The Role of Regional House Price on Migration Turnover: A Simultaneous Equations Model of Regional House Price and Inter-regional Migration

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The Role of Regional House Price on Migration Turnover: 
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Abstract A regional owner-occupier housing market model that sees in-migration as demand and out-migration as supply is constructed to examine the interdependency between house price and gross migration. A pooled cross-section time-series analysis of British regions 1986-1998 revealed that in-migration raises regional house price and out migration lowers house price, while a rise in house price encourages out-migration and discourages in-migration. Therefore in-migration indirectly induces out-migration and vice-versa, via house price changes. The estimates suggest that house price change is responsible for one-fifth of ‘migration turnover’. Controlling for house price rise associated with increased regional labour market advantages, a higher wage attracts labour with the elasticity as large as 3.0. Regional disparities in unemployment and job vacancies were found to be insignificant in encouraging labour mobility, but unemployment reduces inflow and vacancies reduce outflow. While the interdependency of house price and migration limits net-migration because house price rises following an increase in labour demand, it also enhances ‘migration turnover’ by creating incentives to homeowners to move. The paper discusses that the ‘migration turnover’ would reduce spatial qualitative mismatch between labour demand and supply through selective migration.

Key words: inter-regional labour migration, house price, labour market, Great Britain

1. Introduction

Assessments of British labour migration during the last decade largely concluded that inter-regional migration have been playing a minor role in the spatial re-allocation of labour (Pissarides and McMaster, 1990; Hughes and McCormick, 1994; Gordon and Molho, 1997). Most authors point to the issue of labour immobility as a
cause of ineffective labour migration, and it is held as a supply-side explanation for persistent regional unemployment disparities. However, these assessments are primarily made within the framework of classical labour migration theory. British labour is not literally immobile. Currently, 10% of households change their place of residence each year, and 1.5% of which move across regions, although in net terms, only 0.13% of households worth of net migration occur as a consequence of largely offsetting gross in-migration and gross out-migration. It is in this net term that labour is 'immobile'; moreover, this small net migration does not seem to be occurring as classical migration theory would prefer.

Classical migration theory asserts that labour will flow from regions of low demand to those of higher demand, mainly through incentives made by wage differentials. Classical theory predicts the net results but does not comment on gross flows, although it does accept the possibility of bi-directional flows. To assess labour mobility based on the classical notion is to assess only a small fraction of the whole, and thus neglecting the major part. Net migration is less than 10% of all gross flows; the remainder, which I call 'migration turnover', is the main focus of this paper.

While migration turnover can occur purely by random processes, there are several ways in which migration turnover, without net movement, can contribute to greater efficiency in the entire economy. First, migration turnover can reduce the spatial qualitative mismatch between labour demand and supply (Jackman and Savouri, 1992). Migration turnover may not contribute to the redistribution of labour supply and unemployment, but it may contribute in reducing the incidence of unemployment by reducing the mismatch between labour demand and supply. The second contribution is related to the life cycle of labour. The Labour force is not an eternal entity but it is a living entity that is constantly renewed. Migration turnover can occur in parallel to entrance to and exit from the labour market. Migration of young adults to the South East and migration of the retired from the South East (as described in Fielding, 1993) represents this kind of migration turnover that results in a concentration of working age population in the most prosperous labour market in the country. Finally, in relation to the aforementioned, migration turnover can sort labour forces with varying levels of productivity to the productivity level that each regional economy requires. The propensity to migrate is greater for a more productive worker because the opportunity cost of foregone earnings is greater (McCormick and Sheppard, 1992). Migration turnover can inter-regionally match productive workers to high waged jobs. The common thread connecting all of these is that migration turnover is a way to match labour heterogeneity to regional diversity. Because of the selective nature of migration, the implication is that migration turnover leads to a perpetuation or intensification of regional divergence in terms of industrial mix, age composition, economic activity rate, wage and unemployment rates, as opposed to net
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migration leading to regional convergence as predicted in classical labour migration theory. Setting aside issues of regional inequality, a greater match between labour heterogeneity and regional diversity results in greater efficiency of the national economy.

Why is migration turnover such a dominant feature in contemporary British inter-regional migration? This study addresses the notion that there is an overarching constraint on net migration; spatial distribution of housing stock is fixed in a short-run. An inelastic supply of additional housing stock in prosperous regions is much argued in the literature, but the other side of the story is even more important. The durability of housing structure limits the supply of houses, or to be precise, 'housing service flow' to be withdrawn in a short-run. In a society with relatively low population growth and low household formation (0.66% per annum in Britain), net movement of household necessitates the contraction in housing service supply in one region and the expansion elsewhere. But the housing market suffers supply inelasticity in both contraction and of expansion due to durability on the one side, and strict land planning, skill shortage and construction lag on the other. The likely consequence is that a 'short-run' of a housing market is in fact very long, and a wide disparity in regional housing costs persists for a very long time.

While inelasticity in housing (service) supply due to durability of housing structure applies to most of the developed countries, its detrimental effect on net mobility is amplified by the peculiar British housing system that makes housing vacancy a rare occasion. Firstly, the high owner-occupation rate means that majority of households are simultaneously the occupiers and the owners of a house, and as owners, the households prevent their houses from becoming vacant by staying put. Local Authorities offer housing at rents much lower than the market price thus limiting the incidence of housing vacancy. Finally, the private rented sector, which should be most sensitive to rent decline is already small due to adverse housing policies and is made artificially short of supply to meet the demands arising from mobile households for temporary or transitory housing.

However, the fixed spatial distribution of housing stock does not restrict spatial mobility altogether. There is considerable gross migration compared to net movement, hence migration turnover. Since a stock of housing in a region is fixed in a short-run, numbers of households migrating into a region and out from a region should equal. In the absence of a mechanism that induces out-migration as a consequence of in-migration and/or vice-versa, a 'locked in' situation may arise, where both potential in-migrants and out-migrants cannot move even if both parties are motivated to do so. A large part of this analysis explores the mechanism by which efficient migration turnover occur under the assumption of fixed spatial distribution of the housing stock.

A possible mechanism that coordinates the interests of potential in-migrants and
out-migrants is regional housing rent. In a regional housing market with totally inelastic supply of housing service but with flexible rent, any in-migration in excess of out-migration leads to upward pressure in the housing rent. A rent rise will prompt extra out-migration of those individuals on the margin of receiving net advantages by living in the region, which then allows potential in-migrants to move in. In-migration and out-migration would match, and heightened turnover would materialise through changes in housing rent. The adjustment process would work on the other way that any out-migration in excess of in-migration lowers the rent that would induce in-migration from elsewhere. Equilibrium will be met with matched in-migration and out-migration, which sustains the demand for housing service in the region.

However, the peculiarity in the British housing system again necessitates some extra consideration. The regional housing rent is unlikely to play such a short-run adjustment role since it is very difficult to perceive. The private rented sector is very small (less than 10% of households), and many tenants still have their rents controlled by the Fair Rent system, which has little economic basis (Gibb et al, 1999). The social rented sector caters households (20% of households) at rents much lower than market rate. The effects of council housing and rent controls on immobility have been extensively discussed by numerous authors (Hughes and McCormick, 1981; Minford et al, 1988; etc.). Finally, owner-occupiers are not subject to regional rent levels per se.

Alternatively, house price becomes the main concern when owner-occupiers consider whether to move or to stay put. House price is the net present value of the expected net returns, where owner-occupiers can effectively fix their housing rent at the prevailing rent level at the time of purchase of the house. By investing in housing, subsequent rise in housing rent accrue net gain and the investment turns out to be successful. Owner-occupiers would be able to enjoy continuous gains by staying put. If a rise in housing rent results in a asset appreciation, owner-occupiers might even be discouraged from moving in fear of missing out on further appreciation, as Bover et al. (1989) argues in their ‘mobility trap’ thesis. Conversely, a subsequent fall in housing rent might encourage owner-occupiers to shift their investment elsewhere, provided that the owner-occupiers behave as profit maximising agents. However in the event of a dramatic fall in house price, as we have seen in the early 1990s, owner-occupiers become unable to realise the ‘negative equity’ and their mobility is severely damaged (Henley, 1998).

The effect of house price on spatial mobility is complicated because housing is a multi-dimensional complex commodity. Housing is an investment good as well as a consumption good; as a consumption good, it caters not only as a shelter for a household, but also a composite flow of services, such as accessibility to the local labour market, neighbourhood, environment, etc. This multi-sidedness interacts with migrant heterogeneity which makes migration turnover a meaningful behaviour.
Some examples can clarify this point. The regional labour market in the South East is highly advantageous but the advantage is accompanied by high house price. Persons seeking jobs from other parts of the country must pay extra housing cost to have access to the advantageous labour market. Using an analogy, the house price in the South East is a club membership premium that needs to be invested in joining the labour market. However, in the event that the person ceases to be a labour force through ageing, the membership premium can be reclaimed by retiring to a region with lower house price. If the labour market remains advantageous during the entire period and continues to attract jobseekers, he can obtain a full refund or even a capital gain. This analogy highlights that (1) high regional house price would not deter immigration if it were seen as an investment; and (2) high house price would encourage outflow of those who are not fully exploiting the advantages of the region. Supporting evidence for this is given in a comparative study using micro-data that regional house price does not affect job-movers as much as it does to retirees (Thomas, 1993).

To understand the interactions between regional house price and migration turnover, an integrated model with the following prerequisites needs to be constructed. Firstly is the need for a gross migration model incorporating migrant heterogeneity. Although migration turnover can exist purely as a random phenomenon, a migrant turnover having any macroeconomic significance has to have differences in individual attributes among in-migrants, out-migrants and stayers. Secondly is the construction of a regional house price model appropriate for explaining short-run price changes in the owner-occupier sector. The regional house price model needs to incorporate both investment and consumption aspects. Finally, house price and migration must be treated simultaneously so that regional house price and migration interact with each other and house price plays a role in coordinating the interest between in-migrants and out-migrants, in another words that in-migration induces out-migration and vice-versa. The model and its underlying theoretical considerations are discussed in the following section. Empirical results for British regions during the period 1986 to 1998 are given in section 3.

2. The theory and the model

In a regional housing market where construction of new housing is limited, out-migration of existing owner-occupiers in the region is the major source of supply of housing put on the market for sale. The condition applies to British regions where less than 1% of all housing units are constructed each year, and more than 80% of transactions on residential properties during a period are second-hand houses. Under this circumstance, the number of out-migration is closely related to the number of housing units sold in the region. At the same time, in a regional housing market
where rented sector is limited, in-migration often involves a purchase of a house. This also applies to British regions where only 10% of housing units are privately rented and 20% are in the public rented sector. The latter rented sector is hardly an option for inter-regional migrants due to administrative procedure that rations movers across local authorities (Hughes and McCormick, 1981). These circumstances create a closer relationship between housing transaction and in-migration. The centrepiece of the model described below rests on the following approximations that in a regional housing market, the number of out-migration equals to housing supply (or sales), the number of in-migration equals housing demand (or purchases), and the number of migration turnover equals housing transactions.

Migration is assumed to be a function of house prices at origin and destination, while house price is at least partly determined by out-migration and in-migration. This situation represents a typical case of simultaneity that can be expressed using the familiar supply and demand diagram as shown in figure 1. The vertical axis is the regional house price and the horizontal axis is the housing transaction that takes place in a period. The demand and the supply are approximated with in-migration and out-migration (including intra-regional moves), respectively. The slopes of the demand and the supply curves represent the effects of house price on in-migration and out-migration. In-migration is expected to have negative elasticity to the house price (at destination), since lower house price attracts potential in-migrants across the region and keeps intra-regional movers from leaving the region. Price elasticity of in-migration, which is synonymous to the price elasticity of housing demand among moving owner-occupier households, is determined by the distribution of a random utility placed upon owning a house in the region. On the other hand, out-migration is

![Figure 1. A model of regional housing market](image-url)
expected to have a positive elasticity to the house price (at origin), since higher house price encourages potential migrants to realise its housing equity for the purpose of buying alternative property or for 'equity withdrawal'. The price elasticity of out-migration, or the price elasticity of housing supply from the existing owner-occupiers, are also determined by the distribution of a random utility placed upon owner-occupiers' current houses, but also by the transaction costs that incurs on selling the house. A large proportion of the transaction cost is proportional to the house price such as realtor fees and bridging loans. This variable component of the transaction cost would make out-migration less price elastic, while the fixed component of the transaction cost would shift the supply curve upwards thus making fewer houses sold at a given price.

The supply and demand curves identified as above determines an equilibrium house price and an equilibrium housing transactions. Housing transactions represent migration turnovers that occur during a period. In this simplified model that equates in-migration as demand and out-migration as supply, in-migration and out-migration always match and there would be no net-migration. The model is later developed to incorporate the possibility of net-migration, but for now, it is noteworthy that the number of households moving in and moving out would always match, in negligence of new supply of housing stock and household formation. This seems to be an increasingly important characteristic of contemporary migration in Britain.

Given this setting, what would happen if the regional labour market improves and the region becomes more attractive to potential migrants from outside the region? An improvement in regional labour market conditions such as an increase in wage would shift the demand curve to the right resulting in a rise in the house price. Increased house price would encourage out-migration and housing transaction would increase. Therefore, the model predicts that improvement in the labour market conditions would increase both in-migration and out-migration, because out-migration is indirectly related to in-migration through house price changes. The reverse situation should also work in the same way. An increase in out-migration would lower the house price and induces in-migration. The model provides the logic in which changes in in-migration and out-migration correlate positively over time. In an economy with a particularly inelastic supply of housing, net migration is unlikely to occur in ways that classical labour migration theory predicts, because the regional house prices become highly endogenous.

2.1. Basic model

The basic model with the following restrictive assumptions is described first:
(1) All households are owner-occupiers;
(2) All households are economically active; and
(3) Housing transactions occur immediately before or after residential moves. The first and the second assumptions ensure that all moving households are influenced by regional house prices and the regional labour market conditions, but these would be relaxed afterwards. The important assumption is the last one. It restricts that all moving owner-occupier households would sell their houses upon a move, and all moving owner-occupier households would move to a newly purchased house. This seems to be a reasonable approximation of the housing arrangements of the moving owner-occupier households in Britain. Moving owner-occupiers are unlikely to keep and rent their 'old' houses because of the Rent Acts that provide rent controls and security of tenure. The corollary of the disadvantage of owning multiple houses is that households moving into owner-occupier housing are likely to have purchased the house just before the move. This together with the fact that houses are mostly bought to be occupied rather than to rent sets up the condition that housing transactions and (owner-occupier) spatial mobility are nearly identical actions.

The model of regional house price is based on housing transaction. The demand for houses refers to the number of houses to be willingly purchased during a period. The supply of houses refers to the number of houses put on the market for sale during the same period. Under assumption 1, the demand equals the number of households willing to buy a house, and under assumption 3, the demand equals in-migration. Housing demand in region $i$ consists of intra-regional mover households and inter-regional migrant households:

$$D_i = M_{ii} + M_{ci}$$

where $M_{ii}$ is the number of intra-regional moves and $M_{ci}$ is inter-regional in-migration. The subscript $c$ refers to regions complementary to region $i$. The housing supply consists of all the housing units sold by moving households plus other sources of supply:

$$S_i = M_{ii} + M_{ci} - HHF_i + HHE_i + NEW_i - DEM_i$$

where $M_{ce}$ is inter-regional out-migration, $NEW$ is the number of new houses completed, and $HHE$ is the number of household expiry which would return the vacated houses back into the housing market. There are two discounting components in the supply equation, they are $HHF$ household formation and $DEM$ demolitions. Household formations should be subtracted because a part of out-migration (either intra- or inter-regional) is made by newly formed households and their moves do not represent the release of their former houses. Demolitions should also be subtracted since not all the vacated houses will be brought back into the housing market.

All or some of the household flows and housing flows in the housing supply and demand equations are assumed to be functions of the regional house price, and the
equilibrium price will be met under the condition:

\[ S_t = D_t = T_t \]  

where \( T \) is the housing transaction in a period. The structural equations can be solved to give house price equation if the household and housing flows are linear functions of regional house price. However, the housing and household flows can only be multiplicative (or log-linear) functions of regional house price with the simplest approximation. There is a technical problem in deriving house price equation because the supply and demand equations are given with mixed additive and multiplicative functions. This can be dealt with by taking the first derivatives as follows. Demand and supply in their first derivatives are:

\[
\begin{align*}
\dot{D}_t &= \frac{M_{c_t} M_{d_t}}{T_t} + \frac{M_{e_t} M_{d_e}}{T_t} \\
\dot{S}_t &= \frac{M_{c_t} M_{d_t}}{T_t} + \frac{M_{e_t} M_{d_e}}{T_t} \\
&- \frac{HHE_{r_t} HHE_{i_t} + HHE_{r_t} HHE_{i_t}}{T_t} + \frac{NEW_{i_t} NEW_{i_t}}{T_t} - \frac{DEM_{i_t} DEM_{i_t}}{T_t}
\end{align*}
\]

and the equilibrium condition is:

\[ \dot{S}_t = \dot{D}_t = T_t \] (3')

A dot over the variable represents proportional changes over time. For simplicity, let us assume that only household mobility flows (in-migration, out-migration and intra-regional moves) are price elastic (to keep the number of endogenous variables to a minimum). The house price equation is given as:

\[
\begin{align*}
\dot{p}_t &= -\frac{1}{x} \left[ \left( \frac{M_{c_t} M_{d_t} - M_{e_t} M_{e}}{T_t} \right) + \left( \frac{M_{c_t} M_{d_t} - M_{e_t} M_{e}}{T_t} \right) \right] \\
&\quad + \left( \frac{HHE_{r_t} HHE_{i_t} + HHE_{r_t} HHE_{i_t}}{T_t} \right) - \left( \frac{NEW_{i_t} NEW_{i_t}}{T_t} + \frac{DEM_{i_t} DEM_{i_t}}{T_t} \right)
\end{align*}
\]

Variables with hat ('\( \hat{\} \)) are instruments for each variable and \( x \) is the factor that converts quantity balance to price defined as:

\[
x = \frac{M_{e_t}}{T_t} e_s - \frac{M_{d_t}}{T_t} e_d
\]

where \( e_s \) is the price elasticity of supply (or out-migration) and \( e_d \) is the price elasticity of demand (or in-migration). Unlike most house price models, the conversion factor is not constant, the value depends on the shares of out-migration and in-migration to all housing transactions. However, in the empirical estimation we approximate it as being constant around the 'average' across time and space. The house price equation tells us that in-migration, household formation and housing demolitions raise the price while out-migration, household expiry and housing comple-
tions lower the price. In this basic model, intra-regional moves have no part to play as the number of intra-regional movers selling and buying houses always matches (this is because all are assumed to be owner-occupiers behaving according to the same equation). The house price equation comprises two endogenous variables, inter-regional in-migration and out-migration. Specific instrumental variable to be included in the equation depends on how migration is modelled.

Migration equation is specified simply as a multiplicative function of regional variables at origin and destination. With a demonstrative set of explanatory variables, a gross migration flow from region $i$ to $j$ is given by:

$$M_{ij} = f(P_i, P_j, y_i, w_i, w_j, C_{ij}) H_i$$

where $P$ is house price, $y$ is household income, $w$ is wage, $C$ is 'distance deterrence' effect and $H$ is the number of households 'at risk'. The equation resembles a gravity-type formulation, but a population size at the destination is intentionally discarded. This is because the equation is a part of a simultaneous equations model, and house price is an endogenous variable. If there would be an excessive migration to a small region in terms of opportunities (or housing stock to be specific), house price would rise which should check such excessive influx.

The first derivative of the migration equation then becomes a linear function:

$$\frac{dM_{ij}}{dt} = e_{ij} P_i + e_{ij} P_j + \delta y_j + a w_i + b w_j + \dot{H}_i$$

Note here that 'distance deterrence' effect no longer exist, because such effect hardly changes in a short-run. Likewise, any explanatory variables that can be assumed or approximated as constant over time, such as environmental amenity or a stock of past migrants (who are assumed to have higher propensity to move), does not appear in the first derivative form of the migration equation. This has an practical advantage that the analysis can focus on the effects of housing market and labour market variables that fluctuates over time.

Assigning region $i$ as the region in question and region $c$ as a collective of all the other regions, in-migration and out-migration equation in their first derivatives are given by just replacing the subscripts. In-migration and out-migration is specified with the same equation:

$$M_{ci} = e_{ci} P_c + e_{ci} P_i + \delta y_i + a w_i + b w_j + \dot{H}_i$$

All variables are in their first derivatives except $\dot{P}$, which is the percentage point change of first derivatives of house price in the previous period. There is one endogenous variable in the each of the two equations: $\dot{P}$ in the in-migration equation is the house price change at destination and the same variable in the out-migration equation is the house price change at origin. House price change in the complemen-
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The same region \( P \) is regarded as exogenous since the complementary region is much larger than individual regions and migration to and from each region would have little effect on its house price. Price elasticity of supply is expected to be positive \( (e_s > 0) \) and price elasticity of demand is expected to be negative \( (e_d > 0) \). Higher house price therefore encourages out-migration and discourages in-migration. House price inflation is expected to reduce out-migration \( (\sigma < 0) \) as argued in Boyer et al. (1989) because of the fear of missing out on further asset appreciation. Household income is included to comply with the standard house price equation and income elasticity of demand is expected to be positive \( (\beta > 0) \). The expectation for the effects of regional wage is conventional. Higher wage at origin discourages out-migration and higher wage at destination encourages in-migration \( (\sigma < 0, \beta > 0) \). The regional wage is treated as exogenous throughout this paper. Further scrutiny incorporating labour market simultaneity with housing market simultaneity would be made at a later date.

The reduced form house price equation is given by solving house price equation (4) with migration equations (6) and (7):

\[
xP_t = \left( \frac{M_e}{T_t} e_s - \frac{M_e}{T_t} e_d \right) + \hat{P}_e + M_{ei} \sigma \hat{P}_e - \frac{M_e}{T_t} \sigma \hat{P}_e + \frac{M_e}{T_t} \delta \hat{y}_i - \frac{M_e}{T_t} \delta \hat{y}_e
\]

The reduced form house price equation demonstrates the basic properties of the model. With the expected signs discussed above, a house price rise in all other regions \( \hat{P}_e \) would have an indirect positive effect on regional house price changes through migration changes. This is the migration account of the well known ‘ripple’ effect of regional house price that has been extensively examined for the house price boom of the late 1980s (Giussani and Hadjimatheou, 1991). Assuming inter-regional migration as a source of demand and supply allows us to include variables of the other parts of the country in the regional house price equation. An example from the above specification indicates that higher wages in a region raise the house price while higher wages in the rest of the country depress regional house price.

2.2. Incorporating household heterogeneity into the model

Thus far we have treated moving households as homogenous, with all being owner-occupier and economically active. These assumptions seem too restrictive towards understanding the contemporary migration in Britain. Isoda (2000a) demonstrated a clear difference in age-specific net migration pattern in that there is a net inflow of young adults to the South East and a net outflow of retirement age groups from the South East. Thomas (1993) implies that each household type behaves
according to different migration equations, by estimating sensitivities of migration to regional housing and regional labour market factors for each household type using micro data. Isoda (2000b) demonstrated that cyclical sensitivity of migration is strikingly different among migrant attributes. The model attempts to account for existing empirical knowledge by incorporating some of the household heterogeneity within the limits of macro modelling.

The importance and benefit of examining the effect of household composition of migration can be understood by the following discussion, which has been deliberately held back. A rise in regional wage would increase in-migration to the region thus increase the demand for housing. Out-migration is expected to increase if the regional house price rises as a consequence of this labour market change, but the argument thus far ignores the fact that out-migration would also be affected by changes in the regional labour market. If higher wage discourages out-migration as much as it encourages in-migration, the house price rise would be even greater but there would neither be extra out-migration nor extra migration turnover to accompany it. If the exogenous factors affect in-migration and out-migration in an identical way, an empirical analysis using this model would explain nothing about migration turnover. The effects of exogenous factors on in-migration and out-migration would be different if the two have different migrant attribute mix.

In the late 1980s during the economic boom in the London/South East region that accompanied rapid increase in labour demand, out-migration from the region increased even more than in-migration. I have speculated in Isoda (2000a) that proportions of households that are relatively more concerned about housing rather than work (such as retired households) moved out of the region to the regions with lower house price in order to cash-in the housing equity. If a region consists of a greater share of households planning to become economically inactive, labour market advantages in the region will have smaller effect on discouraging out-migration from that region. Since only the economically active households are directly affected by labour market incentives, there is a need to account for the economic activity status of moving households. The same argument applies to housing tenure. Unlike other migration models, regional house prices are treated not as a proxy for housing cost but rather as the price that must be paid to acquire a house and the asset value that can be realised by selling a house. Only owner-occupier movers selling a house and households intending to own a house are directly affected by regional house price and associated housing variables.

The effects of the regional housing market on out-migration depend on the share of households moving out from the owner-occupier sector of the region to total out-migration. The effects on in-migration depend on the share of households moving into the owner-occupier sector of the region to total in-migration. Likewise, the
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effects of the regional labour market on migration depend on the share of the households that are economically active or intend to be active to total migration. The derivation of these conclusions is given in appendix 1. However, we do not have reliable migration flow data on tenure before and after residential move, we must therefore compromise and use surrogates for household mix of migration flows. The surrogates are crude but reasonable; the share of owner-occupier households at origin and at destination for the share of owner-occupier migrants, and the share of economically active households at destination for the share of economically active migrants.

Taking into account the effects of household mix, the migration equation would become:

\[
M_{ei} = \frac{H_{0e}}{H_e} \left( e_s P_c + \sigma \hat{P}_c \right) + \frac{H_{0i}}{H_i} \left( e_d \hat{P}_i + \beta \hat{y}_i \right) + \frac{H_{Ai}}{H_e} \beta \hat{y}_i + \frac{H_{Bi}}{H_i} \beta \hat{y}_i + H_e
\]

(9)

\[
M_{ie} = \frac{H_{0i}}{H_i} \left( e_s P_i + \sigma \hat{P}_i \right) + \frac{H_{0e}}{H_e} \left( e_d \hat{P}_e + \beta \hat{y}_e \right) + \frac{H_{Ai}}{H_e} \beta \hat{y}_e + \frac{H_{Bi}}{H_i} \beta \hat{y}_e + H_i
\]

(10)

where \( H_{0i}/H \) is the ownership rate and \( H_{Ai}/H \) is the household economic activity rate. Interpretations of these equations are straightforward. Housing supply variables (i.e. house price at destination and house price changes) affect out-migration more in the regions where owner occupation rate is higher. Housing demand variables (house price at destination and household income) affect in-migration more in the regions with a higher owner occupation rate, because migration flow into regions with fewer opportunities for the alternative tenure have more households moving into the owner-occupier sector. Note that the effects of the labour market are weighted by the economic activity rate of the destination. What matters here is the economic activity status after the move rather than before the move. A retiring household from the South East would care little about high wages in the South East if they have already decided to retire. For notational simplicity we introduce functions that weights the regional variables as follows:

\[
S_i(x) = \frac{H_{0i}}{H_i} x
\]

(11)

(housing supply weight)

\[
D_i(x) = \frac{H_{0i}}{H_i} x
\]

(12)

(housing demand weight)

\[
A_i(x) = \frac{H_{Ai}}{H_e} x
\]

(13)

(labour market push weight)

\[
B_i(x) = \frac{H_{Bi}}{H_i} x
\]

(14)

(labour market pull weight)

Using these functions, equations (9) and (10) are rewritten as:

\[
M_{ei} = e_s S_i(P_c) + \sigma S_i(\hat{P}_c) + e_d D_i(P_i) - \delta D_i(\hat{y}_i) + \alpha A_i(\hat{y}_c) + \beta B_i(\hat{y}_e) + H_e
\]

(15)

\[
M_{ie} = e_s S_i(P_i) + \sigma S_i(\hat{P}_i) + e_d D_i(P_e) - \delta D_i(\hat{y}_e) + \alpha A_i(\hat{y}_i) + \beta B_i(\hat{y}_c) + H_i
\]

(16)
Later in the empirical application of the model, the equations will be expanded to include other variables. Any variables that are specific to household type would be weighted accordingly using the weighting scheme defined by functions (11) to (14).

While household mix have effects on migration, it also influences how migration affects house price. Since only those migrating to and from an owner-occupier sector of the region are the demand and supply in the owner-occupier housing market, house price equation (4) should be revised as:

$$xP = \left(\frac{M_{*COi}}{T_i} \hat{M}_{*COi} - M_{*COi} \hat{M}_{**C} \right) + \left(\frac{M_{*0|i}}{T_i} \hat{M}_{*0|i} - M_{*0|i} \hat{M}_{*0|i} \right)$$

$$+ \frac{HHE_{*0|i}}{T_i} \frac{HHE_{*0|i}}{T_i} - \left(\frac{NEW_{0|i}}{T_i} NEW_{0|i} - \frac{DEM_{0|i}}{T_i} DEM_{0|i}\right)$$

(17)

The capital subscript represents household type, 'O' refers to owner-occupiers and the asterisk denotes all household types. For example, $M_{*COi}$ reads 'migration from all tenure sectors in complementary region to owner-occupier sector in region i'. Household formation is dropped in the revised equation because new households do not become owner-occupiers 'naturally' but rather by purchasing a house. Instead, there are flows that represent tenure mobility. Intra-regional moves in the equation consist of migration into and out from the owner-occupier sector of the region. The difference between the two is the net increase in owner-occupiers that occurs within the region. Tenure mobility within the region is often the primary determinant of the house price in the existing models; this appears in our equations when moving households are distinguished by tenure.

Migration equations (15) and (16) refer to all households but the endogenous variables required in the house price equation (17) is the migration flows of owner-occupiers. Owner-occupier migration is approximated by the following:

$$\hat{M}_{*COi} = \hat{M}_{COi} + \frac{H_{Ri}}{H_i} (e_d \hat{P}_i + \delta \hat{y}_i)$$

$$= \hat{M}_{COi} + \frac{H_{Ri}}{H_{0i}} e_d D_i(\hat{P}) + \frac{H_{Ri}}{H_{0i}} \delta D_i(\hat{y}_i)$$

$$\hat{M}_{*0|i} = \hat{M}_{0|i} + \frac{H_{Ri}}{H_{0i}} (e_d \hat{P}_i + \sigma \hat{P}_i) + (H_{0i} - \hat{H}_i)$$

$$= \hat{M}_{0|i} + \frac{H_{Ri}}{H_{0i}} e_s S_i(\hat{P}_i) + \frac{H_{Ri}}{H_{0i}} \sigma S_i(\hat{P}_i) + (H_{0i} - \hat{H}_i)$$

(18)

Since migration of all households understates the effect of the regional housing market, the effects of the housing market are supplemented just by the share of alternative tenure in the owner-occupier migration equation. Capital subscript 'R' refers to either public or private renter household. In the owner-occupier out-migration equation, households at 'risk' should also be adjusted (because only owners are eligible for being at 'risk'), and the term $H_{0i} - \hat{H}_i$ is the proportional change in ownership rate.
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(see appendix 2 for the derivation of these approximations).

The house price equation now has intra-regional moves as endogenous variables. Although it is not this study's main interest, intra-regional moves should also be modelled; we model them in the same way as inter-regional migration except, that they are not affected by labour market incentives:

\[ M_{it} = e_dS_i(\hat{P}_i) + e_dD_i(\hat{P}_i) + \delta D_i(\hat{y}_i) + \delta. \quad (20) \]

Labour market variables are omitted because intra-regional movers are assumed to move within commutable labour market areas. Although there would be a myriad of determinants of intra-regional residential moves, they are presumed to be constant over time, and thus are conveniently dropped in the first derivative form of the equation. Intra-regional owner-occupier moves are estimated in the same way as inter-regional migration:

\[ M_{i,0i} = M_{it} + H_{0i} e_d(\hat{P}_i) + H_{0i} \delta D_i(\hat{y}_i) \]

\[ = M_{it} + H_{0i} e_d(\hat{P}_i) + H_{0i} \delta D_i(\hat{y}_i) \quad (21) \]

All the endogenous variables are now specified. Substituting household flows in house price equation (17) with equations (18), (19), (21), (22), bearing in mind that in-migration, out-migration and intra-regional moves are functions of weighted house price \( S_i(\hat{P}_i) + D_i(\hat{P}_i) = (H_{0i}/H_{0i}) \hat{P}_i \), the equation for regional house price weighted by the owner-occupation rate becomes:

\[ S_i(\hat{P}_i) = D_i(\hat{P}_i) = \frac{M_{x=x^{-}}}{x T_i} \hat{M}_{ci} - \frac{M_{x=x^{-}}}{x T_i} \hat{M}_{ci} + \frac{M_{x=x^{-}} - M_{x=x^{-}}}{x T_i} \hat{M}_{i} \]

\[ + \frac{M_{x=x^{-}}}{x T_i} \frac{H_{0i}}{H_{0i}} S_i(\hat{P}_i) - \frac{M_{x=x^{-}}}{x T_i} \frac{H_{0i}}{H_{0i}} \delta S_i(\hat{P}_i) - \frac{M_{x=x^{-}}}{x T_i} \frac{H_{0i}}{H_{0i}} (H_{0i} - H_{0i}) \]

\[ - \frac{HHE_{0i}}{x T_i} - HHE_{0i} - NEW_{0i} - NEW_{0i} + DEM_{0i} - DEM_{0i} \]

\[ (23) \]

in which the conversion factor is

\[ x' = \left[ \frac{M_{x=x^{-}}}{x T_i} \frac{e_d}{T_i} - \frac{M_{x=x^{-}}}{x T_i} \frac{e_d}{T_i} - \frac{M_{x=x^{-}}}{x T_i} (e_d - e_d) \right] / H_{0i} \]

But again the conversion factor is assumed to take a positive constant around average over time and space. The effects of component flows on the regional house price depend on the conversion factor, but also on the shares of each component to total transaction, which is specific to each time period and region. An ‘average’ effects of
the component flows on house price will be estimated in the empirical section, regarding the ratios of the transaction shares to the conversion factor as constant. In particular, the effects of the three spatial mobilities on house price are of special interest. The parameters are defined as:

1. price flexibility of out-migration: \[ \mu_1 = \frac{M_{o,c,i}}{x'T_i} \]
2. price flexibility of in-migration: \[ \mu_2 = \frac{M_{i,c,e}}{x'T_i} \]
3. price flexibility of intra-regional moves: \[ \mu_3 = \frac{M_{i,c,i} - M_{o,c,i}}{x'T_i} \]

These suggest that the effects of migration on house price are greater in an economy in which a greater share of housing transactions takes place between households. The model is almost ready for empirical testing, but before we discuss below how the variables for the ‘complementary’ regions are treated.

2.3. Variables for the complementary regions

Both in-migration and out-migration are functions of regional variables of the region in question and that of ‘complementary’ region. The simplest way to assign variables for the complementary region is to approximate national variables as that of the complementary region. A somewhat more elaborate way is to create a variable for complementary region by aggregating variables of the constituent regions. However, these treatments appear to be too aspatial. Migration is known to have a strong ‘distance deterrence’ effect; that is there are more migration flows between regions close together than between regions far apart. The closer regions would have greater influence than the remote regions. For example, a house price rise of the remote region is unlikely to have as much effect on the regional house price than that of neighbouring regions, because only a small share of out-migration reaches the region in question. The spatial effect can be taken into account by creating weighted aggregate of a variable of the constituent complementary regions according to migration shares to total migration. Modifying the weighting scheme given in equations (11)-(14) creates such variable:

\[
S.c(x) = \sum_{j} M_{i,c} \frac{H_{o,j}}{H_i} x_j = \frac{H_{o,i}}{H_i} x_i
\]
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There are no alterations for functions $S_i$, $D_i$ and $H_i$. The reader might wonder why migration share is used as a weight rather than distance measures; that is because migration equation is examined in its first derivative form. Distance deterrence effect itself drops because it is constant over time. The weighting by migration shares is necessary to create single variable to represent the aggregate effects of each region. The justification for the above weighting scheme is given in the appendix 3.

2.4. Summary: a simultaneous equations model

The simultaneous equations model consists of four equations: inter-regional out-migration, inter-regional in-migration, intra-regional moves, regional house price. Constituent equations (15), (16), (20), (23) are, respectively, summarised and generalised as:

- **Out-migration (%) changes**:
  \[ M_{ic} = f(S_i, D_i, S_i, D_i, A_i, B_i, H_i) \]  
  (34)

- **In-migration (%) changes**:
  \[ M_{ci} = f(S_c, D_c, S_c, D_c, A_c, B_c, H_c) \]  
  (35)

- **Intra-regional moves (%) changes**:
  \[ M_{ii} = f(S_i, D_i, S_i, D_i, 0, 0, H_i) \]  
  (36)

- **Weighted house price (%) changes at origin and destination**:
  \[ S_i(\hat{P}_i) = D_i(\hat{P}_i) = (H_{oi}/H_i)\hat{P}_i \] 
  \[ = g(M_{ic}, M_{ci}, M_{ii}, S_i, D_i, NEW_{oi}, HHE_{oi}, DHE_{oi}, H_{oi} - H_i) \]  
  (37)

where $S$ is housing supply variables, $D$ is housing demand variables, $A$ is labour market push variables, $B$ is labour market pull variables, and $H$ is the number of households at risk. These variables are weighted according to the weighting scheme defined in equations (24)-(33) to adjust for the household mix effect and regional constituency of the migration system. $\hat{P}$ is the proportional change in regional house price; it enters the equations as an interactive term weighted by owner-occupation rate in the region. Endogenous variables are house price at origin for out-migration equation, house price at destination for in-migration equation, and both house prices in the intra-regional moves equation (the two house prices are in fact the same for intra-regional moves). At the same time the three spatial mobilities are all endogenous variables in the regional house price equation, indicating simultaneity among regional house price and spatial mobilities. Although housing completes in the owner-occupier sector ($NEW_{oi}$) is also endogenous in the longer term, for the analysis of annual changes in
house price, we treat it as exogenous under the supposition that as housing completes are elastic to the house price of the previous year(s) but not to the current price\textsuperscript{8}. As the notation implies, the three spatial mobilities are given by the same function, the only difference being the endogeneity of the explanatory variables and that labour market variables are absent (in another words, set to zero) for intra-regional moves. The three mobilities are treated as different observations within a single equation in the empirical section so as to estimate coherent parameters across three equations.

3. Empirical results

The two-stage regression analysis of the simultaneous equations of annual changes in regional house price and spatial mobility is pursued using mixed cross-sectional and time-series data. The study period is 1986-1998, which roughly covers one cycle of economic fluctuations starting with the dramatic house price boom of the late 1980s and the subsequent deep recession, and then the gradual recovery in the mid 1990s. The spatial unit of analysis is the Standard Statistical Regions, which divides Great Britain into ten regions. Although, the optimal spatial unit of analysis for the model is the local labour/housing market area defined by the spatial extent of a commutable area, a lack of house price data limits finer spatial disaggregation.

In order to estimate an identical set of coefficients for the three spatial mobilities, namely intra-regional moves, out-migration and in-migration, the three are treated as different observations in a single equation (see appendix 4 for the full specification). Therefore the number of observations is 10 regions \times 12 one-year periods \times 3 mobilities=360. The system of equations therefore consists of two equations, one for proportional changes in spatial mobility and another for regional house price.

The National Health Service Central Register (NHSCR) migration data is used to derive annual inter-regional migration changes. Although the unit of migration count should ideally be households, the NHSCR data does not record household units. In order to reduce the effect of household size composition, migration counts of males aged 16 and over are used to omit accompanied child migration. Since the NHSCR data does not cover all the moves within Standard Regions, household intra-regional migration counts derived from Labour Force Survey (LFS) is used instead. For annual regional house price changes, the Department of Environment simple-average house price data is applied. All the usual housing market variables found in the housing market literature are considered as candidates for housing supply and demand variables; these include house price changes, household income, Local Authority rents, average mortgage interest rate, mortgage interest relief and inflation. Private sector rent is not considered because reliable data for deriving annual changes does not exist in Britain. For the regional labour market variables wage, unemployment and job
vacancies are examined. Private sector housing completes by region is used as the supply of new housing. All price variables are converted into real prices using the GDP deflator, but the prices are not standardised regionally. No such structural variables as environmental amenity, crime rates, industry mix and spatial accessibility are included in the equations, since these are assumed to be constant over time in the medium term. Limited extrapolation was required to derive consistent variables for years after 1996 following the reorganisations of regions.

The sets of results are summarised in table 1 for the spatial mobility equation and in table 2 for the house price equation. Intercept is not included in either of the equations, but several dummy variables are included. A dummy for intra-regional moves adjusts data quality differences between the LFS and the NHSCR. An error dummy for 1990 and 1991 adjusts for serious undercount in the NHSCR inter-regional mobility data for 1990, which had been caused by transition in the data collection procedure (Stillwell, 1994). The dummy variable assigns the value of $-1$ for inter-regional migration changes 1989-1990 and the value of 1 for migration changes 1990-1991.

The three models in tables 1 and 2 are obtained after numerous experiments. In all models the sets of regressions appeared to be significant at 1% level. The R-squared values around 40% for spatial mobilities might not seem impressive, however, one should first remember that this is an analysis of migration changes, not migration levels. In the existing analyses of migration patterns, up to three quarters of the explanations come from distance deterrence effects or regional fixed effects while regional variables such as wages, unemployment and house price explain the rest. The analyses in here preclude such fixed effects and focuses only on variables that change over time. Second, in migration and out-migration are modelled with the same equation and consistent parameters are estimated. This approach is theoretically more accurate than using ad hoc equations for each in-migration and out-migration to obtain the best fit of the empirical data. On the other hand, the house price equation performed very well. Over 80% of the variation over time and space is explained, and spatial mobilities appear as important variables determining regional house price trajectories and its difference across regions.

3.1. Spatial mobility equation

Models 1 to 3 differs in their labour market variables deployed; model 3 is the preferred model. All models have elements of regional unemployment, job vacancies and wage for both origin and destination. Model 1 uses more conventional measures of labour market push and pull factors, whereas model 3 uses unconventional but theoretically more relevant variables. I will first discuss model 1 with the conventional variables.
Table 1. 2SLS results 1: spatial mobility equation

Dependent variable: spatial mobility (in-migration, out-migration and intra-regional moves combined)

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Endogenous variables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S (house price at origin)</td>
<td>0.71 (1.57)</td>
<td>0.75 (1.90)*</td>
<td>1.01 (2.68)***</td>
</tr>
<tr>
<td>D (house price at dest.)</td>
<td>-1.46 (-2.63)***</td>
<td>-1.22 (-2.43)**</td>
<td>-1.50 (-3.69)***</td>
</tr>
<tr>
<td><strong>Housing variables at origin</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S (house price inflation)</td>
<td>-0.53 (-1.95)*</td>
<td>-0.54 (-2.13)**</td>
<td>-0.72 (-2.91)***</td>
</tr>
<tr>
<td>S (owner HH income)</td>
<td>-0.67 (-2.17)**</td>
<td>-0.76 (-2.44)**</td>
<td>-0.74 (-2.38)**</td>
</tr>
<tr>
<td><strong>Housing variables at destination</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D (house price inflation)</td>
<td>0.73 (2.65)***</td>
<td>0.51 (2.00)**</td>
<td>0.68 (2.69)***</td>
</tr>
<tr>
<td>D (all HH income)</td>
<td>0.71 (1.49)</td>
<td>0.59 (1.20)</td>
<td>0.67 (1.39)</td>
</tr>
<tr>
<td>D (LA housing vacancies)</td>
<td>0.12 (1.43)</td>
<td>0.17 (2.01)**</td>
<td>0.14 (1.83)</td>
</tr>
<tr>
<td><strong>Labour market variables at origin</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A (unemployment rate)</td>
<td>0.11 (0.55)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A (vacancy rate)</td>
<td>-0.13 (-1.22)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A (unemployment flow)</td>
<td></td>
<td>0.08 (0.44)</td>
<td>0.08 (0.40)</td>
</tr>
<tr>
<td>A (vacancy flow)</td>
<td></td>
<td>-0.37 (-1.94)*</td>
<td>-0.40 (-2.11)**</td>
</tr>
<tr>
<td>A (wage)</td>
<td>1.42 (1.30)</td>
<td>1.01 (0.91)</td>
<td></td>
</tr>
<tr>
<td>A (prob. to change job)</td>
<td></td>
<td></td>
<td>2.26 (1.63)*</td>
</tr>
<tr>
<td><strong>Labour market variables at destination</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B (unemployment rate)</td>
<td></td>
<td>-0.37 (-2.92)***</td>
<td>-0.57 (-2.92)***</td>
</tr>
<tr>
<td>B (vacancy rate)</td>
<td>0.01 (0.10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B (unemployment flow)</td>
<td></td>
<td>-0.07 (0.35)</td>
<td>0.13 (0.67)</td>
</tr>
<tr>
<td>B (vacancy flow)</td>
<td>2.23 (2.05)**</td>
<td>2.50 (2.28)**</td>
<td>3.27 (4.84)***</td>
</tr>
<tr>
<td><strong>Other variables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H (household at risk)</td>
<td>-0.96 (-2.06)**</td>
<td>-0.98 (-2.09)**</td>
<td>-1.04 (-2.22)**</td>
</tr>
<tr>
<td>Interest rate</td>
<td>-4.39 (-4.00)*****</td>
<td>-4.30 (-3.98)*****</td>
<td>-4.46 (-4.14)*****</td>
</tr>
<tr>
<td>inflation</td>
<td>5.54 (5.24)*****</td>
<td>5.39 (4.79)**</td>
<td>5.65 (4.92)**</td>
</tr>
<tr>
<td>inflation changes</td>
<td>3.94 (4.53)*****</td>
<td>4.29 (4.65)**</td>
<td>4.42 (4.77)**</td>
</tr>
<tr>
<td>intra-regional move dummy</td>
<td>0.08 (3.22)**</td>
<td>0.03 (3.12)**</td>
<td>0.03 (3.03)**</td>
</tr>
<tr>
<td>1990/91 data error dummy</td>
<td>0.20 (11.81)***</td>
<td>0.17 (10.62)*****</td>
<td>0.17 (9.98)***</td>
</tr>
<tr>
<td>R</td>
<td>0.66</td>
<td>0.66</td>
<td>0.66</td>
</tr>
<tr>
<td>R2</td>
<td>0.43</td>
<td>0.44</td>
<td>0.44</td>
</tr>
<tr>
<td>R2 Adjusted</td>
<td>0.40</td>
<td>0.40</td>
<td>0.41</td>
</tr>
<tr>
<td>SE</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>F</td>
<td>13.75***</td>
<td>13.87***</td>
<td>14.91***</td>
</tr>
<tr>
<td>DF</td>
<td>341</td>
<td>341</td>
<td>341</td>
</tr>
<tr>
<td>N</td>
<td>360</td>
<td>360</td>
<td>360</td>
</tr>
</tbody>
</table>

The result is for combined observations of out/migration, in/migration and intra/regional moves. All variables except dummy variables (including the dependent variable) enter the equation in the first derivatives. Variables in the form of function S, D, A, B, H are the weighted variables that account for the migrant mix effect. Definitions of the functions are given in equations (24) to (33). The asterisks indicate the statistical significance at 10%, 5% and 1%.
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Table 2. 2SLS results 2: regional house price equation

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out-migration</td>
<td>-0.16 (-3.63)**</td>
<td>-0.12 (-3.35)**</td>
<td>-0.10 (-3.11)**</td>
</tr>
<tr>
<td>In-migration</td>
<td>0.22 (4.74)**</td>
<td>0.18 (4.44)**</td>
<td>0.16 (4.38)**</td>
</tr>
<tr>
<td>Intra-regional moves</td>
<td>-0.10 (-2.96)**</td>
<td>-0.14 (-4.53)**</td>
<td>-0.16 (-5.40)**</td>
</tr>
<tr>
<td>Instrument variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S (House price inflation)</td>
<td>0.18 (4.61)**</td>
<td>0.18 (4.61)**</td>
<td>0.18 (4.69)**</td>
</tr>
<tr>
<td>S (Owner HH income)</td>
<td>-0.16 (-1.45)</td>
<td>-0.21 (-1.98)**</td>
<td>-0.24 (-2.26)**</td>
</tr>
<tr>
<td>D (All HH income)</td>
<td>1.37 (11.36)**</td>
<td>1.40 (11.93)**</td>
<td>1.42 (12.10)**</td>
</tr>
<tr>
<td>D (LA housing vacancies)</td>
<td>-0.09 (-3.67)**</td>
<td>-0.08 (-3.27)**</td>
<td>-0.07 (-3.02)**</td>
</tr>
<tr>
<td>Ownership rate</td>
<td>-0.02 (-0.33)</td>
<td>0.00 (-0.06)</td>
<td>0.01 (0.10)</td>
</tr>
<tr>
<td>HH 'Natural' growth</td>
<td>0.00 (4.40)**</td>
<td>0.01 (5.18)**</td>
<td>0.01 (5.51)**</td>
</tr>
<tr>
<td>HH share aged 70+</td>
<td>-0.49 (-0.86)</td>
<td>-0.66 (-1.20)</td>
<td>-0.74 (-1.33)</td>
</tr>
<tr>
<td>Housing completes</td>
<td>-0.03 (-1.78)*</td>
<td>-0.03 (-1.40)</td>
<td>-0.02 (-1.17)</td>
</tr>
<tr>
<td>Housing demolitions</td>
<td>0.01 (3.41)**</td>
<td>0.01 (3.63)**</td>
<td>0.01 (3.69)**</td>
</tr>
<tr>
<td>Inflation rate</td>
<td>1.50 (3.72)**</td>
<td>1.13 (3.13)**</td>
<td>0.95 (2.79)**</td>
</tr>
<tr>
<td>Inflation changes</td>
<td>1.18 (3.31)**</td>
<td>1.38 (4.01)**</td>
<td>1.48 (4.36)**</td>
</tr>
<tr>
<td>Housing completes</td>
<td>0.58 (1.89)*</td>
<td>0.79 (2.72)**</td>
<td>0.39 (3.14)**</td>
</tr>
<tr>
<td>Housing price (complementary)</td>
<td>1.00 (23.68)**</td>
<td>1.00 (24.20)**</td>
<td>1.00 (24.12)**</td>
</tr>
<tr>
<td>R</td>
<td>0.92</td>
<td>0.92</td>
<td>0.92</td>
</tr>
<tr>
<td>R2</td>
<td>0.84</td>
<td>0.84</td>
<td>0.84</td>
</tr>
<tr>
<td>R2 Adjusted</td>
<td>0.83</td>
<td>0.84</td>
<td>0.83</td>
</tr>
<tr>
<td>SE</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>F</td>
<td>110.9***</td>
<td>115.3***</td>
<td>114.4***</td>
</tr>
<tr>
<td>DF</td>
<td>344</td>
<td>344</td>
<td>344</td>
</tr>
<tr>
<td>DF</td>
<td>360</td>
<td>360</td>
<td>360</td>
</tr>
</tbody>
</table>

All variables (including the dependent variable) enter the equation in the first derivatives. Variables in the form of function S, D are the variables weighted by ownership rate. The asterisks indicate the statistical significance at 10%, 5% and 1%.

There are two ways in which the included labour market push and pull variables are expected to influence migration. In essence, classical labour migration models migration in the form below:

$$M_{lc} = f\left(\frac{U_{c1}^{\beta_1}}{U_{c2}^{\beta_2}}, \frac{V_{c1}^{\beta_2}}{V_{c2}^{\beta_2}}, \frac{W_{c1}^{\beta_3}}{W_{c2}^{\beta_3}}\right)$$

of which the parameters are expected to be

$$\alpha_c = \beta_k \ (k=1, 2, 3)$$
Migration would therefore occur until all disparities in labour market conditions are eliminated, or until disparities in one of the conditions compensate for another. Model 1 estimates parameters bearing this classic interpretation in mind, using the stock variables for unemployment and vacancies. Unemployment stock and vacancy stock represent excess supply and excess demand in a regional labour market, respectively. The result in table 1 indicates that unemployment (stock) rates at the destination and wage level at the destination have a significant effect on migration with the expected signs but none of the variables of the origin region appeared to be statistically significant. A same variable at the origin and at the destination seems to have a different effect on migration.

An alternative interpretation of how regional unemployment and vacancies affect migration is offered by the 'job matching approach' by Jackman and Savouri (1992). In this approach, it is assumed that regional unemployment and vacancies exist and coexist partly because of the skill and/or geographical mismatch between labour demand and supply and spatial mobility is expected to reduce such mismatches. Inter-regional labour migration is regarded as a special case of job matching in that a vacancy in a region is matched to a jobseeker from another region. Unemployment is seen as proxy for number of jobseekers in a region, and the expected effects of unemployment and vacancies can be written as below:

$$M_{ie} = f\left( \frac{U_i^{\beta_1}}{V_i^{\beta_2}}, \frac{V_i^{\beta_2}}{U_e^{\beta_1}}, \frac{W_e^{\beta_3}}{W_i^{\beta_3}} \right)$$

The equation denotes that migration occur from regions of high unemployment (thus more jobseekers) to regions with high vacancies. However, since we are dealing with inter-regional migration as a consequence of inter-regional job matching, the effect of regional unemployment on out-migration should be discounted by the vacancy rate of the region, because jobseekers would more likely to find job within the labour market the more vacancies exist in the region. Likewise, the effect of vacancies on in-migration should be discounted by unemployment at the destination region, because the vacancies would be filled by local jobseekers and the vacancies available to inter-regional migrants would be smaller.

In this framework it seems more relevant to use flow variables for unemployment and vacancies, although Jackman and Savouri (1992) themselves have used conventional stock variables in their empirical analysis. Unemployment and vacancy stock supposed to represent jobseekers and job vacancies that are excluded from intra-regional job matching. However, noting that jobseekers in a region do not have perfect information on available jobs within the region, and employers are indifferent to the origin of job applicants, the appropriate variable should represent all job searches and all vacancy notices that emerge in a region during a period.
Based upon the above considerations, the model 2 in table 1 replaces unemployment and vacancy stock with unemployment and vacancy on-flows. The change in model performance is marginal, but this change enables us to discuss the effects of quantity dimension of the labour market on gross migration. Two interpretations can be made for the result in model 2. The first interpretation is that gross migration occurs from regions with a low on-flow of vacancies to the regions with a low incidence of unemployment. This interpretation resembles the neoclassical model in which labour is mobile; if a job seeker cannot find a job in the region of residence, he actively searches for a region with low unemployment, where there are fewer competitors to the vacancy in that region. The migrants intentionally avoid regions with a high unemployment rate because local unemployment lowers the expected wage, and thus reduces the return on migration. This interpretation is relevant for 'speculative' migrants; however, in a contemporary context it seems more relevant to regard migrants as 'contracted', i.e., job engagement is made prior to a move. An alternative interpretation much in the spirit of the 'job matching' approach is that of labour immobility. Job seekers favour local employment, in that availability of job vacancies in the region would discourage inter-regional out-migration. At the same time, unemployment in the region will preoccupy the locally available vacancies, if any exist, and there will be fewer opportunities remain for migrant jobseekers to obtain a job in that region. Since unemployment on-flow in the origin showing zero elasticity to migration and wage at the origin is insignificant, there is no indication that any labour market induced gross out migration would occur. Therefore the latter interpretation seems more plausible in interpreting model 2. Micro studies using individual data demonstrate that, although the unemployed are more likely to migrate than those with jobs, regional unemployment would discourage out-migration in general (Pissarides and Wadsworth, 1989; Hughes and McCormick, 1994). Since the unemployed is not the major constituent of migration flows, the effect of regional unemployment on out-migration becomes ambiguous, and regional unemployment alone is not sufficient in predicting the incidence of gross out-migration in an aggregate model.

Model 3 experiments whether regional wage could become an incentive for inter-regional out-migration. In the classical model of labour mobility, difference in regional wage is the primary signal for prompting labour migration. This expectation applies to net migration but is not simply transferable to gross migration. Gross in-migration and out-migration occur in an offsetting fashion and the regional wage disparities would explain only half of gross migration because almost the other half of the migration flows occur in perverse direction. To assume that all migrants making perverse moves accept lower wages is too naive; a migrant worker may, at an individual level, obtain increase in salary after moving by changing job from a low-paying firm to a high-paying firm. In order to incorporate this individuality within the
limitation of aggregate modelling, I argue that not only does mean wage matter but so does the deviation in wage of the regional wage distribution. Variation in wage received within a region is much greater than variation in mean wage across regions, and thus cases in which migrants making perverse moves increase their wage must be usual. A simple variable to measure the probability of changing job for higher wage is created and included in model 3 as an indicator of incidence of job seeking activity in a region\(^9\). The new variable compares the wage distribution of the region to that of national distribution and gauges the probability of obtaining a higher wage by changing job to any of the job within the country. Assumption is that greater the probability, the greater the jobseekers, and an increase in jobseekers in a region would increase out-migration because a proportion of jobseekers would find employers in other regions.

The new variable (labelled 'probability of changing job') is almost significant at 5% level with the expected sign. Change in overall model performance is again marginal, but generally increases statistical significance of all the other variables and the model becomes more readily interpretable. An increase in probability of changing job for higher wage generally encourage job search. If local vacancies exist, this would result in job matching within the region thereby reduces inter-regional migration. A wage rise (in real terms) in the potential destinations will increase inter-regional migration, but if unemployment exists at the destination, the local unemployment preoccupies job vacancies there and thus limits in-migration. Although quantity dimension of regional labour market (i.e., unemployment and vacancy) does not indicate encouraging effects on labour migration, the wage dimension seems to motivate migration and direct migration flows to higher wage regions. The estimated destination wage elasticity of (in-) migration is very elastic, exhibiting values greater than 3%, much greater than those estimated in existing studies. This suggest that British labour itself is very sensitive to wage signals and labour migration would operate efficiently provided that (1) inter-regional labour market disequilibria are appropriately reflected in regional wage; but also (2) associated changes in endogenous variables would not prevent the wage-induced migration from occurring. The latter point will be addressed later in a discussion on interaction between migration and house price.

Having explicated the gross migration changes in labour market terms, we see that significant effects of housing market variables on spatial mobility as predicted in the theory begins to emerge. As discussed earlier, housing is a multi-dimensional commodity that also provides occupiers access to the local labour market. Without sufficiently controlling for local labour market performance, the mechanism by which the housing market operates cannot be correctly examined. In model 3, house price at origin has a positive effect on owner-occupier out-migration at 1% significance.
The coefficient is interpreted as price elasticity of supply of (second-hand) houses from previous owner-occupiers, and has elastic value of around unity. Conversely, the coefficients for house price at destination (elasticity of demand for home ownership) have a negative elastic value, therefore higher house price reduces in-migration. The difference in absolute values of the two price elasticities is a reflection of different levels of transaction costs that incur on selling and buying houses.

House price inflation during the previous one-year period at origin and destination are also included as 'housing supply' and 'housing demand' variables, respectively. House price inflation is expected to be important variable in determining investment decision on housing; house price inflation has an effect in bringing forward the timing of house purchase (Levin and Wright, 1997) and discourages the sales of houses in the fear of missing out on further asset appreciation (Boyer et al., 1989). The coefficients for house price inflation at origin and at destination confirm both expectations; that house price inflation reduce out-migration by discouraging owner-occupiers to sell houses and increases in-migration by encouraging households to buy houses. These effects have an effect on amplifying house price fluctuations, which result in short-run house price volatility. Household income (at destination) has a positive elasticity on housing demand, but a statistical significance at 10% was not obtained in any of the three models, probably due to a colinearity with the regional wage. Owner-occupier household income (at origin) showed inelastic but significant negative coefficients, which could be interpreted such that a decline in income encourages owners to trade down houses.

Interest rate and inflation are also important variables in determining housing demand, but it seems equally important to all moving households rather than just households moving into owner occupation. Interest rate would affect supply of second-hand houses (outflow from owner-occupation) since most owner-occupiers who leave house move into another owner-occupation, and that may require bridging loans during the period holding two houses. Inflation would affect owner-occupiers intending to trade down houses to cash-in housing equity. Although the effect of interest rate and inflation is expected to differ between households buying a house and selling a house, it has not been possible to include the two national variables as both housing demand and supply factors because of the severe co-linearity. The two national financial variables are therefore included without any weighting in both mobility and house price equations rather than as a time control variable. The empirical result is consistent with the general knowledge that higher interest rates discourage and inflation encourages housing transactions. In addition, the change in inflation rate is included in the model to depict the speculative behaviour of households facing an expected rise in inflation. The acceleration in inflation appeared to have an encouraging effect on housing transactions.
Finally, variables related to Local Authority housing were also included in the equation to account for an alternative to owner-occupation. The experiment with Local Authority rent has been conducted but no significant effect on migration was found. Since rents in public housing are much lower than 'market-clearing' rent and public housing is allocated mainly through waiting lists, it seems that availability of public housing is more important than the rent level. The empirical result indicates that vacancy rate in Local Authority housing encourages in-migration.

3.2. Regional house price equation

The equation for regional house price changes produced high predictive power. Note that neither house price changes of the other region nor lagged house price change are used to obtain this result. The explanatory variables that carry information of other regions are only out-migration changes and in-migration changes that are endogenous variables predicted by the spatial mobility equation. The same set of variables are used in models 1 to 3, the difference of the three is on which instruments are used for the endogenous variables, and the results of the three models for the regional house price equation are nearly identical.

The effects of gross out-migration and gross in-migration on regional house price have a significant expected value. Gross out-migration reduces house price and gross in-migration raises house price. The effect of intra-regional moves indicating a negative effect on regional house price is somewhat intriguing. Equation (23) suggested that intra-regional moves would have a positive effect on house price if net upward tenure mobility within the region is positive (i.e., there are more households becoming owner-occupiers than households becoming renters among intra-regional movers). Owner-occupation rate is rising in general and tenure mobility occur more often by residential moves within region than migrating across region. Suspecting that the negative effect appeared because all housing demand and supply variables are independently included in the house price equation, we experimented to omit all the housing variables from the house price equation, but the negative effect remained. The negative effect of intra-regional mobility on house price can be interpreted that when households are on the move and housing turnover in the region is high, the housing liquidity increases and house price would become lower than otherwise. The argument is reminiscent of Hoyt's 'filtering process' (Hoyt, 1939); where moving households offer their vacated houses at discounted prices.

All the housing supply and demand variables in the spatial mobility equation are also included in the regional house price equation and the estimated parameters are generally consistent with the estimated elasticities in the spatial mobility equation. House price changes in the previous one-year period have a positive effect on regional house price, thus giving instability in house price fluctuations. The effects of owner-
occupier income and of (all) household income have the same signs with those in the spatial mobility equation, but household income showed a strong significant and positive effect on house price. The vacancies in the Local Authority housing lowers regional house price.

For other instrumental variables in house price equation, a proportion of households aged 75 and over, and ‘natural’ household changes (changes in number of household less net household migration) were included as surrogates for household expiry. Both variables show expected signs, suggesting that household expiry would reduce house price. Housing completions (additional supply of housing stock) has the expected sign, but it is statistically insignificant. Housing demolitions (withdrawal of housing service supply), on the other hand, exhibited a surprisingly robust effect on house price. For data on housing demolitions, only the figures for houses demolished and closed by the Local Authority are available, and it is this data which is used in the model. About 0.06% of the housing stock is demolished annually by local authorities, but the figure ranges widely across regions and is highly volatile over time. Generally, more housing stock are being demolished by Local Authorities in Scotland, Wales, and Northern regions. The houses demolished by Local Authorities are mostly abandoned houses and such houses are not expected to provide an effective housing service supply anyway; therefore it is rather surprising that this variable has any significant effect on regional house price. Nevertheless, the result suggests that vacant and abandoned houses in a region depress house prices, even if they are not in reasonable conditions.

The comparisons of absolute values of coefficients suggest that the effects of out-migration and in-migration on regional house price are as important as those of intra-regional moves (housing supply and demand balance within the region) and housing completions (supply of new houses). Housing market studies have often ignored the effect of inter-regional migration on house prices. The effect has been assumed to be negligible, given the fact that inter-regional migration in net terms is so small. However, by treating in-migration and out-migration as endogenous variables in the house price equation, they turned out to be very important determinants of regional house price.

3.3. Interaction between migration and house price

The estimated parameters indicate that there is a bi-directional causal relationship between house price and migration. So far, the elasticities of spatial mobility in table 1 are discussed as if other things can remain constant. However, since regional house price appeared to be endogenous, there is a need to assess the ‘net’ elasticity that includes the associated changes in regional house price. For example, according to the estimates in model 3, a percentage rise in regional wage is expected to increase in-migration by 3.27%. However, not all of this increment materialises because of the
associated rise in house price. Since an increase in in-migration pressure would cause house prices to rise by the house price flexibility of in-migration, the regional house price would rise by 0.51% \((=0.16 \times 3.27\%\)\). This rise in house price discourages in-migration according to the elasticity of in-migration, thus in-migration is reduced by 0.76% \((=-1.50 \times 0.51\%\)\). Therefore the in-migration that materialises from a percentage rise in regional wage is 2.51% \((=3.27\%-0.76\%)\). The relationship between ceteris paribus elasticity and the ‘net’ elasticity for each of the three spatial mobilities is expressed using the following general notation:

\[
\begin{align*}
\text{‘net’ elasticity of out-migration} & : \beta(1 + \mu_1 e_s) \\
\text{‘net’ elasticity of in-migration} & : \beta(1 + \mu_2 e_d) \\
\text{‘net’ elasticity of intra-regional moves} & : \beta[1 + \mu_3 (e_s + e_d)]
\end{align*}
\]

where \(\beta\) represents the elasticities estimated in table 1, \(\mu_1, \mu_2, \mu_3\) are house price flexibilities of out-migration, in-migration and intra-regional moves in table 2, respectively; and \(e_s\) and \(e_d\) are house price elasticities of out-migration and in-migration interpreted respectively as elasticities of supply and demand.

According to the estimates for house price elasticities and flexibilities in model 3, the ‘net’ effect on spatial mobilities for the variables listed in table 1 can be obtained by multiplying 0.90 for out-migration, 0.77 for in-migration, and 1.08 for inter-regional moves. Taking regional wage again as our example, a percentage rise in the wage at the destination increases out-migration by 2.93 \((=0.90 \times 3.27\%)\), and a percentage rise in the wage in the region increases in-migration by 2.51 \((=0.77 \times 3.27\%)\). The ‘net’ effects of wage at the destination on out-migration and in-migration are somewhat reduced than ceteris paribus elasticity, but labour migration can still be regarded as quite elastic to regional wage.

Regional house price has a positive and negative effect on out-migration and in-migration, respectively, and out-migration and in-migration, respectively have a negative and positive effect on house price. House price changes seem to be a mechanism that enables efficient migration turnover. A percentage increase in in-migration pressure raises regional house price by \(\mu_1\%\). This rise in house price prompts out-migration by \(e_s \mu_1\%\), while reducing in-migration by \(e_d \mu_2\%\). According to the estimates in model 3, a percentage increase in in-migration pressure results in an increase in out-migration by 0.16% \((=1.01 \times 0.16\%)\), and an actual in-migration increment of 0.77% \((=1\%-1.50 \times 0.16\%)\) would materialise. Therefore in-migration induces out-migration worth 21% \((=0.16/0.77)\) of its increment. Using a similar calculation, out-migration induces in-migration worth 17% of its increment\(^{11}\). Imagining the following scenario may better explicate the mechanism. Initially, the regional labour markets are in inter-regional equilibrium and no net migration exists. If a positive demand shock in the region induces gross in-migration of a thousand
households, an out-migration of 210 households would also occur. Alternatively, a negative demand shock resulting in out-migration of thousand households would also accompany an in-migration of 170 households. Roughly one-fifth of migration turnovers are therefore produced via regional house price changes alone.

Another interesting experiment on interactions between housing market and migration can be calculated for the effect of housing demolitions on net migration. Similarly using the estimates of model 3, a doubling of housing demolitions raises house price about 1%. This rise in house price leads to 1.0% increase in out-migration and 1.5% reduction in in-migration. Applying the current gross migration rate of 1.5%, we can expect a net (out) migration rate change of +0.04% points. Since the current net migration rate is 0.13%, this is surely an important impact. The implication is that slum clearances had been an effective way to encourage net (out) migration not only by direct eviction but also through house price changes. However, demolitions cannot occur on a mass scale. The housing units demolished annually by the Local Authorities are on the order of thousands in each region. This finding therefore supports the hypothesis that a fixed spatial distribution of housing stock is the underlying constraint for net migration.

The same experiment can be done for the effect of household expiry on net-migration. Since household 'natural' growth raises house price, and the share of households aged 70 and over reduces house price, household expiry reduces house price which in turn raises in-migration and reduces out-migration, other things being equal. The strong negative spatial correlation (−0.75) found between net (in-) migration and natural growth in reported in Isoda (2000a) can be regarded as a geographical projection of inter-generational housing turnover, and the analysis here provides evidence that it is motivated by regional house price disparities created by household expiry.

Having said that interactions between migration and house price are responsible for one-fifth of migration turnover, what are the other explanations for migration turnover? The theory here hypothesised that the observed correlation between immigration and out-migration can be explained by indirect causal relationships via regional house price between the two. Certainly a part of the correlation arises because there are common factors determining both in-migration and out-migration. Such factors are indeed present in the model; they are the national financial variables. Interest rate, inflation rate and acceleration in inflation (of the previous one-year period) all have a robust and strong effect on spatial mobility in general. These national variables are assumed to affect the spatial mobility of all households in the country. These financial variables have an effect on facilitating housing transactions, thereby mobilising both buyers and sellers of houses. Migration can be viewed as an investment for future prospects of the households' livelihood. Interest rates and
inflation are used by the human capital approach as an influence on the migrant’s preference over time in the net present value formula. However in this study interest rates and inflation are assumed to primarily affect the cost of housing arrangements that is necessarily required upon a move.

3.4. Model performance

Before closing this section, we assess the performance of the model in detail. The two-equations model explained about 40% of variation in spatial mobility changes and 80% of variation in regional house price changes. However, since was a mixed cross-sectional and time-series analysis, we have to examine whether the explanation corresponds to temporal changes or geographical variations. Table 3 lists the R-squared between actual and predicted values by region and by year to examine how well the model equations explained the geographical and temporal variations. A glance at the table reveals that it is mostly the temporal changes that the model explained. Geographical variations were poorly predicted by the equations for three spatial mobilities, but were somewhat better for regional house price. One reason why geographical variation is not sufficiently described by the model is that the dependent variables tend to change uniformly across all regions with the national business fluctuations, and geographical variations tend to be much smaller than temporal changes.

Comparisons of overall model performances for three mobilities and house price shows that prediction of intra-regional moves is the worst. Possible explanations include (1) sample survey results are used in deriving intra-regional moves (from LFS) and the data contains a sampling error; (2) labour market variables are not utilised in estimating intra-regional moves under the assumption that local moves do not require a change in job, although the spatial units used are much greater than the local labour market area; and (3) intra-regional moves consist of a greater share of movers changing houses within a rented sector but this type of mobility flow is not fully modelled in this model. Housing market variables have been the only independent variables used for intra-regional moves, and surely they are not sufficient for the overall understanding of intra-regional moves.

Conversely, house price is well predicted especially for its temporal changes. Figure 2 shows the actual and predicted house price changes in the ‘South’ and the ‘North’. House price growth peaked in 1988 and had been negative (in real prices) at the beginning of the 1990s. The actual series shows the ‘ripple effect’ or time lag of the peak between the ‘South’ and the ‘North’. The model explained the geographical variation in house price changes reasonably well but not for 1989. This is the year when house price inflation was reversed first in the regions of the ‘South’, and then spread toward the regions of the ‘North’. Although the model predicted that house
Table 3. Performance of model 3, by year and by region.

<table>
<thead>
<tr>
<th>Year</th>
<th>Intra-regional moves % changes</th>
<th>Out-migration % changes</th>
<th>In-migration % changes</th>
<th>House price (weighted) % changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986/87</td>
<td>16.0%</td>
<td>37.1%</td>
<td>3.5%</td>
<td>35.5%</td>
</tr>
<tr>
<td>1987/88</td>
<td>3.8%</td>
<td>8.1%</td>
<td>44.1%</td>
<td>14.5%</td>
</tr>
<tr>
<td>1988/89</td>
<td>62.2%</td>
<td>3.7%</td>
<td>3.6%</td>
<td>80.1%</td>
</tr>
<tr>
<td>1989/90</td>
<td>9.9%</td>
<td>2.5%</td>
<td>64.1%</td>
<td>8.8%</td>
</tr>
<tr>
<td>1990/91</td>
<td>71.1%</td>
<td>14.0%</td>
<td>11.5%</td>
<td>85.0%</td>
</tr>
<tr>
<td>1991/92</td>
<td>45.5%</td>
<td>0.6%</td>
<td>27.0%</td>
<td>79.1%</td>
</tr>
<tr>
<td>1992/93</td>
<td>41.3%</td>
<td>0.4%</td>
<td>5.7%</td>
<td>68.4%</td>
</tr>
<tr>
<td>1993/94</td>
<td>0.2%</td>
<td>16.0%</td>
<td>68.0%</td>
<td>29.9%</td>
</tr>
<tr>
<td>1994/95</td>
<td>13.7%</td>
<td>0.2%</td>
<td>40.2%</td>
<td>76.5%</td>
</tr>
<tr>
<td>1995/96</td>
<td>9.9%</td>
<td>18.8%</td>
<td>0.1%</td>
<td>21.2%</td>
</tr>
<tr>
<td>1996/97</td>
<td>0.2%</td>
<td>2.8%</td>
<td>11.5%</td>
<td>34.1%</td>
</tr>
<tr>
<td>1997/98</td>
<td>11.8%</td>
<td>4.8%</td>
<td>13.4%</td>
<td>5.7%</td>
</tr>
</tbody>
</table>

(2) Temporal variations by region (N = 12)

- North: 9.7% 62.8% 84.7% 74.3%
- Yorks & Humb: 30.4% 84.8% 75.5% 63.7%
- East Midlands: 38.1% 62.2% 76.3% 68.2%
- East Anglia: 55.3% 51.9% 40.7% 81.3%
- South East: 34.9% 76.3% 39.3% 81.7%
- South West: 56.2% 75.8% 68.4% 88.6%
- West Midlands: 43.5% 80.7% 74.4% 82.1%
- North West: 47.1% 59.5% 43.4% 67.3%
- Wales: 12.0% 62.2% 91.2% 79.6%
- Scotland: 2.4% 82.1% 34.8% 61.4%

(3) All variations (N = 120)

31.5% 65.0% 54.5% 74.8%

R-squared between the actual and predicted values.

price inflation sustained until 1990 in the ‘North’, it did not predict the geographical variation in the timing of the turning points of the house price trajectory.

4. Conclusion

A simultaneous equations model of regional owner-occupier house price and spatial mobility was constructed to examine the interdependency between gross in-migration, gross out-migration and regional house price. Migrant heterogeneity was introduced in this macro model by using weighted explanatory variables in the equa-
tions of regional house price changes and gross migration changes, in order to examine the differential effect due to migrant mix. The aim of this model was twofold: first to examine the role of regional house price changes in enabling migration turnover; and second to consider the role of migration turnover (i.e. gross migration without net migration) on regional labour market disparities.

An empirical application of the model to the case in British regions 1986-1998 revealed that both in-migration and out-migration have a significant effect on regional house price, which are as important as inter-regional housing moves (that relate to intra-regional tenure mobility and household formation) and housing completions. Simultaneously, both in-migration and out-migration are affected by regional house prices; there is therefore an indirect causal link between in-migration to out-migration and vice-versa, via house price changes. House price changes alone generate about one-fifth of migration turnover. Other factors for migration turnover are national financial variables, such as interest rate and inflation, which have an effect in determining the rate of spatial mobility in general. National financial variables influence housing transaction costs and sets the level of housing liquidity.

The hypothesis that the low rate of net migration in Britain is due to fixed spatial distribution of the housing stock has been confirmed empirically that demolition of houses in a region has a strong effect on net (out) migration. If net migration is low, there is little scope for inter-regional migration to adjust regional disparities in labour market conditions in a classical fashion. The limited net migration can be simply expressed using the standard neoclassical wording that the regional labour markets

Figure 2. Actual and predicted regional house price % changes

The South East and the North West were chosen as representative of the 'South' and the 'North', respectively.
(source: Department of Environment)
are in a 'compensating differentials' equilibrium, where regional housing costs compensate for regional labour market advantages. However, such an exposition underestimates the roles of migration turnover and their important implications for regional labour markets. Firstly, life cycle related migration turnover concentrates young adults who are in most need of employment opportunities to the most advantageous regional labour markets (Fielding, 1993). Second, migration turnover reduces geographical skill mismatches between labour supply and demand (Jackman and Savouri, 1992). Finally, migration turnover inter-regionally delivers productive workers to high waged jobs, since opportunity cost of staying put is greater for productive workers (McCormick and Sheppard, 1992). Apart from the issues of regional inequality, a greater match between the region and the labour would reduce the overall unemployment and job dissatisfaction. Without migration turnover, the economy would experience greater labour market mismatches and higher overall unemployment.

The empirical result revealed that regional wage have a significant and strong effect on labour migration; a higher wage attracts labour with the elasticity as large as 3.0. This wage elasticity of in-migration is much greater than those estimated in previous studies, partly because the house price changes associated to wage rise are controlled for by using the simultaneous equations model. Conversely, the quantity dimension of the regional labour market has little direct effect on migration. Regional unemployment and job vacancies are insignificant in encouraging out-migration and in-migration, respectively, confirming the existing literature. Yet, inter-regional migration is still expected to occur from regions of high unemployment to low unemployment, provided that regional unemployment is related to lower regional wage. The 'wage curve' studies estimate that regional unemployment depresses regional wage by an elasticity around —0.1 (Blanchflower and Oswald, 1994; Manning 1994). A halving of the unemployment rate is associated with a 10% rise in wage and a 30% rise in gross in-migration. Workers in a region with fewer job opportunities therefore would find job by migrating to regions offering higher wages.

However, these labour market related migration behaviours do not immediately eliminate regional disparities in labour market conditions; migration occur from a mixture of various motives and gross in-migration is associated with out-migration and vice-versa. In-migration into an advantageous labour market area raises the house price and encourages out-migration. Households out of the labour market (e.g. retired households), workers who are not benefiting from the advantageous labour market (e.g. unemployed), and employees receiving wages less than regional mean wage are encouraged to move out of the region after the house price rise. The process of migration turnover modelled with the interaction between regional house price and inter-regional migration provides an alternative logic for Molho's (1995) 'dynamic
equilibrium' thesis. Migration into a depressed region will continue until the regional house price is raised to the point that outflow matches inflow. Since migration turnover does not substantially alter the labour supply in the region, labour market disparities such as unemployment persist.

The neoclassical exposition also overlooks aforementioned selective nature of migration, and the resultant diversification of regions. Regional disparities, in terms of economic activity rates, labour productivity and even unemployment rates, created by selective migration are not necessarily 'regional' problems, provided that individuals are ensured to migrate across regions to deliberately choose the region suitable to their individual needs and preferences. Under the constraint that the spatial distribution of housing stock is fixed, migration turnover offers a sub-optimal solution to regional disparities in labour market conditions; instead of net-migration eliminating regional disparities, gross migration moves households to match their preferences to diverse regions. The implication here is that migration partly causes sustained regional disparities and diversity. Therefore it is necessary to reconsider the nature of regional inequalities that the regional policies aim to reduce. To the extent that a fixed spatial distribution of housing stock limits net-migration, the traditional regional policy that creates employment in high unemployment regions is supported. However, the policy has to be aimed primarily at achieving a gradual transition in employment decline, and capital incentives should gradually be reduced over time in which its time schedule should be determined by the physical deterioration of existing housing stock. An alternative path, that is not mutually exclusive to above, is to encourage migration turnover. Regional disparities are regional inequalities if households are essentially spatially immobile. Reducing the barrier to spatial mobility would nullify regional inequalities arising from regional labour market disparities. Owner-occupation is often regarded as a barrier to spatial mobility, but another scenario also emerged in our analysis. In the current situation where few alternative options to owner-occupation are available to inter-regional migrants, owner-occupiers seems to finance the relocation cost by the proceeds of their house in order to buy another at the intended destination. If the transaction cost were to be lowered, owner-occupation would not be a severe impediment to spatial mobility. Housing policies to encourage home ownership seem to have indirectly encouraged owner-occupier mobility by making a 'housing career' a profitable business. Owner-occupation had been receiving a number of disproportional implicit and explicit subsidies and has been heavily criticised during the 1980s. The subsidies have therefore been much reduced in the 1990s. However, there has not been a policy designed directly to reduce the transaction cost of house sales and re-purchase. If policy instruments to reduce housing transaction costs can be implemented, a higher spatial mobility can be obtained while keeping 'owning democracy' intact.
The research was conducted at the London School of Economics and Political Science from 1999 to 2001. I would like to thank Prof. Ian Gordon and Dr. Gilles Duranton for their critical suggestions. Statistical data and survey results are supplied by the Data Archive and Manchester Information and Associated Services (MIMAS), and are Crown copyright material. Labour market data are purchased from National Online Manpower Information Service (NOMIS) and are also Crown copyright material. My gratitude goes to the staffs at the Graduate School of Science, Tohoku University, and Prof. Komel Sasaki and Prof. Satoru Masuda on refining this thesis. This research is funded by the Japan Society for the Promotion of Science.

Notes

1) According to the LFS results between the years 1985-1998, 1.47% of households migrated across Standard Statistical Regions annually that resulted in net household migration rate of 0.13%. Thus the inter-regional migration efficiency (ratio of inter-regional net-migration to total inter-regional migration) was 8.6%.

2) A well-known example is the application of the gravity models in econometric analysis. The gross migration attributed to the gravity formula (a function of the population of the origin and destination, and distance deterrence effect) is the stochastic process, which is excluded from economic explanation. Since the gravity formula is identical to a pair of bi-directional flows, the migration turnover is attributed to the stochastic process described by the formula.

3) Forrest (1987) used a similar analogy of the South East house price as a membership cost of an exclusive club, in a context that it leads to social exclusion. I further elaborate the analogy to regard it as a membership premium: the context then becomes rather dynamic in the sense that it will also encourage higher turnover.

4) This housing market model bases on housing transactions among owner-occupiers. An owner-occupier is assumed to make a residential move when the following criterion is met:

$$NPV_a - NPV_0 > TC_s + TCB$$

where $NPV_0$ is the net present value of the present house for an occupier, and $NPV_a$ is the expected utility of an alternative house; $TC_s$ is the transaction cost upon selling the present house which includes realtor and legal fees and interest on bridge financing. $TC_b$ is the transaction cost upon buying an alternative house that includes search costs and moving expenses. The criterion states that net utility gain from moving should exceed all the transaction cost. The criterion is re-written to examine the role of house price:

$$(NPV_a - TC_b - P) + (P - NPV_0 - TC_s) > 0$$

The prices of both present house and alternative house is at market price $P$. The criterion is decomposed into two:

$$NPV_0 < P - TC_s \text{ and } NPV_a > P + TC_b$$

assuming for simplicity that households are risk-averse, that an owner-occupier sells its house
only if the utility of staying put goes below the house price less transaction cost, and a household buys a house only when the utility of owning the house exceed house price plus transaction cost. It is necessary to suppose that each household places idiosyncratic utility to each housing unit in order to regard their residential moves as rational at individual level. Number of sellers and number of buyers at each level of house price are obtained by assuming some kind of random distributions for utility of staying put and expected utility of an alternative house. These are what depicted as supply and demand curves in figure 1. The equilibrium house price is expected to settle at the level where number of sellers and number of buyers match.

5) Private rent has been deregulated and the security of tenure has been much reduced since 1989 by the enactment of the 1988 Housing Act. However, due to the political instability regarding rent policies throughout the post-war period, the situation for moving owner-occupiers has changed very little, and the approximation seems to be valid for most of the 1990s.

6) \[ \ddot{x} = \frac{dx}{dt} \]

7) Using this notation, a structural relationship between endogenous variables \( y_1 \) and \( y_2 \) can be written as \( y_1 = x y_2 + y_3 \), where \( y_3 \) is the exogenous determinant of \( y_1 \). Its first derivative is \( y_1 = \beta y_2 + y_3 \).

8) The supply of new housing is inelastic in the short-run because of the time lag between housing starts and completions which is about one or two years (Gibbs et al, 1999); it is therefore treated as exogenous.

9) First examine a case where an employed individual in a region receiving wage \( w_r \) but changes a job intra-or inter-regionally and receives \( w_s \) after the job change. If he is randomly assigned to a job within a nation, the probability that the individual will increase his wage is:

\[ P(W_s > w_r) = P(\ln \frac{W_s}{W_r} > 0), \]

where the distribution of \( \ln \frac{W_s}{W_r} \) is \( N(\ln \frac{\mu_s}{\mu_r}, \sigma_s^2) \).

The national wage distribution is assumed to be lognormal having median wage \( \mu_n \) and standard proportional deviation (i.e., standard deviation of logarithm of wage) of \( \sigma_n \). For an aggregate probability of employees in the region obtaining higher wages by changing jobs, assuming wage received in the region \( W_r \) is a lognormal distribution of median wage \( \mu_r \) and standard proportional deviation of \( \sigma_r \), the probability would be given by:

\[ P(\ln \frac{W_s}{W_r} > 0), \]

where distribution of \( \ln \frac{W_s}{W_r} \) is \( N(\ln \frac{\mu_s}{\mu_r}, \sigma_s^2 + \sigma_r^2) \).

This probability is used as a proxy for probability of changing job for higher wages. If the region's median wage is exactly the same as the national median wage, the probability will be 50%, regardless of deviation. If the region's median wage is above national median wage, the probability would be below 50% but the probability would be greater the greater the region's wage variation. If the region's median wage is below the national median wage, the probability will be above 50%, but the probability would be lower the greater the region's wage variation. Since the probability takes only positive values between 0 and 1, all regions would have a proportion of workers changing jobs for higher wages, and part of them would become out-migrants if new employees are found outside the region.

10) The house price of the complementary region is listed as an explanatory variable for house price
The Role of Regional House Price on Migration Turnover

The role of regional house price on migration turnover is crucial. This is because the house price equation combines observations for house price change in the region in question (which is an endogenous variable), and house price change of the complementary region (which is an exogenous variable). The house price equation is structured to output the value predicted by the instrumental variables for house price of the region, and to output the exact value for house price of the complementary region. Inclusion of the variable 'house price (complementary)' is for that purpose and its coefficient will always be unity. At the same time, the variable is assigned the value of 0 for observations for house price of the region in question; it therefore has no effect on the prediction of the endogenous house price. Refer to appendix 4 for the actual estimation method.

11) A percentage increase in out-migration pressure lowers regional house price by $\mu_0\% (-0.10\%)$. The fall in house price induces in-migration by $\epsilon_{diui}\% (0.16\% = 1.50\times -0.10\%)$ while reducing out-migration by $\epsilon_{esi}\% (-0.10\% = 1.01\times -0.10\%)$. So a percentage increase in out-migration pressure results in the increase in in-migration by 0.16% and an actual out-migration increment of 0.90% ($=1\%-0.10$ would materialise. Therefore out-migration induces in-migration worth 17% ($=0.16/0.90$) of its increment.

12) The following approximation was used to estimate the net result. By definition, a change in net migration rate is:

$$\frac{\Delta NET_i}{H_i} = \frac{\Delta M_{in}}{H_i} - \frac{\Delta M_{out}}{H_i} = \frac{M_{in}M_{out}}{H_i} - \frac{M_{in}M_{out}}{H_i} M_{out}$$

Under the condition that net migration is much smaller than gross (in and out) migration:

$$\frac{\Delta NET_i}{H_i} \approx \frac{(M_{in} + M_{out})}{2H_i} \frac{M_{in} - M_{out}}{M_{out}}$$

in which $(M_{in} + M_{out})/2H_i$ is the gross migration rate.

References


**APPENDIX**

1. **Migration model incorporating household attribute mix**

   This section models an aggregate migration flow consisting of groups of households with different migration behaviours. Households in a region are classified by economic activity (either active or inactive) and housing tenure (owner-occupier or renter). Four categories of households emerge; (1) Economically active owner-occupiers; (2) Active renters; (3) Inactive owners; and (4) Inactive renters. These households can migrate across tenure as well as across regions. Then, a migration flow from region \(i\) to \(j\) consists of eight migration streams:

   \[
   M_{ij} = M_{AO}(O_i) + M_{IO}(O_i) + M_{AR}(O_i) + M_{IR}(O_i) \\
   + M_{AO}(R_j) + M_{IO}(R_j) + M_{AR}(R_j) + M_{IR}(R_j)
   \]

   The capital letters denote household type:
A for economically active households,
I for economically inactive households,
O for owner-occupier households, and
R for renter households.

Tenure types (O or R) in the parentheses represents the housing sector in the destination region. For example, $M_{AOi}(O_j)$ represents the number of economically active owner-occupier households in region $i$ moving to the owner-occupier sector in region $j$.

Categorising households in this way allows us to deductively assign a different migration equation to each of the eight migration streams. Only economically active households are directly affected by regional labour markets; only owner-occupiers are directly affected by the regional owner-occupier housing market; and only households moving into the owner-occupier sector are affected by the regional owner-occupier housing market at the destination. Therefore, inter-regional migration equations for the eight migration streams are modelled as:

$$
M_{AOi}(O_j) = s_i d_i a_i b_i c_i d_{Oij} H_{AOi}
$$

$$
M_{AOi}(R_j) = s_i a_i b_i c_i d_{Oij} H_{AOi}
$$

$$
M_{O0i}(O_j) = s_i d_i a_i c_i d_{Oij} H_{O0i}
$$

$$
M_{O0i}(R_j) = s_i c_i d_{Oij} H_{O0i}
$$

$$
M_{ARi}(O_j) = d_i a_i b_i c_i d_{ARi} H_{ARi}
$$

$$
M_{ARi}(R_j) = a_i b_i c_i d_{ARi} H_{ARi}
$$

$$
M_{IBi}(O_j) = d_i c_i d_{IBi} H_{IBi}
$$

$$
M_{IBi}(R_j) = c_i d_{IBi} H_{IBi}
$$

where $s_i$ is a composite index of housing market condition of the origin (including house price at the origin), $d_i$ is a composite index of housing market condition at the destination (including house price at the destination), $a_i$ is a composite index of labour market push factor at the origin, $b_i$ is a composite index of labour market pull factor at the destination. All of the above indices are assumed to be multiplicative functions of specific regional variables. $C_{ij}$ is a distance deterrence effect specific to origin-destination pair which may differ among groups but is assumed to be constant overtime. Finally, $H$ with subscripts represents the numbers of households at risk for each group.

Aggregate migration flow between regions is the sum of all eight migration streams, but the migration equations for each migration stream are given in the multiplicative form. This gives rise to the technical aggregation problem and the solution taken in this study is to take the first derivative. The first derivative of equation (3) is:

$$
\frac{d M_{ij}(O_j)}{d t} = \left( s_i d_i a_i b_i c_i d_{ij} H_{ij} \right) \frac{d H_{ij}}{d t}
$$

$$
\frac{d M_{ij}(R_j)}{d t} = \left( s_i a_i b_i c_i d_{ij} H_{ij} \right) \frac{d H_{ij}}{d t}
$$

$$
\frac{d M_{ij}(O_j)}{d t} = \left( s_i d_i a_i c_i d_{ij} H_{ij} \right) \frac{d H_{ij}}{d t}
$$

$$
\frac{d M_{ij}(R_j)}{d t} = \left( s_i c_i d_{ij} H_{ij} \right) \frac{d H_{ij}}{d t}
$$

$$
\frac{d M_{ij}(O_j)}{d t} = \left( d_i a_i b_i c_i d_{ij} H_{ij} \right) \frac{d H_{ij}}{d t}
$$

$$
\frac{d M_{ij}(R_j)}{d t} = \left( a_i b_i c_i d_{ij} H_{ij} \right) \frac{d H_{ij}}{d t}
$$

$$
\frac{d M_{ij}(O_j)}{d t} = \left( d_i c_i d_{ij} H_{ij} \right) \frac{d H_{ij}}{d t}
$$

$$
\frac{d M_{ij}(R_j)}{d t} = \left( c_i d_{ij} H_{ij} \right) \frac{d H_{ij}}{d t}
$$
The equation states that proportional change in aggregate migration flow is the weighted average of the proportional changes in each migration stream. Substituting the derivatives of each migration stream with the defined disaggregate migration function, equation (A1) is rewritten using the derivatives of regional housing market and labour market composite indices:

\[
\frac{\dot{M}_{ij}}{M_{ij}} = \frac{M_{AO}(O_i)}{M_{ij}} \dot{s}_i + \frac{M_{AR}(R_i)}{M_{ij}} \dot{d}_i + \frac{M_A(*)}{M_{ij}} (\dot{a}_i + \dot{b}_i) + \frac{M_{AO}(O_i)}{M_{ij}} \dot{H}_{AO} + \frac{M_{AR}(R_i)}{M_{ij}} \dot{H}_{AR}
\]

The asterisk represents all tenures. The function declares that the aggregate migration flow is dependent on regional housing market and labour market indices that interact with migration share weights. The effect of regional housing market on out-migration would be greater if the proportion of owner-occupiers in migration flow were to be greater; the effect of regional housing market on in-migration would be greater if the proportion of households moving into the owner-occupier sector of the destination region were to be greater; and so forth. If the migration shares are known, the equation can be estimated using conventional linear regression. Reliable estimates for disaggregated inter-regional migration counts are not available, however, but a rough estimates would at least improve the model by accounting for the migrant mix effect. Household shares of the origin and destination are used as surrogates for migration shares:

\[
\frac{M_{AO}(*)}{M_{ij}} \approx \frac{H_{AO}^i}{H_i}, \quad \frac{M_{AR}(*)}{M_{ij}} \approx \frac{H_{AR}^i}{H_i}, \quad \frac{M_A(*)}{M_{ij}} \approx \frac{H_A^i}{H_i}
\]

Share of economically active migrant is substituted by economic activity rate at the destination since what matters is the economic activity status after the move. Substituting these into equation (A2) gives:

\[
\frac{M_{ij}}{H_i} = \frac{H_{AO}^i}{H_i} \dot{s}_i + \frac{H_{AR}^i}{H_i} \dot{d}_i + \frac{H_A^i}{H_i} (\dot{a}_i + \dot{b}_i) + H_i
\]
In sum, each explanatory variable should be weighted accordingly by the share of migrants who are assumed to be directly affected by the variable.

2. Derivation of owner-occupier mobility and its difference to all tenure mobility

Regional house price are affected by owner-occupier out-migration and in-migration. This section specifies owner-occupier migration in relation to all tenure migration to find an appropriate way to include migration in the house price equation.

Inter-regional migration out from owner-occupier sector in region $i$ consists of four migration streams:

$$M_{\text{AOit}}^*(*) = \frac{M_{\text{AOoi}}(O_i)}{M_{\text{AOoi}}^*(*)_j} M_{\text{AOi}}(O_i) + \frac{M_{\text{AOi}}(R_j)}{M_{\text{AOoi}}^*(*)_j} M_{\text{AOi}}(R_j)$$

$$+ \frac{M_{\text{AOi}}(O_i)}{M_{\text{O}}_j} M_{\text{IOi}}(O_j) + \frac{M_{\text{AOi}}(R_j)}{M_{\text{AOoi}}^*(*)_j} M_{\text{IOi}}(R_j),$$

which equals

$$\dot{M}_{\text{AOi}}^*(*) = \dot{s} + \frac{M_{\text{AOoi}}(O_i)}{M_{\text{AOoi}}^*(*)_j} \dot{d} + \frac{M_{\text{AOi}}(O_i)}{M_{\text{AOoi}}^*(*)_j} (\dot{a} + \dot{b}) + \frac{M_{\text{AOi}}(R_i)}{M_{\text{AOoi}}^*(*)_j} \dot{H}_{\text{AOi}} + \frac{M_{\text{AOi}}(R_i)}{M_{\text{AOoi}}^*(*)_j} \dot{H}_{\text{AOi}}.$$

Applying the following migration share approximation

$$\frac{M_{\text{AOi}}(O_i)}{M_{\text{AOoi}}^*(*)_j} \approx \frac{H_{O_i}}{H_j}, \quad \frac{M_{\text{AOi}}(R_i)}{M_{\text{AOoi}}^*(*)_j} \approx \frac{H_{\text{AOi}}}{H_{\text{Oj}}}, \quad \frac{M_{\text{AOi}}(R_i)}{M_{\text{AOoi}}^*(*)_j} \approx \frac{H_{\text{AOi}}}{H_{\text{Oi}}}, \quad \frac{M_{\text{AOi}}(R_i)}{M_{\text{AOoi}}^*(*)_j} \approx \frac{H_{\text{AOi}}}{H_{\text{Oj}}}.$$

owner-occupier out-migration changes is simplified to:

$$M_{\text{AOi}} = \dot{s}_{i} \frac{H_{O_i}}{H_j} \dot{d} + \frac{H_{\text{AOi}}}{H_{\text{Oj}}} (\dot{a} + \dot{b}) + H_{\text{AOi}}.$$

Similarly, inter-regional migration into owner-occupier sector in region $j$ also consist of four migration streams:

$$M_{\text{MSij}}^*(*) = \frac{M_{\text{MSi}}(O_j)}{M_{\text{MSi}}^*(*)_i} M_{\text{MSi}}(O_j) + \frac{M_{\text{MAi}}(O_j)}{M_{\text{MSi}}^*(*)_i} M_{\text{MAi}}(O_j)$$

$$+ \frac{M_{\text{MSi}}(O_j)}{M_{\text{MSi}}^*(*)_i} M_{\text{IOj}}(O_i) + \frac{M_{\text{MAi}}(O_j)}{M_{\text{MSi}}^*(*)_i} M_{\text{IOj}}(O_i),$$

which equals

$$M_{\text{MSij}}^*(*) = \frac{M_{\text{MSi}}(O_j)}{M_{\text{MSi}}^*(*)_i} \dot{s}_{j} + \frac{M_{\text{MSi}}(O_j)}{M_{\text{MSi}}^*(*)_i} (\dot{d} + \dot{a}) + \frac{M_{\text{MAi}}(O_j)}{M_{\text{MSi}}^*(*)_i} \dot{H}_{\text{MAi}} + \frac{M_{\text{MAi}}(O_j)}{M_{\text{MSi}}^*(*)_i} \dot{H}_{\text{MAi}} + \frac{M_{\text{IOj}}(O_i)}{M_{\text{MSi}}^*(*)_i} \dot{H}_{\text{IOj}} + \frac{M_{\text{MAi}}(O_j)}{M_{\text{MSi}}^*(*)_i} \dot{H}_{\text{MAi}}.$$

Applying the following approximation to migration shares,
owner-occupier in-migration changes is simplified to:

\[ M_{ioi} = \frac{H_{oi}}{H_i} \hat{s}_i + \frac{H_{0i}}{H_i} (\hat{d}_i + \hat{b}_i) + H_i \]  

Using the results in equation (A3), owner-occupier out-migration and in-migration are expressed respectively as:

\[ M_{oj} = M_{ij} + \frac{H_{oi}}{H_i} \hat{s}_i + (\hat{H}_{oi} - \hat{H}_i) \]

\[ M_{oi} = M_{ij} + \frac{H_{0i}}{H_i} \hat{d}_j \]

where, \( H_o/H \) is the share of renter households in a region.

Therefore, all tenure migration can be included in house price equation with all the housing market variables and proportional changes in owner-occupation rate.

3. Derivation of regional out-migration and in-migration

This section derives out-migration and in-migration from a region, from individual migration flows specified in equation (A3). Out-migration from a region is a summation of all flows from the region to the complementary regions:

\[ M_{oi} = \sum_{j \neq i} M_{ij} \]

The first derivative of out-migration can be written by substituting migration flows in equation (A3) as:

\[ \dot{M}_{oi} = \sum_{j \neq i} \frac{M_{ij}}{M_{oc}} \dot{M}_{ij} = \frac{H_{0i}}{H_i} \hat{s}_i + \sum \frac{M_{ij}}{M_{oc}} \frac{H_{0j}}{H_j} \hat{d}_j + \sum \frac{M_{ij}}{M_{oc}} \frac{H_{ij}}{H_i} (\hat{d}_i + \hat{b}_i) + \dot{H}_i \]

In-migration (migration to a region from the complementary region) is derived in the same way as:

\[ \dot{M}_{ci} = \sum_{j \neq i} \frac{M_{ij}}{M_{ci}} \dot{M}_{ij} = \sum \frac{M_{ij}}{M_{ci}} \frac{H_{0i}}{H_i} \hat{s}_i + \sum \frac{M_{ij}}{M_{ci}} \frac{H_{0j}}{H_j} \hat{d}_j + \sum \frac{M_{ij}}{M_{ci}} \frac{H_{ij}}{H_i} (\hat{d}_i + \hat{b}_i) + \sum \frac{M_{ij}}{M_{ci}} \dot{H}_j \]

These equations demonstrate that regional variables of the complementary region are the averages of individual regions weighted by migration shares.
4. Actual estimation method to impose inter-equation restriction on parameters

Since equations 34 to 36 representing out-migration, in-migration and intra-regional moves are given in an identical function, a set of parameters consistent for all three equations should be estimated. Therefore in the actual estimation the three spatial mobilities are viewed as three sets of different observations in one equation:

\[
\begin{pmatrix}
\dot{M}_{ic} \\
\dot{M}_{ci} \\
\dot{M}_{it}
\end{pmatrix} =
\begin{pmatrix}
S_i(\hat{P}) & D_i(\hat{P}) & S_i & D_i & A_i & B_i & H_i \\
S_i(\hat{P}) & D_i(\hat{P}) & S_i & D_i & A_i & B_i & H_i \\
S_i(\hat{P}) & D_i(\hat{P}) & S_i & D_i & 0 & 0 & H_i
\end{pmatrix}
\begin{pmatrix}
\varepsilon_s \\
\varepsilon_d \\
\varepsilon_d \\
\sigma \\
\sigma \\
\sigma \\
\delta \\
\delta \\
\delta \\
\alpha \\
\alpha \\
\alpha \\
\beta \\
\beta \\
\beta \\
1 \\
1 \\
1
\end{pmatrix}
\]

This will impose an inter-equation restriction on parameters and allows for consistent coefficients for all three mobilities to be estimated. In the form shown above, there are two (arrays of) endogenous variables; house price at origin and at destination. The house price equation 37 is estimated with the following equations:

\[
\begin{pmatrix}
S_i(\hat{P}) \\
S_i(\hat{P}) \\
S_i(\hat{P})
\end{pmatrix} =
\begin{pmatrix}
\dot{M}_{ic} & \dot{M}_{ci} & \dot{M}_{it} & S_i & D_i & ..., & H_{oi} - \hat{H}_i & \text{instr} & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & S_i(\hat{P}) \\
\dot{M}_{ic} & \dot{M}_{ci} & \dot{M}_{it} & S_i & D_i & ..., & H_{oi} - \hat{H}_i & \text{instr} & 0
\end{pmatrix}
\begin{pmatrix}
\mu_1 & \mu_1 & \mu_1 \\
\mu_2 & \mu_2 & \mu_2 \\
\mu_3 & \mu_3 & \mu_3
\end{pmatrix}
\]

\[
\begin{pmatrix}
D_i(\hat{P}) \\
D_i(\hat{P}) \\
D_i(\hat{P})
\end{pmatrix} =
\begin{pmatrix}
0 & 0 & 0 & 0 & 0 & 0 & 0 & D_i(\hat{P}) \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & D_i(\hat{P}) \\
\dot{M}_{ic} & \dot{M}_{ci} & \dot{M}_{it} & S_i & D_i & ..., & H_{oi} - \hat{H}_i & \text{instr} & 0
\end{pmatrix}
\begin{pmatrix}
\sigma' & \sigma' & \sigma' \\
\delta' & \delta' & \delta' \\
\beta' & \beta' & \beta'
\end{pmatrix}
\]

A row of explanatory variables for house price of the complementary region, \(S_i(\hat{P})\) and \(D_i(\hat{P})\), is all set to zero because it is an exogenous variable and the actual value
with the coefficient 1 is included. All the other instruments in equations 15 to 17 must also be included to estimate three endogenous variables, out-migration, in-migration, and intra-regional moves in the house price equation. The two regional house price equations estimate the same set of coefficients. Therefore in the end the simultaneous equations model consists of two equations, one for spatial mobility and one for regional house price.