

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

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ABSTRACT Issues surrounding the financial benefits of owner occupation and how these are related to a variety of socioeconomic and geographical factors are examined through the development of a microsimulation model of the U.K. housing market. Of particular interest are the ways in which different government subsidies accrue to different types of households over time. The model has been implemented for two U.K. regions and simulations performed over a ten year historic period. Results showing the wide variation in household experience are presented.

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 1970s, 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 1977a, 1977b). 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 Survey, 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; Gray et al. 1980; 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 recognition 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 capturing 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 dynamic 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: first, the difference in housing careers between different households (characterised by age, income, household structure, etc.) within a region; second, the same differences between households in different regions; third, the differences between households which enter the owner occupier sector at different times and the budgets of the same household at different times; and fourth, 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.

2. DEVELOPING MODELS TO EXPLORE HETEROGENEITY IN HOUSING EXPENDITURE AND SUBSIDY

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; and (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 crosssection, 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 microeconomic 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 resulting models solved through the use of sampling. Such is the basis of microsimulation modelling, which we now discuss.

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 to address related effects within the British context.

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

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.

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: first, they receive tax relief on mortgage interest payments; second, they are exempt from tax on the capital gains received on the sale of their property; third, 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 about 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 (Gray et al. 1980). 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 eight 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

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

Under fixed interest rates these reduce to the standard repayment schedules

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

and

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

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 £30,000

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

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

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

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

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:

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

There is a minor complication under current U.K. tax legislation in that the first £5,000 of capital gains is exempt from tax. In the simulations performed below we ignore this allowance.

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 by example. We consider two households, identical with regard to socioeconomic characteristics, the head of which earns (at time $t = 0$) £4,000 pa. Each buys a house at $t = 0$ with a 100 percent mortgage for 2.5 times their income (£10,000) at a fixed interest rate of 12 percent. 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 percent and 13 percent respectively. The tax rate for these households is held at 30 percent. On subsequent moves, the trading behaviour of each household is summarised in the simple expression:

$$\begin{aligned} \text{mortgage advance} &= 2.5 \cdot \text{income} \\ \text{price of house purchased} &= \text{advance} + 0.9 \cdot \text{asset accumulation}. \end{aligned}$$

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 1 and 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 £16,305 - £9,642 = £6,663, which it uses to trade up into a house costing £20,673, for which an advance of £14,640 is sought. On the second move at the end of period $m = 8$ the gain to A is £19,535, 90 percent of which is used to finance a house costing £39,017 for which a mortgage of £21,435 is obtained. Household B on the other hand, moves at the end of

TABLE 1. Mortgage Characteristics and Tax Relief on Interest

| 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 2. Payments and Accumulation in Owner Occupation

| year | Inc | R/I | Household A | | | R/I | Household B | | |
|------|-------|------|-------------|-------|-------|------|-------------|-------|------|
| | | | V(m) | A(m) | Sub | | V(m) | A(m) | 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 | 3840 | 0.20 | 18425 | 8790 | 1769 |
| 6 | 7086 | 0.26 | 26351 | 11945 | 4363 | 0.18 | 20820 | 11428 | 2112 |
| 7 | 7795 | 0.24 | 29777 | 15509 | 4882 | 0.16 | 23526 | 14282 | 2450 |
| 8 | 8547 | 0.22 | 33648 | 19535 | 5396 | 0.15 | 26585 | 17507 | 2783 |
| 9 | 9432 | 0.29 | 44089 | 22815 | 10071 | 0.29 | 42026 | 20752 | 8530 |
| 10 | 10375 | 0.26 | 49821 | 28727 | 10837 | 0.26 | 47489 | 26395 | 9296 |

period $m = 8$ and uses 90 percent of its assets (£17,507) towards a house costing £37,191 on which a mortgage of £21,435 is obtained.

On the two moves, household A is exempt from taxation on the capital gains of £6,305 and £13,011, respectively, household B is exempt from a gain of £16,585 from the single move. In arriving at the total subsidy to each household we have applied a standard tax rate of 30 percent to these gains and added them to the accumulated relief on mortgage interest. The results are shown in Table 2.

There are two features of the calculation worthy of note. First, Table 2 shows the familiar 'front loading' of the debt liability, in which the repayment of a particular house, constant in money terms, becomes a decreasing proportion of income. This feature 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 £2,000 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 £13,459 to purchase A's property. Alternatively, at the income of A and B (£8,574) a house of price £21,435 could be bought with a 100 percent mortgage. This can be compared with the house prices of A (£33,648) and B (£26,585).

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. Second, 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

In this section we describe the main features of the housing simulation model developed to address the issues discussed previously. 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 English House Condition Survey (EHCS) 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 Micro-Data Base

A prior requirement of microsimulation 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 EHCS. 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 3.

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'

TABLE 3. Variables and Classification used in Base Population

| | |
|--------------------------------|--|
| 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 |
| SESG of head | SEG SESG 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 |

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, for example the 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).

Second, there is no information on house purchase price and other variables for owner occupiers who purchased before 1960. To attempt to get around some of these problems in the first instance we created a subsample of households that included only owner occupiers who purchased their house post-1960. Our analysis to date concerns this subpopulation, 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 1,454 (74.4 percent) and 1,427 (72.6 percent) 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 1,007 (51.2 percent) and 1,033 (52.9 percent) 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 3,021 and 3,099 respectively. *A priori* reasoning might suggest that the nonresponse to

the income questions would result in underrepresentation 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 nonresponse 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 percent to 49 percent and that of the 'Southern' data from 56 percent to 52 percent.

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 et al. (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 and 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 the mortgage was 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 and 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 socioeconomic 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. 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.

(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

TABLE 4. Average Annual House Price Rises in the Two Regions

| 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 |

Source: Building Soc. Factbook, 1986.

whether they are single or married. A list of allowances for the period 1976–86 is shown in Table 5. 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 6. 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 of the first £30,000 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.

(iii) *Mobility in the housing system.* We are interested in modelling the movement of households between dwelling units and tenures. For the purposes of this model

TABLE 5. Income Tax Allowances 1976–84

| Year | Single Allowance (£s) | Married Allowance (£s) |
|------|-----------------------|------------------------|
| 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 6. Income Bands and Associated Tax Rates (£s) 1976–84

| Year | Band 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 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 | 7500 | 8000 | 9000 | 10000 | 11000 | 12500 | 14000 | 16000 | 18500 | 24000 | ***** |
| | 25 | 33 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 83 |
| 1979 | 7500 | 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 | | | | | |

***** indicates highest band/rate.

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 7. 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.

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

$$P = x^h \cdot HHi + 0.85 \cdot A \quad (10)$$

where P is house purchase price, x^h is a distribution of proportion of head of households income assigned to a mortgage dependent on head's income, HHi and A is the asset accumulation. A figure of 85 percent 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 percent of the house purchase price.

(ii) Amount of mortgage

From Equation (10) the amount of mortgage (M) is calculated as

$$M = x^h \cdot HHi$$

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

TABLE 7. Probability of Moving — Owner Occupier

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

Source: OPCS (1983).

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

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 subpopulation over time, and are therefore of interest.

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 around 3,000 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 used in detailed substantive interpretation and for model development (for example, 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 percent of southern households received mortgage tax relief of over £250, whilst the corresponding figure for northern households was just 5 percent.

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 percent of 'southern' households receiving more than £2,000 accumulated subsidy on their dwellings compared with 23 percent 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 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 8 and 9. The Tables show that larger number of households in the 'south' are in receipt of high (> £8,000 p.a.) incomes, and that very similar proportions of this high income group receive medium sized (£501-750 p.a.) or large (\geq £750 p.a.) tax relief subsidies in the 'south' and in the 'north'. Conversely, the south has lower absolute numbers of low income (< £8,000 p.a.) earners, although the overwhelming majority (c75 percent) of households on low incomes receive low subsidies (< £250 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 Tables 8 and 9 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 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 their subsidy.

Our other major simulation results relate to capital gains and are summarised in Tables 10 and 11. These tables illustrate the massive emergent disparity in

TABLE 8. Mortgage Tax Relief Subsidy by Income: South 1985

| Income | Subsidy (£ p.a.) | | | | Total |
|--------------|---------------------|------------|-----------|------------|-------|
| | < £250 | £251-£500 | £501-£750 | > £750 | |
| < £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 parentheses denote percentage of row totals.

TABLE 9. Mortgage Tax Relief Subsidy by Income: North 1985

| Income | Subsidy - (£ p.a.) | | | | Total |
|--------------|-----------------------|------------|-----------|-----------|-------|
| | < £250 | £251-£500 | £501-£750 | > £750 | |
| < £8000 | 406 (74.8) | 108 (19.9) | 29 (5.3) | 0 (0) | 543 |
| £8000-£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 parentheses denote percentage of row totals.

TABLE 10. Capital Gains Tax Relief Subsidy by Income: South 1985

| Income | Subsidy (£ p.a.) | | | | Total |
|--------------|---------------------|-------------|-------------|------------|-------|
| | < £1000 | £1001-£1500 | £1501-£2000 | > £2000 | |
| < £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 parentheses denote percentages of row totals.

TABLE 11. Capital Gains Tax Relief Subsidy by Income: North 1985

| Income | Subsidy (£ p.a.) | | | | Total |
|--------------|---------------------|-------------|-------------|-----------|-------|
| | < £1000 | £1001-£1500 | £1501-£2000 | > £2000 | |
| < £8000 | 502 (92.4) | 24 (4.4) | 10 (1.8) | 7 (1.3) | 543 |
| £8000-£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 parentheses denote percentages of row totals.

regional gains over the simulation period; for example, almost half of the households in the south have not been required to pay over £2,000 in capital gains tax, whilst the corresponding figure for the north is less than 4 percent. Viewed in the context of divergent regional incomes the results become even more stark. 92 percent of low income northern households have gained less than £1,000 from capital gains tax relief, whilst only 23 percent 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 £2,000 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 interregional 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 (for example, 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:

- a) Refinement of model relationships, particularly with regard to intertenure 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 1986);
- f) use of the model for short to 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; and
- g) the analysis of policies which have a direct bearing on household transitions and housing finance.

We hope to 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.

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