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A Simple Model of Housing and the Credit Crunch

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1. Introduction

It is hard to imagine that twenty years ago few economists believed that housing was an important part of the economy or a topic worthy of study by macroeconomists. Even today most macroeconomic textbooks rarely devote more than a page or two to the subject.

Since that time four events have transformed the perspective. First, in the UK in the late eighties, policy makers significantly under-estimated that strength of the macroeconomy. More precisely, consumers' expenditure grew faster than traditional consumption functions had predicted. Although still considered controversial (and there are other potential explanations), many analysts argued that the observed positive correlation between strong house price and consumption growth in the late eighties was, in fact, a causal relationship, operating as a form of wealth effect. Second, in 2003, structural housing market differences between the UK and the rest of Europe were a key reason why the UK decided not to join the Economic and Monetary Union (EMU). Third, in the early years of this century, the negative correlation in the US between stock market and house prices was seen as an important factor, preventing the US from going into serious recession. Strongly growing housing asset values were seen as providing support for consumers' expenditure.

But each of these events has been dwarfed by the fall out from the credit crunch, which has housing at its foundations. This is the subject of this paper. Because of the complexity of modern financial markets, it is sometimes easy to forget that the value of mortgage-based securities depends on the value of the underlying asset, i.e. housing. If the foundations are based on sand, then the whole structure of the system will at some point fail. Furthermore, it could be argued that one of the fundamental problems is that financial markets often treat housing in the same way as financial assets. But there are important differences; although financial market models are useful to housing analysis, they need to be adapted, paying due recognition to the distinguishing characteristics of housing, particularly spatial fixity, longevity, heterogeneity, market frictions, and market non-neutralities. Market frictions cover a number of issues including taxation and search costs, but, here, we concentrate particularly on frictions generated by credit market imperfections. These can take a number of forms. Traditionally, in the UK, mortgage rationing arose from the structure of building societies, who acted as a cartel, and typically set interest rates below market clearing levels. This form of rationing disappeared in the early eighties, but some of the theoretical models and analysis conducted at the time remain relevant to the current era of the credit crunch. Even after the abolition of the cartel and the introduction of new mortgage players in the market, it usually remained the case that borrowers did not obtain 100% mortgages. Deposits are required because of asymmetric information and moral hazard.

In the UK, the policy focus of housing switched with the advent of the credit crunch. Prior to this event, policy concentrated on efforts to improve long-run housing affordability, primarily through increasing housing supply. Although this concern may have disappeared from the stage in the short term, the problem is likely to re-emerge in the longer term. Therefore, ideally, optimal policies need to be robust to both the problems underlying the credit crunch and longer-term affordability concerns. In this paper a joint model of housing and mortgage markets is constructed, which provides a framework for analysing such issues. The model is "simple" in that its policy conclusions depend on only two main conditions.

Section 2 sets out basic data on some of the key housing market variables and discusses their trends. Section 3 provides the economic theory in terms of a small model for house prices and mortgages markets, paying particular attention to the role of credit constraints. Section 4 provides empirical estimates of the key model parameters. Section 5 uses the theoretical model to develop ideas on long-run affordability, before policy simulations on the model are conducted in Section 6. Section 7 draws conclusions. Among the conclusions, the paper finds that the evidence of a housing bubble in the UK between 1997 and 2007 is weak, despite the claims of many commentators. Furthermore, the credit crunch suggests that long-term supply policies become even more important, despite the fact that construction is currently falling sharply. As part of the analysis, the paper shows why forecasting house prices is so difficult, but the problems do not arise from market efficiency or because model coefficients are unstable.

2. Key Trends

Figure 1 sets out the variable, which, perhaps, has attracted the greatest attention – the annual growth rate in nominal house prices for the US and UK over the period 1971Q1 to 2008Q2. Two features stand out. First, historically, UK house prices have exhibited much stronger cycles than the US. Second, so far, the slump in the US has been greater than in the UK, although the consensus view in the UK is that greater price falls are still to come. Figure 2 also shows that falls within the US are not uniform. The coastal areas have generally experienced greater volatility and this remains the case in the latest slump. The Pacific states have been particularly badly hit, although this is not to underplay the falls in other areas, notably older, poorer industrial areas, which are particularly reliant on the sub-prime market. Historically, the greater coastal volatility has been attributed to stronger zoning regulations (Abraham and Hendershott 1996, Malpezzi 1999) and similar explanations have been put forward as the cause of the volatility in the UK.

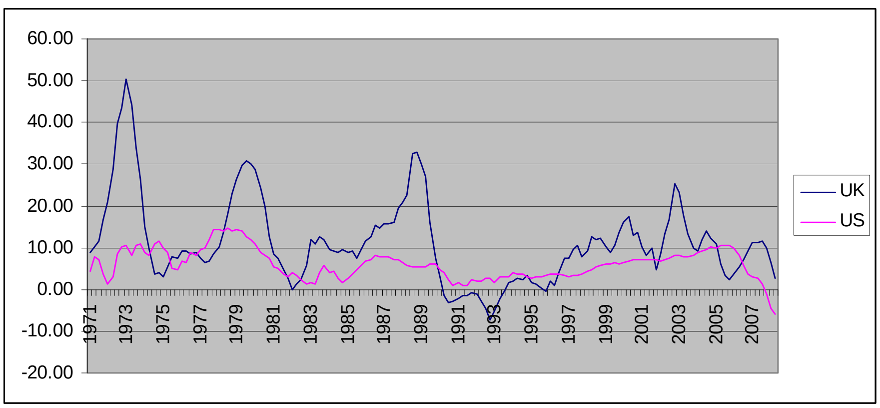


***Figure 1*. Annual Growth in Nominal House Prices (US and UK)**

Source. Freddie Mac Conventional Mortgage Home Price Index; DCLG Mix-Adjusted House Price Index, DCLG Live Table 591.

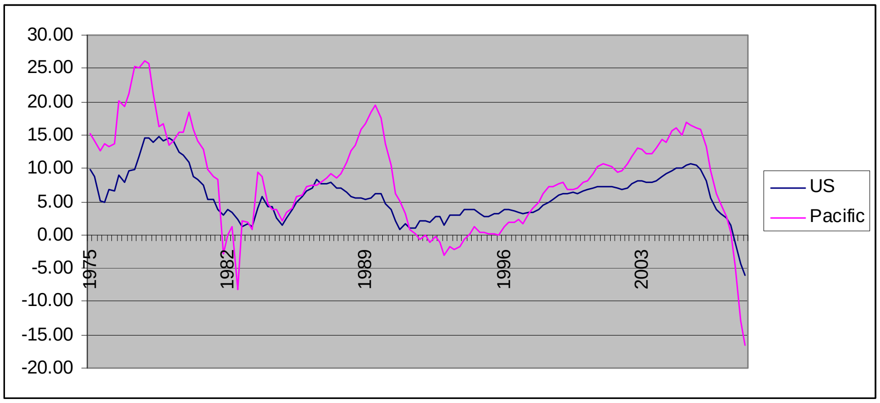


***Figure 2*. Annual Growth in Nominal House Prices (US Average and Pacific States)**
Source. Freddie Mac Conventional Mortgage Home Price Index.

Rather than rates of change, Figure 3 sets out two indicators of long-run trends in the UK- real house prices (PH/P) and the ratio of house prices to household disposable income (PH/Y). The critical feature of both these variables is that neither is stationary (ADF(4) tests give values of 0.90 and -2.09 respectively)[1] The long-run growth rate of real house prices from 1968 is approximately 2.5% Therefore, as a long-run asset, there appear to be advantages to holding housing as part of a portfolio. These trends also lie behind current UK policy to increase housing supply.

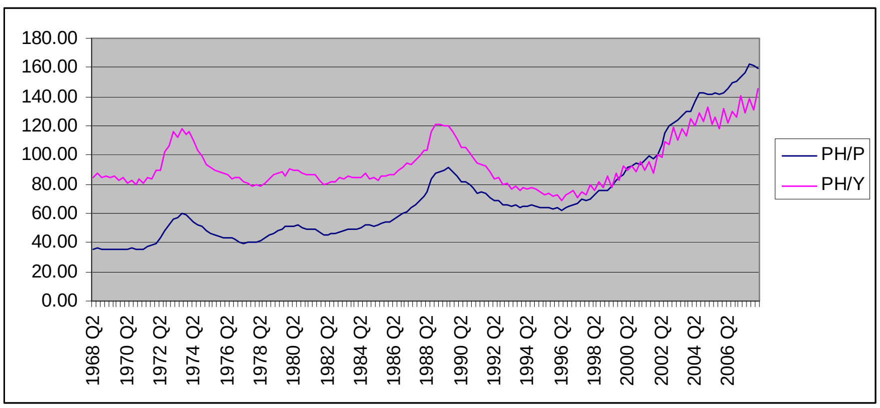


***Figure 3*. Real House Prices (PH/P) and House Prices/Income (PH/Y) (2002Q1=100)**
Sources. DCLG Live Table 591 for house prices; ONS time series RVGK and QWND for incomes and consumer prices.

Figure 4 graphs (i) the difference between the interest rate on a standard variable rate mortgage and Bank of England base rate; (ii) the difference between the mortgage rate

[1] 5% critical values are -2.88.

and 3 month inter Bank rate. All values are monthly averages for the period January 2002 to July 2008. Until late 2006, the two series are similar, but as the sub-prime crisis began to unfurl, the gap between mortgage rates and base rate began to rise sharply. Although the Bank of England cut base rates from the end of 2007, these have not been passed on in terms of lower mortgage rates. Instead, mortgage rates have continued to follow higher wholesale market rates, which, in turn, reflect the increased risk on wholesale markets. So the first consequence of the credit crunch has been higher mortgage interest rates for households.

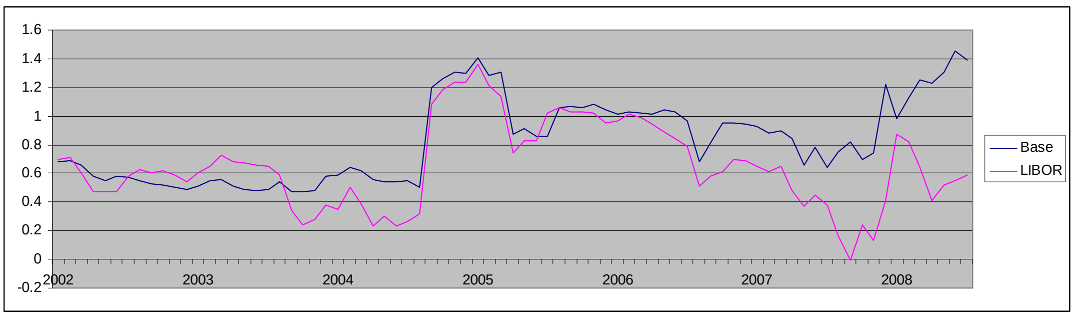


***Figure 4*. Difference between the Mortgage rate and the 3-month Inter Bank Rate (LIBOR) and Base Rate (Base) (% points)**

Sources. CML Table ML5 and Bank of England data base.

The second consequence is in terms of mortgage availability. We demonstrate below that both the price and quantity effects can be analysed consistently within the user cost of capital. As Figure 5 shows, one of the main consequences of the credit crunch is the reduction in the number of loans from the beginning of 2008; levels are approximately half of those two years earlier. Arguably, these effects are much more important than the relatively modest changes to mortgage interest rates. However, although not shown here, reductions in the median percentage advance and income multiples – two methods traditionally altered at times of a shortage of mortgage funds – have shown only small changes. The main changes have been in terms of the number of advances. Aggregate data indicate that, if a household is able to obtain a mortgage, the terms and conditions remain favourable. This is, perhaps, unsurprising; given more rigorous scrutinisation of applications and a consequent improvement in the quality of the loan book, there is little reason why the median loan to income and loan to value ratio should fall.

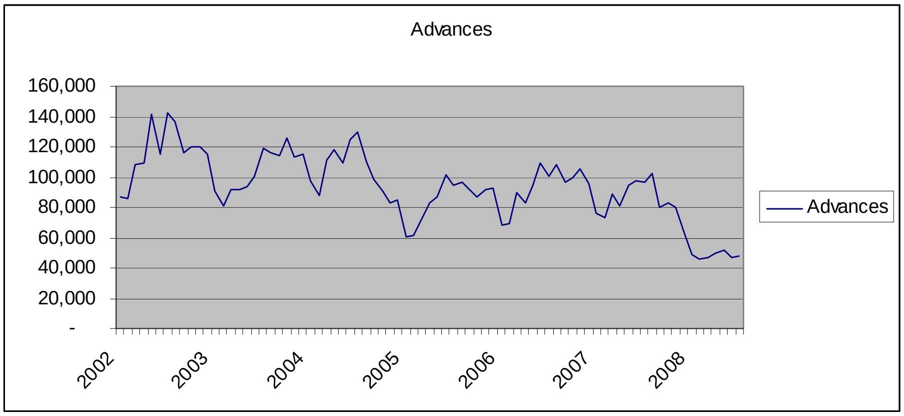


***Figure 5*. Number of Loans for House Purchase**

Sources. CML Table ML4.

Figure 6 shows the ratio of the value of the outstanding mortgage stock to household disposable income. This indicator is sometimes used to demonstrate the increasing reliance on debt by the household sector in recent years. However, four features stand out. First, prior to the early eighties, debt was very low. During this period, mortgages were provided primarily by building societies and the existence of the cartel implied that rationing was the norm. Although low levels of indebtedness (and low arrears and possessions) continued for many years, this is unlikely to have been an unconstrained optimum in terms of household choices and when controls began to be removed and competition increased during the eighties, it was unsurprising that debt to income ratios rose sharply. Second, although analysts generally concentrate on the post-1996 rise in debt, it is important to remember that this was not the first expansion; the 1980s rise was equally important. Third, Figure 6 shows that during the early nineties recession, mortgage debt scarcely fell. Consequently, there is an asymmetric adjustment between upturn and downturn because of the nature of the mortgage contract. If a mortgage is for twenty-five years, the only way in which the household can reduce mortgage payments is by moving, but during the early nineties housing transactions fell sharply because of the emergence of negative equity. Households became locked in to their current properties, adding to the potential default risk. High debt-to-income ratios, therefore, add to housing market risk because of the difficulty of adjusting the mortgage stock at times of falling house prices.

Fourth, the debt to income ratio is clearly non-stationary, but this may be compared with Figure 7, which shows the ratio of mortgage debt outstanding to the estimated market value of the housing stock. This is the aggregate loan to value ratio. Although the numerator in the two graphs is the same, the trend in the latter is less evident. In fact ADF tests do suggest non-stationarity (ADF(4) = -2.04 compared with a 5% critical value of -2.88). But the difference in the trends becomes important in the empirical analysis in later sections. It is perfectly possible for debt as a percentage of the market value of the housing stock to be constant in equilibrium, but for debt (and debt repayments) as a percentage of income to be rising. Finally, Figure 7 also shows that the ratio has been falling or approximately constant in recent years. This is to be expected. The mortgage stock is dominated by existing holders of mortgages, who, in the short run at least, do not adjust fully their debt to the increased equity values in their homes. Full adjustment to any equilibrium is likely to be slow since the ratio is expressed in terms of stocks. This becomes evident in the empirical results below.

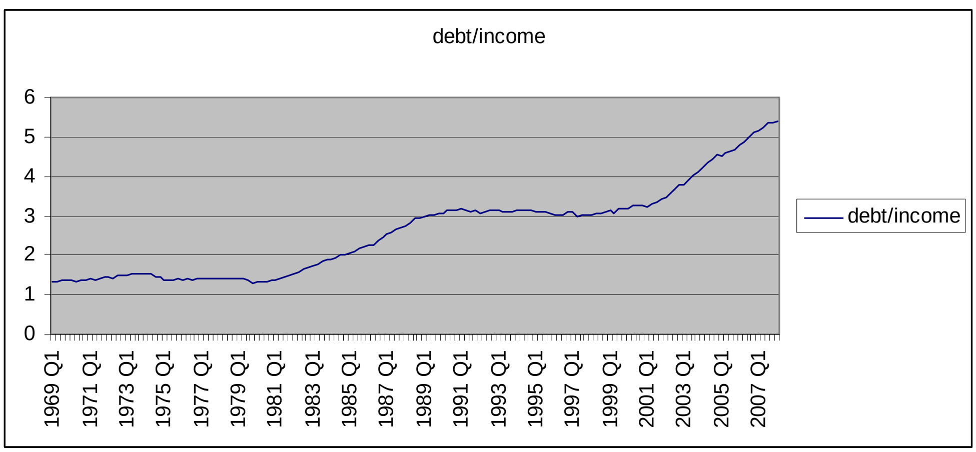


***Figure 6*. Mortgage Debt/Household Disposable Income**

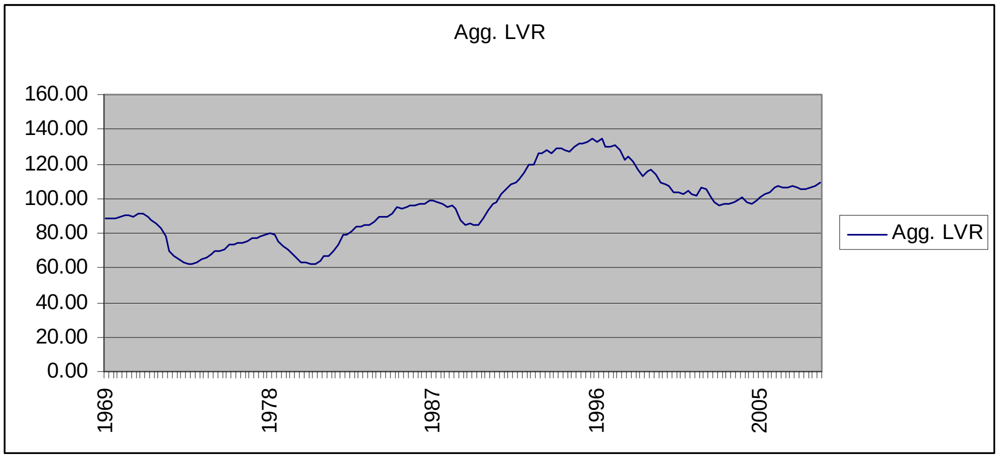


Figure 7. **Ratio of Mortgages Outstanding to the Market Value of the Housing Stock (2002=100)**

3. A Simple Model of Housing and Mortgage Markets

As noted above, mortgage shortages in the UK are not new and, indeed, were the norm until the early eighties. Consequently, some elements of the analytical models developed in this era remain relevant. The standard model begins with a multi-period consumer utility maximisation problem where there are two goods – housing services (for simplicity assumed to be proportional to the housing stock, *H*) and an aggregate consumption good (*C*). Utility maximisation subject to the household budget constraint leads to the standard first-order condition (1), which gives the ratio of the marginal utilities for housing and consumption, μ_H / μ_c. The right hand side of (1) represents the real housing user cost of capital. Versions of this equation have been used extensively by the current author (see Meen 1990a, Meen and Andrew 1998, Meen 2002, Meen 2008, for example). The model can easily be extended to incorporate transactions costs, e.g. stamp duty, property taxes and maintenance expenditures.

$$\mu_H / \mu_c \;=\; g(t)[(1-\theta)i(t) - \pi + \delta - \dot{g}^e / g(t)] \qquad (1)$$

$$\mu_H / \mu_c = g(t)[(1-\theta)i(t) - \pi + \delta - \dot{g}^e / g(t) + \lambda(t)/\mu_c] \qquad (2)$$

where:

g(t)	=	real purchase price of dwellings
θ	=	household marginal tax rate
i(t)	=	market interest rate
δ	=	depreciation rate on housing
π	=	general inflation rate
(.)	=	time derivative

δ, π, θ are assumed to be time invariant

However, the user cost of capital has to be amended if credit constraints are binding (see, for example, Dougherty and Van Order 1982). If there is an absolute constraint on the amount of borrowing, $M(t) < \overline{M}(t)$, then the user cost is defined by (2), where the expression takes into account the shadow price of the rationing constraint, $\lambda(t)$. Therefore, credit restrictions raise housing costs faced by households. Operationally, the problem is how to measure $\lambda(t)$. This is particularly important here because it measures the effect of the credit crunch.

The simplest possibility for measurement is to specify (3):

$$\lambda(t). = \alpha_1(M^d - M^S) \tag{3}$$

(M) is the volume of mortgage advances and (d, s) represent demand and supply respectively. α_1 is a parameter to be determined by the data.

For estimation (2) and the mortgage demand and supply functions have to be operationalised. For (2) we take the model and (modified) results from Meen (2008). Reconsider equation (2). Under arbitrage, and using (3), this implies that (4) holds, where (R) is the imputed rent on owner-occupied housing services.

$$g(t) = R(t)/[(1-\theta)i(t) - \pi + \delta - \dot{g}^e / g(t) + \alpha_1(M^d - M^s)] \tag{4}$$

Equation (4) also forms the basis of the view that there is a fixed relationship between prices and rents. But note:

(i) a fixed relationship depends on a constant discount rate. However the real yield on long-term government bonds fell sharply between 1997 and 2006.

(ii) Furthermore, in a housing context the relevant discount rate is not the yield on bonds, but needs to take account of expected capital gains on housing, credit restrictions and forms of transactions costs.

(iii) Nominal rates may be as relevant as real rates, because of front-end loading. Meen (2008), for example, suggests that this can be taken into account by attaching a coefficient to the capital gains terms in (4) of less than unity. This implies that capital gains have a smaller effect than changes in nominal interest rates.

(iv) The denominator in (4) – the discount rate – can be used to examine the effect of the credit crunch. The total effect consists of any change in interest rates (for example the impact of higher wholesale market rates on mortgage rates), the emergence of mortgage shortages and any effect on expectations.

Furthermore, it cannot be concluded that, because house prices have risen faster than rents internationally, this is evidence that prices are out-of-line with fundamentals Similar arguments hold about the relationship between prices and incomes, (Figure 3); the price to income ratio is often used as an indicator that prices are out of equilibrium, but this is inappropriate in a life-cycle model.

There is a shortage of data in the UK on market or imputed rents to test (4) directly. Usually in the literature, the expected determinants of rents, (equation (6)), are substituted.

$$\Delta \ln(g) = \gamma_1 \Delta \ln(g)_{-1} + \gamma_2 \Delta \ln(X) + \gamma_3 [\ln(g) - \gamma_4 \ln(X)]_{-1} + \mu \qquad (5)$$

$$X' = [RY, RGW, HS, WSH, (M^d - M^S), i, \dot{ph}^e] \qquad (6)$$

RY = real household disposable income
RGW = real wealth
HS = housing stock
$M^{d,s}$ = mortgage demand, supply
i = nominal mortgage interest rate
WSH = the share of wages and salaries in household income
PH = nominal house price
$\dot{ph}^e = \pi + \dot{g}^e / g$ = the expected nominal capital gain on housing.

Substituting (6) into (5) forms the basic price model. The need to incorporate lags in (5) reflects transactions costs, which imply that households may temporarily consume sub-optimal housing quantities. Estimation requires a measure of the excess demand for mortgage funds, denoted $MRAT = M^d - M^S$. Note, however, that in (5) and (6), the nominal interest rate, expected capital gains and mortgage rationing are included as separate terms rather than as the discount rate (*DISCR*) in (4). Therefore, in general, the discount rate can be written as:

$$DISCR = [(1-\theta)i(t) + \delta - \gamma(\pi + \dot{g}^e / g(t)\ ) + \alpha_1(M^d - M^s) + PT + ST] \qquad (7)$$

Estimating the terms separately allows the coefficient α_1 to be obtained. A further difference from (4) is the coefficient (γ) applied to nominal capital gains. A value of less than one implies that nominal rates matter to the determination of house prices as well as real rates. Under free estimation, its estimated value is 0.3. Therefore, nominal interest rates are important in explaining house price changes, consistent with a front-end loading explanation. In principle, a non-unit value could arise from measurement errors in expected capital gains. Here gains are measured by the lagged actual annual percentage change, but the coefficient value is not sensitive to alternative specifications. Finally, for completeness, in (7), property taxes, (*PT*), and stamp duty, (*ST*), have been added; both are expressed as percentages of the average house price.

Prior to the increase in mortgage competition in the early eighties, measuring mortgage rationing was not straightforward, because underlying demand was rarely observed. Meen (1990b) proposed a methodology through identification restrictions on the building society mortgage supply function, taking advantage of the fact that building societies claimed one of their objectives was to meet mortgage demand. However, the subsequent abolition of rationing means that mortgage demand can be estimated directly on data from 1981 until the latest credit crunch. There is little evidence that households faced significant constraints in the intervening period.

The estimated mortgage demand equation is more *ad hoc* than the price equation. Since mortgages can be used for non-housing purposes, through equity withdrawal, the demand equation cannot be derived directly from the price equation, although similar regressors might be expected. The specification exploits Figure 7 and suggests that, in the long run, there should be a relationship between the outstanding mortgage stock and the market value of housing (the aggregate loan to value ratio). This forms an equilibrium correction term, but, importantly, as discussed above, slow adjustment to equilibrium is expected. In the dynamics, the growth in the nominal mortgage stock depends on house prices, nominal interest rates and nominal income (*Y*).

$$\Delta \ln(M^d) = \beta_0 + \beta_1 \Delta \ln(M^d)_{-1} + \beta_2 \Delta \ln(PH) + \beta_3 \Delta \ln(Y) - \beta_4 \Delta \ln(i) - \beta_4 [\ln(M) - \ln(HS) - \ln(PH)]_{-1} + \mu_2 \tag{8}$$

In the absence of rationing:

$$\begin{aligned} &\Delta \ln(M) = \Delta \ln(M^d) \\ &\Delta \ln(M^s) = \Delta \ln(M^d) \\ &MRAT = 0 \end{aligned} \tag{9}$$

Under rationing:

$$\begin{aligned} &\Delta \ln(M) = \Delta \ln(M^s) \\ &\Delta \ln(M^s) = \Delta \ln(\overline{M}) \\ &MRAT = \Delta \ln(M^d) - \Delta \ln(M^s) \end{aligned} \tag{10}$$

On the assumption that the coefficients of the demand function are stable, equation (8) can also be used to derive estimates of $MRAT$ prior to 1981 and in 2008. These estimates are used in the price equation. The joint model can, then, investigate the effects of the credit crunch on the housing market through both (*i*) and (*MRAT*). But equally, important, since the paper is concerned with policies that are robust to the credit crunch and the long-run deterioration in affordability, the long-run solution to the model sheds light on the latter problem.

4. Empirical Results

Table 1 sets out the results from estimating equation (8) over the period 1981Q1 to 2007Q2. The dependent variable approximates the quarterly percentage change in the mortgage stock. Except for the fact that the equation is expressed in logarithms, the dependent variable would be a measure of net mortgage advances in each quarter. Perhaps the most important variable for the later analysis is the (log of) the aggregate loan-to-value ratio, *LVR*. As argued above, on the basis of Figure 7, *LVR* is a form of equilibrium adjustment; as expected adjustment is slow (an adjustment rate of 0.013 percent per quarter), but the t-value is highly significant.

***Table 1*. Mortgage Demand**

Dependent Variable: *Δln(M)*
Method: Least Squares
Sample: 1981Q1 2007Q2
Included observations: 106

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-0.012413	0.003194	-3.886677	0.0002
Δln(M)(-1)	0.792154	0.054155	14.62743	0.0000
Δln (i) (-1)	-0.014911	0.005663	-2.633216	0.0099
Δln(PH)	0.070235	0.017089	4.109883	0.0001
Δln(Y)(-2)	0.048602	0.028044	1.733056	0.0863
LVR(-1)	-0.012605	0.004104	-3.071201	0.0028

R-squared	0.942369	Mean dependent var	0.028947
Adjusted R-squared	0.936966	S.D. dependent var	0.013712
S.E. of regression	0.003443	Log likelihood	456.0270
Sum squared resid	0.001138	Durbin-Watson stat	2.311552

The equation also includes seasonal dummy variables.
$LVR = [\ln(M) - \ln(HS) - \ln(PH)]$

Figure 8 sets out the derived measure of rationing, *MRAT*. This shows strong rationing prior to 1981, some degree of excess supply in the mid-eighties as the economy experienced a recession and controls were relaxed, but little evidence of a shortage of mortgage funds since that time. A re-emergence of rationing is just noticeable at the end of the graph in the first two quarters of 2008. The estimates prior to 1981 and after 2007Q2 assume that the coefficients of the demand function are stable over the rationed periods and, therefore, are valid for the rationing calculation.

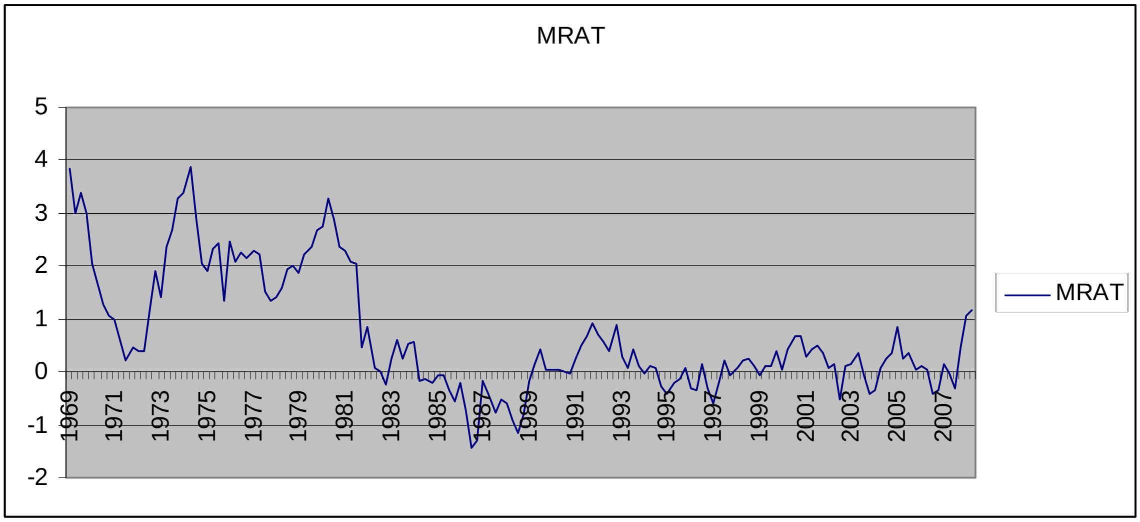


Figure 8**. Mortgage Rationing (%)**

This variable is, then, used as a regressor in the house price equation and in the definition of the discount rate. The results of estimating (5) are given in Table 2. As noted above, initially the coefficients on the mortgage rate, capital gains and rationing are freely estimated. The coefficient on capital gains takes a value of $\gamma = 0.3$ and the coefficient on rationing is estimated at $\alpha_1 = 2.4$. Given these values, a single discount rate variable can be constructed, equation (7), which is then used in the price equation in Table 2. The measure of mortgage rationing and, hence, the value of α_1 depends on the mortgage equation in Table 1. Since this is arguably an *ad hoc* specification, it is useful to know the sensitivity of α_1 to alternative mortgage specification. Meen (1990b) derives a similar measure based on building society optimisation behaviour, relevant to the pre-1981 rationed period. Using this alternative measure in a price equation estimated to 2005Q2, Meen (2008), the coefficient is almost identical at 2.4, although estimation on earlier periods suggests a coefficient of approximately 2.0.

The housing discount rate is graphed in Figure 9. Over the full period shown in the graph from 1970Q1 to 2008Q2, the mean value is 9.1%, allowing for rationing. However, over the boom period 1997Q1 to 2007Q4, the rate averaged 6.4%. Consequently, the lower discount rate is consistent with a rise in the ratio of house prices to rents in recent years. At first sight these average values appear to be high, but they incorporate transactions costs, property taxes and depreciation, not applicable to the discounting of financial assets. Furthermore, the correlation with conventional measures of financial market real interest rates is not high. For example, the correlation with the UK government security 5-year real implied yield is only 0.46 since 1985.

As a form of real interest rate, the housing discount rate is expected to be stationary. Although the series exhibits considerable volatility, the rate is, indeed stationary with an ADF(4) value of -3.80 (5% critical value of -2.88). Using the values of the discount rate in Figure 9 and the outturn values for house prices, equation (4) can be solved for real rents. The model implies that the annual average long-run growth rate in real rents was 1.4% between 1970 and 2007.

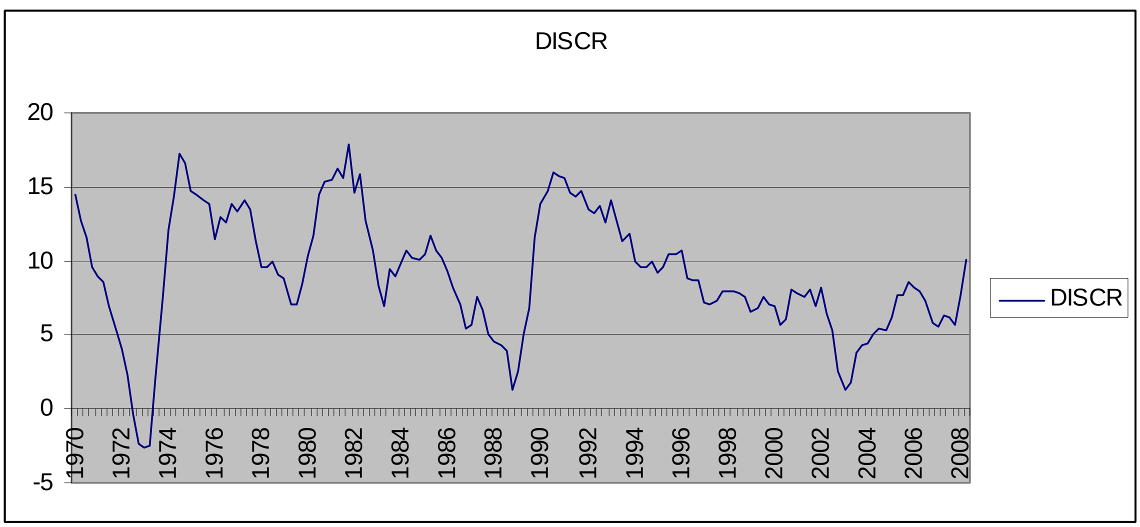


***Figure 9*. Housing Discount Rate (%)**

As noted above, the estimated coefficient on *MRAT* used in the discount rate is 2.4. This implies that a one percentage point increase in rationing raises the discount rate by 2.4 points. For comparison, the average value of rationing in the first half of 2008 was approximately 1% per quarter. Consequently any official interest rate cuts designed to offset the effects of the credit crunch on mortgage availability have to be large. The two percentage point rate cuts by the Bank of England in October and November 2008 were large relative to changes in the last ten years, but only approximately offset the effects of the mortgage supply shortage on the discount rate.

***Table 2*.** **House Prices**

Dependent Variable: : *Δln(g)*
Method: Least Squares
Sample: 1969Q2 2007Q2
Included observations: 153

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-1.134601	0.261112	-4.345261	0.0000
ln(g) (-1)	-0.090495	0.013792	-6.561165	0.0000
DISCR	-0.005361	0.000388	-13.81798	0.0000
ln(RGW) (-1)	0.024512	0.008738	2.805211	0.0057
ln(RY)	0.190793	0.052837	3.610993	0.0004
Δln(RY) (-1)	0.080988	0.044963	1.801208	0.0738
ln(HS) (-1)	-0.137669	0.047996	-2.868318	0.0048
WSHI(-1)	0.366851	0.100385	3.654452	0.0004

R-squared	0.782070	Mean dependent var	0.009808
Adjusted R-squared	0.761688	S.D. dependent var	0.032356
S.E. of regression	0.015795	Log likelihood	424.8946
Sum squared resid	0.034679	Durbin-Watson stat	1.881217
Reset; F(1,138) = 1.81 (p=0.181)		Arch: F(4,144) = 0.33 (p=0.86)	
LM: F(4,135) = 2.28 (p=0.064)		Chow: F(42,97) = 1.85 (p=0.007)	

The equation also includes seasonal dummy variables and dummies to allow for the effect of abolishing double mortgage tax relief in 1998.

Table 2 shows that the discount rate is highly statistically significant (t-value = -13.8), with the expected negative sign. Unsurprisingly, both real incomes and the housing stock also have significant effects. Table 2 also includes an additional variable (*WSH*), which measures the share of wages in household incomes. This reflects the fact that the demand for housing from wage income may differ from investment income. This is discussed in more detail in Meen and Andrew (1998), but is not central to the argument here.

It is useful for the next section to solve the price equation for its long-run solution, equation (11), and to derive the implied income and price elasticities of housing demand.

$$\ln(g) = -12.537 - 0.059DISC + 0.271\ln(RGW) + 2.108\ln(RY) - 1.522\ln(HS) \qquad (11)^2$$

Consequently, for given values of the housing stock, house prices are highly sensitive to both income and the discount rate. It should be noted that an income elasticity of more than two is not necessarily inconstant with a constant long-run price to income ratio. This depends on the other variables. For example, if housing supply is price elastic, then increases in the housing stock will tend to drive down prices. Alternatively, constancy could be achieved through changes in the discount rate. Inverting (11), and solving for the equilibrium in which housing demand equals supply, (*HS*), the income elasticity of housing demand is 1.39 and the price elasticity is -0.66. These estimates are broadly in line with the findings from other time-series studies, e.g. Muellbauer and Murphy (1997).

Equation (11) also shows why forecasting house prices is so difficult, even in the absence of a bubble. There are at least two reasons. First, a wide range of variables affect house prices. Some forecasters only take into account a small number, notably income. But the equation suggests that simple rules based on the price to income ratio are likely to be highly misleading. Second, from (11), the elasticities of house prices with respect to incomes and interest rates are high. Therefore, even if the determinants of house prices are understood exactly, then small errors in forecasting the independent variables are amplified in house price errors. Importantly, neither volatility nor unpredictability in house price movements provides evidence of bubbles.

Table 2 shows little evidence of misspecification in terms of autocorrelation (LM test), heteroscedasticity (ARCH test) or functional form (Reset test). However, the stability of

[2] For given values of *WSH*.

the coefficients is particularly important as a possible indicator of bubbles. If the coefficients of the fundamentals – income, wealth, housing supply and the discount rate show little volatility and are able to predict the 1997 – 2008 period, there would be *prima facie* evidence against the existence of bubbles.

As a first test, Figure 10 shows recursive coefficients for the key coefficients – $ln(g)_{-1}$, $DISCR$, $ln(RGW)_{-1}$, $ln(RY)$, $ln(HS)_{-}$ respectively.. To calculate the time series of coefficients, the equation in Table 2 is, first, estimated up to the end of 1994 and, then extra observations are added in turn until 2007Q2. In general, given the scale of the vertical axes, the coefficients exhibit a high degree of stability. This is particularly evident in the second frame, which shows the coefficient on the discount rate. There is, however, a gradual reduction – but no sharp change - in the adjustment coefficient (frame 1), which suggests that adjustment to the long-run equilibrium has become slightly slower in recent years. This may suggest an increase in transactions costs not captured in the discount rate, although there are other possible explanations.

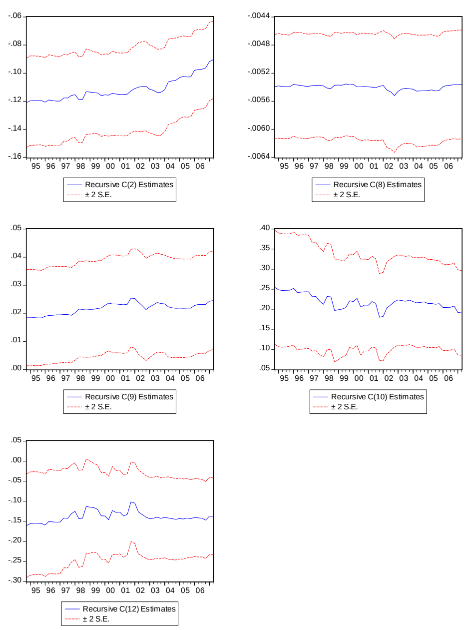
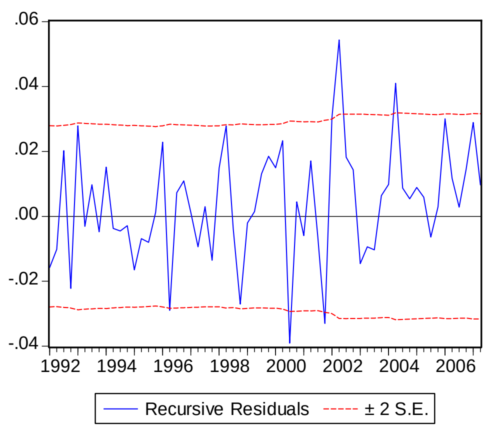


***Figure 10*. Coefficient Stability**

As a second test, Figure 11 shows the recursive residuals from the equation. There are few periods in which the residuals are greater than two standard errors. Third, a Chow test from 1997 yields an F-value (42, 97)=1.85, which suggests some evidence of prediction error. To order to investigate the results of the Chow test further, dummy variables are added to the equation in Table 2 for each quarter from 1997Q1 to 2008Q2. The upper frame of Figure 12 shows the dummy coefficients and the lower frame the corresponding t-values. The coefficients indicate the size of the prediction errors and the t-values their significance. The graphs suggest that the errors have increased in recent years, but, in general, they are not statistically significant. Furthermore, the underprediction in each period is typically in the range 2%-3% (compared with an equation standard error in Table 2 of 1.5%). Importantly, although the equation cannot fully explain the strength of prices in recent years, the errors are nowhere near the estimates of market over-valuation of 20%-30% produced by some commentators, e.g. IMF (2008). Most of the price change since 1997 can be explained in terms of fundamentals rather than as a bubble.



***Figuree11*. Recursive Residuals**

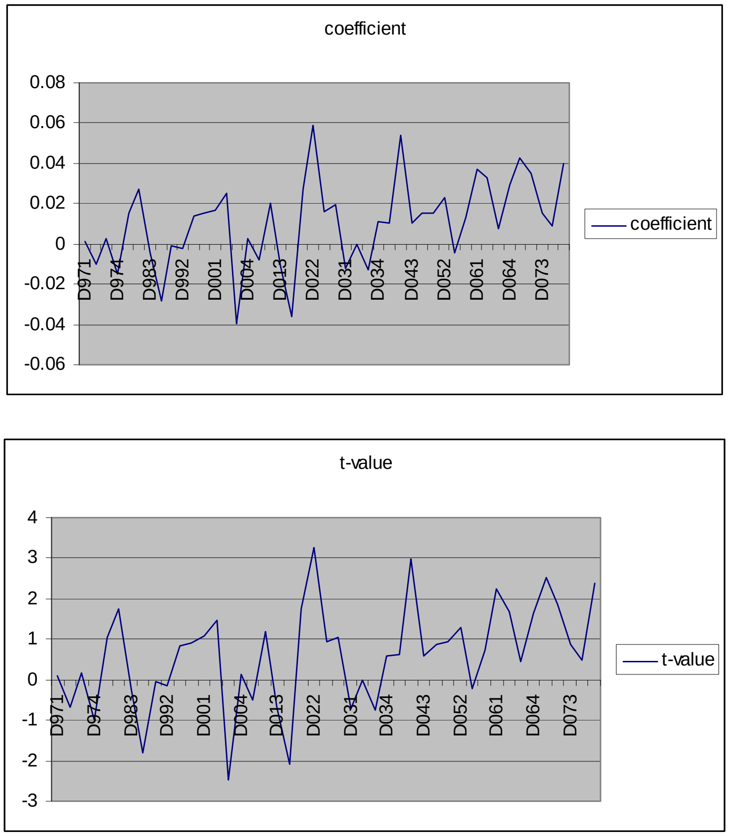
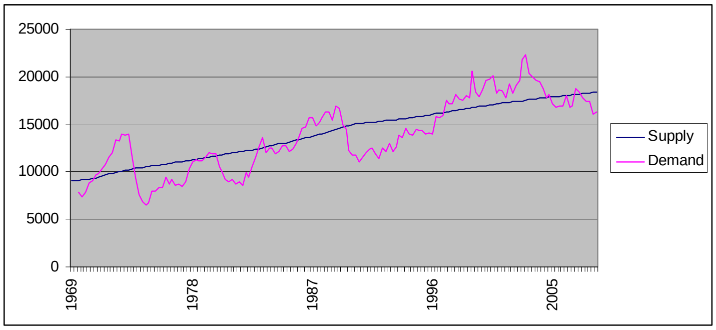


***Figure12*. Dummy Variable Coefficients and t-values**

Finally, the first frame of Figure 13 sets out estimates of the implied equilibrium owner-occupier housing demand (derived by inverting equation 11), which is compared with the actual housing stock. The log difference between the two is given in the second frame and is a measure of the disequilibrium in the housing stock. For positive values, prices are expected to be rising. In general, this is the case, but, interestingly, post-2005 values are negative, indicting that, in terms of fundamentals, the beginnings of a market downturn would be expected. This is also consistent with the slight overprediction of the equation found in the earlier tests. As expected the measure of disequilibrium is stationary; excluding a constant (since on average the expected value is zero if the market returns to equilibrium), the ADF(4) value is -4.11 (critical value -1.94 at 5% level).



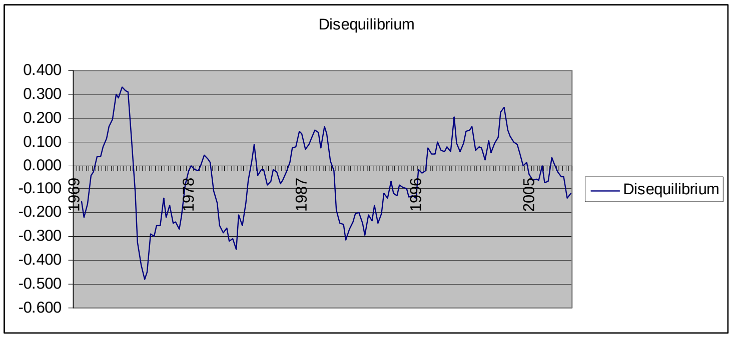


***Figure 13*. Housing Demand, Supply and Disequilibrium**

5. Long-Run Housing Affordability

Government targets for affordability are defined in terms of the ratio of house prices to incomes, both measured at the lowest quartile. In the short run, as house prices fall, this measure will inevitably improve; however, the improvement highlights one of the weaknesses of the target measure – it takes no account of the availability of mortgages, which constrains market entry. By contrast, Figure 9 suggests that the real interest rate facing households has risen recently because of credit restrictions. But, even on its own terms, because of housing supply shortages, there are good reasons to believe that affordability problems will re-emerge once the credit crunch is over. Mortgage shortages may delay entry into home ownership, rather than reduce it permanently. Therefore, policies are required that are robust to both short and long-term problems. The long term can also be analysed using the model.

Since $R(t)$ cannot be measured adequately in the UK, equation (5), rather than (4) is estimated in Table 2 as an approximation. However, its weakness is that this is a test of set of joint hypotheses rather than a direct test of the more parsimonious asset pricing equation. Consequently, although less elegant as a way of emphasising the importance of the discount rate to recent price changes, the equation in Table 2 can also be derived from straightforward demand and supply analysis. The final equations are observationally equivalent. Indeed, much of the empirical house price literature uses this alternative approach.

Therefore, consider the aggregate housing demand function (12), which separates out the main components of the discount rate.

$$\ln(H^d) = a_0 + a_1 \ln(RY) - a_2 \ln(g) + a_3 \ln(HH) - a_4 \ln(i) + a_5 (\dot{ph}) + a_6 (M^d - M^S) + \varepsilon_1 \tag{12}$$

where:

H^d	=	Aggregate demand for owner-occupier housing services
RY	=	Real incomes
g	=	Real house prices
HH	=	Total number of households
i	=	Mortgage interest rate
$M^{d,s}$	=	Mortgage demand, supply
$\dot{ph}$	=	Expected nominal capital gain
ε_1	=	error term

For a fixed (short run) supply of housing services, market equilibrium implies the house price equation (13).

$$\ln(g) = (a_0 / a_2) + (a_1 / a_2) \ln(RY) + (a_3 / a_2) \ln(HH) - (a_4 / a_2) \ln(i) - (1/ a_2) \ln(H^s) +$$
$$+ (a_5 / a_2)(\dot{ph}) + (a_6 / a_2)(M^d - M^S) + \varepsilon_2 \tag{13}$$

where

H^s	=	Supply of housing services

If $a_3 = 1$ (i.e. the demand for housing services rises proportionately to the number of households), then equation (13) can be simplified to (14).

$$\ln(g) = (a_0 / a_2) + (a_1 / a_2) \ln(RY) - (a_4 / a_2) \ln(i) - (1/ a_2) \ln(H^S / HH) + (a_5 / a_2)(\dot{ph})$$
$$+ (a_6 / a_2)(M^d - M^S) + \varepsilon_2 \tag{14}$$

In (14), a proportionate rise in both the housing stock and the number of households leaves real house prices unchanged. But if homogeneity holds, then affordability, ln(g/*RY)*, is constant only if (a_1/a_2) = 1, for given values of the other variables. If (a_1/a_2) > 1, then affordability worsens over time (assuming growing incomes), even if H^S=*HH*. However, (a_1/a_2) > 1 implies that the income elasticity of housing demand is higher than the price elasticity. In Table 2, as noted above, the income elasticity is 1.39 and the price elasticity is -0.66. Therefore, affordability worsens over time unless the supply of housing services rises faster than the number of households or some other market stabiliser operates, for example, changes in interest rates or credit rationing. This is why affordability has begun to improve again.

But this analysis implies that affordability worsens permanently in the long run if credit rationing is removed. Indeed, it is shown in simulations below, that prices exhibit over-shooting as affordability returns to its long-run trend. Consequently, permanent improvements in affordability may require housing supply to rise faster than the number of households. This lies behind the projections of the National Housing and Planning Advice Unit, (NHPAU 2008). But is this a *necessary* condition to improving affordability?

Suppose that, in the long run, there is a fixed relationship between the stock of mortgages and the market value of the housing stock as in Table 1. Therefore, gearing cannot increase without bound, although Figure 7 shows it can still exhibit considerable volatility over the cycle.

Therefore, in long-run equilibrium (15) holds:

$$\ln(M) = \gamma + \ln(PH) + \ln(H^S) \tag{15}$$

Using (14) and the estimated income elasticity of house prices of 2.1, yields (16), ignoring all except the income term.

$$\ln(M) = \gamma + 2.1 * \ln(Y) + \ln(H^S) \tag{16}$$

where Y is nominal income.

Consequently, for a given housing stock, even if the loan to value ratio is constant in the long run, the loan to income ratio rises, if the income elasticity of housing demand is greater than the price elasticity. This appears to be consistent with Figure 6 in a credit unconstrained world. Furthermore, for a given nominal interest rate, interest payments as a percentage of income ($i*M/Y$) rise over time. But this cannot be an equilibrium since it implies that eventually interest payments exceed income. There has to be some set of forces stopping this from happening. There are at least 4 possibilities:

(i) At high gearing, risk rises, so that small random shocks are more likely to cause large crashes, bringing prices back more in line with income.

(ii) Mortgage shortages occur again reversing any boom. The current crash is an example, but more generally unless securitisation continues to increase, the required increase in mortgage demand is unlikely to be financed out of retail deposits if the elasticity of retail deposits with respect to income is less than 2.1 (assuming the estimated income elasticity of house prices above). This is, arguably, one justification for increased reliance on securitisation.

(iii) Housing supply increases more than proportionally, so that affordability does not worsen.

(iv) For the loan to income ratio to be constant in equilibrium, the elasticity of mortgages with respect to house prices in (15) would have to be approximately 0.5 so that mortgage debt as a proportion of the market value of housing would have to fall over time.

This suggests that affordability will not worsen for ever, even if housing supply is not increased. At high debt, the system becomes very risky and more sensitive to random shocks, which reverses any worsening in affordability. Given the controversies surrounding increases in house building, at first sight, it might seem that increases are not necessary – markets will eventually correct any imbalances. However an important justification for a supply-based strategy is that this causes least housing market volatility or disruption. The high elasticities of house prices with respect to incomes and interest rates arise primarily from the inability of supply to adjust adequately. As the supply response increases, the price elasticities fall. Therefore, a policy of strong supply achieves the same result of improving affordability, but with minimum disruption to housing and the wider economy, compared with the alternatives. Arguably, the lower US price volatility in Figure 1 is consistent with this explanation. Goodman and Thibodeau (2008) find that, in US metropolitan areas, there is less evidence of price bubbles in areas which experience stronger supply elasticities. Glaeser *et al* (2008) also indicate that places with more elastic supply have fewer and shorter bubbles.

6. Model Simulations

These issues can be demonstrated further in a simulation model consisting of the equations in Tables 1 and 2. Consequently, house prices and the mortgage stock are the endogenous variables; household income, interest rates, consumer prices and housing supply are the key exogenous variables in the system. Measures of affordability, the loan to value ratio and the loan to income ratio are all determined by identity. The quarterly model is simulated over the period 2008Q3 to 2031Q4, given outturn values for the variables up to 2008Q2. The exogenous variables are projected at values approximately equal to those of the last year.

The base scenario assumes that no further mortgage rationing occurs, so that lenders meet mortgage demand determined by Table 1. The housing stock is assumed to increase by 250,000 units per annum in Great Britain, which is higher than in recent years, but reflects the government's policy commitment to raising housing construction. Using the baseline, three other scenarios are constructed.

- (i) a case in which mortgage rationing continues until the end of 2010.
- (ii) A case in which housing supply is increased by an additional 50,000 units per annum.
- (iii) A case in which the loan to income is held approximately constant. This implies permanent mortgage rationing.

Figures 14 to 17 set out the outcomes for the main variables, expressed as percentage differences from the base scenario. The first two graphs are measures of affordability – the price to income ratio and the user cost of capital – whereas the third and fourth consider the loan to value and loan to income ratios respectively. The housing user cost is defined as the discount rate, (equation 7), multiplied by the real house price. Each scenario is considered in turn.

Case (i) demonstrates that temporary rationing until 2010 has no permanent effect on the outcomes. Indeed, house prices and affordability, measured as the ratio of prices to incomes, exhibit modest overshooting as baseline affordability is re-established. This is even more evident in the user cost of capital. Rationing immediately raises the user cost, although it falls subsequently below base as rationing is removed and as house prices fall. The effects on the loan to value and loan to income ratios are modest.

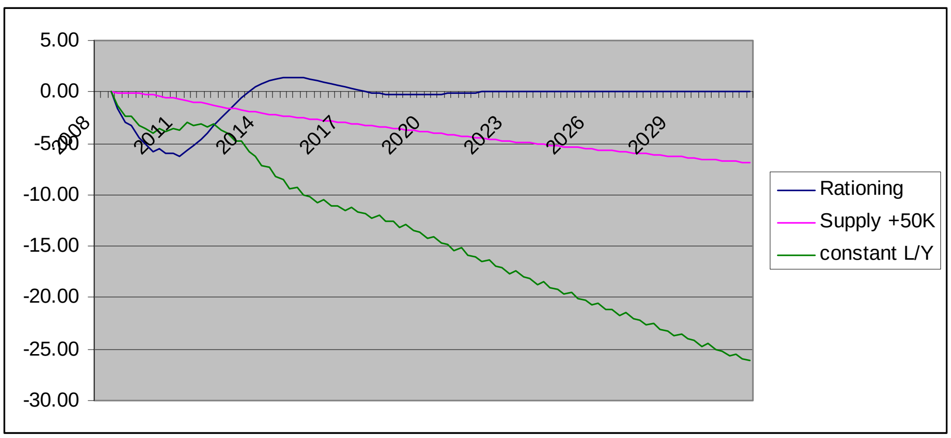


***Figure 14*. Affordability: House Price to Income Ratios (% differences from base scenario)**

Case (ii) demonstrates the benefits of an increase in housing supply. Affordability improves in terms of both the house price to income ratio and the user cost. Furthermore the loan to income ratio falls. In general, as argued in the last section, increases in supply reduce housing market risk and volatility. However the figures also demonstrate that any gains are slow to take place and, consequently, cannot be used for short-term stabilisation. Since the increase in *flow* supply is permanent, the effects on the *stock* cumulate over time. From equation (11), the long-run elasticity of house prices with respect to the housing stock is -1.5. At first sight, it might appear that the increase in supply would have a large effect on prices. But a 50,000 increase in supply is only approximately 0.25% of the housing stock. Cumulated over the whole period, the increase in the stock is approximately 6%. Therefore, the fall in prices in the final year is less than 10%[3].

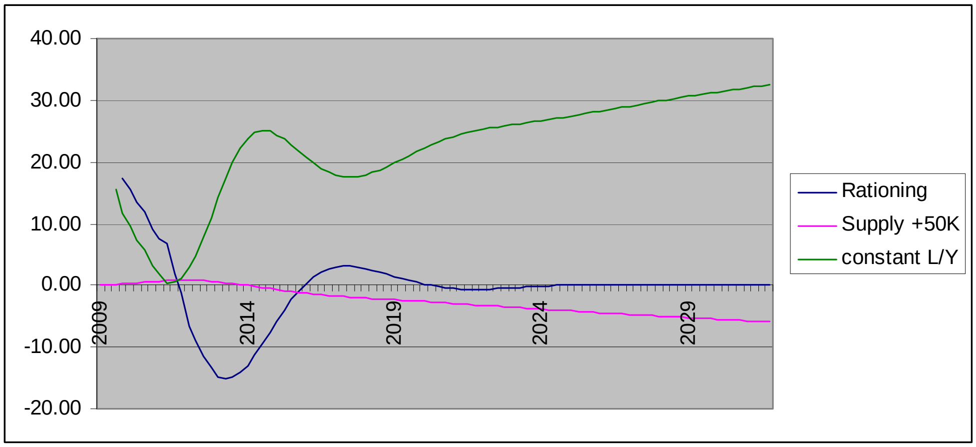


***Figure 15*. Affordability: Housing User Cost of Capital (% differences from base scenario)**

Case (iii) attempts to maintain a constant loan to income ratio. In practice, the simulation is constructed by assuming the mortgage stock increases by 1.25% per quarter. This implies that permanent rationing occurs since the increase is less than demand. In turn, the rationing leads to a permanent increase in the user cost[4], despite the fact that real house prices are lower than in the base. In this scenario, the two measures of affordability present different pictures. Since rationing lowers house prices, the house price to income ratio is approximately 25% lower than base by the final year, Figure 14. From equation (16), the loan to income ratio rises sharply in the base. Therefore imposing constancy in the simulation, means that the difference from base is negative, Figure 17. Furthermore, constancy of the loan to income ratio must imply that the loan to value falls relative to base, Figure 16.

[3] Figure 14 suggests the value is well under 10%. This is because of the lags in the price equation.
[4] The manner in which the simulation has been constructed generates seasonality in the user cost. The values in Figure 15 have been smoothed by taking 4-quarter moving averages.

However, it could be argued that this simulation is artificial. First, there is no easy route whereby mortgage supply could be permanently restricted. Attempts to control mortgage growth were made by the government in the seventies without noticeable success. Furthermore, a cumulative decline in the loan to value ratio cannot represent an equilibrium. At best, therefore, policies of this form can only be temporary.

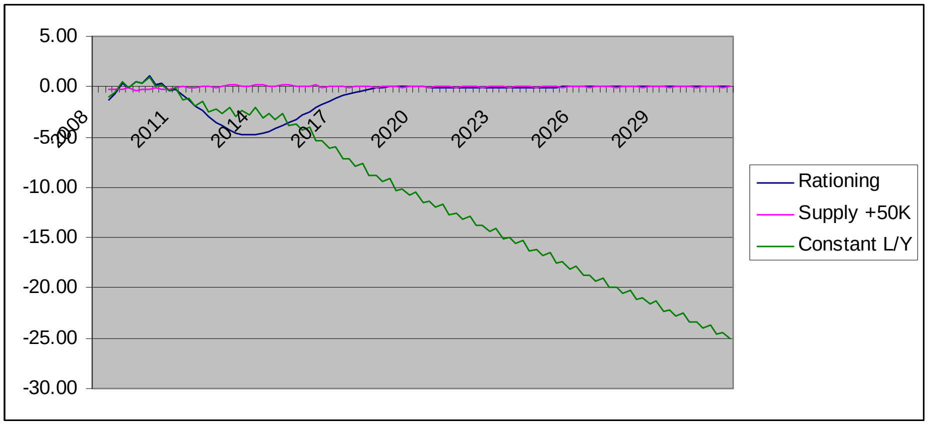


Figure 16. **Loan to Value Ratio (% differences from base scenario)**

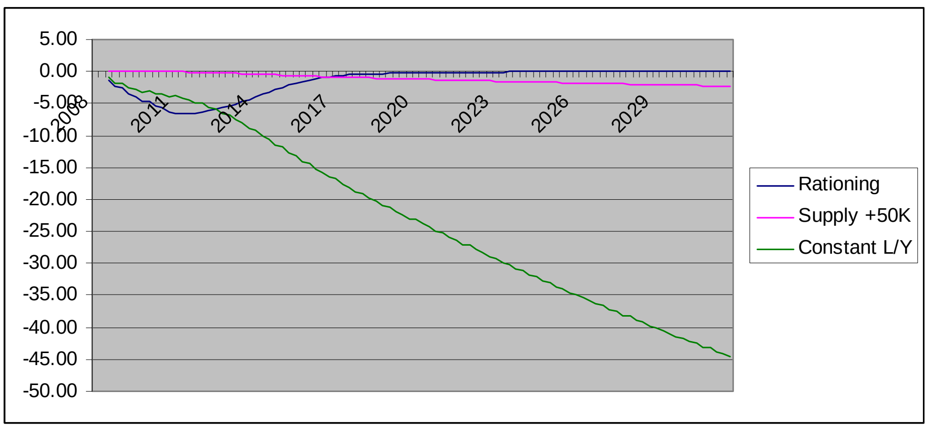


Figure 17. **Loan to Income Ratio (% differences from base scenario)**

7. Conclusions

This is the first formal model of housing and the current credit crunch. It is simple in that its conclusions depend on few parameters. The most important are the ratio of the income elasticity of housing demand to the price elasticity. All UK time-series studies find that the former is greater than the latter, although the evidence is, perhaps, less clear cut on cross-section micro data. Most of the results are derived on the assumption that the aggregate loan to value ratio is constant in the long run, although this is less critical to the conclusions and the assumption can be varied.

It is sometimes forgotten that mortgage rationing was the norm until the early eighties in the UK and the economy proceeded without major disasters. Furthermore, housing models developed in those days had to take account of rationing and much of the theory remains relevant today. Therefore, it is possible to construct a theoretical model of house prices and mortgage markets, which can be estimated on time-series data. From this, quantitative estimates can be derived of the effects of the credit crunch on house prices. A number of conclusions can be drawn.

1. There is little evidence of a major bubble in UK house prices between 1996 and 2007. The argument that a bubble occurred often relies on flawed analysis. This arises partly from the application of standard financial asset pricing models that are not relevant without modification to housing.
2. The UK's long-run housing problems (affordability) have not disappeared. It remains just as important to increase housing supply as before the credit crunch. Indeed, increases in housing supply reduce the probability of the same problem occurring again, because it reduces the sensitivity of house prices to demand shocks. But, of course, supply is currently falling sharply. Furthermore, the benefits take place only slowly.
3. As long as the credit crunch is temporary, i.e. households are not permanently constrained in their access to funds and the credit crunch does not lead to a permanent change in behaviour, then house prices and affordability are expected

to return to trend after the end of the crisis. Indeed, there may be a degree of overshooting to compensate.

4. Even if the ratio of mortgage debt to the market value of housing (the aggregate loan to value ratio) is constant, this implies that mortgage repayment to income ratios still increase. This increases the long-term riskiness of the system in response to shocks.
5. Rationing has large effects on the user cost and, hence, on house prices. The relatively modest reductions in UK mortgage interest rates in 2008 were insufficient to offset the effects of the shortage of mortgage funds.
6. Predictions of future house price movements will generally be wrong. Short-run house price movements are almost unpredictable, but not because the market is efficient or because the model coefficients are volatile.

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