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Demographics, human capital, and the demand for housing

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ABSTRACT

This paper investigates how the demand for residential real estate depends on age and other demographic characteristics at the household level. Based on a detailed cross-sectional survey of English households, it finds that housing demand is significantly determined by a household's human capital, and that housing demand generally increases with age. After retirement it declines, but only to a small extent. High education levels, good health, and high income will increase a household's demand for housing even when households age. These results are relevant for countries that experience population shrinkage, but where total housing demand could still grow in the future despite stagnating household numbers and aging populations. The paper further shows that changes in demographics lead to very heterogeneous demand responses for different housing attributes, providing information regarding the future qualitative demand for housing.

1. Introduction

Demographic change is a key challenge for many industrialized countries. To give some brief examples, the United Nations Population Division, 2012 estimates that Russia will have lost 24% of its current population by the year 2050. For Bulgaria, the expected decline in total population is 35% in the same period. On a regional level, population changes are even more pronounced. The German federal state of Thuringia, for example, has already been losing 1% of its population annually for a number of years (Thüringer Landesamt für Statistik, 2008). Beside the rapid changes in total population numbers, societies will age dramatically. In South Korea, for instance, the median age is increasing three years every five years and the share of inhabitants older than 60 years will increase from 14% now to 42% in 2050 (UNPD, 2012). International demographic dynamics dwarf the so-called baby bust in the US.

So these are big issues, and they are likely to have a substantial impact on housing markets worldwide. Nevertheless, the literature studying demographics and housing markets is small, especially outside of the US. This paper provides new evidence regarding the effect of an aging society on the demand for housing. It does this on the basis of a high-quality micro-dataset for England, which is very rich in terms of household characteristics and the quality of the dwellings they occupy.

The first to study the possible effects of demographic changes on housing demand and house prices were Mankiw and Weil (1989), who modeled the per-capita quantity of housing demand as a function of age. Analyzing 1970 census data for the US, they found demand for housing to be very low for residents younger than 20 years, to shoot up for 20–35 years-olds, and to decline constantly thereafter. Furthermore, they created a time series of housing demand and regressed it against the aggregated housing quantity (represented by the net stock of residential capital). This revealed no significant dependency, but they did find that real house prices depended on demand as defined by their model. Mankiw and Weil concluded that

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the ageing baby-boom generations move out of the high-demand age classes would drive total demand down and result in a sharp drop in house prices.

Criticism of this paper came from many directions: Peek and Wilcox (1991) investigated the movements of house price indices and found that real after-tax interest rates and construction costs were the main determinants of price swings. Demographic variables like income and age were significant but did not have the importance suggested by Mankiw and Weil. Hendershott's (Hendershott, 1991) main point of critique was the lack of predictive power of the Mankiw and Weil models for the 1970s and 1980s, making their predictions for the 1990s unreliable. In addition, he criticized the negative time trend in their basic equation, which accounts for most of the predicted price decline Mankiw and Weil had explained by demographics.

Engelhardt and Poterba (1991) applied the Mankiw and Weil approach to data for Canada. They observed an age-housing demand relationship similar to the one Mankiw and Weil found for the US, but Canadian house prices were not determined by the derived demand variable.

Green and Hendershott (1996) propelled the debate to the next level. It followed Mankiw and Weil in linking per capita housing expenditures and demographic information based on cross-sectional data from the 1980 census. The methodology, however, advanced in two aspects: first, Green and Hendershott controlled for the quantity *and* quality of housing services a household consumes in a hedonic framework and estimated marginal prices for each hedonic characteristic of a dwelling. Second, they regressed each marginal price against the demographic variables of the household. These innovations made it possible to keep the quantity of housing services consumed constant (by defining a constant quality house) *and* to explicitly link these prices to the demographic profile. Green and Hendershott found that demand for housing does not decline with age, but rather that education and income determine the quantity of housing services consumed. This implies that Mankiw and Weil underestimated the housing services the baby-boom generation would demand in the future by not controlling for the fact that younger generations enjoyed a better education and accumulated more wealth than their predecessors.

Given the tectonic shifts in global demographics, it is surprising how few studies have researched the effect of demographics on housing markets in Europe and Asia. For Japan, Ohtake and Shintani (1996) find that demographic change has a significant effect on house prices through the short-run adjustment process in the housing market. Ermisch (1996) establishes a link between age (among other demographic variables) and the level of housing services demanded in six British agglomerations. Lee et al. (2001) find evidence that demographics do explain the amount of housing services demanded in Austria. Neuteboom and Brounen (2007) predict Dutch housing demand to increase with household age. Lindh and Malmberg (2008) show that the populations age structure is related to residential construction in Sweden and other OECD countries.

The most recent paper in this literature is Takáts (2012), who found a significant link between population growth rates and house prices, using a macroeconomic panel for 22 advanced economies for the years 1970 through 2010. His paper showed that when the population grows by 1%, real house prices move up by the same rate. An increase in the share of the elderly in a society is associated with lower house price growth. The underlying economic model is elegant, but the author measures all housing units and all households with the same yardstick. Differences in housing characteristics and heterogeneity in the residents' demographic profiles are not considered. Given the past rise in education levels, shrinking household sizes, and both longer and healthier lives, a household-level analysis of demographic trends on housing demand will provide additional insights in housing demand in *changing* societies.

This paper extends the existing literature in three directions: first, it refines the existing methodology and models the demographic dynamics more carefully. We separate *life cycle variables*, which change according to the household's position in the life cycle, from *cohort variables*, which do not change with age. Instead of allowing every demographic variable to vary (like Mankiw and Weil, 1989), or keeping all demographics constant (like Green and Hendershott, 1996) we explicitly consider only the change in the life cycle variables like income or household size over time. This leads to a more robust projection of housing demand.

Second, a very detailed micro-dataset provides information on the hedonic attributes of a representative share of English residential real estate in combination with extensive demographic information on the respective households. The majority of earlier studies utilized publicly available census data which are easy to analyze and allow for very large and representative samples, but which offer only very basic information on the physical attributes of dwellings.[1] Fortunately, our data set offers rich information on the physical characteristics of individual homes, their interior and exterior condition, energy efficiency, the local environment, and the attitudes of the inhabiting households towards their residence as well as similarly detailed information on the household's demographic profile. Overall, more than 900 variables are coded in the data set, of which approximately two thirds are relating to the dwelling, and one third to the household. Our paper shows that changes in demographics lead to very heterogeneous demand responses for different housing attributes. Disregarding these differences and assuming all households to have homogeneous and static preferences – and all dwellings to be the same – is an oversimplification that may lead to biased estimation results.

Third, using English data gives us the opportunity to analyze an environment different from the US. This international perspective is crucial since demographic changes in the United States are, although important, not as pressing as the more severe developments in Europe and Asia.

[1] Green and Hendershott (1996), for instance, had to restrict their analysis to 18 hedonic variables of housing quality, including 8 regional dummies.

The US are projected to experience further population growth (albeit at a lower rate than before) combined with a younger age distribution than most European countries.

Britain is unlikely to witness a demographic contraction as grave as many Central and Eastern European countries in the coming decades, but the situation is very distinct from the US or Canada. British population growth is leveling off more rapidly and the population's age structure is already older than in America. Until 2050, the projected population growth in Britain is about half that of America.[2] This makes the UK an interesting environment to investigate the implications of demographic change on housing markets.

The remainder of the study is organized as follows: This introduction is followed by sections that develop the empirical methodology, introduce the data and present the results. A discussion of the main results concludes the paper.

2. Method

We refine the three-step estimation strategy pioneered by Green and Hendershott (1996). First, we estimate the relationship between the flow of housing services and the hedonic characteristics of the dwelling (Rosen, 1974):

$$q = f(Z), \tag{1}$$

where Z is a vector of the hedonic characteristics of the house and q is the amount a household paid for the housing services generated by the dwelling it lives in.

For renters, we directly quantify q by the sum of rent, energy, service costs (if not included in the rent already), and the local council tax, if applicable.[3] For homeowners, we cannot observe q directly but have to impute a theoretical rent, which is the opportunity cost of holding home equity (and not investing this amount in a comparable asset class) less the expected capital gains plus direct cost: $q_{owner} = V \cdot (r_f + \rho - g) + K$, where V is the current appraised value of the dwelling, r_f the risk-free interest rate, ρ a risk premium for residential real estate, g the expected capital gain, and K is the sum of all direct costs for maintenance, energy, and council tax.

Then, we take the partial derivatives of f and obtain the real marginal contribution q_i of each hedonic characteristic i to housing demand:

$$q_i = \frac{\partial f}{\partial z_i}(Z). \tag{2}$$

In the last step, the marginal contributions obtained from Eq. (2) are regressed against the demographic characteristics of the household:

$$q_i = g_i(Z, A, X, Y), \tag{3}$$

where X is a vector of the demographic characteristics of the household. The household's age A and income Y are controlled for separately (Green and Hendershott, 1996).

When Eq. (1) is homogeneous of degree one, the aggregated housing service of a house can be computed (based on Euler's theorem) as:

$$q = \sum_{i=1}^{n} q_i z_i, \tag{4}$$

where z_i is the amount and q_i the marginal price of characteristic i included in the house. Finally, total demand for housing q can be obtained by summing over the age classes and N housing characteristics:

$$q = \sum_{a=1}^{a=5} \sum_{i=1}^{i=N} w_a q_{ia}, \tag{5}$$

where w_a is the share of households in age-class a.

Again following Green and Hendershott (1996) in selecting functional forms for Eqs. (1) and (3), we use the translog function by Christensen et al. (1975) to estimate Eq. (1):

$$ln(q) = \alpha_0 + \sum_{i=1}^{i=N} \alpha_i ln(z_i) + 0.5 \sum_{i=1}^{i=N} \sum_{j=1}^{j=N} \beta_{ij} ln(z_i) ln(z_j) + \epsilon; \tag{1'}$$

with α_0 being the intercept, α_i the coefficient of characteristic i, and β_{ij} is the coefficient of the characteristics i and j interacting. We do not assume that the error terms ϵ are independent and normally distributed but use heteroskedasticity robust standard errors (White's estimator).[4] The coefficients β are estimated subject to the symmetry restriction $\beta_{ij} = \beta_{ji}$

Ekeland et al. (2002) show that empirical results estimated from hedonic models depend on functional assumptions that may be arbitrary. Although we are convinced that the translog can be defended from a practical and theoretical point of view, we also try semi-log and linear models with varying sets of explanatory variables and verify that our hedonic regression estimates for Eq. (1′) are not artifacts caused by the choice of a specific functional form.

A crucial advantage of the translog function becomes apparent when calculating q_i by taking partial derivatives from q with respect to z_i.[5]

$$q_i = \left(\alpha_i + \sum_{j=1}^{N} \beta_{ij} ln(z_j) \right) \frac{q}{z_i}. \tag{2'}$$

As Green and Hendershott (1996) point out, a translog function does not impose a common price for each hedonic characteristic, like e.g. a linear model would. Instead,

[2] The United Nations project the population growth from 2010 to 2050 to be 15%, while the US will enjoy a total population increase of 28% (UNDP, 2012).

[3] Council tax is the only residential property tax in the UK. Council tax is paid by the resident and not necessarily by the owner. We account for council tax support granted to economically weak households. Full time students are excempt from council tax.

[4] The estimated coefficients that enter Eq. (2′) will remain unbiased even in the presense of heteroscadasticity in the error terms – but the standard errors in Table 4 would be wrong.

[5] With q being the antilog of (1′), taking partial derivatives (chain rule) of q leads to $\frac{\partial q}{\partial z_i} = q\left(\frac{\partial}{\partial z_i} ln(q)\right)$. Plugging in ((1′)) for $ln(q)$ and dropping terms that do not depend on z_i results in: $q\left(\frac{\partial}{\partial z_i}(\alpha_i ln(z_i)) + \frac{\partial}{\partial z_i}\left(0.5\sum_{j=1}^{N}\beta_{ij} ln(z_i) ln(z_j)\right) + \frac{\partial}{\partial z_i}\left(0.5\sum_{j=1}^{N}\beta_{ji} ln(z_i) ln(z_j)\right)\right) = \frac{\alpha_i q}{z_i} + 0.5q\sum_{j=1}^{N}\frac{\beta_{ij} ln(z_j)}{z_i} + 0.5q\sum_{j=1}^{N}\frac{\beta_{ji} ln(z_j)}{z_i}$. Using the symmetry constraint $\beta_{ij} = \beta_{ji}$, we can further simplify and obtain Eq. (2′).

substantial variation in q_i is generated by nonlinearities in Eqs. (1′) and (2′). Even in the ideal case of perfect markets and identical cost functions for housing suppliers, sufficient variation in q_i will be caused by differences in dwelling-specific hedonic configurations and levels of q. This enables us to link marginal prices to a household's demographic profile in the next step, regressing q_i on the demographic variables and on the level of z_i:

$$q_i = \gamma_0 + \gamma_z z_i + \sum_{a=1}^{a=5} \gamma_a A_a + \psi X + \gamma_y Y + \sum_{a=1}^{a=5} \gamma_{ya} Y A_a + \mu \qquad (3')$$

Here, the γ's are coefficients for the intercept and the level of z_i, A_a are dummies for 5 age cohorts. Y is the household's income, while the vector ψ contains the coefficients for the other demographic variables in X, and μ is independently and normally distributed. The service flow provided by the ith hedonic characteristic given a specific demographic profile (A, X, Y) can later be calculated by evaluating Eq. (3′).

Eq. (2′) states that imputed prices for each hedonic characteristic are in fact marginal prices: the level of the hedonic characteristic z_i influences the marginal price q_i (Green and Hendershott, 1996). For example, the willingness to pay for one additional square meter of interior floor space depends on the current size of the dwelling. However, a household's unobservable taste will impact both the price and the quantity – someone with a strong preference for detached homes will not only be willing to pay more for one but is also likely to live in one. In this case, the error term μ will be correlated to the left hand side q_i, and to avoid this endogeneity we use two-stage least squares (2SLS), as suggested by Bartik (1987). Finding truly exogenous instrumental variables that allow us to estimate levels for each hedonic attribute in the first regression is a challenge. Geographic classifications are commonly used instruments (Bartik, 1987; Green and Hendershott, 1996; Woolridge, 2010) since they can be easily defended as demand shifters uncorrelated to unobserved tastes. This is why we also employ regional dummies as instruments.

In contrast to Green and Hendershott, we do not use non-housing income as an instrument since we cannot be certain that income (even net of housing) is uncorrelated with a household's social background, which is likely to influence housing tastes. Fortunately, our sample offers information as to whether a dwelling has been inherited, which we use as an instrument instead: Somebody who inherited a house did not choose the hedonic specification of it. At the same time, inherited houses tend to be bigger (median for interior floor space is 22% higher) and to be erected earlier and thereby possess hedonic attributes different from those that have not been passed on.[6] When regressing the marginal prices of regional dummies, we do not employ instruments – again, the regions are considered exogenous variables.

The left hand side of Eq. (3′) features the derived variable q_i. Although this metric includes regression coefficients from Eq. (1′), the marginal prices are not fitted values (see Eq. 2) and can be used without further adjustments as the dependent variables in Eq. (3′).

We carefully model the changes in the households' demographic characteristics as they age. In our sample, variables like educational level, gender, and ethnicity show clear differences across cohorts (see Table 3). We do not expect these to change as cohorts grow older and therefore keep them constant per cohort. However, variables like the household's size, employment status, physical fitness, and income,[7] as well as the presence of children and the average retirement level in a cohort are unlikely to stay constant throughout the life-cycle (see Ermisch, 1996). We assume for every cohort that these life-cycle variables have the same values as they did for the cohorts before them at that age.

The cross-sectional nature of our data does not allow us to disentangle age- and cohort-related income dynamics – with just one snapshot in time, we cannot tell whether a particular cohort will earn more or less when reaching the age of an earlier cohort. Like Campbell et al. (2001), we therefore use income dynamics estimates derived from a separate household panel when calibrating life-cycle income dynamics. We use the 1991–2001 waves from the British Household Panel Survey (BHPS) and estimate a fixed effects model that identifies representative income paths.[8] We then extrapolate the income for each household in our English Housing Condition Survey sample at different age levels based on these age-income paths. To give an example, the BHPS predicts an income increase by 15% from age 45 to 50. We apply this growth rate to predict the income levels at 50 of those currently aged 45. Projected Income will indeed be lower than the sample means for the younger cohorts and higher for seniors.

Like any hedonic study in housing, the hedonic regression suggested in this paper is likely to suffer from omitted variable bias by some degree. Despite the good level of detail in the hedonic variables, we cannot exclude the possibility of a bias in the estimated regression coefficients which subsequently influences the marginal prices of observed attributes. We do not see a viable empirical solution to this concern. Partial remedies like spatial models (e.g. Pace and LeSage, 2010) are not feasible for this sample as fine-grained location data are missing. The ultimate goal of this paper, however, is not to establish unbiased marginal prices for each hedonic characteristic but to link housing demand to demographics. If one hedonic variable is subject to omitted variable bias, it effectively describes a bundle of several underlying attributes. We cannot fully disentangle the true

[6] As a robustness check, we also estimate Eq. (3′) with robust ordinary least squares and verify that the regression results are not contradicting.

[7] Hwang and Quigley (2006), who established the causality relationship between income and housing services consumed, found that exogenous increases in aggregated income drive house prices up.

[8] The British Household Panel Survey data and documentation is available at https://www.iser.essex.ac.uk/bhps. We estimate the following panel regression:

$$ln(income)_{i,t} = \alpha_i + \sum_{a=21}^{a=75} \beta_a A_{a,i,t} + \sum_{a=21}^{a=75} \sum_{edu=1}^{edu=3} \gamma_{a,edu} AEduc_{a,edu,i,t} + \epsilon_{i,t}$$

where α_i is capturing household fixed effects, A_a is a dummy variable equal to 1 for households headed by someone aged a (and 0 otherwise), $AEduc$ are age-education interaction dummies, β and γ are coefficients, and ϵ is independently and normally distributed. The full panel regression results are available from the authors upon request.

Table 1
Regional distributions of housing type and age of dwelling.

Region	Dwelling type (in %)					Dwelling age cohort (in %)								
	Small terraced	Large terraced	(Semi-) detached	Bungalow	Apartment	Pre 1850	1850–1899	1900–1918	1919–1944	1945–1964	1965–1974	1975–1980	1981–1990	1990–2001
North East	12	17	47	10	13	1	4	10	18	26	17	6	11	7
Yorkshire & Humber	14	16	45	12	12	3	11	9	18	22	14	6	11	5
North West & Mersey	16	18	45	8	13	2	11	12	20	20	13	5	11	6
East Midlands	10	12	55	14	8	4	7	7	14	22	16	8	13	8
West Midlands	15	16	49	7	14	2	7	8	19	25	16	6	11	6
South West	12	15	45	14	13	7	8	7	12	20	15	8	15	7
Eastern	12	12	46	15	15	4	5	5	12	22	19	9	14	9
South East	10	14	48	10	18	3	8	7	13	23	17	8	14	7
Outer London	13	20	32	2	34	0	8	10	39	15	11	4	7	5
Inner London	7	22	5	1	65	1	21	14	15	17	12	5	9	6
England total	13	16	44	10	18	3	9	9	17	22	15	7	12	7

Dwelling types are relatively similarly distributed in 8 out of 10 regions. (Semi-) detached houses and bungalows make up the largest share, followed by terraced houses and apartments. Inner and Outer London, however, have a different structure, with fewer houses and a higher share of apartments. Large regional differences with respect to the age structure of houses can be observed.

Table 2
Total number of owner occupied or privately rented dwellings and average dwelling prices.

Regions	Tenure (in %)			Average price (in £)			
	# (in million)	Owner occupied	Private rent	Terraced	Detached	Bungalow	Apartments
North East	0.77	90.5	9.5	42,774	75,285	79,332	40,079
Yorkshire & Humber	1.65	87.2	12.8	48,417	85,245	76,334	58,836
North West & Mersey	2.20	88.6	11.4	43,952	94,270	84,649	53,722
East Midlands	1.48	89.2	10.8	52,883	102,856	93,336	38,154
West Midlands	1.60	92.2	7.8	54,454	105,750	111,789	56,894
South West	1.78	88.4	11.6	84,107	145,635	125,584	72,046
Eastern	1.89	89.2	10.8	96,356	153,136	117,680	76,201
South East	2.90	87.4	12.6	111,728	215,237	159,019	83,024
Outer London	1.50	85.4	14.6	152,590	242,808	211,440	112,374
Inner London	0.69	71.7	28.3	295,674	491,748	217,515	173,685
England total	16.57	87.7	12.3	90,996	161,360	125,771	73,640

Notes: A pronounced north-south difference can be observed. Prices of dwellings in the northern regions are less than half the prices of those in the southern regions (not correcting for quality). London has a special role again, with private residential property values being twice as high as the national average.

effect of each of these core quality characteristics, but implicitly treat them as one out of many bundles of housing services that jointly account for total housing services consumed. As long as the relative attractiveness of the components within each of these bundles does not change as residents' demographic profiles change, the aggregate housing demand as a function of demographics will be unaffected by any omitted variable bias.

3. Data

This paper builds on data collected for the English Housing Condition Survey (EHCS). The EHCS is a study undertaken by the Office of the Deputy Prime Minister to assess the condition of the English[9] housing stock and to evaluate the effect of housing market policies. A representative cross-section of households is interviewed about their views on their home and neighborhood, their income and housing costs, and about demographic details of the household and its members. Additional information on the interior and exterior condition of the dwelling, its energy efficiency, and the local environment is obtained by a subsequent professional inspection. Each dwelling's market value is estimated by two professional appraisers independently (Office of the Deputy Prime Minister, 2003). From 1971 until 2001, the EHCS was conducted every five years. Since April 2002 the EHCS has been running on a continuous basis.

The EHCS gradually evolved over time, which prevents us from combining multiple survey-years as quasi-panels. Several demographic key variables like the education of the household's members were only introduced in 2001. Our later analysis shows that especially the educational achievement is crucial in explaining the willingness to pay for housing, thus we do not consider the pre-2001 cross-sections, which lack this information. After 2001, the number of observations per year is only half of the

[9] Similar studies have been undertaken for Wales and Scotland, but unfortunately these surveys are not entirely equivalent to the EHCS. We will therefore use English data only.

Table 3
Mean values for demographic variable, per cohort.

Variable	Cohort				
	15–29	30–39	40–49	50–64	65–85
Income (£)	17,242	23,497	25,096	20,479	10,568
Household size	2.45	3.03	3.15	2.27	1.58
Retired	0.00	0.00	0.01	0.17	0.92
Children in household	0.20	0.50	0.47	0.11	0.00
Longterm illness	0.07	0.10	0.17	0.28	0.36
Disability	0.02	0.03	0.05	0.12	0.16
Female HRP	0.33	0.21	0.20	0.20	0.37
Ethnic black	0.04	0.04	0.03	0.01	0.01
Ethnic Asian	0.05	0.04	0.05	0.03	0.01
Education					
No formal	0.12	0.13	0.25	0.42	0.68
Up to GCSE	0.36	0.38	0.29	0.20	0.13
Up to A level	0.23	0.20	0.17	0.12	0.07
Up to degree	0.20	0.18	0.19	0.16	0.09
Higher degree/postgrad.	0.08	0.11	0.11	0.10	0.03
Projected income (£)	15,312	22,619	25,085	21,010	10,887

Notes: The table presents mean values for core demographic variables in 2001, weighted for national representativeness. Income is the mean annual net income at the household level, including income from savings, pensions and housing benefits. *Projected income* is calculated using British Household Panel Survey (BHPS) income dynamics (Fig. 1): For each age-range, this value represents the theoretical mean income of all cohorts at this age. These values are lower for younger cohorts since the cohort aged 15–29 in 2001 has a higher real income than the 50–64 cohort 35 years earlier.

2001 survey and the level of detail is substantially lower, making pooling of data from several years or follow-up analyses for later years unfeasible.[10]

For 17,500 dwellings a full interview, physical survey, and market valuation is obtained. Excluding vacant dwellings leaves us with a sample of 16,749 households covering all tenures and regions. The EHCS is based on a stratified sample with over-sampling of the rented tenures, which otherwise would be too small a sample to allow for reliable statistical inference. As a consequence of this sampling technique, each observation must later be weighted with a grossing factor when calculating aggregated national figures from this sample (ODPM, 2002).

The rental market for housing is subject to two strong sources of governmental intervention: first, Local Authorities (LA) and Registered Social Landlords (RSL) offer relatively inexpensive housing to low- and middle-income households. Affordability is important, since the median of the income[11] of tenants from RSL or LA dwellings is only two thirds of the median of income renters in the unregulated market. Second, a substantial share of low-income households are eligible for direct housing subsidies, especially the very young and the old households. When housing benefits are paid, they amount to 85% of rent, on average.

For this study, both forms of state intervention cause severe distortions, since it is likely that subsidies will shift demand for different housing attributes upward, and the choice of dwelling characteristics will no longer be solely determined by the household's housing preferences and budget. We therefore exclude all dwellings rented from Local Authorities and Registered Social Landlords, which further reduces our sample to 9453 observations. The remaining observations are still representative for 80% of the English housing stock, according to the government office conducting the survey (ODPM, 2002).

The EHCS classifies dwellings into the following categories: small terraced houses, large terraced houses, (semi-) detached houses, bungalows, and apartments.[12] Dwelling types are relatively similarly distributed in 8 out of 10 regions. (Semi-) detached houses and bungalows make up the largest share (54%), followed by terraced houses (29%) and apartments (18%). Inner and Outer London, however, have a different structure, with fewer houses (35% and 67%, respectively) and a higher share of apartments.[13]

With respect to the year of construction, all dwellings are clustered into 9 groups.[14] We observe large regional differences in the age of the housing stock. Our data suggest a natural selection process in favor of quality: Buildings erected before 1900 (all other attributes equal) are the most sought after houses (Table 4, last column). High-quality

[10] Overall, demographic changes between 2001 and 2004 are not very pronounced, since the period is relatively short. Possible changes in demand patterns over time will be mainly caused by other factors like the expected changes in house prices, risk premia, or the cost of housing finance. In sum, we prefer the richness of the 2001 data set over the combination of more years.

[11] Income is the annual net income of the household reference person and any partner from wages, pensions, savings and social benefits. It does not include housing related benefits such as council tax benefit, housing benefit, Income Support Mortgage Interest or any payments made under a Mortgage Payment Protection Insurance policy (ODPM, 2002).

[12] A *small terraced house* is a house forming part of a block where at least one house is attached to two or more other houses. It has a floor space up to 70 m^2, in contrast to the *medium/large terraced house*, which is bigger than 70 m^2. *Semi-detached houses* are houses that are attached to one other house, whereas none of the habitable structure of a *detached house* is joined to another dwelling. *Bungalows* are houses with all of the habitable accommodation on one floor. We do not further classify *apartments* into possible sub-categories like apartments in high-rise versus low-rise buildings or converted apartments versus purpose-built apartments.

[13] Table 1 provides additional summary statistics.

[14] The EHCS construction-classifications are: pre 1850, 1850–1899, 1900–1918, 1919–1944, 1945–1964, 1965–1974, 1975–1980, 1981–1990, 1991–2001.

Table 4
Mean values, hedonic regression results, and estimated marginal prices (q_i).

Variable	Mean	Coefficient	Interaction with dwell. type					Mean q_i
			Bungalow	Detached	Med./large terraced	Semi-det.	Small terraced	
Intercept		**6.91** [0.09]						
ln(Int. area)	4.44	**0.26** [0.02]	**0.31** [0.03]	**0.35** [0.03]	**0.22** [0.04]	**0.22** [0.03]	−**0.12** [0.05]	27.41
ln(Lot size)	5.52	−**0.01** [0]	**0.01** [0]	**0.02** [0.01]	**0.02** [0]	**0.01** [0]	**0.01** [0]	0.18
$Region_{Yorks\&Humber}$	0.10	**0.05** [0.02]	−**0.1** [0.03]	−0.07 [0.04]	0 [0.03]	−**0.06** [0.03]	−0.02 [0.03]	3.01
$Region_{WMidlands}$	0.10	**0.08** [0.02]	0.03 [0.03]	**0.12** [0.04]	**0.08** [0.03]	**0.06** [0.03]	0.06 [0.03]	66.29
$Region_{SW}$	0.10	**0.16** [0.02]	**0.1** [0.03]	**0.14** [0.04]	**0.16** [0.03]	**0.11** [0.03]	**0.18** [0.03]	155.04
$Region_{SE}$	0.16	**0.21** [0.02]	0.06 [0.04]	**0.28** [0.04]	**0.15** [0.04]	**0.16** [0.03]	**0.17** [0.04]	469.80
$Region_{O/London}$	0.09	**0.49** [0.03]	**0.24** [0.07]	**0.28** [0.07]	**0.32** [0.04]	**0.35** [0.03]	**0.21** [0.04]	498.39
$Region_{NW\&Mersey}$	0.14	**0.07** [0.02]	−0.06 [0.04]	0.02 [0.04]	−0.02 [0.03]	0.01 [0.03]	−0.01 [0.03]	35.72
$Region_{I/London}$	0.06	**0.46** [0.02]	0.04 [0.09]	**0.41** [0.12]	**0.49** [0.04]	**0.43** [0.06]	**0.24** [0.05]	289.46
$Region_{EMidlands}$	0.09	**0.08** [0.02]	−0.03 [0.03]	−0.01 [0.04]	0.02 [0.03]	−0.04 [0.03]	0.04 [0.03]	24.28
$Region_{Eastern}$	0.11	**0.14** [0.02]	0.02 [0.03]	**0.21** [0.04]	**0.2** [0.03]	**0.18** [0.03]	**0.2** [0.04]	192.02
Parking	0.63	**0.03** [0.01]	**0.06** [0.03]	0.09 [0.05]	0.01 [0.02]	**0.03** [0.02]	0.02 [0.02]	331.06
Owner occ.	0.71	**0.09** [0.02]	0.01 [0.03]	**0.2** [0.06]	−**0.17** [0.02]	−0.04 [0.02]	−**0.27** [0.02]	437.90
No vacancies	0.86	0 [0.01]	0 [0.02]	−0.05 [0.03]	**0.07** [0.02]	**0.04** [0.02]	0.02 [0.02]	37.97
$Neig_{Urban}$	0.22	−0.02 [0.02]	−0.06 [0.04]	−**0.12** [0.04]	−0.02 [0.03]	0 [0.03]	−0.03 [0.03]	−40.77
$Neigh_{Suburban}$	0.55	0 [0.02]	−0.03 [0.02]	−0.05 [0.03]	−0.02 [0.03]	0.01 [0.02]	−0.01 [0.03]	−52.92
$Neigh_{CityCenter}$	0.03	0.05 [0.03]	−0.14 [0.09]	**0.23** [0.09]	0.07 [0.06]	−0.05 [0.07]	−0.04 [0.05]	13.87
High demand	0.28	**0.15** [0.02]	0.03 [0.03]	**0.08** [0.03]	**0.12** [0.03]	**0.07** [0.02]	**0.1** [0.03]	462.64
Central heat.	0.94	0 [0.02]	−0.06 [0.08]	0.07 [0.08]	**0.07** [0.03]	0 [0.03]	0.05 [0.03]	149.53
Public transp.	0.12	**0.03** [0.02]	−0.04 [0.03]	0.04 [0.04]	0 [0.03]	−0.03 [0.02]	0 [0.03]	20.06
$YOC_{pre1850}$	0.03	**0.19** [0.07]	−0.11 [0.12]	−0.08 [0.08]	0.15 [0.09]	0.11 [0.08]	−0.07 [0.09]	48.75
$YOC_{1981-1990}$	0.12	−**0.06** [0.03]	−0.01 [0.04]	0.06 [0.04]	0.07 [0.05]	**0.08** [0.04]	0.07 [0.04]	−7.33
$YOC_{1975-1980}$	0.07	−**0.1** [0.03]	0.07 [0.04]	**0.1** [0.04]	**0.11** [0.05]	**0.09** [0.04]	0.09 [0.05]	−8.76
$YOC_{1965-1974}$	0.15	−**0.14** [0.03]	0.08 [0.04]	**0.15** [0.04]	**0.14** [0.05]	**0.15** [0.04]	**0.1** [0.04]	−23.95
$YOC_{1945-1964}$	0.21	−**0.15** [0.02]	**0.13** [0.04]	**0.21** [0.04]	**0.16** [0.05]	**0.13** [0.03]	**0.09** [0.04]	−24.65
$YOC_{1919-1944}$	0.18	−0.02 [0.03]	0.01 [0.05]	**0.13** [0.04]	0.08 [0.05]	0.06 [0.04]	−0.02 [0.04]	38.93
$YOC_{1900-1918}$	0.09	0.01 [0.04]	−0.08 [0.12]	0.1 [0.06]	0.09 [0.06]	**0.13** [0.05]	0.02 [0.05]	38.40
$YOC_{1850-1899}$	0.09	**0.12** [0.04]	−0.16 [0.1]	−0.1 [0.06]	0.02 [0.06]	0.05 [0.05]	−0.08 [0.05]	57.24
$Type_{SmallTerraced}$	0.13	0.38 [0.21]					−1.62	
$Type_{Semi-detached}$	0.28	−**1.11** [0.12]					322.22	
$Type_{Med/LargeTerraced}$	0.16	−**1.27** [0.19]					94.73	
$Type_{Detached}$	0.16	−**1.71** [0.18]					893.30	
$Type_{Bungalow}$	0.10	−**1.18** [0.16]					163.46	
		# observations		9453	Adjusted R^2		0.66	

Notes: The table presents means of the explanatory variables (first column) and regression coefficients from Eq. (1′). Robust standard errors in brackets. Coefficients that are sigificantly different from 0 at the 5% confidence level in bold. Marginal prices q_i in £/year (last column) are calculated using Eq. (2′). The average values of q_i are average annual premium residents pay for an additional unit of *i*. For example, living in a detached house (in contrast to an apartment) is valued £893.

dwellings or houses at unique locations are more likely to survive, which will be reflected in relatively higher values for the very old cohorts.

A pronounced north–south difference can be observed in our sample with regard to age. Prices of dwellings in the northern regions are less than half of those in the southern regions (not correcting for quality). London has a special role again, with residential property values being twice as high as the national average (Table 2).

3.8% of all households in our sample live in dwellings that fail to meet minimal quality standards and are regarded 'unfit' for housing according to the law.[15] Again, Inner London has a special position with twice the national percentage of unfit dwellings, which might be caused by the relatively old housing stock and low home-ownership rates, but it is also possible that this is the result of a rational trade-off between the advantages of living in a large metropolis, and the disadvantages of living in a very low-quality (but likely also cheap) dwelling.

When analyzing the demographic characteristics of households in our sample, we follow the EHCS definition for *Household Reference Persons (HRP)*, representing the household's social and economic position. The HRP is the person in whose name the dwelling is owned or rented or who is otherwise responsible for the accommodation. When two or more people jointly own or rent the dwelling, the person with the highest income is taken as HRP (ODPM, 2002).

Educational levels differ significantly across age groups in the sample. More than 50% of all residents aged 65 and above do not reach the General Certificate of Secondary Education (GCSE) or comparable level, as opposed to merely 12% for the 25–29-year-olds. Of the 25–29-year-olds 38% are holding a university degree, compared to less

[15] For a dwelling to be fit under Section 604 of the 1989 Local Government and Housing Act it must satisfy criteria related to: the state of (dis)repair; structural stability; dampness; lighting, heating and ventilation; water supply; drainage; facilities for food preparation; and the presence, location and functioning of essential utilities (WC, bath/shower, and sink).

Table 5
Explaining marginal prices by demographic attributes

House characteristic	Intercept	z_i	HH Size	Retired	Children	Female	Ethnic (vs. white)		Education level (versus no formal)			
							Asian	Black	GCSE	A level	Degree	Higher
$YOC_{pre1850}$	−**21**[9]	**1526**[86]	1[2]	**23**[7]	7[6]	**15**[4]	−3[10]	1[10]	−5[5]	−4[6]	−2[7]	**28**[9]
$YOC_{1850-1899}$	−**129**[14]	**1498**[59]	**14**[3]	18[11]	6[9]	**13**[6]	−**117**[16]	−**51**[15]	−**18**[7]	1[9]	−6[10]	3[12]
$YOC_{1900-1918}$	−**57**[9]	**386**[51]	**14**[1]	5[6]	−**14**[4]	3[3]	−**25**[9]	−**18**[8]	5[4]	**22**[5]	**32**[5]	**55**[7]
$YOC_{1919-1944}$	−**55**[8]	**219**[23]	**4**[1]	**19**[6]	4[5]	−2[3]	13[8]	−**18**[8]	**16**[4]	**32**[5]	**41**[5]	**60**[6]
$YOC_{1945-1964}$	−**203**[22]	**304**[60]	**6**[2]	**19**[9]	6[7]	−4[5]	17[14]	−**39**[12]	**31**[6]	**58**[9]	**80**[11]	**78**[13]
$YOC_{1965-1974}$	−**89**[13]	**149**[61]	**9**[1]	−8[6]	2[4]	−2[3]	−**29**[8]	−**29**[8]	**10**[4]	−1[5]	**15**[5]	12[7]
$YOC_{1975-1980}$	−**18**[3]	−45[29]	**4**[0]	−3[2]	−3[2]	−2[1]	−**8**[3]	−**6**[3]	1[1]	−1[2]	0[2]	**5**[2]
$YOC_{1981-1990}$	−**8**[2]	−**67**[20]	**2**[0]	−**4**[2]	1[1]	1[1]	−4[2]	−**8**[2]	2[1]	**3**[1]	3[1]	0[2]
Public transp.	−**21**[4]	**269**[11]	**3**[1]	1[3]	−**6**[2]	0[2]	−3[4]	−**14**[4]	3[2]	**5**[2]	**12**[3]	**18**[3]
Central heat.	−**222**[63]	**156**[71]	**35**[2]	13[10]	−**17**[8]	**21**[6]	9[13]	−**38**[13]	**34**[6]	**79**[8]	**147**[9]	**210**[11]
High demand	−**214**[24]	**1520**[24]	**38**[5]	**53**[19]	−26[15]	**27**[11]	−8[26]	−**64**[26]	**29**[12]	**74**[16]	**221**[16]	**313**[21]
$Neigh_{CityCenter}$	−**20**[5]	**531**[20]	**5**[1]	1[4]	−**8**[3]	1[2]	−1[6]	−**38**[6]	5[3]	5[3]	**12**[3]	**21**[5]
$Neigh_{Suburban}$	**34**[7]	−**41**[8]	−**5**[1]	−**19**[4]	−2[3]	0[2]	3[6]	**17**[6]	−**9**[3]	−**31**[3]	−**47**[3]	−**57**[4]
$Neig_{Urban}$	**59**[6]	−**234**[10]	−**8**[1]	−**12**[4]	4[3]	0[3]	**39**[7]	**41**[7]	−**12**[3]	−**21**[4]	−**30**[4]	−**40**[5]
No vacancies	−**100**[17]	**198**[18]	**22**[2]	−**37**[9]	−**41**[7]	7[5]	**39**[11]	5[12]	−11[6]	−**19**[7]	−**49**[7]	−**22**[9]
Owner occ.	−**529**[47]	**1337**[143]	**41**[9]	78[40]	**62**[29]	**205**[31]	−**304**[49]	16[58]	−**105**[36]	−55[49]	83[54]	**175**[57]
Parking	−**263**[16]	**623**[28]	**8**[3]	**66**[12]	**25**[9]	**44**[8]	19[17]	3[18]	15[8]	**66**[11]	**151**[11]	**208**[13]
$Region_{Eastern}$	−**116**[13]	**1550**[30]	**9**[3]	34[20]	24[15]	**28**[11]	−14[10]	−**19**[9]	**17**[9]	**51**[14]	**70**[16]	**74**[25]
$Region_{EMidlands}$	−**9**[2]	**266**[5]	**2**[1]	2[3]	−1[2]	2[1]	−1[2]	−1[1]	**3**[1]	**5**[2]	**13**[2]	**17**[3]
$Region_{l/London}$	−**319**[57]	**5212**[157]	**76**[16]	**106**[49]	−59[51]	17[33]	−**387**[110]	−**991**[128]	**106**[28]	**176**[43]	**417**[59]	**626**[105]
$Region_{NW\&Mersey}$	−**12**[2]	**237**[4]	**2**[1]	3[3]	2[2]	−1[1]	−5[3]	−**2**[1]	**5**[1]	**10**[2]	**14**[3]	**22**[5]
$Region_{O/London}$	−**516**[136]	**5169**[112]	**39**[16]	**117**[44]	62[46]	27[26]	45[69]	−**236**[55]	29[22]	**115**[40]	**118**[49]	**225**[73]
$Region_{SE}$	−**201**[26]	**2438**[55]	**24**[6]	34[36]	−12[20]	4[15]	−**50**[17]	−16[12]	24[15]	**71**[23]	**222**[35]	**231**[49]
$Region_{SW}$	−**97**[11]	**1417**[24]	**17**[4]	13[15]	−8[10]	−**11**[5]	−**22**[6]	−**16**[7]	**22**[6]	**52**[10]	**78**[10]	**113**[20]
$Region_{WMidlands}$	−**54**[7]	**584**[13]	**9**[1]	5[6]	−6[5]	2[3]	−**16**[7]	−**19**[4]	**7**[3]	**22**[5]	**36**[6]	**55**[10]
$Region_{Yorks\&Humber}$	4[4]	**48**[3]	1[1]	−**4**[2]	−**3**[1]	**2**[1]	**6**[2]	2[1]	−1[1]	2[1]	−2[1]	−1[2]
$Type_{Bungalow}$	−**91**[24]	**1589**[129]	**15**[5]	19[19]	−17[14]	−1[11]	−6[24]	2[25]	**44**[12]	**77**[14]	**71**[15]	**71**[20]
$Type_{Detached}$	−**486**[76]	**5371**[293]	21[14]	**168**[61]	41[46]	**159**[34]	17[80]	−24[82]	−26[40]	67[55]	**184**[70]	**205**[80]
$Type_{Med/LargeTerraced}$	−**255**[85]	**5181**[563]	−**222**[38]	**160**[72]	**258**[68]	−**103**[43]	−**371**[109]	150[92]	58[43]	**163**[55]	**309**[57]	**358**[73]
$Type_{Semi-detached}$	4[66]	−**1428**[161]	**116**[13]	83[51]	**95**[39]	−39[30]	−**353**[74]	−**274**[74]	**106**[32]	**193**[40]	**151**[42]	**171**[55]
$Type_{SmallTerraced}$	**312**[53]	−**1112**[170]	2[5]	−**60**19]	−7[14]	**37**[10]	−11[23]	24[24]	−**35**[12]	−**54**[16]	−**71**[17]	−**61**[21]
Lot size (m^2)	**0.26**[0.02]	−**0.00**[0.00]	**0.04**[0.00]	**0.06**[0.02]	−**0.06**[0.01]	−0.00[0.01]	0.02[0.02]	−0.03[0.03]	**0.07**[0.01]	**0.12**[0.01]	**0.21**[0.01]	**0.32**[0.02]
Interior space (m^2)	**33.04**[2.23]	−**0.48**[0.05]	**4.40**[0.38]	**5.52**[0.83]	−**1.49**[0.61]	−0.12[0.45]	−**3.95**[1.07]	−**7.20**[1.18]	**5.16**[0.56]	**12.07**[0.82]	**19.51**[1.17]	**24.26**[1.42]
$YOC_{pre1850}$	−1[5]	7[7]	−4[9]	1[9]	−**18**[9]	−**79**[12]	0.27[0.30]	0.14[0.39]	0.44[0.33]	**1.42**[0.36]	**6.95**[0.62]	
$YOC_{1850-1899}$	−4[7]	11[10]	−24[14]	18[13]	**30**[13]	**43**[18]	−0.01[0.44]	**1.94**[0.57]	0.15[0.48]	**1.21**[0.52]	0.08[0.88]	
$YOC_{1900-1918}$	−3[4]	−3[5]	−**15**[7]	10[7]	**21**[7]	18[10]	−0.24[0.23]	**1.15**[0.30]	**0.52**[0.25]	0.50[0.27]	**1.36**[0.46]	
$YOC_{1919-1944}$	−4[4]	−4[5]	−10[7]	7[7]	−3[7]	−9[10]	−0.28[0.24]	**0.93**[0.31]	**0.57**[0.26]	**2.04**[0.28]	**3.04**[0.48]	
$YOC_{1945-1964}$	−10[6]	−1[8]	7[11]	**41**[10]	**44**[10]	11[14]	**1.14**[0.37]	0.14[0.45]	−0.57[0.39]	−0.20[0.41]	1.36[0.71]	
$YOC_{1965-1974}$	−6[4]	1[5]	2[7]	11[7]	**19**[7]	**20**[10]	0.03[0.23]	0.58[0.30]	0.13[0.25]	0.13[0.28]	0.20[0.47]	
$YOC_{1975-1980}$	−**3**[1]	−3[2]	4[2]	**6**[2]	**5**[2]	1[3]	0.05[0.08]	−0.01[0.10]	−0.06[0.09]	0.01[0.09]	0.26[0.16]	
$YOC_{1981-1990}$	0[1]	−3[2]	2[2]	**6**[2]	**4**[2]	−4[3]	**0.20**[0.07]	−0.09[0.09]	−**0.19**[0.08]	−**0.20**[0.08]	−0.02[0.15]	
Public transp.	−**7**[2]	**6**[3]	−5[4]	−6[4]	−5[4]	−**25**[5]	0.19[0.12]	−0.02[0.16]	−0.10[0.14]	0.08[0.15]	**1.60**[0.25]	
Central heat.	−**24**[6]	−**20**[9]	−14[12]	**51**[11]	**34**[11]	−20[16]	**2.26**[0.39]	0.86[0.50]	−0.84[0.43]	**2.03**[0.46]	**5.15**[0.78]	
High demand	−**34**[12]	−26[17]	−**98**[24]	22[22]	−4[23]	−62[32]	0.15[0.79]	**5.49**[1.01]	**2.06**[0.86]	**8.37**[0.92]	**13.92**[1.57]	
$Neigh_{CityCenter}$	−1[3]	−2[4]	−**20**[5]	−1[5]	1[5]	3[7]	−0.04[0.17]	**1.08**[0.22]	0.06[0.19]	0.38[0.20]	0.01[0.35]	
$Neigh_{Suburban}$	**8**[3]	2[4]	5[5]	−**18**[5]	−**13**[5]	10[7]	0.01[0.17]	−**0.73**[0.22]	−0.29[0.19]	−**1.44**[0.20]	−**3.23**[0.34]	

$Neig_{Urban}$	**7**[3]	3[4]	**13**[6]	−6[5]	−10[5]	10[7]	−0.20[0.18]	−**0.70**[0.23]	−0.02[0.20]	−0.36[0.21]	−**2.85**[0.36]
No vacancies	−1[5]	11[8]	−**45**[11]	−**37**[10]	−8[10]	**29**[14]	−**1.22**[0.35]	**2.14**[0.45]	**1.03**[0.38]	−**1.76**[0.41]	−**4.75**[0.69]
Owner occ.	**106**[30]	29[35]	−57[48]	−**197**[67]	−**290**[73]	−**322**[67]	0.60[1.63]	−**7.37**[2.06]	1.00[1.66]	**14.02**[1.74]	**24.98**[3.28]
Parking	−9[8]	−**30**[11]	−13[15]	**53**[15]	13[16]	−**53**[20]	**2.59**[0.49]	0.04[0.64]	−0.83[0.54]	**4.43**[0.58]	**10.97**[1.04]
$Region_{Eastern}$	−9[7]	−7[9]	−8[14]	29[35]	**42**[21]	−139[71]	0.61[0.39]	**2.13**[0.79]	1.40[1.70]	1.94[1.11]	**16.04**[6.01]
$Region_{EMidlands}$	−**3**[1]	1[1]	−**8**[4]	−1[2]	0[2]	−**8**[4]	−0.12[0.08]	**0.45**[0.20]	0.18[0.10]	**0.23**[0.10]	**0.71**[0.23]
$Region_{I/London}$	−30[33]	−**71**[33]	−**389**[92]	−55[71]	5[67]	40[77]	−1.02[1.13]	**15.20**[4.92]	4.14[2.82]	**6.49**[3.05]	2.02[3.99]
$Region_{NW\&Mersey}$	−**3**[1]	−**4**[2]	−3[2]	1[2]	3[2]	−8[8]	−0.09[0.06]	**0.23**[0.10]	0.16[0.09]	**0.23**[0.10]	1.07[0.65]
$Region_{O/London}$	−17[25]	−**68**[24]	68[133]	**298**[133]	245[165]	76[173]	**20.16**[9.24]	−10.10[9.34]	−**18.45**[9.27]	−10.21[10.74]	5.40[13.68]
$Region_{SE}$	−23[17]	−26[16]	−29[28]	51[47]	−45[81]	−6[54]	−0.80[0.67]	**4.48**[1.54]	3.58[2.30]	**13.13**[4.29]	**9.31**[2.69]
$Region_{SW}$	−9[6]	−**17**[7]	6[11]	19[12]	**40**[14]	14[22]	−0.43[0.35]	0.71[0.42]	0.69[0.43]	**1.54**[0.63]	**4.26**[1.33]
$Region_{WMidlands}$	−**10**[3]	−3[3]	3[5]	**17**[5]	**21**[7]	15[9]	0.27[0.19]	0.33[0.30]	−0.12[0.24]	0.36[0.39]	0.71[0.61]
$Region_{Yorks\&Humber}$	0[1]	−1[1]	−1[4]	−6[4]	−5[4]	−2[4]	0.20[0.26]	−0.33[0.26]	−0.23[0.25]	−0.33[0.26]	−0.50[0.27]
$Type_{Bungalow}$	−**48**[12]	−**75**[16]	12[22]	21[21]	5[23]	−**199**[33]	−0.28[0.72]	−0.02[0.93]	0.38[0.79]	**3.09**[0.94]	**17.34**[1.60]
$Type_{Detached}$	8[38]	−55[52]	**146**[72]	**221**[72]	81[76]	−**285**[99]	**19.88**[2.35]	−**16.64**[3.08]	−**14.83**[2.57]	2.70[3.30]	**41.47**[5.92]
$Type_{Med/LargeTerraced}$	−**104**[45]	63[61]	−**294**[85]	−**196**[81]	−**246**[90]	−121[120]	−3.33[2.78]	**7.43**[3.55]	3.50[3.04]	**13.11**[3.77]	6.74[6.20]
$Type_{Semi-detached}$	−**76**[32]	−**114**[45]	−57[62]	**311**[60]	**282**[65]	161[86]	0.39[2.02]	**13.29**[2.60]	1.69[2.21]	**9.50**[2.61]	**11.56**[4.46]
$Type_{SmallTerraced}$	3[11]	16[16]	8[22]	−**120**[24]	−**145**[28]	−**167**[39]	0.01[0.71]	−**3.37**[0.96]	−0.61[0.78]	−1.54[0.93]	−0.37[1.56]
Lot size (m^2)	−**0.03**[0.01]	−**0.03**[0.01]	−**0.05**[0.02]	**0.09**[0.02]	**0.09**[0.02]	0.00[0.03]	**0.00**[0.00]	**0.00**[0.00]	−0.00[0.00]	**0.00**[0.00]	**0.01**[0.00]
Interior space (m^2)	−**3.42**[0.52]	−**3.01**[0.73]	−**2.57**[0.98]	**9.99**[1.05]	**10.31**[1.14]	**3.49**[1.34]	**0.21**[0.03]	**0.30**[0.05]	−0.06[0.04]	**0.36**[0.05]	**0.98**[0.10]

Notes: The rows presents results for 33 individually estimated regression models (Eq. (3′)), each explaining the marginal price (q_i) paid by households for a specific hedonic dwelling characteristic. Standard errors in brackets. Coefficients that are significantly different from 0 at the 5% confidence levels in bold.

than 15% for people older than 65. Since education is the most prominent determinant of human capital, one obviously needs to control for it.

We regard tenure as a typical example of a life-cycle driven variable, and our data confirms this. Students and young professionals heading a household first tend to live in privately let dwellings. The share of privately rented houses decreases by half between age 20 and 30, as people leave school or university and start working, start families, and buy their own homes. From age 30 until 40, the share drops again by half and stays low thereafter. The very low home-ownership rate among residents aged 70 and older, however, could be caused by a negative cohort effect for this generation.

4. Results

When estimating the user cost of housing for home owners q_{owner}, we set r_f to 4.78%, which was the yield for 20-year British government bonds in 2001. g is set to 2.5%, which is the average real annual growth rate of the Halifax housing index for 1983–2001. For the risk premium ρ we take one half of the UK equity premium of 4.2%, as estimated by Dimson et al. (2003). Figures for the direct housing costs are provided in the EHCS data set. We subsequently try a number of alternative specifications for the interest rate, the equity premium and the expected price appreciation. This scales the vector of marginal prices but does not affect their relative magnitude.

We estimate Eq. (1′) by ordinary least squares with robust standard errors (White's estimator). Table 4 presents the coefficients for a model featuring 33 hedonic variables combined with interaction terms with housing types, tallying up to 174 coefficients in total.[16] The adjusted R^2 for the model is 0.66.

For each observation we calculate marginal prices for the 33 hedonic variables based on Eq. (2′). The last column of Table 4 lists the mean of these partial derivatives q_i, which can be understood as the premium (or discount) households are willing to pay for one more unit of the hedonic characteristic. The signs of the partial derivatives are all as expected: positive for sought-after characteristics and negative for unpopular attributes. As an example, residents are willing to pay (on average) an additional £893 a year for living in a detached house, when compared to an apartment, which is the reference house type. Not surprisingly, a residence in London comes at a hefty premium when compared to the North East.

Houses constructed in the 19th century are preferred over more recently erected structures. Houses built before 1900 are most attractive, while the least attractive construction period is 1945–1974. Older houses apparently have features like architecture or neighborhood attractiveness that are not captured in our control variables but which are accounted for in the building period dummy. Other attributes like interior space, parking space or a

[16] We also estimated the model with interaction terms for all variable combinations, which inflated the number of coefficients to a scale unpresentable in a paper. The core results did not change qualitatively, however.

garage, central heating, or a larger lot size all have positive derivatives.

Living in a city center (as opposed to a rural environment) is more attractive than a suburban residential or an urban area. As expected, areas experiencing high demand are more expensive. Locations with many vacancies, on the other hand, come at a discount. Links to public transportation close to the house make a place more attractive.

In the last step, we link the marginal hedonic prices to demographics: The rows of Table 5 presents the coefficients from each estimation of Eq. 3, regressing the marginal prices for each hedonic attribute (in the first column) against 21 variables capturing the demographic profile of the households.[17] Columns 2–23 explain how the willingness to pay for individual housing services varies with age, household composition, household type, economic situation of the household, income, employment status, educational level, ethnicity, and attitudes of the inhabitants regarding the dwelling they live in.

The demand for most housing components increases with household size. Especially interior space, lot size and (semi-) detached houses are more in demand as household size increases.[18] Negative (and statistically significant) coefficients for $z_{Interiorspace}$ and $z_{Lotsize}$ indicate declining marginal utilities for space and lotsize.

Higher levels of income shift the reservation prices for almost all housing components upwards (or downwards for unpopular attributes). As an example, we estimate that the premium a household in the age cohort 15–29 is willing to pay for living in a detached house (versus living in a small terraced house) increases by 2 pence when income increases by 1 pound. Beside this direct income effect, we observe that a household's human capital is determining its current housing consumption decision.

We would expect that the optimal level of housing consumption does not depend on current income solely, but to a large extent on the present value of future streams of income. The more income a household can expect, the more housing services it can (and wishes to) consume over its lifetime. Borrowing on mortgage allows young households to smoothen their consumption inter-temporally, as higher levels of housing consumption are possible in earlier years already. Assuming a concave housing utility curve, the smoothing of housing consumption increases a household's lifetime utility. In addition, transaction costs are reduced, as the level of housing services does not necessarily need to be readjusted each time current income changes. The household will only move to a larger (smaller) home in case the expected value of human capital changes significantly.

Unfortunately, human capital is not easily measurable. We therefore have to rely on education and health as proxies for human capital, assuming higher levels of education and better health to be related to higher future income. As an illustration, a well-educated young professional can expect that her income will increase more in subsequent years than the income of a less educated person with the same level of current income. Our results show that, after controlling for income, households headed by university graduates are willing to pay more (less) for all sought-after (unpopular) goods than households with lower educational achievements. This holds true for less advanced educational levels as well: having passed GCSE lets the household demand more housing than households without any conventional education (our reference group).[19]

Similarly, health plays an important role in housing demand. In our sample, households with members suffering from long-term illnesses or disabilities consume less housing services. This does not imply that housing has a lower priority for the ill or disabled. Health problems impair human wealth as future incomes are expected to be lower, which apparently depresses overall housing consumption.

The coefficients for the age cohorts demonstrate that cohort preferences should not be mistaken for an age effect: The coefficients for the age cohorts in the regression explaining the premium for detached houses, for instance, indicate that households aged 40–49 value detached houses most (£221 above youngest cohort) while the 65–85 cohort has the lowest willingness to pay for this attribute.

The coefficients for the cohort-income interaction show that the middle-aged cohorts' housing demand is more sensitive to income than demand by the youngest one, as indicated by mostly significant and positive cohort-income coefficients.

The highest income sensitivities are found for the oldest cohort. This does not imply that older people spend more on housing in absolute terms. Given the lower income for retirees, it is rather the relative share of the income devoted to housing that drives up the coefficients. People simply stay in their houses after retiring, consuming the same amount of housing as before. This inter-temporal smoothing of housing consumption makes sense from an investor's life cycle perspective as well: owner-occupiers build up housing wealth during their working years and consume more than otherwise possible when retiring. For aging owner-occupiers, housing services are often as big as income. This could imply that people do not account for the opportunity costs of not renting out or selling the paid-off house they are living in, but that would not explain why elderly renters pay relatively more as well, since they have to make rent payments in cash. We believe that moving is costly for older people emotionally and socially, since they are leaving a place they often have lived

[17] We regress the marginal prices q_i against the following demographic variables: age-group dummies (15–29, 30–39, 40–49, 50–64, 65–85), education dummies (up to GCSE/O level/CSE Equivalent; up to A level or equivalent; up to degree or degree equivalent; higher degree/postgraduate qualification), employment status (full time work, retired), gender, persons with long-term illness in household, ethnicity (black, Asian), disabled members of household, presence of children, the household's income, the interactions of income with age, and the household's size.

[18] Single-person households do not have demand patterns very different from multi-person households after controlling for household size. We therefore subsequently drop this variable from our estimations.

[19] Relaxed borrowing constraints could be an alternative explanation, since banks could be more willing to provide mortgages to better educated customers.

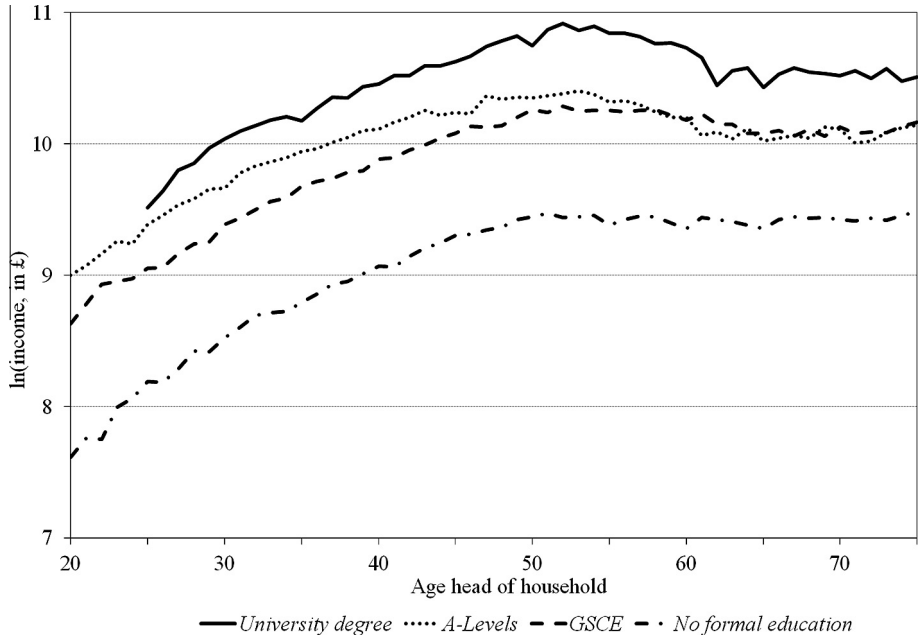

Fig. 1. Income dynamics for British households *Notes:* Students take the A-Level exams at age 18 and those who pass can enter the universtity, making this exam comparable to the Advanced Placement Exam in the US. The General Certificate of Secondary Education (GCSE) is usually taken two years earlier.

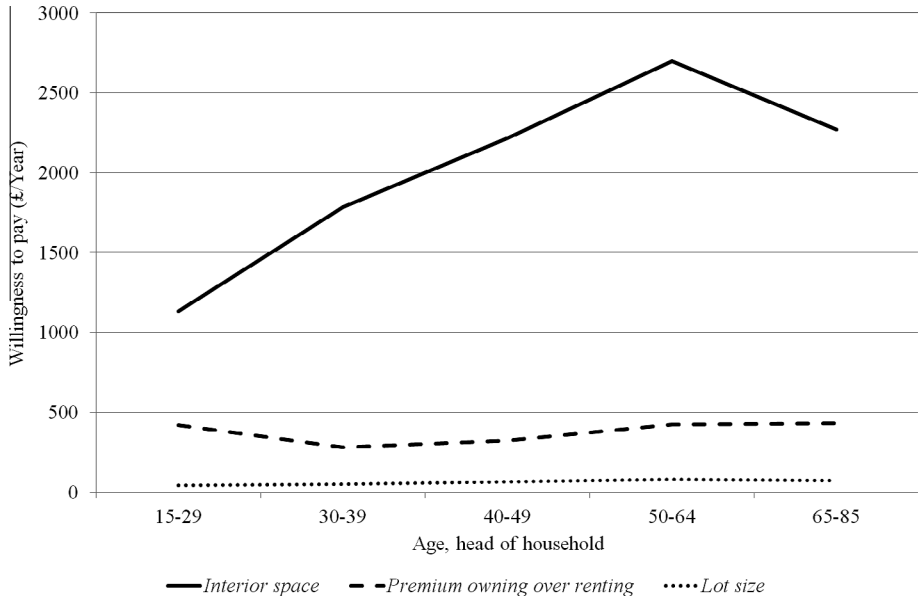

Fig. 2. Demand for interior floor space, owner occupancy, lot size. *Notes:* The willingness to pay for interior space increases in age. From age 15–29 through age 50–64, the rental value attributed to the average interior space (85 m^2) more than doubles from £1130 to £2700 before falling to £2270 at age 65–85. Demand for other core hedonics like lot size or owning the dwelling does not depend on age, but remains constant throughout the life-cycle.

in for years. In the same line of reasoning, it is not surprising that most of the coefficients for the variable indicating retirement are positive and significant, indicating a constant willingness to pay for housing even when income decreases.

Only few black and Asian households are included in the sample, and they are not evenly distributed geographically. After controlling for age, income, education, household type and size, we find Asian and black households to attach a (relative) discount on being home owners,

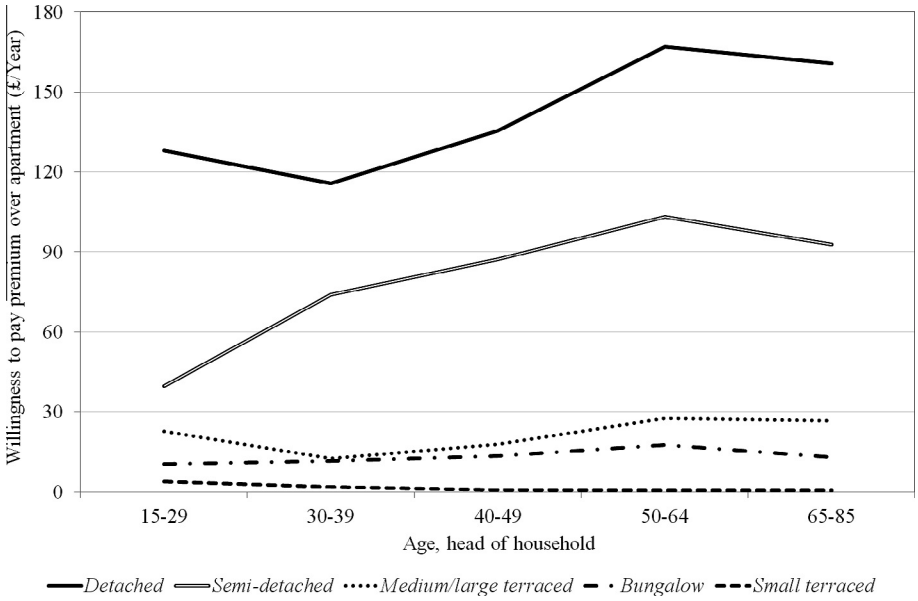

Fig. 3. Demand for dwelling types. *Notes:* Age-specific demand differs across housing types. While a household's demand for detached and semi-detached homes increases in age (relative to apartments), no difference can be observed for terraced houses or bungalows (versus apartments).

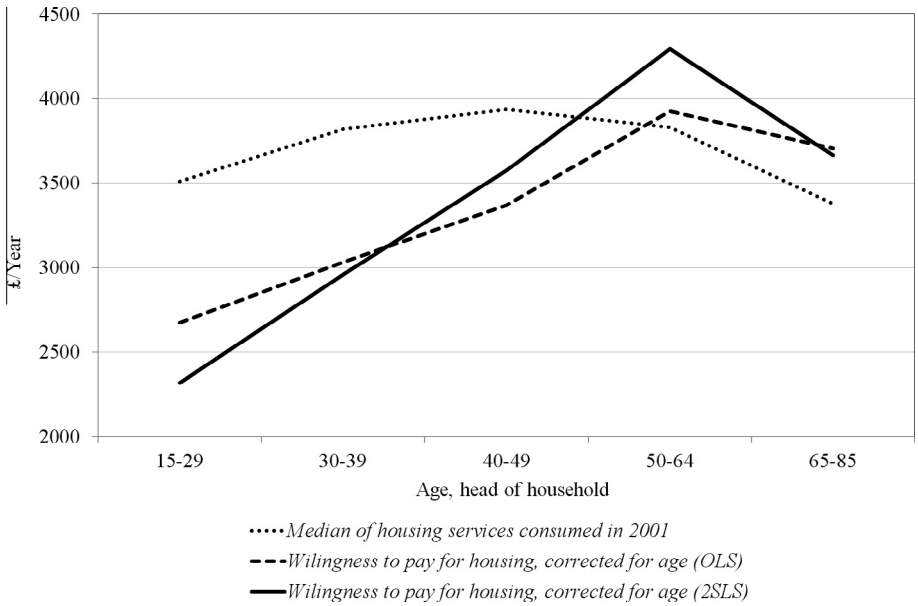

Fig. 4. Willingness to pay for housing as a function of age. *Notes:* The solid line depicts the willingness to pay for an average dwelling as a household ages, employing the 2SLS framework (Eq. 1′,2′,3′****, and 4). The dashed line is estimated using OLS instead of 2SLS. Demand for housing services increases fastest at ages 35–45 and peaks just before retirement (60–65). For retirees, housing demand is slowly decreasing again but remains above levels when these households were aged 25–45. In this analysis, demographic characteristics like education or ethnicity are kept constant while life-cycle related factors like income, health or household size adjust with age. The dotted line shows the median of housing services consumed by each cohort in 2001.

having a parking lot, or residing in high demand locations, while terraced and semi-detached homes carry a premium. These results do not necessarily imply different tastes with regard to these characteristics directly, but we could interpret them as a preference for traditional migrant neighborhoods in the historic city centers.

Having established the link between marginal prices and demographics, we can now evaluate how the marginal prices (q_{ia}) for each hedonic attribute change as a function of age. Subsequently, we calculate the demand for a standard home based on national averages for all hedonic characteristics in our sample, and based on age-income

dynamics we estimated using data from the British Household Panel Survey (BHPS).

Fig. 1 shows that, in general, a households income first increases with age, peaks around age 52, declines until age 65 and stabilizes subsequently. The better a household is educated, the more pronounced dynamics can be observed. For instance, income first quadruples for households headed by university graduates from age 25–52, and decreases again by one third as the members of the household retire, before it stabilizes. For lower educational levels, both the increase and the decline are less steep. Households whose head has enjoyed no formal education start at very low income levels, experience robust income growth until age 55, but do not suffer from income losses as they reach retirement. This surprising result could be linked to state transfers to the elderly and, more likely, to cohort effects in disguise: 68% of all household heads in the 65–85 age cohort received basic schooling only, while for the youngest cohort, the share drops to as low as 12% (Table 3).

Housing attributes are not created equal when it comes to demand as a function of age, as Fig. 2 shows. The willingness to pay for interior space is very sensitive to age: From age 15–29 through age 50–64, the amount allocated to the average interior space (85 m^2) more than doubles from £1130 to £2700 before falling to £2270 at age 65–85. Demand for other core hedonics like lot size or owning the dwelling does not depend on age, but remains constant throughout the life-cycle.

It is interesting to note that age-specific demand also differs across housing types (see Fig. 3). While the demand for detached and semi-detached houses grows faster than the demand for apartments (base line), no difference can be observed for bungalows or terraced houses versus apartments. Seniors apparently do not wish to move to smaller places or exchange a detached home for an apartment – on the contrary, a detached home seems to be the most desired housing type for retirement.

The solid line in Fig. 4 depicts the age-specific willingness to pay for an entire 'average' English house. This demand is calculated as the sum of the marginal prices q_{ia} for each hedonic characteristic and age group (based on the 2SLS coefficients from Eq. (3′) multiplied with the nation-wide average value for each hedonic attribute (as specified in the first column of Table 4).

Demand for housing services increases fastest at ages 15–29 and 30–39, continues to grow for another 15 years and peaks just before retirement (60–65). For 50–64 year old households, the demand for housing is about 85% higher than the demand of 15–29 year olds and still 45% percent above demand levels of the 30–39 year old households. For retirees, housing demand is slowly decreasing again but remains above the levels when these households were aged 15–49.

The dotted line shows the same metric when Eq. (3′) is estimated with ordinary least squares instead of a two stage least squares regression. The differences in demand across ages are less pronounced as unobservable tastes lead to a bias in the coefficients.

The dashed line in Fig. 4 represents the median willingness to pay for housing services for each cohort in 2001. Median values are already higher for the younger cohorts and lower for the older ones, since this ad-hoc metric ignores existing differences in income and human capital across cohorts.

The pattern of the graph is quite robust to changes in the chosen specifications. Using different reference groups, alternative regression models, or different assumptions for the user-cost of housing q does not alter the overall shape qualitatively. Using a semi-logarithmic functional form for (1′) does not change the results significantly either. The level of the total demand, however, is sensitive to the user cost of housing assumed: a higher (lower) value will shift all three graphs upwards (downwards) in comparable ways.

5. Conclusion

This paper investigates how the demand for residential real estate depends on age and other demographic characteristics at the household level. It contributes to the current debate in three ways: First, based on a very detailed 2001 cross-section of English households, we find that human capital, as proxied by education and health, is a key driver for housing demand. For instance, each additional level of education a household has achieved, drives up its willingness to pay for housing services. On the other hand, factors like chronic illnesses that impair human capital have a negative impact on housing consumption. This implies that the frequently aired opinion that housing demand will decline in age can be rejected. Since younger cohorts are better educated, and are healthier and wealthier than the generations before, an aging society will likely demand more housing on an aggregated level, even if the total number of households stops growing.

Second, we refine the existing methodology by distinguishing between life cycle variables that are expected to change with age for each household, and cohort variables, that are determined by the household's birth-cohort and not by age. Earlier studies either let all demographics change with age, or kept all variables constant during the entire household life cycle. Modeling a household's demographic attributes along its life cycle is crucial, since demographic changes lead to very heterogeneous demand responses for each of different housing attributes.

Third, our findings have important policy implications for European countries beside England. Despite the cultural and economic heterogeneity within Europe, the upward-sloping age–demand-relationship observed in England should be a reasonable proxy for other European nations, even in case of different demographic profiles. Today, Europe is facing an unprecedented demographic change: The entire area reaching from Germany in the west, to Russia in the east, and to the Balkans in the south is losing population already today – and this development is expected to gain momentum in the next decades (United Nations Population Division, 2012).

A regional housing market with unattractive economic perspectives and living conditions faces a double challenge: not only does the total number of households decline, but households having enjoyed a better education

are more likely than the less educated to move away to more prosperous regions. Without a younger generation that gets better educated and more wealthy than the generations before, the pressure on housing demand caused by population shrinkage cannot be off-set. In these regions, falling house prices are likely, especially without large-scale interference in housing supply.

Cross-sections can obviously provide information for one moment in time only. Disentangling age effects common to all households from cohort effects remains a challenge as studies have to assume that cohorts have similar preferences when it comes to housing. The findings of this paper will not hold up in case of inter-generational differences in tastes (Myers, 1999). Given the high premia historical buildings command (Table 4), it does not seem unreasonable to assume that housing tastes have not changed dramatically in the last centuries. Nevertheless, this study is based on one single cross-section and will therefore remain subject to this limitation.

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