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THE IMPACT OF SUPPLY CONSTRAINTS ON HOUSE PRICES IN ENGLAND

Abstract

We explore the impact of different types of supply constraints on house prices in England by exploiting a unique panel dataset of 353 local planning authorities ranging from 1974 to 2008. Using exogenous variation from a policy reform, vote shares and historical density to identify the endogenous constraints-measures, we find that: i) Regulatory constraints have a substantive positive long-run impact on the house price-earnings elasticity; ii) The effect of constraints due to scarcity of developable land is largely confined to highly urbanised areas; iii) Uneven topography has a quantitatively less meaningful impact; and iv) The effects of supply constraints are greater during boom than bust periods.

JEL classification: G12, R11, R21, R31, R52.

Keywords: house prices, housing supply, supply constraints, land use regulation.

1. Introduction

House values in England – particularly in London and the South East of the country – are amongst the highest in the world. The average price of a single detached freehold house in Kensington and Chelsea in 2008 – the last year of our sample period – was £4.3M. Of course, the royal borough of Kensington and Chelsea is extraordinary in many respects. However, house values were also extremely high in less exceptional places. The mean price of an equivalent house in Richmond, a nice 'greenish' London suburb was £1.2M; in the rather distressed but maybe transforming London borough of Hackney it still fetched £767k. Perhaps most astonishingly, even in rural places (e.g., Cotswold in the West of England; £470k) and in struggling cities (e.g., Birmingham in the West Midlands; £353k) house prices are very high by international standards.[1] These statistics are even more astounding when housing size is taken into account. A new-build house is 38 percent smaller in the UK than in densely populated Germany and 40 percent smaller than in the even more densely populated Netherlands (Statistics Sweden, 2005).

Real house prices – but not real incomes – have grown faster in the UK over the last 40 years than in any other OECD country.[2] As a consequence of this, a genuine 'housing affordability crisis' has been developing. Young households are particularly strongly affected; they increasingly struggle to get their feet on the owner-occupied housing ladder. Although existing homeowners nominally benefit from higher asset prices, they are also in some sense adversely affected. They cannot realise the 'gains' unless they downsize housing consumption, give up owner-occupation and rent instead or sell their houses and move abroad. In the interim high house prices force them to live in comparably cramped spaces.

Price volatility is similarly extraordinary. During the last full real estate cycle *real* house values in the UK as a whole first rose by 83 percent during the upswing of the 1980s; they subsequently declined by 38 percent during the downturn of the first half of the 1990s. This swing is substantially larger than that of the most volatile metro area in the US during the same cycle period: real values in Los Angeles rose by 67 percent and declined by 33 percent.[3]

In this paper we set out to explore the causal long-run impact of various types of supply constraints on house prices in England. Our main focus is on how *regulatory constraints* affect the sensitivity of house prices to changes in demand. The proposition that the English planning system impacts house prices is not far-fetched. The planning system is widely viewed as inflexible. Historically, it ignored market signals and has failed adequately to cope with changing socio-economic conditions. This rigid supply regime has been suggested – but

[1] Average prices are based on actual transaction prices – provided by the Land Registry – of *all* single detached freehold houses sold during 2008.

[2] Measured between 1971q1 and 2011q1 (OECD Economic Outlook database, 2011). Nationwide house price data suggests that prices have grown faster in England since 1973q4 than in any other UK country.

[3] The calculations for the UK are based on the Nationwide house price index. The nominal index is deflated by the retail price index that excludes mortgage interest payments in order to obtain a real price index. The troughs of the cycle were in 1982 and 1995, the peak was in 1989. The figures for Los Angeles are taken from Glaeser *et al.* (2008) who investigate the cyclical behaviour of 79 metro areas in the US. Real prices in Los Angeles rose between 1984 and 1989 and declined between 1990 and 1994.

not tested – to be an important cause of England's excessively high level and volatility of house prices.

An alternative proposition is that the high house prices are driven – at least in part – by strong demand for housing in conjunction with *physical (or geographical) constraints*. The *scarcity of developable land* and *uneven topography (steep slopes)* may both limit the long-run response of housing supply to demand induced price changes: whereas scarcity related constraints may be binding in highly developed locations such as the Greater London Area, slope related constraints may affect prices in rugged areas in the North and West of England. In this paper we carefully control for such physical supply constraints and disentangle and identify the separate impacts of the different types of constraints.

To do so, we compile a panel dataset that combines house price and earnings information – spanning 35 years and covering 353 English local planning authorities (LPAs) – with rich and direct information on regulatory and physical supply constraints for these locations. Exploiting this data and using exogenous variation from a policy reform, vote shares and historical density to identify the causal effects of the otherwise endogenous constraints-measures, we find that local regulatory constraints have a very substantive positive long-run impact on the response of local house prices to changes in local earnings. According to our baseline estimate, house prices would be around 35 percent lower if, hypothetically, all regulatory constraints were removed. More pragmatically: had the South East, the most regulated English region, the regulatory restrictiveness of the North East, still highly regulated in an international context, house prices in the South East would be roughly 25 percent lower. The effect of constraints due to local scarcity of developable land is largely confined to highly urbanised areas. The local impact of uneven topography is quantitatively less important. Hypothetically removing both types of physical supply constraints, again according to our baseline estimate, would reduce house prices by 15 percent.

We also find that the effects of the various supply constraints on the price earnings elasticity are greater during boom than bust periods. The year fixed effects in our estimates imply cyclical behaviour also at the aggregate level. However, most of the cyclicality can be explained by local demand fluctuations in conjunction with local supply constraints.

Our contribution to the literature is threefold: (i) We use a unique panel dataset to disentangle the impact of local regulatory supply constraints from two types of local physical constraints (the degree of residential development and ruggedness) on house prices in England; (ii) We identify – using an Instrumental Variables (IV) approach – causal impacts of these constraints by examining the extent to which they amplify the impact of earnings on house prices; and (iii) We provide a thorough quantitative interpretation of the estimated effects.

2. Background

A few studies suggest that the extraordinarily high real house price growth in the UK over the last 40 years and in particular since the mid-1990s may be linked to the British planning system (e.g., Cheshire and Sheppard, 2002; Barker, 2004 and 2006; OECD, 2004; Evans and Hartwich, 2005). In fact early research on this topic indicates that the British planning system may have already imposed binding constraints as early as the beginning of the 1970s (Hall *et al.,* 1973). Cameron *et al.* (2006) investigate the proposition that regional house prices between 1972 and 2003 in Britain have deviated from fundamentals ('bubble hypothesis'). They find no evidence suggesting a 'bubble', instead their results are consistent with lack of house building in conjunction with strong demand growth as a major driver of house price appreciation during their sample period, consistent with the main findings in this paper.

A number of recent studies investigate the economic impact of the British planning system, including its effect on house prices. For example, Bramley (1998) explores the effect of various measures of planning restraint on various outcome measures including house prices in a cross-section of English locations. One important contribution of this study is that it provides an early discussion on (i) how planning constraints should be measured and (ii) endogeneity problems associated with different types of measures. Cheshire and Sheppard (2002) and Ball *et al.* (2009) convincingly illustrate the high gross and net costs of the planning system for a single LPA in England. Cheshire and Hilber (2008) find that the gross cost imposed by regulatory restrictions – measured as a 'regulatory tax' – varies substantially across British office markets and over time, with the highest cost being observed in the Greater London Area. The estimated regulatory tax for Westminster, perhaps one of *the* most regulated places in the world, exceeds 800% of marginal construction costs. The lowest costs are being observed in Newcastle; the estimated tax is negative during the mid/late 1980s. The time trend is positive in most markets, consistent with the proposition that land use regulation policies in England may have become more binding over time.

Outside of the UK, research on the impact of land use regulation on house prices has mainly focused on the US. A number of recent studies document that land use regulation reduces the housing supply price elasticity (e.g., Green *et al.*, 2005; Quigley and Raphael, 2005; Saiz, 2010) whilst raising price levels (e.g., Glaeser and Gyourko, 2003; Glaeser *et al.*, 2005a and b; Quigley and Raphael, 2005; Saks, 2008). Particularly relevant to our study, Saks (2008) shows that metro areas with few barriers to construction experience more residential construction and smaller increases in house prices in response to an increase in housing demand. Glaeser *et al.* (2005 a and b) conjecture that tight land use controls may be largely to blame for the exorbitant rise in housing prices in parts of the US during the late 1990s and early 2000s. Glaeser et al. (2005a) uncover that the 'regulatory tax' exceeds 50 percent of condominium prices in places such as Manhattan or San Francisco but is negligible in places such as Pittsburgh or Houston.

Glaeser and Ward (2009), however, do not find a significant impact of local land use regulation on house prices across local municipalities in the Greater Boston area. They argue that since this area constitutes of many nearby and rather similar towns, households would not accept a regulation-induced rise in prices in one place, because they could easily substitute it for another nearby place. As a consequence, in their sample, local constraints on housing supply may only have an impact on prices at the level of the Greater Boston area. The same argument should not apply, however, to studies that consider locations that are less close substitutes such as metro areas in the US or, arguably, LPAs in England.

A few studies suggest that *physical supply constraints* affect the supply price elasticity and that therefore demand shocks should have a stronger impact on house prices in places with more limited supply of developable land. Hilber and Mayer (2009) demonstrate that the more developed 50 percent of municipalities in Massachusetts (with comparably less open and developable land for new construction) have more inelastic supply of new housing and that in these places demand shocks are capitalised to a greater extent into house prices. This finding implies that the more and less developed places in Massachusetts are sufficiently imperfect substitutes to ensure a differential price response to demand shocks. Saiz (2010) measures the amount of developable land based on the presence of water bodies and high elevation in the US, demonstrating that most metropolitan areas that are widely regarded as supply-inelastic are severely land-constrained by topography. Saiz documents that topographical constraints correlate positively and strongly with regulatory barriers to development and that both types of constraints negatively affect the elasticity of housing supply. Our findings for England are consistent with the implication that both types of constraints reduce the long-term responsiveness of new construction to demand induced price changes.

A few recent studies explore the impact of the supply side on *house price volatility*. Glaeser *et al.* (2008) illustrate that during boom phases house prices in the US grow much more strongly in metro areas with inelastic supply. They also report that the level of mean reversion during bust phases is enormous; however, the price elasticity and price declines are hardly correlated. The implication is that metro areas with more inelastic supply will have higher price volatility but this is, consistent with our findings for England, mainly driven by stronger price reactions during upswings. Paciorek (2012) documents a strong positive relationship at the city-level in the US between the volatility of house prices and the stringency of regulation of new housing supply. His estimates and simulations suggest that supply constraints increase volatility through two channels: (i) Regulation lowers the elasticity of new housing supply by increasing lags in the permit process and by adding to the cost of supplying new houses on the margin and (ii) geographic limitations on the area available for building houses lead to less investment on average relative to the existing housing stock, leaving less scope for the supply response to attenuate the effects of a demand shock.

On the theoretical side, a number of models assume heterogeneity in tastes for locations inducing imperfect substitutability between locations (Aura and Davidoff, 2008; Gyourko *et al.*, 2012; Hilber and Robert-Nicoud, 2012). In such models supply constraints may raise prices because they constrain the number of households so that the marginal household has a higher willingness to pay for residing in the place. Hilber and Robert-Nicoud (2012) provide a theoretical explanation and empirical evidence for the US consistent with this explanation for why more developed places tend to be more regulated. More desirable locations are more developed and hence owners of developed land will be relatively more politically influential than owners of undeveloped land. Land use constraints benefit the former group (via increasing property prices) but hurt the latter (via increasing development costs). Hence, as a consequence of political economy forces, more developed places will be more regulated. This theoretical insight has implications for our empirical work: local regulatory constraints may be endogenous to local land scarcity. It is thus important to control for both types of constraints and identify their causal effects using an IV approach.

3. Theoretical Considerations and Testable Predictions

In theory, in a world without any long-term supply constraints, *sustained* house price levels should not substantially exceed marginal production costs, even if demand fluctuates. In a world where supply constraints are binding but locations are all perfect or nearly perfect substitutes and households are all identical and perfectly mobile (i.e., the local housing demand curve is perfectly elastic), supply constraints should not affect the response of local house prices to local demand shocks. In such a setting, households would not accept any difference in the price of housing unless they were perfectly compensated. Any positive local demand shock would therefore be fully capitalised into higher house prices, independent of the price elasticity of local housing supply. Similarly, aggregate demand shocks should raise house prices everywhere in the country. In a panel data setting, these aggregate effects should be picked up by time fixed effects.

In a setting where supply constraints vary across space, land plots in different locations are imperfect substitutes (places differ in their natural amenities and in local public services and some of these are in scarce supply), households are not perfectly mobile (for example due to relocation costs imposed by the stamp duty or estate agent fees or due to personal attachments to place-specific social networks) and vary in their preferences for amenities and local public goods, the local demand curves should be less than perfectly elastic (downward sloping). In such a setting, in places in which long-term supply constraints are more binding, local demand shifts should have a larger impact on local house prices and comparably strong local demand should lead to comparably higher house prices over time.

We argue that our empirical setting with 353 English LPAs resembles the latter setting. Hence, we would expect house prices to respond more strongly to local demand shocks in LPAs that are more severely supply constrained. In our empirical work we observe variation in three types of local supply constraints: regulatory constraints, land scarcity related and slope related constraints. Earnings of local residents are arguably the main driver of local housing demand and we proceed using this measure as our local demand shifter.

Formally, assuming that functional relationships are log-linear, we can express the *demand for housing* $Q_{j,t}^{D}$ in location (or LPA) *j* and period *t* as:

$$\log\ Q_{j,t}^{D} = \varepsilon^{D} \log\ P_{j,t} + \varepsilon^{Y} \log\ Y_{j,t} + \alpha_{j}^{D} + \beta_{t}^{D} + \nu_{j,t}^{D}. \qquad (1)$$

House prices and earnings are denoted $P_{j,t}$ and $Y_{j,t}$ respectively and $\nu_{j,t}^{D}$ reflects idiosyncratic unobserved heterogeneity. Time-invariant local conditions like amenities are captured by location (LPA) fixed effects α_{j}^{D}. The period fixed effects β_{t}^{D} represent variation in macroeconomic conditions such as movements in the mortgage interest rate and overall income growth; they pick up the cyclicality in the *aggregate* England housing market. The price and earnings elasticities of local housing demand, denoted ε^{D} and ε^{Y}, depend on the degree of substitutability between locations. As long as substitutability is imperfect, these elasticities will be finite. Note that this specification rules out local heterogeneity in demand elasticities. Such heterogeneity would generate an attenuation bias in our supply constraints measures, for which our IV approach, described below, corrects.

We can express local *housing supply* as a function of local house prices, time-invariant local settings such as soil conditions, time-varying national determinants such as the price of construction inputs and supply specific unobserved heterogeneity:

$$\log\ Q_{j,t}^{S} = \varepsilon_j^S \log\ P_{j,t} + \alpha_j^S + \beta_t^S + \nu_{j,t}^S . \qquad (2)$$

Crucially, we allow the price elasticity of housing supply ε_j^S to vary across locations.

With prices equating demand to supply in the long run, we should observe the following relationship between house prices and earnings:

$$\log\ P_{j,t} = \varepsilon_j^{PY} \log\ Y_{j,t} + \alpha_j + \beta_t + \nu_{j,t} , \qquad (3)$$

where the fixed effects α_j and β_t are linear combinations of the demand and supply-specific fixed effects and $\nu_{j,t}$ is a linear combination of demand and supply-specific unobserved heterogeneity. Treating housing as a normal good, the long-run elasticity of house prices with respect to earnings $\varepsilon_j^{PY} = \varepsilon^{Y} \big/ \varepsilon_j^S - \varepsilon^D$ has the comparative static property:

$$\partial \varepsilon_j^{PY} \big/ \partial \varepsilon_j^S < 0 , \qquad (4)$$

that is, the more elastic local housing supply (the less constrained local supply), the smaller the long-run impact of earnings on prices. We can thus formulate our main proposition: *Local house prices respond more sensitively to local earnings shocks in more supply constrained locations.*

In our empirical work, we estimate a modified version of equation (3), in which variation in ε_j^{PY} is captured by interaction effects of earnings with several supply constraints:

$$\log\ P_{j,t} = \gamma + \sum\nolimits_k \delta_k X_j^k \times \log\ Y_{j,t} + \alpha_j + \beta_t + \nu_{j,t} , \qquad (5)$$

where X_j^k, $k = 1,..., K$, consists of indicators for regulatory and physical supply constraints.

4. Empirical Analysis

4.1. Data

We use LPA-level house price and income data from 1974 to 2008 and geographically match this data, using 2001 English district shape files, with regulatory data derived from public records, physical constraints data derived from satellite imagery and historical population density and composition controls derived from the Census. We briefly describe the variables below. Details on the computation of the variables are given in Appendix A. Summary statistics for the baseline sample are provided in Table 1.

Our mix-adjusted *house price index* is derived from transaction price data from the Council of Mortgage Lenders (CML) (1974 to 1995) and the Land Registry (1995 to 2008). Our proxy for local housing demand, the *total weekly gross earnings for full-time male workers*, comes from the New Earnings Survey (NES) (1974 to 2004) and the Annual Survey of Hours and Earnings (ASHE) (2004 to 2008).

We obtained our measures of LPA-level regulatory restrictiveness from the Department of Communities and Local Government (DCLG). Our key measure – the *refusal rate of 'major' residential projects* – is defined by the DCLG as the share of residential projects consisting of 10 or more dwellings that was refused by an LPA in any particular year.[4] Appendix Figure B1 illustrates the average refusal rate by LPA, measured between 1979 and 2008. Refusal rates over the last 30 years have been clearly highest in the Greater London Area and in the South and lowest in the North of the country. The second variable – the delay rate for major residential projects – is defined as the number of decisions that are delayed over 13 weeks in any particular LPA and year relative to all decisions made in that LPA and year. The 13 weeks-threshold is a 'performance' target introduced by the Labour government in 2002 with the intent to speed up the planning process. We use the *change in the delay rate pre- and post- the policy reform* as an instrumental variable to identify the potentially endogenous refusal rate. We discuss the rationale for this in the next section.

The literature broadly suggests two types of physical supply constraints measures. The first measure, the *share developed land* – the share of all developable land that is already developed – is derived from the 1990 Land Cover Map of Great Britain (LCMGB). As Appendix Figure B2 illustrates, local scarcity of open developable land is greatest in the Greater London Area and in and around the larger cities in the West Midlands (Birmingham) and the Northwest (Manchester). There are various reasons for why housing supply is typically less elastic in locations in which less open developable land is available. In a nutshell; the more land already in urban use, the more expensive it is to convert additional plots of land to residential use (Hilber and Mayer, 2009; Hilber, 2010).

The second measure is derived from elevation data from PANORAMA DTM. Burchfield *et al.* (2005) and Saiz (2010) suggest that ruggedness and steep slopes impose barriers to new residential development. Following Burchfield *et al.* (2005), we use the *range in elevation*, defined as the difference between the minimum and the maximum elevation in an LPA, as a proxy for whether an LPA is in mountainous area. Mountains at the fringe of development may hamper urban expansion. Appendix Figure B3 illustrates spatial variation in the elevation ranges across England, suggesting that steepness induced constraints may be greatest in the North and the West. The correlation between our elevation range indicator and the 'share developed land' is negative and fairly strong (-0.48), consistent with the proposition that uneven topography hampers residential development.

Our analysis includes a number of additional variables from various sources. The LPA-level *share of votes for the Labour party* in the 1983 General Election is derived from the British

[4] The refusal rate of planning applications is a standard measure to capture regulatory restrictiveness. It is for example used in Cheshire and Sheppard (1989), Preston *et al.* (1996) or Bramley (1998).

Election Studies Information System. The *historical population density* for 1911 and the various composition controls originate from the British Census.

4.2. Endogeneity Concerns and Identification Strategy

Two of our supply constraints measures – the *refusal rate* and the *share developed land* – are subject to endogeneity concerns. Moreover, changes in earnings may be driven in part by changes in the composition of the local labour force rather than by labour demand shocks. Below we discuss how we address these concerns.

4.2.1. Identifying the refusal rate

The post-1947 British planning system has been characterised by LPAs deriving very limited fiscal benefits from permitting development but facing most or all of the development related infrastructure and congestion costs. As a consequence, LPAs often side with NIMBYs ('not in my backyard' residents) and hinder or refuse altogether new development projects within their borders – especially larger projects that require costly new infrastructure provisions. In this context, we would expect that LPAs that are comparably more restrictive refuse a greater share of major development projects.[5] Our preferred measure of regulatory restrictiveness is then the *refusal rate for major residential projects*. Alas this measure, like all other direct measures of regulatory restrictiveness, is endogenous. One concern is that refusal rates are higher during boom periods when housing demand and hence house prices are high. 'Ambitious' projects may only be put forward during boom periods and bureaucrats may be overwhelmed with large piles of applications and so unable to deal with all of them. NIMBYs may also try harder to block new developments during boom times. We address these particular endogeneity concerns by using the *average refusal rate* over the entire period for which we have data (1979 to 2008). However, at least one endogeneity concern remains, even when employing the average refusal rate and location fixed effects: developers may be less likely to submit a planning application in the first instance, when they know that the relevant LPA is very restrictive and the chance of refusal high. So in restrictive LPAs the observed refusal rate may underestimate the 'true' tightness of the local planning regime. In order to address this and other potential endogeneity concerns related to our refusal rate measure, we use two separate identification strategies.

The *first identification strategy* exploits exogenous variation derived from a 2002 policy reform. On the 1st of April 2002 the Labour government introduced three new targets with the intention of speeding up the planning process. The main effect of the reform was that after 2002 an explicit target for *major development projects* was in place, so LPAs could no longer significantly delay those projects and still meet their target by approving smaller projects more speedily. Of course not meeting targets is an option for LPAs. In fact, to our knowledge there are no explicit formal sanctions if an LPA does not meet a particular target. However, in practice the central government has powerful 'tools' of withholding financial resources to LPAs and of removing their leeway in decision-making such that LPAs *de facto* do have

[5] The restrictiveness may differ across LPAs for example because of differences in the vested interests and ideology of the constituency or because the benefits associated with certain development projects are greater for certain LPAs than others. For instance, LPAs with high unemployment rates may have greater incentives to permit development because of short-term job creation during the construction process. See Cheshire and Hilber (2008) for evidence in favor of this proposition.

significant incentives to fulfil the government targets at least in the medium term; being on the ‘watch list’ for a short period of time may have less severe consequences. However, as is often the case, the policy reform had some perverse impacts such as major applications being turned down more quickly to meet the deadline, fewer pre-application discussions or longer delays in considering conditions (Barker, 2006).

Our identification strategy exploits the fact that LPAs did have the option to substitute one form of ‘penalised’ restrictiveness (not meeting the delay target) with other ‘non-penalised’ forms (e.g., rejecting major applications in order to meet the key target). The observable implication is that *changes* in the refusal rate and *changes* in the delay rate should be uncorrelated before it became clear that the targets are introduced (all planning parameters are optimised in pre-reform equilibrium) but should become negatively correlated afterwards, as the restrictive LPAs can be expected to have altered their behaviour to reject more major residential applications (an *increase* in the refusal rate) in order to meet their delay target (a *reduction* in the delay rate). After the adjustment process induced by the policy reform is completed, the two variables can be expected to become uncorrelated again in the new equilibrium. The solid line in Figure 1 illustrates this point by plotting the regression coefficient of the two measures, *change* in refusal rate and *change* in delay rate, over time. The coefficient is relatively close to zero and not statistically different from zero for most years until about two years prior to the introduction of the new targets. Then it turns strongly negative post-reform, before returning again to close to zero, consistent with our proposition.

Our identifying assumption is that the policy reform had a differential impact on more and less restrictive LPAs. The most restrictive LPAs should have had the strongest incentives to delay major residential projects pre-reform, so were most likely not to meet the new key target. They also should have had the strongest incentives post-reform to reduce their delay rate for major projects by refusing a greater share of them in order to meet the key target. For less restrictive LPAs, with low refusal rates to begin with, there was no or less need to alter their behaviour to accommodate the target. Hence, rather than looking at the delay rate of an LPA, our instrument is the *change in the delay rate pre- and post-reform*; the most restrictive LPAs should have had the greatest decrease in the delay rate. In our empirical work we use the average of the delay rates between 1994 and 1996 as our measure of the delay rate *prior* to the reform. This time window is clearly before the involved agents started to anticipate the reform. Figure 1 suggests that during this time period the correlation between the change in the refusal rate and the change in the delay rate was indeed reasonably close to zero. As post reform window we use the period between 2004 and 2006. Figure 1 suggests that most of the adjustment process had taken place during this time period: the negative correlation between the change in refusal rate and the change in delay rate during this period was quite strong.

Our *second identification strategy* exploits exogenous variation arising from spatial variation in the share of votes to the Labour party at the General Election of 1983. Political party composition has been used for example by Sadun (2008) as an instrument for the restrictiveness of the local planning system.[6] The rationale for this is as follows: low and

[6] Sadun (2008) explores whether planning regulation in Britain protects independent retailers. She argues that Conservatives have traditionally been associated with a strong opposition towards big-box retailing.

middle income Labour voters have traditionally cared more about housing affordability and less about protection of house values; fewer low income residents own homes. Hence, we would expect the local share of votes to the Labour party to be negatively associated with the restrictiveness of the local planning system. Our identifying assumption is that, controlling for location fixed effects, the share of votes to Labour in 1983 affects the impact of earnings on house prices only through planning restrictiveness. We chose a General Election rather than a local election as the latter may be significantly affected by *local* housing market conditions or opposition to large scale local development projects. We chose the General Election of 1983 as it is the earliest year for which we could obtain General Election data that can be geographically matched to the LPA-level.

4.2.2. Identifying the share developed land

Whilst one of our physical constraints measures – the elevation range – is clearly exogenous, the share developed land in 1990 is arguably endogenous as well. How developed a particular location is, is an equilibrium outcome; the result of demand and supply side pressures. For example, in more desirable places, better-off residents will have greater demand for housing and these places will consequently be more developed. Similarly, more restrictive LPAs should have more open land for future development, all else equal. Hence, contemporaneous land scarcity could be in part explained by the tightness of the planning system during our sample period (e.g., through allocation of Greenbelts) or in fact by many other contemporaneous factors that may also affect house prices. In order to address this endogeneity concern we use historic population density in 1911 as an instrument to identify the share developed land in 1990. This instrument pre-dates the 'birth' of the modern British planning system – the Town and Country Planning Act of 1947 – by several decades. Our identifying assumption is that the population density almost 100 years ago will be indicative of early forms of agglomeration (and local amenities), so we expect the variable to be strongly correlated with the share of developed land almost 100 years later but, controlling for LPA fixed effects that capture local amenities, we would not expect historic density to directly (other than through land scarcity) explain *changes* in contemporaneous house prices.

4.2.3. Controlling for composition effects

In our empirical analysis we use male weekly earnings at LPA-level as a shifter of the local housing demand curve, interpreting a change in earnings as an exogenous demand shock. Such a shock may, for example, be caused by a shock to an industry that is well represented in the area. However, changes in earnings may also be driven, at least in part, by changes in the composition of the local labour force. Positive labour demand shocks and an increase in the share of highly skilled residents can both be expected to increase house prices through increasing housing demand and we would expect that the effect on house prices is greater in both cases in places with more constrained supply. However, to the extent that earnings variation is driven by changes in the household composition rather than exogenous demand shocks, the impact of earnings on house prices may be smaller. This is because sorting induced changes in earnings do not induce migration: households do not gain by moving since their skill level is unchanged. Put differently, our earnings measure may be endogenous to composition effects. Omitting composition controls may lead us to underestimate the effect of genuine earnings shocks on house prices. In an attempt to address this concern we therefore control for household composition at the LPA-level in one of our robustness checks (see section 4.6).[7] We note, however, that the *impact of supply constraints* on the house price earnings elasticity should be virtually by the inclusion of composition controls. This is because we instrument for scarcity related and regulatory supply constraints.

4.3. Empirical Baseline IV-Specification

Following the empirical specification in equation (5), we interact all three measures of local supply constraints – regulatory restrictiveness, land scarcity and uneven topography – with local annual earnings – our measure of local demand – and include annual earnings as a separate control. We instrument the refusal rate and the share developed land by employing the identification strategies discussed above. This approach allows us to assess to what extent the three supply constraints amplify the impact of earnings on house prices. Our baseline specification is:

$$\begin{aligned} \log\ \mathit{house\ price}_{j,t} &= \beta_0 + \beta_1 \log\ \mathit{earnings}_{j,t} + \beta_2 \log\ \mathit{earnings}_{j,t} \times \overline{\boldsymbol{refusal\ rate}}_{\boldsymbol{j}} \\ &+ \beta_3 \log\ \mathit{earnings}_{j,t} \times \boldsymbol{\%developed}_{\boldsymbol{j}} + \beta_4 \log\ \mathit{earnings}_{j,t} \times \mathit{elevation}_j \\ &+ \sum_{i=1}^{34} \beta_{4+i}\, D_t + \sum_{i=1}^{352} \beta_{38+i}\, D_j + \varepsilon_{j,t}\ . \end{aligned} \tag{6}$$

The **bold** variables are instrumented to identify causal effects. The upper bar indicates an average over all years, for which we have planning application data.

We standardise all three supply constraint measures to ease interpretation of the coefficients. We subtract the sample mean of each supply constraint measure from the measure itself and divide this difference by the standard deviation of the measure. This transformation allows us to interpret the estimated coefficients as *an increase in the house price-earnings elasticity due to a one standard deviation increase in the respective constraint measure*. By implication, the coefficient on the earnings variable can be interpreted as the house price-earnings elasticity for an LPA with average levels of supply constraints.

4.4. Main Results

Table 2 summarises our main findings. In column (1) of Panel A we report the results of a naïve OLS specification that does not take into account any endogeneity concerns. The specification includes LPA- and year-fixed effects to capture all unobserved characteristics that are either time-invariant or do not vary across space. All observations are clustered by pre-1996 counties as the earnings and house price data for earlier years had to be partly inferred from county-level information (see Appendix A for details). The coefficient on the price-earnings elasticity is highly statistically significant and positive, taking a value of 0.32, implying that in an LPA with average levels of constraints, a (permanent) 10 percent increase

[7] Ideally, we would identify the causal effect of earnings by employing an IV approach. However, apart from the lack of a valid *and* strong instrument to identify the earnings measure, we face the problem that instrumenting for earnings would mean that we instrument both terms of the relevant interaction effects. This would make weak identification and hence bias towards OLS highly likely.

in earnings raises house prices by 3.2 percent. The coefficients on the earnings × supply constraints interactions point to modest but statistically significant heterogeneity of this elasticity across LPAs: the house price-earnings elasticity rises to 0.38 in an LPA in which the refusal rate is one standard deviation above the English average and to 0.41 in an LPA in which the share developed land is one standard deviation above the English average. The elevation range does not appear to affect the house price-earnings elasticity in a statistically significant manner.

Results for our baseline IV specification in equation (6) are reported in columns (2) to (4) of Panel A. The specification in column (2) uses all available instruments to identify the endogenous variables, columns (3) and (4) drop, respectively, the *share votes to Labour* and the *change in delay rate*. The corresponding first-stage results are shown in columns (1) to (6) of Panel B.

The IV results of our preferred specification with *all* instruments, reported in column (2) of Panel A, indicate that a one standard deviation increase in the refusal rate raises the house price-earnings elasticity by 0.29 and a one standard deviation increase in the share of developed land raises the elasticity by 0.30. The coefficients on the two interaction terms are more than four times and more than three times larger than the corresponding ones in the naïve OLS-estimate. Furthermore, the estimates now point to the elevation range as a statistically significant barrier to construction as well: a one standard deviation increase in this variable raises the house price-earnings elasticity by 0.095. Conditional on the validity of our exclusion restrictions, these may be interpreted as causal effects. The coefficient on earnings is smaller than in the previous specification yet it is imprecisely estimated.

We should emphasise here that the estimated coefficients do not take into account the fact that in most LPAs regulatory constraints are much more severe than local land scarcity induced constraints. The distribution of the latter variable is much more skewed (skewness=1.18) than the former (skewness=0.33). Only in the most urbanised areas physical supply constraints are genuinely binding *in a quantitative sense*. We further explore the quantitative significance of our findings in a counterfactual analysis in section 5.

The remaining TSLS-specifications reported in columns (3) and (4) of Panel A test the sensitivity of our results to the strategy employed to identify the refusal rate. In column (3) we only use the change in delay rate to identify the impact of the refusal rate. In column (4) we only use the share of votes to Labour. Given the different nature of the two identification strategies, it is reassuring that the effect of regulatory constraints on the house price-earnings elasticity is highly significant in both cases. Estimates of both regulatory and physical constraints are higher when we use the share of votes to Labour as an instrument. Our preferred specification in column (2) yields effects that are in between the two estimates.

Corresponding first-stage results in Panel B suggest that our instruments for the refusal rate and the share developed land all have the predicted signs and are highly statistically significant. The Kleibergen-Paap F-statistic suggests that weak identification may not be a concern, even when we only use the change in delay rate or the share votes to Labour as single instruments to identify the refusal rate.

The year fixed effects in our various estimates in Table 2 – illustrated in Figure 2 – imply cyclical behaviour at the aggregate level. Our counterfactual analysis in section 5 explores to what extent cyclical behaviour can be explained by local supply constraints.

4.5. Results for Boom and Bust Periods

Barriers to construction ought to matter less during periods with weak local housing demand. Since the existing housing stock is durable, when local demand is falling, the relevant part of the supply curve is almost perfectly inelastic, irrespective of the presence of any man-made or physical supply constraints – the supply curve is 'kinked' (Glaeser and Gyourko, 2005).

Table 3 tests the conjecture that supply constraints are more binding during boom than bust periods. We define 'bust periods' as years when average real house price growth in England was negative: from 1974 to 1977, in 1981 and 1982, from 1990 to 1996 and in 2008.[8] The remaining years are, somewhat casually, labelled 'boom periods'. Results from separately estimating our preferred specification on the sub-samples of boom and bust years are shown in columns (1) and (2). Consistent with theory, we find that the impact of a one standard deviation increase in the refusal rate is almost twice as large during 'booms' than 'busts', raising the house price-earnings elasticity by 0.27 and 0.15, respectively. A one standard deviation increase in the share of developed land raises the house price-earnings elasticity by 0.29 during 'booms' and by 0.20 during 'busts'. The difference between these effects – tested either separately or jointly – is statistically significant.

4.6. Robustness Checks

In an attempt to check the robustness of our main findings, we carried out a number of additional tests. To begin with, in Table 4 we directly control for *composition effects*. Since demographic and industry specific information on the local labour force are not available at LPA-level on an annual basis, we derive this information from the decennial Census. In particular, we consider the share of the population aged between 45-64, the share of local employment in manufacturing and the share of the population that is highly educated. Column (1) replicates our preferred IV specification from column (2) of Table 2 but limits the sample only to the Census years 1981, 1991 and 2001. In columns (2) to (4) we add the composition controls, one at a time. Finally, column (5) includes all composition controls. The coefficients on the interaction terms earnings × refusal rate and earnings × share developed land are quantitatively meaningful, highly statistically significant and stable across all five specifications. The interaction term earnings × elevation range is consistently positive but not statistically significant in any of the five specifications. Importantly, however, the positive coefficient is again stable across specifications. Overall, these findings are strongly suggestive that our results are not noticeably affected by changes in household composition.

Our main analysis is conducted at the LPA-level. Housing markets of proximate LPAs may be strongly integrated, however, so that carrying out the analysis at a higher level of spatial aggregation may be more appropriate. As a robustness check, in Table 5 we therefore report

[8] We could not infer an average growth rate for the first year in our sample, but national house price data leave little doubt that 1974 was a bust year (see e.g., Muellbauer and Murphy, 1997).

specifications for three alternative geographical scales: Travel to Work Areas (TTWAs), Functional Urban Regions (FURs) and Pre-1996 counties. TTWAs, of which there are 150 in England, are designed to capture local labour markets. TTWAs are subdivided into urban and rural areas; as a further robustness check we also estimate our main specification on the subset of 71 urban TTWAs. FURs constitute an alternative definition of integrated urban housing markets, which is based on commuting patterns in 1990. Our sample consists of 55 FURs and 46 Pre-1996 counties.

Table 5 reports results at different geographical scales for our preferred specification (column 2 of Table 2). LPA-level results are reproduced in column (1) for ease of comparison. Columns (2) to (5) report results for alternative geographical scales. All observations are weighted with the number of households in the 1990 Census, since the different geographical units vary enormously in their household size. For instance, the smallest TTWA, Berwick, contains hardly more than 10,000 households, whereas the number of households exceeds 3 million in London. In order to make coefficients comparable across specifications, we standardise supply constraints to their standard deviation at LPA level, so that at each geographical scale, coefficients correspond to a one LPA-level standard deviation change.

Results turn out to be remarkably homogeneous across different geographical scales, indicating that our results are largely unaffected by spatial correlation between LPAs. The estimated impact of a one LPA-level standard deviation increase in refusal rates on the house price-earnings elasticity ranges from 0.23 for urban TTWAs to 0.33 for pre-1996 counties, while the estimated impact of a one LPA-level standard deviation increase in the share of developed land ranges from 0.22 for pre-1996 counties to 0.30 at the LPA level. The coefficients are always highly statistically significant. Results for the elevation range are similarly homogeneous. The Kleibergen-Paap F-statistic suggests that at higher spatial levels of aggregation, identification tends to become stronger.

We carried out a large number of additional robustness checks. We briefly discuss these checks here but refer the interested reader to Hilber and Vermeulen (2010) for detailed results. In a first set of tests, we replicate our analysis but use alternative measures for our supply constraint proxies. To begin with, we utilise a measure for share developed land that treats semi-developable land as non-developable. ‘Semi-developable’ land includes land cover categories that are common in *flood risk areas*. It also includes land cover categories that are at the margin of being developable because of e.g. geological constraints, technical constraints or viability considerations. Next, we use alternative measures to proxy for slope related physical constraints. Specifically we use two measures that are based on the range between highest and lowest altitude (dummy variables that take the value of one if the elevation range in metres is in the top 75th / in the top 90th percentile). The two measures take into account that the effect of ruggedness may be highly non-linear. We then repeat this exercise but use an altogether different measure for slope related constraints: the standard deviation of slopes in degrees. Finally, we experiment with an alternative proxy measure for regulatory restrictiveness; the price of bulk land, that is, the price of land with planning permission at the urban fringe. Results are very similar in all cases.

In a second set of tests, we explore the robustness of our findings to changes in the definitions of our instruments. We alter the pre- and post-reform time window of our change-in-delay-rate instrument by one year in each direction. We also use the share of votes to Labour in alternative General Election years: 1997 (a Labour landslide unlike 1983, which was a Conservative landslide), 2005 (a comparably close Labour victory) and the average of the three years 1983, 1997 and 2005. Again, results are virtually unaltered in all cases.

In a last set of checks, we drop the City of London or all LPAs in the Greater London Area (GLA) to see to what extent our results are driven by the capital. Interestingly, when we drop the entire GLA, the positive coefficient on the share developed land × earnings interaction term becomes much smaller and statistically insignificant, suggesting that the impact of the share developed land on the price-earnings elasticity may be largely confined to the highly urbanised GLA. This finding is consistent with the fact, discussed in section 4.4, that the share developed land measure is highly skewed and that the effect of the share developed land on house prices in our main analysis is only quantitatively meaningful in the most highly urbanised LPAs.

5. Counterfactual Analysis

In this section, we carry out a counterfactual analysis in order to develop a better understanding of the quantitative implications of our empirical results. Before turning to a discussion of the results, we should stress that these results ought to be interpreted with some caution. Our counterfactual scenarios are based on the estimated impact of *local* supply constraints on *local* house prices. Since the substitutability of housing across LPAs is likely to be considerable, some of the effects of *local* supply constraints may operate at the *aggregate level*. In the unrealistic extreme case of perfect substitutability, constraints on local supply would not affect local prices at all relative to prices in other places, but they would push up the aggregate price level. Incorporating such repercussions at the aggregate level would require a full general equilibrium analysis of all local housing markets in England, which is beyond the scope of this paper. By implication, our counterfactuals represent a potentially significant underestimation of the aggregate implications of supply constraints and, in particular, of the planning system. We underestimate the effect of regulatory constraints even further to the extent that they were already binding in 1974. This is a real possibility given that the British Town and Country Planning Act was already introduced in 1947. In fact, evidence provided by Hall *et al.* (1973) suggests that this was likely the case.

We conduct our counterfactual analysis on the basis of the three TSLS specifications reported in Table 2. Our preferred specification with all instruments provides a 'baseline estimate'. The two distinct identification strategies for the refusal rate measure provide a bandwidth of plausible quantitative effects: in the context of the caveats discussed above, they offer a 'lowest bound' and 'lower upper bound' estimate, respectively. Each specification yields a prediction of local house prices conditional on local earnings, local supply constraints and LPA and period fixed effects. Counterfactual scenarios are then obtained by predicting house prices with supply constraints set to zero one by one. Removing supply constraints entirely may be unrealistic in practice; however, the corresponding counterfactual scenarios allow us to get a sense of how important quantitatively the separate constraints are for house price levels. In order to quantify the impact of local income dynamics in the absence of supply constraints, we also subtract the ‘independent’ earnings term. This is done for each LPA separately first, and then we take the averages of the predicted house prices and counterfactual scenarios over all locations to derive a counterfactual scenario for the *‘average’ English LPA*. Note in this context that predicted house prices are identical to average prices over the regression sample because of the period fixed effects. Finally, we transform the scenarios to levels in 2008 £.

The results of this exercise are summarised in Table 6. Figure 3 illustrates the impact of the various local supply constraints and the independent effect of local earnings fluctuations graphically and over the entire sample period. Appendix Figure B4 illustrates the scenarios for a few distinctive LPAs that are known to be comparably restrictive or unrestrictive: Westminster and Newcastle upon Tyne were the most and least restrictive markets with respect to regulating office space in Cheshire and Hilber (2008). Reading and Darlington represent a relatively restrictive and a relatively relaxed local authority in Cheshire and Sheppard (1995). Finally, we vary the regulatory restrictiveness of the ‘average’ LPA to four alternative levels: the 10^{th} and the 90^{th} percentile of the restrictiveness distribution and the level of the least and most restrictive English region, that is, the North East and the South East. Figure 4 illustrates the predicted real house prices over the sample period for the ‘average’ English LPA and the four counterfactual scenarios.

Bearing the various caveats in mind, the scenarios point to a substantial impact of regulatory supply constraints: house prices in the ‘average’ LPA in England in 2008 would be 21.5 (lowest bound) to 38.1 percent (lower upper bound) lower if the planning system were completely relaxed. The baseline estimate yields a reduction of 35 percent. The standard deviation of prices during the sample period would be between 29.7 and 51.6 percent lower, with the baseline being 47.6 percent. Removing all regulatory barriers is not very realistic, but Figure 4 illustrates that even setting the restrictiveness level to the 10^{th} percentile of the distribution or to the level measured in the North East yields very substantial reductions in house prices. House prices would be roughly 25 percent lower in the South East, had it the restrictiveness level of the North East.

Consistent with the observation that physical supply constraints are genuinely binding in a quantitative sense only in few highly urbanized areas (section 4.4), our counterfactual analysis points to a modest average impact relative to that of regulatory constraints: house prices (their standard deviation) would be 9.9 to 10.5 (12.6 to 13.1) percent lower absent of scarcity constraints and 2.8 to 3.1 (3.3 to 3.6) percent lower in the absence of elevation differentials. As the Appendix Figure B4 illustrates, the impact of the different types of constraints varies significantly across locations. In the densely developed borough of Westminster, physical constraints matter most, regulatory constraints are most important in the prosperous provincial town of Reading and in Newcastle and Darlington house prices are comparably little influenced by supply constraints. As expected, local earnings have little impact on house prices once supply constraints are removed.

Finally, not all of the house price dynamics is explained by local earnings dynamics and the differential effects it has depending on local supply constraints. Even when holding local earnings and their interactions with local supply constraints constant, average house prices in England, as illustrated in Figure 3, would have increased between 1974 and 2008 in real terms. We speculate that this residual price dynamics reflects, at least in part, the *aggregate* impact of local supply constraints in conjunction with local earnings fluctuations, as discussed above. It may also be the result of macro-economic factors such as fluctuations in interest rates, financial liberalization or aggregate income shocks. However, in line with life-cycle macro-models that assume that the supply of land is inelastic (e.g., Ortalo-Magne and Rady, 2006; Kiyotaki et al., 2011), the impacts of these aggregate demand factors still depend on supply constraints such as those introduced by the rigid English land use planning system. We also cannot rule out that the residual effects are due to adaptive expectations in conjunction with construction lags, although, as already discussed in section 2, Cameron *et al.* (2006) provide evidence against the 'bubble hypothesis' for UK regions, at least for the period between 1972 and 2003.

6. Conclusions

Housing affordability has been a vital policy concern in Britain for the larger part of the past one and a half decades, leading many to speak of an 'affordability crisis'. Especially young households increasingly struggle to get 'their feet on the property ladder' and to afford a 'decent home', particularly in the Greater London Area and the South of the country but also elsewhere. The financial crisis has temporarily shifted concerns to a potential collapse of the housing market, but even if housing affordability may have marginally risen during the crisis (which is not entirely clear as real incomes declined in most areas), the topic is likely to make a comeback on the policy agenda once the economy recovers and house prices or mortgage interest rates are on the rise again. Our findings point to the planning system as an important causal factor behind this 'affordability crisis'. Moreover, recent studies have suggested that regulatory constraints have become more binding over the last few decades (Cheshire and Hilber, 2008; Glaeser *et al.* 2005b) and may become even more binding in the future (Hilber and Robert-Nicoud, 2012). To the extent the latter is true our findings imply that affordability problems may become even worse during future upswings, especially in highly urbanised areas, where the house price to income ratio may rise even more dramatically than elsewhere.

Our empirical analysis suggests that the planning system has also made house prices substantially more volatile. Most owner-occupiers have to 'overinvest' in housing due to an investment constraint induced by owner-occupied housing (Henderson and Ioannides, 1983). Hence, in contrast to corporate and institutional investors, constrained owner-occupier households cannot adequately diversify their portfolios. An increase in house price volatility increases this distortion and therefore reduces the likelihood of owning, all else equal (Turner, 2003; Hilber, 2005). Existing homeowners may be to some extent protected from price fluctuations. If they move within the same market, then if they buy high they should be able to sell high (and vice versa). Even if households move between markets they will be protected to the extent that the covariance in house prices between the two markets is high (Sinai and

Souleles, 2012). However, this argument does not apply to first-time buyers who typically face severe credit constraints (having low levels of accumulated wealth and relatively junior salaries), are in need of high leverage and are fully exposed to market conditions.[9] These are also the households that are most affected by the ‘affordability crisis’.

An increase in house price volatility, through the consumption channel, also has important negative consequences for the macro-economy. A higher degree of house price volatility may lead to increased volatility of consumption and reduced macro-economic stability. It was these types of considerations that lead the UK government to scrutinise the planning system and its relationship with the wider economy in the first instance (Barker, 2004, 2006).

Finally, we note that our findings do not *necessarily* suggest that the British planning system as a whole is welfare decreasing. There are considerable potential benefits from some aspects of regulation (internalization of negative externalities; provision of local public goods; reduction of uncertainty[10]) that will be positively capitalised into land values, so are not due to pure costs imposed by regulatory supply constraints. Cheshire and Sheppard (2002) did estimate the net welfare effects of restrictions on land supply in Reading. Their estimates imply that the restrictions had a small effect on benefits relative to costs, resulting in a net welfare cost equivalent to nearly 4 percent as an annual income tax. However, since our study merely quantifies the *total impact* of regulatory supply constraints on house prices, we are not able to take a conclusive stand on the net welfare impact. Nevertheless, our findings have important and worrying policy implications, at least for certain groups of the population.

[9] In England most first-time buyers are almost fully exposed to the interest rate risk. Mortgage lenders often offer a two year fixed rate – the so called ‘teaser rate’ – but this subsequently becomes a flexible rate, determined by market conditions. Hence housing affordability is adversely affected if interest rates increase unexpectedly.

[10] For example, strict planning controls reduce the uncertainty that a neighbour may add an extra story to the house and remove one’s own views on a beautiful lake. However, as for example Mayo and Sheppard (2001) or Ball *et al.* (2009) point out, lengthy and costly planning applications with uncertain outcomes also generate uncertainty on the side of developers and/or future occupants.

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TABLES

TABLE 1
Summary statistics (regression sample)

	Obs.	Mean	Std. Dev. overall	Std. Dev. between	Std. Dev. within	Min	Max
Panel data							
Real house price index (1974 = 100)	12355	142.9	71.1	14.7	69.6	35.8	711.2
Real male weekly earnings (2008 GBP)	12355	485.4	117.6	68.1	95.9	223.9	1394.1
Refusal rate of major residential projects (%), 1979-2008	10539	25.4	17.3	8.7	15.0	0	100.0
Share of major residential decisions over 13 weeks (%), 1979-2008 (delay rate)	10539	43.4	22.4	8.6	20.7	0	100.0
Share of population aged between 45 and 64 years (%), Census years 1981, 1991 & 2001	1059	23.1	2.1	1.5	1.5	14.5	32.1
Share of workforce employed in manufacturing (%, Census)	1059	19.9	8.2	5.7	5.9	4.5	52.8
Share higher educated (%, Census)	1059	9.3	8.8	3.2	8.2	0.24	59.1
Total number of households (Census)	1059	52819	37240	36872	5467	2001	390792
Cross-sectional data							
Average refusal rate over period 1979 - 2008 (%) [1)]	353	25.4	8.7			0	50.9
Share of developable land developed in 1990 (%) [2)]	353	25.7	23.3			0.9	97.6
Change in delays between 1994-1996 and 2004-2006	353	-3.1	22.0			-63.5	53.1
Share of votes for Labour, 1983 General Election (%)	353	16.3	9.1			0.1	41.0
Population density in 1911 (persons per km2)	353	668.3	2434.6			0	22028.8
Range between highest and lowest altitude (m)	353	208.8	171.2			5.0	975.0

Notes: [1)] Skewness = 0.33; median = 0.25 [2)] Skewness = 1.18; median = 0.15.

TABLE 2

Baseline specifications: OLS and TSLS (N=12355, LPAs=353)

PANEL A – Dependent variable: Log (real house price index)

	OLS	TSLS: *Second stage*		
	(1)	(2)	(3)	(4)
Log(real male weekly earnings)	0.317***	0.0887	0.200**	0.0436
	(0.0494)	(0.0859)	(0.0811)	(0.103)
Av. refusal rate of major residential projects × log(real male weekly earnings)	0.0669***	**0.293*** **	**0.164*** **	**0.339*** **
	(0.0157)	**(0.0566)**	**(0.0627)**	**(0.0635)**
Share of developable land developed in 1990 × log(real male weekly earnings)	0.0935**	**0.295*** **	**0.234*** **	**0.331*** **
	(0.0399)	**(0.0493)**	**(0.0437)**	**(0.0498)**
Range between highest and lowest altitude × log(real male weekly earnings)	-0.000473	0.0951**	0.0714**	0.112***
	(0.0214)	(0.0388)	(0.0322)	(0.0427)
LPA fixed effects (and constant)	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
R-squared overall / within / between	0.327 / 0.957 / 0.0877			
Kleibergen-Paap F		11.75	10.70	10.54

PANEL B – TSLS: *First stage*

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Refusal × Earnings	Developed × Earnings	Refusal × Earnings	Developed × Earnings	Refusal × Earnings	Developed × Earnings
Log(real male weekly earnings)	0.523**	-0.0486	0.926***	-0.266**	0.562**	-0.0383
	(0.215)	(0.105)	(0.310)	(0.126)	(0.236)	(0.107)
Change in delay rate b/w 1994-1996 and 2004-2006 × log(real male weekly earnings)	-0.139***	-0.0364	-0.241***	0.0188		
	(0.0410)	(0.0306)	(0.0556)	(0.0326)		
Share votes for Labour in 1983 × log(real male weekly earnings)	-0.516***	0.278***			-0.549***	0.269***
	(0.0746)	(0.0505)			(0.0789)	(0.0486)
Population density in 1911 (persons per km2) × log(real male weekly earnings)	-0.154***	0.429***	-0.250***	0.480***	-0.159***	0.428***
	(0.0211)	(0.0379)	(0.0312)	(0.0405)	(0.0225)	(0.0386)
Range between highest and lowest altitude × log(real male weekly earnings)	-0.00296	-0.400***	0.0361	-0.421***	-0.0226	-0.405***
	(0.0550)	(0.0842)	(0.0616)	(0.0901)	(0.0564)	(0.0858)
LPA fixed effects (and constant)	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared overall model	0.363	0.560	0.106	0.495	0.345	0.559
R-squared within model	0.376	0.655	0.205	0.609	0.361	0.654
R-squared between model	0.363	0.560	0.106	0.495	0.345	0.559

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. **Bold** variables are endogenously determined. All supply constraints measures are standardised. Observations are clustered by pre-1996 counties.

TABLE 3
The impact of supply constraints during boom and bust periods (TSLS, 2nd stage)

VARIABLES	(1) Boom	(2) Bust
Log(real male weekly earnings)	0.115	0.0651
	(0.0792)	(0.104)
Refusal rate × log(real male weekly earnings) †	**0.267*** **	**0.152** **
	(0.0549)	**(0.0605)**
Share developed in 1990 × log(real male weekly earnings) †	**0.290*** **	**0.200*** **
	(0.0447)	**(0.0508)**
Range in altitude × log(real male weekly earnings)	0.0967**	0.0938***
	(0.0415)	(0.0337)
Local authority fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	7766	4589
Number of LPAs	353	353
Kleibergen-Paap F	11.37	11.52

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. **Bold** variables are endogenously determined. All supply constraints measures are standardised. Observations are clustered by pre-1996 counties. Boom is defined as: national real HP growth > 0%. Bust is defined as: national real HP growth < 0%. † Test of equality of the coefficient rejects with p=0.02. Joint test of equality of all three interaction effect-coefficients rejects with p=0.01.

TABLE 4
Robustness check: Adding composition controls
(TSLS, 2nd stage, based on Census years 1981, 1991 and 2001 only)

	Dependent variable: Log(real house price index)				
	(1)	(2)	(3)	(4)	(5)
	No controls	Add age	Add industry	Add education	All controls
Log(real male weekly earnings)	0.0621	0.141	0.0193	0.0814	0.127
	(0.165)	(0.137)	(0.197)	(0.161)	(0.149)
Av. refusal rate of major residential projects × log(real male weekly earnings)	**0.631*** **	**0.590*** **	**0.676*** **	**0.601*** **	**0.588*** **
	(0.106)	**(0.0804)**	**(0.135)**	**(0.111)**	**(0.0995)**
Share of developable land developed in 1990 × log(real male weekly earnings)	**0.508*** **	**0.584*** **	**0.537*** **	**0.476*** **	**0.563*** **
	(0.0865)	**(0.0793)**	**(0.105)**	**(0.105)**	**(0.118)**
Range between highest and lowest altitude × log(real male weekly earnings)	0.0775	0.0802	0.0922	0.0640	0.0744
	(0.0649)	(0.0543)	(0.0738)	(0.0658)	(0.0596)
Share of residents aged between 45 and 64		0.0272***			0.0263***
		(0.00668)			(0.00916)
Share of residents employed in manufacturing			-0.00188		-0.00114
			(0.00265)		(0.00235)
Share of highly educated residents				0.00112	0.00157
				(0.00337)	(0.00358)
Local authority fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	1059	1059	1059	1059	1059
Number of LPAs	353	353	353	353	353
Kleibergen-Paap F	9.958	16.32	6.269	3.038	3.481

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. **Bold** variables are endogenously determined. All supply constraints measures are standardised. Observations are clustered by pre-1996 counties.

TABLE 5
Robustness check: Baseline specification for different geographical scales
(TSLS, 2^{nd} stage)

	(1)	(2)	(3)	(4)	(5)
	Dependent variable: Log(real house price index)				
Geographical unit:	Local Planning Authority	Travel to Work Area	*Urban* Travel to Work Area	Functional Urban Region	Pre-1996 County
Log(real male weekly earnings)	0.0887	0.217	0.341**	0.395**	0.0746
	(0.0859)	(0.132)	(0.172)	(0.173)	(0.241)
Av. refusal rate of major residential projects × log(real male weekly earnings)	**0.293*** **	**0.267*** **	**0.228*** **	**0.263*** **	**0.326*** **
	(0.0566)	**(0.0362)**	**(0.0386)**	**(0.0638)**	**(0.0630)**
Share of developable land developed in 1990 × log(real male weekly earnings)	**0.295*** **	**0.217*** **	**0.236*** **	**0.236*** **	**0.216*** **
	(0.0493)	**(0.0339)**	**(0.0401)**	**(0.0789)**	**(0.0317)**
Range between highest and lowest altitude × log(real male weekly earnings)	0.0951**	0.0580**	0.0846***	0.0744*	0.0705**
	(0.0388)	(0.0251)	(0.0323)	(0.0393)	(0.0308)
Geographical unit fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	12355	5250	2485	1925	1610
Number of geographical units	353	150	71	55	46
Kleibergen-Paap F	11.75	64.90	44.66	26.90	31.87

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. **Bold** variables are endogenously determined. All supply constraints measures are standardised. The coefficients can be interpreted as an increase in the house price-earnings elasticity due to a one standard deviation increase (based on the LPA-sample) in one of the constraint measures. Observations are clustered by pre-1996 counties.

TABLE 6
Counterfactual analysis for average English local planning authority

PANEL A
Counterfactual volatility of real house prices in average English LPA (in 2008 GBP), N=35
Baseline Estimates

Variable	Value in 1974	Value in 2008	Std. Dev.	Min	Max
Predicted	79183.6	225820.2	53265.2	57659.7	234176.3
Predicted without planning	79183.6	146850.7	27921.6	58371.0	151896.2
- and share developed set to zero	79183.6	123890.9	21247.2	56410.2	128060.3
- and elevation range set to zero	79183.6	117295.2	19468.1	54064.3	121269.1
- and earnings assumed constant	79183.6	112201.0	18138.0	52254.4	115972.7

PANEL B
Counterfactual volatility of real house prices in average English LPA (in 2008 GBP), N=35
Lowest Bound Estimates

Variable	Value in 1974	Value in 2008	Std. Dev.	Min	Max
Predicted	79183.6	225820.2	53265.2	57659.7	234176.3
Predicted without planning	79183.6	177377.8	37448.2	58183.9	183677.9
- and share developed set to zero	79183.6	155025.9	30450.2	58450.9	160445.6
- and elevation range set to zero	79183.6	148765.1	28547.5	58492.1	153991.2
- and earnings assumed constant	79183.6	134690.0	24347.7	57466.0	139342.1

PANEL C
Counterfactual volatility of real house prices in average English LPA (in 2008 GBP), N=35
Lower Upper Bound Estimates

Variable	Value in 1974	Value in 2008	Std. Dev.	Min	Max
Predicted	79183.6	225820.2	53265.2	57659.7	234176.3
Predicted without planning	79183.6	139698.8	25776.3	57854.3	144455.7
- and share developed set to zero	79183.6	115884.6	19077.1	53591.8	119741.0
- and elevation range set to zero	79183.6	108848.4	17296.7	51047.7	112498.7
- and earnings assumed constant	79183.6	105890.7	16578.3	49980.6	109424.5

FIGURES

FIGURE 1
Relationship between change in refusal rate and
change in planning delay rate for major residential applications

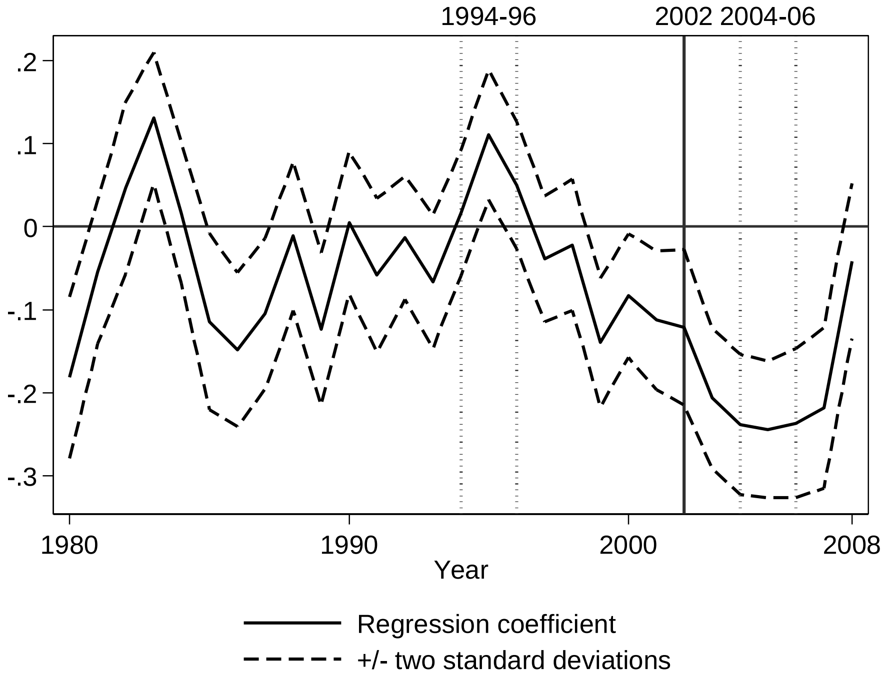


FIGURE 2
Year fixed effects:
Impact of unobserved characteristics at aggregate level

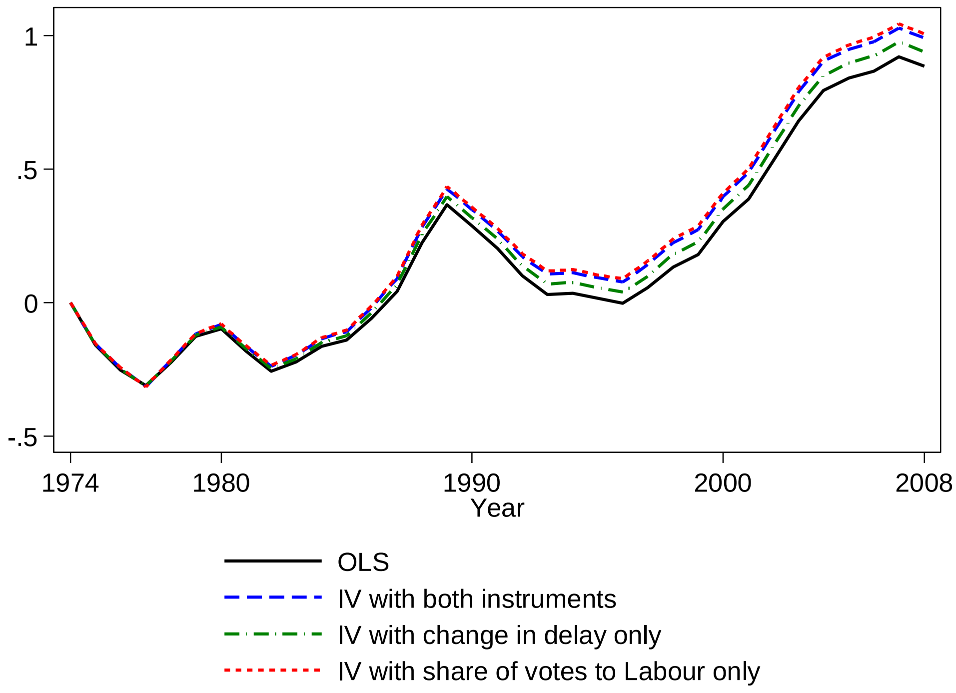


FIGURE 3
The impact of supply constraints on house prices in average English LPA:
Baseline estimate (TSLS)

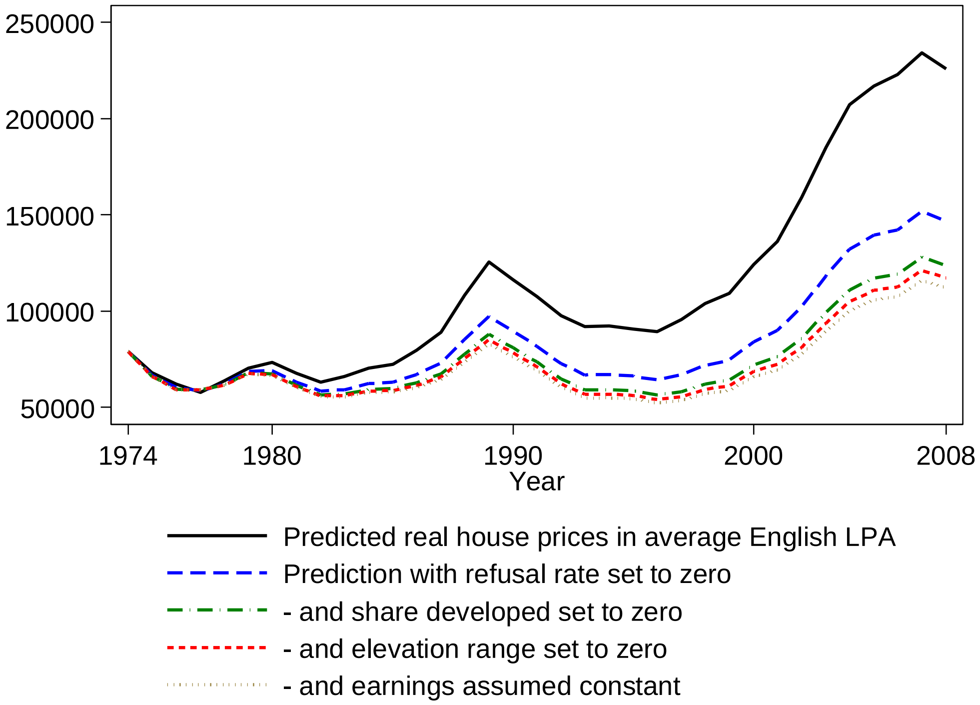
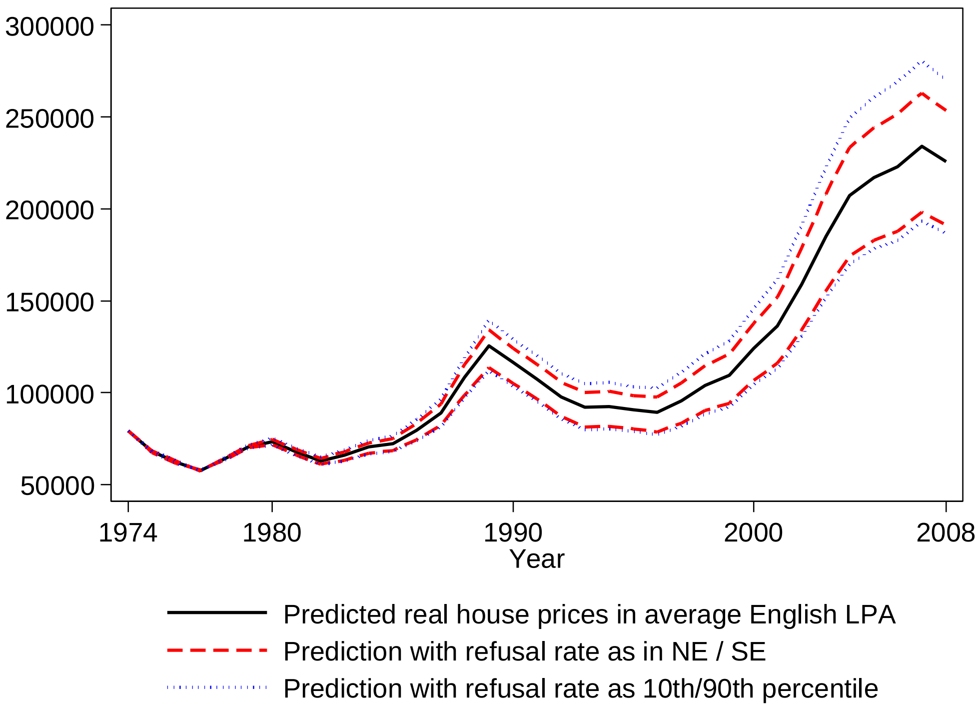


FIGURE 4
Regulatory restrictiveness and house prices: 90th vs. 10th percentile and
Northeast vs. Southeast



APPENDIX

Appendix A: Detailed Description of Data and Sources

This appendix provides details on the various sources and computation of variables used in our empirical analysis.

Real house price index

We obtained the house price data from the Council of Mortgage Lenders (CML) (1974 to 1995) and from the Land Registry (1995 to 2008).[11] For the purpose of our analysis we need to construct a house price index. We do so by taking account of the composition of sales in terms of housing types by adopting a *mix-adjustment* approach (see e.g., Wall, 1998). Essentially, this index holds constant the share of each housing type, analogous to consumer price indices that measure the cost of a fixed basket of goods and services. For the CML and the Land Registry data separately, we have first determined LPA-specific weights by averaging the share of sales of each type over the period of observation: 1974 to 1995 for the CML data and 1995 to 2008 for the Land Registry data. The type 'other' has been discarded in the CML data. These weights were subsequently used for computing weighted average house prices, by multiplying weights with mean house prices for each type and summing over all types. Weighted prices form the CML data were divided by weighted prices in 1974 and weighted prices from the Land Registry data were divided by weighted prices in 1995. A continued index for the period between 1974 and 2008 was then created by multiplying the Land Registry index with the CML index value for 1995. The real price index was obtained by deflating the nominal series with a Retail Price Index for all items excluding mortgage interest payments obtained from the Office of National Statistics (ONS)[12], and by setting values for 1974 to 100 in all LPAs.

One issue encountered in this approach is that for some housing type$\times$LPA$\times$year combinations, no transactions were observed so that we could not compute a mean price. This occurred more frequently in the sparser CML data (9 percent of all housing type$\times$LPA$\times$year cells). Of these cases, 89 percent could be imputed with mean prices at the county level, 11 percent were imputed with mean prices at the level of Government Office regions, and the remaining 5 cells had to be imputed with national averages. The potential bias due to imputation is limited, as empty cells are more likely to occur for types with a low weight: the

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[11] The CML data are derived from two successive surveys. The Survey of Mortgage Lenders (SML) consists of house price data for the period from 1992 to 2004, while the Local Authority Mortgages Survey, 5% Sample Survey of Building Society Mortgages (SSBSM) consists of data from 1974 to 1991. In contrast to the Land Registry data, which contain all housing transactions in England, the SML and SSBSM are samples, in which the geographical scale is less fine; slightly more than 100 LPAs for most years. The CML data contain more housing characteristics, but for reasons of consistency, we construct a mix-adjusted index using information on the housing type only. The data are geographically matched in such a way that LPAs in the same CML-location have the same price index for the period from 1974 to 1995. (For the years with an overlap of CML and Land Registry data we prefer the latter as the much larger sample size ensures greater reliability.)

[12] The RPI for all items excluding mortgage interest payments was available only from 1978 onwards, so for the period 1974 – 1977 it was imputed with the general RPI. Note that deflation does not affect our estimation results, because of the period fixed effects.

average weight of missing cells was 0.02 and for cells in which the county mean was missing as well it was 0.01. So these imputations hardly affect the weighted average house price in an LPA. In the Land Registry data, less than 0.7 percent of cells were missing and the average weight was 0.05. All of these cases could be imputed with mean prices at the county level.

Real weekly earnings of full-time working men

We obtained data on total weekly gross earnings for full-time male workers from 1974 onward. Specifically, for the period between 1997 and 2008 we obtained LPA-level earnings data from the Annual Survey of Hours and Earnings (ASHE)/New Earnings Survey (NES).[13] For the period between 1974 and 1996 we obtained the earnings data at the county- and London borough level from the NES. We geographically matched this data to the LPA-level. For some LPAs there is a sizeable gap in earnings between 1996 and 1997. These gaps are caused by the fact that the pre-1997 data is measured at the county (or borough) level, while the post-1996 data is measured at the LPA-level. The gap has been bridged by using county-level earnings information for 1997 and by using the growth rates from the county-level data to generate an imputed LPA-level time-series for earlier years. A few LPAs in our panel have some gaps in earnings information (1.7 percent of all cells are missing). For missing observations at the tails of the time-series we use growth rates from the county-level/region-level earnings indices to impute the earnings figures. For all other gaps we use the 'pattern' of growth at the country/region-level. For a handful of cases the earnings trends at the LPA-level and the county-level go in different directions. Here we use alternative sensible imputation strategies. We carried out a number of robustness checks, which confirm that our findings are not sensitive to the particularities of the imputation strategy. In fact our findings are virtually unchanged if we do not impute the missing earnings figures at all. Real earnings, finally, are obtained by deflating the nominal series with the Retail Price Index.

Planning induced supply constraints

We obtained detailed information on the direct regulatory decisions (refusal rates and planning delays) for all English LPAs on an annual basis between 1979 and 2008 from the Planning Statistics Group at the Department for Communities and Local Government (DCLG). In compiling the panel data for the refusal and delay rates at LPA-level from 1979 to 2008 (on an annual basis), we kept track of changes in LPA boundaries (mainly mergers) over time, matching all the data to 2001 LPA boundaries.[14]

Physical constraints derived from land cover and elevation data

Our *share developed land* measure is derived from the Land Cover Map of Great Britain (LCMGB). The first LCMGB was developed in 1990 as part of the long-running series of UK Countryside Surveys. The LCMGB provides data, derived from satellite images, allocating

[13] The ASHE was developed to replace the NES in 2004. This change included improvements to the coverage of employees, imputation for item non-response and the weighting of earnings estimates.

[14] Observations on National Park Authorities (NPAs) have been discarded. Observations on Urban Development Corporations (UDCs) have been added to LPA observations if their boundaries were confined within a single LPA, and they were discarded if they dealt with developments in multiple LPAs. The number of applications considered by UDCs and NPAs is typically small compared to the number of applications considered by LPAs.

land to 25 cover types on a 25 metre grid. We obtained the 1990 LCMGB from the Centre for Ecology and Hydrology.

In order to get an operational measure of the *share developed land* (i.e., the share of all developable land that is already developed) we categorised different land use classes into non-developable land, developable yet undeveloped land and developed land, in a way similar to Hilber and Mayer (2009), Hilber (2010) or Hilber and Robert-Nicoud (2012). Specifically, we classified the following land uses as *'developed'*: 'suburban/rural developed' and 'urban development'. We classified as *'non-developable'*: 'sea/estuary', 'inland water', 'costal bare ground', 'saltmarsh', 'ruderal weed' and 'felled forest'. We classified as 'developable': 'grass heath', 'mown/grazed turf', 'meadow/verge/semi-natural swards', 'bracken', 'dense shrub heath', 'scrub/orchard', 'deciduous woodland', 'coniferous/evergreen woodland', 'tilled land', 'inland bare ground' and 'open shrub heath'. Finally, we classified as *'semi-developable'*: 'rough/marsh grass', 'moorland grass', 'open shrub moor', 'dense shrub moor', 'upland bog' and 'lowland bog'. Semi-developable land was added as a separate category for the purpose of robustness checks. About one percent of all land cover in 1990 was unclassified. We have discarded this category from our computations. From these classes, we compute the share of developed land (either inclusive or exclusive of semi-developable land in the denominator of the formula) as an indicator for physical supply constraints. We report our regressions using the measure that includes semi-developable land as developable; however, all our results are virtually unchanged if we use the alternative measure that classifies semi-developable land as non-developable.

As a second set of measures for physical constraints we assembled elevation data for England by merging 525 separate elevation raster/grid files from the 1:50,000-scale Land-Form PANORAMA DTM. Each file provides a 20 kilometre by 20 kilometre tile which is equally divided by a 50 metre grid and the heights are represented as values at the intersections of this grid.

Other instrumental and control variables

We use the *share of votes for the Labour party in the 1983, 1997 and 2005 General Elections* at LPA-level as instruments to identify the local refusal rate (the latter two are used only in robustness checks). The source of the underlying Constituency level raw data is the British Election Studies Information System. We geographically matched the election results at Constituency level to the LPA-level using GIS. More specifically, we used the Constituency-level boundaries for the relevant years to match the raw data to the 2001 LPA-level boundaries. As instrument for the *share developed land* we use *historical population density for 1911*, derived from the British Census. We geographically matched the available town-level data from 1911 to 2001 LPA boundaries using GIS.[15] We obtained estimates of the *price of bulk land* in excess of two hectares at LPA-level in 2007 from the Valuation Office. The estimates assume that the land is situated in a typical location for the area, has planning permission, services to the edge of the site and is ripe for development. To the extent that the market for most of the residential land in the locality is made up of brown-field sites this fact

[15] The town-level data were derived from the UK data archive. Latitude and longitude information was added using the OS Gazetteer.

will be reflected in the valuations. Likewise to the extent that the planning permissions in the location generally include an element of affordable housing, this will also be reflected in the land values, to the same extent as the market would.

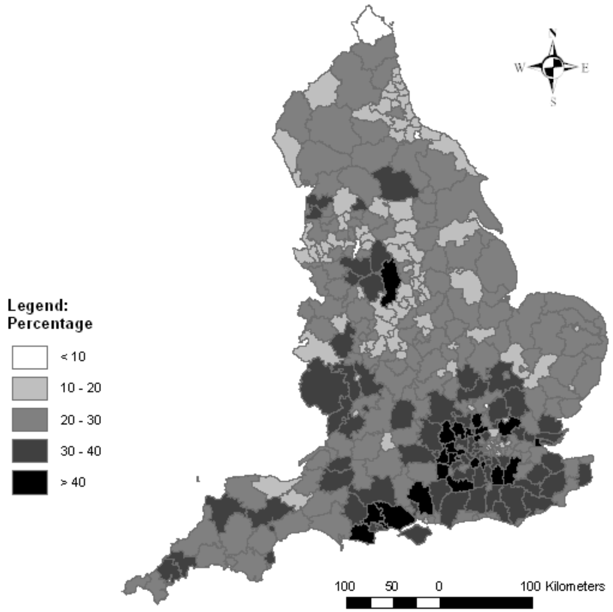
In order to control for composition effects we include a number of control variable**s** derived from the 1981, 1991 and 2001 Census. Specifically, we include the *share of population aged between 45 and 64 years*, the *share of the workforce employed in manufacturing* and the *share higher educated*. The Census definition for highly educated varies between years: in 1981 it is the share of persons over 18 with a degree, professional or vocational education. In 1991 it is the share persons over 18 with at least a degree and in 2001 it is the share people over 16 with at least a degree. The slight changes in definitions in the variable over the three Census years are unlikely to bias our results because we control for year fixed effects, which capture potential differences in levels. The cross-sectional variation should not be notably affected by whether the sample universe is defined as over 16 or over 18. We also derive the *total number of households in an LPA* from the Census. We use the latter variable for weighting purposes.

Aggregation to alternative geographical scales

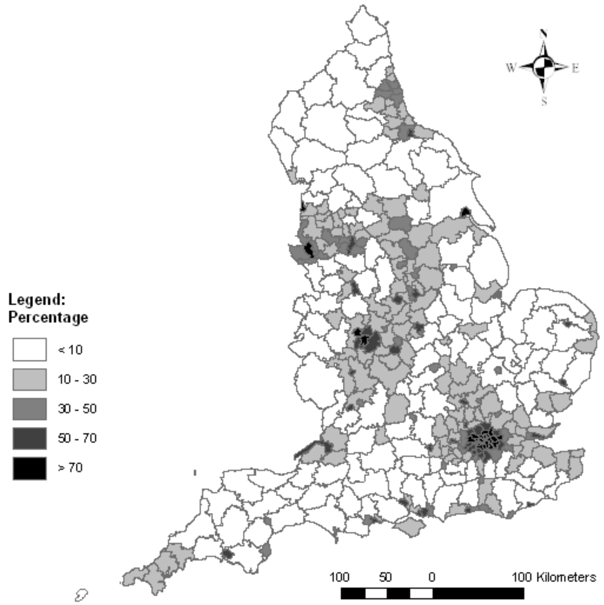
We have aggregated our data from the LPA level to three alternative geographical housing market definitions (TTWAs, FURs and Pre-1996 counties) in the following way. Averages of LPA-level house prices and earnings are weighted by the number of households in the 1990 Census. Regulation data were created by first aggregating all applications, refusals and delays and then computing the relevant rates. Similarly, land cover and population data were first scaled to the different area definitions before computing the relevant rates. Elevation variables are weighted by area. Election outcomes are weighted again by the number of households in the 1990 Census.

Appendix B: Appendix Figures

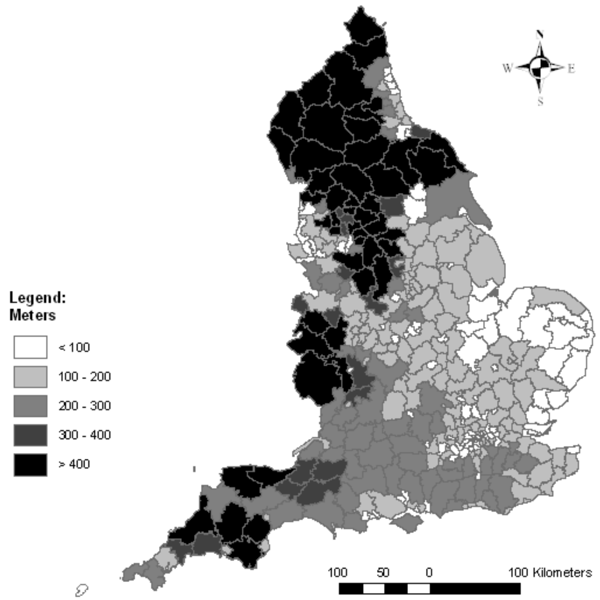
APPENDIX FIGURE B1
Average refusal rate – major residential projects over 1979-2008



APPENDIX FIGURE B2
Share developable land developed in 1990



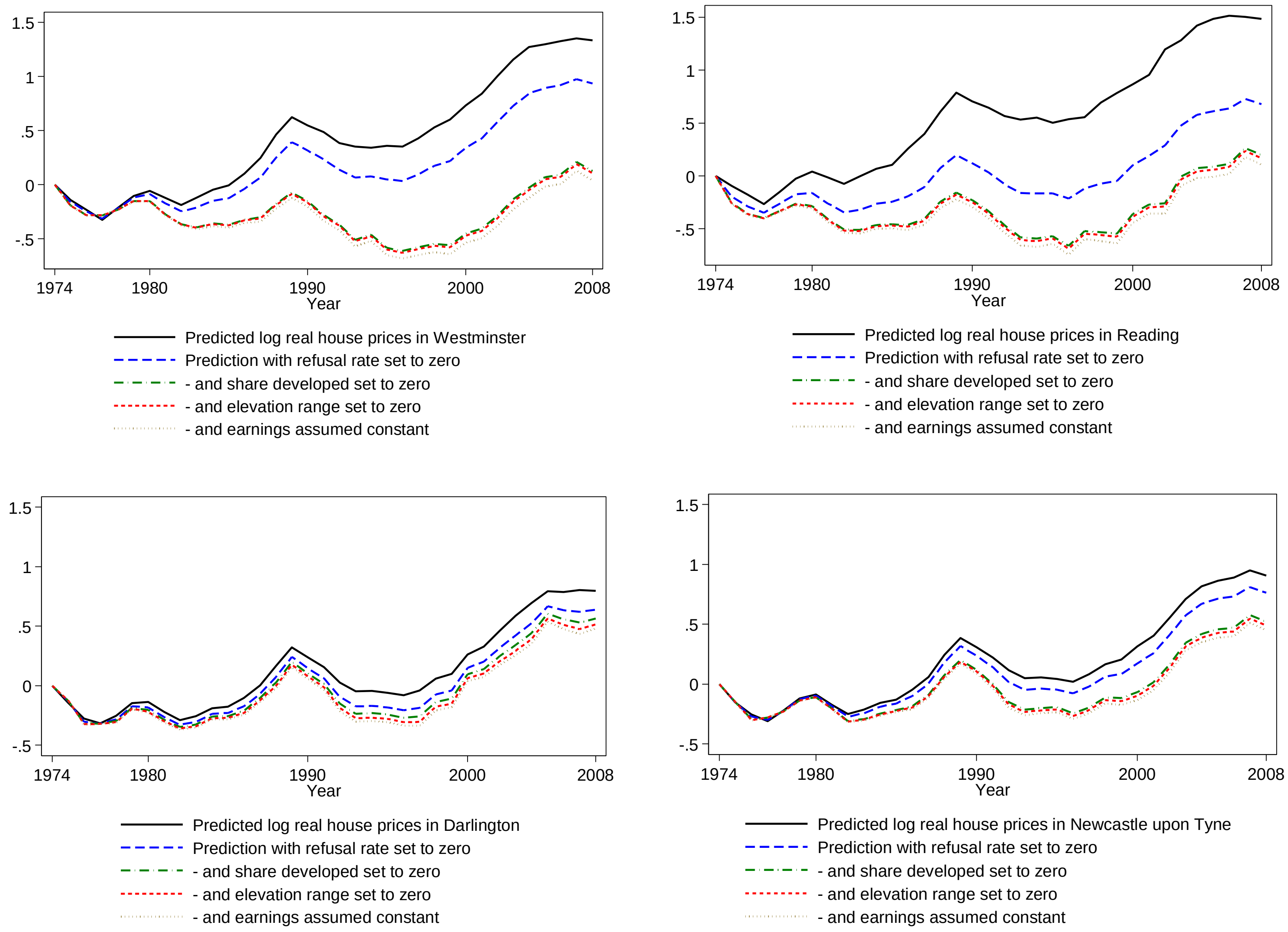
APPENDIX FIGURE B3
Elevation range



Note: Missing value for Council of the Isles of Scilly

APPENDIX FIGURE B4

Predicted log of real house prices in selected LPAs under alternative supply constraints-scenarios: Baseline estimates



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