A long-run model of housing affordability

Report

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Abstract
As a result of the recommendations of the Barker Review of Housing Supply in 2004, the Department of Communities and Local Government in England commissioned the construction of an econometric model of regional housing markets in order to examine the effects of different levels of housing construction on long-run affordability. The model has been regularly used as part of the policy making process in England. The paper describes the structure of the model, which includes sectors covering house prices, household formation, tenure, migration flows, demographics and labour markets. Furthermore, through simulation analysis, the paper examines some of the key policy questions that have occurred in UK housing in recent years.

JEL Classification: R15.

Key words: Econometric models; house prices; migration; household formation; tenure; housing supply; affordability.

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1. Introduction

In 2003, the UK government decided against membership of the Economic and Monetary Union, based on the outcome of five economic tests (HM Treasury 2003). Housing market structural differences between the UK and other parts of Europe contributed to the rejection as these were seen as high risk factors in the achievement of economic convergence. Amongst the differences were the restrictiveness of the UK planning system, high levels of household debt (arising from the openness of the finance system) and the dominance of variable as opposed to fixed-rate mortgages, which suggested that common changes to official interest rates within European Monetary Union could have different macro economic effects in the UK compared with some other European economies. However a key difference between the UK and other countries was the observed stronger long-run increase in real house prices. Although still considered controversial[1], rising real house prices have been argued to generate wealth and collateral effects, which contribute to rising household consumption, to inflation and to affordability problems.

Subsequently, the Barker Review of Housing Supply (Barker 2004) was set up to consider the lack of responsiveness of housing supply to market conditions (notably to the rise in house prices) and the role of the planning process in inhibiting supply. At the time of the Barker Review, between 1971 and 2001, the trend increase in real house prices in the UK stood at 2.4 per cent pa[2] compared with a European average of 1.1 per cent. Partial econometric analysis included in the Interim Barker Report (Barker 2003, Table 3.4) found that to reduce UK trend price growth to the European average would require an approximate doubling of the level of housing production. The final Baker Review Report proposed the setting of national and regional affordability targets so that the planning system would become more responsive to market signals, generating higher levels of housing supply and reducing price pressures.

The government of the time accepted the need for affordability targets, but, nonetheless, targets give rise to technical difficulties; for example, what level of housing production is necessary in each region, given the interactions between house prices, production, inter-regional migration, household formation and labour market activity? As a result, the Department of Communities and Local Government (CLG) commissioned the construction of the Affordability Model, which is the subject of this paper to answer these questions. The first version of the model became operational in May 2005 (ODPM 2005) with subsequent

[1] See Meen (2010) for a discussion of the issues.
[2] Over the period 1971 to 2009, the UK trend rate rose to over 3 per cent pa.

extensions taking place until 2010. These extensions included the modelling of tenure, immigration and the addition of a short-run quarterly model to capture the effects of the credit crunch. The short-run model is not discussed here and details are given in Meen (2009). The Affordability Model has been used extensively within CLG for policy analysis and by the National Housing and Planning Advice Unit, which was also set up as a recommendation of the Barker Review[3].

A prior question to model construction is the appropriate definition of affordability. The official measure is the ratio of house prices to earnings, both measured at the lower quartile, and this is employed as the main indicator in the model, although other measures can be constructed, such as mortgage repayment to income ratios or the user cost of capital. Perhaps the main problem of price/earnings ratios is the neglect of changes in interest rates. One of the main reasons why price/earnings ratios worsened in all regions this century was the fall in nominal interest rates. Furthermore, the ratio fell in the post-2007 recession, but access to housing for first-time buyers did not improve, because of the shortage of mortgage funds. Although the user cost of capital can, in principle, take account of credit restrictions, price/earnings ratios do not.

The model covers the nine English Government Office Regions. Scotland, Northern Ireland and Wales are excluded because housing policy is not determined by CLG in these areas, although, of course, interactions between these countries and England are important, particularly through migration flows. Arguably, as administrative areas, regions are also not the most appropriate scale of analysis and more explicit Housing Market Areas need to be defined. But Government Office Regions are relevant here, given the primary concern with the impact of planning decisions.

Rather than describe each model equation precisely, the paper takes an overview, identifying the factors, which determine the model key properties. In Section 2, the model structure is set out in terms of differential equations, highlighting some of the central features of the model. The section also shows the main exogenous variables in the model including policy instruments, so that, in principle, the effect of each exogenous variable on affordability can be derived from the reduced form. In practice, the presence of lags, the conjunction of aggregate time-series and micro econometric equations and the combination of linear, logarithmic and probit estimation mean that the solutions cannot be derived analytically and have to be obtained by simulation. Section 3 discusses the equation structures in more detail, whilst placing the detailed econometrics in appendices. In Section 4, the effects of changes to the exogenous/policy variables are considered - housing supply, interest rates and immigration are all explored. More generally, the policy messages that have arisen over the course of the project are examined. For example, allowing for the effects of affordability on household formation gives rise to very different time paths from official trend-based projections. The reasons for

[3] The National Housing and Planning Advice Unit was disbanded by the new coalition government in June 2010.

the failure of home-ownership to expand this century are also considered. Section 5, finally, provides a note of caution and briefly considers possible future research directions, again concentrating on policy challenges.

2. Model structure: A simplified overview

The model can be described succinctly as a set of differential equations (1 or 2)[4]. Equation (3), then, defines affordability by identity. Equation (1) is specified generically for each region (although there are some regional-specific variations outlined later), where nine key endogenous variables (Y in (2)) are expressed as a function of six exogenous (primarily policy) variables (X). The endogenous variable vector can be broken into three blocs: (i) the housing sector covers house prices, the housing stock, the number of households and the two tenure shares for renting and ownership; (ii) the labour sector covers average earnings and employment (also unemployment); (iii) the demographic segment includes population and migration flows. Notice that household numbers are included as part of the housing bloc rather than the demographics, since they are affected by affordability.

In fact, the blocs are not independent and there are important inter-linkages, determined by the values of the coefficient matrices in (2). Since B and H are fundamental to long-run model properties, (4) expands them to highlight the key coefficients and sets to zero those where there is no effect. As an illustration of the interpretation of (1), the first equation in the system relates the rate of change of house prices to the level of house prices, the housing stock, the number of households and average earnings (endogenous variables) and the market interest rate and credit restrictions (exogenous). Ω is a form of spatial weights matrix, where PH_j (j=1…9) represents house prices in the nine regions. The terms, therefore, imply that, in each region, prices are a function of prices in other regions. In fact, the coefficients $\omega_{1j} = 0$ for the four southern regions (London, South East, East and South West), but the non-zero weights for the Midlands and Northern regions represent the well-known “ripple effect” (Alexander and Barrow 1994, Ashworth and Parker 1997, Cook 2003, 2004, Drake 1993, 1995, Giussani and Hadjimatheou 1991, MacDonald and Taylor 1993, Meen 1999). The final row of the spatial weights matrix reflects the fact that migration flows depend on relative house prices, rather than just own region prices.

[4] Although the model is estimated in discrete time on annual data

Although migration flows and price diffusion provide the main inter-regional linkages, there are additional influences not captured in (1), which are suppressed here for simplicity. For example, house prices in the South East are related to earnings in London as well as the own region because of strong commuting flows. Also *relative* housing availability affects migration flows in addition to relative prices.

$$\begin{bmatrix} 1 & \alpha_{12} & \alpha_{13}\ldots\ldots & \alpha_{19} \\ \alpha_{21} & 1 & \alpha_{23}\ldots\ldots & \alpha_{29} \\ : & : & : & : \\ \alpha_{91} & \alpha_{92} & \alpha_{93}\ldots\ldots & 1 \end{bmatrix} \begin{bmatrix} \dot{PH} \\ \dot{HS} \\ \dot{HH} \\ \dot{OO} \\ \dot{RT} \\ \dot{W} \\ \dot{E} \\ \dot{POP} \\ \dot{IMD} \end{bmatrix} = \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13}\ldots\ldots & \beta_{19} \\ \beta_{21} & \beta_{22} & \beta_{23}\ldots\ldots & \beta_{29} \\ : & : & : & : \\ \beta_{91} & \beta_{92} & \beta_{93}\ldots\ldots & \beta_{99} \end{bmatrix} \begin{bmatrix} PH \\ HS \\ HH \\ OO \\ RT \\ W \\ E \\ POP \\ IMD \end{bmatrix}$$

$$+ \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13}\ldots\ldots & \gamma_{16} \\ \gamma_{21} & \gamma_{22} & \gamma_{23}\ldots\ldots & \gamma_{26} \\ : & : & : & : \\ \gamma_{91} & \gamma_{92} & \gamma_{93}\ldots\ldots & \gamma_{96} \end{bmatrix} \begin{bmatrix} R \\ NC \\ IMF \\ BR \\ DR \\ M \end{bmatrix} + \begin{bmatrix} \omega_{11} & \omega_{12} & \omega_{13} & \ldots & \omega_{19} \\ 0 & 0 & 0 & 0 & 0 \\ : & : & : & : & : \\ 0 & 0 & 0 & 0 & 0 \\ \omega_{91} & \omega_{92} & \omega_{93} & \ldots & \omega_{99} \end{bmatrix} \begin{bmatrix} PH_1 \\ PH_2 \\ : \\ PH_9 \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ : \\ \varepsilon_9 \end{bmatrix} \qquad (1)$$

or: $\mathrm{A}\dot{Y} = \mathrm{B}Y + \mathrm{H}X + \Omega PH + \mathrm{E}$ (2)

and: $AFFORD = PH/W$ (3)

PH = Index of average real house prices (lower quartile also used in the model), (2002=100)
HS = Housing stock (000s)
HH = Stock of households (000s)
OO = Owner-occupancy rate (%)
RT = Rental rate (%)
W = Median real earnings (lower quartile also used in the model) (£ pa)
E = Employment (000s)
POP = Population (000s)
IMD = Net inter-regional migration (000s)
R = Market interest rate (%)

NC = New house construction (000s)
IMF = Net international migration flows (000s)
BR = Birth rate (%)
DR = Death rate (%)
M = Measure of credit restrictions
ε = Error term
(.) denotes time derivative.

$$\begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} & 0 & 0 & \beta_{16} & 0 & 0 & 0 \\ 0 & \beta_{22} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \beta_{31} & 0 & \beta_{33} & 0 & 0 & \beta_{36} & 0 & \beta_{38} & 0 \\ \beta_{41} & 0 & \beta_{43} & \beta_{44} & 0 & \beta_{46} & 0 & 0 & 0 \\ \beta_{51} & 0 & \beta_{53} & 0 & \beta_{55} & \beta_{56} & 0 & 0 & 0 \\ \beta_{61} & 0 & 0 & 0 & 0 & \beta_{66} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \beta_{77} & \beta_{78} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \beta_{88} & \beta_{89} \\ \beta_{91} & \beta_{92} & \beta_{93} & 0 & 0 & 0 & 0 & 0 & \beta_{99} \end{bmatrix} \begin{bmatrix} \gamma_{11} & 0 & 0 & 0 & 0 & \gamma_{16} \\ 0 & \gamma_{22} & 0 & 0 & 0 & 0 \\ \gamma_{31} & 0 & 0 & 0 & 0 & 0 \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & 0 & 0 & \gamma_{46} \\ \gamma_{51} & \gamma_{52} & \gamma_{53} & 0 & 0 & \gamma_{56} \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \gamma_{83} & \gamma_{84} & \gamma_{85} & 0 \\ \gamma_{91} & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \tag{4}$$

3. Further model details

Although (1)-(4) reflect the generic form, the properties of the model are determined by the parameter values and this section sheds light on the most important coefficients, taking the equations in turn. However, the paper concentrates on the housing and demographic blocs, since the feedback effects from housing to the labour market are relatively weak as shown in (4). The first equation for prices is estimated in logarithms and, taking region *j=1* as an example, its long-run solution can be written as (5):

$$\ln(PH_j) = -(\beta_{12}/\beta_{11})\ln HS_j + (\beta_{13}/\beta_{11})\ln HH_j + (\beta_{16}/\beta_{11})\ln W_j - (\gamma_{11}/\beta_{11})R_j \\ -(\gamma_{16}/\beta_{11})M_j + \sum_{j=2}^{9}(\omega_{1j}/\beta_{11})\ln(PH_j) + \varepsilon_{1j} \tag{5}$$

As noted above, $\omega_{1j} \neq 0$ only for the Midlands and Northern regions. For the former, prices in the Midlands are related to prices in the South and those in the Northern regions are related to prices in the Midlands. A further (data-validated) restriction for most regions is that $\beta_{12} = -\beta_{13}$, which implies price homogeneity with respect to equal percentage changes in the housing stock and the number of households. Note that planning policy has historically attempted to match new housing provision to the expected increase in the number of households. However, this policy does not ensure that affordability (equation 3) remains constant unless

$(\beta_{16} / \beta_{11})$ =1 or (*R, M*) increases over time. In fact, estimation suggests the former (the earnings elasticity) is approximately 2.0 (see Appendix 1). Meen and Andrew (2008) show that an elasticity of greater than unity occurs if the income elasticity of housing demand is greater than the price elasticity. This important property lies behind the key finding of the National Housing and Planning Advice Unit that affordability is expected to worsen over time, unless housing supply rises faster than the number of households (National Housing and Planning Advice Unit 2007).

Furthermore, notice that housing supply is measured by the *stock* rather than the *flow* of new construction. Since new construction is, typically, only approximately 1 per cent of the housing stock, this implies that increases in construction have to be large and continuing to have a significant effect on affordability. This controversial result lies behind the finding in the Barker Review that production would need to approximately double in order to reduce UK real house price growth to average European levels.

Also it should be noted that rather than the nominal interest rate (*R*) the model, additionally, uses the more general concept of the user cost of capital as a determinant given by (6). Therefore, in addition to the exogenous interest and tax variables, costs include an endogenous capital gains term. Note that the latter includes a parameter $\lambda_1 = 0.3$, consistent with earlier work in Meen (2008). This implies that nominal as well as real interest rates impact housing demand. Furthermore, the final term in (6) recognises that credit restrictions raise the user cost, since constraints act as a form of "virtual" interest rate (see Meen 2009 for further discussion).

$$UCC = R - \lambda_1 P\dot{H} - PT - ST + \lambda_2 M \qquad (6)$$

UCC = user cost of capital
PT = property tax rate (as percentage of property value)
ST = stamp duty rate (as percentage of property value)

Finally, despite the fact that house prices broadly move in line with each other across the four Southern regions, the econometrics suggest that London behaves differently from the other regions. In particular, London housing is more like an investment market, where stock market prices have a direct effect, but own region earnings have little if any influence. But, despite these differences, prices still move similarly across the South because of induced migration flows, which remove differences in price growth rates. The model price equations are set out in detail in Appendix 1.

The second equation in (1) defines the change in the housing stock. Since new construction adds directly to the stock, $\gamma_{22} = 1$[5]. Furthermore β_{22} reflects the depreciation of the stock through demolitions. Since demolitions are currently small

[5] The change in the stock, by definition, also includes changes in use and conversions of property, which are small relative to new construction, although non-negligible.

in England, this coefficient is also close to one. The Affordability Model was originally set up to analyse the effects of exogenous increases in housing supply. Consequently *NC* is included in the exogenous variable vector in (1). However, in principle, new supply is expected to be responsive to changes in house prices. Indeed, the Introduction stressed the importance of the supply responsiveness. Recent work on the model, (Ball *et al* 2010), explores supply elasticities in Britain at national, regional, local and firm level and compares the results with the USA and Australia. As a result of this work, a facility now exists in the model to endogenise construction and to explore the impact of different price elasticities of supply. However, in this paper, supply is maintained as a policy variable, which can be influenced by the planning system, although, of course, most construction is carried out by the private sector.

The third equation in (1) defines household formation as a function of house prices, earnings, population (endogenous) and the market interest rate (full details of the estimated equation are given in Appendix 2). Therefore combinations of demographic and economic factors (the latter can be combined into a measure affordability) affect household formation. But in contrast to the price equations, which employ regional time-series data in estimation, these equations use micro panel data from the British Household Panel Survey. More precisely, probit estimation yields the probability that any individual with a given set of demographic and economic characteristics will be the head of a household.

Demographic characteristics include age, gender, marital status, the presence of children and, importantly, status in the previous year. This is, quantitatively, the most important predictor of current headship status; once individuals have formed a household, changes in economic circumstances have only a limited influence, but economic conditions have a stronger influence on the decisions of individuals yet to form households. Overall, the model identifies 416 classes of household for each region.

Examples are given in the next section. Since the demographic sector determines population by age, gender and marital status, the total number of households can readily be determined by multiplying the population in each group by the estimated headship probabilities. However, the key difference from official household projections should be stressed. Official projections are trend based and make no allowance for changes in economic conditions. But since (as noted above), the model projects worsening affordability, unless housing supply grows rapidly, the model, typically, generates lower headship rates and household formation than official projections.

This raises the wider question of market adjustment to increases in housing supply and the impact of housing shortages. Clearly, one of the most important mechanisms is through a change in house prices and, consequently, to affordability. This, in turn, affects new household formation. But prices do not clear housing markets immediately; markets can remain in disequilibrium for considerable periods of time. In this case, quantity adjustment takes place as well. Furthermore, it is arguable that, because of historical housing supply shortages, some quantity variables have been permanently below their long-run equilibrium values, notably vacancies and demolitions. Therefore, if higher levels of new construction occur, vacancies and demolitions become part of the long-run adjustment process in addition to prices. The nature of the required adjustment is highlighted in (7). The equation relates the number of households to the number of housing units. It is important to stress that this relationship is in terms of *units* rather than housing services. Typically a four bedroom house contains more services than a two room flat, but (7) does not take that into account.

The distinction is important to the model; (7) lies behind the conventional planning view that changes in net additions to the housing stock have to match the expected increase in the number of households (taken from official household projections). However, it was shown above that this rule is insufficient to ensure stability in housing affordability. Typically, affordability will worsen over time under this rule.

$$\Delta HH = \Delta HS - \Delta SEC - \Delta VAC + CONV - DEM + \Delta SHARE \qquad (7)$$

HH	= number of households
HS	= number of new housing units
SEC	= second homes
VAC	= vacancies
CONV	= net gains from conversions and changes in property use
DEM	= demolitions
SHARE	= sharing households – the number of dwellings shared

In a market economy, in response to an increase in new housing supply (ΔHS), adjustment to a new equilibrium under (7) can take place through a combination of any of the quantity variables as well as through prices. In fact, only a proportion of the adjustment occurs through an increase in the number of new households. In other words, an increase in new housing construction is not usually matched by a corresponding increase in new households in any region[6]. Therefore, for equilibrium, second homes, vacancies, conversions, demolitions or sharing must adjust. It has been argued that, historically, vacancies and demolitions have not fulfilled this role. For example, demolitions have been low since the ending of the major slum clearance programmes that took place between the fifties and seventies. Similarly, vacancies appear to have been low by international standards. However, there are two weaknesses in this argument. First, historical levels of demolitions and vacancies reflect past housing market shortages. In this case, the expected life of a dwelling rises, reducing demolitions. Under a system that improves affordability and reflects the market, both vacancies and demolitions would be expected to be higher than in the past. Second, although (7) must hold, it is insufficient since it is defined in terms of units rather than reflecting differences in the quantity of housing services within each unit. The model is designed to ensure

[6] There are, however, exceptions. In “unbalanced” increases in construction, migration flows may induce equal increases in the number of households (see ODPM 2005).

(7) holds, but also reflects housing quality. The practical reason for this is that if the number of new units is increased, but this is matched by an increase in demolitions, the housing stock is unchanged in terms of units and from (5) there would be no change to house prices. But since new construction is expected to contain a higher level of services than the poorest elements of the existing stock[7], the model defines the concept of an effective housing stock, where, on the basis of hedonic estimates, the existing stock is weighted by the implicit level of services. When demolitions occur, the model assumes that those elements with the lowest levels of services are replaced first. This ensures that the quality of the housing stock rises over time. In practice, significant levels of demolitions only take place when projected levels of construction are much higher than in the past, partly because vacancy rates are lower than the model suggests should be the case in equilibrium. If affordability improves, the opportunity cost of holding dwellings empty falls and higher vacancies are expected.

The fourth and fifth equations in (1) determine tenure shares and are recursive to the rest of the housing bloc. Equation (1) distinguishes only between ownership and renting, although, in practice, renting is further sub-divided between the private and social sectors. The choice between the rental sectors depends partly on availability in the social sector, but also reflects incomes and the demographic characteristics of the households. Again probit estimation of the tenure probabilities is conducted on panel data from the BHPS. Details of the results are provided in Appendix 2.

The model adopts a two stage, hierarchical approach. In the first stage, the probability that each household is an owner or in the rented sector is calculated. In the second stage, the probabilities of being a private or social renter are estimated, conditional on the household being a renter in the first stage. As noted above, these probabilities vary with demographic characteristics. But there are four classes of economic variables, which have a fundamental influence:

- Income
- Relative housing costs in the tenure
- Credit restrictions
- Housing supply constraints

Unsurprisingly, higher income households have a greater probability of being owners. Furthermore, credit constraints are less likely to be binding since they will find it easier to accumulate the increased deposit requirements, which typify periods of mortgage rationing. Similarly, those on low incomes have a higher probability, not only of being renters, but also of being in the social sector. Relative tenure prices are particularly important. Arguably, the improvements in private renting in the mid-nineties means that renting provides a closer substitute to

[7] Although it should be noted that an increasing proportion of new building in recent years has been in flats on brownfield sites.

ownership in terms of housing quality; therefore we would expect that tenure choices should become more sensitive to the relative costs.

Credit constraints are also important. Notable US work in this area can be found in Haurin *et al* (1994, 1997). Andrew *et al* (2006) have conducted related work on UK data. In these studies, credit constraints arise not from a shortage of mortgage funds *per se*, but because of asymmetric information between borrower and lender. As noted earlier, the existence of a credit market constraint, in effect, raises the user cost of capital. Therefore, the constraints modify the prices in the tenure.

But the constraint has to be operationalised. US work concentrates on two potential constraints – an income multiple constraint, which reflects repayments for a given level of interest rates, and a wealth constraint, necessary for the raising of the initial deposit. None, one or both constraints may be binding. For example, at a time of low nominal interest rates, the importance of an income constraint may be limited, but as house prices rise, the ability to meet the deposit becomes more difficult, without relying on family and friends. Benito (2006) argues that the deposit constraint is important in explaining variations in the response of house price inflation to shocks in the UK. The empirical results from the model find that the constraints are only potentially binding for the under 40 age group.

At least historically, the older age groups appear to have accumulated sufficient assets by that stage of their life cycles. However, it has to be recognised that this may not hold in the future and binding credit constraints could be a feature that extend further into housing careers. The model includes dummy variables for the individuals according to whether each constraint is binding or not. One of the important features of such constraints is that they do not necessarily provide a permanent hurdle to home ownership; rather they delay entry until the household can accumulate sufficient resources, through saving, to meet the deposit requirement.

A further issue is the relationship between rents and ownership costs. Since this is a general equilibrium model, both have to be determined within the model. The results in Appendix 2 suggest that tenure is sensitive to differences in relative tenure costs. Therefore, in models that are simulated over the long run, relative prices have to be tied together or, eventually, all households may be in the same tenure without some other equilibrating mechanism. Since, under these conditions, the credit constraints are likely to become more or less binding, they are likely to be a part of this mechanism. The model imposes a simple form of the arbitrage relationship.

The demographic bloc[8] (the eighth and ninth equations in (1)) determines population by age/gender/marital status, which feeds into the model's household projections. The bloc relies on official projections of birth and death rates, which are, therefore, exogenous variables in (1). However, regional population projections differ from official sources because of the migration flows, both inter-regional and international. The latter can be either endogenised (and relative world house prices play a role in some equations) or fixed exogenously at officially-projected levels. In the next section, the second option is chosen. Inter-regional migration flows are important to the model's properties, not least because "unbalanced" increases in house building, i.e. increases only in a small number of locations, generates population inflows so that little improvement in affordability occurs.

Gross inflows and outflows are treated separately, although the two are not independent. The formal modelling refers to outflows from each region, but since most outflows are to contiguous regions, outflows are distributed to each region according to a fixed weights matrix. These weights are shown in Appendix 3. The dependent variable for gross outflows is expressed as a percentage of the resident population and the key variables are relative house prices (levels and rates of change), relative housing availability, measured by the ratio of households to the number of dwellings, relative unemployment rates and the mortgage interest. The latter reflects the fact that transactions and mobility fall at times of high interest rates.

4. Policy implications of the model

The paper concentrates on five issues that have arisen during the project:

- The impact of housing supply on affordability
- The effects of affordability on household formation
- Aspirations for owner-occupation
- International migration and the effects on prices, domestic household formation and inter-regional migration
- Regional variations in response to national policy shocks

These issues can be quantified through the system of equations (1-4), or more precisely through the equations set out in the appendices. This requires the construction of a baseline scenario[9], conditional on initial values for Y_0, (generally published time-series data up to 2009, although earlier for some of the micro survey data), constant estimated values for the parameter matrices, A, B, H and Ω, and projected values for the exogenous variables, X, over an arbitrary future time period, taken to be 2031. This period is sufficient to ensure that the

[8] As noted above, the feedback effects from housing to the labour market are relative weak (although house prices affect earnings) and, for the purposes of this paper, can be treated as exogenous as a simplification.
[9] Coded as an Excel spreadsheet model.

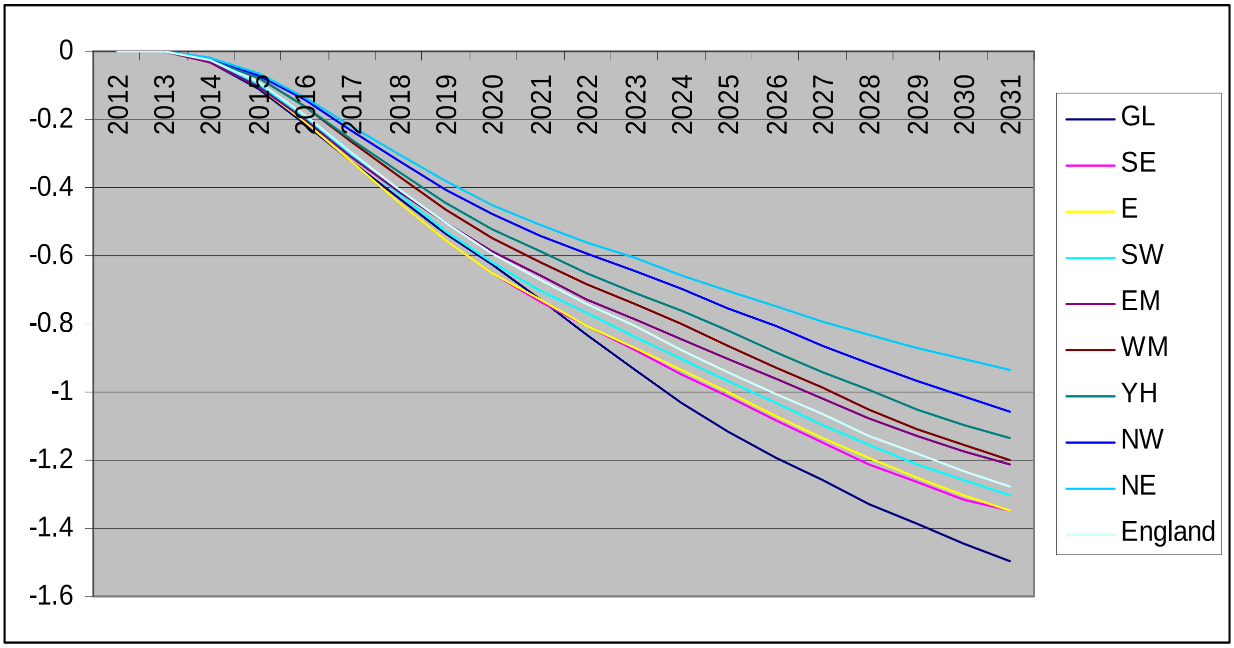
endogenous variables settle to their long-run growth paths. Therefore, the model determines both the dynamics (primarily through A) and the steady-state growth path. Given the baseline, the bullet points above can be analysed by a series of changes to the X vector.

4.1 The impact of housing supply on affordability

As discussed in the Introduction, the model was originally developed to consider the required levels of housing production, necessary to meet regional affordability targets. Therefore, the effect of increases in production on affordability is the most basic question for the model. Figure 1a shows the impact of a *permanent* 50 per cent increase in private housing starts, relative to the baseline. In the base scenario, total starts are approximately 180,000 per annum, so a 50 per cent increase is large and implies a level of net housing additions slightly higher than the previous Labour government's housing supply target of 240,000 units. For England as a whole, the model implies that affordability might improve by approximately 1.3 points by the final year (compared with a price/earnings ratio of 10.5 in the base).

Therefore, arguably, large increases in construction produce modest improvements in affordability and, as suggested in the Introduction, even larger increases are required to bring real price growth to the European average. It should be noted, however, that in contrast to demand shocks where changes to affordability can be large, but temporary, these are permanent changes to affordability. Nevertheless, construction increases are required to be long-lasting and cannot be used for short-run market stabilisation. These conclusions arise from equation (5), where it is shown that the *stock* of dwellings rather than the *flow* of new housing supply is the key determinant. Although the elasticity of prices with respect to the stock is high (-2.0 in most regions), new construction is a small annual contributor to the stock. Figure 1a also finds that common percentage changes to construction produce differential effects between the regions.

The improvement to affordability is greater in the southern regions, where supply shortages are greater. Figure 1b repeats the simulation, but limits the increase to 10 years. In this case, the maximum improvement for England as a whole is less than 1 percentage point and the improvement falls away as more household formation is induced.



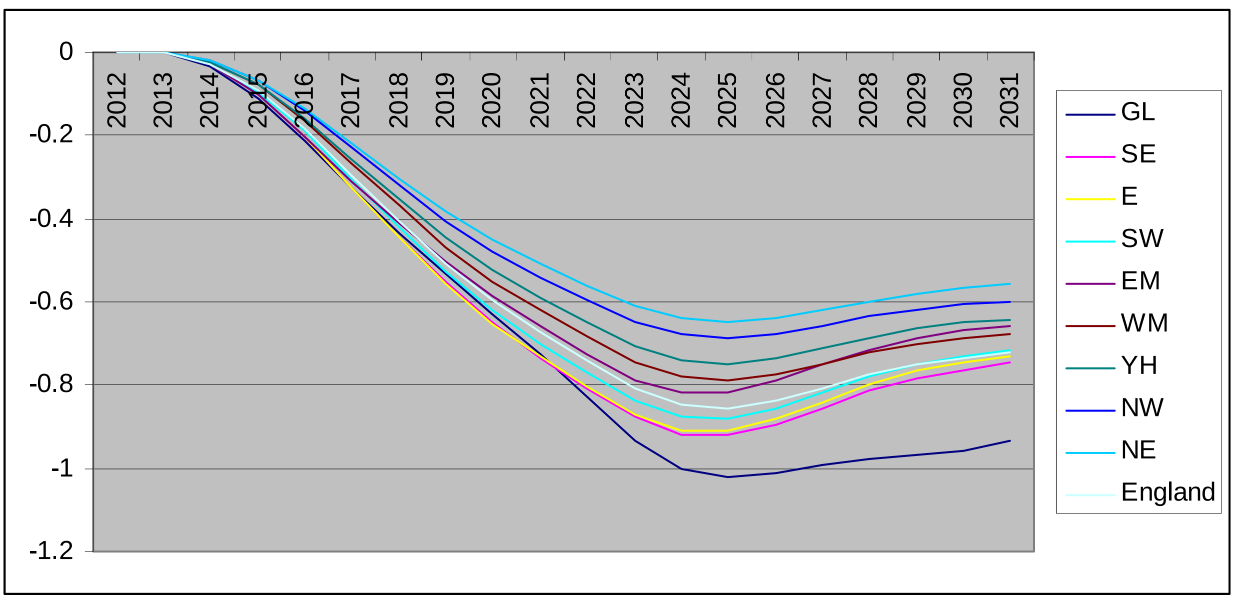
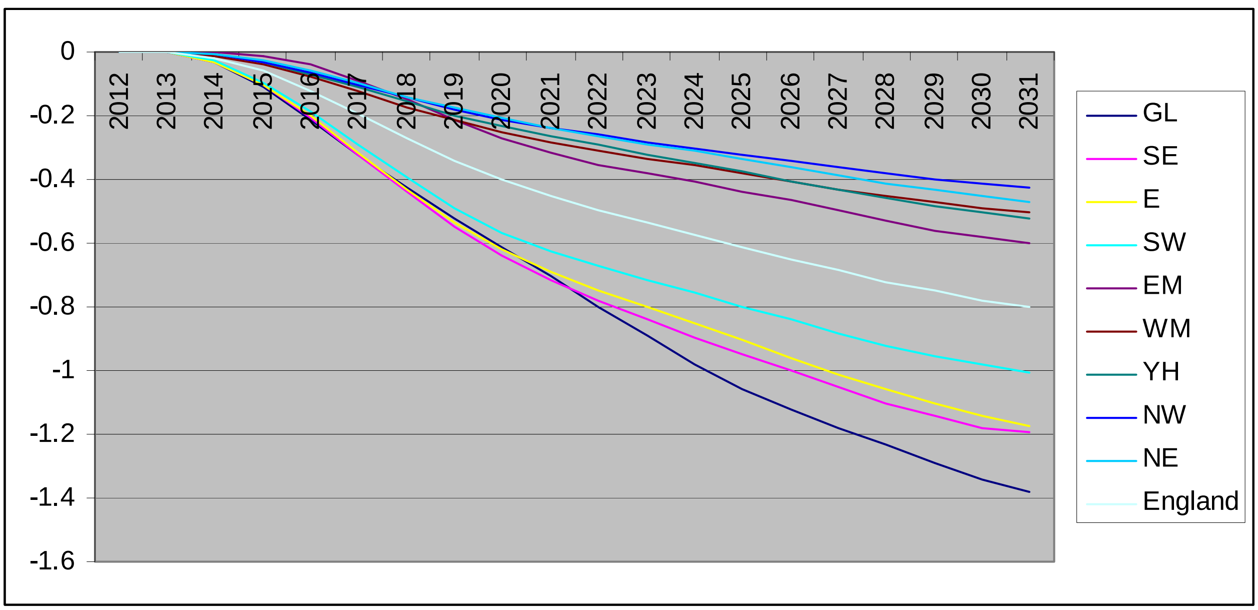


Figure 1(a) 50 per cent permanent increase in private housing starts (b) 10-year increase - all regions (effects on the ratio of house prices to earnings, differences from base)

The regional dispersion of the effects from supply increases are highlighted further in Figure 2. The first frame shows the change in affordability arising from a 50 per cent permanent increase in construction in the southern regions alone. For England as a whole, affordability improves by 0.8 points by the final year. The improvement for the southern regions is approximately 1.2 points, but there is still an improvement in the regions where no increase in construction took place (by 0.5 points). The increase in southern supply induces migration inflows to the south and outflows from the remaining regions, which improves affordability in the latter. By contrast the second frame shows the same 50 per cent change in the Northern and Midlands regions[10]. In this case, affordability in England improves by a more modest 0.5 points, but by 0.6 points in the Midlands/North and a modest 0.2 points in the South.

A final point to note is that balanced increases in housing supply, i.e. across all regions or groups of regions, are capable to producing an increase in affordability, although modest unless increases are large and long-lasting. Nevertheless, it may be difficult, or impossible, to achieve affordability targets at sub-regional levels. This is because local authorities, for example, may be close substitutes in terms of location for many households, so that increasing construction in a small number of areas generates strong population inflows, offsetting any improvement in affordability. Simulations were conducted in ODPM (2005), where increases in supply in two local authorities – Reading and Knowsley were considered. In the former – a wealthy southern town – little improvement in affordability occurred due to migration, whereas deprived, Northern Knowsley experienced few population inflows.



[10] The absolute changes in construction are also similar in the two simulations. The southern regions account for approximately 52% of starts and the Midlands/North for 48%.

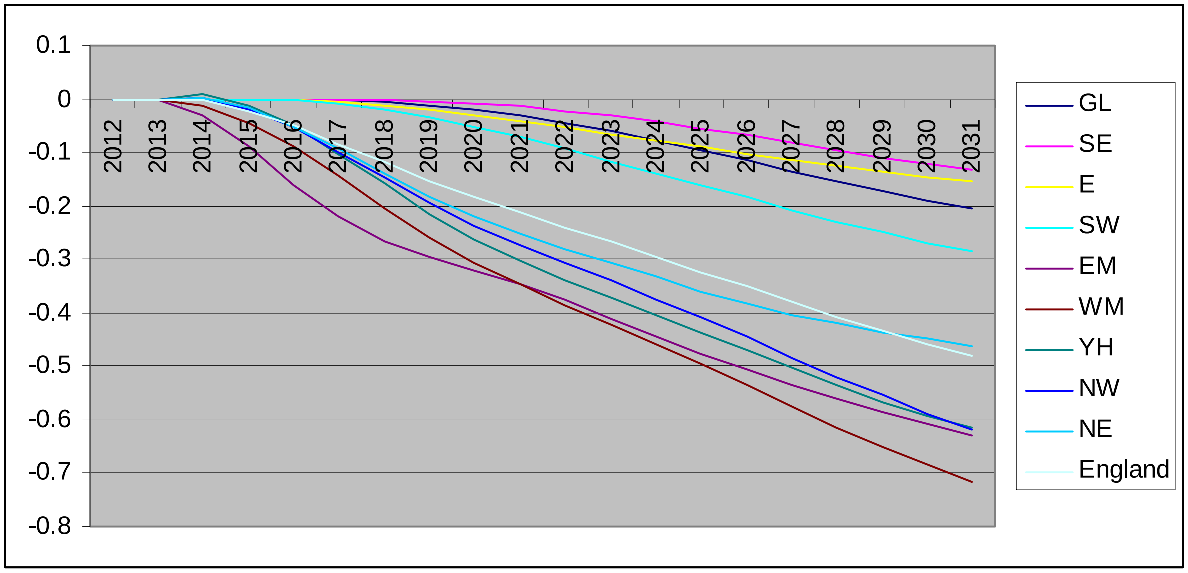


Figure 2: 50 per cent increase in private housing starts – (a) Southern regions; (b) Midlands and Northern regions (effects on the ratio of house prices to earnings, differences from base)

4.2 The effects of affordability on household formation

Official household projections are trend-based, relying primarily on census information, but also taking into account more recent information from the Labour Force Survey (LFS). However, there are a number of problems. First, Meen and Andrew (2008) show that, historically, household projections have over-predicted the outturn (although *forecast* revisions have tended to be upwards). Second, LFS data have recently shown sharp reductions in household representative rates for younger age groups (DCLG 2010). Third, as trend-based projections, they take no account of changes in economic conditions (or more precisely encompass average behaviour over the past). Fourth, the projections are used as a basis for construction plans (see equation 7) and as a possible indicator of housing need, but it is, by no means, clear that the official projections are suitable for either.

A possible explanation for both past over-prediction and recent falling household representative rates is the worsening of affordability for potential new households. Since equation (5) implies a further decline over the future, unless housing supply increases at a faster rate than household formation, an expected model outcome is a slower rate of household growth than in official projections. In order to demonstrate the model sensitivity of household formation to affordability, Table 1 shows household formation probabilities for an illustrative selection of the 416 household types. The most striking feature is the importance of persistence. If individuals are already in separate households, the second half of the table shows that their current status is largely invariant to economic and demographic characteristics. However, this is not true if individuals were living with parents or sharing in the previous time period. For example, comparing rows 6 and 7, receiving an income in the fourth quartile rather than the first raises the household formation probability by approximately 10 percentage points.

Table 1: Probabilities of household formation (London 2006)

	Probability (%)
Previously Not Separate Household	
Female, 25-29, single, no children, income quartile 4	25.1
Male, 20-24, single, no children, income quartile 2	8.2
Male, 30-34, single, no children, income quartile 4	22.0
Male, 30-34, partner, children, income quartile 4	63.4
Male, 30-34, partner, children, income quartile 1	52.1
Previously Separate Household	
Female, 25-29, single, no children, income quartile 4	96.7
Male, 30-34, single, no children, income quartile 4	95.9
Male, 30-34, partner, children, income quartile 4	99.8
Male, 30-34, partner, children, income quartile 1	99.5

Aggregating over all household types and regions, it is possible to compare official and model projections. 2006-based official projections (DCLG 2009) suggest total households of 27.8 million in 2031. Model baseline projections suggest a level of approximately 1.8 million lower, although the precise numbers are base-dependent. Note that this does not imply that 1.8 million fewer houses should be produced; rather it shows that, given housing shortages, part of the adjustment is likely to take place through a lower level of new household formation.

An alternative presentation is to examine the average household size. Official projections indicate a continuing fall over time, whereas Figure 3 suggests that worsening affordability would limit the scope. This is particularly the case in London where affordability is worst, but size is broadly constant in the northern regions. This raises social as well as economic issues concerning acceptable household sizes, but the projections do not suggest that, in general, household sizes would rise rapidly in a market system or that widespread overcrowding would occur.

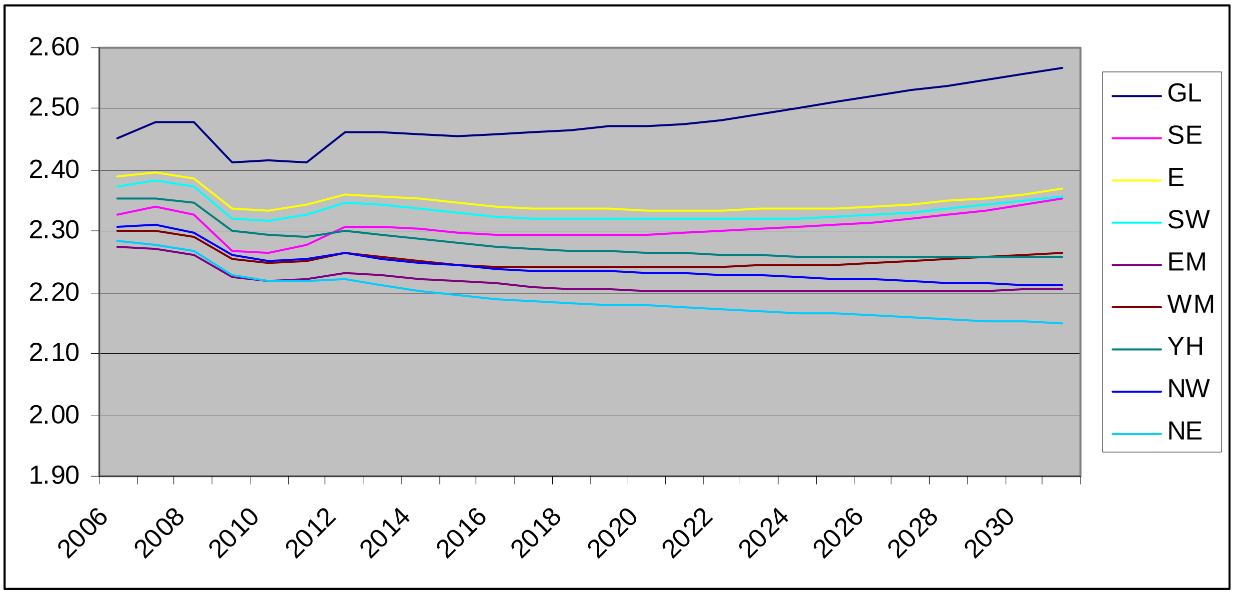


Figure 3: Average household size

4.3 Aspirations for home-ownership

Aggregate home-ownership rates in England fell from 70.9 per cent in 2003 to 67.7 per cent in 2009 and the average age of entry into home-ownership rose sharply. Two questions are addressed in this section. First, why has the ownership rate fallen, given that the decline started well before the credit crunch? Second, is it possible to raise the home-ownership rate sustainably, i.e. without raising the rate of house price inflation?

Table 2 sets out the estimated ownership probabilities for a small selection of household types, varying by income, demographics and previous status. The table, again, demonstrates the importance of persistence, but for households who were previously renting, rises in income have a significant effect on the probability of ownership. However, changes in income are unlikely to have been the main cause of the fall in home-ownership; rather increasing deposit requirements for first-time buyers are a more important factor. Between 1988 and 2009, the average deposit made by former owner-occupiers ranged between 31 per cent and 39 per cent, but ranged between 10 per cent and 28 per cent (in 2009) for first-time buyers.

Therefore, the gap between the required deposits of the two groups has narrowed, despite the fact that existing owners have gained equity in their current properties as prices rose. A decreasing share of mortgage advances has gone to first-time buyers and, despite the rise in securitisation over this period, first-time buyers have faced increasing difficulties in access to home-ownership. Consequently, it is unsurprising that owner-occupation rates have failed to increase. Rising debt levels have benefited existing owners rather than encouraging higher home ownership rates.

Table 2: Ownership probabilities for previous renters and previous owners (South East, 2006, %)

Female Head, Aged 30-34, Single, No Children		
	Previous Owner	**Previous Renter**
Income Quartile 2	94.3	2.6
Income Quartile 4	96.6	4.5
Male Head, Aged 35-39, Partner, With Children		
	Previous Owner	**Previous Renter**
Income Quartile 2	98.4	8.6
Income Quartile 4	99.2	13.2

To illustrate this further, Table 3 sets out the estimated years in the baseline scenario, when the deposit requirements no longer form a binding constraint on access to home-ownership[11]. These projections assume that the restrictions on lending arising from the credit crunch do not continue into the future. Nevertheless, households are still required to accumulate a deposit through saving, because of asymmetric information. The table indicates that, even in the absence of aggregate funding shortages, only households in the top two quartiles of the national income distribution would be unconstrained by the end of the projection period in the four southern regions[12], although, in the remaining lower-priced regions, saving for the deposit would allow the removal of the constraint at an earlier stage and at a lower income quartile.

Although those in the lowest quartile would never be unconstrained, it should be noted that this does not imply that ownership probabilities are zero even for these groups. The constraint simply lowers the probability of ownership. Furthermore, and importantly for many groups, the table implies that deposit requirements delay entry to ownership – through the creation of a temporary hurdle – rather than preventing ownership permanently. Finally, it should also be noted that the model does not allow for the possibility that relatives contribute to the deposit, which has been important in recent years.

[11] These assume a 5 per cent savings rate for each household.
[12] The table illustrates the particular difficulties for London households in achieving ownership. However, it should be remembered that the quartiles refer to national incomes, rather than London income quartiles, which are considerably higher.

Table 3: Years in which the deposit constraint ceases to bind (Male, 30-34, partner and children)

Region	Quartile 1	Quartile 2	Quartile 3	Quartile 4
London	-	-	2026	2017
South East	-	-	2020	2013
East	-	-	2016	2011
South West	-	-	2016	2011
East Midlands	-	2024	2012	2010
West Midlands	-	2026	2013	2010
Yorkshire/ Humberside	-	2023	2011	2010
North West	-	2022	2011	2010
North East	-	2019	2011	2010

In general, demand-side subsidies to households are expected to be capitalised into house prices and may have little effect in raising home-ownership rates, particularly in the UK where the price elasticity of supply is low, Ball *et al* (2010). Instead, sustainable increases in home-ownership require increases in housing supply. Figure 4 shows the effects on home-ownership rates of the earlier 50 per cent permanent increase in housing production. First, the improvement in affordability increases the number of households in each region, since the headship probabilities rise. But, although this implies that the total *number* of home-owners increases, it does not necessarily follow that the share rises, particularly since, by assumption, the relative costs of owning and renting remain constant.

Nevertheless, the ownership rate does increase modestly, by approximately 0.25 percentage points in the final year. But the time path is more interesting. In all regions, there is little effect until the fall in prices relaxes the deposit constraint at which point ownership rates “jump”. From Table 3, the increases do not all take place in the same year. However, the short-run increases, relative to the baseline, are greater than the long-run increases, because, as argued above, credit restrictions primarily delay the time path of entry to ownership. Overall, substantial increases in housing supply only lead to modest permanent effects on ownership rates, but they are non-inflationary compared to demand subsidies.

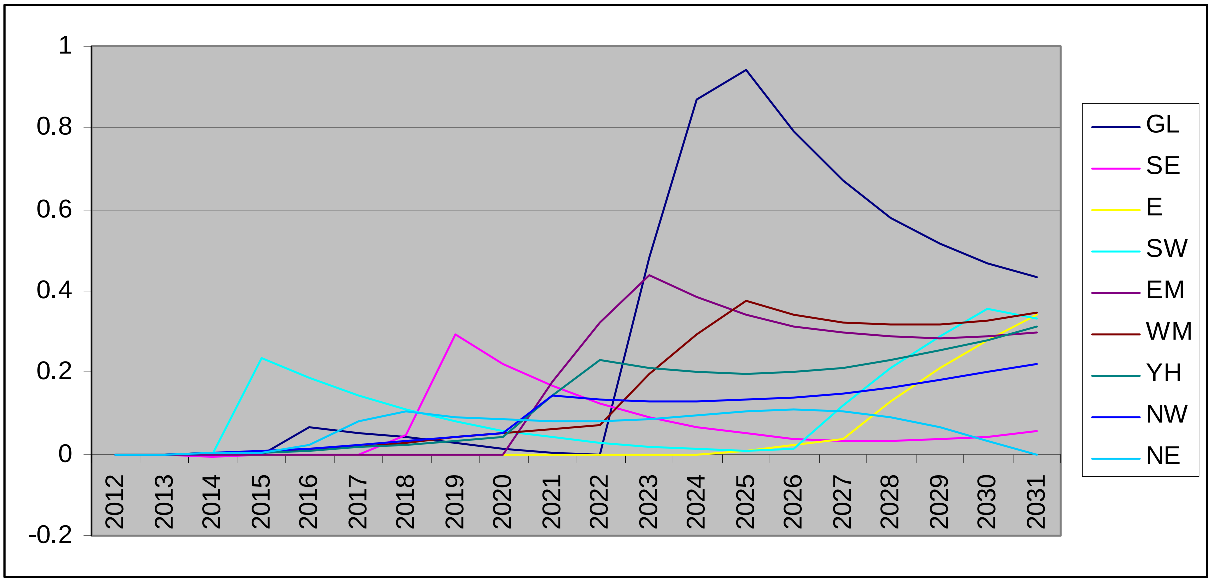


Figure 4: Home-ownership rates (% point differences from base, 50 per cent increase in private starts)

4.4 The effects of international immigration

Little empirical information exists for the UK on the housing market consequences of immigration, a point noted by the House of Lords (2008). Despite the fact that approximately a third of household growth in England over the next 15-20 years is expected to come from immigration, with a substantially higher proportion in London, there have been few attempts to model the impact on English housing markets, (Nygaard 2010 is a recent exception). Initially, migrants tend to consume lower levels of housing services than the UK born and are concentrated in the private rental sector, but over time, they tend to converge towards the tenure and housing consumption patterns experienced by domestic residents. The 2008 House of Lords report quotes evidence that only a small element of the worsening of affordability since 2000 can be attributed to immigration.

Furthermore, the evidence stated if net migration were to be zero over the next 20 years, compared with a projection of 190,000 per annum, prices might be approximately 13 per cent lower than would have been the case. At first sight, this appears to be modest, but the impact may be more subtle than this suggests. A possible explanation for the weak result is that the effects of international migration are diffused over the regions. Hatton and Tani (2005) find empirical support for this view and provide evidence that the net inter-regional migration rate is negatively related to the net international immigration rate. This implies, for example, that international migrants, who disproportionately head for London when they first arrive, generate outflows of domestic populations to the surrounding regions. Consequently, the rise in housing costs in London might be limited, but some increases in costs in other regions are also likely to be experienced.

A spatial diffusion process of this form is a feature of the Affordability Model. As an illustration, Figure 5 assumes a 50,000 per annum increase in gross in-migration relative to the baseline[13]. Since a high percentage is likely to be located initially in London, the largest effects on house prices are in this region (Figure 5a). However, prices also rise (to a smaller extent) in the other regions. This is, partly, because some of the international migrants are based outside London, but also because of the spatial diffusion from London.

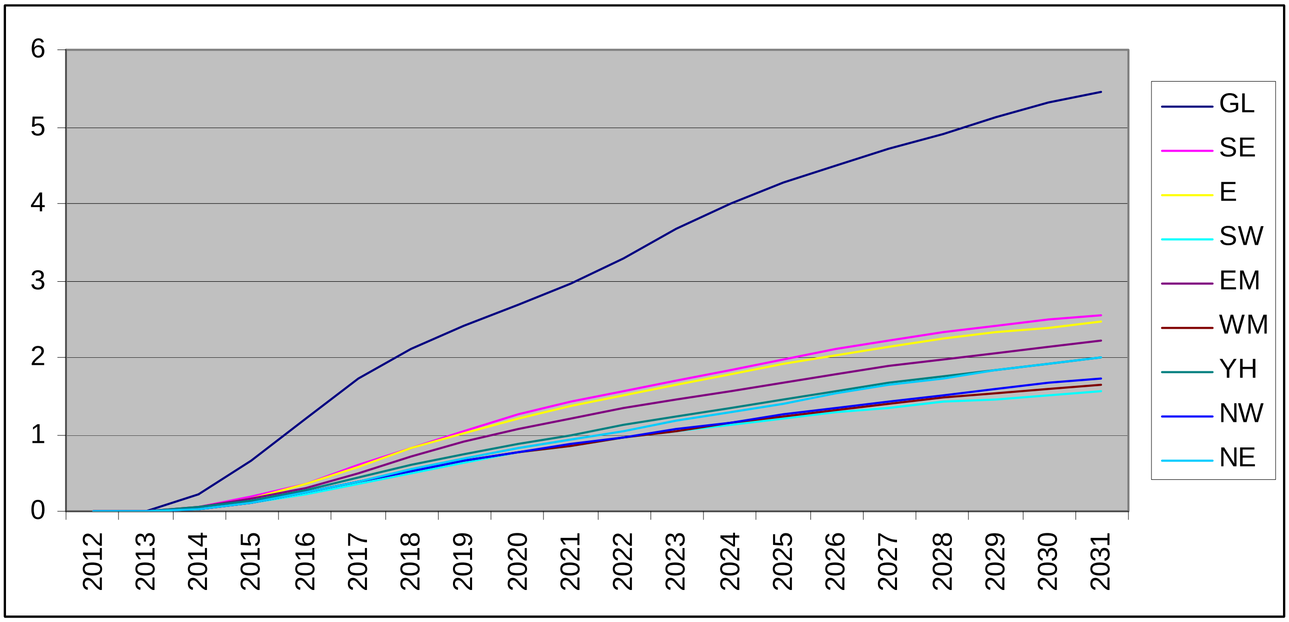


Figure 5a: Effects of 50,000 pa increase in migrants – house prices (% differences from a base scenario)

This can be seen in Figure 5b, which shows the net inter-regional population flows; London loses population to other regions. Figure 5c shows a further feature of the adjustment process, through changes in the rate of household formation. As housing costs rise in response to immigration, not only does spatial diffusion take place through migration, but household formation *within* regions is expected to fall. Domestic households may be crowded out and have to remain with parents or share for longer. In Figure 5c the total number of *households* rises nationally by approximately 295,000 in the final year (summing over the regions); but over a 20 year period the number of migrant *individuals* is assumed to increase by a million (50,000*20). Although the extent of crowding out depends on the average household size, the figures imply a significant degree of crowding out. For example, if the average size is 2.3, this would imply a direct increase in households from migration of approximately 435,000. The difference from 295,000 is an indication of the degree of crowding out.

[13] The simulation also assumes that none subsequently returns home so that the net increase is the same as the gross increase.

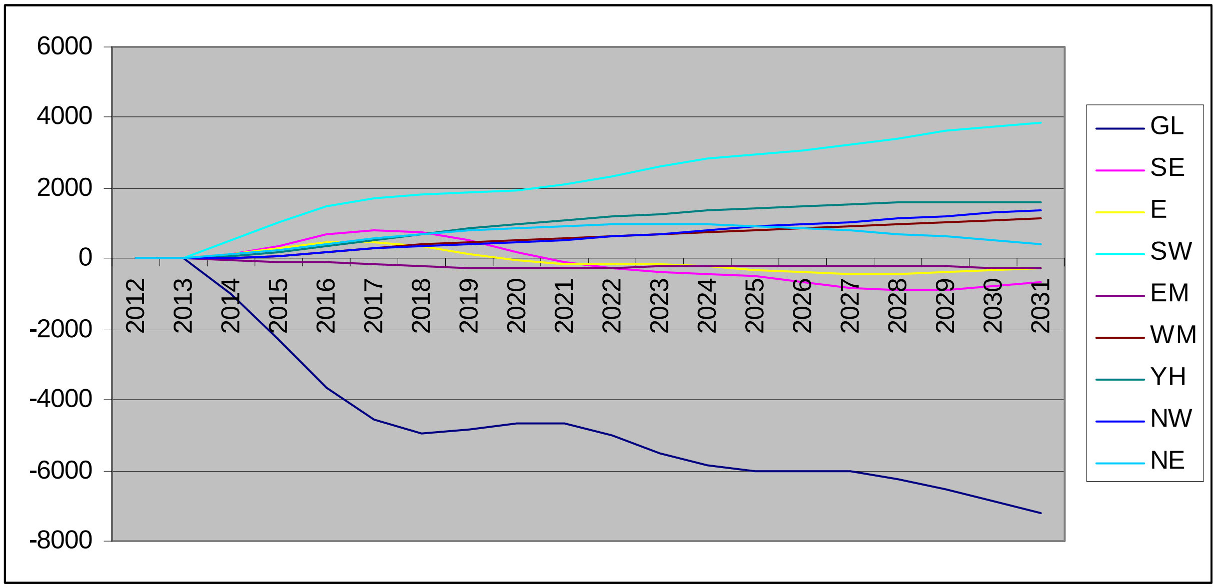


Figure 5b: Effects of 50,000 pa increase in migrants – net regional flows (differences from base scenario)

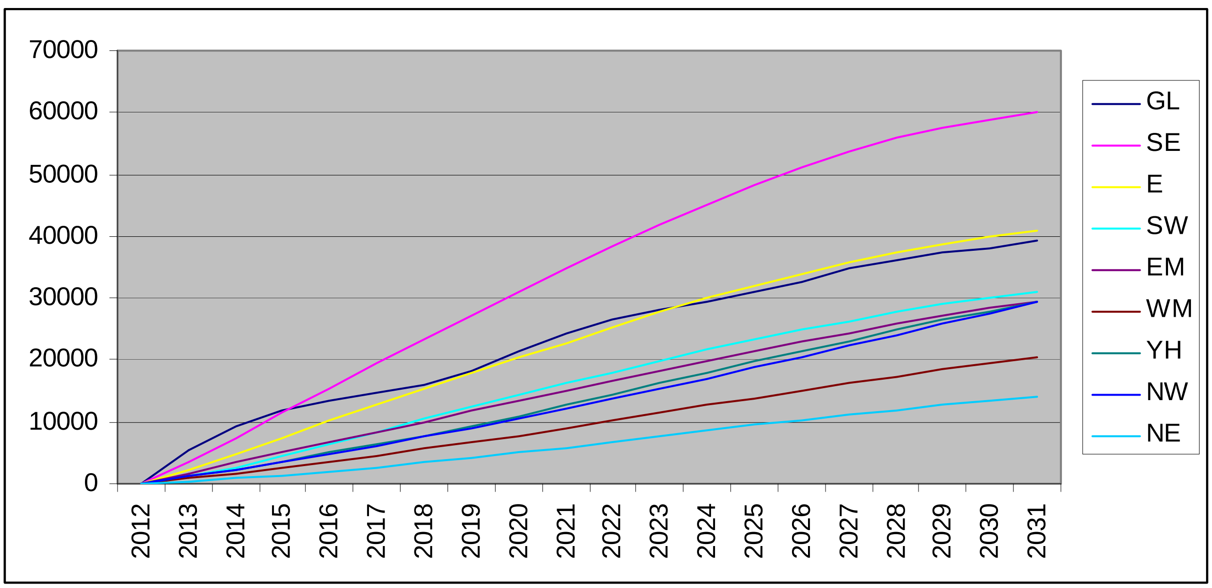


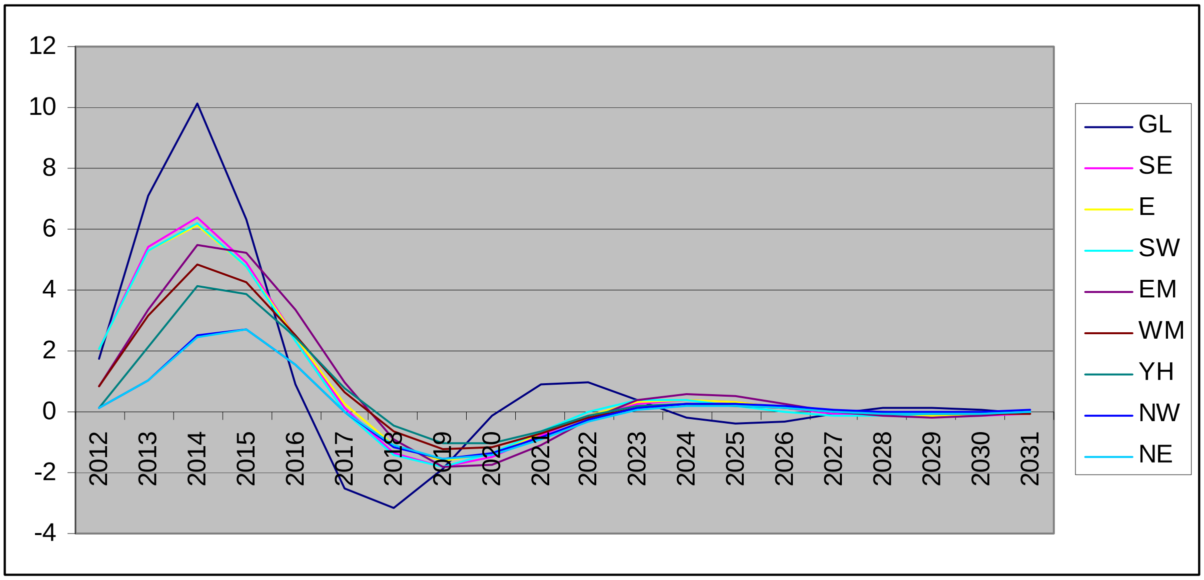
Figure 5c: Effects of 50,000 pa increase in migrants – household formation (differences from base scenario)

4.5 Regional variations in response to national shocks

Previous sub-sections have already demonstrated that changes to housing supply do not necessarily produce the same effects across the regions, although there are distinct spatial patterns. Furthermore, common national policy changes, for example, to interest rates also produce differential regional effects, arising from variations in the interest rate coefficients in the house price equations (see Appendix 1). But, again, the coefficient differences are non-random and exhibit identifiable spatial patterns. This is demonstrated through a temporary (2 year) one percentage point reduction in mortgage interest rates. However, the simulations are conducted (a) in the absence of credit market constraints (b) in the context of constraints similar to those occurring in the credit crunch. The unconstrained simulations in Figure 6a illustrate that the largest effects are in London, followed by the remaining southern regions, then the Midlands with the smallest effects in the North.

The figures concentrate on house prices rather than affordability since, under the official measure, a cut in interest rates produces a worsening of affordability as prices rise. The pattern of responses was first identified in Meen (1999), where it was argued that the pattern was consistent with spatial patterns of indebtedness. Those areas that are most indebted, i.e. London and the South, face the greatest risks and, therefore, are more likely to be responsive to changes in interest rates. It was also argued that the pattern was consistent with the ripple effect. The second frame of Figure 6 concentrates on the South East, but similar issues arise in other regions.

This demonstrates that interest rates are less powerful as a policy instrument when credit constraints are binding. This is because increasing mortgage queues (as mortgage demand rises) act as a buffer to housing demand and price increases. Arguably, this is one reason why the Bank of England had to reduce bank rate to a record 0.5 per cent during the credit crunch in an attempt to boost the market. But the effect of an interest rate change in the South East is only approximately half of that in an unconstrained market.



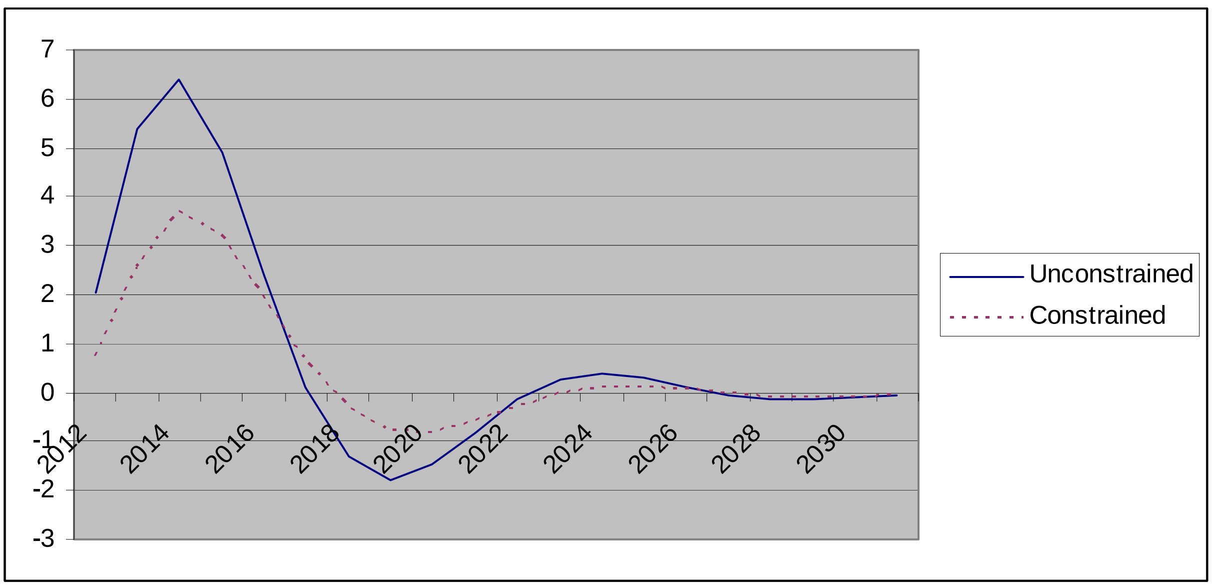


Figure 6: Effects of a temporary 1 per cent point cut in mortgage rates (house prices, % differences from base): (a) no credit constraints, (b) credit constrained versus unconstrained (South East only)

5. Concluding comments

A final note of caution is necessary. Although the model is sophisticated relative to most housing models, it is still a model, with unknown prediction errors over the long time periods into the future for which it is used. The simulations presented in Section 4 are point estimates, but the results are best considered as an aid to thought rather than providing exact solutions. Good policy making is not about just pressing the buttons of the model.

The model also assumes that the parameters estimated on past data will continue into the future, which is certainly questionable. The parameters, themselves, may change with policy. Furthermore, there are important issues that are likely to rise in the future and may generate changes to the coefficients. The most important of these could be the consequences of the build up of household debt since the early 1980s – the credit crunch hardly made a dent in this – and, if the model projections were to prove accurate, would imply an even greater increase in debt over the future. The model (and no other model) has fully addressed the implications of this, but one plausible result could be that housing markets become more sensitive to both random shocks to the economy and to policy changes. The simulations in Section 4.5 suggested that those regions that are most indebted are more responsive to interest rate changes. This is an important area for further research.

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Appendix 1: House Price Equations (SUR Estimates, 1981-2006)

This Appendix provides details of the price equations in the model, which are based on the specifications in Meen (1999). Estimation uses DCLG mix-adjusted regional price data. However, the definitions of the administrative regions changed from Standard Statistical Regions to Government Office Regions (Government Office Regions) in 1992. Many of the boundaries remained unchanged (London, South West, East Midlands, West Midlands), but the former South East and East Anglia became a new South East and East. Similarly, the former North and North West became a new North West and North East. In order to conduct estimation over consistent spatial boundaries, the regions where the borders have changed have been amalgamated into broader North (the Government Office Region North West and North East) and South (South East and East) regions. The aggregation uses weights based on the relative sizes of the owner-occupier housing stocks in each region. Consequently, the results shown here are for seven rather than the full nine regions.

Table 1A shows the equation for London, which finds no role for own region earnings, but a strong effect from the stock market. Note that (through ECM), the housing stock has an elasticity of -3.0, which is larger than in the other regions. The user cost also has a strong effect.

Table 1A: London dependent variable = Δg

	GL
constant	-5.479 (3.2)
ECM_{-1}	-0.263 (6.8)
$(hh)_{-1}$	1.350 (4.6)
UCC	-0.018 (6.9)
Δpsh	0.148 (3.4)
psh_{-1}	0.136 (4.6)
Δrw_{-1}	1.534 (3.8)
CCI_{-1}	1.274 (3.5)
R^2	0.92
Eqn St. Error	0.032
DW	2.14

t-values in brackets
Dummy variable for the abolition of double mortgage tax relief included
$ECM = g + 3.0*hs$

Results for the remaining Southern Regions are shown in Table 2A. In contrast to London, stock market prices are insignificant, but earnings have a strong effect. The long-run user cost semi-elasticity is similar to that for London. The equations also include data-validated restrictions through the error correction terms (*ECM*). The precise restrictions are shown in the table legend. They imply that the long-run elasticity of house prices with respect to average earnings is 2.0 and with respect to the ratio of the housing stock to the number of households is -2.0. At first sight these may seem high, but are consistent with the regional findings of

Cameron *et al* (2006) and the extensive UK work on national house prices (Meen 2008). Note that, in the South, earnings are an average of own region and London values in order to allow for commuting and the fact that earnings are measured on a workplace basis.

Table 2A: South and South West dependent variable = Δg

	Fixed Effects Panel	
ECM_{-1}	-0.282 (5.0)	
UCC	-0.020 (6.7)	
CCI_{-1}	0.777 (4.1)	
	South West	**South**
R^2	0.72	0.75
SEE	0.057	0.054
DW	1.87	1.55

$ECM = [(g - 2.0*(0.5*rw_{south}+0.5*rw_{London}) + 2.0*(hs - hh)]$ for the South
$ECM = [(g - 2.0*rw_{sw} + 2.0*(hs - hh)]$ for the South West

Equations for the remaining regions are expressed as relative prices rather than the level. This introduces a form of spatial lag, which is consistent *a priori* with a ripple effect. Therefore, in the case of East and West Midlands (Table 3A), the relationships are expressed in terms of deviations from the South. Similarly, the equations for the northern regions (Table 4A) are expressed relative to the West Midlands.

Table 3A: Midland dependent variable = $\Delta(g\text{-}g_{south})$

	East Midlands	West Midlands
Constant	0.124 (3.7)	0.059 (2.0)
$\Delta(UR\text{-}UR_{south})$	-0.048 (3.1)	-
$\Delta(UCC\text{-}UCC_{south})$	-0.020 (6.2)**	-0.020 (6.2)**
$\Delta(RM)$	0.012 (2.1)**	0.012 (2.1)**
ecm_{-1}	-0.537 (5.3)	-0.320 (3.6)
$(UR - UR_{south})_{-1}$	-0.046 (3.6)	-0.023 (4.2)
$(UCC - UCC_{south})_{-1}$	-0.022 (5.3)**	-0.022 (5.3)**
RM_{-1}	0.005 (1.5)**	0.005 (1.5)**
R^2	0.72	0.69
SEE	0.031	0.033
DW	1.61	1.89

$ecm = (g\text{-}g_{south}) - (rwh\text{-}rwh_{south})$
$rwh = rw - (hs - hh)$
** denotes common coefficient to both regions

Table 4A: North and Yorkshire and Humberside dependent variable = $\Delta(g-g_{wm})$

	North	Yorks & Humber
Constant	-0.056 (2.3)	-0.003 (0.2)
$\Delta(rw-rw_{wm})$	-	0.757 (2.7)
$\Delta(RM)$	0.007 (1.3)**	0.007 (1.3)**
ecm_{-1}	-0.336 (4.9)	-0.540 (6.3)
$(UR-UR_{wm})_{-1}$	-0.024 (2.6)	-
$(UCC-UCC_{wm})_{-1}$	-	-0.010 (3.4)
RM_{-1}	0.016 (4.2)	0.007 (2.7)
DUM88	-0.174 (6.0)	-0.154 (5.6)
R^2	0.70	0.68
SEE	0.032	0.031
DW	1.89	1.67

$ecm = (g-g_{wm}) - (rwh-rwh_{wm})$; *wm* denotes West Midlands
$rwh = rw-(hs-hh)$
** denotes common coefficient to both regions

G = *PH/PC*
PH = Regional index of mix-adjusted house price, 2002=100 (CLG)
PC = Consumers' expenditure deflator (ONS)
RW = W/PC
W = Regional median earnings, £ per week (ASHE/NES)
HS = Stock of dwellings, 000s (CLG)
HH = Number of households 000s, (CLG)
RM = Mortgage interest rate, % (ONS)
PT = Regional average council tax charge on Band D property expressed as percentage of average house prices, % (calculated from ONS data).
ST = Stamp duty rate on average priced property in each region, % (calculated from HM Revenue & Customs data)
PSH = Index of stock market prices, expressed relative to *PC* (ONS)
UCC = user cost of capital = $RM - 0.3*100*\Delta\ln(PH)_{-1} + ST + PT$
UR = Regional claimant count unemployment rate %, (ONS)
CCI = Indicator of credit rationing, taken from Fernandez-Corugedo and Muellbauer (2004).
Lower case denotes logarithms.

Appendix 2: Household formation and tenure equations (probit estimates)

(i) Household formation

The model estimates three sets of headship rate equations – for the under 39 age group, for the 40-59 group and the over 60s. Table 5A sets out the probit equation for the first group, which is the most important for the model, since the older age groups have, typically, already formed households and the younger group is more sensitive to economic influences. The coefficients cannot be interpreted directly as marginal effects, but, nevertheless, in line with most findings in the literature, demographic factors are more important than the economic variables, real income, housing costs and regional unemployment. However, despite the fact that housing costs are borderline significant, given the large changes to affordability that may take place in projections, the economic terms still play an important part in determining the rate of household formation. It should be noted that the most appropriate measure of housing costs is not clear theoretically and measurement error may bias the coefficient downwards.

Table 5A: Household formation probabilities, age band under 39, (1992-2002)

Variable	Coef.	Robust Std. Err.	Z-value
ageband_1	.5865	.0794	7.38
ageband_2	.8679	.0902	9.62
ageband_3	.9801	.1031	9.51
ageband_4	1.024	.1031	9.93
spouse	.9722	.0579	16.80
kid	.1425	.0635	2.25
acqsp_1	2.369	.1209	19.59
acqsp_2	-1.484	.1450	-10.23
rinterest	-.0602	.0378	-1.59
rincome	.0123	.0039	3.14
hform	2.507	.0664	37.75
male	-.2147	.0445	-4.82
un	-.0763	.0392	-1.95

Equation also includes year and region dummies
Pseudo R^2 = 0.7823

ageband_1	=	individual aged 20-24
ageband_2	=	individual aged 25-29
ageband_3	=	individual aged 30-34
ageband_4	=	individual aged 35-39 (NB. 16-19 is the default category)
spouse	=	individual has a partner
kid	=	individual has children
acqsp_1	=	individual gained a partner in the previous period
acqsp_2	=	individual lost a partner in the previous period
rinterest	=	real regional housing costs (R*PH/PC)
rincome	=	real individual income
hform	=	individual was a household head in the previous period
male	=	dummy variable = 1 if individual is male
un	=	regional unemployment rate.

(ii) Tenure

Tenure choice models are estimated for the three age groups 20-39, 40-59, 60+. Results for the first group are given below. This is, arguably, the most important group since it is most heavily affected by credit restrictions and is more likely to change tenure status. Each equation is estimated across the BHPS waves from 1991 to 2002, although the first wave is used to construct the lags. Formally, the presented results refer to a probit model with sample selection, where the income variable is instrumented for potential endogeneity. The bottom half of the table sets out the factors that determine the probability of *not* being an owner, whereas the top half models the probability of being in the *private* rental sector, conditional on not being an owner. Note that inertia is an important part of behaviour. Therefore, one of the most important determinants of current tenure is last year's tenure. Households, typically, do not respond immediately to changes in economic or demographic factors.

All the key variables in the 20-39 age group equation are significant. At first sight, income appears to be insignificant. However income also enters through the income multiples term (one of the credit constraints), which is significant. Arguably, there is no need to include a separate income term once the credit restriction is added. Both marriage and cohabitation increase the probability of ownership, although those in the latter state have a lower probability than the former. Having children lowers the probability of ownership, conditional on the other variables. The high costs of having children are well known. This also reflects the fact that single parents with children receive higher priority in social housing. For the under 40s, male heads have a higher ownership probability.

The most controversial elements, however, are the coefficients on the housing user cost and rental terms in the ownership equation. Although the coefficients are highly significant the restriction that the coefficients are equal and opposite in sign could not be imposed. Since we expect the relative price to be the appropriate variable, this is surprising. Furthermore, in a long-run model, this causes difficulty in simulation. Although not entirely satisfactory, the simulation model imposes the theoretical restriction, which is not accepted by the data, that the coefficients are equal, using the average of the two cost coefficients. A second feature of the cost terms concerns the definition of the user cost. In contrast to equation (6), the variables include no capital gains element. Inclusion of capital gains was heavily rejected by the data.

The choice between private and social renting is also related to demographic and economic variables. The specification attempts to capture the fact that entry to the social sector is partly administered, with potential entrants needing to meet certain criteria, but households also have some choice based on relative costs, particularly in regions that do not suffer excess demand. A relatively simple specification cannot hope to capture the full complexities of an administered system, but, nevertheless, the results appear to possess some of the expected features. For example, those with children and those on low incomes are more likely to be in the social sector. There is, again, a high degree of persistence between the two rented sectors. Those already in social housing do not quickly move out even if their incomes rise.

The equation allows differential price effects between the four southern regions and the rest of the country. More precisely, since access to social housing is more constrained in the South, we expect the relative price coefficients to be smaller. To capture this, two relative price terms are included; the first *relrsrs* applies to all regions, whereas the effect for the southern regions is the sum of the coefficients on *relrsrs* and *SOUTHRELRSRS*, i.e. 0.563-0.446 = 0.117. Note also that in the renting equation, the restriction that the coefficients on private and social rents are equal can be accepted by the data.

Table 6A: Tenure probabilities, age 20-39

Probit model with sample selection

	Coef.	Robust Std. Err.	Z-value
PRS			
maritals-1	-.386	.1475	-2.62
maritals-2	-.6588	.1448	-4.55
nchild	-.2634	.04378	-6.02
relrsrs	.5630	.14909	3.78
SOUTHRELRSRS	-.4462	.13211	-3.38
rahincome	.0362	.01181	3.07
lsrs	-2.24	.11185	-20.04
constant	.8573	.34337	2.50
nothomeown			
maritals-1	-.5791	.1068	-5.42
maritals-2	-.4663	.1116	-4.18
nchild	.0615	.0298	2.07
rahincome	-.0087	.0065	-1.34
UCC	.4506	.0501	8.99
rrent	-.6476	.0397	-16.31
modWC	.5796	.0892	6.50
modYC	.5947	.1589	3.74
loo	-2.334	.0799	-29.21
headmale	-.089	.0705	-1.26
Iloun	-.0955	.0540	-1.77
constant	2.55	.9307	2.74

Equation includes region and time dummies

Variables	Definition
nchild	no. of children
maritals-1	spouse present and married
maritals-2	spouse present and cohabiting
headmale	male head of household
rahincome	real household income (£000s)
modWC	Indicator of binding deposit constraint (0,1)
modYC	Indicator of binding income multiple constraint (0,1)
rsrs	real social rents (£1,000)
UCC	housing user cost (£1,000)
rrent	real private rents (£1,000)
relrsrs	rsrs - rrent
SOUTH	Southern Regions (London, SE, EA, SW)
SOUTHRELRSRS	SOUTH*relrsrs
loo	In owner occupation in the previous period
llsrs	In social renting in the previous period
lloun	Regional unemployment rate

Appendix 3: Interregional migration

Gross inflows and outflows are treated separately, although the two are not independent. Estimation is based on data from the National Health Service Central Register. Below, the gross outflows for each region are formally modelled. However, given each gross outflow, the gross inflows are defined, if assumptions are made about migration distances. Most migration is to contiguous regions. For example, approximately 60 per cent of total migration flows take place between the four southern regions (measured as the sum of inflows and outflows in the four regions as a proportion of total English inflows and outflows). Therefore, it is assumed that outflows are distributed to each region according to the fixed weights in Table 7A, which are derived from the 2005 shares, and, for each region, can be read directly from the rows.

Table 7A: Migration flows (2005, shares)

				Origin					
	NE	**NW**	**YH**	**EM**	**WM**	**E**	**GL**	**SE**	**SW**
Destination									
North East	0.000	0.072	0.107	0.036	0.027	0.026	0.019	0.024	0.026
North West	0.177	0.000	0.210	0.105	0.145	0.065	0.058	0.066	0.080
Yorkshire and The Humber	0.267	0.214	0.000	0.179	0.092	0.077	0.048	0.060	0.059
East Midlands	0.090	0.110	0.199	0.000	0.184	0.150	0.059	0.098	0.077
West Midlands	0.066	0.144	0.088	0.159	0.000	0.069	0.057	0.078	0.133
East	0.078	0.082	0.084	0.150	0.082	0.000	0.264	0.142	0.099
London	0.141	0.143	0.125	0.121	0.139	0.259	0.000	0.295	0.171
South East	0.117	0.135	0.114	0.156	0.153	0.243	0.398	0.000	0.355
South West	0.063	0.099	0.072	0.094	0.178	0.112	0.098	0.237	0.000

For gross migration outflows, the dependent variable is expressed as a percentage of the resident population. For the purposes of the model, the key parameters are those with respect to relative house prices and housing availability. For estimation, the variables representing prices and availability in the *alternative* region need to be defined ($g_j, (hh_j - hs_j)$). These are, again constructed using the weights in Table 7A. Therefore, the model incorporates a form of distance decay, since contiguous regions typically have higher weights. Results are shown in Table 8A. The relative availability variable (row 4) is uniformly positive and significant in all regions except the West Midlands and North West, where no significant effect could be found. Arguably, these are the regions that have higher proportions of low demand areas and, consequently, housing shortages are less severe.

Similarly row 3 indicates that relative house prices are uniformly positive, except in the North East where prices have no significant effect. Since this is the cheapest region of England, again, this is perhaps unsurprising. Furthermore the data-validated restriction that the coefficient is the same in the four southern regions and Yorkshire and Humberside can be imposed. The data suggest that the two Midlands regions have to be treated slightly differently. From rows 11 and 12, the equation for outflows from the East Midlands includes relative prices in West Midlands and *vice versa* with the same negative coefficient. This implies, for example, that high relative prices in the East Midlands reduce outflows from the West Midlands. Table 7A shows that the East Midlands is the primary destination for migrants from the West Midlands.

Table 8A suggests that high interest rates reduce migration flows, but the effects of unemployment differentials are not uniform. Finally, the relative rate of change of house prices, $(\dot{ph}_i - \dot{ph}_j)_{-1}$, attempts to capture price expectations, measured by the relative percentage change in prices over the previous year. In principle, this is part of the user cost of capital in addition to *RM*. However the findings are mixed; in most regions the variable is insignificant and although the variable takes the expected negative sign in East Midlands and Yorkshire and Humberside, it is positive in London. This may represent the fact that prices are higher in London than elsewhere and rapidly rising prices require households to leave London, particularly since a much smaller share of households in London are owners than elsewhere and, hence, do not gain from rising prices on existing properties.

Table 8A: Out-migration (% of regional population) – (MIGOUT/POP) Estimation period 1982-2006, SUR Estimates

	GL	SE	E	SW	EM	WM	YH	NW	NE
Constant	1.295 (4.6)	1.876 (11.7)	2.552 (32.2)	1.667 (7.7)	1.585 (8.6)	1.665 (9.5)	0.779 (8.0)	0.400 (3.9)	0.389 (3.9)
$(g_i - g_j)_{-1}$	0.873** (6.9)	0.873** (6.9)	0.873** (6.9)	0.873** (6.9)	. -	-	0.873** (6.9)	0.166 (3.0)	-
$[(hh_i\text{-}hh_j)\text{-}(hs_i\text{-}hs_j)]_{-1}$	7.982 (4.4)	4.545 (2.6)	12.132 (4.3)	18.112 (6.9)	11.372 (5.0)	-	4.127 (3.0)	-	8.621 (3.6)
$(\dot{ph}_i - \dot{ph}_j)_{-1}$	0.018 (5.3)	-	-	-	-0.004 (2.8)	-	-0.004 (3.0)	-	-
$(UR_i\text{-}UR_j)_{-1}$	0.170 (3.0)	-	-0.237 (6.0)	-	0.076 (2.4)	-0.094 (6.2)	-	-	0.017 (3.6)
ΔRM	-0.085 (5.4)	-0.038* (3.8)	-0.038* (3.8)	-0.022 (3.4)	-	-	-	-	-
RM_{-1}	-	-0.030+ (4.6)	-0.030+ (4.6)	-0.024 (5.1)	-0.022 (5.2)	-0.018 (5.1)	-	-	-
$(MIGOUT/POP)_{-1}$	0.629 (7.4)	0.431 (8.4)	-	0.386 (4.7)	0.412 (6.3)	0.324 (5.1)	0.595 (11.5)	0.730 (11.6)	0.734 (11.8)
$(g_{wm} - g_j)_{-1}$	-	-	-	-	-0.286++ (3.7)		-	-	-
$(g_{em} - g_j)_{-1}$	-	-	-	-	-	-0.286++ (3.7)	-	-	-
R^2	0.87	0.80	0.73	0.84	0.92	0.96	0.88	0.87	0.91
SEE	0.118	0.097	0.085	0.058	0.051	0.027	0.044	0.030	0.034
DW	1.80	1.59	1.99	1.75	1.67	1.60	2.04	2.02	2.05

*, **, + , ++ denote common coefficients in the regions. One year dummy variables for 1990 are also included in all regions except London. The National Health Service Register was affected by new computers in that year. Further one year dummies were included for some regions.
t-values in brackets.