggest that the non-response to the income questions would result in under-representation of higher income groups, although our analysis of the effects of screening by SEG suggest that the elimination rate is fairly constant across social groups. More serious is the non-response rate of those who own their own dwelling outright to the question concerning purchase price of dwelling. The impact of this is to reduce the owner occupier share of the 'Northern' data from 53% to 49% and that of the 'Southern' data from 56% to 52%.

4.2 THE MODELLING SYSTEM.

The microsimulation model is implemented through the use of

list processing whereby each household in the sample is tested for a series of potential events and their associated attributes are updated. A full description of the methodology is provided in Clarke and Holm (1987) or Orcutt, Merz and Quinke (1986) and we only sketch the briefest of details here. Transitions, such as residential mobility, are handled through the use of Monte Carlo sampling in which probabilities of transitions are stored in the form of look-up tables and random numbers drawn and compared with probability distributions.

The model consists of a number of steps that are repeated for each year of the simulation. We can discuss each step in turn:

(i) Calculating additional data items for 1976.

For each household in the sample we wish to calculate a number of additional data items for the base year. These include:

a) Term of the mortgage

This is given by subtracting the year mortgage taken out from the year of final repayment.

b) Current house value

This variable is calculated by inflating the house purchase price by the average regional house price inflation in the period since purchase. That is:

$$v = h * (1+p)^n \quad (9)$$

where v is 1976 house value

h is house purchase price

p is average house price inflation in region i during the period since purchase.

n is the number of years since purchase

It would be possible to refine this mechanism by disaggregating inflation by house type. House price inflation data was obtained from the Building Society Factbook 1986 (Building Society Association, 1987) and relates to building society mortgaged transactions.

c) Asset and Capital accumulation

Capital accumulated by household is taken as the difference between the current value of the property and the original house purchase price. Asset accumulation is the difference between current house value and original purchase price. This is an important variable in determining the purchase price and mortgage for movers.

d) Amount of mortgage outstanding

Equation (2) is used for calculating mortgage outstanding.

(ii) Annual updating of housing and socio-economic characteristics

For each year of the simulation period a number of variables are updated. These include:

(a) Head of household's income.

This is assumed to increase by the average regional wage increase across all occupations and is obtained from the New Earnings Survey published by the Department of Employment (Dept. of Employment, 1987). An obvious improvement would be to disaggregate this by occupation group and sex. It would also be useful to incorporate some of the effects of the Stock Exchange Big Bang in terms of wage increases in the South region. These are very difficult to detect from official sources. A further limitation is that we do not at this stage account for occupational mobility or unemployment.

(b) Head of household's age

This is incremented by one each year.

(c) House value.

This is incremented by the average regional house price inflation pertaining to the simulation year, as shown in Table 4.2. The same comments apply as in (i)(b) above. In particular the use of a regional average will not pick up the very steep price rises that have occurred in parts of the study regions, such as central London. This could be the subject of further refinement at a later stage.

YEAR	' NORTH'	' SOUTH'
1976	10.8	7.0
1977	10.4	7.8
1978	13.4	18.1
1979	25.6	33.4
1980	21.1	21.6
1981	8.4	3.8
1982	2.3	1.5
1983	10.4	12.6
1984	7.1	14.7

TABLE 4.2 AVERAGE ANNUAL HOUSE PRICE
RISES IN THE TWO REGIONS. (SOURCE:
BUILDING SOC. FACTBOOK, 1986)

(d) Mortgage repayments

The amount of annual mortgage repayments is calculated using equation (2). The repayments are split into capital and interest repayments as described above.

(e) Amount of mortgage outstanding

This is simply calculated by subtracting the capital repayments from the amount outstanding at the beginning of the year.

(f) Asset and Capital Accumulation

The new value of assets accumulated is calculated by subtracting the amount of mortgage outstanding from the value of the dwelling unit. The capital accumulated during the year is taken as the difference between the current capital and that of the previous year.

(g) Mortgage tax relief.

In the U.K., as we have noted, owner occupiers purchasing their house with the assistance of a mortgage are entitled to tax relief on the interest payments on the mortgage. This relief is allowed at the highest marginal rates of taxation on interest paid on the first \$30,000 of the mortgage (\$25,000 up to 1982). To calculate the amount of this subsidy we first need to calculate what the marginal rate of tax paid is. This is achieved as follows. We take the head of household's income and subtract the personal allowance from this total, dependent on whether they are single or married. A list of allowances for the period 1976-1986 is shown in table 4.3. On the remaining taxable income the appropriate tax band is determined by comparing this residual income with the tax bands published by the Inland Revenue for each year (source: Central Statistical Office, 1988). These bands are shown alongside the corresponding tax rates in table 4.4. Clearly this assignment could be refined, to take account of unearned income and other tax allowances.

Once the tax rate is determined it is multiplied by the interest payments on the first \$30000 of the mortgage to determine the amount of subsidy received in that year.

(h) Exemption from capital gains tax

Since 1961 households have paid no capital gains tax on the increased value of their principal property. We can estimate the value of this subsidy to each household by multiplying the capital accumulated by the marginal rate

of taxation.

YEAR	SINGLE ALLOWANCE	MARRIED ALLOWANCE
1976	735	1085
1977	945	1455
1978	985	1535
1979	1165	1815
1980	1375	2145
1981	1375	2145
1982	1565	2455
1983	1785	2795
1984	2055	3155

TABLE 4.3 INCOME TAX ALLOWANCES 1976-84

(iii) Mobility in the Housing System

We are interested in attempting to model the movement of households between dwelling units and tenures. For the purposes of this model we distinguish between two types of households: those already in owner-occupation and those in other tenure categories. For owner occupiers we test for movement based on the age of head of household. Probabilities of moving are given in table 4.5

Not all owner-occupiers stay within this sector and we used a probability of 0.86 for staying within owner-occupation, a figure derived from the 1978 Housing Green Paper. These probabilities need further refinement, notably to generate a times series that reflects annual changes in rates of movement, and there is also a need to incorporate a duration of residence effect. These factors are on our research agenda.

Households who are outside the owner occupied sector are assigned a probability of moving into this sector. Both these probabilities were obtained from the Housing Green Paper. Again there is the possibility of substantially refining these mechanisms.

YEAR	BAND	1	2	3	4	5	6	7	8	9	10	
1976		6000	7000	8000	9000	10000	12000	14000	16000	21000	*****	*
		34	40	45	50	55	60	65	70	75	83	*
1977		6000	7000	8000	9000	10000	12000	14000	16000	21000	*****	*
		34	40	45	50	55	60	65	70	75	83	*
1978		750	8000	9000	10000	11000	12500	14000	16000	18500	24000	*****
		25	33	40	45	50	55	60	65	70	75	83
1979		750	10000	12000	15000	20000	25000	*****	*****	*****	*****	*****
		25	30	40	45	50	55	60				
1980		11250	13250	16750	22250	27750	*****	*****	*****	*****	*****	*****
		30	40	45	50	55	60					
1981		11250	13250	16750	22250	27750	*****	*****	*****	*****	*****	*****
		30	40	45	50	55	60					
1982		12800	15100	19100	25300	31500	*****	*****	*****	*****	*****	*****
		30	40	45	50	55	60					
1983		14600	17200	21800	28900	36000	*****	*****	*****	*****	*****	*****
		30	40	45	50	55	60					
1984		15400	18200	23100	30600	38100	*****	*****	*****	*****	*****	*****
		30	40	45	50	55	60					

TABLE 4.4 INCOME BANDS AND ASSOCIATED TAX RATES 1976-84
(***** indicates highest band/rate)

Age of head	16 - 29	30 - 44	45 - 64	65+
Probability	0.253	0.103	0.040	0.020

TABLE 4.5 PROBABILITY OF MOVING - OWNER OCCUPIER
(source OPCS 'Recently Moving Households')

For all movers we use the following mechanism for determining the characteristics of the new purchase:

(i) House price

a) Exchange movers

House price is calculated using the following formula:

$$P = x_h \cdot HH_i + 0.85 \cdot A_h \quad (11)$$

where P is house purchase price, x is a distribution of proportion of head of households income assigned to a mortgage dependent on head's income, HH_i , and A is the asset accumulation. A figure of 0.85 of assets being ploughed back into house purchase is arbitrarily taken given an almost complete lack of information on this subject. Some Building Society data gives the amount of deposit as a function of income, but we have not discovered any details relating to the proportion of assets placed as the deposit. This is therefore an area of further research and at the moment we can only resort to sensitivity analysis.

b) First time buyers

Here we use a similar formula as above, but with a fixed income multiplier of 2.5 and a deposit of 10% of the house purchase price.

(ii) Amount of Mortgage

From (11) the amount of mortgage (M) is calculated as

$$M = x_h \cdot HH_i$$

For first time buyers x_h is set at 2.5

(iii) Term of mortgage

This is determined on the basis of the age of head of household, using data from the Nationwide Building Society survey of movers, 1978.

The remaining variables, such as repayments, amount outstanding, and so on can easily be calculated from the formulae described earlier.

There are some obvious deficiencies of the existing model framework in addition to those described above. Notably, we do

not address the issue of new household formation or dissolution. In other words, we have no new households entering our sample list and the household size and status of our existing households is only affected by death, and not other processes such as migration, divorce, leaving home, and so on. Improvements incorporating these effects will shortly be implemented, using the household demographic model described in Clarke (1986).

5 SIMULATION RESULTS.

5.1 INTRODUCTION

In this section we present some preliminary results obtained from running the housing model over a ten year period (1976-85) for the two data bases. In presenting the results we particularly focus on the issues of subsidy as it relates to different household types and households who have had different housing careers. As we noted above, the simulation is performed on a fixed set of households in that no new households are added to the lists over time. As such the results pertain to a sub-set of the full population and therefore cannot be easily translated into 'whole' population results. However we feel that the results demonstrate the relative differences in housing careers of this sub-population over time, and are therefore of interest.

5.2 MODEL SIMULATIONS

The model described in section 4 has been implemented in FORTRAN on a COMPAQ 386 PC. For a ten year simulation with a population size of c3000 it takes about four minutes of elapsed time to run. People often comment on the demands that microsimulation models make on computer resources, and while the model structure is relatively simple, avoiding any recursive computation, this demonstrates that it is not always the case!

We undertook separate analyses for our 'north' and 'south' data sets with the intention of making a snapshot of the changed financial circumstances of the members of our two sub-samples at the end of a ten year period (1985). A characteristic of our microsimulation approach is that large numbers of cross-tabulations of all model variables are produced in a routine manner, and these are each of use in detailed substantive interpretation and for model development (e.g. sensitivity analysis). However in the present broad brush overview, this detail is as likely to obscure the central findings as it is to illuminate them, and so we present only a very few aggregated tables and a summary narrative.

For 1976 our summary statistics of the distribution of house values and of incomes identify stark differences between the high cost, high income 'south' and the lower cost, lower income 'north'. Assuming that there is little regional variation in the

average multiple of income that households invest in housing, it comes as no surprise that the distribution of incomes is mirrored by the distribution of mortgage tax relief subsidy. For both regions, high incomes are generally associated with high tax relief, although there are some high incomes with small mortgages (usually because they are in the second half of their mortgage term) who do not receive much subsidy. For 1976, the regional differential in the incomes of our sample means that some 27% of southern households received mortgage tax relief of over 250 pounds, whilst the corresponding figure for northern households was just 5%.

Our second set of summary statistics concerned the distribution of capital gains tax relief subsidy by income for the two regions. Capital gain was calculated on the basis of the summed difference between the estimated value of the house for every year since purchase and the original purchase price. Tax at the marginal rate was applied in order to identify the portion of capital gain which would have been forfeited had the investment been in almost any other commodity other than housing. A north-south difference in amount of subsidy is evident, with 37% of 'southern' households receiving more than 2000 pounds accumulated subsidy on their dwellings compared with 23% in the 'north'. Our preliminary analysis suggested a strong relationship between capital gains and house value. Our subsequent simulation took the accumulated capital gains as the base to which capital tax gains subsidy was added in annual increments. Everything else being equal, households with high value houses would continue to accrue the largest capital gains, with the proviso that, as described in section 3.3, residential mobility could also enable households in quite modestly priced houses to accrue substantial gains, through 'trading up'.

The first of our simulation results for 1985 are shown in tables 5.1 and 5.2. The tables show that larger number of households in the 'south' are in receipt of high (>15000 pounds p.a.) incomes, and that very similar proportions of this high income group receive medium sized (501-750 pounds p.a.) or large (751 pounds p.a.) tax relief subsidies in the 'south' and in the 'north'. Conversely, the south has lower absolute numbers of low income (<8000 pounds p.a.) earners, although the overwhelming majority (c75%) of households on low incomes receive low subsidies (<250 pounds p.a.) in both the north and south. Taken together, what is clear is that housing fiscal policy is clearly reinforcing income inequalities between the two regions. An unexpected result shown in table 5.1 and 5.2 is the high incidence of low tax relief subsidy amongst the high income groups. There are three explanatory factors behind this. First, average 1976 house prices were a fairly low multiple of household incomes, relative to the preceding and following time periods. This may have caused a preponderance of low mortgage advances amongst the high income groups in our sample. Secondly, descriptive statistics illustrate that many of the high income groups either have long established

TABLE 5.1

MORTGAGE TAX RELIEF SUBSIDY BY INCOME : SOUTH 1985

INCOME	SUBSIDY (£ p.a.)	< £250	£251-£500	£501-£750	> £750	Total
< £8000		302 (72.7)	81 (19.8)	27 (6.6)	0 (0)	410
£8000-£15000		224 (44.6)	128 (25.5)	81 (16.1)	69 (13.7)	502
> £15000		528 (61.3)	134 (15.6)	97 (11.3)	103 (11.9)	862
		1054	343	205	172	1774

(figures in brackets denote % of row totals)

TABLE 5.2

MORTGAGE TAX RELIEF SUBSIDY BY INCOME : NORTH 1985

INCOME	SUBSIDY (£ p.a.)	< £250	£251-£500	£501-£750	> £750	Total
< £8000		406 (74.8)	108 (19.9)	29 (5.3)	0 (0)	543
£8001-£15000		265 (47.1)	121 (21.5)	96 (17.1)	81 (14.4)	563
> £15000		334 (68.2)	46 (9.4)	45 (9.2)	65 (13.3)	490
		1005	275	170	146	1596

(figures in brackets denote % of row totals)

mortgages or actually own their dwellings outright. As such they would only receive small amounts of tax relief subsidy. Thirdly, a large proportion of high income groups were classified as 'non-movers' over the simulation period, thus not trading up and increasing their debt and hence subsidy.

Our other major simulation results relate to capital gains and are summarised in tables 5.3 and 5.4. These tables illustrate the massive emergent disparity in regional gains over the simulation period: for example, almost half of the households in the south have not been required to pay over 2000 pounds in capital gains tax, whilst the corresponding figure for the north is less than 4%. Viewed in the context of divergent regional incomes the results become even more stark. 92% of low income northern households have gained less than 1000 pounds from capital gains tax relief, whilst only 23% of a much smaller southern counterpart fare this badly. At the other end of the spectrum, only one tenth of the small northern high income group realise over 2000 pounds from this tax free source, whilst the figure for the south is greater than two-thirds.

As presently construed, our model clearly identifies differential regional house price inflation and capital gains tax relief as the driving forces behind inter-regional disparity in fiscal subsidy between 1976 and 1985. That is to say, already expensive housing assets in the south appreciated more rapidly than cheaper assets in the north, and the privileged tax status of owner-occupiers has amplified this inequality. However, our results remain conditional upon the assumptions that were forced upon us by the quality of data to hand. Moreover we make no implication that these results necessarily hold over different spatial scales or over different time periods. Future research will be needed to flesh out these results in the light of improved data (e.g. on house prices and residential mobility), the changing role of the different fiscal stimulants to owner occupation, and to an improved understanding of the most appropriate spatial scales at which to monitor the flows of subsidy into the housing market. We hope to attack these and other tasks in future papers.

6 DIRECTIONS FOR FURTHER RESEARCH

We have described a framework for exploring the temporal development of diversity in housing careers and have presented some initial results on the variation in the expenditure and subsidy of households in the two samples over the period 1976-85.

There are many directions for further research suggested by the present analysis relating to both the present study context, and to others, notably, forecasting and policy analysis. Among this list are:

TABLE 5.3

CAPITAL GAINS TAX RELIEF SUBSIDY BY INCOME : SOUTH 1985

INCOME	SUBSIDY (£ p.a.)	< £1000	£1001-£1500	£1501-£2000	> £2000	Total
< £8000		96 (23.4)	121 (29.5)	94 (22.9)	99 (24.1)	410
£8000-£15000		72 (14.3)	120 (23.9)	134 (26.7)	176 (35.1)	502
> £15000		85 (9.9)	106 (12.3)	83 (9.6)	588 (68.2)	862
		253	347	311	863	1774

(figures in brackets denote % of row totals)

TABLE 5.4

CAPITAL GAINS TAX RELIEF SUBSIDY BY INCOME : NORTH 1985

INCOME	SUBSIDY (£ p.a.)	< £1000	£1001-£1500	£1500-£2000	> £2000	Total
< £8000		502 (92.4)	24 (4.4)	10 (1.8)	7 (1.3)	543
£8001-£15000		509 (90.4)	39 (6.9)	8 (1.4)	7 (1.2)	563
> £15000		249 (50.8)	147 (30.0)	45 (9.2)	49 (10.0)	490
		1260	210	63	63	1596

(figures in brackets denote % of row totals)

- a) Refinement of model relationships, particularly with regard to inter-tenure moves and the economics of house purchase;
- b) Sensitivity analysis of the present and related models to variations in the key parameters and assumptions, particularly in relation to trading behaviour;
- c) the explicit incorporation of demographic and economic processes to generate the demand for housing; in this regard we would compare the representation of first-time buyers in any time period by generating them endogenously through household formation processes;
- d) validation of the model by access to other data sets, possibly longitudinal, but in the first instance similar cross-sectional surveys conducted in 1981 and 1986.
- e) more detailed exploration of the demand - supply interactions which would include a consideration of the chains of moves which relate mobility, filtering, and price formation (see Williams, Keys and Clarke, 1985);
- f) use of the model for short/medium term forecasting of the evolution of variability under assumed or projected changes in exogenous variables. An investigation of the changes in the structure of households on housing demand and associated finance would also be an interesting area of application;
- g) the analysis of policies which have a direct bearing on household transitions and housing finance.

We hope we have demonstrated the potential of this type of approach for examining the multitude of issues surrounding housing expenditure and subsidy over time and we hope to be able to report further developments shortly.

REFERENCES

- Atkinson, A B and King, M A (1988) Housing Policy, Taxation and Reform. **Midland Bank Review**, Spring 1988
- Balchin, P N (1985) **Housing Policy: An Introduction** Croom Helm, London
- Byler, J W and Gale, S (1978) Social Accounts and Planning for Changes in Urban Housing Markets, **Environment and Planning A**, 10, 247-266
- Chartered Institute of Public Finance and Accountancy (1981)

Housing Rents, Costs and Subsidies: a Discussion Document.
Prepared by A Gray, N Hepworth and J Odling-Smee.

Birkin, M, and Clarke, M (1988) **SYNTHESIS: A Synthetic Spatial Information System for Urban and Regional Analysis**, with methods and examples. **Environment and Planning, A**, forthcoming.

Building Societies Association (1986) **Building Society Factbook 1985** , BSA, London

Clarke, M (1986) Demographic Processes and Household Dynamics: a Microsimulation Approach, in R Woods and P H Rees (eds) **Population Structures and Models**, Allen and Unwin, London

Clarke, M and Holm, E (1987) Microsimulation Methods in Spatial Analysis and Planning **Geografiska Annaler**, **69 B** 154-164

Clarke, M, Keys, P and Williams, H C W L (1981) Microanalysis and Simulation of Socio-Economic Systems: progress and prospect. In **Quantitative Geography** (eds R J Bennett and N Wrigley) Routledge and Kegan Paul

Clarke, M and Spowage, M (1984) Integrated Models for Public Policy Analysis: An example of the Practical Use of Simulation Models in Health Care Planning. **Papers of the Regional Science Association**, **55**, 25-45

Department of Employment (1987) **New Earnings Survey**, HMSO, London

H MS O (1977) **Housing Policy: A Consultative Document** (Cmd 6851)

H MSO (1977) **Housing Policy: Technical Volumes**
Department of the Environment.

Kain, J F, and Apgar, W C (1985) **Housing and Neighborhood Dynamics: a Simulation Study** Harvard University Press, Cambridge, Mass

Kilroy, B (1978) **Housing Finance - Organic Reform?** Labour Economic, Finance and Taxation Association, London

O'Dell, A (1980) An assessment of the errors in a housing survey, **Urban Studies**, **17** 217-222

O.P.C.S. (1983) **Recently Moving Households**, HMSO, London

Orcutt, G, Caldwell, S, and Wertheimer II, R (1976) **Policy Exploration Through Microanalytic Simulation**, Urban Institute, Washington D C

Orcutt, G, Greenberger, M, Korbal, J, and Rivlin, A (1961)
Microanalysis of socioeconomic systems: a Simulation Study
Harper and Row, New York

Robinson, R, O'Sullivan, T, and LeGrand, J (1985) Inequality
and Housing **Urban Studies 22, 249-256**

Orcutt, G H, Merz, J, and Quinke, M (eds) (1986)
**Microanalytic Simulation Models to Support Social and
Financial Policy** North Holland, Amsterdam

Whitehead, C (197) Neutrality between tenures: a Critique
of the HPR Comparisons

Williams, H C W L (1981) The use of Microsimulation in
Travel Activity Analysis. Paper Presented at the
International Conference on Travel Demand Analysis. St
Catherine's College, Oxford 9-11 July 1981