Bubbles or Fundamentals? Understanding Boom and Bust Episodes in the Housing Market*

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February 14, 2012

Abstract

In this paper we revisit the connection between changes in interest rates, loan-to-value ratios and expectations in influencing housing prices. We construct a two good general equilibrium model in which housing is a composite good produced using structures and land. We show that changes in interest rates that are viewed as permanent have a large impact on house prices, while increases in LTV have smaller effects. We also show that if the model is to account for the actual boom and bust in house prices, it must be the case that households were exposed to multiple expectations shocks. Contrary to conventional wisdom, we show that the model can reconcile the disconnectness between house values and rents, addressing an open puzzle in the literature.

*The authors are grateful to the stimulating discussions with Morris Davis, Dirk Krueger, Felix Kubler, Don Schlagenhauf, and the seminar participant at the 2011 Macro Workshop in Brisbane, University of Wisconsin-Madison, Florida State University, University of Miami. The editorial comments from Judith Ahlers have been useful. The views expressed herein do not necessarily reflect those of the Federal Reserve Bank of St. Louis nor those of the Federal Reserve System.

1. Introduction

House prices in the U.S. increased by 55% between 2002 and 2007, and decreased by 35% between 2008 and 2012. These large swings in the price of an asset that accounts for a significant fraction of the wealth of U.S. households are widely viewed as a major factor that contributed to the 2008 financial crisis. There is less consensus about the causes of the movements in house prices. In this paper we revisit the role played by the interest rate, the fraction of an asset that can be collateralized and shocks to expectations in accounting for movements in house prices. In some sense, we take a step backwards by studying a very simple model that allows us to highlight the roles played by those factors in a general equilibrium setting.

We develop an extremely simple two sector general equilibrium model. We model houses as being produced with structures –themselves the output of the rest of the economy– and land –which we take to be in fixed supply.[1] We assume that the financial sector is segmented with the interest rate on loans collateralized by the value of the housing stock potentially lower than the rate of return on non-housing capital. Moreover, in our experiments we restrict ourselves to representative agent economies and, hence, we view the changes in the stock of mortgages as being financed by the rest of the world.

We use the model to evaluate the impact of changes in the external interest rate and in the loan-to-value ratio –our measure of financial market liberalization– on housing prices. In our setting expectations of the future behavior of these variables play a significant role. We study a sequence of economies distinguished by shocks to expectations. Starting from a steady state we explore the impact of decreases in the relevant interest rate that are viewed as permanent. These changes, accompanied by increases in the loan-to-value ratio generate a boom in housing prices that matches the data. Moreover, as in the U.S. economy, a large fraction of that increase corresponds to higher land rents while a more modest component is associated with larger structures. We find that the changes in interest rates account for a much larger fraction of the change in housing values than changes in financial market conditions. However, the effect is non-linear and we show that, in the transition, interaction effects are significant. The best fit of the model is associated with the case in which households revise in every period their expectations of the long run interest rates. Even though the change in house value generates large income effects, some specifications of the model display reasonable predictions about macro variables. As expected, the income effect increases the demand for savings and this lowers the equilibrium domestic interest rates with the consequent increase in investment.

In our model the bust in housing prices is associated with a reversal in expectations about the long run interest rate and a tightening of financial market conditions. We assume that around 2008 households change their views about the length of time that interest rates would remain low. In our base case, we model expectations of low interest rates as lasting for about 12 years, and the

[1] Davis and Heathcote (2006) document that the dynamics for the prices of residential land and residential structures are substantially different. They find that the real price index for residential land almost tripled between 1975 and 2005, whereas the real price of structures increased by only 24 percent.

slowly increasing to their pre-shock level. This anticipated increase suffices to generate a decrease in house values of about 30%, even though contemporaneous interest rates do not move. Moreover, this shock to expectations contribute to a decrease in consumption and output. However, this falls short of the actual changes, which suggests that to explain the behavior of macro aggregates it is necessary to resort to shocks other than the ones we model.

Our model is related to several recent analyses of the interaction between financial variables and housing prices. Glaeser and Gyourko (2010) consider a generalized version of the standard user cost model of home valuation that allows for mean-reverting interest rates, mobility, prepayment and elastic housing supply and credit-constrained home buyers and conclude that the effect of interest rates on home prices was very modest. The authors also point out that since interest rates actually fell during the period that home prices collapsed, they "obviously cannot account for the fall in prices in that period." Our model can be seen as a general equilibrium version of a user cost model where prepayment, the housing supply, and credit-constraints are endogenously determined. A key feature of our model, not present in Glaeser and Gyourko's analysis, is that homes can be used collateral in credit markets. The price of a home must then reflect the standard user cost equation, plus a term that captures the value of the relaxation of credit constraints. More important, our analysis suggests that fluctuations in the liquidity value of a home, that arise from changes in the interest rates or loan to value ratios, can account for the bulk of the observed changes in home values. Our analysis agrees with the observations of Glaeser and Gyourko that changes in interest rates or loan to value ratios must have been relatively unexpected, and perceived as relatively long lasting to account for the observed movements in home values.

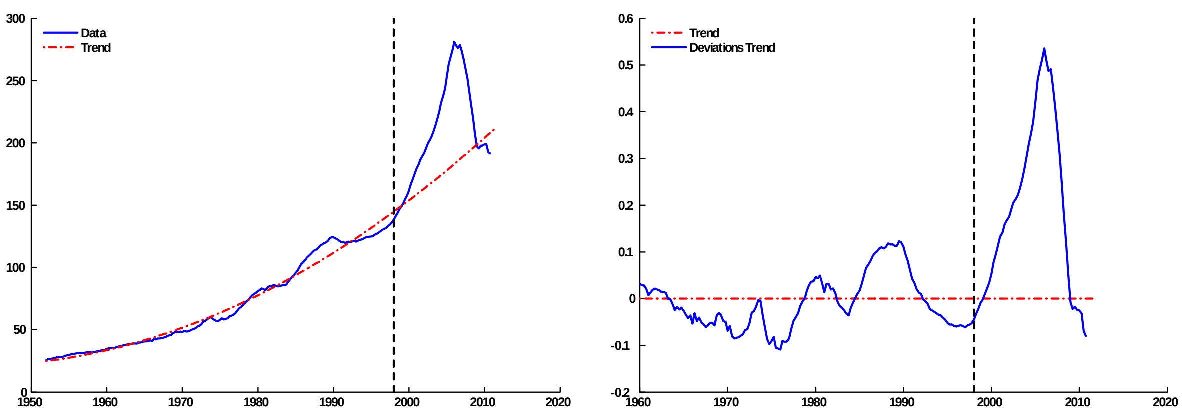
Kiyotaki et. al. (2011) and Favilukis et. al. (2011) also consider general equilibrium models with houses serving as collateral for credit markets. The main focus of the first paper are the wealth and welfare implications of fluctuations in home values driven by fundamentals in a setting with heterogeneous households. To study the cross sectional implications of these fluctuations, the authors employ an overlapping generations model with agents that differ in lifetime productivity. The framework is that of a small open economy and capital can move freely and costlessly across countries and across the consumption and housing sector. Their quantitative analysis, however, focuses exclusively on the boom episode of the early 2000s. For the model to generate a realistic boom in home values it is necessary for productivity growth to increase permanently, and for interest rates to fall, also permanently. Unfortunately, key macroeconomic aggregates in the U.S. do not seem to be following a faster trend, or to even grow substantially above trend in recent decades. The small open economy framework adopted is an important reason for the undesirable quantitative predictions of the model. In particular, lower world-wide interest rates must lower the returns of capital overall. Capital and consumption must change substantially in the long-run, which maybe difficult to reconcile with the data. Our model, instead, adopts a segmented financial markets structure. There is a market for borrowing and lending that takes interest rates as given, but it is only for collateralized loans. The economy is otherwise closed. As a result, long-run capital and output in the non-housing sector are independent of the world interest rate and the loan to value ratio. Changes in the world-wide interest rate do have general equilibrium effects along the transition, however, which allow for interesting interactions between the housing and non-housing sector.

Favilikus et. al. (2011) are interested in the role of time-varying risk premia for fluctuations in home values and consumption and wealth heterogeneity. The model is a rich overlapping generations model with agents that face a stochastic earning profile and incomplete financial markets. In their specification, changes in financial market conditions result, in equilibrium, in a smoother stochastic process of consumption through better self-insurance of labor income risk. A smoother consumption process results in a lower risk premium and this, in turn, in higher prices for risky assets. Favilikus et. al. (2011) either ignore the role of land (assuming that it is not used in the housing sector) or eliminate the associated income effects by assume that changes in land rents are matched by changes in government spending. This, reduces the impact of the increase in housing value over aggregate variables.

2. Empirical Evidence

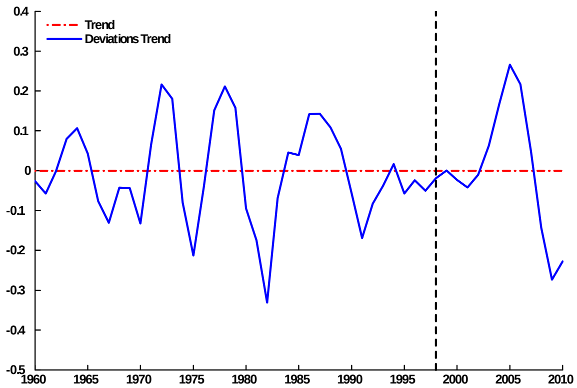
This section provides empirical evidence of the boom and bust cycle in the United States and other countries (Spain and Japan). The purpose is to determine the magnitudes of these boom and bust episodes and the changes in the contributing factors. The first magnitude that needs to be determined is the size of the boom and bust cycle. Figure 1 summarizes the evolution of house prices between 1970 and 2011. It is clear from the figure that the recent boom and bust episode represents a sizeable deviation from the historical trend.

Figure 1: House prices and deviations from trend



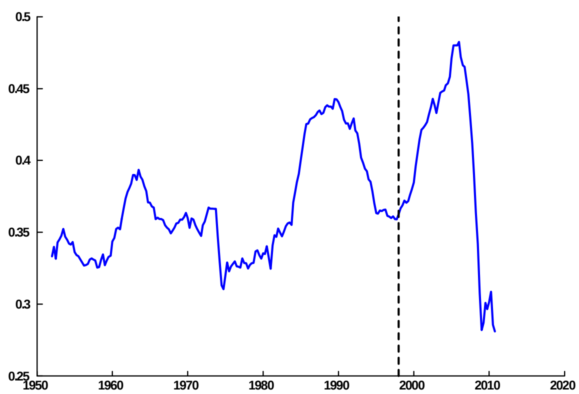
The magnitude of the boom suggests a 50 percent increase over the historical trend whereas the bust is roughly 30 percent. The same exercise using the Case-Shiller should give numbers is excess of 60 percent. The magnitude of the house price increase is surprising, once it is considered the 30 percent increase in residential investment relative to trend as suggested by Figure 2.

Figure 2: New privately owned housing capital



In addition to the increase in the size of the housing capital via residential investment, Davis and Heathcote (2006) argue that a sizeable increase in the value is due to the price of land. Between 1998 and 2006 the contribution of land in the value of housing increase from 36 percent to 58 percent. Figure 3 illustrates the fraction of the value of housing capital due to land.

Figure 3: Contribution value of land in housing capital



There has been other periods where land prices have increased, but house prices have remained more stable compared with the recent boom-bust episode. It is important to mention that the magnitudes observed in the U.S. are not that special. Other OECD countries also had similar episodes.

3. The Model

We consider an economy where time is discrete and indexed by $t = 0, 1, 2, \ldots$ There is a representative household that lives forever and values (non-housing) consumption and housing services. We use non-housing consumption as the numeraire. Preferences over sequences of non-housing consumption and housing, $\{c_t, h_t\}_{t\geq 0}$, can be represented by

$$\sum_{t=0}^{\infty} \beta^t u(c_t, h_t),$$

where u and β satisfy the usual assumptions Households have an endowment of one unit of time per period, which they supply inelastically to the market in order to receive a wage rate w_t. They are also the owners of non-housing capital, K_t, which they rent to firms at rate r_t. The stock of non-housing capital evolves following the standard law of motion

$$K_{t+1} = x_t + (1 - \delta_k)K_t,$$

where $0 \leq \delta_k \leq 1$ is the depreciation rate, and x_t is non-housing investment. Households own a stock of residential structures, S_t, which depreciate at rate δ_s, and land, L_t, which does not depreciate. Structures and land produce a flow of housing services according to function $h_t = G(S_t, L_t)$. Land prices, p_t^ℓ, are taken as given. Purchases of land are denoted by ℓ_t. Land will be assumed to be in fixed supply, but from the perspective of the household, the stock of land follows

$$L_t = \ell_t + L_{t-1}.$$

We will assume investment in residential structures, s_t, is irreversible. Hence, we must distinguish the price of installed structures, p_t^s, from the price of new residential investment goods which, in the base case, will be equal to one in equilibrium. Following Sargent (1980) we let households choose their total purchase of *installed structures* for next period, S_{t-1}^d, while taking into account that their current holdings (after depreciation) are valued at $p_t^s(1 - \delta_s)S_{t-1}$. Hence, from the point of view of an individual household, its stock of residential structures satisfies

$$S_{t+1} = s_t + S_{t-1}^d,$$

where s_t is the (non-negative) investment in *new structures* which, in our base case, has price one. By a slight abuse of notation we specify that the aggregate law of motion of structures is

$$S_t = s_t + (1 - \delta_s)S_{t-1}.$$

Given our assumption that there is a representative household, equilibrium implies $S_{t-1}^d = (1 - \delta^s)S_{t-1}$, and the price of installed structures will adjust to guarantee this is the case.

We assume that financial markets are segmented. In our simple model, we view the market for collateralized borrowing (the market for mortgages) as distinct from the financial market that is used to finance capital investments. We denote by B_t the stock of collateralized debt at the beginning of period t, and by r_t^* the interest rate, while D_t indicates the stock of non-collaterlized debt (and the relevant interest rate is denoted by r_t^d).

The law of motion of B_t is given by

$$B_{t+1} = b_{t+1} + (1 - \triangle)B_t,$$

where $0 \leq \triangle \leq 1$ is the fraction of the stock of debt that must be repaid in every period[2]. Since we study a deterministic economy we abstract away from default.

In this exercise we concentrate on equilibria in which $r_t^d \geq r_t^*$, that is, the domestic interest rate —which will equal the rate of return on capital— exceeds the rate at which the rest of the world is willing to hold mortgage backed assets. To prevent arbitrage, it is necessary to restrict the amount of foreign borrowing. Our specification is very simple: we set the upper bound on mortgage debt to a fraction of the market value of the stock of housing. Thus, borrowing must satisfy

$$b_{t+1} \leq \max\{0, \phi_t(p_t^s S_t + p_t^\ell L_t) - (1 - \triangle)B_t\},$$

where ϕ_t is a measure of the loan-to-value ratios in new borrowing at time t. Note that when the constraint is not binding this specification implies that next period's (i.e. $t+1$) stock of debt equals $\phi_t(p_t^s S_t + p_t^\ell L_t)$. If the value of the housing stock drops so that the constraint is binding, the specification requires that the households repay an amount $\triangle B_t$ of the existing stock of mortgages (this follows from the law of motion and $b_{t+1} = 0$).

The relevant constraints for the household problem are the standard non-negativity constraints and

$$\begin{gathered}
c_t + (r_t^* + \triangle)\, B_t + p_t^\ell l_t + x_t + q_t s_t + p_t^s S_t^d + (1 + r_t^d) D_t = \\
r_t K_t + w_t + p_t^s (1 - \delta_s) S_{t-1} + b_{t+1} + D_{t+1} \\
K_{t+1} = x_t + (1 - \delta_k) K_t \\
B_{t+1} = b_{t+1} + (1 - \triangle) B_t, \\
S_{t+1} = s_t + S_{t-1}^d, \\
L_t = L_{t-1} + \ell_t \\
b_{t+1} \leq \max\{0, \phi_t(p_t^s S_t + p_t^\ell L_t) - (1 - \triangle) B_t\} \\
h_t = G(S_t, L_t)
\end{gathered}$$

The final element of our economy is a representative firm that produces the non-housing consumption good. This firm rents capital and labor from households using a constant returns to scale technology $F(K_t, N_t)$. Wages and the interest rate on capital are competitively determined and

[2]This specification is a simple approach to capturing the real world heterogeneity in the average duration of mortgage contracts. It implies that the average maturity of the debt is approximately $1/\Delta$.

must therefore be given by marginal productivities

$$r_t = F_K(K, N), w_t = F_N(K, N).$$

Our definition of competitive equilibrium is standard and, hence we omit it. The only special feature is that market clearing in the market for land requires that, in equilibrium, $\ell_t = 0$ and $L_t = \bar{L}$. The aggregate feasibility constraint in this open economy is

$$c_t + x_t + q_t s_t + (1 + r_t^*) B_t = F(K_t, N_t) + B_{t+1}.$$

4. Analysis of the model

In this section we describe some simple properties of the model in the long run and during the transition after a shock.

4.1. Steady State

In the steady state —with the domestic rate denoted by r— the following relations hold (I am imposing $p^s = q$).

$$\begin{aligned} p^\ell &= (1+r)\frac{u_h}{u_c} G_L(S, L) \frac{1}{r - \phi(r - r^*)} \\ q &= (1+r)\frac{u_h}{u_c} G_S(S, L) \frac{1}{r + \delta_s - \phi(r - r^*)} \\ V &= qS + p^\ell L, \\ Y - C - \delta_s q S &= \phi r^* V \end{aligned}$$

where

$$Y = F(K^*, 1) - \delta^k K^*$$

is independent of any of the factors we are interested in.

These equations imply that

$$p^\ell = q \frac{r + \delta_s - \phi(r - r^*)}{r - \phi(r - r^*)} \frac{G_L(S, L)}{G_S(S, L)}$$

To better understand the workings of the model, we next explore the implications imposing the functional forms that we use in our numerical exercise. Let

$$\begin{aligned} u(c, h) &= \frac{[\alpha_c c^{-\rho} + (1 - \alpha_c) h^{-\rho}]^{-\frac{1-\theta}{\rho}}}{1 - \theta}, \\ G(S, L) &= z_h [\alpha_s S^{-\mu} + (1 - \alpha_s) L^{-\mu}]^{-\frac{1}{\mu}}, \end{aligned}$$

and we assume that both μ and ρ are positive. Imposing these functional forms, the second equation can be solved for c. The result is

$$p^{\ell} = q\frac{r+\delta_s-\phi(r-r^*)}{r-\phi(r-r^*)}\frac{1-\alpha_s}{\alpha_s}\left(\frac{S}{L}\right)^{1+\mu}$$

$$c(S,\phi,r^*,q) = \left[\frac{r+\delta_s-\phi(r-r^*)}{1+r}\frac{q\alpha_c}{\alpha_s(1-\alpha_c)}S^{1+\mu}G(S,L)^{\rho-\mu}\right]^{\frac{1}{1+\rho}},$$

$$V^1(S,\phi,r^*,q) = qS\left[1+\frac{1-\alpha_s}{\alpha_s}\frac{r+\delta_s-\phi(r-r^*)}{r-\phi(r-r^*)}\left(\frac{S}{L}\right)^{1+\mu}\right]$$

$$V^2(S,\phi,r^*,q) = \frac{Y-c(S,\phi,r^*,q)-\delta_s qS}{\phi r^*}.$$

Thus, it is useful to view the equilibrium as the intersection of two loci, V^1 and V^2. This gives a pair, (S,V) that yield the equilibrium level of structures and the value of the housing stock.

These functions have the following properties:

$$\lim_{S\to 0} V^1(S,\phi,r^*,q) = 0,\ \lim_{S\to\infty} V^1(S,\phi,r^*,q) = \infty,\ V^1_S > 0,\ V^1_\phi > 0,\ V^1_{r^*} < 0,\ V^1_q > 0$$

$$\lim_{S\to 0} V^2(S,\phi,r^*,q) = \frac{Y}{\phi r^*},\ \exists S^H(\phi,r^*,q) \text{ such that } V^1(S^H,\phi,r^*,q) = 0 \text{ and}$$

$$V^2_S \le 0,\ V^2_\phi \le 0,\ V^2_{r^*} < 0,\ V^2_q < 0.$$

Consider now the effect of an increase in ϕ. This shifts the $V^1(S,\phi,r^*,q)$ up, and the $V^2(S,\phi,r^*,q)$ down. This implies that the new level of S is lower but it has an ambiguous impact on the value of the housing stock. Similarly, a decrease in r^* shifts the $V^1(S,\phi,r^*,q)$ and the $V^2(S,\phi,r^*,q)$ up and it unambiguously increases the value of the housing stock, V, but has an ambiguous effect on the quantity consumed as S can either increase or decrease. Finally, an increase in q, the $V^1(S,\phi,r^*,q)$ up, and the $V^2(S,\phi,r^*,q)$ down and qualitatively has the same effect as an increase in $\phi : S$ decreases but the impact on V is ambiguous.

5. Quantitative Analysis: Housing Boom-and-Bust Episodes

5.1. Calibration

The quantitative evaluation of the model requires specifying parameter values and functional forms. The parameters of the model are set such that the certain steady state variables and ratios match the long-run averages of their data counterparts between 1952-1997. This is from the post war period to the start of the housing boom when home prices significantly departed from trend. The implied parameter values are relatively robust to choice of the sample period.

The utility and housing production function we employ for our quantitative analysis have the CES specification given in our previous section. As is common in the literature, we also assume the production function of the consumption good is Cobb-Douglas,

$$F(K, L) = zK^{\alpha}N^{1-\alpha},$$

where α represents the capital share and z represents the productivity of the goods sector.

The model parameters are determined to match the relevant aggregates. This requires to make several adjustments in the data to be compatible with the model. First, the model does not have either a government or a foreign sector. Therefore, the models notion of GDP only refers to the private sector i.e. Total GDP minus government consumption and investment expenditures. Second, the model makes an explicit distinction between consumption and housing services. In the NIPA personal consumption expenditures include housing services. During the sample period , this averaged 8.97 percent of GDP. In the model, non-housing consumption corresponds to NIPA consumption - housing services + net exports. The last term adjusts for the lack of a foreign sector in our model. The average value for non-housing consumption during the relevant period is 68.5 percent of GDP. Finally, proprietors income cannot be unambiguously attributed to either labor or capital. The standard convention is to assign a constant fraction of this income is assigned to each factor as in the overall economy.

The steady state conditions can be used to determine the majority of the relevant parameters. The remaining are solved numerically as a system of nonlinear equations.

- In the model, the share of labor in non-housing GDP (defined as private GDP minus housing services) corresponds to $1 - \alpha$. Labor income maps into NIPA compensation of employees (excluding the government) plus $(1 - \alpha)$ of proprietors income. The average value for this share observed in the data is matched by setting $\alpha = 0.259$.

- The discount rate β is determine to pin-down the domestic interest rate in a steady-state, $r^d = \frac{1}{\beta} - 1$. The target value is 4% and that implies $\beta = 0.96$.

- The steady-state the Euler equation for capital implies a steady-state non-residential capital to non-housing GDP ratio equal

$$\frac{K}{Y} = \frac{\alpha\beta}{1 - \beta(1 - \delta_k)}$$

where productive output is given by $Y = zK^{\alpha}N^{1-\alpha}$. For the sample period, this ratio averaged 1.7 in the U.S. data, and this allows to solve for the non-residential capital depreciation rate, δ_k. We normalize non-housing GDP to 100, which gives a value for z.

- The aggregate resource constraint can be used to determine the level of leverage that is consistent with the key macro aggregates. In steady-state this expression in ratios is given by

$$\frac{c}{Y} + \frac{\delta_k K + \delta_s S}{Y} + r^*\phi\frac{[p^{\ell}L + qS]}{Y} = 1.$$

During our sample period, non-housing consumption, the value of structures, and the value of residential real estate as ratios to non-housing GDP averaged 0.77, 1.16, and 1.84, respectively. Setting the depreciation rate to $\delta_s = 0.015$, which is standard in the literature, normalizing the stock of land to 100, and considering an effective real cost of borrowing of $r^* = 0.03$, uniquely determines the economy's leverage ratio. The implied value is $\phi = 0.50$ that is consistent with the Flow of Funds level of mortgage debt once you adjust for the fact that roughly 30 percent of the homeowners do not have a mortgage.

- The elasticity parameters in the utility function and the technology that combines structures and land to determine housing services are determined consistent with the estimates in the literature. These elasticities are given by $\varepsilon_{ch} = 1/(1+\rho) = 0.25$ and $\varepsilon_{sl} = 1/(1+\gamma) = 0.5$.

- The last two parameter values ϵ, η, are calculated using the steady state Euler equations for structures
$$1 = \beta\left(1 - \delta^s + RG_S\right) + (1 - \beta(1+r^*))\phi p^s,$$
and land holdings
$$p^l = \left(\beta p^l + RG_L\right) + (\frac{1}{\beta} - (1+r^*))\phi p^l.$$
Since these equations do not have close form solution, the parameters are determined as part of the steady state calculations. The set of targets that the model is designed to fit is summarized in Table 2

Table 2: Parameterization of the Model —1952-1998

Variable	Target
1) Normalization GDP	100
2) Value of the stock of structures to GDP	103
3) Non housing consumption to GDP	68.4
4) Value of land to GDP	60
5) Non housing capital to GDP	198
6) Value of housing services to GDP	8.97
7) Capital income share	0.25
8) Residential investment to GDP	
9) Value of land/output	0.66
10) Value of housing/output	2.71

and the parameter values used in the numerical simulations are summarized in Table 2.

Table 3: Parameter values

		Value
1) Productivity goods technology	$z =$	26.44
2) Productivity housing technology	$z_h =$	0.89
3) Discount rate	$\beta =$	0.96
4) Share consumption goods	$\alpha_c =$	0.88
5) Share of structures	$\alpha_s =$	0.80
6) Capital share	$\alpha =$	0.26
7) Depreciation capital	$\delta_k =$	0.11
8) Depreciation structures	$\delta_s =$	0.015
9) Collateral constraint	$\phi =$	0.50
10) Elasticity parameter $u(c, h)$	$\rho =$	1
11) Elasticity parameter $G(S, L)$	$\gamma =$	3

5.2. Housing Boom and Bust Episodes

In this section we consider the quantitative impact of shocks to the actual cost of borrowing and/or the tightness of credit markets, as well as shocks to expectations of their possible trends. Our analysis will be focused on the transition after these shocks. The success of the theory will be judged on whether the time series of the model can reproduce essential futures of the data. Namely, modest fluctuations in aggregate quantities together with large fluctuations in home values that come mostly from changes in the price of land.

The baseline experiment considers two shocks. The first one occurs in 1999 and consists of lower expectations about mortgage interest rates. The trends of r_t^* we introduce match those in the data, and we assume lower rates into the indefinite future. The second shock occurs in 2008. Interest rates are expected to continue at their 2008 levels until 2020, and are then expected to gradually return to their pre-boom levels.

Our second experiment evaluates the impact of changes in credit conditions. It considers the baseline experiment, but introduces two additional shocks. The first one is in 1999, whereby people expect credit conditions to improve. The sequence of ϕ_t we introduce is such that we match evidence on the loan to value ratio of the U.S. data. Looser credit standards are expected to last into the indefinite future. The second shock occurs also in 2008 and takes a reduced form view of the financial crises whereby ϕ falls immediately to its pre-boom levels.

Finally, we explore the quantitative implications of alternative expectations on the same sequence of interest and loan to value ratios. In particular, we follow Ludvigson et al (2011), and assume that people expect current values to persist into the indefinite future every period, and are surprised with a new shock every single period of the transition.

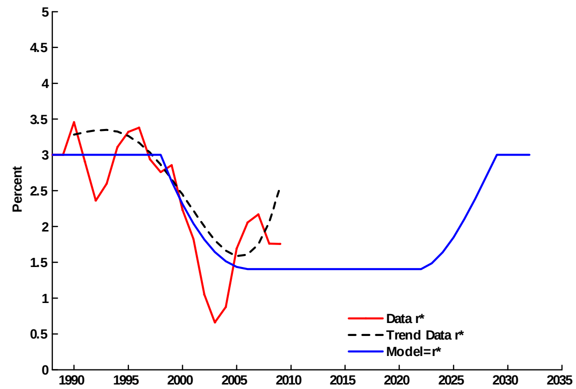
Our method to numerically solve for equilibria works directly on the first order conditions, for each set of expectations, imposing steady state values after a long enough period, T. We let

$T = 130$; which results in a highly accurate solution (our maximum Euler equation residuals along simulations are of order 10^{-16}).

5.3. Changes in the cost of credit

The underlying sequence of mortgage interest rates for the two shocks we consider in the baseline experiment is summarized in Figure 4. Rates start at 3% and decline, initially fast, and then more gradually, reaching a 1.4% level. Relative to its previous steady state, the difference between domestic and foreign interest rate widens.

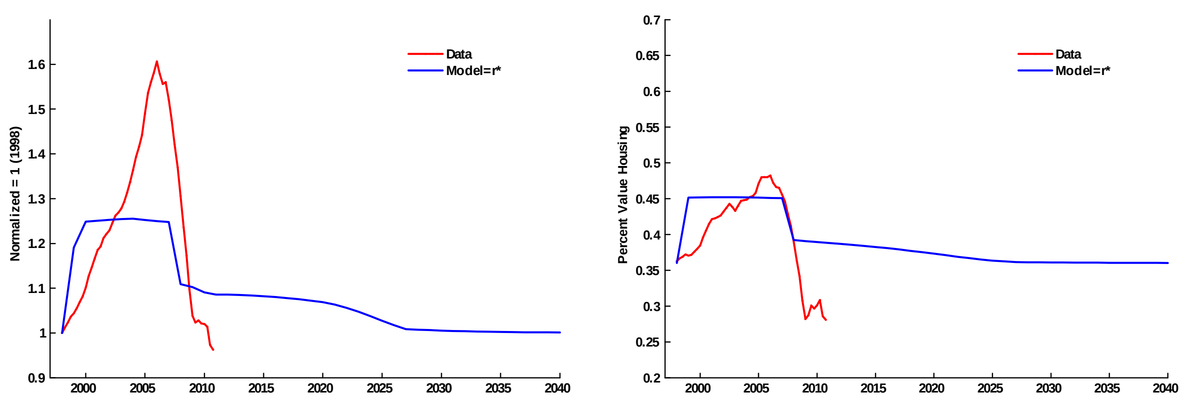
Figure 4: Underlying sequence of shocks ($\mathbf{r}^*$)



The lower cost of credit, is perceived as permanent, therefore households have an income effect that allows them to consume more goods and housing services. The increase in the demand for housing services, increases the rate of return of land and structures. Land is in fixed supply and its price must therefore increase. The increase in the value of housing components relaxes the borrowing constraint that feeds back into the demand for housing. For these two reasons, lower interest rates increase home values. Figure 5 summarizes the model implications for house values and the contribution of land to total value.

Figure 5: House prices and land

House values **Contribution land to value**



The model with this two surprise shocks generates an increase in the value of housing capital of 25 percent. Consistent with the data, the model predicts that a significant contribution in the increase of housing capital is due to the contribution of land, and not from changes in structures. Agents foresee the full sequence of interest rate in 1999 home values capitalize such changes and 2/3 of the 25% total predicted increase in home values occurs on impact.

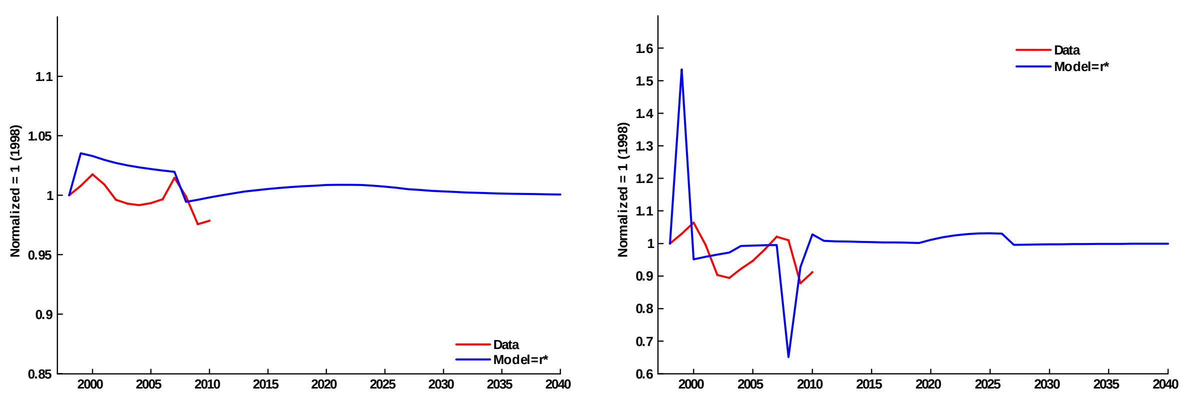
The increase in homes values is due to a substantial wealth effects. To understand the magnitude of this effects it is useful to look at the individuals budget constraint. Before the shock individuals were simply rolling over their debt, paying interest only.

$$C = F(K^*, 1) - \delta^k K^* - \delta_s q S - \phi r^* V.$$

Debt equaled fraction $\phi = 0.5$ of the pre shock home values, $1.84Y_0$. The shock causes home values to increase by 25% on impact. Individuals can therefore roll over their debt $(1.84 \times 0.5 \times Y_0)$, pay interest and the mandatory payments, and still have $0.25 \times 0.5 \times 1.84(1 - r^* - \triangle)Y_0$ additional income on their budget constraint. This corresponds, under our calibration to about 20% of non-housing GDP in extra income that must be distributed among consumption and investment. This is a large unexpected increase in income part of which, according to the permanent income hypothesis, will be saved. This additional savings lower the domestic interest rate. Notice also that, upon the arrival of the news about the lower cost of borrowing, the stock of housing is fixed (the stock of structures is a state and the supply of land is fixed), consumption and housing are complement goods in the utility function. As a result,capital investment absorbs the bulk of the wealth effect in the short-run. Figure 6 compares the model implications for consumption and investment.

Figure 6: Macro Aggregates

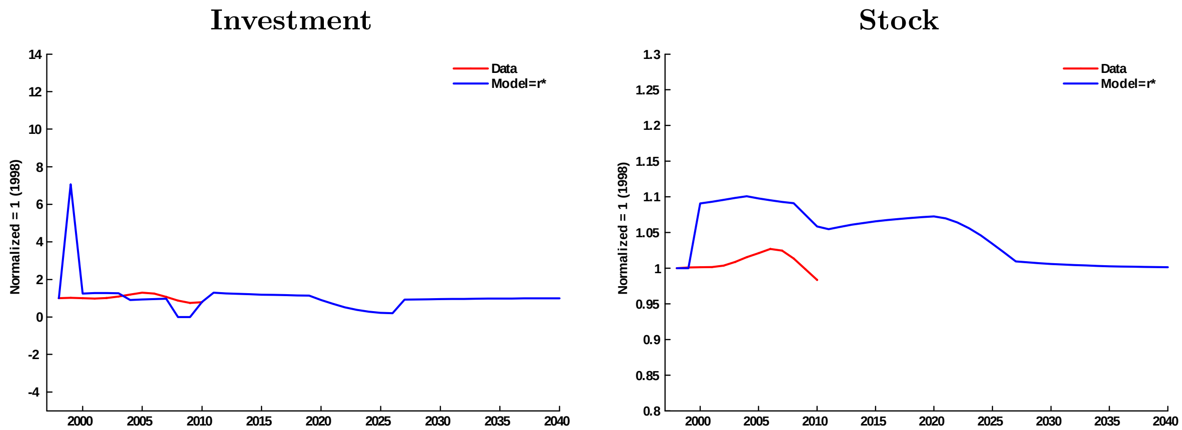
Consumption **Capital Investment**



The model predicts that consumption increases by about 3.5% points on impact, which is a little higher than what is observed in the data, and remains high up to 2007. One period after the shock, capital in non-residential structures increases by 6% and starts declining quickly thereafter. As a result of the initial increase in the capital stock the domestic interest rate falls from 4% to 3.3% on impact, causing a boom in non-residential investment at the time of the shock. Capital investment absorbs the majority of the income effects with an increase that is larger than the observed in the data. With preferences that allow for more substitution between consumption and housing services, the capital investment increases less at the expense of consumption. However, the effects in house prices are smaller.

Structures play an important role in the model. For the consumer, structures provide housing services but also provide collateral value. During the boom, residential investment provide an additional benefit that is the relaxation of the borrowing constraint. Part of the initial wealth effect is invested in structures. Figure 7 summarizes the model prediction for residential investment and the stock of structures.

Figure 7: Structures

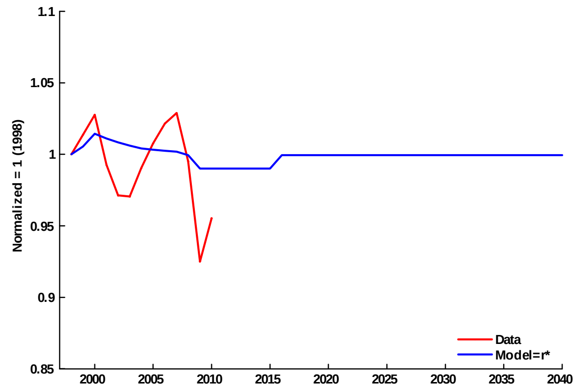


The wealth effect is not that visible in the data, but there was an increase in residential investment as a fraction of output and also in the stock of structures.

By the time the second shock hits the economy is fairly close to what would have been its steady state. The expectation of higher interests rates, even when the interest rate is known to remain low for the following decade (2007-2017), causes agents to rebalance their stocks of debt and residential structures. The price of land and of structures are the discounted present values of the flows they generate (including collateral values). Higher future rates lower present values on impact. Further, as home values go down and cross the threshold that makes households be "under water," the role of housing as a cheap source of credit is (temporarily) destroyed, pushing home values further down. Home values decline by 10% on impact, and continue declining for a prolonged period of time. The transition is very slow because irreversibility binds and the stock of residential structures declines at a very slow rate, equal to the rate of depreciation δ_s, or 1.5% per year. Debt before the shock is a fraction of the higher home values. The sudden decline in home values has, by a symmetric effect to the one described above, a strong negative wealth effect. Consumption and investment fall strongly as the shock hits.

Finally, Figure 8 shows a modest GDP expansion associated to the period of declining interest rates, together with a sudden recession on impact of the second shock.

Figure 8: Effects on aggregate output

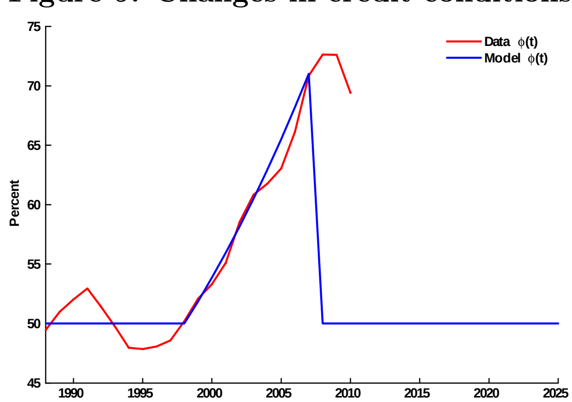


Despite the significant wealth effects, the boom in aggregate output is very small. The model can generate housing booms with very small changes in aggregate output. Overall, consumption and GDP display modest fluctuations compatible with the data, while accounting for about half of the increase in home values. Non-residential investment moves too much relative to the data. As we discuss below, however, alternative information structures can deliver more realistic movements in both, home values and investment.

5.4. Changes in credit conditions

The empirical evidence suggests that low rates where accompanied by better credit conditions. The model can be used to analyze the contribution of credit conditions in house prices. The next simulation considers the same time line for changes in the cost of borrowing but relaxes credit conditions according to the sequence of ϕ_t illustrated in Figure 9. The path to credit conditions is taken to capture changes in leverage in the economy.

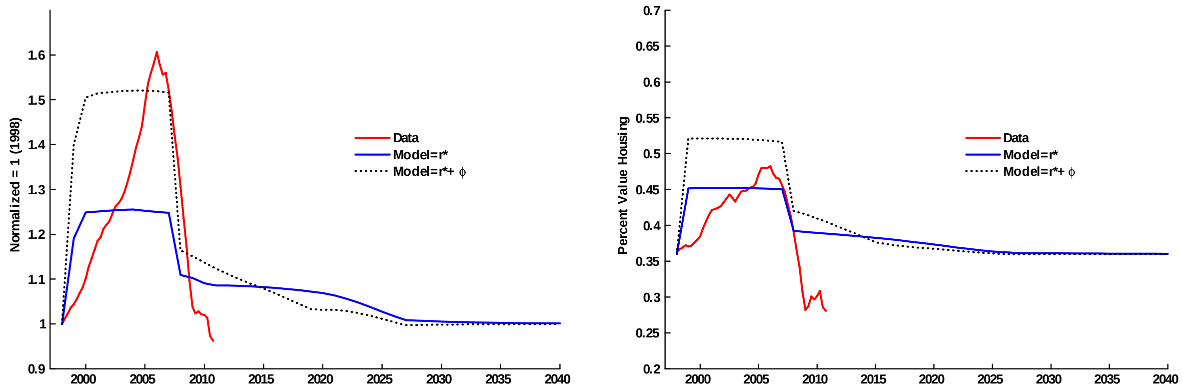
Figure 9: Changes in credit conditions



As discussed in Section 4, changes in ϕ have an ambiguous effect on home values that interacts in important ways with the current levels of the interest rate. Indeed, when we consider experiments where we increase ϕ without moving the interest rate from its pre-shock level of $r^* = 3\%$ home values fall as ϕ increases. As r^* falls sufficiently increases in ϕ do translate into higher home values. Hence, when interests rates fall as in the benchmark experiment and credit conditions are also relaxed the overall impact on home values is about 50%. Figure 10 compares the results of this simulation and the ones when only the cost of borrowing changes.

Figure 10: House prices and land

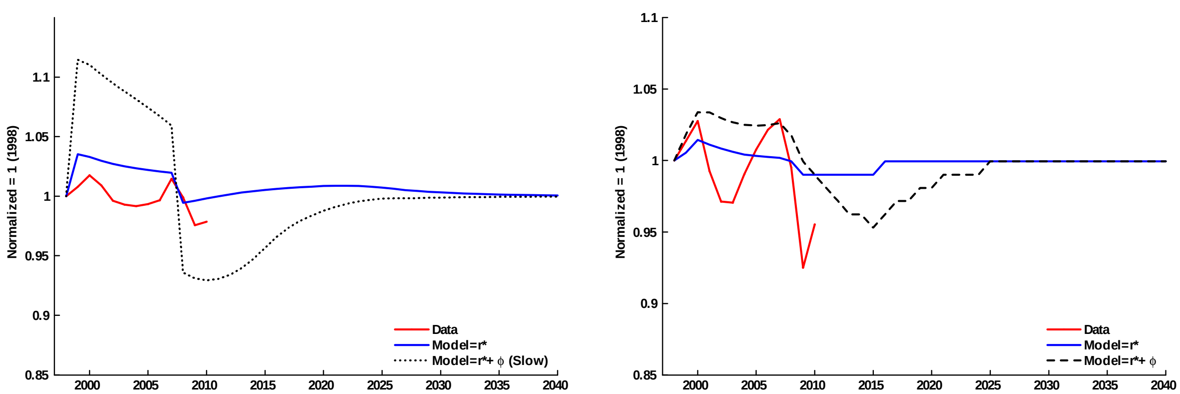
House values **Contribution land to value**



The model captures the magnitude of the housing boom as well as its composition via an increase in the price of land. Almost all of the increase is capitalized as the news of lower future interest rates and looser credit markets. The overall patterns of equilibrium time series are very similar to those in the baseline experiment, but reflecting the stronger wealth effect that results in this experiment. The model can account for the total of the observed increase in home values, but the wealth effects are absorbed via increases in consumption, investment, and GDP. Figure 11 illustrates that the macroeconomic variables move more than the baseline case.

Figure 11: Macro aggregates

Consumption **Output**



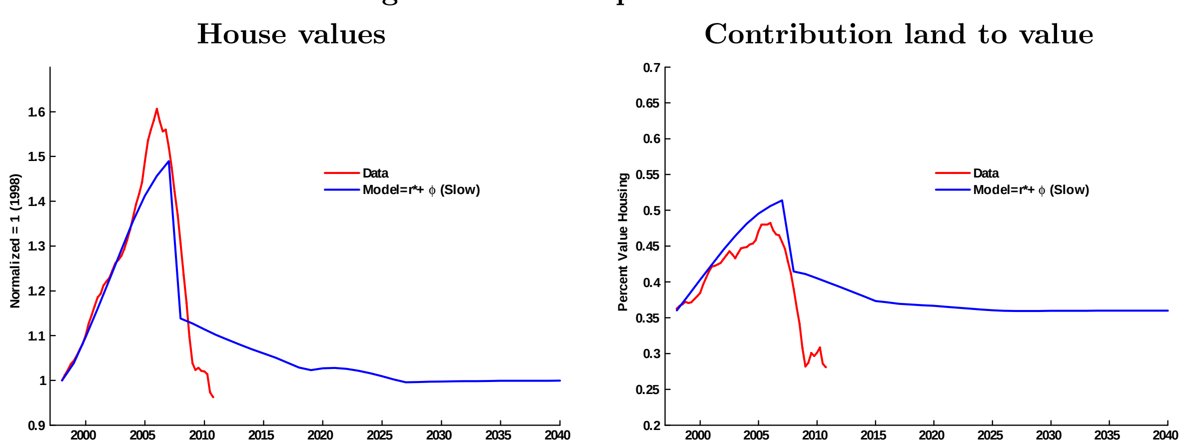
The higher LTV ratio during the boom increases the economy exposure to unexpected shocks. The arrival of future increases in the cost of borrowing and tightening of credit conditions generates a very rapid decline in house values. The excessive borrowing generates a significant deleverage process that reduces aggregate consumption, investment, and output. The adjustment to the new steady state implies slow consumption growth and a decline in housing services (too much housing) that reduces the fundamental value of homes $R = u_h/u_c$. Home values slowly decline until convergence to the new steady state. The expansion of credit has important consequences to fuel the housing boom, but it also affects the bust. When the boom is only driven by low rates, the boom and bust cycle are more moderate.

In this simulations, home values increase too fast relative to what happened in the U.S. and consumption/investment increase more than in the U.S. economy.

5.5. Alternative Expectations

The counterfactual boom in non-residential investment and the too fast increase in home values predicted by the model can be roughly reconciled with the data under the information structure of shocks considered by Ludvigson et al (2011). The idea is to mitigate the size of the wealth effect by slowing the arrival of news. The path of news is the same as in the previous experiments, but the news arrive at a different pace. Now, every time the interest rate falls and credit conditions are relaxed people perceived such changes as permanent, the wealth effect is smaller. Therefore, the effects in consumption, investment, and out should be smaller. The question is whether a slower arrival of new can still generate a sizeable increase in house prices. Figure 12 summarizes the implied house values.

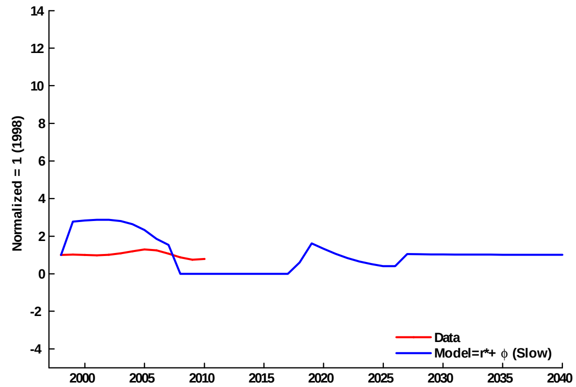
Figure 12: House prices and land



The slow arrival of news about the relaxation of cost of credit and credit conditions, generates a path of house prices that is very close to the one observed in the data. The asymmetry between the boom and the bust is due to the collateral constraint. Without the large wealth effects prices increase at a low rate until rates stop falling. During the bust, the collateral value of housing instantly disappears, and prices collapse. This suggests that a slow arrival of news combined with an asymmetric borrowing constraint can replicate the path of house prices as well as the composition. The contribution of land to the value of housing capital is consistent with the observed in the data.

The more modest wealth effects significantly reduce the response of residential investment. The previous experiments exhibit a large response to relaxation of credit conditions, but with a slow arrival of news, the dynamics of investment is consistent with the data as summarized in Figure 13.

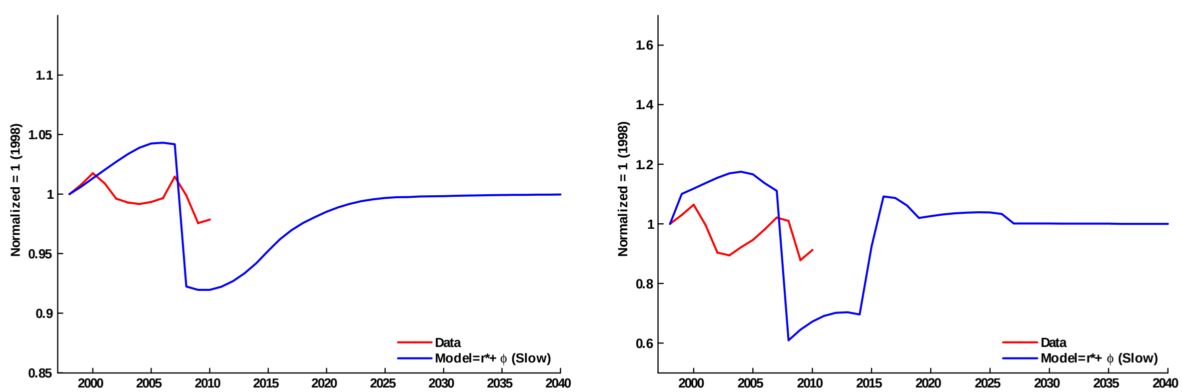
Figure 13: Residential investment in structures



The same argument can be used for the other macro aggregates. Figure 14 suggests that the magnitude of wealth effects does not need to be large to generate house price booms. The macro aggregates implied by the model are also consistent with the data. During the boom, consumption grows very slowly and never exceeds 5 percent, and the bust is characterized by a rapid decline in consumption.

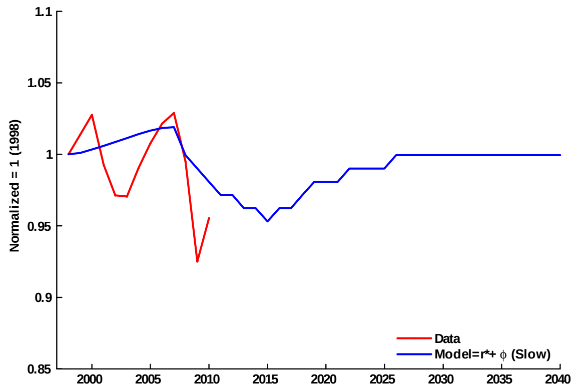
Figure 14: Macro aggregates

Consumption **Capital Investment**



The model performance with respect to capital investment and GDP are better with a small wealth effect. Instead of having increases over 50 percent, the model generates fluctuations in aggregate quantities are similar to those in the data. Figure 15 summarizes the path of output when information arrives slowly.

Figure 15: Effects on aggregate output



One important lesson from this experiments is that wealth effects are not a necessary ingredient to understand housing booms. The relaxation of borrowing constraints increases the collateral value, and this happens even when the news about future rates changes are very slow.

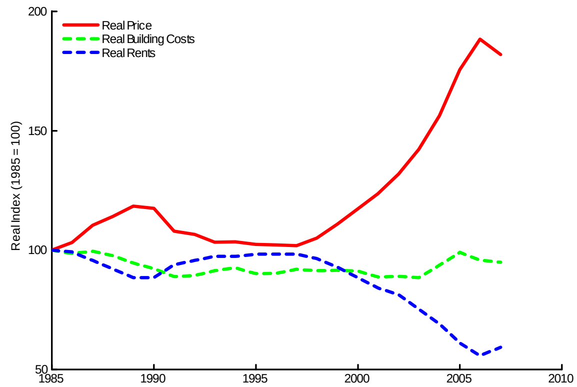
5.6. Decomposing House Prices: Fundamentals vs. Non-Fundamentals

This section addresses one of the most important puzzle in the literature. That is the disconnectedness between house prices and rents. A standard user cost equation for determining the value of housing capital has the following simple recursive relation, that relates it to the flow of housing services (rents) and future capital gains/losses:

$$p_t^f = R_{t+1} G(S_t, L_t) + E_t[\frac{p_{t+1}^f}{1 + r_{t+1}}] \tag{5.1a}$$

where $R_t = u_c(c_t, h_t)/u_h(c_t, h_t)$ represents rents, r_t is the discount rate, and $G(S_t, L_t)$ represents the flow from housing services for a given level of structures, S_t, and land, L_t. Shiller (2007) argues that it does not appear possible to explain the boom in terms of fundamentals such as rents or construction costs. Figure 16 summarizes the time series for real rents and construction cost (replacement value of structures) evidence used by Shiller to suggest no connection between fundamentals and house prices.

Figure 16: House prices and fundamentals



This has been presented as a puzzle for conventional economic theory. For example Shiller argues that "a psychological theory that represents the boom as taking place because of a feedback mechanism or social epidemic that encourages a view of housing as an important investment opportunity, fits the evidence better."

In the steady state of the baseline model, the value of the housing capital is determined by fundamentals (rents and interest rates), but also by the collateral value. In our quantitative experiments the value of collateral is relatively small, accounting for 10% of house values. However, along the transition path the collateral value of home changes as the price of its components changes (i.e. price of land), and the quantity of structures increases. In addition, the internal rate of interest changes as capital accumulation, and consumption adjust along the transition path..

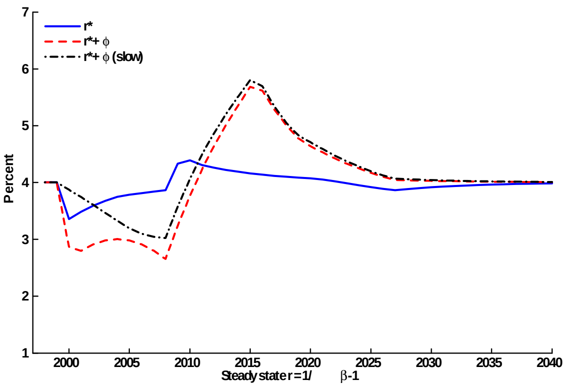
We can use the model to decompose the determinants of house prices by separating the fundamental components (rents and interest rates) from non-fundamental components (the liquidity value of homes). This also allows to separate the impact of changes in the "internal interest rate" from the cost of borrowing r_t^*. It is worth mentioning that this decomposition can only be done because we have full access to the price sequence for every set of expectations. During the boom, house prices incorporate the optimistic expectations that changes in the cost of borrowing are permanent. Therefore, the future house prices are expected to remain high. When households realize that the change is transitory, the adjustment of expectations and behavior generates a decline in house prices. As such, part of the continuation value of house prices is never realized, but that information has already been incorporated during the boom period. As such, the resulting boom and bust generates a sequence of rents that cannot be used by the econometrician to uncover the underlying pricing process.

The decomposition isolates change in fundamental pricing due to changes in rents from changes due to the interest rate. In addition to computing the "fundamental" value of homes using the data from the model, and the user cost equation above, we compute "fundamental" user-cost value

$$p_t^{f_0} = R_{t+1}G(S_t, L_t) + E_t[\frac{p_{t+1}^{f_0}}{1+r_0}]$$

where the interest rate remains constant at the initial steady state value of 4 percent. It is important to emphasize that in our model asset prices are discounted at the domestic or internal rate of interest. Hence, the increase in house values are not due to exogenous changes in the discount rate as would happen in a small open economy. This alternative decomposition isolates the changes in the domestic interest rate from changes in rates. Figure 17 illustrates the movements in the internal rate of interest, r_t^d, for the three different experiments.

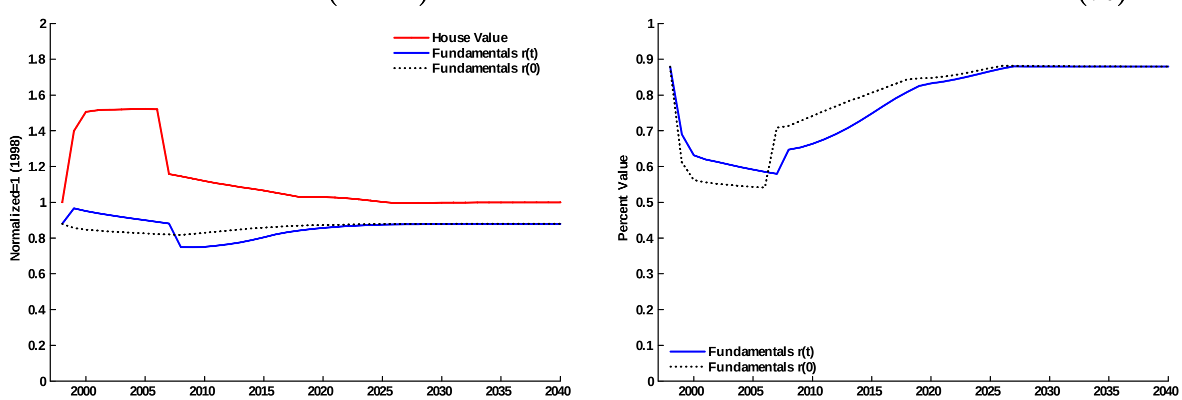
Figure 17: Domestic interest rates (r_t^d)



The simulations where the wealth effect is large have important initial responses of the interest rate. As the wealth effects become small, the response on impact is almost inexistent. Since interest rates decline from 4 to 3 percent between 2000 and 2008, we want to see the effect in house prices. Figure 18 summarizes the decomposition of house values by separating the total value associated to fundamentals and non-fundamentals, as well as the percent of fundamentals in the total value.

Figure 18: Decomposition fundamentals vs. non-fundamentals

Total value (levels) **Contribution fundamentals (%)**



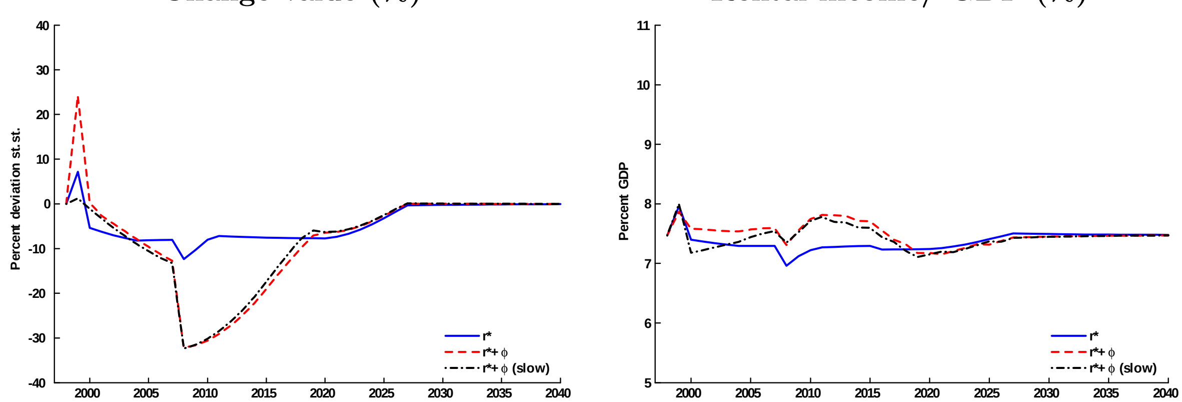
In the baseline steady state, the model predicts that the fundamental component represents roughly 90 percent of the value. During the housing boom, the composition changes because rents decline and the collateral value of homes increases. During the housing boom fundamentals only account for 60 percent of the total value, that is a 30 percent decline. The model is consistent with the data predicting that we should not expect to see rents to move very much. The key to understand this behavior is the endogenous housing supply and the complementarity of housing services. When the cost of accessing to credit markets declines, households want to consume more goods and housing. Since housing services are determined as a composite good that combines structures and fixed land , the only alternative is to produce more structures per unit of land. The production of additional structures increases housing services over the consumption of goods, causing rents to fall, $R = u_h/u_c$.

In a model where housing supply is fixed, rents are entirely determined by consumption. Therefore, housing booms can only be rationalized with increases in rents, in addition to other non-fundamental components. Conventional wisdom suggests that models with a fixed supply have a better chance to rationalize house price dynamics, because the housing supply is fixed in the short-run. Since the data does not seem to support this correlation, once has to question the underlying forces of such a model. The present model shows that formalizing the supply side of the housing market is a necessary step to understand the disconnectedness between house prices and fundamentals.

The decline in the internal interest rate has a positive effect in house prices, but it is very small to rationalize the housing boom. Only measuring the fundamental value, the decline in interest rate should only generate a 12 percent increase in the value of housing capital. This result is consistent with Glaesser et al. (2011) that argues that interest rate declines have been too small to explain the boom. Their user cost model with exogenous rents generates slightly larger effects in house prices. This is because in this model, the housing boom generates a decline in the value of rents consistent Figure 16. Holding rents constant should generate larger effects in house values, but in the model housing plays a role relaxing borrowing constraints, and it is the ultimate responsible for rents to fall. Figure 19 summarizes the dynamics of rents along the transition path.

Figure 19: Role of housing rents

Change value (%) **Rental income/ GDP (%)**



The left panel measures the percent deviation with respect to the baseline value. When the wealth effect is large, consumption responds while housing is fixed and rents increase for only one period. As the economy builds more structures, consumption growths at a lower rate than housing services and rents decline. As the wealth effects become smaller, the initial effect is mitigated. Despite the increase in housing services, its composition on GDP remains very stable between 7 and 8 percent. The increase in the quantity of housing services is compensated by a decline in its price.

6. Conclusions

In this paper we revisit the connection between changes in interest rates, loan-to-value ratios and expectations in influencing housing prices. We construct a two good general equilibrium model in which housing is a composite good produced using structures and land. We show that changes in interest rates that are viewed as permanent have a large impact on house prices, while increases in LTV have smaller effects. We also show that if the model is to account for the actual boom and bust in house prices, it must be the case that households were exposed to multiple expectations shocks. Contrary to conventional wisdom, we show that the model can reconcile the disconnectedness between house values and rents, addressing an open puzzle in the literature.

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