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Short-term effects of house prices on birth rates

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Summary
This paper explores the effects of house prices on fertility rates using a new instrumental variable strategy, exploiting exogenous variation in house prices induced by planning restrictions. Using data from English counties, the instrumental variable estimates indicate that: a 10 per cent increase in house prices leads to a 2.8 per cent increase in births among owners and a 4.9 per cent decrease in births among renters. Once calculated at the mean home ownership rate the net effect is a 1.3 per cent fall in birth rates. In addition, I document that the positive home owners effect is primarily driven by the older cohort and the negative price effect among renters is mainly driven by those aged 20-29. A further assessment of house prices and fertility nexus reveals that these effects vary by region and demographic subgroup. Taken together, the results imply that local real estate market conditions may potentially change the age structure and population dynamics of a country, including many emerging markets and transition countries.

Keywords: house prices, birth rates, rents, home equity

JEL Classification: J13, R21, R23

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1 Introduction

The price changes in the housing market have been a much-debated topic in the United Kingdom over the past years. According to the Land Registry data, average house prices have increased by nearly 290 per cent between 1995 and 2013, from £67,000 to £234,000, in England with some counties experiencing a more than 900 per cent rise in house prices. Subsequently, these strong movements in the property market generated inevitable effects on households' wealth and disposable income. For example, the British newspaper *The Guardian* reported in a recent (2015) article that:

"Based on Land Registry and HMRC data, a homebuyer earning the median salary for their region in 1995 would have had to spend between 3.2 times and 4.4 times their salary on a house, depending on where they lived. In 2012-13, the median house price had risen to between 6.1 times and 12.2 times median regional incomes."

In 2013, *The Telegraph*, another British newspaper, argued that household consumption was sensitive to changes in housing wealth:

"Rising house prices in many areas of the country are creating an opportunity for homeowners who are asset rich but cash poor to release equity from their homes."

In 2011, the BBC quoted the chief executive of the Shelter, a housing charity, who said:

"We have become depressingly familiar with first-time buyers being priced out of the housing market, but the impact of unaffordable rents is more dramatic. With no cheaper alternative, ordinary people are forced to cut their spending on essentials like schools and families."

Lastly, in a brief article in 2007, the BBC cited a reader's comment to reflect the importance of the price and availability of housing on families:

"House prices are currently the main obstacle to stable family life and stable parenting."

Indeed, this unique housing market structure, and its close link to household spending decisions,

suggest a plausible connection between housing tenure and having children in England. In an attempt to unravel this relationship, I investigate how birth rates are affected by changes in house prices separately for home owners and renters through income and price effects. There are two ways of looking at this interaction. On the one hand, given that housing wealth is a major component of the household's assets for home owners and empirically housing wealth and consumption tend to move in the same direction (for example, Campbell and Cocco, 2007; Case, Quigley and Shiller, 2005 & 2011), an increase in house prices should lead to an increase in demand for children, if children are a normal good.[1] For tenants, on the other hand, higher rent payments may force them to reduce their consumption in line with the increase in cost of housing and should generate a negative price effect on the demand for children.

Despite the logical appeal of these arguments, to date there have been few studies that set out to present an analysis of this relationship. The current available evidence mainly comes from the United States (for example, Lovenheim and Mumford, 2013; Dettling and Kearney, 2014) and from Hong Kong (Yi and Zhang, 2010).[2] However, a further analysis is necessary as the housing market in England stands out in international context. It is mainly because: (i) houses in England are overvalued, and the prices are among the highest in the world (Kuenzel and Bjørnbak, 2008); (ii) prices exhibit extreme volatility – real house prices in England as a whole are substantially more volatile than in the most volatile metro areas in the United States (Hilber and Vermeulen, 2016); (iii) in terms of size, houses are substantially smaller than in the United States and any other European countries (Morgan and Cruickshank, 2014); (iv) house prices have risen faster than in any other OECD country and have far outstripped earnings growth (Hilber, 2015); and (v) private sector rents are the highest in Europe, and renters spend nearly 40 per cent of their income on paying their rent in comparison to the European average of 28 per cent

[1] Becker's (1960) quality (that is, the number of children) and quantity (that is, whether the parents provide separate bedrooms, send their children to nursery school, private colleges and so on) approach suggests that a rise in income may have depressing effects on birth rates if income elasticity for the number of children is considerably lower than that for quality of children.

[2] I do not review the fertility literature in detail here. For studies using US data, see Butz and Ward (1979), Currie and Schwandt (2014) and Schaller (2016). Studies using data from other countries include, among others: Adsera (2005), Ahn and Mira (2002), Aksoy (2016), and Luedicke et al. (2010). See Sobotka, Vegard, and Philipov (2011) for a wider review of the earlier literature.

(National Housing Federation, 2015). Therefore, special attention should be devoted to England as it exhibits different housing market characteristics than other countries.

Another reason for concern is that some previous studies are subject to a possible endogeneity bias. For example, assuming that the housing supply is fixed in the short term, if people who plan to have a child and expand their families demand larger houses, then the direction of causation runs from birth rates to house prices. This implies a case of reverse causation. In addition, there are strong reasons to suspect that the existing studies suffer from omitted variable bias. Since house prices for dwelling units are determined by a number of factors, the failure to control for demand shifters that play a part in affecting house prices as well as birth rates may bias estimates of the house price-fertility rate nexus. For instance, holding all else equal, a rise in household liquid assets (that is, non-housing wealth) or one-person family formation, may potentially affect both constructs. In order to establish a causal relationship and be able to assess the effect of house price on birth rates, I propose a clear identification strategy that takes the aforementioned factors into account.

This paper extends the emerging literature on house prices and birth rates by using novel source of variation from England. More specifically, I exploit the regulatory constraints on the housing market by refusal rates for major development projects in English counties, which is generated by outdated planning regulations. The current planning system maintains many of the mechanisms introduced in the Town and Country Planning Act of 1947 which has been characterised as quite complex and inefficient, preventing new housing developments coming forward. This constrained housing supply can be attributed to the lack of incentives of local authorities to respond to the planning permission applications in a positive and timely manner. There are several reasons put forward to explain how regulatory constraints can affect house prices. For example, Barker (2004) suggests that the housing supply in England does not respond to price signals, mostly because of the constraints embedded in the planning system. Rouwendal and Vermeulen (2007) and Saiz (2010) show that restrictions on land supply have negatively affected new housing construction despite the increases in house prices. Similarly, Hilber and Vermeulen (2016)

argue that planning rules are particularly important in driving up house prices in England and have a substantive positive impact on the house price-earnings elasticity.

In this paper, I use rich data sets of English counties spanning from 1996 to 2014 to investigate the effects of house prices on birth rates. I first present OLS results of how fertility rates respond to increases in house prices, estimated separately for home owners and renters. To address omitted variables bias I (i) extensively control for demographic characteristics, and (ii) take full advantage of the panel data structure by including county, year and age group fixed effects as well as county-specific linear and quadratic time trends. While the net effect of house prices on birth rates is negative, the OLS estimation establishes a strong positive relationship between house prices and fertility rates among home owners and a negative relationship among renters. The association between house prices and birth rates is stronger in supply constrained areas, especially in south-east England, including London. Moreover, results from the demographic subgroups and alternative house price measures analyses also confirm the main empirical findings. Lastly, the IV specifications yield coefficients that are larger in magnitude in which the fully saturated specification indicates that a 10 per cent increase in house prices is associated with 4.9 per cent fall in births among renters and 2.8 per cent increase in births among home owners. At the mean ownership rate the net effect is negative and leads to a 1.3 per cent fall in births.

The contribution of this paper to the literature is three-fold. First, I provide evidence on the impact of house prices on fertility rates from a country with a highly restricted housing market, which has not been studied previously. These findings provide new evidence on how country-specific factors influence birth rates by showing the importance of housing market regulations. Second, I deal with the endogeneity of house prices in a robust manner and I exploit a novel source of variation, that is refusal rates for major development projects. This direct measure of planning restrictiveness makes a distinctive contribution to the literature and distinguishes the current study from previous papers which rely on survey data. Third, I carefully disentangle the impact of house prices from other factors and tackle the possible endogeneity of house prices with respect to internal migration (that is, mobility) by accounting for net population changes

for each county-year cell. The focus on England provides a distinct addition to the literature and this research will further our knowledge about an increasingly important and understudied socio-economic problem.

The remaining part of the paper proceeds as follows: the next section discusses the planning system and process in England. Section 3 introduces the data description and sources. The fourth section presents the empirical strategy and the fifth section presents the results. Lastly, section 6 offers a discussion and concludes.

2 The planning system and process in England

In 1947, the UK parliament legislated a bill called The Town and Country Planning Act which nationalised the right to develop land and established a new system, indicating that individual planning permission was needed from a local authority for all land development and housing projects. The legislation has continued to evolve on a number of occasions with the last major changes made in 2011, namely by the Localism Act (2011), in an attempt to move towards decentralised planning.[3]

The planning system delegates regional planning bodies (RPBs) to oversee land use and number of houses being built in England. In this centralised system, the RPBs decide the allocation of land and impose housing targets on local (planning) authorities through the five year plans (to avoid confusion, I will henceforth replace the term local (planning) authority by county).[4] The local planning committees then allocate land use based on planning applications received. As outlined by the regulations, the standard process for obtaining planning permission is as follows. Upon receiving applications, the counties publicise the projects to start the formal consultation phase which lasts for at least three weeks. After this period, a county needs to decide within 8 weeks for minor projects, for example household projects cases, and within 13 weeks for major development projects such as large housing sites.[5]

However, granting planning permission is not as straightforward as it may seem. Despite the various alterations made over time, the regulatory framework is still identified as one of the main barriers to new housing supply (see Cheshire and Sheppard, 2002; Barker, 2004 and 2006; Evans and Hartwich, 2005, Hilber and Vermeulen, 2016) and characterised by three main properties:

[3]Over the years, the planning system has undergone a number of major changes, the titles of which are as follows: Town and Country Planning Act (1990) introduced the concept of "plan-led development", Planning and Compulsory Purchase Act (2004) initiated compulsory acquisition of land for development and other planning purposes, Planning Act (2008) aimed to accelerate the process for granting permissions for major new infrastructure projects such airports, roads, dams, energy facilities and so on.

[4]In England the local planning authorities are 32 London borough councils, 36 metropolitan borough councils, 201 non-metropolitan district councils, 55 unitary authority councils, the City of London Corporation and the Council of the Isles of Scilly.

[5]This time frame initiated by the Labour government in 2002 in order to shorten the processing time.

(i) centralised land use approach and complications in determining the level of housing supply in counties; (ii) complex application process and under-resourced planning departments; and (iii) the lack of financial incentives for counties to deliver essential infrastructure and amenities.

Although the primary goal of the centralised system is to encourage the housing supply, this top-down system fails to take annual housing demand changes and associated price movements into account. Indeed, the Department of Communities and Local Government's (DCLG) 2011 report suggests that regional strategies have antagonised local residents, setting them against development plans and housing targets. Such opposition is mainly driven by concerns that adequate public services (road, public transportation, hospital, schools and so on) will not be provided and house prices will be gradually eroded. Consequently, the planning authorities mainly focus on the interests of the local residents and tend to preserve the land from development, which distorts the local housing market equilibrium.

Ineffectiveness of the current housing planning practices also arises from the fact that authorities do not have sufficient resources and planners (such as technical staff and legal services) to respond to the complex application process in a timely manner. [6]For example, household projects and major development projects are subject to the same application procedure, one that often leaves too few resources available to properly evaluate the large-scale development applications. This, in turn, results in delays or refusal of submissions in order to meet targets set by the central system.[7] Political concerns are also widely embedded in local level planning. Cambridge Centre for Housing and Planning Research (CCHPR) (2014) – commissioned by the DCLG – reports that elected members (that is, councillors – representatives elected to a county) may refuse applications that planning officers have recommended for approval based on non-technical grounds.[8]

[6]In addition to the public consultation, local planning authorities have to consult a number of departments (for example the local highway authority, environment agency, English Heritage, health and safety executive and so on) who may be influenced by a proposed housing project.

[7]According to the Home Builders Federation, as of January 2015, more than 150,000 applications were waiting to advance from the "outline" planning stage to the "detailed" planning stage.

[8]Local councillors have a conclusive say in planning decisions made in their area. Each planning committee consists of local councillors who come from different political parties. When a committee makes a decision, councillors usually consider (though they are not lawfully obliged to do so) a recommendation report written by planning staff.

Turning to the lack of financial incentives, counties are unwilling to support housing growth due to lack of funding for infrastructure provision. In the current system, the government uses different resources (such as census data, school enrolment and so on) to determine the amount of funding. [9] However, these data sources are mainly backward-looking and are not updated annually. Consequently, the funding stream is not based on the actual needs of the local communities, and disadvantages counties that experience rapid housing growth (Barker, 2004). In other words, new housing developments impose a formidable fiscal burden on counties and the internalisation of the associated cost by local residents.

As briefly introduced above, the planning structure is not able to cope effectively with the house prices in response to changes in demand, causing a mismatch between the goals of the central system and those of local communities. I therefore propose to use refusal rates for major development projects to capture the effects of regulatory constraints on house prices. This serves as a "catch-all" variable and combines land scarcity, policy restrictiveness, and local land use policy measures. The advantages and disadvantages of this measure will be further discussed in the following section.

Councillors may accept the recommendation directly or discuss the application further before deciding to accept or refuse the application.

[9]The UK government uses the "four-block" model (the relative needs, the relative resource, the central allocation and the floor damping) to allocate funds to counties since 2006. The calculations mainly rely on demographic, economic and social data to define the share of revenue spending for each county given a fixed national total. This model also recognises the differences in the amount of local income which individual counties have the potential to raise. The full details of the calculations can be found in the *Local Government Finance Report* which is published annually by parliament.

3 Data

The data used in this paper come from:

- the UK Land Registry
- the Department for Communities and Local Government (DCLG)
- the confidential version of the UK Labour Force Survey (LFS)
- the Office for National Statistics (ONS)
- the Family Resources Survey (FRS).

The level of analysis is age group-county-year cell and the details on how the balanced panel data was constructed are provided below.

3.1 Data on house prices and refusal rates

I obtain house price index (HPI) data from the UK Land Registry over the period 1995- 2013. This index is based on actual residential sales transactions and includes information on more than 24 million sales and uses over 7 million identified pairs to compile the index. More specifically, it takes the difference in prices between January 1995 and the last time sale price, then averages these changes at county level. In addition, it accounts for seasonality as well as depreciation or appreciation of properties over time and is designed for "like for like" evaluation between houses.

It uses a sample size that is larger than all other data available and also has a number of other advantages.[10] First, the repeat sales method minimises the concerns about unobserved heterogeneity in house prices through following the same property over time. Second, the index includes all cash and mortgage transactions. Third, it is based on actual property transactions, in other words, it eliminates the bias that arises from mortgage valuation approvals (see Chandler and Disney, 2014).

[10]The sample size in ONS, Nationwide and Halifax house price indices are considerably smaller. It is because they are solely based on mortgage lending and exclude cash transactions. Further information about the index can be found at: https://www.gov.uk/guidance/about-the-price-paid-data.

I obtained the decisions on major (residential) development projects data from the DCLG and constructed the refusal rates based on the following definition: the proportion of development projects with 10 or more dwellings that was refused by a planning authority. To construct the panel data, I matched counties and local planning authorities based on 2001 borderlines.

3.2 Time variant county characteristics, home ownership rates, and birth rates

I control for a number of time-variant determinants of birth rates in my main specification. More specifically, for each county-age group-year cell, I control for gross weekly wages, unemployment rate, gross household assets excluding housing wealth, share of college graduates, share of foreign born population, share of other ethnicities, share of one-person family, share of non-married individuals and net internal migration (that is, net change in population by a county in a given year).[11]

I use the LFS to construct demographic characteristics, labour market controls and information on housing tenure. The LFS is a nationally representative survey of the whole population of the United Kingdom and the current sample size is about 41,000 households for every quarter. The main advantage of the LFS in the current framework is that the low tier geographical classification allows for aggregation and matching the corresponding data at the local planning authority level. Mean home ownership rates are constructed for each age group-county cell and kept constant at baseline to minimise endogeneity concerns and to account for compositional changes over time. It is important to note that home ownership rates have remained largely unchanged over the sample period.

Data on internal migration come from the ONS. It refers to residential moves between different geographic areas within England and provides the most complete components of change for the

[11]The unemployment measure is based on the International Labour Organization (ILO) definition which outlines unemployment as all people who are without work but are nevertheless available for and seeking employment. Gross weekly wages are CPI adjusted and calculated for both males and females while excluding the weekly earnings less than £25 and more than £10,000 a week.

mid-year population series which are updated annually. In particular, I use net migration estimates that reflect the number of movements across counties and serve as a satisfactory explanation for sorting patterns in response to changes in house prices.

The data on household (liquid) assets, including fixed term investments, are obtained from the Family Resources Survey (FRS). The FRS is a continuous survey of households. For each financial year (April to March) more than 20,000 private households are interviewed and the survey provides detailed information on the income resources and conditions of families in England. I use this information to disentangle any possible confounding effects of other types of wealth.

The birth count data used in this analysis are from the ONS. These statistics include counts of live births and stillbirths by mother's area of usual residence and age group. Age-specific fertility rates (ASFRs) are constructed for age bands 20-29 and 30-44 by dividing the number of births by the corresponding female population in a given county-age group-year cell. Because the data do not provide information to determine the date of conception, I matched the ASFRs with one year lagged, t-1, county level characteristics and house prices. Using all previously mentioned data, I have 5,624 age group-county-year observations.

3.3 Descriptive statistics and trends

In Table A, I present descriptive statistics by age groups, 20-29 (column 1) and 30-44 (column 2). The age groups differ from each other in a number of ways. For instance, the fertility rate is higher for the age band 20-29, at around 90 births per 1,000 women. The same cohort also earns and saves less on average, is more likely to be unemployed and renting, and is less likely to live alone, be married and hold a university degree. Age band 30-44 on average earns and saves more, is less likely to be unemployed or renting and is more likely to live alone, be highly educated and married. With regards to the country of birth and ethnicity, there are almost no substantial differences between the two groups.

Charts 1 and 2 show trends in age-specific fertility rates and house prices at the national level. The birth rate for those aged 20-29 appears to fluctuate strongly: it fell to 84 births per 1,000 women in 2002, and then reached their peak of 96 births in 2007 before sharply declining again. With regard to the 30-44 age band, birth rates follow a pro-cyclical trend and reach their highest point of 64 in 2008, sharply dropping until 2010 and rebounding afterwards. Overall, differences in demographic and labour market characteristics as well as trends highlight the importance of accounting for other factors that may confound the association between house prices and birth rates.

Table B presents the means and standard deviations for house prices and refusal rates. In terms of house prices, a first look at the data shows that house prices vary greatly across regions. Over the sample period, the mean house price was £172,001 with a standard deviation of £103,024 and considerably higher in the south, including Greater London, than in the rest of England. Table B also reports the average refusal rates. Similar to house prices, the refusal rates exhibit a significant amount of variation across regions and are the highest in the south.

Chart 3 plots histograms of the share of refusal rates for each region over the sample period in which the charts have been put on a common x-scale. Altogether, it suggests that refusal rates vary across regions independently of the price patterns. Chart A.1 in the appendix plots the variation in refusal rate trends across regions. It shows that the trends are non-linear due to the onset of the financial crisis and some regions have experienced larger increases in refusal rates. Moreover, the regions that are large and exhibit substantial variation in shares appear to stand out sharply in terms of house prices. Lastly, Chart 4 shows that weekly rents closely track movements in house prices.

4 Estimation methodology

4.1 Empirical strategy

In order to identify the causal effects of house prices on current birth rates, it is vital to have a variable that is exogenous to birth rates and strongly correlated with county-level house prices. As introduced above, I use refusal rates for major development projects as a source of exogenous variation in house prices in England that successfully captures the regulatory and supply side constraints on the housing market. Similar to Dettling and Kearney (2014), the fully saturated model specification that I estimate is given by the equation:

$$\begin{aligned} log(Birth_{cgt}) &= \beta_0 + \beta_1 HP_{c(t-1)} + \beta_2 HP_{c(t-1)} * Own_{cg} + \beta_3 Own_{cg} \\ &\quad + X_{cg(t-1)} + \theta_c + \delta_g + \gamma_t + \gamma_{c(t-1)} + \varepsilon_{cgt} \end{aligned} \tag{1}$$

where c, g, and t index counties, age groups and years respectively. The data set consists of a balanced panel of 148 counties, two age groups (20-29 and 30-44) and each observed over from 1995 to 2013. $\text{Birth}_{\text{cgt}}$ is the log of the age-specific fertility rates given county, age group and year. $HP_{\text{c(t-1)}}$ is the house price index and shows how an increase in house prices affects the relationship between house prices and fertility rates among renters and existing owners who might plan to move to a larger property with an additional child. $HP_{\text{c(t-1)}}$*Own_{cg}, house price index is interacted with a baseline measure of ownership rates (1995) and captures the relationship between house prices and fertility rates among home owners.

$X_{\text{cg(t-1)}}$ is a vector of control variables and has three main components: (i) labour market controls; (ii) demographic characteristics; and (iii) non-housing wealth and net population change. First, to account for pro-cyclical variation in labour market outcomes, I include the unemployment rate and the natural log of average weekly gross household income. Second, to adjust for the

effect of demographic structure on fertility rates I directly control for time varying observable demographic characteristics. These variables are as follows: share of non-UK born population, share of college graduates, share of non-white individuals, share of one-person family, share of non-married individuals and share of individuals who came to England less than a year ago. Third, I include net population change to account for potential sorting (that is, mobility) patterns. More specifically, migration can be expected to affect house prices from the demand side. Hence, it is included to improve precision and, if correlated with house prices, also to address potential omitted variable bias. The log of non-housing wealth disentangles the effect of the housing wealth from other possible confounding wealth effects.

To account for other unobservable characteristics, I exploit the panel aspects of the data set. In particular, county fixed effect, ϑ_{c} , and age group fixed effect, δ_g, are included to minimise all variation in birth rates caused by factors that vary across counties as well as age groups and are constant over time. Year fixed effects, γ_{t} , are included to eliminate the time variant macro-economic shocks that lead changes in fertility rates shared by all counties and age groups over time. County-specific linear and quadratic time trends, $\gamma_{\text{c(t-1)}}$, remove variation in intra-county fertility rates caused by factors that are county specific over time. ϵ_{cgt} is the unobserved determinants of fertility. Standard errors are clustered at age group-county level and all regressions are weighted by the relevant female population in each cell. In fully saturated models, the birth rate-house price estimates are identified exploiting within-county variation in house prices in which county-specific time trends are expected to minimise the unobservable effects that may be correlated with other explanatory variables.

4.2 Instrumentation strategy

The primary aim of this paper is to provide causal effects of house prices on fertility rates. However, there are inherent reverse causality and omitted variables bias issues if the above relation

was estimated using OLS. For instance, if people who plan to have a child demand larger houses, this may eventually lead the direction of causation to run from birth rates to house prices. They may also be jointly affected by some omit-ted factors. Furthermore, measurement error in house prices may cause attenuation bias. An alternative strategy that addresses these issues would be to use an instrumental variable that affects county level house prices yet are unrelated to fertility rates and to re-estimate equation (1) using 2SLS method.[12] This method would be useful in establishing causal links.

To find a valid instrument, I focus on one of the main factors that drives the house prices upwards in England: a restrictive planning system (Barker, 2006, DCLG 2011, CCHPR 2014, Hilber and Vermeulen, 2016). The regime is restrictive and mostly characterised by high refusal rates for (new) major development projects. It is defined as the fraction of housing projects with 10 or more dwellings that were rejected by a local planning authority and a commonly used measure to capture regulatory restrictiveness (Cheshire and Sheppard, 1989; Preston et al., 1996; Hilber and Vermeulen, 2016).

Since there is a long period between planning approval and a dwelling being built, and to account for pro-cyclical changes in decisions owing to high housing demand, I use three-year moving average refusal rates (that is the three years leading up to the current period). This also allows me to use a more informative measure rather than concentrating on year-to-year variations which may not be able to fully capture the scope and functions of the planning system. I assume that the link between three-year moving average refusal rates for major development projects and county level house price trends would not have been systematically correlated with county level birth rates. There are three justifications for this identifying assumption. First, using moving averages helps to reduce potential endogeneity concerns arising from changes in refusal rates that are driven by the local demographic structure. It is mainly because these estimates cannot be affected by contemporaneous omitted variables. Second, it seems that the decisions on applications are

[12]I perform 2SLS estimation following Balli and Sorensen (2013) to avoid a "forbidden regression" (see, Wooldridge 2002). To be specific, I estimate 2SLS structural-equation model with two instruments: refusalrate and refusalrate*ownership and use vce(robust) to account for heteroskedastic errors.

more likely to be shaped by the central government. As discussed in section 2, the housing targets are exogenously determined and given to the counties by the RPBs leaving them little room for manoeuvre to cope successfully with the house prices in response to changes in local housing demand. Third, targets are set by using backward-looking data, and hence should not be influenced by the current birth rates. Within this context, identification is achieved by an exclusion restriction that refusal rates for major development projects should affect birth rates only through supply induced variation in house prices.

Empirically, the refusal rates are highly positively correlated with house prices over the sample period at the aggregate level. However, the main concern of whether refusal rates exogenously determine birth rates requires further investigation. One potential concern is that a more profitable real estate market may encourage developers to apply for more projects, leading to artificially high refusal rates in some counties. In this case, my instrument would be correlated with the second-stage residuals. Although including county and year fixed effects in the estimating equation should address this issue, I additionally examine the validity of my results by using alternative instruments: (i) change in project approval delay rate before and after the 2002 policy reform; (ii) baseline refusal rates in 1994; (iii) average refusal rates between 1995 and 2013; and (iv) a different measure: the number of accepted dwellings over baseline housing stock, as an instrumental variable. This measure attempts to isolate the effects from the number of permissions asked. That is, if counties of the same size systematically grant the similar number of permissions with the different number of applications received (that is, high versus low), then refusal rates would be contaminated by the number of applications. In such a case, estimates would be both qualitatively and quantitatively different. It is worth noting that the results of these alternative measures are similar to the presented IV results, thus confirming the validity of the instrument.

5 Empirical results

This section presents three sets of results. I first show Ordinary Least Squares (OLS) estimates. I then focus on IV/2SLS results outlined in section 4.2. Lastly, I present findings for demographic subgroups and with different house price measures.

5.1 OLS estimates

Table 1 presents the results from the OLS estimation where the dependent variable is the log of the age-specific fertility rate. I estimate models separately for the full sample in the top panel, for those aged 20-29 in the middle panel, and for those aged 30-44 in the bottom panel. Column 1 reports the estimation with all fixed effects included (county, year and age group); column 2 adds demographic characteristics and net change in population; column 3 adds labour market characteristics and gross household assets excluding housing wealth; column 4 adds county-specific linear time trends; column 5 adds county-specific quadratic time trends.

The HousePrice*OwnershipRate interaction coefficient in the first column yields a positive and statistically significant estimate of .002 and the House Price coefficient yields a negative and statistically significant estimate of -.011. More specifically, the coefficient on the former measure the estimated effect in the hypothetical case of only home owners (that is, age group-year-county cell with a home ownership rate of 1) and the latter quantify the estimated effect in the hypothetical case of zero home owners (that is, age group-year-county cell with a home ownership rate of 0). After adding more controls and time trends (columns 2 to 5), the results consistently and significantly show that for home owners an increase in house price is positively associated with birth rates whereas the opposite is true for renters. In the fully saturated model (column 5), the magnitude of the relationship indicates that a 10 per cent increase in house prices leads to a 0.8 per cent rise in fertility rates among home owners. For renters, the same amount of increase in

the house prices causes a 1.7 per cent fall in the fertility rate. These results confirm Dettling and Kearney's (2014) finding that house prices significantly and differently affect birth rates among home owners and renters. The net effect at the mean home ownership rate is negative, which suggests that birth rates move counter-cyclically and the negative price effect dominates the income effect in England. This finding is different than those found in the United States (Dettling and Kearney, 2014) and there are a number of possible explanations. First, it may be because of the adverse effects of a restrictive housing market on renters who spend around 50 per cent (as high as 70 per cent in London) of their gross disposable income on rent.[13] Second, house prices have risen much faster than earnings, which has made getting onto the property ladder even harder for the average first-time buyer. Third, unlike in the United States, the rental cost has closely tracked movements in house prices while earnings have remained relatively stable, subsequently leading to a fall in disposable income. Fourth, young families, who are mostly renters, have been priced out of the rental markets and rental accommodation has become unaffordable. Altogether, these factors can potentially create barriers to family formation and make having children financially "prohibitive" for renters, leading to a fall in birth rates at the aggregate level over the sample period.

In the middle and bottom panels of Table 1, I show that the negative price effect among renters is mainly driven by those aged 20-29. In contrast, the positive effect of house prices on birth rates is driven primarily by the older cohort (those aged 30-44), in which people are significantly more likely to be home owners and less likely to postpone having children. These findings support the notion that housing costs exert downward pressure on the fertility outcome of young adults and that there is a connection between getting on the property ladder and building a family.

Regarding the other variables listed in Table 2 in the Appendix, unemployment rate and non-housing wealth positively and significantly affect the birth rates. The coefficient on gross weekly wages is also positive but insignificant in all models. Recall that I included net population change in an attempt to account for mobility and, hence, expected to see positive coefficients. Indeed,

[13] Author's own calculation from the English Housing Survey, 2013-2014.

the positive and significant point estimates suggest that the variable does a good job in addressing the sorting issue in response to changes in house prices. Inclusion of county-specific time trends makes the coefficients larger both for home owners and for renters. This implies that the county-specific fertility trends driven by the omitted fertility determinants tend to move in the opposite direction of the trends in house prices over the sample period.[14]

The analysis continues with a stratification of the regressions with county level housing supply characteristics so as to gain further insights into the housing market basis of this result. More specifically, I split the sample by the observations in the upper quartile of home ownership distribution versus the ones in the lower quartile. The first two columns of Table 3 suggest that the fertility rate is the most responsive to house price changes in more supply constrained counties where ownership rate is above the 75th percentile. In these counties, a 10 per cent increase in house prices leads to a 1.2 per cent increase in birth rates among home owners and a 2.3 per cent decrease in birth rates among renters. It is mainly because the supply shortage leads to higher house prices, generating a larger income effect for home owners and a larger negative price effect for renters. In areas where home ownership rate sits at the bottom quartile, coefficients are smaller in magnitude and mostly significant at the conventional levels. Altogether, the results in this table suggest that the effects are more pronounced and seem to be driven by supply constrained counties.

The differences across demographic groups are highlighted in Table 4 in which I expect to find that non-native, less educated and non-white groups to be "more" affected by increases in house prices. Overall, the estimates are parallel to this notion. For example, a 10 per cent increase in house prices leads to a 2.3 per cent decrease among the foreign born population. For home owners, the same amount of increase is associated with 1.6 per cent in birth rates. Overall, similar to the findings in Table 1, renters between the ages of 20 and 29 seem to be more negatively affected than the older cohort. On the one hand, this may be because this cohort witnessed substantially higher rises in rents, they earn less on average and are less likely to borrow to

[14]Inclusion of ownership-county specific and age group-county specific linear time trends made little difference to the values in column 5.

finance their child-related expenses. On the other hand, the significantly higher coefficient on house prices and birth rates among the older cohort may suggest that this cohort benefits from the long-standing real house price growth. In other groups, the results maintain the expected sign of direction while being significant in most cases. The following section of this paper is concerned with endogeneity of house prices and instrumental variable estimation results are presented.

5.2 IV estimates

In this section I present the IV estimates of the house price-fertility relationship using county level refusal rates for major development projects as an instrument for county-level house prices. As previously discussed in section 4.2, if the estimates suffer from omitted variables that are not picked up by the linear trends and the fixed effects, the OLS specifications will yield biased point estimates. In addition, if high fertility rates lead to a rise in housing demand and, in turn, increase house prices, the OLS results will provide wrong statistical inference.

Before discussing the instrumental variable estimates, a discussion on the validity and power of the instrument is needed. Table A1 in the appendix presents the first stage estimates of the instrument and successively adds more controls in the models similar to Table 1. In all specifications, the first-stage relationship between refusal rate and house prices is strongly positive: three-year moving average refusal rates are significantly associated with house price growth at the 1 per cent level (column 1 in Table A1), and this relationship is robust to the inclusion of demographic and labour market controls (columns 2 and 3) as well as county-specific time trends (columns 4 and 5). Overall, the instrument seems to exert stronger positive effects on house prices as more controls are included and have predictive power. Recall that refusal rates are used to capture the restrictiveness of the planning system and higher refusal rates typically lead to increases in house prices. It is an expected outcome, since the planning system in England tends to be protective. The results for the first stage F-test also show that the first-stage relationships are fairly strong.

In addition, I employ alternative measures for the instrumental variable, including the change in the approval delay rate (before and after the 2002 reform) of major residential projects (that is, the number of decisions that are delayed over 13 weeks in any given county-year cell relative to all decisions made in that county-year cell), baseline refusal rates in 1994, average refusal rates between 1995 and 2013 and the number of accepted dwellings over baseline housing stock. The change in the delay rate measure uses the exogenous variation generated by the policy reform introduced in 2002 to shorten the length of the planning application process.[15] The point estimates at the first stage are positive as expected and mostly statistically significant (these models not shown). However, the first-stage F-tests in some cases are less than 10, so results with alternative measures should be interpreted with caution.[16]

Table 2 presents the IV estimates in which I replicate the OLS specifications from Table 1. Again, I only report the coefficients of main interest. The IV-2SLS fixed- effects framework results show that: (i) the impact of house prices on birth rates among home owners is positive and significant at 1 per cent confidence, with a point estimate of 0.028 (standard error 0.008 in column 5 of Table 2); and (ii) the impact of house prices on birth rates among renters is negative and significant at 1 per cent confidence, with a point estimate of 0.049 (standard error 0.016 in column 5 of Table 2). Overall, in each model, the IV coefficients are larger than the OLS estimates. The OLS point estimates range from 0.2 per cent to 0.8 per cent for home owners and from 1.1 per cent to 1.7 per cent for renters. The corresponding interval for the IV results range from 0.6 per cent to 2.8 per cent for home owners and 2 per cent to 4.9 per cent for renters.

In the middle and bottom panels of Table 2, I report the estimates by age groups, following the baseline specification. I document important differences in these models. Both in the middle and bottom panels, I find the usual pattern that home owners' birth rates respond positively to house price increases, whereas the opposite is true for renters. However, the middle panel columns for those aged 20-29 show that the negative effect of house prices on renters' birth rate is much

[15] I thank Christian Hilber for suggesting I use the delay rate as an alternative instrument and his generosity in sharing these data. The merits of this measure have been discussed at length by Hilber and Vermeulen (2016).

[16] See Table A3 in the Appendix.

larger than those implied by the older age group. In contrast, the results for those aged 30-44 show that the overall housing wealth effects are larger than those found in the 20-29 age band, and the home owner results in the top panel are mainly driven by the older age group. Altogether, these findings suggest that the causal relationship between house prices and birth rates holds for both home owners/renters and among those aged 20-29 and 30-44.

Table 3 presents results based on the housing supply constraints. In general, the pattern remains similar to the OLS findings. Column 3 presents results for the counties with "low ownership rate" in which the IV results are almost three times larger than the OLS estimates and significant at conventional levels. For the counties with high ownership rate, in column 4, the IV results are also substantially larger and also significant at 1 per cent.

However, the IV results for the demographic groups are not so strong. First stage values of the F test for triple interactions are less than 10 in below degree level estimates. Therefore, the OLS estimates may be preferable to IV estimates for these categories. Other estimates are significant at conventional levels and the effects of house prices on birth rates are even stronger than those from the OLS regressions for both home owners and renters. In particular, the coefficients on the foreign born and other ethnicity interactions exceed the OLS estimate considerably, indicating that these groups are the most affected. The following part of the results explore whether the responses remain robust to alternative housing price measures.

5.3 Robustness checks

The results presented thus far demonstrate the fact that house price is an important determinant of the fertility rate outcome. Even though the effects vary with estimation features of the model, an increase in house price clearly has a positive impact on birth rates among home owners and has a negative impact on birth rates among renters. Nevertheless, I conduct additional analyses in order to detect whether the main findings remain stable to the different measures of the house prices, namely, median house prices, lower quartile house prices and lagged house prices – that

is (t-2) and (t-3) –. In fact, the results mostly hold through columns 1 to 3 and 5 to 7 of Table 5. For the median and lower quartile house prices, the magnitude of the point estimates is similar to those found in the main OLS and IV specifications. When I use the lagged house prices, the effects get smaller and become insignificant at higher lags. Nevertheless, the results are still in line with the main findings of this paper.

Table 6 investigates birth rate differences when splitting the sample by region (that is, based on mother's area of usual residence) in which I observe quite a distinctive pattern for birth rates. Prior work has reported that local scarcity of open developable land is the greatest in south-east England and this region-based analysis may contribute to the understanding of the house prices and fertility relationship (Hilber & Vermeulen, 2016). While there are many differences between (Greater) London and the rest of England, one of the most noticeable in this context is that house prices are likely to exert stronger effects on birth rates in London due to high variation in property prices and rents. I find in column 7 of Table 6 that the estimated coefficient on the interaction term is positive in sign, considerably larger in magnitude (compared with the main specification) and statistically significant at the 1 per cent level. In contrast, in column 7, estimates show that renters in London experience a considerably low fertility rate, and again this effect is much larger than the baseline results. For southern England (excluding Greater London), I estimate sizeable effects for both home owners and renters, though the coefficients are smaller than those documented for London. Results for the East and West Midlands return evidence that house prices do not significantly affect birth rates in these regions. There is, however, evidence from columns 1 to 3 about significant effects of house prices on birth rates in the northern part of the country. These region-based findings are particularly noteworthy, because they provide supportive evidence for the validity of the main argument of this paper and confirm the causal link between house prices and birth rates. In addition, the region estimates somewhat indicate that the main results are mostly driven by the regions in southern England including Greater London.[17]

Table 7 presents further results by housing boom and bust periods from the fully saturated OLS

[17] I do not report region results by age groups for the sake of space. Overall, these estimates are mostly in line with those reported in tables 1 and 2.

and IV specifications. I find that the impact of house prices on fertility rates is larger during "boom" years. Table 8 examines house price effects with additional controls. In column 1, I reprint the full sample IV estimates, columns 2-5 show the results of including alternative housing market controls (share of first time buyers at the regional level, share of two or more bedroom apartments at the regional level, share of new dwellings at the regional level, share of new dwellings at the regional level, and number of transactions (sales) at the county level) individually. Table 8 indicates that the coefficients on the birth rates are largely invariant to the inclusion of additional housing market characteristics, with no exception. I also estimated models in combination with each other and house prices interacted with the regional level controls, and these did not fundamentally change the main findings.[18]

[18]These results are not presented in the current tables but are available upon request.

6 Conclusion

Using the refusal rates for major development projects as an instrumental variable for house prices, the results presented in this paper show that house prices significantly affect birth rates in England. I found a significant positive birth rate coefficient for home owners and a significant negative birth rate coefficient for renters. There are also significant effects for younger (aged 20-29) and older (30-44) home owners and renters. The positive "home owner" effect is mainly driven by those aged 30-44 and the negative "renter" effect is driven by those aged 20-29. At the aggregate level the net effect is negative, in other words the negative price effect dominates the income effect. The expected variation in house prices and fertility rates according to demographic characteristics is also documented. The results for the foreign-born population and those with a less than degree level education are particularly large in magnitude. Moreover, the findings do not depend on the estimation methodology used, even though I do find relatively larger coefficients when I instrument for county-level house prices.

I also find similar results when I use different measures of house prices. In both OLS and IV results I find evidence that the median and lower quartile house prices significantly affect birth rates. This finding, again, is reproduced when I instrument for house prices. For the lagged house prices, the results indicate that house prices have a significant impact on fertility rates. However, the point estimates attenuate towards zero at higher lags. These findings for the different length of lags cast an important behavioural interpretation of the fertility responses to housing market trends. That is, people seem to take house price changes in previous years into account.

The findings of this study are potentially important from a public policy standpoint: if the negative effect of house prices on fertility rates is mainly driven by the younger cohort (that is, couples put off having children because they aren't able to afford suitable accommodation), it may be possible to reverse this trend through the design of better housing and/or child benefit schemes. One example would be to scrap the Help-to-Buy ISA's maximum purchase cap of £250,000 and £450,000 for London. This cap limits couples to buy two or more-bedroom family homes and

creates a barrier for young potential first-time buyers. If such government schemes help people to not only get a foot on the housing ladder but also afford a family house rather than a flat, they could decrease the number of privately rented households with children. I offer these suggestions with a cautionary reminder that further individual-level analysis and careful case studies are necessary to explain the causal mechanism and to design more effective policy responses.

Lastly, although the study has successfully demonstrated the aforementioned findings, it is however limited by the use of total birth rates, and the findings cannot be transferable to birth order and comment on the quality-quantity trade-off. Future research should, therefore, concentrate on the investigation of birth order and the potential relationship between house prices and the quality of children.

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Table A: Descriptive characteristics

Variables	Aged 20-29	Aged 30-44
Fertility rate (1,000s)	90.06 (22.83)	55.47 (21.26)
Home ownership rate	54.49 (15.81)	69.88 (12.46)
Home ownership rate (1995)	60.21 (14.18)	73.87 (11.34)
Gross weekly wages	333.67 (122.66)	518.47 (203.66)
Unemployment rate	9.48 (5.14)	5.32 (3.21)
Gross household liquid assets	3,463 (2,998)	5,687 (4,781)
Degree level	27.62 (11.47)	31.05 (12.10
A level	27.72 (7.35)	20.25 (5.49)
Below A level	44.66 (11.31)	48.70 (10.33)
Foreign born	14.64 (14.02)	16.28 (15.70)
Other ethnicities	13.65 (15.19)	12.95 (14.77)
One person family	7.94 (4.39)	10.41 (4.29)
Single	77.97 (8.45)	28.11 (9.41)
N	2812	2812

Notes: Within cell means (standard deviations). The table provides within cell means for the age-specific demographic characteristics for the 148 counties used in the analysis. Fertility rates are constructed by dividing the number of births by the corresponding female population using mid-year population estimates based on censuses, in which female ages range between 20 and 44. Source for county level birth data is UK Office for National Statistics. The UK Labour Force Survey is being used to construct county-year-age group specific unemployment rates, gross weekly wages and demographic characteristics. The gross weekly wages are calculated by dividing self-reported gross annual pay by the number of weeks worked in the same calendar year and are CPI adjusted to 2005 pounds. Unemployment rates refer to the percentage of economically active people who are unemployed by ILO standards. Household assets are self-reported and exclude housing wealth.

Table B: Descriptive characteristics

Regions	House prices	House price index	Refusal rate	Net population change
North East	82,593 (30,750)	150.68 (57.48)	17.35 (12.63)	178 (190)
North West	86,628 (35,749)	161.02 (60.44)	17.70 (10.83)	502 (1898)
Yorkshire and the Humber	88,102 (37,969)	157.75 (61.29)	19.15 (11.14)	1454 (2169)
East Midlands	101,340 (43,747)	180.30 (66.53)	21.75 (12.92)	3075 (2565)
West Midlands	103,408 (43,567)	171.93 (61.13)	21.64 (14.53)	1361 (2310)
East of England	122,050 (51,059)	205.57 (76.21)	24.32 (16.54)	4176 (3486)
Greater London	237,185 (128,183)	259.37 (110.70)	31.60 (20.63)	2404 (2263)
South East	154,706 (66,743)	216.42 (80.01)	34.34 (15.98)	2280 (3140)
South West	131,603 (52,734)	213.40 (82.16)	25.57 (13.91)	2242 (1915)

Notes: Within cell means (standard deviations). This table provides aggregate level variables averaged across 9 regions (148 counties) and 19 years (1995-2013) used in the analysis. Land Registry data on House Prices and House Price Index are based on reports from the individual house price records of all residential property sales in England. Data on Refusal Rates for Major Development Projects are obtained from the Department of Communities and Local Government. It is defined as the proportion of housing projects consisting of at least 10 dwellings that was refused by a local planning authority in one calendar year. Net Population Change data come from the Office for National Statistics – Population Estimates Unit and provide detailed information on the components of population change for counties, London boroughs and districts in England. According to the ONS (2015), the estimated resident population of an area includes all those people who usually live there, regardless of nationality. Arriving international migrants are included in the usually resident population if they remain in England for at least a year. Emigrants are excluded if they remain outside England for at least a year, which is consistent with the United Nations definition of a long-term migrant. Armed forces stationed outside of England are excluded. Students are taken to be usually resident at their term time address. Internal migration flows presented in the table reflect the number of movements that cross local authority boundaries.

Chart 1: Age-specific fertility rates (aged 20-29) and house prices

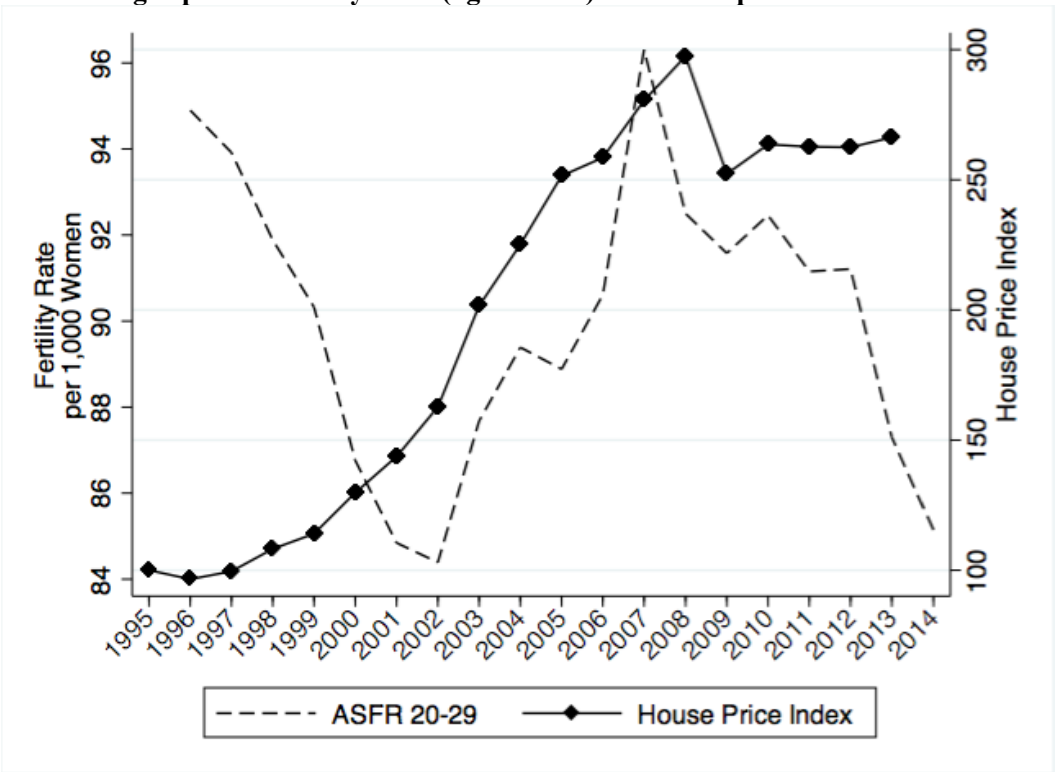

Chart 2: Age-specific fertility rates (aged 30-44) and house prices

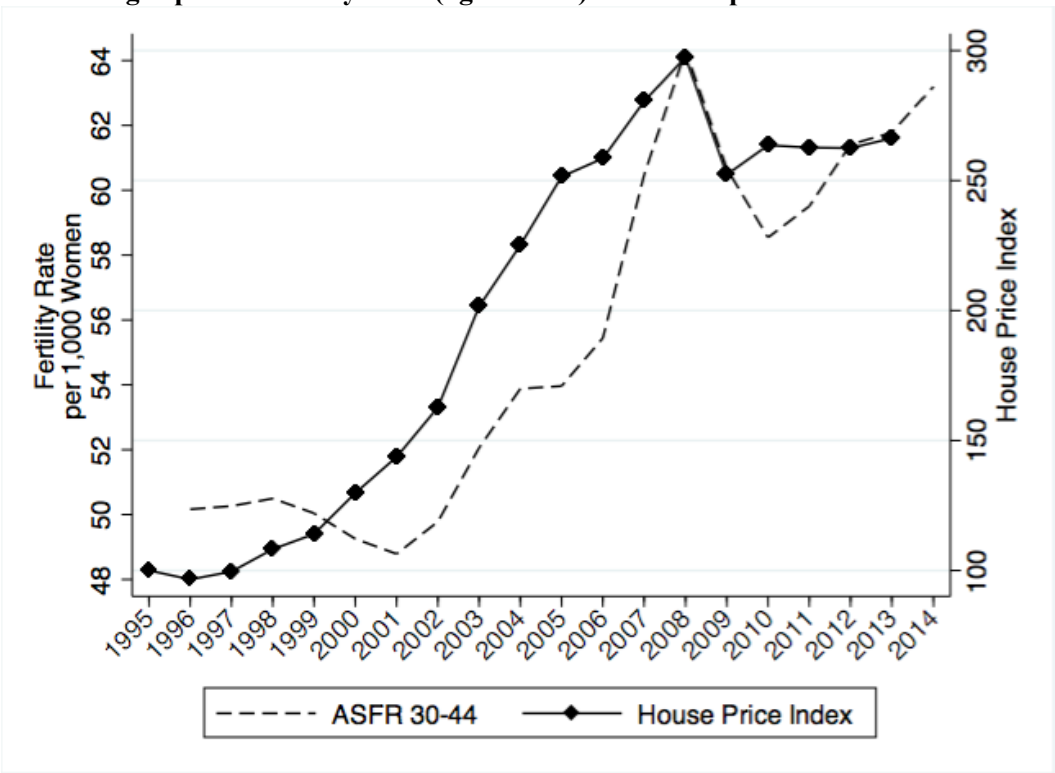

Chart 3: Shares of refusal rates across regions

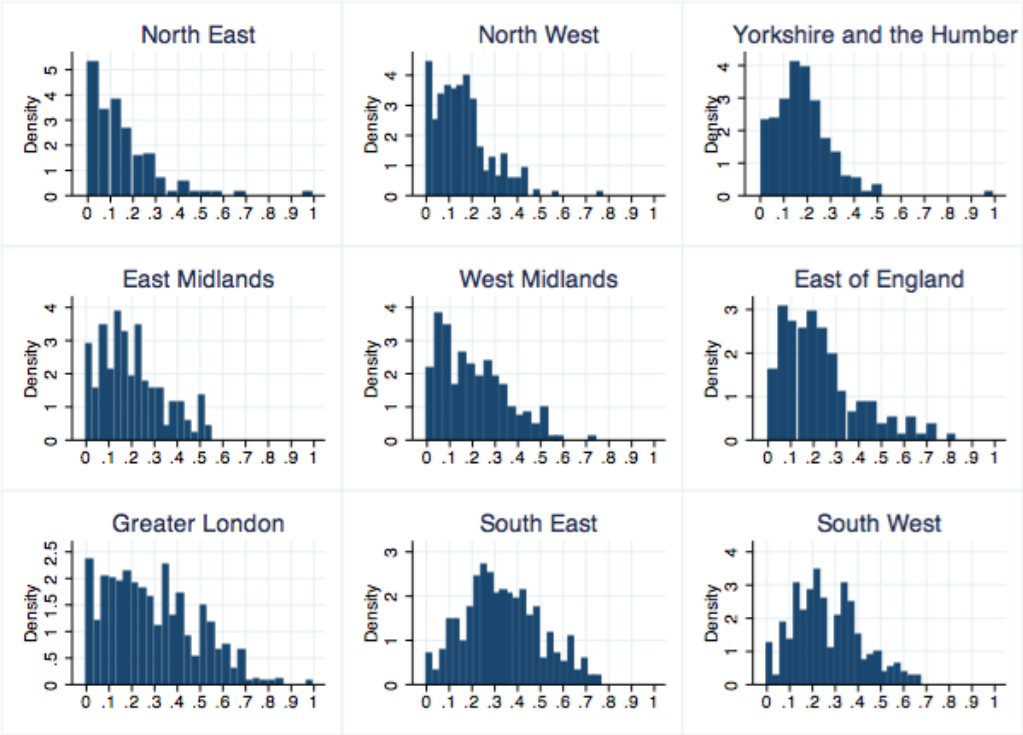

Chart 4: Rents and house prices

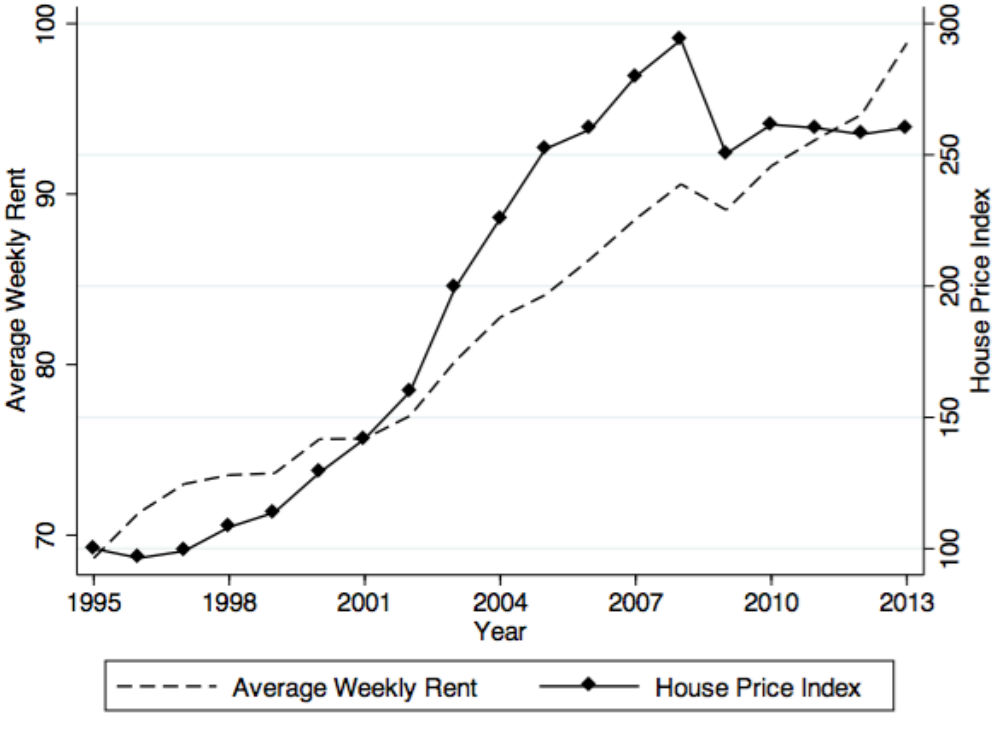

Table 1: House prices and birth rates – OLS estimations

Controls for ➔	(1) OLS Fixed effects	(2) OLS + demographic characteristics	(3) OLS + labor market characteristics	(4) OLS + county linear trends	(5) OLS + county quadratic trends
Full sample					
HPI*Ownership	0.002***	0.004*	0.007**	0.009**	0.008***
	(0.000)	(0.002)	(0.003)	(0.004)	(0.002)
House price(HPI)	-0.011***	-0.017***	-0.013***	-0.019**	-0.017***
	(0.002)	(0.004)	(0.003)	(0.007)	(0.004)
R-squared	0.303	0.489	0.578	0.704	0.816
N	5624	5624	5624	5624	5624
Aged 20-29					
HPI*Ownership	0.002*	0.002*	0.003*	0.004***	0.004***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
House price(HPI)	-0.014***	-0.019***	-0.018***	-0.024***	-0.020***
	(0.004)	(0.006)	(0.005)	(0.007)	(0.005)
R-squared	0.298	0.454	0.608	0.704	0.803
N	2812	2812	2812	2812	2812
Aged 30-44					
HPI*Ownership	0.004***	0.007***	0.012***	0.014***	0.013***
	(0.001)	(0.002)	(0.003)	(0.004)	(0.003)
House price(HPI)	-0.002	-0.004*	-0.003**	-0.006*	-0.004*
	(0.002)	(0.002)	(0.001)	(0.003)	(0.002)
R-squared	0.343	0.466	0.661	0.713	0.835
N	2812	2812	2812	2812	2812

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Robust standard errors, clustered at the age group-county level, are in parentheses. Column 1 includes: age, year and county fixed effects, column 2 adds: share of non-UK born population, share of college graduates, share of non-white individuals, share of one-person family, share of non-married individuals, share of households with at least one child and share of individuals who came to England less than a year ago and net population change, column 3 adds: unemployment rate, the average weekly gross household income and non-housing wealth, column 4 adds: county linear time trends and column 5 adds: county quadratic time trends.

Table 2: House prices and birth rates – IV/2SLS estimations

Controls for ➔	(1) IV Fixed effects	(2) IV + demographic characteristics	(3) IV + labor market characteristics	(4) IV + county linear trends	(5) IV + county quadratic trends
Full sample					
HPI*Ownership	0.006**	0.014**	0.023**	0.026**	0.028***
	(0.002)	(0.006)	(0.008)	(0.010)	(0.008)
House price(HPI)	-0.020***	-0.028***	-0.035***	-0.043***	-0.049***
	(0.006)	(0.009)	(0.011)	(0.014)	(0.016)
R-squared	0.298	0.439	0.517	0.710	0.802
N	5624	5624	5624	5624	5624
Aged 20-29					
HPI*ownership	0.009**	0.008**	0.016**	0.011***	0.012**
	(0.004)	(0.003)	(0.007)	(0.003)	(0.005)
House price(HPI)	-0.030***	-0.037***	-0.044***	-0.051***	-0.062***
	(0.009)	(0.012)	(0.013)	(0.016)	(0.019)
R-squared	0.363	0.496	0.562	0.704	0.819
N	2812	2812	2812	2812	2812
Aged 30-44					
HPI*ownership	0.012***	0.020***	0.030**	0.034***	0.036***
	(0.004)	(0.006)	(0.012)	(0.010)	(0.011)
House price(HPI)	-0.008	-0.013***	-0.014***	-0.019**	-0.021***
	(0.005)	(0.004)	(0.004)	(0.008)	(0.007)
R-squared	0.383	0.488	0.601	0.744	0.825
N	2812	2812	2812	2812	2812

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. For details on control variables, see notes to Table 1.

Table 3: House prices and birth rates – high vs. low ownership rates

	(1) OLS Low ownership (25^{th} percentile)	(2) OLS High ownership (75^{th} percentile)	(3) IV Low ownership (25^{th} percentile)	(4) IV High ownership (75^{th} percentile)
Full sample				
HPI*ownership	0.006*	0.012***	0.015**	0.025***
	(0.003)	(0.003)	(0.006)	(0.007)
House price(HPI)	-0.008**	-0.023***	-0.017**	-0.064***
	(0.003)	(0.006)	(0.007)	(0.021)
R-squared	0.758	0.777	0.813	0.828
N	1406	1406	1406	1406
Aged 20-29				
HPI*ownership	0.007	0.009***	0.029**	0.052***
	(0.012)	(0.002)	(0.012)	(0.014)
House price(HPI)	-0.011**	-0.031**	-0.036**	-0.091***
	(0.004)	(0.011)	(0.015)	(0.028)
R-squared	0.764	0.782	0.833	0.835
N	1406	1406	1406	1406
Aged 30-44				
HPI*ownership	0.004**	0.021***	0.015***	0.069***
	(0.001)	(0.005)	(0.004)	(0.020)
House price(HPI)	-0.004	-0.015***	-0.013*	-0.040***
	(0.004)	(0.004)	(0.007)	(0.012)
R-squared	0.742	0.798	0.799	0.823
N	1406	1406	1406	1406

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. For details on control variables, see notes to Table 1.

Table 4: House prices and birth rates – various interactions

	(1) Full sample OLS	(2) Full sample IV	(3) Aged 20-29 OLS	(4) Aged 20-29 IV	(5) Aged 30-44 OLS	(6) Aged 30-44 IV
HPI*Ownership*Foreign-born	0.016*	0.038*	0.008*	0.044***	0.010**	0.048*
	(0.007)	(0.020)	(0.003)	(0.017)	(0.004)	(0.020)
House price(HPI)*Foreign-born	-0.023**	-0.072**	-0.030***	-0.085***	-0.018**	-0.032**
	(0.010)	(0.031)	(0.007)	(0.018)	(0.003)	(0.012)
R-squared	0.713	0.748	0.799	0.801	0.756	0.813
N	5624	5624	2812	2812	2812	2812
HPI*Alevelorbelow	0.005*	0.023	0.003	0.014	0.006	0.051*
	(0.002)	(0.013)	(0.008)	(0.022)	(0.010)	(0.023)
House price(HPI)*Alevelorbelow	-0.018**	-0.051**	-0.011**	-0.036**	-0.021**	-0.056*
	(0.007)	(0.018)	(0.004)	(0.013)	(0.004)	(0.026)
R-squared	0.778	0.743	0.796	0.825	0.788	0.802
N	5624	5624	2812	2812	2812	2812
HPI*Ownership*OtherEthnicities	0.004	0.012*	0.009**	0.018**	0.004**	0.019***
	(0.004)	(0.007)	(0.003)	(0.008)	(0.001)	(0.005)
House price(HPI)*OtherEthnicities	-0.005*	-0.019***	-0.016*	-0.049**	-0.013*	-0.012*
	(0.002)	(0.006)	(0.008)	(0.020)	(0.005)	(0.006)
R-squared	0.746	0.788	0.754	0.810	0.780	0.804
N	5624	5624	2812	2812	2812	2812

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. For details on control variables, see notes to Table 1.

Table 5: House prices and birth rates – alternative house price measures

	(1) OLS Median house prices	(2) OLS Lower quartile house prices	(3) OLS Average house price, *t-2*	(4) OLS Average house prices, *t-3*	(5) IV Median house prices	(6) IV Lower quartile house prices	(7) IV Average house price, *t-2*	(8) IV Average house prices, *t-3*
Full sample								
HPI*Ownership	0.011*	0.003*	0.008*	0.003	0.023*	0.014**	0.012*	0.006
	(0.005)	(0.001)	(0.004)	(0.017)	(0.012)	(0.005)	(0.006)	(0.025)
House price(HPI)	-0.017***	-0.011***	-0.008*	-0.006	-0.040***	-0.041***	-0.022**	-0.016
	(0.005)	(0.003)	(0.004)	(0.011)	(0.013)	(0.013)	(0.008)	(0.018)
R-squared	0.802	0.788	0.765	0.741	0.813	0.788	0.772	0.766
N	5624	5624	5328	5032	5624	5624	5328	5032
Aged 20-29								
HPI*Ownership	0.006*	0.011**	0.005	0.000	0.013**	0.019*	0.006	0.002
	(0.003)	(0.004)	(0.006)	(0.010)	(0.005)	(0.010)	(0.011)	(0.013)
House price(HPI)	-0.025**	-0.014**	-0.010**	-0.008	-0.070***	-0.033**	-0.013	-0.010
	(0.010)	(0.005)	(0.004)	(0.008)	(0.019)	(0.013)	(0.010)	(0.015)
R-squared	0.798	0.777	0.801	0.765	0.757	0.794	0.786	0.731
N	2812	2812	2664	2516	2812	2812	2664	2516
Aged 30-44								
HPI*Ownership	0.018**	0.016***	0.013**	0.006	0.038**	0.030***	0.029**	0.011
	(0.007)	(0.005)	(0.005)	(0.006)	(0.014)	(0.009)	(0.012)	(0.012)
House price(HPI)	-0.008**	-0.010**	-0.005*	-0.003*	-0.020**	-0.018*	-0.019***	-0.007
	(0.003)	(0.004)	(0.003)	(0.002)	(0.008)	(0.009)	(0.006)	(0.007)
R-squared	0.813	0.801	0.801	0.743	0.813	0.743	0.779	0.745
N	2812	2812	2664	2516	2812	2812	2664	2516

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. For details on control variables, see notes to Table 1.

Table 6: House prices and birth rates – by regions

Regions➔	(1) North East	(2) North West	(3) Yorkshire and the Humber	(4) East Midlands	(5) West Midlands	(6) East of England	(7) Greater London	(8) South East	(9) South West
OLS									
HPI*Ownership	0.007*	0.011***	0.005	0.007**	0.016	0.011***	0.017***	0.012***	0.006**
	(0.004)	(0.003)	(0.011)	(0.002)	(0.018)	(0.002)	(0.005)	(0.003)	(0.002)
House price(HPI)	-0.004**	-0.016**	0.002	-0.009	-0.007	-0.019***	-0.031***	-0.022***	-0.010***
	(0.001)	(0.006)	(0.009)	(0.006)	(0.015)	(0.005)	(0.009)	(0.005)	(0.003)
R-squared	0.786	0.752	0.744	0.756	0.778	0.772	0.789	0.769	0.790
N	456	836	570	342	532	380	1216	722	570
IV									
HPI*Ownership	0.018	0.034***	0.018*	0.013	0.022	0.037***	0.040***	0.025***	0.018**
	(0.013)	(0.011)	(0.009)	(0.010)	(0.027)	(0.010)	(0.013)	(0.008)	(0.007)
House price(HPI)	-0.012**	-0.054**	-0.010	-0.014	-0.021	-0.059**	-0.071***	-0.049***	-0.028***
	(0.005)	(0.021)	(0.032)	(0.012)	(0.036)	(0.018)	(0.022)	(0.015)	(0.008)
R-squared	0.802	0.767	0.765	0.771	0.745	0.761	0.802	0.804	0.810
N	456	836	570	342	532	380	1216	722	570

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. For details on control variables, see notes to Table 1.

Table 7: House prices and birth rates – housing boom and housing bust periods

	(1) IV Baseline estimate (Table 2, Column 5)	(2) OLS Housing boom 1995-2008 & 2012-2013 (inc.)	(3) OLS Housing bust 2009-2011 (inc.)	(4) IV Housing boom 1995-2008 & 2012-2013 (inc.)	(5) IV Housing bust 2009-2011 (inc.)
Full sample					
HPI*Ownership	0.028***	0.013**	0.004*	0.029***	0.013*
	(0.008)	(0.005)	(0.002)	(0.009)	(0.006)
House price(HPI)	-0.049***	-0.022***	-0.008**	-0.056***	-0.015**
	(0.016)	(0.007)	(0.003)	(0.018)	(0.006)
R-squared	0.802	0.758	0.747	0.766	0.734
N	5624	4736	888	4736	888
Aged 20-29					
HPI*Ownership	0.012**	0.008***	0.003	0.015**	0.005
	(0.005)	(0.002)	(0.004)	(0.006)	(0.011)
House price(HPI)	-0.062***	-0.021***	-0.008**	-0.050***	-0.021**
	(0.019)	(0.006)	(0.003)	(0.015)	(0.008)
R-squared	0.819	0.763	0.735	0.774	0.724
N	2812	2368	444	2368	444
Aged 30-44					
HPI*Ownership	0.036***	0.011***	0.008*	0.035***	0.016**
	(0.011)	(0.003)	(0.004)	(0.009)	(0.006)
House price(HPI)	-0.021***	-0.007*	-0.003	-0.024***	-0.007*
	(0.007)	(0.003)	(0.002)	(0.007)	(0.004)
R-squared	0.825	0.772	0.730	0.780	0.733
N	2812	2368	444	2368	444

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. For details on control variables, see notes to Table 1.

Table 8: House prices and birth rates – alternative controls

	(1) IV Baseline estimate (Table 2, Column 5)	(2) IV Baseline estimate + share of first time buyers (regional level)	(3) IV Baseline estimate + share of two or more bedroom apartments (regional level)	(4) IV Baseline estimate + share of new dwellings (regional level)	(5) IV Baseline estimate + number of transactions (county level)
Full Sample					
HPI*Ownership	0.028***	0.025***	0.018**	0.024**	0.023**
	(0.008)	(0.007)	(0.007)	(0.010)	(0.008)
House price(HPI)	-0.049***	-0.051***	-0.043***	-0.055***	-0.042***
	(0.016)	(0.017)	(0.014)	(0.016)	(0.013)
R-squared	0.802	0.805	0.811	0.809	0.813
N	5624	5624	5624	5624	5624
Aged 20-29					
HPI*Ownership	0.012**	0.018*	0.015*	0.015**	0.013**
	(0.005)	(0.008)	(0.007)	(0.00)	(0.005)
House price(HPI)	-0.062***	-0.054***	-0.050***	-0.060***	-0.058***
	(0.019)	(0.016)	(0.015)	(0.018)	(0.019)
R-squared	0.819	0.827	0.830	0.829	0.835
N	2812	2812	2812	2812	2812
Aged 30-44					
HPI*Ownership	0.036***	0.029***	0.033***	0.039***	0.030**
	(0.011)	(0.009)	(0.009)	(0.013)	(0.012)
House price(HPI)	-0.021***	-0.018***	-0.025***	-0.024**	-0.019**
	(0.007)	(0.005)	(0.008)	(0.010)	(0.008)
R-squared	0.825	0.815	0.820	0.818	0.816
N	2812	2812	2812	2812	2812

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. For details on control variables, see notes to Table 1.

Chart A.1. Variation in refusal rates across regions

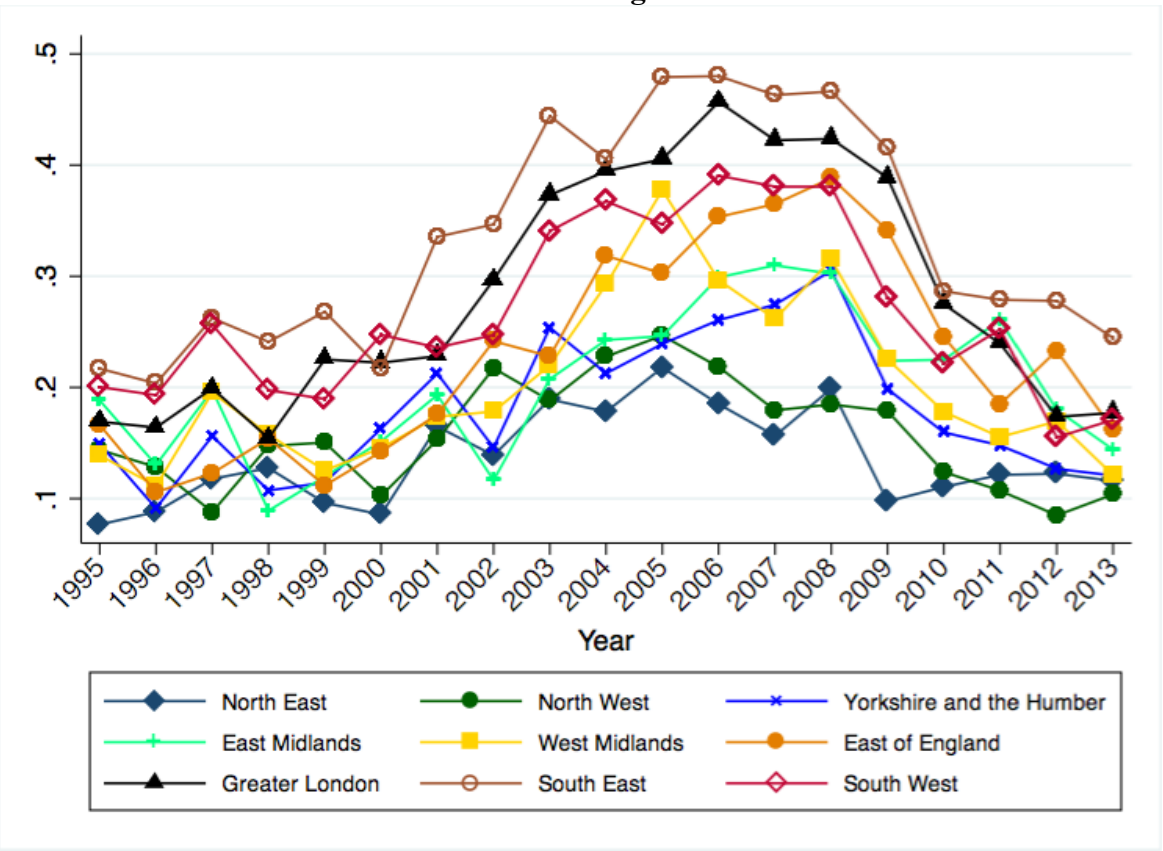

Chart A.2. Refusal rates and house prices by regions

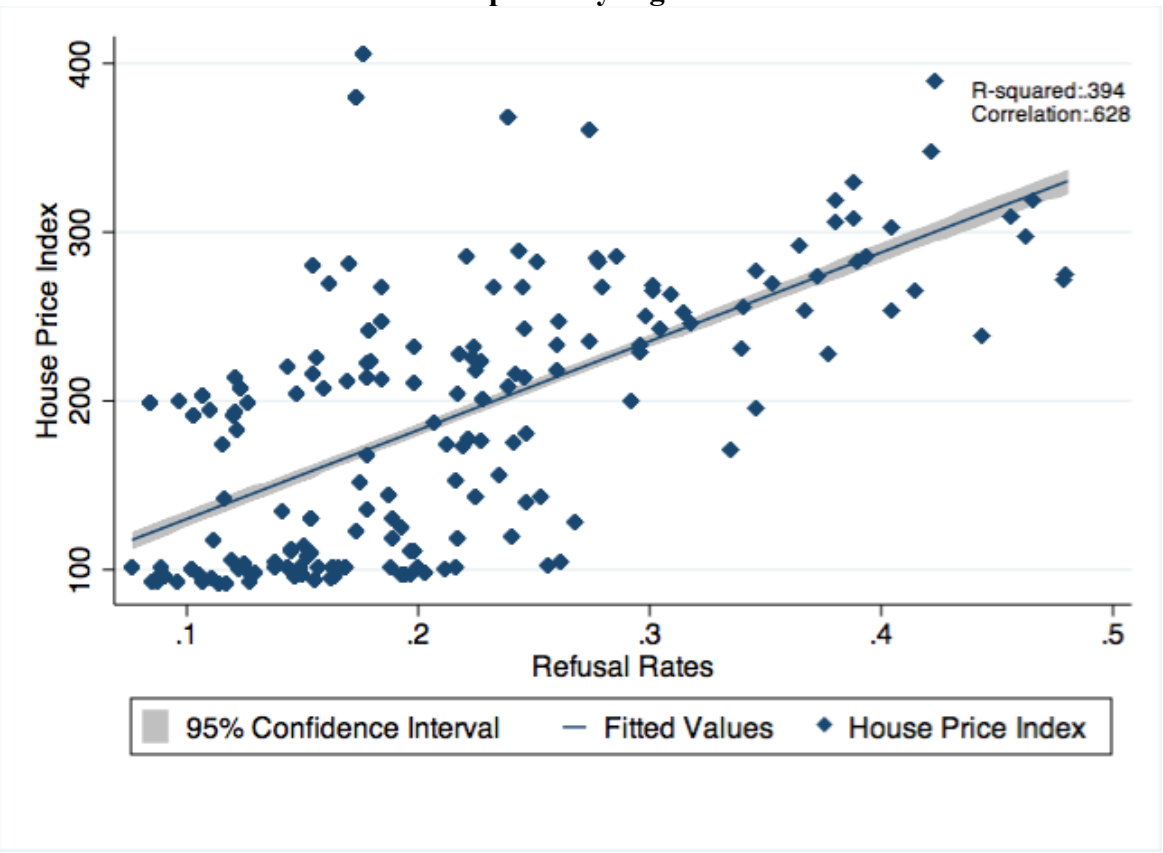

Chart A.3. Housing Wealth and Household Wealth

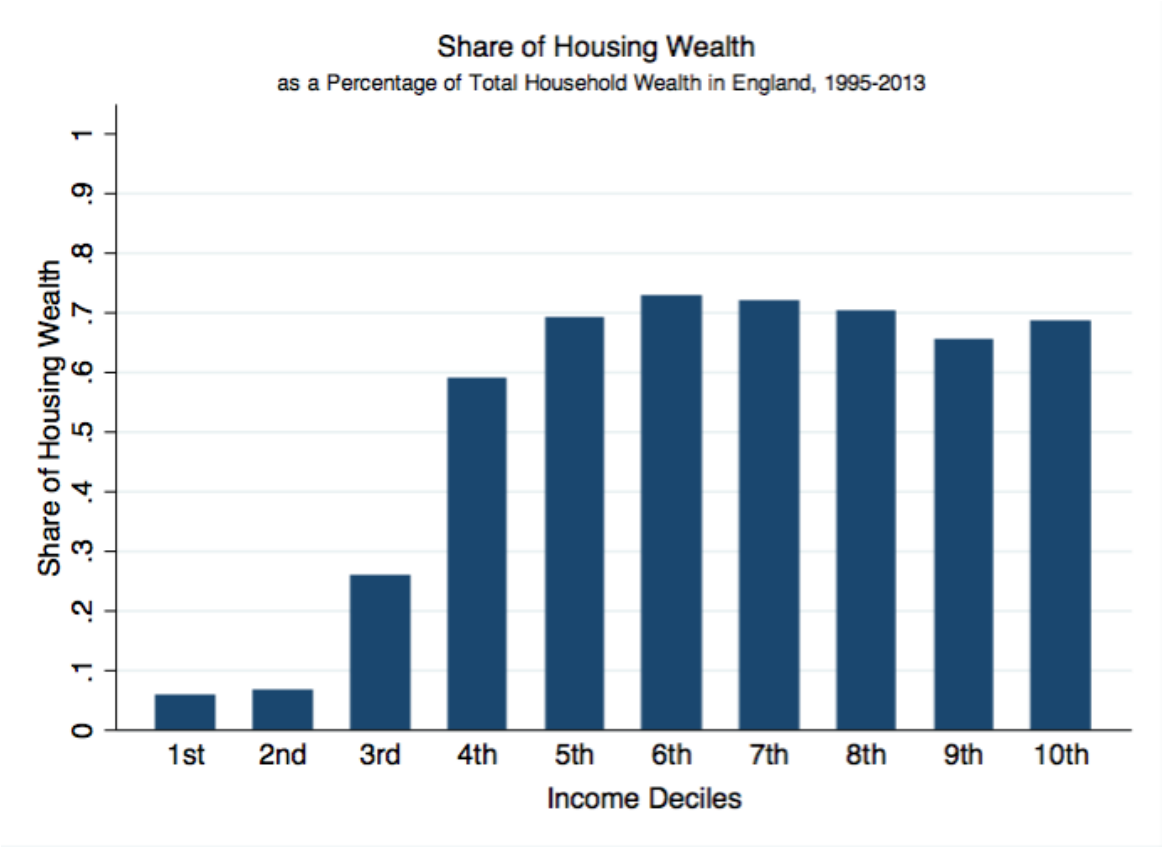

Table A.1 First-stage regressions of refusal rates on county level house prices

Controls for ➔	(1) FS Fixed effects	(2) FS + demographic characteristics	(3) FS + labor market characteristics	(4) FS + county linear trends	(5) FS + county quadratic trends
3 Year MA Refusal Rates	0.038***	0.046**	0.044***	0.053***	0.050***
	(0.008)	(0.018)	(0.013)	(0.017)	(0.015)
First Stage R-squared	0.402	0.455	0.466	0.703	0.826
F Statistic	12.02	11.70	13.83	15.65	18.46
N	5624	5624	5624	5624	5624

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. For details on control variables, see notes to Table 1.

Table A.2 Expanded set of coefficient estimates, (i.e., column 5 of table 1 and 2)

	(1) OLS	(2) IV
HPI*Ownership	0.008**	0.028***
	(0.002)	(0.008)
House price(HPI)	-0.017***	-0.049***
	(0.004)	(0.016)
Gross weekly wages $_{ct-1}$	0.001	0.004
	(0.003)	(0.010)
Unemployment rate $_{ct-1}$	0.012**	0.020*
	(0.004)	(0.009)
Gross household assets $_{ct-1}$	0.023***	0.039**
	(0.007)	(0.016)
Degree level $_{ct-1}$	-0.009*	-0.023*
	(0.004)	(0.012)
Foreign born $_{ct-1}$	0.001	0.004
	(0.003)	(0.005)
Other ethnicities $_{ct-1}$	0.006	0.008
	(0.006)	(0.010)
One person family $_{ct-1}$	-0.008	-0.012
	(0.008)	(0.019)
Single $_{ct-1}$	-0.001	-0.003
	(0.004)	(0.007)
Net population change $_{ct-1}$	0.012**	0.032**
	(0.004)	(0.013)
Fixed effects	Yes	Yes
County specific time trends	Yes	Yes
R-squared	0.816	0.802
N	5624	5624

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. For details on control variables, see notes to Table 1.

Table A.3 House prices and birth rates – alternative IV/2SLS estimations

Instruments ➔	(1) Change in delay Rate	(2) Average refusal rates between 1995-2013	(3) Refusal rates in 1994	(4) Change in delay Rate*refusal rates	(5) The number of accepted dwellings over baseline housing stock
Full sample					
HPI*Ownership	0.035**	0.024*	0.019	0.032***	0.017*
	(0.013)	(0.015)	(0.010)	(0.010)	(0.008)
House price(HPI)	-0.053**	-0.045**	-0.039*	-0.049***	-0.036**
	(0.020)	(0.018)	(0.019)	(0.015)	(0.014)
R-squared	0.822	0.777	0.781	0.801	0.768
N	5624	5624	5624	5624	5624
First stage F statistic	12.05	9.78	7.82	13.56	8.55

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. For details on control variables, see notes to Table 1.