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IZA DP No. 6668

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June 2012

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zur Zukunft der Arbeit
Institute for the Study
of Labor

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IZA Discussion Paper No. 6668
June 2012

ABSTRACT

The Impact of Population Ageing on House Prices: A Micro-simulation Approach

This paper attempts to estimate the impact of population ageing on house prices. There is considerable debate about whether population ageing puts downwards or upwards pressure on house prices. The empirical approach differs from earlier studies of this relationship, which are mainly regression analyses of macro time-series data. A micro-simulation methodology is adopted that combines a macro-level house price model with a micro-level household formation model. The case study is Scotland, a country that is expected to age rapidly in the future. The parameters of the household formation model are estimated with panel data from the British Household Panel Survey covering the period 1999-2008. The estimates are then used to carry out a set of simulations. The simulations are based on a set of population projections that represent a considerable range in the rate of population ageing. The main finding from the simulations is that population ageing – or more generally changes in age structure – is not likely a main determinant of house prices, at least in Scotland.

JEL Classification: J1, R2

Keywords: population ageing, house prices, Scotland

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(1) Introduction

In an influential paper, Mankiw and Weil (1989) examined the impact of demographic change on house prices in the United States. They concluded that changes in the size and age distribution of the population would cause large and predictable changes in house prices. With cross-section data from two censuses (1960 and 1980), they demonstrated that the demand for owner-occupied housing increases to around age 30, then flattens out to around age 40 and then steadily declines. Based on the shape of this relationship, they hypothesised that the ageing of the large cohorts born in the so-called “baby-boom” (c. 1946-64) would put upwards pressure on house prices in the 1970s and 1980s. In turn the ageing of the smaller cohorts born in the so-called “baby bust” that followed (c. 1965-76), would put significant downward pressure on house prices in the 1990s and beyond. Their analysis suggested that the combined changes in housing demand caused by the ageing of the baby-boom and baby-bust generations would cause a decline in house prices in the 1990s.

The empirical evidence suggests that the opposite happened--real house prices increased substantially, if unevenly, in this period (see for example, Levin, Montagnoli and Wright, 2009). Between 1990 and 2010 UK house prices have been volatile but overall rising. Talking 2002 quarter 1 equal to 100, a mix-adjusted house price index (DCLG live tables) indicates that house prices had peaked in the 3rd quarter of 1989 and the continued to fall until the first quarter of 1993. Prices were thereafter flat until picking up after the 2nd quarter of 1996, when UK house prices started their long climb until the downturn after 2007 quarter 3 (index =183.6). A modest fall took prices back before they stabilised. Scottish house prices, starting from a lower absolute base, grew unevenly but avoided the main downturn with only two quarters of decline in 1991 but did flatten out in the mid to late 1990s. Growth commenced after 1998 but only really picked up in the mid 2000s. Scotland’s index peaked in the 2nd quarter of 2008 (223.3 with Scottish house prices set at 100 in 2002:2). Unlike the UK as a whole, however, they have not obviously resumed a growth pattern in the period up till the end of 2011. Looking at the more recent period ONS mix-adjusted monthly house price data suggests that February 2012 Scottish house prices remain 12% below their 2008 (monthly) peak compared with UK prices, which remain 7% below their peak in 2008 (CHMA, 2012).

Why was the forecast of house prices by Mankiw and Weil so badly wrong? Their analysis has been sharply criticized on three broad main grounds. First, it was regarded as implausible because cross-section estimates were used to forecast future values. Second, it paid insufficient attention to supply responses. Third, their cross-sectional analysis did not control for a wide enough range of “other variables” thought to affect the price of housing such as temporal changes in income and wealth. More generally, these criticisms point to the difficulty of modelling house prices with standard multiple regression statistical techniques. Consequently the application of other methodologies needs to be explored.

The study of Mankiw and Weil (1989) has led to a large body of research concerned with the relationship between demographic change and house prices (egs. DiPasquale and Wheaton, 1994; Engelhardt and Poterba, 1991; Ermisch, 1995, 1996; Ermisch and Di Salvo, 1997; Fortin and Leclerc, 2002; Green and Hendershott, 1996; Hamilton, 1991; Hendershott, 1991; Holland, 1991; Holly and Jones, 1997; McFadden, 1994; Meen, 1998; Mankiw and Weil, 1991, Ohtake and Shintani, 1996; Pitkin and Myers, 1994; Swan, 1995; Terrones and Otrok, 2004; Woodward, 1991). However, despite this effort there is no agreement on whether population ageing—or more generally changes in age structure—will put upwards or downward pressure on house prices.

The purpose of this paper is to empirically explore the relationship between population ageing and house prices using a micro-simulation methodology. The model is then used to evaluate this relationship in Scotland, a country that is expected to age rapidly in the future. The remainder of this paper is organised as follows. The model structure is described in Section 2. The data sources are described and the model parameters are estimated with Scottish data in Section 3. In Section 4, the estimated models are linked in order to provide a framework for empirically evaluating the impact of population ageing on house prices. Several population projections, which represent different rates of population ageing, are used to isolate the impact of age structure changes in house prices. The main conclusion, which is stated in Section 5, is that population ageing is not a key determinant of house prices, at least in Scotland.

(2) Model Structure

The empirical model is based on the micro-simulation framework developed in Leishman et al. (2008). The model is concerned with the relationships between housing supply, demographic change, labour market outcomes and housing affordability. In this paper, the focus is on the housing and demographic components of this larger, more complex system. In this respect, we follow the approach outlined in Meen (2011). With this model it is possible to examine the long-run impacts of population ageing on a variety of housing market outcomes. However, the focus here is on house prices. The model is a combination of a macro-level house price specification and a micro-level household formation specification. Both are described below.

(2.1) House Price Specification

The house price specification is derived from an autoregressive distributed lag partial adjustment model. More specifically, a long run model:

$$p_t^* = \alpha_0 + \alpha_1 hhds_t + \alpha_2 uc_t + \alpha_3 p2y_t + \alpha_4 dpsh_t \quad (1)$$

is coupled with a partial adjustment model:

$$p_t - p_{t-1} = \lambda\left(p_t^* - p_{t-1}\right) \quad (2)$$

where p_t is natural logarithm of real median house prices; $hhds_t$ is natural logarithm of the ratio of households to dwellings; $dpsh_t$ is an index of real capital asset returns; y_t is the natural logarithm of real median household income; and uc_t is the user cost of capital.

The ratio of households to dwellings (*hhds*) is an indicator of demand pressure on the housing stock. It is established in Meen (2011) and Leishman et al (2008) as an important source of inflationary pressure. Meanwhile, we also rely on the work reported by Meen (2011) in which the long run elasticity of housing prices to household incomes is approximately 2. On that basis, we define a second 'error correction' term as the ratio of median housing prices to twice median household incomes. That is, *p2y* is the natural logarithm of the ratio of median housing prices to twice median household incomes

Substituting (2) into (1) gives the house price model:

$$p_t = \lambda\alpha_0 + \lambda\alpha_1 hhds_t + \lambda\alpha_2 uc_t + \lambda\alpha_3 p2y_t + \lambda\alpha_4 dpsh_t + (1-\lambda)p_{t-1} \quad (3)$$

or

$$p_t = \beta_0 + \beta_1 hhds_t + \beta_2 uc_t + \beta_3 p2y_t + \beta_4 dpsh_t + \beta_5 p_{t-1} \quad (4)$$

The error correction terms (*hhds* and *p2y*) can be specified as lagged terms. The speed of adjustment, λ can be calculated as ($1-\beta_5$) The derivation of the long-run solution simply requires division of each coefficient by the speed of adjustment parameter.

This model is estimated the aggregate Scottish level. Just as there are important variations in the levels and volatility of house prices between UK nations (see above), the same applies to lower levels of aggregation where there are both distinct housing market areas (e.g. the Greater Glasgow/Clydeside conurbation relative to Edinburgh and the Lothians) and also the distinct likelihood of local level submarkets with persistent house price differentials within these broader housing market areas. Gibb, et al (2000) for greater Glasgow was a recent attempt to run a Scottish housing market simulation at these lower levels of spatial aggregation.

(2.2) Household Formation Specification

Following Andrew and Meen (2003) and Andrew (2010), a binary probit model is used to estimate the propensities of individuals to form independent households. It assumes that individuals' probabilities of forming independent households are derived from their demographic attributes (such as gender age, marital status and dependent children) and economic factors (especially labour market income and housing costs):

$$P(y_{it} = 1 \mid x_{it}) = \Phi(\beta' x_{it}) \tag{5}$$

where: *P(·)* denotes the probability of household formation. y_{it} is the dependent variable, which takes the value of one if an individual is observed in an independent household, and zero otherwise. x_{it} is a vector of attributes for the i-th individual at time period t, including age, gender, marital status, whether the individual has dependent children, labour market earnings, and the opportunity costs associated with the decision to form a household (usually proxied by typical housing costs). Φ is the cumulative distribution function of the standard normal distribution. Based on this initial probit model, we examine whether the propensities of forming independent households are constant over time within each age group. This is achieved by including age-time interaction terms thus allowing for the possibility that changing propensities to form a household over time are specific to age groups.

We further consider individuals' tenure choice decisions and try to nest these decisions within the household formation model. We estimate three separate binary probit models: the dependent variable y_{it} taking the value of one if an individual forms an independent household as a home-owner, a private renter, and a social renter, respectively; y_{it} equal to zero if an individual does not form an independent household. Alternatively, a multinomial probit specification is considered, to model probabilities for different outcomes in such a way that they sum up to unity. With this specification the outcome has four possibilities (i.e. $J=4$): $j=1$ is the decision not to form an independent household; $j=2$ is the decision to form an independent household as an owner; $j=3$ is the decision to be a private renter; and $j=4$ is the decision to be a "social renter" (public housing).

(2.3) Simulation Framework

The above micro-level model of household formation choices can be interacted with the macro-level model of house prices to generate a simulation framework useful for evaluating the impact of population ageing on house prices. Since the house price model is estimated as a partial adjustment model, it is concerned with the determination of house price change in the short-run, with an associated long-run solution. The ratio of households to dwelling stock in the country is posited as a partial determinant of house prices in the long run, and of short run adjustments in house prices. Given that the micro models concern household formation, the households to dwellings explanatory variable in the house price model is dependent on the summed predictions of the household formation model.

(3) Model Estimates for Scotland

(3.1) Data

The house price model is estimated using a time series dataset spanning 1981-2010. Housing price growth is derived from a median house price series for Scotland assembled from a combination of Register of Sasines/Land Register sources and the Survey of Mortgage Lenders. Estimates of population, households and the dwelling stock are from Scottish Government Statistics. The mortgage interest rate is the average Bank and Building Society initial mortgage rate, which is from the Bank of England.

The data used to estimate the household formation models are drawn from the British Household Panel Study (BHPS) (Taylor et al., 2010). We use a 1999-2008 study period reflecting the sample boost from 1999 onwards in Scotland. The panel data provide detailed information on individuals and their household formation status. The dataset includes information on 4,908 individuals, of whom 1,509 are represented in each of the 10 waves.

(3.2) House Price Model Estimates

The house price model assumes that a long run, or desirable, level of house prices is implied by explanatory variables including the user cost of capital, household incomes and the ratio of households to dwelling stock. The user cost variable is a composite of mortgage interest rates and expected house price growth, as well as allowances for depreciation and taxation. Ideally, we would measure the marginal rate of taxation on personal income and the rate of property taxation. However, without being able to access a much richer micro dataset than available in this study, we have chosen to ignore the personal and property taxation elements of user cost and have taken the approach of defining user cost based simply on mortgage interest rates and expected price growth. The latter is defined as a simple adaptive expectations term in which expected price growth in time period t is equivalent to 75% of observed growth in t-1 and 25% in t-2.

We diverge from the general specification by optimising the lag structure of several of the variables. In particular, longer lag terms provide stronger explanatory performance. This applies particularly to the wealth term, real growth in FTSE-100 index, the inclusion of which is in itself a divergence from the general partial adjustment specification summarised earlier in the paper. The estimates are shown in Table 1.

<<<< Table 1 About Here >>>>

The estimates reveal a strong explanatory performance despite the limited set of explanatory variables included in the equation. The user cost of capital (lagged on period) is significant and negative, in line with expectations. Given the one lag specification, the implication is that observed price growth in *t-2* and *t-3* set price expectations in time period t. Growth in the real FTSE-100 index is significant and negative, suggesting a counter cyclical relationship between housing prices and capital market returns. It is possible to construct a theoretical argument in favour of either a positive or negative coefficient on this variable. For example, we might suppose that an increase in wealth generally would give rise to higher levels of housing consumption, and a positive link to housing prices. Alternatively, the UK has a long established history of private individuals investing heavily, and sometimes speculatively, in housing assets. Plausibly, the investment motivated element of demand for housing should run counter cyclically, through arbitrage, to financial markets.

The price of housing relative to household incomes, and the ratio of households to dwelling stock are important ‘error correction’ variables, as discussed earlier in the paper. The model is not estimated as a co-integrated system, so the short run model summarised in Table 1 is not formally an error correction model. However, the long run solution to the estimation results is based on the notion that the long run level of prices is determined by the long run level of the two variables mentioned. In that sense, the short-run equation acts as an error correction model. The price to income ratio is significant and negative, and the ratio of households to dwellings is significant and positive. Thus, in keeping with prior expectations, housing prices are subject to downward pressure when price levels are high relative to income and to upward pressure when the ratio of households to dwelling stock is high.

(3.3) Household Formation Model Estimates

The descriptive statistics for the variables included in the household formation model are shown in Table 2. This model is estimated first as a binary panel probit that controls for unobserved individual heterogeneity through random effects. It is important to note that these models include a lagged dependent variable as an explanatory variable to capture state dependence - those who formed independent households in the past are more likely to live independently in the future. The inclusion of random effects help control of unobserved individual characteristics ("unobserved heterogeneity").

<<<< Table 2 About Here >>>>

The estimates of the models are summarised in Table 3, beginning with a model of household formation with a simple specification that omits BHPS wave and interactions between BHPS wave and age group. The second model summarised is also for household formation, and the specification includes the BHPS wave and interaction terms. Separate estimations are undertaken for household formation disaggregated by each main tenure. Each of these also includes the BHPS wave and interaction terms.

The status of household formation at time (t-1) has been shown to significantly influence the probability of forming independent households at time t. The model specifications each include the lagged dependent variable. In addition, it is well established that including a lagged dependent variable leads to bias in conventional panel regression models (see for example, Chay and Hyslop 2000). Heckman (1981) provides a possible method to deal with this problem. The method involves estimating the distribution of the initial conditions (t=1) by a different process but makes the estimation correlated with the main process (t=2,…,T). Thus, the estimators approximate the joint probability of the dependent variable in all sequences. In our application the two models are estimated simultaneously in a system, with the "first" being a static probit model without including lagged dependent variables and the "second" being a random effects probit model with lagged dependent variables.

The results confirm that age is an important determinant of household formation, with propensities to form a household rising progressively with age band. Change in partnership or marital status are also significant predictors, particularly for the decision to form a household generally, and to form an owner occupier household. Meanwhile, presence of a partner increases propensities in all tenures, but presence of dependent children increases propensities only in the social rented tenure. Income is significant and positive in the household formation, owner occupation and private renting equations, but is significant and negative in the combined household formation / social renting equation. Although the model is estimated for Scotland as a whole, labour market earnings may vary quite substantially at sub-regional or local level. We tackle these sub-regional variations partially by using local authority codes attached to BHPS individuals to measure owner occupied housing costs at local authority level rather than at the level of Scotland as a whole. The housing cost variable is used to derive a mortgage cost variable (based on prevailing mortgage interest rates in each BHPS wave). This mortgage cost variable is significant (with a positive coefficient) only in the household formation/privately renting equation as shown in Table 3.

<<<< Table 3 About Here >>>>

Turning to the specific hypothesis that propensities to form an owner occupied household are changing (for different age groups) over time, we can see that there is some support in the results shown in Table 3. The BHPS wave number variable is significant and negative in the household formation model (third column), but is not significant in any of the household formation models disaggregated by tenure. This suggests that propensities to form a household are falling over time within the BHPS sample. The fact that a statistically significant effect is not present for any of the models disaggregated by tenure is paradoxical, but it may reflect more complex interactions between the main tenures than accounted for in these specifications. Interactions between age group and BHPS wave are generally insignificant, but with the exception of the wave/over 75 age group interaction in the main household formation model (third column) and the wave/35-44 age group interaction in the privately rented household formation model. The former is interesting because it suggests that the over 75 age group are more likely to form a household over time. Whether this positive effect is sufficient to outweigh the generally falling propensity of people to form a household over time (i.e. the BHPS wave variable coefficient) is difficult to determine outwith a simulation. Although five models are summarised in table 3, columns 2 and 3 are of particular interest in that these are used to carry out a simulation, and this is discussed later in the paper.

The final household formation model is a multinomial probit model estimated on the pooled dataset clustered by individuals. One advantage of this approach is that it constrains predicted probabilities to sum to one. The multinomial probit estimation sets ‘not forming a household’ as the reference category. The results confirm earlier results that age is an important driver of the decision to form an owner occupier or social renting household, and propensities rise with age. For those forming a privately renting household the 25-34 and 35-

44 band effects are not significantly different to the age band 15-24 reference category. However, three of the four higher age bands are significant and negative. Another obvious difference between the multinomial and earlier binomial estimation results relates to the mortgage cost variable. This is now weakly significant and positive for household formation and privately renting, and significant and negative for household formation and social renting. Thus, while it is surprising that high mortgage costs do not appear to reduce household formation in owner occupation, they appear to boost household formation in the private rented sector, although the significance level is low. It is also surprising that higher mortgage costs appear to reduce the propensity of individuals to form a social rented household. It is possible that unmeasured differences in local housing market conditions are playing a role in the results although, as noted earlier, the mortgage cost variable is calculated using the median house price measured at local authority level.

<<<<< Table 4 About Here >>>>

Turning to the wave and wave / age band interactions, we can see that the multinomial estimation produces slightly different results compared to the binomial models. The BHPS wave variable persists in its significance and negative effect on the propensity to form an owner occupier or privately renting household. However, in addition to finding that the over 75 age group has a higher propensity to form an owner occupier household over time, the results now suggest higher propensities for the 45-54 and 55-64 age groups in both owner occupier and private rented tenures.

To summarise, we have presented the results for three approaches to estimating the propensity of individuals to form a household. By nesting the tenure choice decision within the household formation decision, we are able to observe, to an extent, the tenure specific influences on household formation and to gain an indication on how these may be changing over time. The estimation results include a central core of largely confirmatory results including gender, age, household composition, relationship status and economic factors. The role of mortgage costs is uncertain from the estimation results. While there is some weak evidence that higher costs contribute to demand for private rented housing, the insignificance of the variable in the owner occupier equations for household formation is surprising.

The two estimation approaches reveal considerable instability in the BHPS wave and age group interaction terms. However, the notion that household formation rates are falling over time, and particularly for the owner occupier sector, is well supported by the results. There are indications that wave/age interactions for older age groups at least partly offset this effect, but the instability of the results between estimations leads us away from drawing strong conclusions on this point. However, the results do at least give a strong suggestion that falling propensities to form a household (particularly in owner occupation) affect younger individuals in the sample. This supports and is supported by findings from other recent studies including Andrew (2010) and Andrew and Meen (2003).

(4) Evaluating the Impact of Population Ageing on House Prices

In this section we examine empirically the possible long-run impacts of population ageing on house prices. The simulations draw on the estimated house price equation discussed in the previous section and a simplified household formation equation. The simulations are based on the most recent set of population projections carried out by the Scottish Government (National Records for Scotland, 2011). The base year for these projections is 2010. The simulation period is 25 years, up until 2035. It is clear that the Scottish population will age rapidly in the future. The rate of population ageing will be determined by future levels of fertility, mortality and net-migration. Therefore, by varying assumptions relating to these three demographic variables, different time paths of the rate of population ageing will be generated. The linked house price-household formation equations can be used to estimate house price paths based on these different population ageing scenarios.

Seven sets of population projections are considered. The “principal” projection assumes that in the long-run fertility will remain at 1.7 births per women, life expectancy for men/women will increase to 87.1 year for women 83.1 years for men by 2050; and net-migration will be positive at +17,500 people per year. This projection will be used to form the baseline that the scenarios will be compared to. The remaining projections assume higher or lower levels of these variables. The “high” fertility projection assumes a long-run fertility rate of 1.9 births per woman while the “low” fertility projection assumes a rate of 1.5 births per woman. High mortality implies a slower increase in life expectancy. More specifically, the “high” mortality projection assumes life expectancy will increase to 83.5 years for women and 78.4 years for men. In the “low” mortality projection, life expectancy will increase to 86.7 years for women and 83.3 years for men. The “high” net-migration projection assumes a net-migration level of +26,000 people per year, while the “low” net migration projection assumes a net migration level of +9,000 people per year. It is important to note that in these projections assumption (e.g. “high” fertility) relating to the two other main demographic variables (e.g. mortality and net-migration) are the same as in the principal projection.

Table 6 summarises what this range of assumptions implies about future rates of population ageing in Scotland. There is no agreed upon method on how to measure population ageing, although it is common to consider changes in population age shares and the medial age of the population. The values for the base year of 2010 are also shown. All the scenarios suggest significant population ageing captured by the sizable increase in the median age of the population and the large increases in the share of the total population in 60-74 and 75+ age groups. Based on the differences observed in Table 6, we also conclude that the different assumptions have generated age structure changes that represent significant differences in the rate of population ageing.

<<<< Table 6 About Here >>>>

The simulations requires a number of other assumptions, particularly in relation to household incomes, housing costs and, above all, the propensities of people in various age groups to have partners and children. To permit the simulations we assume that real household incomes rise at a steady annual 3%, and that propensities to form a relationship or have children remain at levels observed during the 1999-2008 period used to estimate the household formation equation. However, these propensities are set independently for each group, defined by age and gender. It is also important to stress that these simulations are not forecasts of house price growth.

Turning to the house price model, we set mortgage interest rates and stock market returns to their 2000-2006 average values on the basis that this period represents typical housing market conditions, ignoring the boom in asset prices of the late 1980s, the early 1990s recession and the recent credit crunch and global financial crisis. This set of assumptions allows us to focus on the role of demographic trends in determining house prices in the long run, although we do assume an annual rate of household income growth of 3%, as noted earlier. Although the assumptions are arbitrary, the same set is used in each of the simulations, and the purpose of the simulations is to provide a comparison between alternative population projections. Finally, we assume an annual rate of net additions to the Scottish housing stock of 0.7% - the average during the 1981-2010 study period.

The house price component of the simulations therefore isolates a single variable: the ratio of households to dwellings. Given that the household formation equation yields estimates of total households under seven scenarios, the simulations therefore yield seven sets of long-run house price paths holding all other factors constant. The results are summarised in Table 7.

<<<< Table 7 About Here >>>>

Table 7 shows the simulated values of house prices in 2035 (i.e. the end of the simulation period) in terms of an index that has a value of 1.0 in 2010 (i.e. the base year).

Based on our assumptions, all seven demographic scenarios are associated with significant real house price growth. The principal population projection implies an 82 per cent increase in this 25 year period. What is also noticeable in this table, is that the other demographic scenarios do not generate house prices in 2035 that are wildly different from the baseline case. The biggest difference is for the “high” net migration scenario, which implies a 91 per cent increase, a difference of less than 10 percentage points compare to the base-line case. This provides some evidence supporting the conclusion that population ageing is not a key determinant of house prices.

Further evidence in support of this conclusion can found in Figures 1-3. These figures show the paths of house prices for the baseline scenario and the “high” versus “low” scenarios for each of the three main demographic variables separately. These figures confirm that all the scenarios imply increasing real house prices in the long-run. Figure 1 is for fertility and there is virtually no difference in these paths except in the final few years of the simulation period. Figure 2 is for mortality and the situation is similar. Figure 3 is for net-migration. In this case, the paths start to diverge after about 6-7 years, with the “high” net-migration scenario being associated with a higher house prince growth. It is worth noting that the “high migration” scenario is associated with the second smallest increase in the median age of the population—the smallest increase is for the “high fertility scenario”. In fact, the correlation between changes in house prices and changes in the median age of the population is negative, suggesting that population ageing puts downward pressure on house prices but this effect is small.

<<<<< Figures 1-3 About Here >>>>

(5) Concluding Comments

In this paper we explore the possible impacts of population ageing on house prices in two ways. First, by examining several household formation equation estimations we show that the propensity of individuals to form a household is falling over time – specifically in the period 1999-2008. There is evidence that these falling propensities are counter balanced, to an extent, by rising propensities to form a household among older age groups and particularly those over 75. While the interaction terms between BHPS wave and individual age group generally support the findings of earlier studies of household formation, the presence of many insignificant terms and low levels of significance on others argue against attempting a micro-simulation based on these estimations. Therefore, second, we examine the results of a set of long-run simulations that link a macro-model of house prices to a more robust, but simpler, model of household formation. Given that propensities to form a household differ between age groups, this specification nevertheless allows us to examine the possible impacts of population ageing on household formation, the likely total number of households in Scotland, and thence house price growth in the period to 2035.

The analysis presented in the paper represents evidence that is consistent with the view that change in age structure is not a particularly important determinant of house prices - at least in Scotland. In particular, population projections that assume higher or lower growth in life expectancy give rise to only marginally different predicted house price levels in 2035, the end of the simulation period. A larger difference is predicted compared with the baseline forecast when we consider population projections that assume higher net migration, but even in this case the difference is relatively modest considering the fact that such a long simulation period (25 years) is adopted.

Finally, given that the household formation specification omits wave / age group interactions, it is possible that our simulation approach leads to some under estimation of the full impacts of population ageing on house prices. The insights obtained from the estimation of household formation equations with BHPS wave and age group interactions suggest that younger people are less likely to form new households over time, and that older people are more likely. The net effects on the total number of households cannot readily be predicted in the absence of sufficiently robust econometric results to allow a micro-simulation that takes account of changing propensities by age group over time. In the context of this special issue our Scotland-specific results suggest modest age-related impacts on house prices even with bolder population projections. Even if this is in the absence of the wave and age group interactions, which might produce more robust estimates – our evidence thus far is of a limited price effect. This may of course be different elsewhere and suggests a clear strategy for future research concerned with the impacts of population ageing on house prices.

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Table 1
House Price Equation Estimates

Variable	Coefficient	t statistic	Description
uc(t-1)	-0.886	-5.4***	User cost
p2y(t-1)	-0.224	-5.4***	Ratio of median price to income
hhds(t-1)	0.345	6.6***	Ratio of households to dwellings
dpsh(t-2)	-0.214	-3.4***	Growth in real FTSE100 index
Dum1992	-0.189	-4.0***	Time dummy - 1992
Dum2007	0.233	5.0***	Time dummy - 2007
R-squared	0.77		
Durbin-Watson	1.67		

Note *** significant at 1%

Table 2
Descriptive Statistics for Variables Included in Household Formation Equation

Variable	**Mean**	**Std. Dev.**
Form an independent household	86.3%	--
Tenure:		
Owner-occupier	72.2%	--
Social-renter	22.6%	--
Private renter	5.2%	--
Male	45.3%	
Age	45.9 years	18.3
New spouse	1.5%	--
Become widowed	7.5%	--
Become divorced	7.6%	--
Partner present	61.6%	--
Child present	28.2%	--
Income in previous month	£1,212	£1,259
Mortgage cost	£616	£257

Table 3 **Dynamic Binary Panel Probit Models of Household Formation and Tenure Choice**					
Explanatory Variables	Form a household vs. not form a household (simple)	Form a household vs. not form a household	Form a household and home-ownership vs. not form a household	Form a household and private renting vs. not form a household	Form a household and social renting vs. not form a household
Form a household in previous year	2.8048*** 0.0558	2.8018*** 0.0559	2.4837*** -0.1356	2.0362*** -0.1673	2.5477*** -0.1711
Male	-0.1347*** 0.0472	-0.1372*** 0.0473	-0.2730** -0.1376	-0.0167 -0.1661	-0.3717** -0.1854
Ageband 25-34	0.2529*** 0.0659	0.1323 0.1462	1.0955*** -0.3514	-0.3544 -0.3705	1.1819** -0.4624
Ageband 35-44	0.5148*** 0.0823	0.5063*** 0.1797	2.1947*** -0.475	0.9896** -0.5038	1.9007*** -0.5889
Ageband 45-54	0.6651*** 0.0941	0.506** 0.1995	1.9538*** -0.4741	0.0673 -0.783	2.8741*** -0.6945
Ageband 55-64	0.9002*** 0.1122	0.619** 0.2551	2.3466*** -0.6145	0.7543 -0.9458	3.3329*** -0.6992
Ageband 65-74	0.8095*** 0.1222	0.9369*** 0.2709	3.5054*** -0.8395	0.7636 -1.1453	5.1544*** -0.9579
Ageband over 75	0.7973*** 0.1247	0.2232 0.2349	2.3482*** -0.6315	1.2742 -1.8249	3.2351*** -0.9332
wave		-0.0425** 0.0186	-0.0256 -0.0665	-0.0436 -0.059	-0.0809 -0.0844
Wave*ageband 25-34		0.022 0.0236	-0.0561 -0.0681	0.0408 -0.0639	-0.1001 -0.0919
Wave*ageband 35-44		0.0027 0.0278	-0.0837 -0.0775	-0.2201** -0.094	0.0057 -0.1014
Wave*ageband 45-54		0.0293 0.032	0.0241 -0.083	0.0058 -0.1412	-0.037 -0.109
Wave*ageband 55-64		0.0506 0.0402	0.0335 -0.0993	-0.1718 -0.1568	0.0159 -0.1174
Wave*ageband 65-74		-0.018 0.0391	-0.0763 -0.1217	0.0203 -0.2005	-0.1858 -0.1215

Wave*ageband over 75		0.105*** 0.0388	0.0824 -0.098	-0.2759 -0.524	0.1973 -0.1415
New spouse	1.4469*** 0.1369	1.4571*** 0.1375	1.0933*** -0.3055	1.4355*** -0.3515	0.5401 -0.4164
Become Widowed	0.2064* 0.121	0.2044* 0.1219	0.5675 -0.3466	0.0985 -0.838	0.3542 -0.3888
Become divorced	-0.0972 0.0773	-0.0982 0.0775	0.0622 -0.1998	0.0419 -0.2768	0.0358 -0.2463
Partner present	0.8698*** 0.0738	0.874*** 0.0741	2.4533*** -0.2716	1.3030*** -0.3217	2.0442*** -0.3589
Child present	0.1925*** 0.0729	0.1971*** 0.0731	0.1332 -0.1944	0.2781 -0.2384	1.3624*** -0.2341
Income in previous month	0.0002*** 0	0.0002*** 0	0.0005*** -0.0001	0.0002** -0.0001	0 -0.0001
Mortgage cost	-0.0002* 0.0001	0 0.0001	0 -0.0004	0.0006 -0.0005	0.0005 -0.0006
Constant	-1.4531*** 0.0716	-1.3433*** 0.0976	-2.6373*** -0.3141	-2.1961*** -0.2603	-2.7266*** -0.4061
Log likelihood	-1774.0648	-1767.422	-918.6177	-617.5346	-716.0905
N	23,873	23,873	21,359	5,363	9,796
Note: * significant at 10%; ** significant at 5%; *** significant at 1%; Age band between 15 and 24 is the default category; standard errors in parentheses					

Table 4
Multinomial Probit Models of Household Formation and Tenure Choice

Explanatory Variables	Form a household and home-ownership vs. not form a household	Form a household and private renting vs. not form a household	Form a household and social renting vs. not form a household
Form a household in previous year	3.5647*** (0.1073)	3.3225*** (0.1229)	3.7368*** (0.1170)
Male	-0.3525*** (0.0724)	-0.0371 (0.0855)	-0.0564 (0.0758)
Ageband 25-34	0.5333** (0.2407)	-0.3382 (0.2371)	0.3970 (0.2457)
Ageband 35-44	1.0859*** (0.2644)	-0.2737 (0.2701)	0.8493*** (0.2612)
Ageband 45-54	1.1688*** (0.2768)	-0.9347*** (0.3165)	0.9014*** (0.2761)
Ageband 55-64	1.2235*** (0.2782)	-0.8064** (0.3317)	1.3317*** (0.2685)
Ageband 65-74	1.6156*** (0.3752)	-0.1970 (0.4141)	1.6060*** (0.3731)
Ageband over 75	0.6818** (0.3386)	-0.8952** (0.3771)	0.8352** (0.3354)
Wave	-0.1262*** (0.0364)	-0.0824*** (0.0298)	0.0053 (0.0335)
Wave*ageband 25-34	0.0591 (0.0406)	0.0508 (0.0380)	0.0154 (0.0404)
Wave*ageband 35-44	0.0571 (0.0416)	0.0217 (0.0391)	-0.0139 (0.0398)
Wave*ageband 45-54	0.0893** (0.0447)	0.1102** (0.0466)	0.0095 (0.0429)
Wave*ageband 55-64	0.1161** (0.0459)	0.0987** (0.0490)	0.0207 (0.0437)
Wave*ageband 65-74	0.0466 (0.0508)	-0.0170 (0.0548)	-0.0557 (0.0499)
Wave*ageband over 75	0.2071*** (0.0529)	0.0704 (0.0566)	0.0827 (0.0519)
New spouse	1.6255*** (0.2209)	2.2705*** (0.2226)	2.3082*** (0.2276)
Become Widowed	0.3936** (0.1783)	0.0012 (0.2223)	0.1756 (0.1870)
Become divorced	-0.3466*** (0.1239)	-0.1650 (0.1442)	0.2085 (0.1288)
Partner present	1.6001*** (0.1120)	0.6265*** (0.1315)	0.6003*** (0.1240)

Child present	0.2155** (0.1057)	-0.0613 (0.1238)	0.5883*** (0.1126)
Income in previous month	0.0005*** (0.0001)	0.0001** (0.0001)	-0.0003*** (0.0001)
Mortgage cost	0.0003 (0.0002)	0.0004* (0.0002)	-0.0005** (0.0002)
Constant	-2.9474*** (0.1927)	-2.3869*** (0.1556)	-2.5551*** (0.1869)
Log likelihood	-14,083		
N	23,106		

Note: * significant at 10%; ** significant at 5%; *** significant at 1%; Age band between 15 and 24 is the default category; standard errors in parentheses

Table 5
Projected Age Structure, Scotland, 2035

	% in age group						
Scenario:	0-14	15-29	30-44	45-59	60-74	75+	Median age
Principal	15.3	17.5	18.3	18.5	17.7	12.8	44.2
High fertility	16.6	17.9	17.8	18.0	17.2	12.5	43.3
Low fertility	13.9	16.9	18.8	19.0	18.2	13.2	45.3
High mortality	15.5	17.7	18.5	18.6	17.6	12.1	43.8
Low mortality	15.1	17.3	18.1	18.3	17.7	13.5	44.6
High net-migration	15.5	17.5	18.8	18.5	17.2	12.4	43.7
Low net-migration	15.0	17.4	17.7	18.4	18.2	13.3	44.9
Values in 2010	16.3	19.8	19.8	20.9	15.3	7.8	40.7

Table 6
Simulated House Prices, Scotland, 2035

Scenario:	2035 median house price (2010 base=1)
Principal	1.818
High fertility	1.833
Low fertility	1.795
High mortality	1.787
Low mortality	1.849
High net-migration	1.908
Low net-migration	1.732

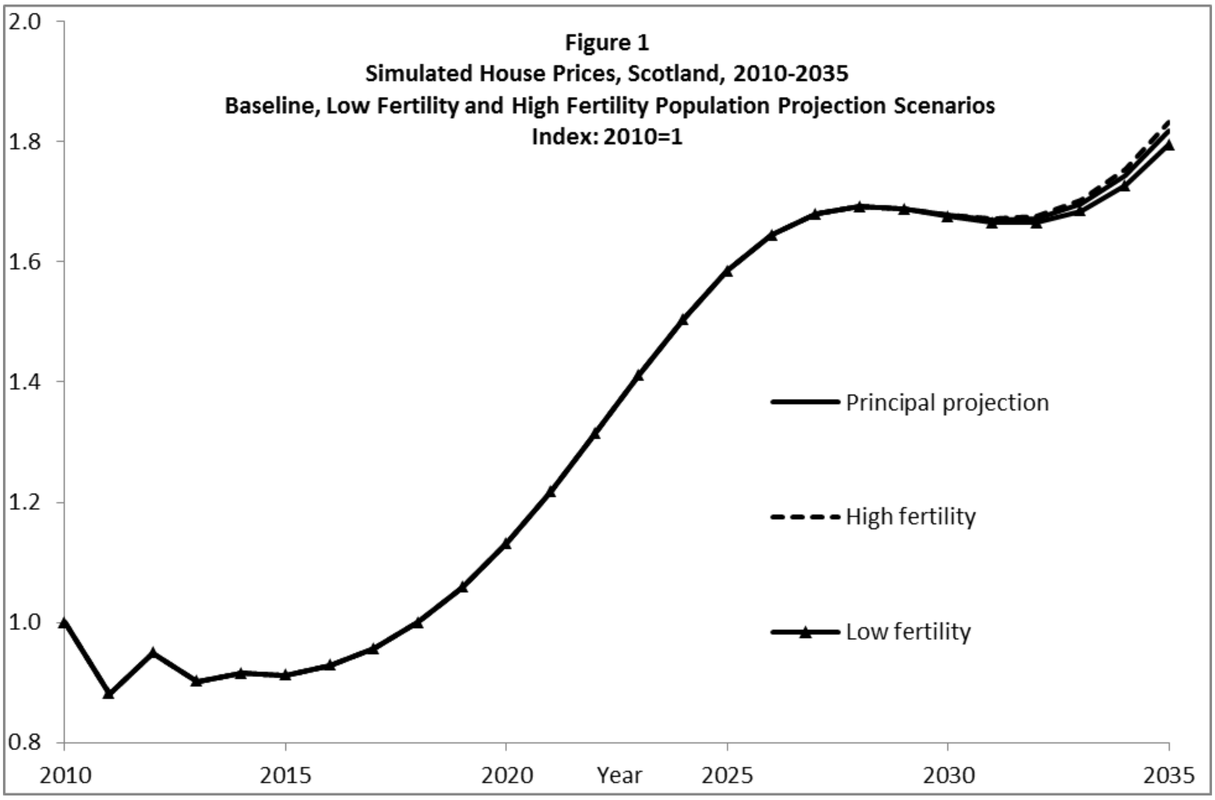
Figure 1
Simulated House Prices, Scotland, 2010-2035
Baseline, Low Fertility and High Fertility Population Projection Scenarios
Index: 2010=1
2.0
1.8
1.6
1.4
1.2
1.0
0.8
2010
2015
2020
Year
2025
2030
2035
Principal projection
High fertility
Low fertility

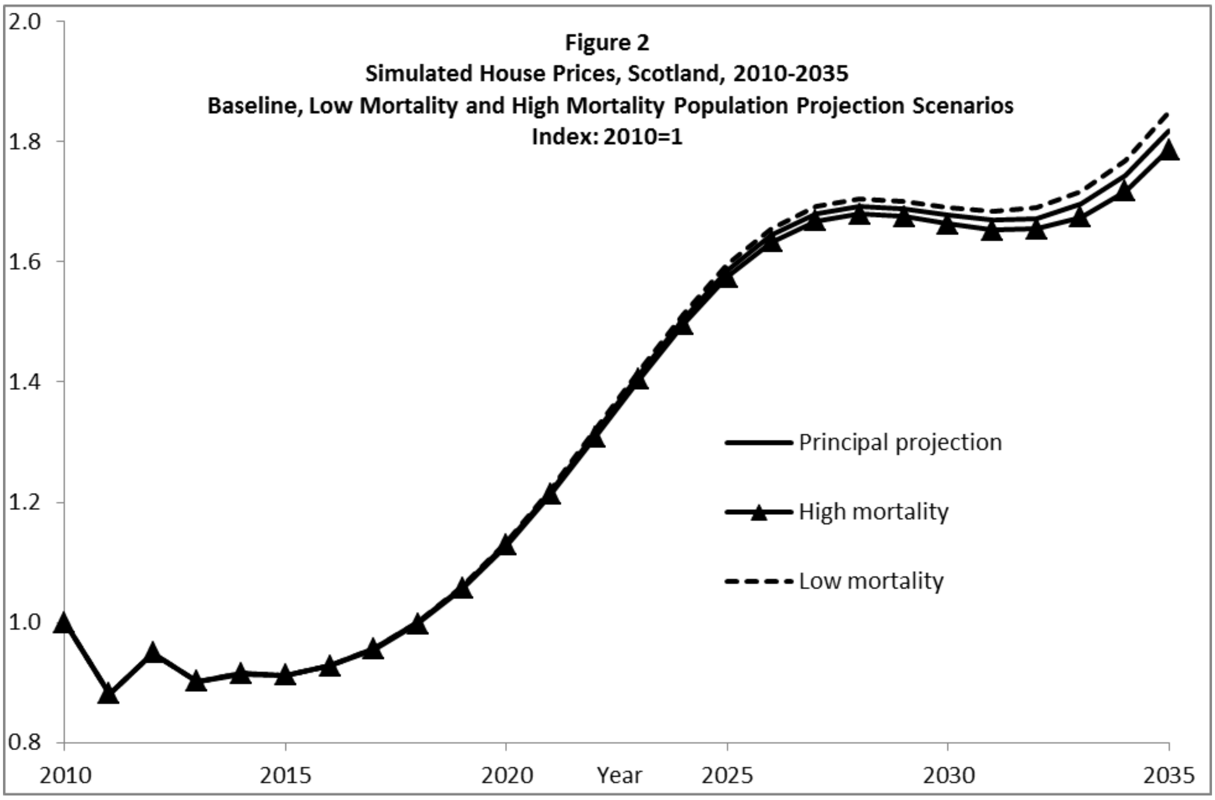
Figure 2
Simulated House Prices, Scotland, 2010-2035
Baseline, Low Mortality and High Mortality Population Projection Scenarios
Index: 2010=1
2.0
1.8
1.6
1.4
1.2
1.0
0.8
2010
2015
2020
Year
2025
2030
2035
Principal projection
High mortality
Low mortality

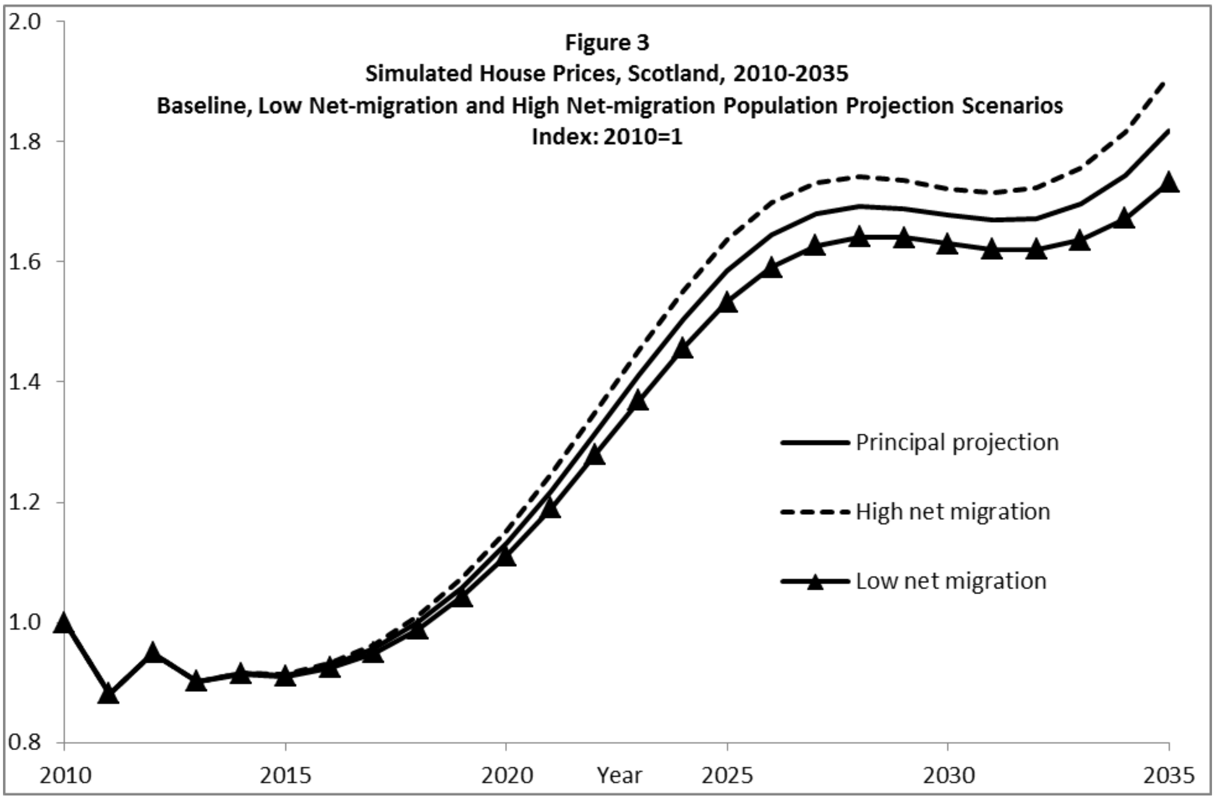
Figure 3
Simulated House Prices, Scotland, 2010-2035
Baseline, Low Net-migration and High Net-migration Population Projection Scenarios
Index: 2010=1
2.0
1.8
1.6
1.4
1.2
1.0
0.8
2010
2015
2020
Year
2025
2030
2035
Principal projection
High net migration
Low net migration