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Housing Market Dynamics: Any News?*

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Abstract

This paper quantifies the role of expectation-driven cycles for housing market fluctuations in the United States. We find that news shocks: (1) account for a sizable fraction of the variability in house prices and other macroeconomic variables over the business cycle and (2) significantly contributed to booms and busts episodes in house prices over the last three decades. By linking news shocks to agents' expectations, we find that house prices were positively related to inflation expectations during the boom of the late 1970's while they were negatively related to interest rate expectations during the housing boom that peaked in the mid-2000's.

Keywords: bayesian estimation, news shocks, housing market, financial frictions, inflation and interest rate expectations.

JEL codes: C50, E32, E44.

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1 Introduction

Are expectations about future macroeconomic conditions related to housing market dynamics? Macroeconomic models of the housing market mainly rely on fundamental developments in the economy to explain fluctuations in house prices and residential investment. Among others, Davis and Heathcote (2005) develop a multi-sector model of the housing market that matches the co-movement of residential investment with GDP and other components of GDP by assuming technology shocks as the only source of fluctuations; Iacoviello and Neri (2010) add real, nominal, and financial frictions, along with a larger set of shocks, to the multi-sector framework and highlight the role of housing preference shock, technology and monetary factors.[1]

Survey evidence shows that house prices dynamics are significantly related to expectations and particularly to optimism about future house prices appreciation. For instance, Case and Shiller (2003) document that expectations of future house price increases had a role in past housing booms in the U.S.; Piazzesi and Schneider (2009) use the University of Michigan Survey of Consumers to show that during the boom that peaked in the mid-2000's, expectations of rising house prices significantly increased. Few authors have also studied the transmission mechanism of expectations on future fundamentals to house prices in macro models. Lambertini, Mendicino and Punzi (2010) show that changes in expectations of future macroeconomic developments can generate empirically plausible boom-bust cycles in the housing market; Tomura (2010) documents that uncertainty about the duration of a period of temporary high income growth can generate housing booms in an open economy model; Adam, Kuang and Marcet (2011) explain the joint dynamics of house prices and the current account over the years 2001-2008 by relying on a model of "internally rational" agents that form beliefs about how house prices relate to economic fundamentals; Burnside, Eichenbaum and Rebelo (2011) document that heterogeneous beliefs about long-run fundamentals can lead to booms and busts in the housing market.

The aim of this paper is to quantify the role of expectations-driven cycles for housing market fluctuations. Relying on the results of Lambertini, Mendicino and Punzi (2010), we introduce news shocks in the multi-sector model of the housing market developed by Iacoviello and Neri (2010) that features collateralized household debt and credit frictions *à la* Kyiotaki and Moore (1997). Their framework is particularly relevant to the purpose of this paper since its rich modelling structure allows for the quantifying of important alternative sources of optimism generated in different sectors of the economy, e.g., the housing market, the production sector, inflationary factors and the conduct of monetary policy. News shocks related to these sectors of the economy could potentially be

[1] See, also, Aoki, Proudman, and Vlieghe (2004), Finocchiaro and Queijo von Heideken (2009), Iacoviello (2005), Kyiotaki, Michaelides, and Nikolov (2010), Liu, Tao and Wang (2011), Piazzesi, Schneider and Tuzel (2007), Rios-Rull and Sanchez Marcos (2006), Silos (2007).

relevant sources of housing market fluctuations since, unlike most unanticipated shocks, they can generate the co-movement observed in the data during periods of boom-bust cycles in house prices. Thus, we allow for news shocks over different time horizons and estimate the model using U.S. data and Bayesian methods.

This paper provides several insightful results. First, the model that allows for news shocks is strongly preferred in terms of overall goodness of fit. In particular, the data favor the inclusion of news shocks over a longer time-horizon. Further, expected macroeconomic developments are found to be an important source of fluctuations in house prices and other macroeconomic variables. News shocks explain around 40 percent of business cycle fluctuations in house prices and a sizable fraction of variations in consumption, residential and non-residential investment. Expectations about future cost-push shocks are the largest contributors to business cycle fluctuations. Among other news shocks, news related to productivity explain almost one-quarter of the variability in business investment. News shocks related to monetary factors account for a larger fraction of variations in house prices and consumption than expectations about future productivity shocks.

Second, news shocks contribute to the boom-phases in house prices, whereas the busts are almost entirely the result of unanticipated monetary policy and productivity shocks. Expectations of cost-push shocks are found to be important for the run up in house prices and residential investment during the boom of the late 1970's. Investment specific news shocks are the main contributor to residential investment growth during the cycle of the late 1990's. Expectations of housing productivity shocks and investment specific shocks somewhat contribute to changes in house prices during the latest boom, whereas expected downward cost pressures on inflation muted its increase over the same period.

Last, exploring the linkage between news shocks and expectations, we find that the model is successful in matching the dynamics of the survey-based inflation and interest rate expectations and the co-movement of these expectations with house prices. Under the assumption of debt contracts in nominal terms, changes in the expected real rates affect households borrowing and investment decisions. Thus, the model suggests an important role of inflation or interest rates expectations for movements in house prices. First, we show that news shocks account for a large fraction of variation in the model-generated expectations: inflation expectations are mainly related to news on the cost-push shock, while a large part of variations in interest rate expectations is explained by news on the shock to the target of the central bank and on the investment-specific shock. The importance of the latter shock is mainly related to the GDP growth component of the interest-rate rule followed by the monetary authority. Then, using survey-based expectations on inflation and interest rates, we test the plausibility of the expectation channel featured by the model. On the base of Granger causality tests we find that news shocks also contain statistically significant information for survey-based inflation and interest rate expectations. As a result, the model mimics particularly well the evidence that higher inflation expectations are strongly related to house prices during the boom of the 1970's whereas lower interest rate expectations are significantly related to the run up in house prices during the latest boom. The link between interest rate expectations and house prices over the last decade seems to be mainly driven by the systematic component of the policy rule, and, in particular, on expectations about GDP growth as opposed to news on monetary policy shocks.

Our results support the idea that expectations about future macroeconomic developments affect economic choices and, in particular, housing and credit decisions. Piazzesi and Schneider (2010) input survey-based expectations into an endowment model economy with nominal credit and housing collateral and show that heterogeneous inflation expectations induce disagreement about the real rate and thus, turn out to account for the increase in credit volumes and the portfolio shift towards real estate during the Great Inflation of the 1970's. Our general equilibrium analysis abstracts from heterogeneity in expectations. However, since the dynamics of the model are mainly driven by the borrowers, we can conjecture that allowing for heterogenous expectations would not change our results. In fact, if, as in Piazzesi and Schneider (2010), the borrowers are the ones who have higher inflation expectations, then they will also perceive a lower real interest rate than the lenders, and, thus, prefer to increase their demand for external funds as well as housing investment. In contrast, the lenders, expecting higher real interest rates, would be willing to lend more. Thus, disagreement about the real interest rate could potentially stimulate credit flows and exacerbate housing dynamics even further.

This paper is closely related to the empirical literature that explores the role of news shocks over the business cycle. Among others, Beaudry and Portier (2006) show that business cycle fluctuations in the data are primarily driven by changes in agents' expectations about future technological growth; Schmitt-Grohe and Uribe (2010), using a real business cycle model, document that news on future neutral productivity shocks, investment-specific shocks, and government spending shocks account for more than two thirds of predicted aggregate fluctuations in postwar U.S. data; Milani and Treadwell (2009) find that, in a new Keynesian framework, news shocks about the policy rate play a larger role in the business cycle than unanticipated monetary policy shocks.[2] We contribute to this strand of the business cycle literature by documenting the role of news shocks in housing market fluctuations and exploring the linkage between news shocks and agents' expectations on inflation and interest rates. To the best of our knowledge, very few papers analyze the ability of DSGE models to match the dynamics of expectations. These other studies mainly focus on how

[2] See also Barsky and Sims (2009), Fujiwara, Hirose and Shintani (2011), Khan and Tsoukalas (2009), Badarinza and Margaritov (2011) and Kurmann and Otrok (2010).

alternative assumptions regarding agents' information about the central bank's inflation target help to match inflation expectations.[3]

The rest of the paper is organized as follows. Section 2 describes the model. Section 3 describes the estimation methodology. Section 4 comments on the results of news shocks as a source of fluctuations in the housing market and Section 5 relate agents' expectations to house prices. Section 6 concludes.

2 The Model

We rely on the model of the housing market developed by Iacoviello and Neri (2010). The model features real, nominal, and financial frictions, as well as a large set of shocks. Three sectors of production are assumed: a non-durable goods sector, a non-residential investment sector, and a residential sector. Households differ in terms of their discount factor and gain utility from non-durable consumption, leisure, and housing services. In addition, housing can be used as collateral for loans. For completeness, we describe the main features of the model in the next subsections.

2.1 Households

The economy is populated by a continuum of households of two types: patient and impatient. Impatient households discount the future at a higher rate than patient households. Thus, in equilibrium, impatient households are net borrowers while patient households are net lenders. We, henceforth, interchangeably refer to patient and impatient households as Lenders and Borrowers, respectively. Discount factor heterogeneity generates credit flows between agents. This feature was originally introduced in macro models by Kiyotaki and Moore (1997) and extended to a model of the housing market by Iacoviello (2005). Both types of households consume, work in two sectors, namely in the non-durable goods sector and the housing sector, and accumulate housing.

Lenders Lenders, maximize the following lifetime utility:

$$U_t = E_t \sum_{t=0}^{\infty} (\beta^t G_C)^t z_t \left\{ \Gamma_c \ln\left(c_t - \varepsilon c_{t-1}\right) + j_t\, ln\, h_t - \frac{\tau_t}{1+\eta} \left[(n_{c,t})^{1+\xi} + (n_{h,t})^{1+\xi} \right]^{\frac{1+\eta}{1+\xi}} \right\},$$

[3] In particular, Schorfheide (2005) estimates on U.S. data two versions of a DSGE, featuring either full information or learning regarding the target inflation rate, and shows that, during the period 1982-1985, inflation expectations calculated from the learning model track the survey forecasts more accurately than the full-information forecasts; Del Negro and Eusepi (2010) using inflation expectations as an observable show that when agents have perfect information about the value of the policymaker's inflation target model helps to better fit the dynamics of inflation expectations.

where β is the discount factor ($0 < \beta' < \beta < 1$), ε is the external habits parameter ($0 < \varepsilon < 1$), η is the inverse of the elasticity of work effort with respect to the real wage ($\eta > 0$), and ξ defines the degree of substitution between hours worked in the two sectors ($\xi \geq 0$). G_C is the trend growth rate of real consumption and Γ_c is a scaling factor of the marginal utility of consumption. z_t, j_t and τ_t are shocks to the intertemporal preferences, housing demand and labor supply that follow $AR(1)$ processes. Lenders decide how much to consume, c_t, the amount of hours devoted to work in each sector, $n_{c,t}$ and $n_{h,t}$, the accumulation of housing h_t (priced at q_t), the supply of intermediate inputs $k_{b,t}$ (priced at $p_{b,t}$), the stock of land l_t (that is priced at $p_{l,t}$), and the stock of capital used in the two sectors of production, $k_{c,t}$ and $k_{h,t}$. Lenders also choose the capital utilization rate in each sector, $z_{c,t}$ and $z_{h,t}$ (subject to a convex cost $a(\bullet)$). Finally, they decide on the amount of lending, b_t. Loans yield a riskless (gross) nominal interest rate denoted by R_t. On the other hand, Lenders receive wage income ($w_{c,t}$ and $w_{h,t}$ are the real wages in each sector, relative to the consumption good price), income from renting capital (at the real rental rates $R_{c,t}$ and $R_{h,t}$) and land (at the real rental rate $R_{l,t}$), and from supplying intermediate goods to firms. Capital in the non-durable goods sector and in the housing sector as well as land depreciate at (quarterly) rates δ_{kc}, δ_{kh} and δ_h. Finally, Lenders receive (lump-sum) dividends from owning firms and from labor unions (D_t). Thus, their period budget constraint is:

$$c_t + \frac{k_{c,t}}{A_{k,t}} + k_{h,t} + k_{b,t} + q_t h_t + p_{l,t} l_t - b_t = \frac{w_{c,t} n_{c,t}}{X_{wc,t}} + \frac{w_{h,t} n_{h,t}}{X_{wh,t}} +$$

$$+\left(R_{c,t} z_{c,t} + \frac{1-\delta_{kc}}{A_{k,t}}\right) k_{ct-1} + (R_{h,t} z_{h,t} + 1 - \delta_{kh}) k_{ht-1} + p_{b,t} k_{b,t} + (p_{l,t} + R_{l,t}) l_{t-1} + q_t(1-\delta_h) h_{t-1}$$
$$+D_t - \frac{R_{t-1} b_{t-1}}{\pi_t} - \phi_{c,t} - \phi_{h,t} - \frac{a(z_{c,t}) k_{c,t-1}}{A_{k,t}} - a(z_{h,t}) k_{h,t-1},$$

where π_t is the (quarter-on-quarter) inflation rate in the consumption goods sector. $A_{k,t}$ is an investment-specific technology shock that represents the marginal cost of producing consumption good sector specific capital.[4] G_{IK_c} and G_{IK_h} are the trend growth rates of capital used in the two sectors of production and $\phi_{c,t}$ and $\phi_{h,t}$ are convex adjustment costs for capital.[5]

Both types of households supply labor to unions in the two sectors of production. The unions

[4] This follows the same process as productivity in the non-durable goods and housing sectors, see below.

[5] $\phi_{c,t} = \frac{\phi_{kc}}{2G_{IK_c}}\left(\frac{k_{c,t}}{k_{c,t-1}} - G_{IK_c}\right)^2 \frac{k_{c,t-1}}{(1+\gamma_{AK})^t}$ is the good-sector capital adjustment cost, and $\phi_{h,t} = \frac{\phi_{kh}}{2G_{IKh}}\left(\frac{k_{h,t}}{k_{h,t-1}} - G_{IK_h}\right)^2 k_{h,t-1}$ is the housing-sector capital adjustment cost; γ_{AK} represents the long-run net growth rate of technology in business capital, ϕ_{kc} and ϕ_{kh} are the coefficients for adjustment cost (i.e., the relative prices of installing the existing capital) for capital used in the consumption sector and housing sector, respectively.

differentiate labor services and sell it in a monopolistic competitive labor market. Thus, there is a wedge between the wage paid by firms to labor unions and those received by households ($X_{wc,t}$ and $X_{wh,t}$ denote the markups in the non-durable and housing sectors, respectively). Wages are set according to a Calvo (1983) scheme (with a $1-\theta_{w,c}$ exogenous probability of re-optimization when labor is supplied to the non-durable goods sector union and a $1-\theta_{w,h}$ is the probability in the housing sector) with partial indexation to past inflation (with parameters $\iota_{w,c}$ and $\iota_{w,h}$ in the corresponding sectors).

Borrowers Borrowers' and Lenders' utility function are similarly defined.[6] Borrowers do not own capital, land or firms. They only receive dividends from labor unions. Hence, the borrowers period budget constraint is:

$$c_t^{'} + q_t\left(h_t^{'} - (1-\delta_h)h_{t-1}^{'}\right) - b_t^{'} \leq \frac{w_{c,t}^{'} n_{c,t}^{'}}{X_{wc,t}^{'}} + \frac{w_{h,t}^{'} n_{h,t}^{'}}{X_{wh,t}^{'}} + D_t^{'} - \frac{R_{t-1} b_{t-1}^{'}}{\pi_t}.$$

Borrowers are constrained in that they may only borrow up to a fraction of the expected present value of next-period value of their housing stock:

$$b_t^{'} \leq m E_t\left(\frac{q_{t+1} h_t^{'} \pi_{t+1}}{R_t}\right),$$

where $m \leq 1$ represents the loan-to-value ratio.[7]

2.2 Firms

Non-durable goods, business capital and housing are produced by a continuum of wholesale firms that act under perfect competition. Price rigidities are introduced in the non-durable sector, while retail sale prices of housing are assumed to be flexible.

Wholesale firms Wholesale firms operate in a perfect competition flexible price market and produce both non-durable goods, Y_t, and new houses, IH_t. To produce non-durable goods the wholesale firms use labor (supplied by both types of households) and capital as inputs of production while the producers of new houses also use intermediate goods and land. Production technologies

[6] Variables and parameters with a prime ($'$) refer to Borrowers while those without a prime refer to Lenders.

[7] Given the assumed difference in the discount factor, the borrowing restriction holds with equality in the steady state. As common in the literature, we solve the model assuming that the constraint is also binding in a neighbourhood of the steady state. See, among others, Campbell and Hercowitz (2004), Iacoviello (2005), Iacoviello and Minetti (2006), Iacoviello and Neri (2010), Sterk (2010).

are assumed to be Cobb-Douglas:

$$Y_t = \left(A_{c,t} \left(n_{c,t}\right)^{\alpha} \left(n^{'}_{c,t}\right)^{1-\alpha} \right)^{1-\mu_c} \left(z_{c,t} k_{c,t-1}\right)^{\mu_c}$$

$$IH_t = \left(A_{h,t} \left(n_{h,t}\right)^{\alpha} \left(n^{'}_{h,t}\right)^{1-\alpha} \right)^{1-\mu_h-\mu_b-\mu_l} \left(z_{h,t} k_{h,t-1}\right)^{\mu_h} k_{b,t}^{\mu_b} l_{t-1}^{\mu_l}.$$

where α is a parameter that measures the labor income share of Lenders and $A_{h,t}$ and $A_{c,t}$ are the productivity shocks to the non-durable goods sector and housing sector, respectively. The productivity shocks are defined as:[8]

$$\ln(A_{x,t}) = t \ln(1 + \gamma_{A_x}) + \ln(Z_{x,t}), \quad x = c, h$$

where $\ln(Z_{c,t})$ and $\ln(Z_{h,t})$ follow $AR(1)$ processes (with serially uncorrelated, zero mean innovations with standard-deviations σ_{A_c} and σ_{Ah}) and γ_{A_c} and γ_{A_h} are the long-run net growth rates of technology in each sector, such that:

$$\ln(Z_{z,t}) = \rho_{Az} \ln(Z_{z,t-1}) + u_{z,t}.$$

Retailers Wholesale firms in the non-durable goods sector sell their output under perfect competition to retailers that act under monopolistic competition when selling the goods to households. Retailers differentiate the non-durable goods and then sell them to households, charging a markup, X_t, over the wholesale price. Retailers set their prices under a Calvo-type mechanism (the exogenous probability of re-optimization is equal to $1 - \theta_\pi$) with partial indexation to past inflation (driven by parameter ι_π). This setup leads to the following forward-looking Phillips curve:

$$ln\pi_t - \iota_\pi ln\pi_{t-1} = \beta G_C \left(E_t ln\pi_{t+1} - \iota_\pi ln\pi_t\right) - \epsilon_\pi ln(\frac{X_t}{X}) + u_{p,t}$$

where $\epsilon_\pi = \frac{(1-\theta_\pi)(1-\beta\theta_\pi)}{\theta_\pi}$ and $u_{p,t}$ is an i.i.d. cost-push shock.

[8] The investment-specific technology shock, $A_{k,t}$, is similarly defined.

2.3 Monetary Policy Authority

The monetary authority sets the (gross) nominal interest rate according to the following Taylor-type rule:

$$R_t = R_{t-1}^{r_R} \frac{\pi_t^{(1-r_R)r_\pi}}{A_{s,t}} \left(\frac{GDP_t}{G_C GDP_{t-1}} \right)^{(1-r_R)r_Y} rr^{(1-r_R)} u_{R,t}$$

where rr is the steady-state real interest rate, GDP is the economy's gross domestic product, $u_{R,t}$ is an i.i.d. shock and $A_{s,t}$ is a persistent shock to the central bank's inflation target.

2.4 News Shocks

In the model there are seven $AR(1)$ shocks – z_t, j_t, τ_t, $A_{h,t}$, $A_{c,t}$, $A_{k,t}$ and $A_{s,t}$ – and two i.i.d. shocks: $u_{p,t}$ and $u_{R,t}$. Expectations of future macroeconomic developments are introduced as in the existing news shock literature. We assume that the error term of the shocks, with the exception of preferences ,$u_{x,t}$, consists of an unanticipated component, $\varepsilon_{x,t}^0$, and anticipated changes n quarters in advance, $\varepsilon_{x,t-n}^n$, with $n = \{4, 8\}$,

$$u_{x,t} = \varepsilon_{x,t}^0 + \varepsilon_{x,t-4}^4 + \varepsilon_{x,t-8}^8,$$

where $\varepsilon_{x,t}$ is i.i.d and $x = \{c, h, k, p, R, s\}$. Thus, at time $t - n$ agents receive a signal about future macroeconomic conditions at time t. As in Schmitt-Grohe and Uribe (2010) we assume anticipated changes four and eight quarters ahead. This assumption allows for revisions in expectations, e.g., $\varepsilon_{x,t-8}^8$can be revised at time $t - 4$ (up or down, partially or completely, in the latter case $\varepsilon_{x,t-4}^4 = -\varepsilon_{x,t-8}^8$) and $\varepsilon_{x,t-4}^4 + \varepsilon_{x,t-8}^8$ can be revised at time 0 (again, partially or completely, in the latter case $\varepsilon_{x,t}^0 = -(\varepsilon_{x,t-4}^4 + \varepsilon_{x,t-8}^8)$ and $u_{x,t} = 0$).

3 Estimation

In this section, we describe both the estimation methodology and the data used. We briefly comment on the estimation results. Last, we evaluate the model both in terms of overall goodness of fit and in matching data moments.

3.1 Methodology

The set of structural parameters of the model describing technology, adjustment costs, price and wage rigidities, the monetary policy rule, and the shocks is estimated using Bayesian techniques. We proceed in two steps. First, we obtain the mode of the posterior distribution which summarizes information about the likelihood of the data and the priors on the parameters' distributions by numerically maximizing the log of the posterior. We then approximate the inverse of the Hessian matrix evaluated at the mode. We subsequently use the random walk Metropolis-Hastings algorithm to simulate the posterior, where the covariance matrix of the proposal distribution is proportional to the inverse Hessian at the posterior mode computed in the first step. After checking for convergence, we perform statistical inference on the model's parameters or functions of the parameters, such as second moments.[9] For recent surveys of Bayesian methods, see An and Schorfheide (2007) and Fernandéz-Villaverde (2010).

In setting the parameters' prior distributions, we follow Iacoviello and Neri (2010). In particular, we use a beta distribution for the serial correlations of the shocks, ρ_{Ax}, and an inverse gamma distribution for the standard deviations of the shocks, σ_x. In order to avoid over-weighting *a priori* the anticipated component of the shocks, we assume that the variance of the unanticipated innovation is equal to the sum of the variances of the anticipated components.[10]

$$\left(\sigma_x^0\right)^2 = \left(\sigma_x^4\right)^2 + \left(\sigma_x^8\right)^2 .$$

Introducing news shocks to the model adds 12 additional parameters. In order to make the estimation less cumbersome, we reduce the set of parameters by calibrating the parameters that affect the steady state of the model. Most of these parameters are calibrated as in Iacoviello and Neri (2010) while others are set to the mean estimated values reported in their estimates. Thus, as in most of the estimated DSGE models, the steady state ratios are unchanged during the estimation. As common in the literature, we also fix the autoregressive parameters of the inflation targeting shock.[11] See Table 1.

In order to avoid concerns related to the identifiability of shocks and parameters in the model, we check for local identification before the estimation. According to Iskrev (2010), a parameter θ_i is locally weakly identified if either (1) the matrix $\Gamma(\boldsymbol{\theta})$ that collects the reduced-form parameters of the solution of the model is insensitive to changes in θ_i or (2) if the effects on $\Gamma(\boldsymbol{\theta})$ of changing θ_i can be offset by changing other parameters.[12] Implementing this methodology we find that all estimated parameters are locally identified.

[9] To perform inference we discard the first 10 per cent of observations. For further details on the estimation and the convergence of the algorithm see the accompanying Estimation Appendix.

[10] See, i.e., Fujiwara, Hirose and Shintani (2011).

[11] See, among others, Adolfson et al. (2007) and Iacoviello and Neri (2010).

[12] The analysis consists of evaluating the ranks of Jacobian matrices. The Jacobian matrix $\frac{\partial \Gamma(\boldsymbol{\theta})}{\partial \boldsymbol{\theta}}$ must have full column rank in order for the parameters to be identifiable. See Iskrev (2010) for a description of the methodology.

3.2 Data

As in Iacoviello and Neri (2010), we consider ten observables: real consumption per capita, real private business and residential fixed investment per capita, quarterly inflation, nominal short-term interest rate, real house prices, hours worked per capita in the consumption-good and the housing sectors, and the nominal wage quarterly change in the consumption and housing sector.[13] Real variables are deflated by the output implicit price deflator in the non-farm business sector. We also follow Iacoviello and Neri (2010) in allowing for measurement error in hours and wage growth in the housing sector. We use data from 1965Q1 to 2007Q4.[14]

3.3 Parameter Estimates

Tables 2 and 3 display the priors chosen for the model's parameters and the standard deviations of the shocks, as well as the posterior mean, standard deviations and the 95 percent probability intervals. The posterior estimates of the model's parameters feature a substantial degree of wage and price stickiness, and a low degree of indexation in prices and wages in the consumption sector. The estimated monetary policy rule features a moderate response to inflation, a modest degree of interest-rate smoothing, and a positive reaction to GDP growth. Finally, all shocks are quite persistent and moderately volatile. News shocks display a much lower volatility than unanticipated shocks.

We do not find sizable differences with respect to the estimates reported by Iacoviello and Neri (2010). We find a slightly higher response to inflation and GDP growth and a lower response to the lagged interest rate in the Taylor Rule as well as higher stickiness and lower indexation in the Phillips Curve. These differences are mainly related to revisions in the series for inflation.[15]

3.4 Overall Goodness of Fit

In order to evaluate the importance of news shocks for the overall goodness of fit of the model, we compare the estimated model presented above against two other specifications: without news shocks ($u_{x,t} = \varepsilon^0_{x,t}$) and with news only at a 4 quarter horizon ($u_{x,t} = \varepsilon^0_{x,t} + \varepsilon^4_{x,t-4}$). The latter specification helps us to assess the potential importance of signal revisions.

[13] For details on the series used and the data transformations see the Appendix.

[14] Since we are interested in understanding housing market dynamics over the average business cycle we do not include the period of extreme macroeconomic fluctuations that characterized the recent financial crisis. A version of the model with the addition of a collateral shocks has been separately estimated. Due to the lack of data on debt and house holding of credit constraint households, we find it difficult to identify such a shock and thus capture the dynamics of the recent credit crunch.

[15] Iacoviello and Neri (2010) used data from 1965Q1 to 2006Q4. Therefore, we use a different vintage of the data set.

Table 4 reports the log marginal data density of each model, the difference with respect to the log marginal data density of the model without news shocks, and the implied Bayes factor.[16] Both versions of the model that allow for news shocks display a significantly higher log data density compared to the no-news model. Accordingly, the Bayes factor indicates decisive evidence in favor of the models with news shocks, see Jeffreys (1961) and Kass and Raftery (1995). In order for the model without news to be preferred, we would need a priori probability over this model 1.7×10^{25} larger than the prior belief about the model with 4 and 8-quarter ahead news.[17] Thus, we conclude that the data strongly favor the inclusion of news shocks. Moreover, the model that also includes longer horizon signals outperforms all other specifications in terms of overall goodness of fit.

All versions of the model are estimated using our updated data set. See Section 3.2. As a last check, in the last three rows of the table 4 we report the Bayes factor using Iacoviello and Neri (2010) data set. The same results hold.

3.5 Model and Data Moments

Table 5 reports a set of moments implied by the model with 4- and 8-quarter ahead news shocks as well as the corresponding moments in the data. In particular, we report the standard deviations of a few key variables: house prices, residential and business investment, consumption, hours worked in the consumption and housing sector, and nominal wage growth in both sectors. We also show the correlation of these variables with house prices. Overall, the model performs reasonably well in capturing the main features of the data.

As for the variables' standard deviations, those implied by the model are broadly in line with the data for most of the observables.[18] The volatility of consumption relative to GDP is somewhat higher in the model than in the data. The model also overpredicts the volatility of hours in both sectors. Regarding the correlations with house prices, the results are also broadly in line with the data as the model generates co-movement of house prices with investment, consumption and hours, and also implies a low correlation with wage growth.

4 News Shocks and Housing Market Dynamics

In this section, we quantify the role of news shocks for housing market dynamics. First, we analyze the contribution of news shocks for selected variables over the business cycle. Then, we assess their

[16] Given that *a priori* we assign equal probability to each model, the Bayes factor equals the posterior odds ratio.

[17] 6.4×10^{12} larger than the prior belief about the model with 4-quarter ahead news shocks.

[18] Following Iacoviello and Neri (2009), GDP is defined as the sum of consumption and investment at constant prices $GDP_t = C_t + IK_t + qIH_t$, where q is real housing prices along the balanced growth path in terms of the price of the consumption good.

role for the observed house prices booms and busts over the sample period.

4.1 Business Cycle Fluctuations

Are news shocks a relevant source of business cycle fluctuations? Table 6 shows the contribution of the anticipated and unanticipated components of the shocks to the unconditional variance of the observable variables at business cycle frequencies. News shocks account for slightly less than 40 percent of the variance in house prices, about 13 percent of the variance in residential investment, and more than half of the variance of consumption, business investment, and inflation. Expectations 8-quarters ahead account for most of the variations reported above. Regarding the different types of news shocks, news related to cost-push shocks are by far the most important source of fluctuations among the anticipated shocks. See Table 7. In particular, expectations about future cost push shocks explain slightly less than 30 percent of the variability in house prices, more than 40 percent of variations in consumption, business investment and inflation, and have about the same importance as news on productivity shocks for explaining residential investment. News shocks related to monetary factors are mainly driven by the persistent shock to the target of the central bank and explain a bit more of variations in house prices and consumption than news of productivity shocks. News shocks about productivity in the three sectors explain almost one-quarter of the variability in business investment.

Despite the relevant contribution of news shocks, the unanticipated component of the shocks remains an important source of business cycle fluctuations. As in Iacoviello and Neri (2010), preference shocks have a considerable role in explaining house prices and investment. This result is mainly driven by the housing preference shock, which in the model resembles a housing demand shock. Unanticipated monetary shocks explain a bit less than 10 percent of the variability in house prices and investment, and about 14 percent of the volatility of the other variables. Productivity shocks explain around 30 and 10 percent of the variability in residential investment and house prices, respectively. This result is mainly related to housing productivity shocks. Contrary to news shocks, the unanticipated component of the cost-push shock is not among the main drivers of fluctuations.

4.1.1 Understanding News Shocks

The real business cycle literature has demonstrated the prominent role of unanticipated productivity and investment specific shocks in driving business cycles.[19] In a standard representative agent

[19] See among others, Prescott (1986) and King and Rebelo (1999). Grenwood, Hercowitz and Krusell (2000) and Fisher (2006) have shown that investment-specific technological shocks have been often identified as one of the main sources of business cycle fluctuations. This result has been confirmed recently by Justiniano, Primiceri and Tambalotti

model, these shocks turn out to be an important source of business cycle fluctuations since they can generate the co-movement among the most relevant macroeconomic variables observed in the data. In contrast to the standard representative agent model, in the model presented above, all unanticipated shocks, with exception of the cost-push shock, do not generate pro-cyclical behavior in either investment or hours worked. Figure 1 reports the effect of selected unanticipated shocks on key macroeconomic variables in the model. News shocks in this model generate pro-cyclicality among all relevant variables.[20] See Figure 2. Thus, one plausible reason for the importance of news shocks is related to the fact that these shocks are able to generate co-movement among a broad set of macroeconomic variables as observed during periods of boom-bust cycles in house prices.[21] News shocks are not only a sizable source of fluctuations in house prices, but also explain a large part of the variance in consumption and business investment and thus, strongly contribute to the co-movement across these variables.[22]

Which unanticipated shocks loose importance once we introduce news shocks in the model? To address this question, we compare the role of the unanticipated shocks in the estimated model without news shocks ($u_{x,t} = \varepsilon^0_{x,t}$) against the model with news shocks ($u_{x,t} = \varepsilon^0_{x,t} + \varepsilon^4_{x,t-4} + \varepsilon^8_{x,t-8}$). See Table 8. In the model without news shocks, cost-push shocks are as important as productivity and monetary policy shocks in accounting for the observed variability in house prices and business investment. Cost-push shocks are also a main source of fluctuations in consumption. The introduction of news shocks as a source of fluctuations significantly reduces the importance of unanticipated cost-push shocks and gives a predominant role to the anticipated component of this shock. As for residential investment, consumption and business investment we also find a less sizable role for productivity and monetary factors. The importance of the unanticipated component of all shocks is significantly reduced for house prices.

(2010) in an estimated New-Keynesian model. Few other authors have also highlighted the importance of preference shocks.

[20] For a recent discussion of the theoretical literature on news shocks and the co-movement problem see Krusell and McKay (2010).

[21] Lambertini, Mendicino and Punzi (2010) document that, over the last three decades, housing prices boom-bust cycles in the U. S. have been characterized on average by co-movement in GDP, consumption, business investment, hours worked, real wages and housing investment.

[22] Housing preference shocks have been previously highlighted as an important source of co-movement between house prices and consumption in models of collateral constraints at the household level. However, in the absence of collateral constraints at the firm level, preference shocks turn out to be not very important for business investment, and thus, contribute little to the co-movement among house prices, consumption and business investment. See Liu, Wang ans Zha (2011). In contrast, in the current set up news shocks are an important source of fluctuations in business investment, along with consumption and house prices.

4.2 Boom-Bust Cycles in House Prices

In this section, we quantify the contribution of different shocks to house price growth over boom-bust episodes. To identify the main cycles in real house prices, we use the Bry-Boschan algorithm with a one-year minimum criterion to define a cycle phase. The peaks and troughs of the four cycles identified with this method coincide with local maxima and minima of the real house price series. See Figure 3. We report the results for the main two booms that peak in 1979Q4 and 2005Q4, respectively. Real residential investment displays co-movement with house prices during the first two decades of the sample. The peaks in residential investment anticipate the peaks in house prices only by one quarter. In contrast, during the last two decades, the cycles of residential investment and house prices turn out to be unsynchronized. House prices generally increase since the mid-1990's to 2005Q3. In contrast, residential investment displays a different pattern and more closely follow the US economic cycle. Leading the NBER business activity peak by a few quarters, the series displays a peak in 2000Q3, whereas the decline in housing investment ends in 2003Q1, a few quarters after the through of activity. Thus, we also consider an alternative cycle for residential investment peaking in 2000Q3, as identified by the Bry-Boschan algorithm.

Table 9 reports the contribution of the estimated shocks to house prices and residential investment growth during each boom- and bust-phase. Adding up the contribution of news and unanticipated shocks we find that: (i) cost-push shocks display a sizable contribution to the run up in house prices and residential investment of the late 1970's; (ii) monetary and productivity factors are found to be important for the subsequent bust; (iii) productivity accounts for more than half of the increase in house prices and residential investment during the most recent period; (iv) monetary factors significantly contribute to the early bust-phase of the more recent cycle in house prices; (v) housing preference shocks significantly contribute to changes in house prices, whereas the contribution of these shocks to changes in residential investment is not sizable.

Is there any role for news shocks during housing market booms and busts? Regarding the relative importance of the anticipated and unanticipated component of shocks for changes in house prices, news shocks contribute to the boom-phases, whereas the busts are almost entirely the result of unanticipated monetary policy and productivity shocks. News shocks also sizably contributed to changes in residential investment. See Tables 10 and 11.

News on cost-push shocks are found to be important for the run up in house prices and residential investment during the boom of the late 1970's. In particular, expectations of cost-push shocks contribute to around 30 percent of the run up in housing prices and 80 percent of residential investment growth. Unanticipated productivity and monetary shocks mainly account for the subsequent bust. It is worth highlighting that expectations of cost-push shocks significantly contributed to housing market dynamics during the entire 1970's. Further, since the two cycles observed in that decade peaked during the 1973 and 1979 oil crisis, news on cost push shocks are plausibly related to exogenous oil price shocks.[23]

Despite a more sizable role for the unanticipated component of productivity and monetary policy shocks, news about productivity shocks in the housing sector and investment specific news shocks account together for about 20 percent of the increase in house prices over the latest boom. Supporting the idea of a productivity-driven economic expansion mainly related to expectations of a "New Economy", investment specific news shocks were the main contributors to residential investment growth during the second-half of the 1990's.[24] Further, investment specific news shocks together with expectations of downward cost pressures on inflation account entirely for the subsequent decline. The contribution of news about cost-push shocks also considerably muted the run up in house prices over its entire boom phase.

Summarizing, expectation-driven cycles are mainly related to news regarding cost-push shocks, shocks to productivity in the housing sector and investment-specific technology shocks. In contrast, the contribution of the unanticipated component of the shocks is mainly related to monetary factors and productivity in the two sectors of production.

5 Interpreting News Shocks: the Role of Expectations

Results presented above show that news about future cost-push, housing productivity, and investment specific shocks are important sources of housing market fluctuations. Given that the effect of news shocks mainly works through expectations, we now investigate the importance of expectations for the transmission of news shocks to house prices. The assumption of nominal debt contracts suggests a role for both inflation and interest rates expectations. The housing pricing equation derived from the model can be expressed as

$$q_t = E_t \sum_{j=0}^{\infty} \beta^j \frac{u_{c,t+1}}{u_{c,t}} \frac{u_{h,t+j}}{u_{c,t+1}} \left(G_C \left(1-\delta_h\right)\right)^j, \tag{1}$$

where $\beta^j \frac{u_{c,t+1}}{u_{c,t}}$ is the stochastic discount factor or *pricing kernel* and $\frac{u_{h,t+j}}{u_{c,t+1}}$ is the marginal rate of substitution between housing and consumption. Agents choose housing and consumption goods such that the sum of the current and expected marginal rate of substitution between the two goods, discounted by $\beta^j \frac{u_{c,t+1}}{u_{c,t}}$, is equal to the relative price of houses. Movements in the real interest rate,

[23] As for the first cycle of the early 1970's, news on inflation and housing productivity together account for about 17 percent of the boom and 65 percent of the bust in house prices. See the accompanying Estimation Appendix for further details.

[24] See, among others, Jerman and Quadrini (2003) and Shiller (2000) for detailed account on productivity growth driven by computer technology and the use of new equipment since the mid-1990's.

i.e. the inverse of the *pricing kernel*, determine house price dynamics. Since debt contracts are in nominal terms, expected inflation affects the debt decisions of the households and also enters the optimality condition for housing investment. Lower expected real rates, through either higher expected inflation rates or lower interest rates, induce households to borrow more and to increase their housing investment, therefore contributing to an increase in house prices and credit flows.

We proceed in two steps. First, we quantify the contribution of news shocks to the model-based expectations and test the model's ability to match survey-based expectations. Second, we explore the linkages between agents' expectations and house prices.

5.1 Survey- versus Model-based Expectations

Are news shocks related to agents' expectations? Table 12 reports the variance decomposition of the model-based expectations about inflation and interest rates generated over the sample period.[25] Inflation expectations are mostly explained by the anticipated component of the cost-push shock and the shock to the target of the central bank. In particular, news of future inflationary shocks explain around 50 percent of the variability in both 1- and 4-quarter ahead inflation expectations, with a predominant role for news shocks over longer horizon. In contrast, interest rate expectations are also driven by news of inflation targeting shocks and investment specific shocks. The importance of the anticipated components of the investment specific shock is plausibly related to the GDP component of the interest-rate rule. In fact, investment specific news shocks are among the driving forces of investment which itself represents a significant share of GDP.

As an alternative validation of the model, we assess the plausibility of the model generated expectations by relating them to survey estimates of expected inflation and interest rates.[26] We measure observed inflation expectations using the 1- and 4-quarter ahead expected GDP deflator quarterly change estimated by the Federal Reserve Bank of Philadelphia Survey of Professional Forecasters (SPF). Alternatively, we also use the expected change in prices from the University of Michigan Survey of Consumers.[27] Interest rate expectations are measured by the 1- and 4-quarter ahead expectations for the three-month Treasury bill rate provided by the SPF. We find that both inflation and interest rates expectations generated by the model are in line with the survey-based expectations. See Figure 4.

Next, we evaluate the information content of news shocks for the observed expectations on

[25] Expectations on inflatio and interest rates are not among the observables used in the estimation.

[26] Previous papers that explore the ability of DSGE models to fit the dynamics of inflation expectations focus on alternative assumptions regarding agents' information on the target of the central bank. See, i.e., Schorfheide (2005) and Del Negro and Eusepi (2010).

[27] In the Michigan survey, the question asked is "By what percent do you expect prices to go up, on the average, during the next 12 months?". We use the mean of the responses to this question.

the base of the Granger causality test. We focus on the news shocks that are more relevant to each type of expectations generated by the model. The results of the test show that news shocks contain statistically significant information for all measures of observed inflation and interest rate expectations. See Tables 13 and 14.[28] Thus, news shocks are found to be important in explaining model-generated expectations about inflation and interest rates. Further, they also contain significant information for survey-based expectations.

5.2 Expectations and House Prices

Next, we explore the relationship between expectations and house prices. The link documented above between news shocks and agents' expectations suggests an important role for both inflation and interest rate expectations in house prices fluctuations. Table 15 reports the correlations between house prices and expectations over the observed boom and bust episodes. Survey based inflation expectations are strongly positively correlated with house prices during the boom-bust cycle of the late 1970's. In contrast, the correlation becomes weaker during the more recent cycle. Observed interest rate expectations are negatively correlated with house prices during the recent boom and positively correlated during the bust-phase. See also Figure 5. One plausible reason for the weaker co-movement of inflation expectations and house prices during the more recent boom, could be related to the ability of the monetary authority to stabilize both inflation and inflation expectations since the mid-1980's. This could also explain the countercyclical behavior of interest rate expectations during the latest house price boom. In fact, under more stable inflation expectations, expected lower future real rates would be mainly related to expectations of a lower nominal interest rate.

As for the model-based expectations, inflation expectations are positively correlated with house prices during the boom-bust episodes, whereas the relationship between interest rate expectations and house prices varies through time and became negative during the most recent period of run up in house prices. See Table 15. By visual inspection, we can see that the expected interest rate declined during the early phase of the more recent boom (2000Q3-2004Q1) and the trough in interest rate expectations anticipate the peak in house prices.

Interest rate expectations in the model are mainly driven by the systematic component of the policy rule. In fact, interest rate expectations seem to be strongly linked to expectations regarding both inflation and GDP growth as opposed to news about monetary policy shocks. The negative correlation between house prices and interest rate expectations during the more recent booms is explained by a decline in model-based expectations regarding GDP growth. In fact, during the

[28] The number of lags included in the tests was chosen based on the Akaike information criteria. The results are however robust to the introduction of alternative numbers of lags.

early phase of the more recent house prices boom that coincided with the 2001 recession period, interest rate expectations decline given a deterioration of GDP growth expectations. See Figure 6.

Summarizing, the model performs reasonably well in capturing the relationship between expectations and house prices. In particular, it is able to match the co-movement between house prices and inflation expectations during the earlier cycles in housing prices and the counter-cyclical behavior of interest rate expectations during the more recent boom.

6 Conclusions

This paper quantifies the role of expectations-driven cycles for housing market fluctuations in the United States. Due to their ability to generate pro-cyclical and hump-shaped dynamics, news shocks emerge as relevant sources of macroeconomic fluctuations and explain a sizable fraction of variation in house prices and housing investment and more than half of the variation in consumption and business investment. Housing productivity, investment-specific and cost-push news shocks, are among the main sources of business cycle fluctuations.

News shocks also significantly contribute to booms and busts in housing prices. In particular, expectations about cost-push shocks turn out to be an important factor during the booms of the 1970's while investment-specific shocks are more relevant after the 1980's. News shocks also turn out to be important for inflation and interest rate expectations that in the context of debt contracts in nominal terms play a decisive role in agents decisions and thus house prices movement. Exploring the link between news shocks and expectations, we find that the estimated model effectively captures the relationship of house prices with higher inflation expectations during the booms of the 1970's, and with lower interest rate expectations during the more recent boom.

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Appendix A

A Data

A.1 Observables

In the following we describe in detail the data used in the estimation:

- Real consumption: Real Personal Consumption Expenditure (seasonally adjusted, billions of chained 2005 dollars), divided by the Civilian Noninstitutional Population. Log-transformed and normalized to zero in 1965:1.
- Business Fixed Investment: Real Private Nonresidential Fixed Investment (seasonally adjusted, billions of chained 2005 dollars), divided by the Civilian Noninstitutional Population. Log-transformed and normalized to zero in 1965:1.
- Residential Investment: Real Private Residential Fixed Investment (seasonally adjusted, billions of chained 2005 dollars), divided by the Civilian Noninstitutional Population. Log-transformed and normalized to zero in 1965:1.
- Hours Worked in Consumption Sector: Total Nonfarm Payrolls less all employees in the construction sector times Average Weekly Hours of Production Workers divided the Civilian Noninstitutional Population. Log-transformed and normalized to zero in 1965:1.
- Hours Worked in Housing Sector: All Employees in the Construction Sector, times Average Weekly Hours of Construction Workers divided by the Civilian Noninstitutional Population. Log-transformed and normalized to zero in 1965:1.
- Growth in Nominal Wage in Consumption-good Sector: Average Hourly Earnings of Production/ Nonsupervisory Workers on Private Nonfarm Payrolls, Total Private. Demeaned.
- Growth in Nominal Wage in Housing Sector: Average Hourly Earnings of Production/ Nonsupervisory Workers in the Construction Industry. Demeaned.
- Real House Prices: Census Bureau House Price Index (new one-family houses sold including value of lot) deflated with the implicit price deflator for the nonfarm business sector. Demeaned.
- Inflation: quarter-on-quarter log differences in the implicit price deflator for output in the nonfarm business sector. Demeaned.

- Nominal Short-term Interest Rate: 3-month Treasury Bill Rate (Secondary Market Rate), expressed in quarterly units. Demeaned.

The data series as described above are shown in Figure A.1.

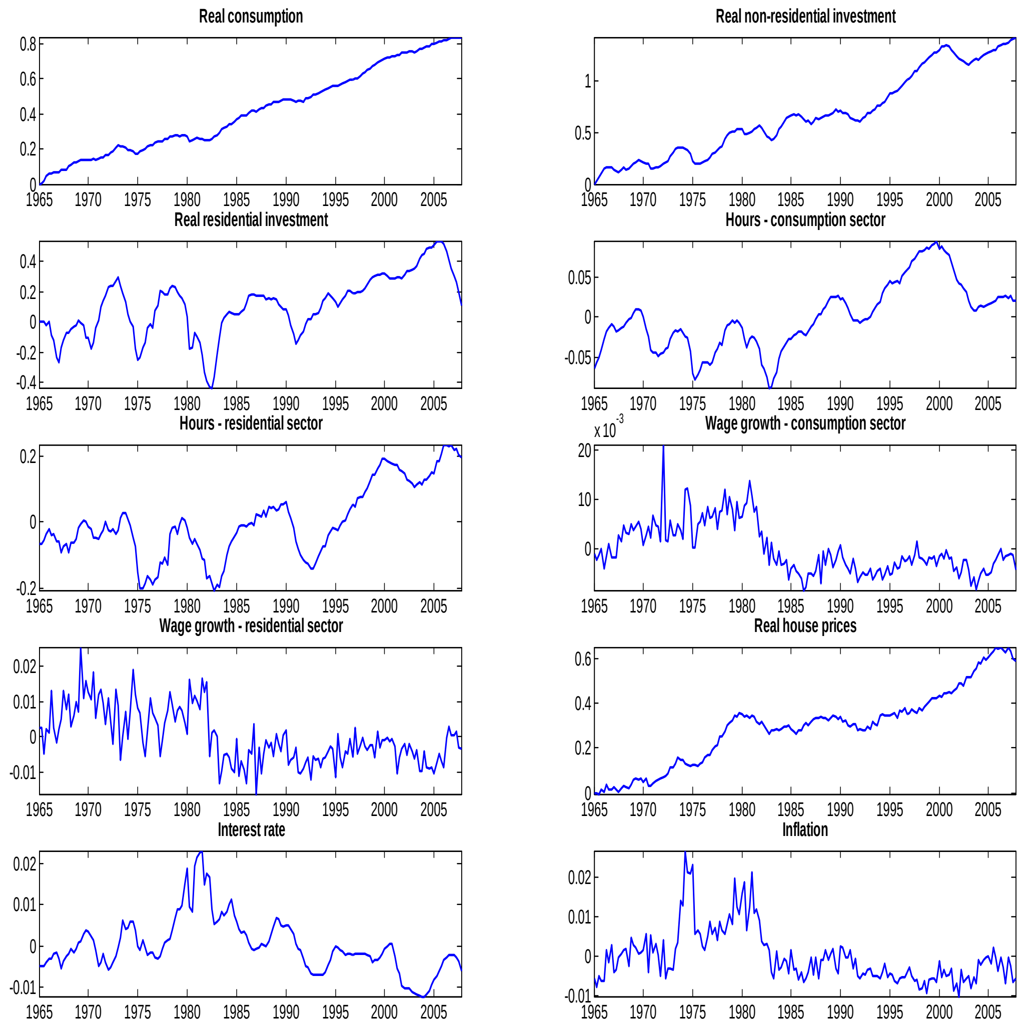


Figure A.1: Data

A.2 Expectations

The survey-based expectations data analysed in the paper are:

- Inflation expectations: 1- and 4-quarter ahead expected GDP deflator quarterly change estimated by the Federal Reserve Bank of Philadelphia Survey of Professional Forecasters (median of responses) or, alternatively, the expected change in prices from the University of Michigan Survey of Consumers.[29] Demeaned.

- Interest rate expectations: 1- and 4-quarter ahead expectations for the three-month Treasury bill rate provided by the Federal Reserve Bank of Philadelphia Survey of Professional Forecasters. Demeaned.

These data are ploted in Figure 4.

[29] In the Michigan survey, the question asked is "By what percent do you expect prices to go up, on the average, during the next 12 months?".

Table 1: Calibrated parameters

Technology		*Preferences*	
μ_c	0.35	β	0.9925
μ_h	0.10	β'	0.97
μ_l	0.10	ξ	0.66
μ_b	0.10	ξ'	0.97
α	0.79	j	0.12
δ_h	0.01	η	0.52
δ_{kc}	0.025	η'	0.51
δ_{kh}	0.03		
X	1.15	*Other*	
X_{wc}	1.15	m	0.85
X_{wh}	1.15	ρ_s	0.975
γ_{AC}	0.0032		
γ_{AH}	0.0008		
γ_{AK}	0.0027		

Source: Iacoviello and Neri (2010).

Table 2: Estimation results

Parameter		Prior			Posterior		
		Type	Mean	Stdev	Mean	5%	95%
Habits	ε	Beta	0.50	0.075	0.3263	0.2469	0.4003
	$\varepsilon\prime$	Beta	0.50	0.075	0.6018	0.5009	0.6991
Investment adjustment costs	$\phi_{k,c}$	Gamma	10	10.01	14.9672	11.4618	18.3434
	$\phi_{k,h}$	Gamma	10	10.46	10.7674	6.6969	14.9466
Calvo prob. - prices	θ_{π}	Beta	0.667	0.05	0.8997	0.8817	0.9181
Calvo prob. - wages cons. sector	$\theta_{w,c}$	Beta	0.667	0.05	0.8580	0.8170	0.8979
Calvo prob. - wages hous. sector	$\theta_{w,h}$	Beta	0.667	0.05	0.9020	0.8829	0.9215
Indexation - prices	ι_{π}	Beta	0.50	0.20	0.0446	0.0058	0.0824
Indexation - wages cons. sector	$\iota_{w,c}$	Beta	0.50	0.20	0.0535	0.0056	0.0982
Indexation - wages hous. sector	$\iota_{w,h}$	Beta	0.50	0.20	0.4844	0.2442	0.7238
Cap. utilization adjustment costs	ζ	Beta	0.50	0.20	0.6840	0.5111	0.8622
Taylor rule - Smoothing	r_R	Beta	0.75	0.10	0.6552	0.5946	0.7150
Taylor rule - Inflation response	r_{π}	Normal	1.50	0.10	1.5654	1.4664	1.6624
Taylor rule - Output growth response	r_Y	Normal	0.00	0.10	0.8025	0.7066	0.9018
Autoregressive parameters							
Prod. consumption sector	ρ_{AC}	Beta	0.80	0.10	0.9531	0.9289	0.9772
Prod. housing sector	ρ_{AH}	Beta	0.80	0.10	0.9970	0.9943	0.9997
Prod. capital sector	ρ_{AK}	Beta	0.80	0.10	0.9756	0.9593	0.9925
Preferences - housing	ρ_j	Beta	0.80	0.10	0.9454	0.9230	0.9672
Preferences - labor	ρ_{τ}	Beta	0.80	0.10	0.9458	0.9213	0.9707
Preferences - intertemporal	ρ_z	Beta	0.80	0.10	0.8061	0.6121	0.9600

Table 3: Estimation results (cont.)

Parameter		Prior			Posterior		
		Type	Mean	Stdev	Mean	5%	95%
Stand. deviation - unanticipated shocks							
Prod. consumption sector	σ_{AC}	Inv.Gam	0.001	0.01	0.0096	0.0086	0.0106
Prod. housing sector	σ_{AH}	Inv.Gam	0.001	0.01	0.0187	0.0162	0.0211
Prod. capital sector	σ_{AK}	Inv.Gam	0.001	0.01	0.0015	0.0002	0.0036
Preferences - housing	σ_j	Inv.Gam	0.001	0.01	0.0606	0.0431	0.0793
Preferences - labor	σ_τ	Inv.Gam	0.001	0.01	0.0589	0.0339	0.0826
Preferences - intertemporal	σ_z	Inv.Gam	0.001	0.01	0.0107	0.0074	0.0138
Cost push	σ_p	Inv.Gam	0.001	0.01	0.0016	0.0010	0.0022
Monetary policy	σ_R	Inv.Gam	0.001	0.01	0.0031	0.0024	0.0036
Inflation objective	$\sigma_s * 100$	Inv.Gam	0.1	1	0.0239	0.0178	0.0299
Stand. deviation - ant. shocks 4-q ahead							
Prod. consumption sector	σ_{AC4}	Inv.Gam	0.0035	0.02	0.0005	0.0002	0.0010
Prod. housing sector	σ_{AH4}	Inv.Gam	0.0035	0.02	0.0007	0.0002	0.0016
Prod. capital sector	σ_{AK4}	Inv.Gam	0.0035	0.02	0.0006	0.0002	0.0010
Cost push	σ_{p4}	Inv.Gam	0.0035	0.02	0.0004	0.0002	0.0008
Monetary policy	σ_{R4}	Inv.Gam	0.0035	0.02	0.0004	0.0002	0.0006
Inflation objective*100	$\sigma_{s4} * 100$	Inv.Gam	0.35	2	0.0250	0.0156	0.0344
Stand. deviation - ant. shocks: 8-q ahead							
Prod. consumption sector	σ_{AC8}	Inv.Gam	0.0035	0.02	0.0007	0.0002	0.0014
Prod. housing sector	σ_{AH8}	Inv.Gam	0.0035	0.02	0.0040	0.0002	0.0103
Prod. capital sector	σ_{AK8}	Inv.Gam	0.0035	0.02	0.0094	0.0069	0.0120
Cost push	σ_{p8}	Inv.Gam	0.0035	0.02	0.0026	0.0019	0.0034
Monetary policy	σ_{R8}	Inv.Gam	0.0035	0.02	0.0004	0.0002	0.0007
Inflation objective*100	$\sigma_{s8} * 100$	Inv.Gam	0.35	2	0.0323	0.0174	0.0474
Stand. deviation - measurement errors							
Hours worked - housing	$\sigma_{n,h}$	Inv.Gam	0.001	0.01	0.1445	0.1306	0.1587
Wages - housing	$\sigma_{w,h}$	Inv.Gam	0.001	0.01	0.0081	0.0071	0.0091

Table 4: Model Comparison

	No news	News 4	News 4&8
Benchmark (1965-2007)			
Log Marginal Data Density	4809.49	4838.97	4867.60
Difference	-	29.48	58.11
Implied Bayes factor	1	6.4×10^{12}	1.7×10^{25}
I&N data (1965-2006)			
Log Marginal Data Density	4693.44	4720.69	4743.11
Difference	-	27.25	49.67
Implied Bayes factor	1	6.8×10^{11}	3.7×10^{21}

Note: Log Marginal Data Density based on the Modified Harmonic Mean Estimator.

Table 5: Moments

	House Pr.	Housing Inv.	Business Inv.	Consumption	Hours		ΔWages	
	Q	IH	IK	C	NC	NH	ΔWC	ΔWH
Standard-deviation (relative to GDP)								
Data	0.906	4.518	2.097	0.541	0.624	1.792	0.111	0.209
Mean	0.801	3.387	1.695	0.757	1.212	3.668	0.257	0.171
5%	0.684	3.519	1.915	0.703	1.104	3.557	0.259	0.179
95%	0.971	3.644	1.586	0.770	1.325	4.169	0.227	0.174
Correlation with house prices (Q)								
Data	1	0.467	0.493	0.456	0.599	0.684	0.161	0.163
Mean	1	0.519	0.587	0.690	0.658	0.614	0.250	0.312
5%	1	0.303	0.590	0.754	0.670	0.410	0.236	0.218
95%	1	0.662	0.527	0.623	0.607	0.740	0.265	0.363

HP filtered series.

Table 6: VarianceDecomposition: Anticipated vs Unanticipated

	Anticipated			**Unanticipated**
	Total	4 -quarter	8-quarter	Total
House Prices (Q)	36.62	1.20	35.42	63.38
Housing Inv. (IH)	12.59	0.52	12.07	87.43
Consumption (C)	54.84	1.65	53.19	45.16
Business Inv. (IK)	72.11	1.77	70.34	27.89
Inflation (π)	63.36	10.62	52.74	36.63

Parameters set at the posterior mean; HP filtered series.

Table 7: Variance Decomposition

	Anticipated			Unanticipated			
	Production	Cost Push	Mon.Pol.	Product.	Cost Push	Mon.Pol.	Preferences
	AC+AH+AK	UP	UR+AS	AC+AH+AK	UP	UR+AS	j+z+$\mathcal{T}$
House Prices (Q)	3.62	28.52	4.48	10.42	0.70	9.27	42.99
Housing Inv. (IH)	5.18	5.29	2.12	33.43	0.15	9.51	44.34
Consumption (C)	4.22	44.65	5.97	3.41	0.76	13.95	27.04
Business Inv. (IK)	23.91	44.53	3.67	2.10	0.99	14.57	10.23
Inflation (π)	1.33	45.19	16.84	2.19	10.09	13.61	10.74

Parameters set at the posterior mean; HP filtered series.

Table 8: Variance decomposition: News vs No-News

	Unanticipated Shocks							
	Prod.	Cost Push	Mon. Pol.	Prefer.	Prod.	Cost Push	Mon.Pol.	Prefer.
	AC+AH+AK	UP	UR+AS	j+z+$\mathcal{T}$	AC+AH+AK	UP	UR+AS	j+z+$\mathcal{T}$
House Prices (Q)	13.84	14.16	14.70	57.30	10.42	0.70	9.27	42.99
Housing Inv. (IH)	48.89	2.19	8.63	40.30	33.43	0.15	9.51	44.34
Consumption (C)	7.89	30.43	33.70	27.97	3.41	0.76	13.95	27.04
Business Inv. (IK)	23.90	29.77	37.06	9.27	2.10	0.99	14.57	10.23
Inflation (π)	1.23	81.72	10.74	6.31	2.19	10.09	13.61	10.74

Left panel: contribution of unanticipated shocks, No News Model; Right Panel: contribution of unanticipated shocks, Model with News; Parameters set at the posterior mean; HP filtered series.

Table 9: Shocks Contribution to Booms and Busts

Booms and Busts		Productivity	Cost Push	Mon. Pol.	H. Pref.
dated based on Q	% change	AH+AC+AK	UP	UR+AS	j
House prices (Q)					
1976 Q2 - 1979 Q4	17.44	1.21	5.50	-1.03	14.81
1980 Q1 - 1985 Q3	-16.61	-8.62	10.82	-4.61	-11.79
1992 Q4 - 2005 Q4	20.53	14.09	-14.22	3.38	8.58
2006 Q1 - 2007 Q4	-8.72	-0.49	0.66	-3.18	-6.23
Res. investment (IH)					
1976 Q2 - 1979 Q4	20.51	14.22	17.38	-3.37	2.23
1980 Q1 - 1985 Q3	-3.77	-1.49	18.60	-13.73	-1.14
1992 Q4 - 2005 Q4	25.29	28.84	-33.74	9.33	0.81
2006 Q1 - 2007 Q4	6.79	7.18	5.06	-8.55	0.61
dated based on IH					
Res. investment (IH)					
1992 Q1 - 2000 Q3	48.86	38.72	-11.81	4.03	-0.88
2000 Q4-2003 Q1	-25.65	-13.57	-10.84	-1.90	-0.20
2003 Q2-2007 Q4	12.81	11.70	-7.31	2.61	1.97

Parameters set at the posterior mean.

Table 10: Shocks Contribution to Booms and Busts: house prices (Q)

		Shocks Contribution									
Booms and Busts	House prices	Anticipated					Unanticipated				
Q cycles	% change	UP	AH	AK	AC	UR+AS	UP	AH	AK	AC	UR+AS
1976 Q2 - 1979 Q4	17.44	5.36	2.04	-2.44	-0.01	-1.03	0.14	3.31	-0.01	-1.69	0.00
1980 Q1 - 1985 Q3	-16.61	10.92	-0.88	2.74	0.00	1.11	-0.11	-8.16	0.00	-2.34	-5.71
1992 Q4 - 2005 Q4	20.53	-14.06	2.50	1.51	0.01	-1.01	-0.17	5.57	0.01	4.50	4.38
2006 Q1 - 2007 Q4	-8.72	0.69	-0.39	0.50	0.00	-0.09	-0.03	-0.36	0.00	-0.23	-3.09

Parameters set at the posterior mean.

Table 11: Shocks Contribution to Booms and Busts: housing investment (IH)

		Shocks Contribution									
Booms and Busts	Res. inv.	Anticipated					Unanticipated				
Q cycles	% change	UP	AH	AK	AC	UR+AS	UP	AH	AK	AC	UR+AS
1976 Q2 - 1979 Q4	20.51	17.05	1.70	14.69	-0.01	-3.17	0.33	-0.12	0.02	-2.30	-0.19
1980 Q1 - 1985 Q3	-3.77	18.92	-0.61	3.94	0.01	1.37	-0.32	-0.59	0.04	-4.28	-15.10
1992 Q4 - 2005 Q4	25.29	-33.35	0.59	20.02	0.01	-1.64	-0.39	0.18	0.04	8.00	10.98
2006 Q1 - 2007 Q4	6.79	5.13	0.01	8.11	-0.00	0.28	-0.07	-0.30	0.01	-0.66	-8.83
IH cycles											
1992 Q1 - 2000 Q3	48.86	-11.47	0.10	33.91	0.01	-0.53	-0.34	0.20	0.08	4.43	4.56
2000 Q4 - 2003 Q1	-25.65	-10.86	-0.34	-14.60	0.00	-0.38	0.02	0.10	-0.03	1.29	-1.53
2003 Q2 - 2007 Q4	12.81	-7.06	0.80	9.81	-0.00	0.09	-0.26	-0.43	0.01	1.52	2.52

Parameters set at the posterior mean.

Table 12: Model-based expectations: variance decomposition

	Anticipated shocks							Unanticipated shocks
	Total	Cost Push (UP)		Inf. Target (AS)		Inv. Specific (AK)		
		4-quarter	8-quarter	4-quarter	8-quarter	4-quarter	8-quarter	Total
Inflation exp.								
1 quarter ahead	72.19	1.64	49.27	10.21	9.13			27.78
4 quarter ahead	78.97	0.86	53.20	11.26	12.10			21.01
Int. rate exp.								
1 quarter ahead	72.04	0.11	14.63	14.90	15.33	0.06	22.23	27.95
4 quarter ahead	80.38	0.05	7.42	18.78	27.14	0.01	23.62	19.65

Parameters set at the posterior mean.

Table 13: Granger causality tests - Inflation expectations

	SPF						**Michigan Survey**		
	1 quarter ahead			4 quarter ahead			4 quarter ahead		
	F-statistic	p-value		F-statistic	p-value		F-statistic	p-value	
Cost-push (UP)									
4 quarter ahead	6.8299	[0.0000]	***	3.2492	[0.0417]	**	15.743	[0.0000]	***
8 quarter ahead	14.570	[0.0000]	***	11.8680	[0.0000]	***	31.954	[0.0000]	***

The null hypothesis is that the shock does not Granger cause inflation expectations.

*** 1%, ** 5%, * 10% significance.

Table 14: Granger causality tests - Interest rate expectations (SPF)

	1 quarter ahead			4 quarter ahead		
	F-statistic	p-value		F-statistic	p-value	
Cost-push shock (UP)						
4-quarter ahead	20.569	[0.0000]	***	11.603	[0.0000]	**
8-quarter ahead	19.380	[0.0000]	***	8.431	[0.0000]	***
Prod. K shock (AK)						
4-quarter ahead	25.476	[0.0000]	***	26.500	[0.0000]	***
8-quarter ahead	30.842	[0.0000]	***	51.915	[0.0000]	***
Inf. Target shock (AS)						
4-quarter ahead	15.685	[0.0000]	***	4.451	[0.0011]	***
8-quarter ahead	17.377	[0.0000]	***	2.435	[0.0928]	*

The null hypothesis is that the shock does not Granger cause interest rate.

expectations. *** 1%, ** 5%, * 10% significance.

Table 15: Expectations and House Prices

	Correlation with House Prices							
	Survey-based Expectations (SPF)				Model-based Expectations			
	Inflation		Interest Rate		Inflation		Interest Rate	
	1Q	4Q	1Q	4Q	1Q	4Q	1Q	4Q
Booms and Busts Cycles								
1976 Q2 - 1979 Q4	0.885	0.782			0.839	0.836	0.946	0.941
1980 Q1 - 1985 Q3	0.938	0.922	0.873	0.880	0.926	0.873	0.741	0.833
1992 Q4 - 2005 Q4	-0.356	-0.482	-0.551	-0.512	0.553	-0.101	-0.513	-0.333
2006 Q1 - 2007 Q4	-0.144	0.317	0.631	0.601	0.915	0.803	0.773	0.471
Overall								
1970 Q4 - 2007 Q4	0.967	0.495			0.486	0.465	0.461	0.501
1980 Q1 - 2007 Q4			0.223	0.176			0.193	0.242

1- and 4-quarter-ahead expectations.

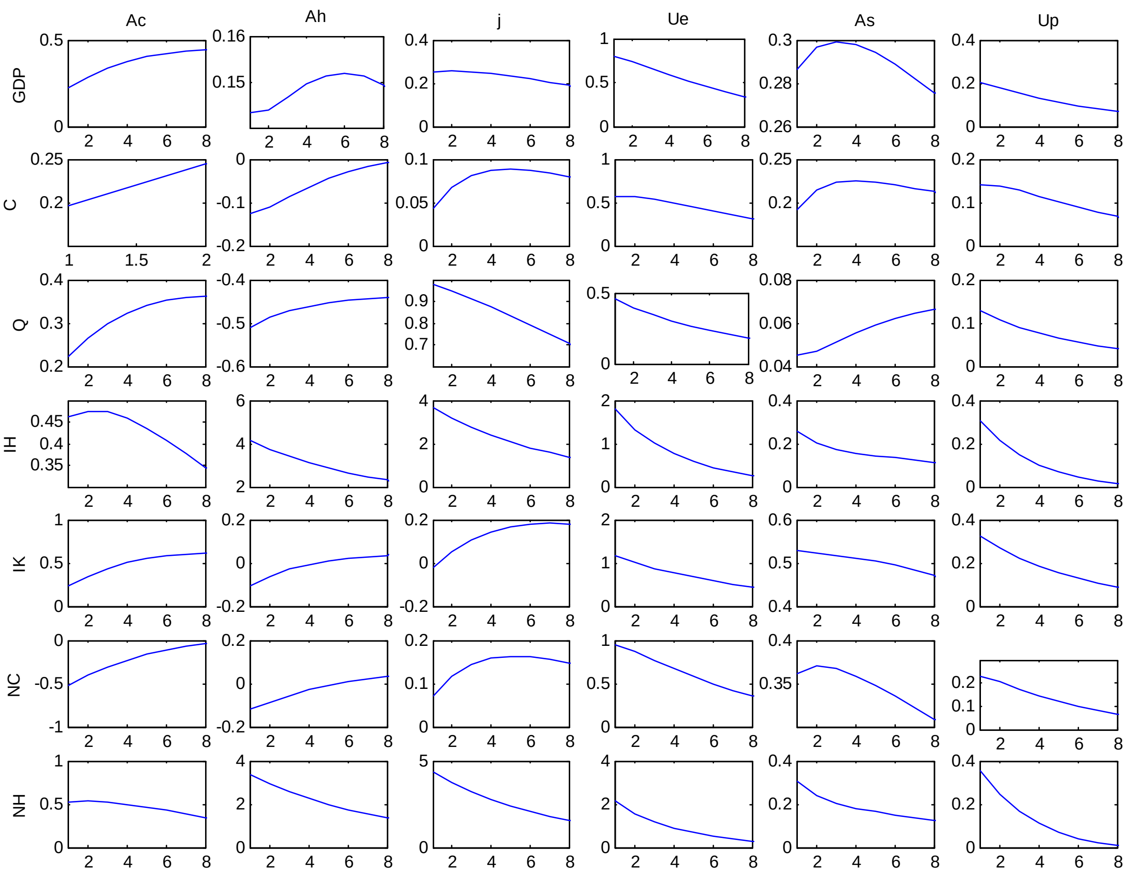


Figure 1: Impulse-Response Functions: Unanticipated Shocks

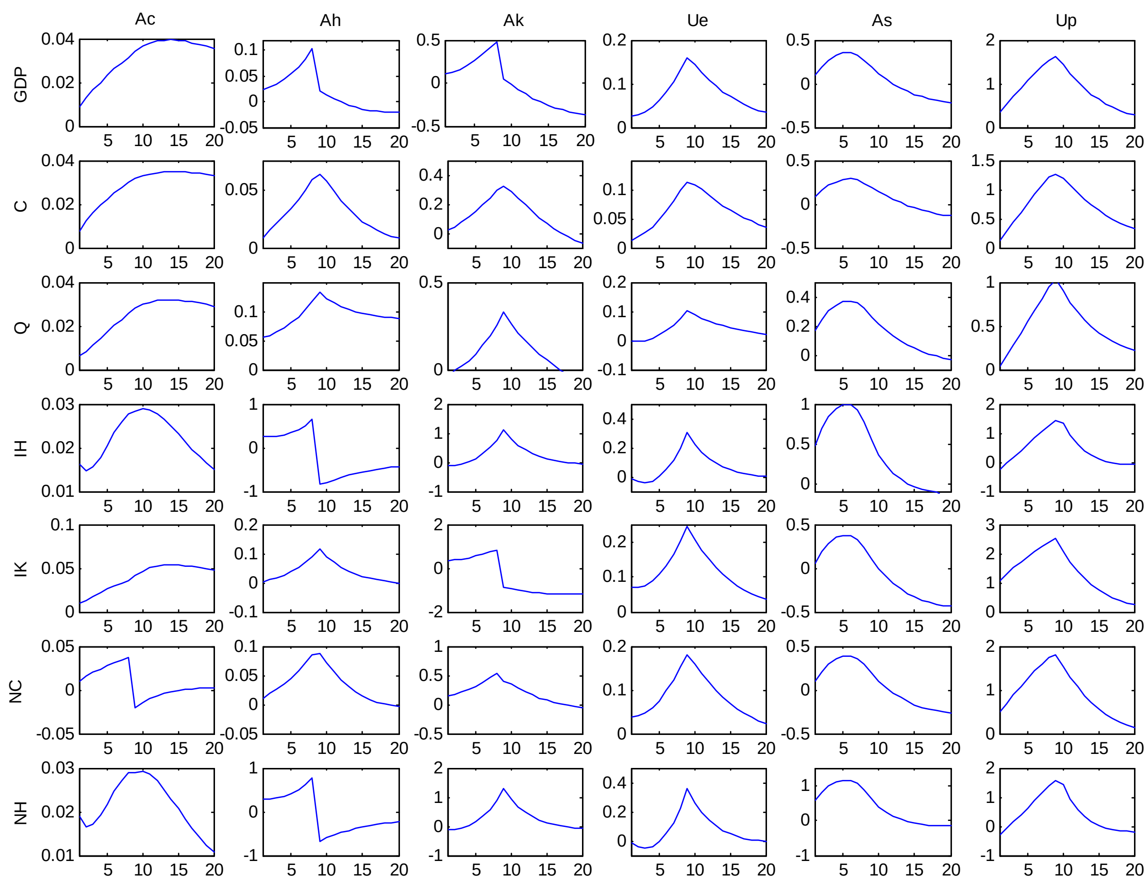
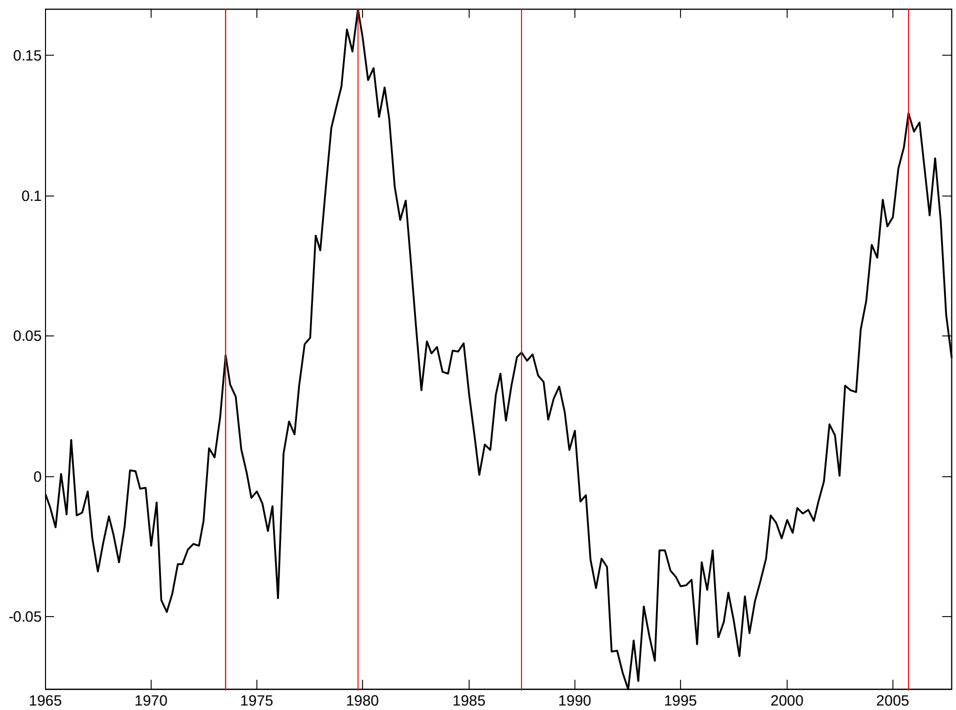


Figure 2: Impulse-Response Functions: News Shocks (1 stdev shock)



Notes: Real house prices in deviations from trend. Red solid lines indicate peaks.

Figure 3: Real House Prices

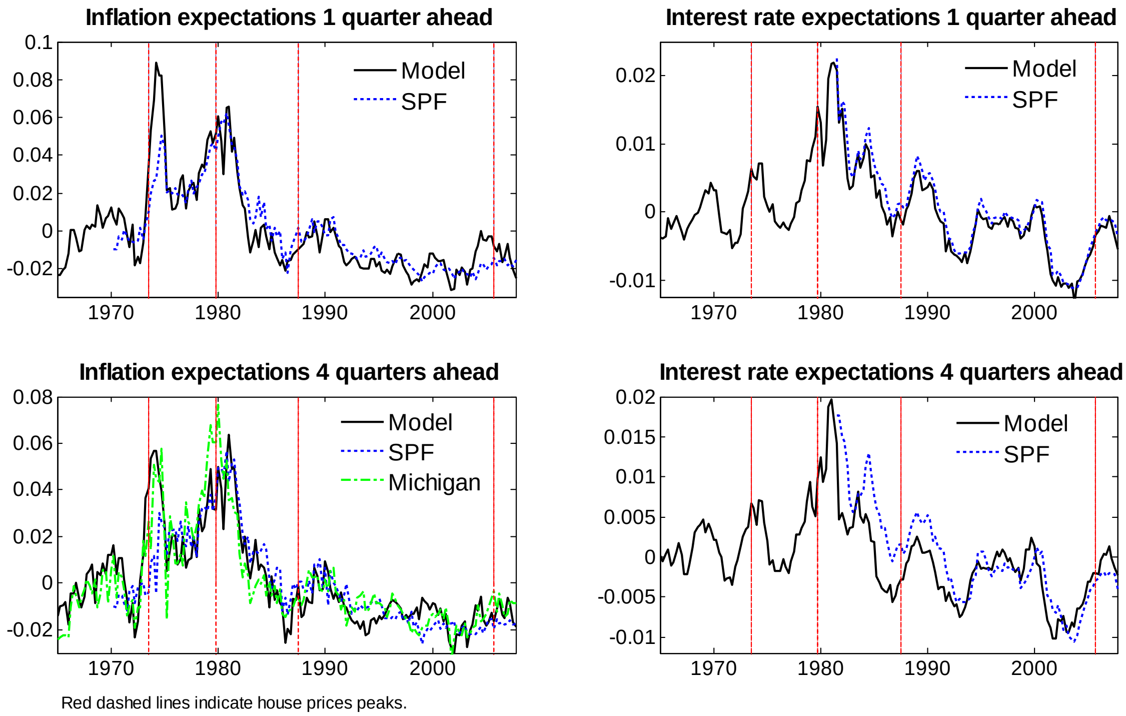


Figure 4: Model- vs Survey-Based Expectations

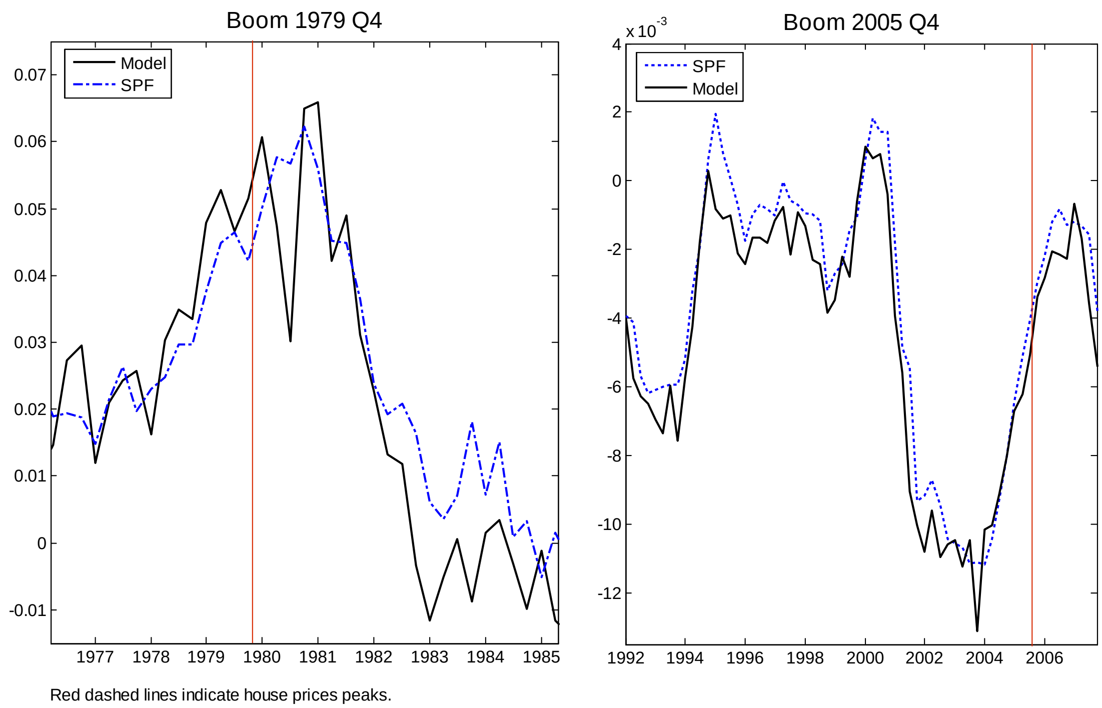


Figure 5: Housing Booms and Expectations

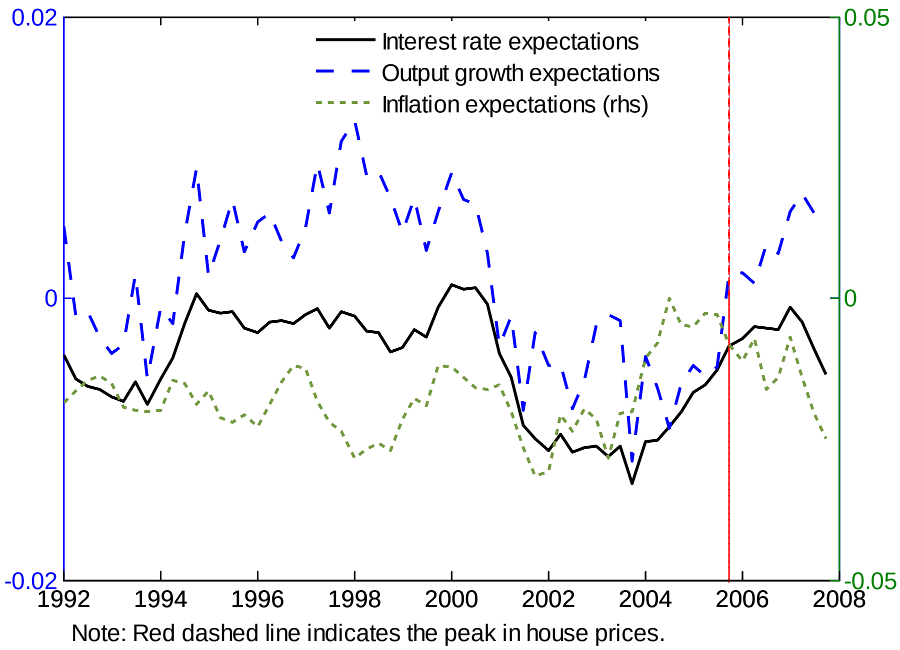


Figure 6: GDP Growth Model-based Expectations 1-quarter ahead

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