The Real Interest Rate Effect on the Price Elasticity of House Supply

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Abstract:

A dramatic fall in the annual rent to house price ratio and long real interest rates during a period of relatively static real rents in the UK suggests that the stream of future imputed rents became discounted at successively lower interest rates from 1995 onwards. This paper argues that the decline in long real interest rates over this period likely contributed not only to rising house prices but also to the inelastic supply response. We develop a simple algebraic model that demonstrates how the price elasticity of house supply is lower when interest rate movements (rather than demography or income changes, for example) cause the change in house prices. Our empirical results show that a fall in the long term real interest rates significantly increases the annual growth rate in residential land prices. It is this increased cost of land – and hence the cost of building a house – that depresses the price elasticity of supply.

JEL Classification: R21, R31

Keywords: housing supply; real interest rates; price elasticity of supply

1 Introduction

This paper explores interrelationships between prices of residential land with outline planning permission, real interest rates, and the apparent inability and/or unwillingness of the construction industry to respond to house price signals. Existing empirical research on housing supply has tended to focus on the *measurement* of price elasticities, rather than *explaining* the variation in elasticities across areas and time periods. Supply elasticities are typically estimated as a parameter in reduced form model [1], or a multiple equation system [2].

A limited number of studies have, however, attempted to provide empirical evidence to support a particular explanation of why supply elasticities vary over time or

space. [3], for example, demonstrate "the effects of … regulations on market prices" and show, "using comparisons to the U.S., Thailand, and Korea, that countries with more stringent regulatory environments have a less elastic supply of housing." (p.372). Estimates by [4] and [5] suggest that developers are averse to building on brownfield land, implying that the imposition of UK quotas to encourage builders to develop brownfield sites reduced the overall responsiveness of new construction.[1] [6] uses census data to verify that central city supply of housing is less responsive than in the suburbs where there is greater availability of undeveloped land.

Others have speculated on causes of supply unresponsiveness but have not provided direct empirical verification (e.g. [7] show how the unpredictability of development controls can lead to land-banking and perverse supply responses to price changes. [8] suggests that low elasticities can arise from the combination of development risk and the unintended capital market distortions caused by state intervention. [9] establishes a link between low housing supply elasticities and shortages of skilled labour that may explain the apparently lower price elasticity of supply during a boom observed by [5].

Among the various explanations that have been put forward, no study to date has proposed a fundamental role for long term real interest rates in determining price elasticity of supply of housing. Interest rates are sometimes included as part of a larger system of equations [2] but the causation is usually is provided by the fact that private market rents grew at a much slower pace, from £382 to £522[2] per month over assumed

[1] [5] estimates that, for every 1 per cent increase in the proportion of development on recycled land, new construction overall is found to fall by 0.3 per cent during boom periods, and by 0.9 per cent during slumps, equivalent to a decline in construction of around 0.6 per cent across both periods.

[2] Average private monthly rental data is provided by the Office of the Deputy Prime Minister see http://www.odpm.gov.uk/pub/279/Table731Excel25Kb_id1156279.xls. However, data for 2005 has not yet been released. An estimated value is used, equal to the 2004 monthly rental based on Table 704 http://www.odpm.gov.uk/pub/286/Table740Excel16Kb_id1156286.xls that supports anecdotal evidence that private rental market stagnated in 2005 following a surge in buy-to-lets. The last actual value was £522 for the year 2004

to arise from the impact on house-builders' borrowing costs. The contribution of the current paper is to establish a direct and central role for real interest rates in the determination of housing supply.

Our findings are potentially important, particularly in the UK where the comparatively low price elasticity of supply of new houses [1,9,10] has been the subject of much concern and debate [9,11), largely because of the extraordinary rise in house prices over the last decade [12,13,14]. Average house prices in England and Wales rose from £73,000 in 1996 to £200,000 in 2005, but only a small fraction this price rise can be attributed to general price inflation. Inflation alone would have raised house prices from £73,000 in 1996 to £100,000 in 2005. That is, house owners received an average unexpected tax free capital gain of £100,000 while rent payers vis-à-vis house owners experienced a substantial adverse redistribution of wealth. It is clear that factors other than the rise in the general price level were responsible for the rise in house prices during this period.

A clue this ten years period. The 2005 private market rent was 1.4 times the 1996 rent, but after removing the effect of general price inflation, the 2005 real rent was only 1.09 times the 1996 rent. The ratio of annual rent to house price collapsed from 6.3% in 1996 to 3.1% in 2005. This collapse in the annual rent to house price ratio is important because it suggests the possibility of real interest rate effects.

Buying a house is equivalent to purchasing the right to live in a house without paying rent. That is, the equilibrium market value of a house is equal to the future stream of rents that house purchase enables the buyer to avoid. The dramatic fall in the annual rent to house price ratio during a period of relatively static real rent suggests that the stream of future rents became discounted at successively lower interest rates as this decade progressed. If rising house prices had been caused by factors other than falling

interest rates, for example, an increased number of households due to immigration or rising divorce rates, rents should have increased in the roughly same proportion as house prices.

There is a prima facie case for attributing much of the phenomenal rise in real house prices to the large decline in long real interest rates over this nine-year period. This view reflects [15]'s equilibrium asset pricing model that relates house prices to rents via real interest rates. The innovation in our paper, however, is to suggest that the decline in long real interest rates over this period may have also contributed to the inelastic supply response.

Section 2 presents the case for connecting house prices, real interest rates and the price elasticity of supply. The first step develops a simple algebraic model that explains why house price movements generated by real interest rates movements cause weaker supply responses than house price movements caused by other factors, such as changes in the expected rental value. This provides a basis for the hypothesis that house price movements caused by changes in real interest rates are associated with a lower price elasticity of supply in countries, regions and areas where land represents a relatively high proportion of the cost of building a house. The second stage is an empirical analysis demonstrating that the rise in house prices observed between 1996 and 2005 is consistent with the observed unanticipated collapse in long-term real interest rates. The third step is an empirical analysis that tests the theoretical model by testing the hypothesis that the building land prices are negatively related to the real interest rate.

2. The Model

The quantity of new houses supplied Q_s is positively related to the price P, and negatively related to the cost of building a new house C. This is shown in Eq.1 as:

$$Q_s = f(P,C) \qquad \frac{\partial Q_s}{\partial P} > 0, \frac{\partial Q_s}{\partial C} < 0. \qquad (1)$$

The price P is the equilibrium market valuation of a new house that is equal to the discounted sum of the future stream of rents that house purchase enables the buyer to avoid, shown as a perpetuity in Eq.2 as:

$$P = \frac{h}{r} \qquad (2)$$

where h is the annual rental net of maintenance to prevent depreciation, and r is the real interest rate.

The cost of building a new house C consists of two components, the first being the cost of the land and the second being all other construction costs excluding land. Eq.3 expresses the value of the land L used to build the house as sum of the future stream of foregone alternative (l) land rental use as a car park or for agriculture or the real option value of holding the land, discounted at the real interest rate r,

$$C = \frac{l}{r} + W \qquad (3)$$

where W refers to all other construction costs including labour and materials.

Assuming a linear supply curve where the supply response to a change in C is the identical negative of the supply response to an equal change in P, and substituting Eq.2 and Eq.3 into Eq.1 gives:

$$\begin{aligned} Q_s &= a + b[P - C] \\ &= a + \frac{bh}{r} - \frac{bl}{r} - bW \end{aligned} \qquad (4)$$

Eq. [4] shows that falling real interest rates would raise both house prices and land prices. Eq. [4] also shows that falling interest rates would increase the profitability of land development because h must exceed l for any development to occur. Consequently developers have a speculative incentive to postpone land development during a period of falling interest rates. More generally, the real option of postponing land development derives its value from the possibility that the present value of profit from future development may exceed the profit from immediate development. [7] show how stochastic delays in planning approval create incentives to postpone development.

In the present context, uncertainty about future profit caused by stochastic movements in real interest rates may likewise create an incentive to delay development. Systematic speculation about future house price inflation caused by past house price rises associated with successive reductions in real interest rates could strengthen the incentive to delay development even to the point of a backwards bending supply curve. However, neither of these two effects is explicitly modelled in the capitalised rents shown in Eq [4].

The elasticity of supply E_{QS} with respect to price is by definition:

$$E_{QS} = \frac{\partial Q_s}{\partial P} \cdot \frac{P}{Q_s} \qquad (5)$$

The magnitude of E_{QS} differs, depending on whether $\frac{\partial Q_s}{\partial P}$ in Eq. 5 is caused by a change in r or a change h. The two cases are considered below:

Case 1 Partially differentiating Q_S with respect to P in Eq.4, $\frac{\partial Q_s}{\partial P}$ for a change in h where r is constant gives

$$\frac{\partial Q_s}{\partial P} = \frac{\partial Q_s}{\partial h} \cdot \frac{\partial h}{\partial P} = \frac{b}{r} \cdot r = b \qquad (6)$$

Case 2 Partially differentiating Q_S with respect to P in Eq.4, $\frac{\partial Q_s}{\partial P}$ for a change in r where h is constant gives

$$\frac{\partial Q_s}{\partial P} = \frac{\partial Q_s}{\partial r} \cdot \frac{\partial r}{\partial P} = \frac{b[l-h]}{r^2} \cdot \frac{-h}{P^2} = \frac{bh[h-l]}{r^2 P^2} = b\left[1 - \frac{l}{h}\right] \qquad (7)$$

The ratio of Case 2 to Case 1 is equal to $\frac{1-\frac{l}{h}}{1}$ *(8)*.

That is, the magnitude of the term $\frac{\partial Q_s}{\partial P}$ in the price elasticity of supply equation Eq. 5 is smaller for a price rise caused by a change in the real interest rate, and the reduced

magnitude of this price elasticity of supply compared with the price elasticity of supply associated with a house price rise caused by *h* depends on the ratio of $\frac{l}{h}$.

At one extreme, where land values are so low that there is a negligible foregone alternative in terms of real option value of holding the land, or land rental use as a car park or for agriculture, $\frac{l}{h}$=0, and the price elasticity of supply is not reduced at all. At the other extreme, where land values are so high that the foregone alternative in terms of real option value of holding the land, or land rental use as a car park is equal to the house rental, $\frac{l}{h}$=1, and the price elasticity of supply is zero. Therefore the price elasticity of house supply is lower where interest rate movements cause the change in house prices. The general relationship between the price elasticity of supply for houses and the real interest rate can be derived.

$$\frac{\partial E_{QS}}{\partial r} = \frac{\partial E_{QS}}{\partial P} \cdot \frac{\partial P}{\partial r} \qquad (9)$$

Substitute Eq. [7] into Eq.[5] gives

$$E_{QS} = b\left[1 - \frac{l}{h}\right] \cdot \frac{P}{Q_S} \qquad (10)$$

$$\frac{\partial E_{QS}}{\partial P} = \frac{b}{Q_S}\left[1 - \frac{l}{h}\right] \qquad (11)$$

Substitute Eq.[11] into Eq.[9] gives

$$\frac{\partial E_{QS}}{\partial R} = \frac{b}{Q_S}\left[1-\frac{l}{h}\right]\cdot\frac{P^2}{-h} = \frac{-bP^2}{Q_S h}\cdot\left[1-\frac{l}{h}\right] \qquad (12)$$

The limiting case of a perfectly price elastic supply curve for houses (b=∞) appears to present a paradox. A perfectly elastic supply curve means that any shift in the demand for houses, however caused, would be accommodated without any change in price. Nevertheless, house prices should rise in response to a reduction in the real interest rate, because the price of a house is the discounted present value of the future net rental stream. This apparent inconsistency would be resolved by a reduction in the market rent so that any positive demand shift would leave house prices unchanged yet house prices would be the capitalised rent at the lower interest rate.

3. House Prices and Real Interest Rates

[15,16] used equilibrium asset pricing models to show how rents and real interest rates determine house prices. Average mix-adjusted house prices in England and Wales rose 174% from £72,948 to £199,749 in the nine years between June 1996 and June 2005. After adjusting for general inflation, real house price rose 118% over this period. However, only a small part of the 118% increase in average real house prices could have been caused by the small real increase of 8.8% in rentals over this period.

There are two grounds for believing that much of the rise in house prices relative to rentals may be attributed to falling real interest rates over this period. First, if rising house prices had been caused by factors other than falling interest rates, for example, an increased number of households due to immigration or rising divorce rates, rents should have increased in the roughly the same proportion as house prices. Second, it is possible

to compare the ex ante term structures of real interest rates in 1996 and 2005 in order to demonstrate that the rise in house prices between 1996 and 2005 is consistent with an unanticipated collapse in long-term real interest rates.

This hypothesis can be examined by comparing two alternative scenarios between 1996 and 2005. In the first scenario the person takes out a mortgage for £72,948, buys a house, lives in it, and sells the house in 2005 at the market price of £199,749. In the second scenario the person takes out the same mortgage but uses the £72,948 to purchase index-linked UK government perpetuity bonds instead of a house. This security does not exist but it is possible to construct an equivalent synthetic bond from available Bank of England data. The person in the second scenario lives in a rented house, receives coupon interest net of income tax from the perpetuity bond, and sells the perpetuity in 2005. The present value of the difference between the cash flows from the two alternative scenarios is £637. That is, the incremental cash flow analysis between these two scenarios shows them to be almost financially equivalent.

Real interest rates declined sharply between 1996:06 and 2005:06. In 1996:06 the five year real spot interest was 3.59% and the 23 year forward real interest rate was 4.07%. In 2005:06 the five year real spot interest was 1.72% and the 23 year forward real interest rate was 1.18%. This unanticipated decline in real interest rates was responsible for the hypothetical 3% indexed perpetuity bond price rising from £88.11 to £281.78 between these two dates, raising the present value of the future real income streams from £72,948 worth of indexed bonds at 1996:05 to £233,296 at 2005:06. The same decline in real interest rates was responsible for the rise in the present value of the future rental stream avoided by house purchase from £72,948 to £199,749. The difference between the selling prices of the two assets (£233,296 and £199,749) is fully explained, apart from £637, by the present value of the incremental cash flows generated

by the renter, that is, the cost of rental minus the net-of-tax coupon payments. We conclude that the fall in real interest rates was a major contributor to the tax free capital gain of £126,801 per average house-owner in England and Wales over the nine years.

The difference between the two alternative scenarios has a net present value of £637, which is negligible. However, depreciation (maintenance) costs incurred by the house-owner were not included in the calculation and this would leave the house-owner worse off. On the other hand any real increase in rental over time should out-perform the indexed-bond holder who has no real income growth. Therefore we cannot claim to have found an exact equivalence between owning and renting that would be maintained over a substantially longer holding period as real rents grow.

Supply Response to House Prices

This section combines the real interest rate effect on house prices with the real interest rate effect on the price elasticity of supply. Most consumer durable real prices fell between 1996 and 2005, despite the decline in interest rates during this decade. The clue here is to note that the price of fine art such as Monet paintings and Stradivari violins followed the same path as house prices. There was no possibility of increased supply in response to a rise in the price of the product of deceased artists. However, there should have been a strong supply response by the construction industry following the real house price rise.

The apparent inability or unwillingness by the construction industry to respond to price signals is therefore an unsolved policy puzzle. Land is a major input into the production of houses but land also has an asset value. Consequently, the fall in interest rates would raise the supply curve for new houses as well as raising the demand curve

for houses. This may explain the consistent empirical findings by housing economists [1,2,5] that the supply of new houses is stubbornly unresponsive to price changes.

The hypothesis is that falling interest rates raise the supply curve for new houses as well as raising the demand for houses. This can be tested by analysing the impact of the real interest rate on the prices of land *L* with planning permission.

The relationship can be obtained from a regression model of the form:

$$G_L = \alpha + \beta r + \gamma X + \varepsilon \quad , \qquad (9)$$

where G_L is the annual growth in the real price of land with planning permission and r is the real interest rate; X is a vector of other factors thought to determine the growth rate in the price of building land; and ε is a well-behaved error term. The theoretical expectation is that the growth rate in the real price of residential land with outline planning permission will rise with real household disposable income that is included in *X*, and fall with the real interest rate.

4. Data

The empirical analysis uses region specific annual panel data 1990 to 2006. Land valuation indexes for residential land prices with outline planning permission over nine regions were obtained from Table 563 http://www.communities.gov.uk/pub/152/Table563Excel31Kb_id1156152.xls. Fifteen year ex ante 15 year real spot interest rates on the last day of April for each year were obtained from The Bank of England website at http://213.225.136.206/statistics/yieldcurve/index.htm. Annual gross disposable household income per head Y_t was obtained from

http://www.statistics.gov.uk/articles/economic_trends/Regional_Accounts_1998_part_2.pdf and http://www.statistics.gov.uk/pdfdir/gdhi0506.pdf.

The parameters of interest in *(9)* are estimated by fitting the following pooled model:

$$G_{Lit} = \alpha_0 + \beta r_{it} + \gamma G_{Yt} + \varepsilon_{it} \quad , \qquad (10)$$

where G_{Lit} is the growth in the price of building land in region i in year t, α_0 is a constant, and ε_{it} is a random error term. We are only interested in estimates of the parameters linking 15 year spot real interest rates to annual growth in building land prices. This equation should incorporate other variables (that is, the X in *(9)*) that are thought to affect the growth in building land prices. It is hoped that the growth in real income GY adequately captures these omitted variables.

The estimates of *(10)* are shown in Column 1 of Table 1.

Table 1 Model Estimates

Model	**Real Interest rate growth** **Parameter T-Statistic**
α_0	**0.337 (10.0)**
R	**-10.609 (9.8)**
G_Y	**1.586 (9.5)**
R^2	**0.62**
N	**153** **1991 – 2005 (9 regions)**

DW	**1.57**

Equation *(10)* was also estimated with dummies that allowed the slope and intercept coefficients to differ between the nine different regions in the sample. In both cases Wald tests for the significance of the dummies did not improve the regression equation at the five per cent level.

The results show that an increase of one percentage point in the long (15 year) spot real interest rate reduces the annual growth rate in residential land prices with outline planning permission by ten percentage points. Consequently falling real interest rates have two effects. First, there is a rise in house price as the lower discount rate increases the present value of expected future rents avoided by house ownership. Second, there is a rise in the cost of building land, and this increased cost of building a house depresses the price elasticity of supply for houses when the house price rise is caused by falling interest rates.

Our empirical analysis assumes that households are indifferent between living in rented and owner-occupied house, being based on a no-arbitrage house-price model in which equilibrium house rents and prices are connected by real interest rates. However, [17] Ortalo-Magne and Rady (1999) argue that younger households always prefer owner-occupation to rental, and that lack of liquidity together with credit constraints prevent this group moving from rented to owner-occupied housing during the early stages of their life. Their model shows how financial liberalisation in the 1980's explains the increase in owner occupancy rate of young households during that boom. That period of financial liberalisation is now history, but the credit constraint mechanism could be re-activated by auto-correlated reductions in the interest rate.

Falling interest rates 1996 to 2005 raise the valuation of owner-occupancy defined as the discounted present value of future rents avoided. However, higher house prices require a larger down payment deposit for any given maximum ratio of loan to property value. The larger down payment represent a constraint for younger households wishing to switch from renting to home ownership, and this in turn would constrain the number of first time buyers entering the market. These important features of actual house markets would not alter the generality of our findings.

5. Conclusion

The real rise in house prices over the last decade appears to be strongly associated with a dramatic fall in long real interest rates between 1996 and 2005. However, real house price rises caused by real interest reductions are also likely to result in a muted a supply response, and the empirical analysis is consistent with this theoretical prediction.

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Appendix

The price of the synthetic 3.5% inflation index-linked UK government perpetuity was £88.11 in 1996:06. This price was calculated using Bank of England real spot interest rates for the first 24 years along the term to which was added a perpetuity starting at year 24, calculated using the 24 year forward real interest rate, that was discounted back to 1996:06. The present value of this series of cash flows was £88.11 which allowed the renter to purchase 827.95 bonds with the £72948 that was not spent buying a house. From 1996:06 to 2005:06 the renter paid rent but received the inflation indexed £3.50 coupon on each of the 827.95 bonds net of 20% income tax on the coupon interest.

At 2005:06 the house owner sells his house for £199,749 making a tax free capital gain of £126,801 on the initial outlay of £72,948. Owning a house was very profitable, but at 2005:06 the renter also sells his 827.95 bonds for £281.78 each, netting a total of £233,296. The gain to the renter who sells the bonds for £233.296 exceeds the gain to the house owner who sells the house for £199,749. After taking account of the after-tax positive cash flows from the coupon interest on the bonds and the negative cash flows from paying rent, the present value of the difference between the cash flows between the two scenarios is about £600 which is negligible. That is, the gain from owning the house was equivalent to the gain from renting and owning inflation indexed perpetuity bonds. The house owner and the bond owner both gained the virtually the identical amount from the fall in real interest rates over this period.

It is easy to confirm that the decline in real interest rates over these nine years was unexpected by comparing each forward real interest rate along the term at June 1996 with the equivalent forward real interest rates nine years earlier along the term at June 2005. For example, on 30 June 1996 the 15 year forward real interest rate for a one

year loan commencing 30 June 2010 was 3.91%. On 30 June 2005 the 6 year forward real interest rate, that is, for a one year loan commencing 30 June 2010 was 1.58%, and the 15 year forward real interest rate had fallen to 1.4%.