Aggregate Shocks and The Brazilian Housing Market Dynamics

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Abstract

In this paper we seek to understand the recent dynamics of the Brazilian housing market, which experienced a significant growth in recent years. In particular, we assess the effects of aggregate productivity and monetary policy shocks on housing market variables. Moreover, we also investigate the effects of shocks to housing prices that are orthogonal to business cycle movements. We use a SVAR approach with sign restriction backed by a Dynamic Stochastic General Equilibrium (DSGE) model estimated for Brazil. The empirical results show that the housing market responds positively to aggregate productivity shocks, while a contractionary monetary policy shock depress housing output, demand and prices. Additionally, we find monetary policy as an important source of variation in housing prices and financing, while productivity shocks explain a substantial share of housing production movements. We also show that the behavior of housing prices is mostly driven by shocks to housing prices that are orthogonal to business cycles movements.

Keywords: Housing Markets, Business Cycle, Monetary Policy, DSGE, SVAR Models, Sign Restrictions.

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1 Introduction

In most economies, the housing market is an important sector to the economic activity and in Brazil this is not different. For instance, according to the Brazilian Chamber of Construction Industry, in 2013, the housing market generated approximately R$ 53 billion in revenue, representing roughly 4.5% of GDP and 9% of total employment. Moreover, between 2000 and 2013, the civilian construction GDP grew, on average, 3.6% per year. Same period when the Brazilian economy experienced relatively higher growth rates (3.5% per year on average). Therefore, we seek to understand the recent dynamics of the housing market in Brazil and how aggregate shocks were responsible for its movements. By aggregate shocks, we mean productivity, monetary policy and housing price shocks.

There are several candidates that may explain the recent evolution of the Brazilian housing market raging from a speculative price bubble in this sector to a mere correction of lagged prices of these assets. However, the most frequent explanation for this phenomenon has been the monetary and fiscal stimulus adopted by the Brazilian government in recent years. Subsidized credit for the purchase of residential property, fixed housing supply in the short term, high cost of production, increase in real income and subsidized interest rates are examples of factors that may have contributed significantly to the recent market development and the increase in housing prices (Mendonça and Sachsida, 2012; Mendonça, 2013).

Analyzing the joint evolution of the construction sector output and the economic activity is possible to see that the housing sector has a positive association with the performance of the Brazilian GDP.[1] On the one hand, this association can be explained by the participation of construction sector in the composition of GDP and total investment. Therefore, better performance in the housing sector could spillover to the aggregate economy. On the other hand, higher economy-wide output growth rates could spillover to the housing sector, yielding higher sectoral growth rates, employment, demand for housing, etc. Regarding the latter effect, we show that after a positive aggregate productivity shock the housing market features a pro-cyclical behavior, where housing output, prices and loans increase after the shock.

Additionally, the literature has suggested that monetary policy may have important

[1]The correlation between real GDP and real output in civilian construction is roughly 0.7 in Brazil in the period of analysis.

direct and indirect effects on the housing market. For instance, Mishkin (2007) highlights the importance of housing as an asset such that nominal interest rates may affect the housing market through different channels, such as: (1) capital utilization costs, (2) expectations on housing prices, (3) housing supply, (4) wealth effect on housing prices, (5) credit channel on the household's expenditure, and (6) credit channel in the housing demand.[2]

Therefore, after a contractionary monetary policy shock we would expect a decline in housing demand, due to lower aggregate income and higher mortgage related interest rates, which it would in effect depress housing prices and housing production. This intuition is in line with our empirical findings, where we show that after a contractionary monetary policy shock housing financing, output and prices decline in Brazil.

We also investigate the effects of housing prices shocks that are orthogonal to business cycle movements due to either productivity shocks or monetary policy shocks. We show that a positive housing price shock leads to a persistent increase in housing output in Brazil and hence offering a complementary explanation for the recent dynamics in the housing sector in Brazil. We also present some evidence supporting the idea that higher housing prices in recent years were caused not only by an expansionary monetary policy and the boom phase of business cycles in Brazil, but also by shocks to housing prices due to "market sentiments". The latter shock explains from 46% to 33% of housing prices movements in Brazil.

The results discussed above are drawn from the estimation of a Structural Vector Autoregressive model, where the structural shocks are identified through a sign restriction approach on the Impulse Response Functions as in Mountford and Uhlig (2009). The restrictions are drawn from an estimated Dynamic Stochastic General Equilibrium (DSGE) model using Brazilian data. We also perform a Variance Decomposition of housing market variables. We find that although productivity shocks explain a good share of housing output, monetary policy is also important to explain movements in both housing prices and financing.

Recent economic literature keep a close eye on the housing market dynamics and the effect of macroeconomic policies on it. Iacoviello (2005) and Iacoviello and Neri (2010) argue that credit market frictions, such as the presence of collateral constraints, can exacerbate the effects of monetary policy shocks on the economy. For instance, according

[2]In Brazil, interest rates related to mortgage contracts are regulated by the government. Despite of that, this rate responds to movements in the interest rate used in conducting the monetary policy.

to Mishkin (2007), an expansionist monetary policy resulting in higher housing prices implies more potential collateral for the owner, who can improve both the amount and the conditions of the available credit for the households, prompting more spending.[3]

In what regards the Brazilian economy, for the best of our knowledge, Mendonça et al. (2011) is the only work analyzing the effects of monetary policy on the housing market. They conclude that an increase in the interest rate has a strong effect on the housing market through the credit market, national index of civil construction prices (INCC), and industrial product of civil construction (INDCV). The credit stock for housing financing decreases by 2% readily after the monetary shock while the INCC and INDCV presents a longer reduction depicting a strong persistence during the analyzed period.

After this introduction, we present the DSGE model used to back the restrictions applied on our empirical strategy presented in section 3. The dynamics of the housing market are presented next followed by the conclusions.

2 Theoretical Dynamics of Housing Market

In this section we present the theoretical model that motivates the restrictions to be imposed in the empirical model. The model follows Iacoviello (2005) closely and depicts an infinite horizon economy, populated by patient and impatient households, entrepreneurs, retailers and a central bank. Impatient households have higher discount rates than patient households and also are limited in the amount of debt they can borrow. Both types of households consume nondurable final goods, demand housing and work for the entrepreneurs in a monopolistic competitive labor market. Entrepreneurs combines labor, physical capital and housing to produce a homogeneous intermediate good. They also are assumed to be credit constrained. Retailers transform the intermediate good into a composite final good at no cost. Nominal rigidities are assumed at the retail level according to a Calvo (1983) mechanism. The central bank sets the nominal interest rate according to a Taylor rule. Differently from Iacoviello (2005) and to be consistent with our empirical strategy, we consider only three exogenous shocks in the DSGE model: a productivity shock, a monetary policy shock, and a housing preference shock. The latter proxies for a housing price shock. Next we will describe the problem faced by each agent.

[3] Giuliodori et al. (2002); Iacoviello (2002); Iacoviello and Minetti (2003); Calza et al. (2006) also discuss the responses of housing prices to monetary policy shocks.

2.1 Patient households

There is a continuum of patient households indexed by i, where $i \in (0,1)$. Each family maximizes a lifetime utility given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\ln c_t^P + j_t \ln h_t^P - \frac{(L_t^P)^\eta}{\eta} \right]$$

where $\beta \in (0,1)$ is the discount factor, c_t^P is consumption at t, h_t^P is housing at t, and L_t^P are hours of work.The budget constraint faced by the patient household is given by

$$c_t^P + q_t(h_t^P - h_{t-1}^P) + \frac{R_{t-1} b_{t-1}^P}{\pi_t} = b_t^P + w_t^P L_t^P + F_t + T_t^P - \Phi_h^P$$

where $q_t \equiv Q_t/P_t$ is the housing price in real terms, $w_t^P \equiv W_t^P/P_t$ is the real wage, R_t is the gross nominal interest rate, b_{t-1}^P is the real debt, $\pi_t \equiv P_t/P_{t-1}$ denotes the gross inflation rate, F_t are profits received from retailers and T_t^P is net cash inflows from participating in state-contigent security markets. $\Phi_t^P \equiv \phi_h \frac{(h_t^P - h_{t-1}^P)^2 q_t h_{t-1}^P}{2}$ represents a housing adjustment cost.

2.2 Impatient households

The maximization problem faced by impatient households is similar to the one faced by patient households. The differences are twofold. First, they discount the future more heavily, and second they are credit constrained. Again there is a continuum of impatient households indexed by i, where $i \in (0,1)$ and each family maximizes a lifetime utility given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} (\beta^{NP})^t \left[\ln c_t^{NP} + j_t \ln h_t^{NP} - \frac{(L_t^{NP})^\eta}{\eta} \right]$$

where $\beta^{NP} \in (0,1)$ is the impatient discount factor and $\beta^{NP} < \beta$, c_t^{NP} is consumption at t, h_t^{NP} is housing at t, L_t^{NP} are hours of work.The budget constraint faced by this type of household is given by

$$c_t^{NP} + q_t(h_t^{NP} - h_{t-1}^{NP}) + \frac{R_{t-1} b_{t-1}^{NP}}{\pi_t} = b_t^{NP} + w_t^{NP} L_t^{NP} + T_t^{NP} - \Phi_t^{NP}$$

where w_t^{NP} is the real wage, b_{t-1}^{NP} is the real debt and T_t^{NP} is net cash inflows from participating in state-contigent security markets. Φ_t^{NP} depicts the housing adjustment cost faced by impatient households. The borrowing constraint is

$$b_t^{NP} \leqslant m^{NP} E_t \left(\frac{q_{t+1} h_t^{NP} \pi_{t+1}}{R_t} \right)$$

where m^{NP} is the maximum loan-to-value ratio. This constrain establishes that the amount of borrowing is related to the (discounted) expected value of housing in the next period.

2.3 Entrepreneurs

Entrepreneurs combine labor from both households (L^P and L^{NP}), capital (K_{t-1}) and housing to produce an intermediate good (Y_t) according to a production technology

$$Y_t = A_t K_{t-1}^{\mu} h_{t-1}^{\upsilon} (L_t^P)^{\alpha(1-\mu-\upsilon)} (L_t^{NP})^{(1-\alpha)(1-\mu-\upsilon)} \tag{1}$$

where α denotes the relative size of patient households and A_t represents the level of technology. Entrepreneurs are risk averse and maximize a discount utility given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \gamma^t \ln c_t$$

subject to the production technology (1) and to a flow of funds constraint

$$Y_t/X_t + b_t = c_t + q_t(h_t - h_{t-1}) + \frac{R_{t-1} b_{t-1}}{\pi_t} + w_t^P L_t^P + w_t^{NP} L_t^{NP} + I_t + \Phi_{K,t} + \Phi_{he,t}$$

where $X_t \equiv \frac{P}{P^{\vartheta}}$ is the markup of the final good over the intermediate good. I_t depicts the investment in capital and evolves according to $I_t = K_t - (1-\delta)K_{t-1}$, where δ is the depreciation rate. $\Phi_{K,t}$ and $\Phi_{he,t}$ are adjustment costs in capital and housing, respectively and are given by

$$\Phi_{K,t} \equiv \frac{\phi_k}{2\delta} \left(\frac{I_t}{K_{t-1}} - \delta \right)^2 K_{t-1}$$

$$\Phi_{e,t} \equiv \frac{\phi_e}{2} \left(\frac{h_t - h_{t-1}}{h_{t-1}} \right)^2 q_t h_{t-1}$$

The adjustment cost in housing proxies for transaction costs or conversion costs of residential housing into commercial housing, and vice-versa (Iacoviello, 2005). Entrepreneurs are also borrowing constrained. In real terms the borrowing constraint is

$$b_t \leqslant m E_t \left(\frac{q_{t+1} h_t \pi_{t+1}}{R_t} \right)$$

where m is the maximum loan-to-value ratio.

2.4 Retailers

Nominal rigidities are introduced at the retail level (Bernanke et al., 1999). There is a continuum of retailers, indexed by z, where $z \in (0, 1)$, that buys the intermediate good, Y_t, at the price P_t^{ϑ}, and transforms into a differentiate good, $Y_t(z)$, at no cost. Retailers sell the differentiate goods at the price $P_t(z)$. The differentiated goods are aggregated into a final good Y_t^f according to

$$Y_t^f = \int_0^1 \left[P_t(z)^{1-\epsilon} dz \right]^{\frac{1}{1-\epsilon}},$$

where $\epsilon > 1$. The corresponding aggregate price index is given by

$$P_t = \int_0^1 \left[Y_t(z)^{\frac{\epsilon-1}{\epsilon}} dz \right]^{\frac{\epsilon}{\epsilon-1}}$$

Each retailer chooses the sale price $P_t(z)$ taking as given P_t^{ϑ} and the individual demand curve

$$Y_t(z) = \left(\frac{P_t(z)}{P_t} \right)^{-\epsilon} Y_t^f$$

To introduce nominal rigidities, we assume that every period, a fraction $1 - \omega$, where $0 < \omega < 1$, of retailers can choose optimal prices, whereas the remaining fraction indexes prices to past inflation. The optimal price, $P_t^*(z)$, is chosen such that:

$$\sum_{k=0}^{\infty} E_t \left\{ \Delta_{t,k} \left(\frac{P_t^*(z)}{P_{t+k}} - \frac{X}{X_{t+k}} \right) Y_{t+k}^* \right\} = 0$$

where $\Delta_{t,k} \equiv \beta \left(\frac{c_t^P}{c_{t+k}^P} \right)$ is the patient household intertemporal marginal rate of substitution, $X \equiv \frac{\epsilon}{\epsilon - 1}$ is the steady-state markup and $Y_{t+k}^*(z) = \left(\frac{P_t^*(z)}{P_{t+k}} \right)^{-\epsilon} Y_t$ denotes the demand at the "reset" price.

2.5 Monetary policy

We assume the central bank sets the nominal interest rate according to a Taylor rule

$$\hat{R}_t = \rho_r \hat{R}_t + (1 - \rho_r) [r_\pi E_t \hat{\pi}_t + r_y \hat{y}_t] + e_{R,t}$$

where a hat over the variable represents log-deviations from the non-stochastic steady-state.

2.6 Shocks

The model displays three exogenous shocks: a monetary policy shock, $e_{R,t}$, an aggregate productivity shock, $e_{A,t}$ and a housing preference shock , $e_{j,t}$. All shocks are assumed to be $iid(0, \sigma_\ell)$ where $\ell = R, j, A$. The stochastic processes defining the evolution of productivity level, A_t and housing preference, j_t are given, respectively, by

$$A_t = \rho_A A_t + e_{A,t}$$

$$j_t = \rho_j j_t + e_{j,t}.$$

2.7 Equilibrium

The equilibrium in this economy is characterized by a set of allocations

$$\{h_t, h_t^P, h_t^{NP}, L_t^P, L_t^{NP}, c_t, c_t^P, c_t^{NP}, b_t, b_t^P, b_t^{NP}, K_t\}_{t=0}^{\infty}$$

and prices $\{P_t, P_t^*, X_t, R_t, w_t^P, w_t^{NP}, q_t\}_{t=0}^{\infty}$ such that all the optimality conditions associated to the above maximization problems are satisfied, given initial values

$$\{h_{t-1}, h_{t-1}^P, h_{t-1}^{NP}, b_{t-1}, b_{t-1}^P, b_{t-1}^{NP}, K_{t-1}, P_{t-1}, R_{t-1}\}$$

, a sequence of shocks $\{e_{R,t}, e_{j,t}, e_{A,t}\}$ and that the following market clearing conditions are satisfied:

$$\begin{aligned}
&\text{(Housing Market)} && H = h_t + h_t^P + h_t^{NP}, \\
&\text{(Goods Market)} && Y_t = c_t + c_t^P + c_t^{NP} + I_t, \\
&\text{(Loans Market)} && 0 = b_t + b_t^P + b_t^{NP}.
\end{aligned}$$

2.8 Solution Method and Econometric Methodology

We compute a first order Taylor approximation of the log-linear equilibrium conditions around the non-stochastic steady state and we use the method proposed by Sims (2002) to find the model solution.

2.8.1 Priors and Calibrated Parameters

Some parameters are fixed during the estimation process, others are estimated. The fixed parameters are from Iacoviello (2005) and are standard in the literature. Table 1 presents a description of the parameters that were kept fixed and the ones that are estimated. We choose to estimate the persistence and standard deviation of shocks and also the parameters of the monetary policy rule.

We use prior distributions that have been used in previous studies. For instance, for the persistence of shocks, we choose a beta distribution with a prior mean of 0.8 and standard deviation 0.1. While for the standard deviation of shocks, we use inverse gamma distributions. Finally, for the Taylor rule we use a gamma distribution for ρ_r, and normal distributions for r_π and r_y. We assume that the monetary authority responds gradually to output and inflation deviations from their steady state values.

2.8.2 Data used in the estimation

The data used in the estimation will be better explained in the data section of the SVAR analysis. In the Bayesian estimation of the posterior distribution of deep parameters we have employed data on real GDP, nominal interest rates, housing prices and inflation. All data is treated as deviations from a trend computed using a HP filter ($\lambda = 1600$).

2.8.3 Results of the Bayesian estimation of the Posterior Distribution

Table 2 presents the mean values, standard deviations and confidence interval for each estimated parameter. The joint posterior distribution of parameters was obtained us-

Table 1: Fixed Parameters

Symbol	Description	Value
β^{P}	Patient household discount factor	0.99
β^{NP}	Impatient household discount factor	0.95
γ	Entrepreneurs discount factor	0.98
j	Weight on housing services	0.1
η	Weight on labor supply	1.01
μ	Capital share	0.3
υ	Housing share	0.03
α	Patient household wage share	0.64
m	Loan-to-value entrepreneur	0.89
m^{NP}	Loan-to-value household	0.55
ψ	Capital adjustment cost	2
δ	Depreciation rate	0.03
ϕ	Housing adjustment cost	0
X	Steady-state gross mark-up	1.05
ω	Calvo pricing parameter	0.75

ing a Metropolis-Hastings algorithm. In particular, we have generated 2 independent sequences each composed of 2,000,000 draws. The average acceptance ratio along the chains was 30%, and we have assessed convergence using the methods proposed by Brooks and Gelman (1998). We have discarded the first 1,000,000 draws to assure independence of initial conditions. The statistics of interest were computed from the ergodic joint posterior distributions of the deep parameters.

Figure 1 depicts the theoretical impulse response functions for selected variables: real GDP per capita, inflation rate, nominal interest rate and real housing prices. They are among the variables we will use in our empirical model. According to the model, a productivity shock raises GDP above its steady state value, while reducing the inflation rate. In response to higher GDP and to a lower inflation environment, the central bank lowers the nominal interest rate. Housing prices also increases after the shock. The impacts of a contractionary monetary policy shock are quite standard. Both real GDP and the inflation rate falls as the nominal interest rate increases. A housing preference shock yields a small increase in real GDP and small decline in inflation. Housing prices increases after the housing preference shock.

We are particularly interested in using the above theoretical impulse responses to

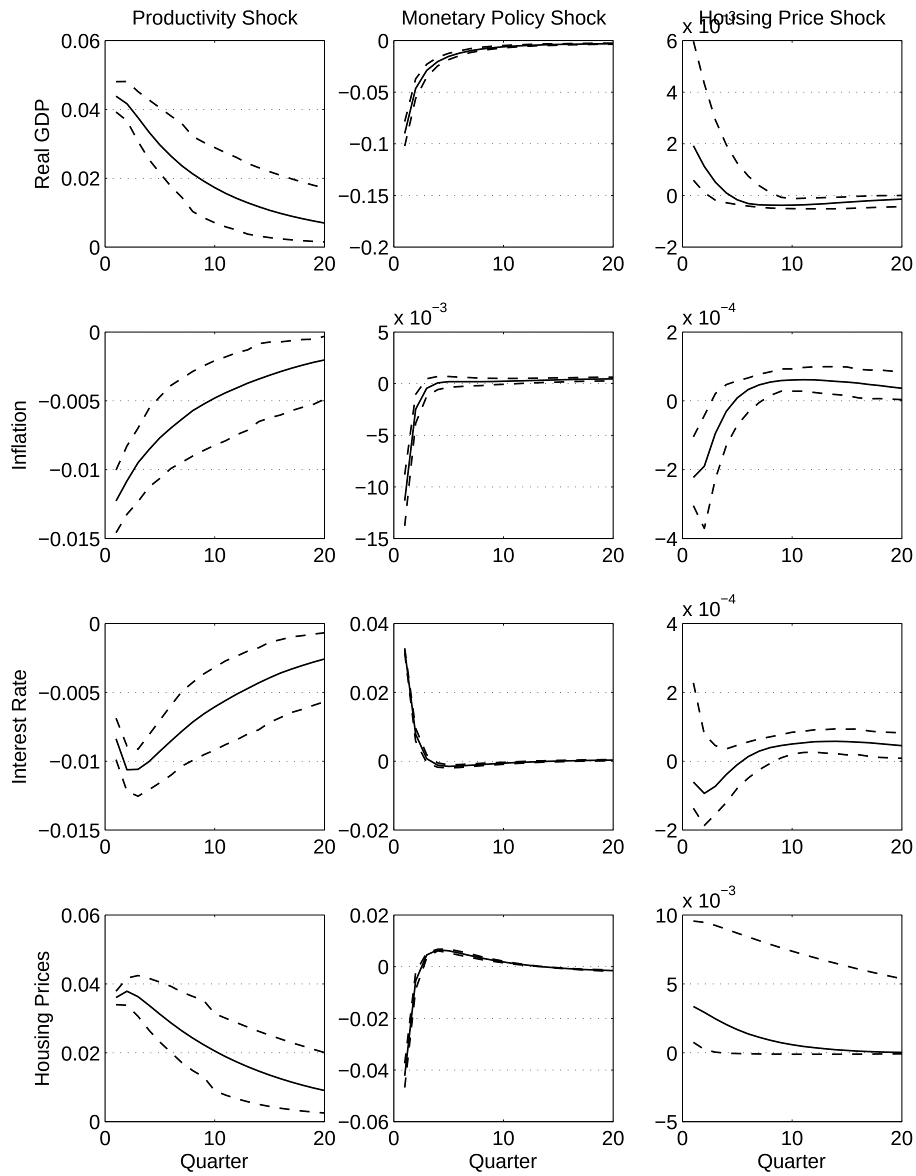

Figure 1: Theoretical IRF

Note: The solid line depicts the median response, while the dashed lines represent the 68% confidence interval.

Table 2: Results from Metropolis-Hastings (parameters)

	Prior dist	Prior mean	Prior SD	Post. mean	Post. SD	HPD inf	HPD sup
ρ_j	beta	0.850	0.1000	0.860	0.1027	0.7173	0.9999
ρ_A	beta	0.850	0.1000	0.901	0.0380	0.8469	0.9606
σ_j	invg	0.050	2.0000	0.060	0.0871	0.0106	0.1037
σ_A	invg	0.050	2.0000	0.057	0.1006	0.0110	0.0897
σ_R	invg	0.050	2.0000	0.048	0.0442	0.0110	0.0913
r_R	beta	0.800	0.1000	0.430	0.0563	0.3380	0.5230
r_π	norm	1.500	0.1000	1.678	0.0864	1.5368	1.8200
r_Y	norm	0.125	0.0500	0.141	0.0306	0.0909	0.1914

motivate the restrictions imposed on the sign of the empirical impulse response functions in the SVAR model. We will discuss this in the next section.

3 Empirical Strategy

In this section we briefly describe the empirical strategy we follow to analyze the dynamics of housing market. We first explain the SVAR which is a workhorse empirical model to analyze macroeconomic dynamic since Sims (1980). Then, we explain the sign restriction strategy used to recover the response to structural shocks. Lastly, we present the data we use in the analysis.

3.1 Empirical Model

The empirical model can be represented as follows:

$$A_0 y_t = \sum_{\ell=1}^{p} A_\ell y_{t-\ell} + \epsilon_t \quad \text{for} \quad t = 1, \dots, T \tag{2}$$

This is a Structural Vector Autoregression model where y_t is a n-dimensional column vector of endogenous variables, A_0 is a $n \times n$ matrix of contemporaneous impacts, A_ℓ are $n \times n$ matrices of lagged variables parameters, ϵ_t is a n-dimensional white noise processes, $\epsilon_t \sim \mathcal{N}(0, \Sigma_\epsilon)$, p is the number of lags and T is the sample size.

Premultiplying the system (2) by A_0^{-1}, yields the usual reduced form VAR:

$$y_t = \sum_{\ell=1}^{p} B_\ell y_{t-\ell} + u_t \quad \text{for} \quad t = 1, \dots, T,$$

where $B_\ell = A_0^{-1} A_\ell$ for $\ell = 1, 2, \dots, p$; $u_t = A_0^{-1} \epsilon_t$ and $\Omega = E[u_t u_t']$ is the variance-covariance matrix of the residuals.

As the reduced form system is the one to be estimated, the identification task is to obtain the orthogonal impulse response functions (IRF's) from the reduced form errors, u_t. There are different ways to achieve this, in this paper we adopt a sign restriction approach. This method will be explained in the next subsection.

3.2 Sign Restrictions

The main idea of the sign restriction approach is to identify structural shocks by imposing a number of restrictions on the sign of some impulse responses, while remaining agnostic about the responses of the variables of interest. One advantage of this method is that there is no need to impose restrictions on the entire A_0 matrix, which it is the case in the recursive and non-recursive strategy. In line with our theoretical model, we identify three structural shocks: a technology shock, a monetary policy shock and a housing demand shock. To understand how this identification strategy works, let c_k be the k-th column vector of a matrix C, so that $CC' = \Omega$ and c_k is the impulse vector for the k-th variable. Since we are interested in identifying only m shocks, in which $m \leqslant n$, Mountford and Uhlig (2009) show that identifying m shocks is the same as finding an impulse matrix $m \times n$ that is a sub-matrix of C. Such impulse matrix, $[c^{(1)}, \dots, c^{(m)}]$, can be represented as the product

$$[c^{(1)}, \dots, c^{(m)}]_{(m \times n)} = \tilde{C}\Lambda,$$

where $\Lambda = [\lambda^{(1)}, \dots, \lambda^{(m)}]$ is a $m \times n$ orthonormal matrix such that $\Lambda\Lambda' = I_m$ and $\tilde{C}$ is a lower triangular Cholesky factor of Ω.

Let $c = c^{(s)}$, $s = 1, 2, \dots, m$ be one of the columns of the impulse matrix $\tilde{C}\Lambda$ and $\lambda = \lambda^{(s)} = \tilde{C}^{-1}\lambda$ be the corresponding column of Λ. Uhlig (2005) shows that any impulse response c can be obtained as a linear combination of the impulse responses under a Cholesky decomposition of Ω. Let $r_{ji}(k)$ be the impulse response of the j-th variable to the i-th shock in the Cholesky decomposition of Ω at horizon k and define $r_i(k)$ to represent the vector of responses $[r_{1i}(k), \ldots, r_{mi}(k)]$. Then the m-dimensional impulse response $r_c^{(s)}(k)$ to the vector $c^{(s)}$ is given by:

$$r_c^{(s)}(k) = \sum_{i=1}^{m} \lambda_i r_i(k). \quad (3)$$

Based on (3), we can identify the impulse response vector corresponding to the structural innovations. These restrictions are not enough to correctly identify the shocks, as many impulse responses may satisfy them. Therefore we follow Uhlig (2005) and define a criterion function $f(\cdot)$ in the unit sphere, which penalizes every deviation from the relevant sign restrictions. Therefore sign restrictions are imposed by minimizing

$$c = argmin \Psi(\tilde{C}\lambda),$$

where the criterion function $\Psi(c)$ is given by

$$\Psi(c) = \sum_{j \in J_{s,+}} \sum_{k=0}^{K} f\left(-\frac{r_{jc}(k)}{s_j}\right) + \sum_{j \in J_{s,-}} \sum_{k=0}^{K} f\left(\frac{r_{jc}(k)}{s_j}\right).$$

The criterion function, Ψ above is minimized subject to the orthogonality restrictions. It sums the penalties over the horizon $k = 0, \ldots, K$ following the shock and over the indices of variables with positive $(J_{s,+})$ and negative $(J_{s,-})$ sign restrictions, respectively.

The restrictions we impose are based on the theoretical impulse responses obtained in the first part of this paper. Table 3 depicts these restrictions.

Table 3: Sign Restrictions

Variables	Shocks		
	Productivity	Monetary Policy	Housing Price
Real GDP	+	-	?
Nominal Interest Rate	-	+	?
Inflation	-	-	?
Civilian Construction Output	+	?	?
Housing Financing	?	?	?
Housing Prices	?	?	+

These restrictions are quite intuitive. In particular, a productivity shock raises GDP while reducing the inflation rate. In response to higher GDP and to a lower inflation environment, the central bank lowers the nominal interest rate. To improve identification, we impose an additional restriction that real output per capita in the civilian construction sector also increases after a productivity shock (civilian construction output and real GDP co-moves positively along the business cycles, as we have shown previously. The correlation between the two series is 0.68 in the data). On the other hand, a monetary policy shock, raises the nominal interest rate and yields a decline in real GDP and inflation. No other restrictions are imposed. A housing preference shock is assumed only to increase the real housing prices, while the remaining variables are left unrestricted.

3.3 Data

We use quarterly data on real GDP, inflation rate, nominal interest rate, real housing prices, real output in the housing sector (civilian construction) and the amount of housing financing (number of mortgage contracts). National account variables, output in the housing sector and financing are per capita variables. Total GDP and housing GDP are in real terms deflated by the GDP deflator. The data ranges from the second quarter of 2001 to the second quarter of 2014. National account variables, housing prices, financing and output are HP filtered ($\lambda = 1600$). The data is also seasonally adjusted where relevant. National account data are from Instituto de Pesquisa Econômica Aplicada - IPEA and Instituto Brasileiro de Geografia e Estatística - IBGE. The nominal interest rate is from the Central Bank of Brazil. Inflation rate is the CPI inflation rate from IBGE (IPCA - Indice de Preços ao Consumidor Ampliado). National account variables, housing financing and housing prices are in logs, while the nominal interest rate, and the inflation rate are in percentage terms. Both the nominal interest rate and the inflation rate are defined as the quarterly average of monthly rates, where the rates are in quarterly terms.

Figure 2 displays the cyclical components (HP filtered $\lambda = 1600$) for real GDP, real civilian construction GDP (our proxy for housing production), nominal interest rate, housing prices and housing financing. Panel (a) shows the evolution at business cycle frequency of housing variables and real GDP. While Panel (b) shows the joint evolution of the same variables and the nominal interest rate. It is clear that housing variables co-move positively with aggregate GDP, while such relationship is not so clear when we look at the joint evolution of housing variables and the nominal interest rate.

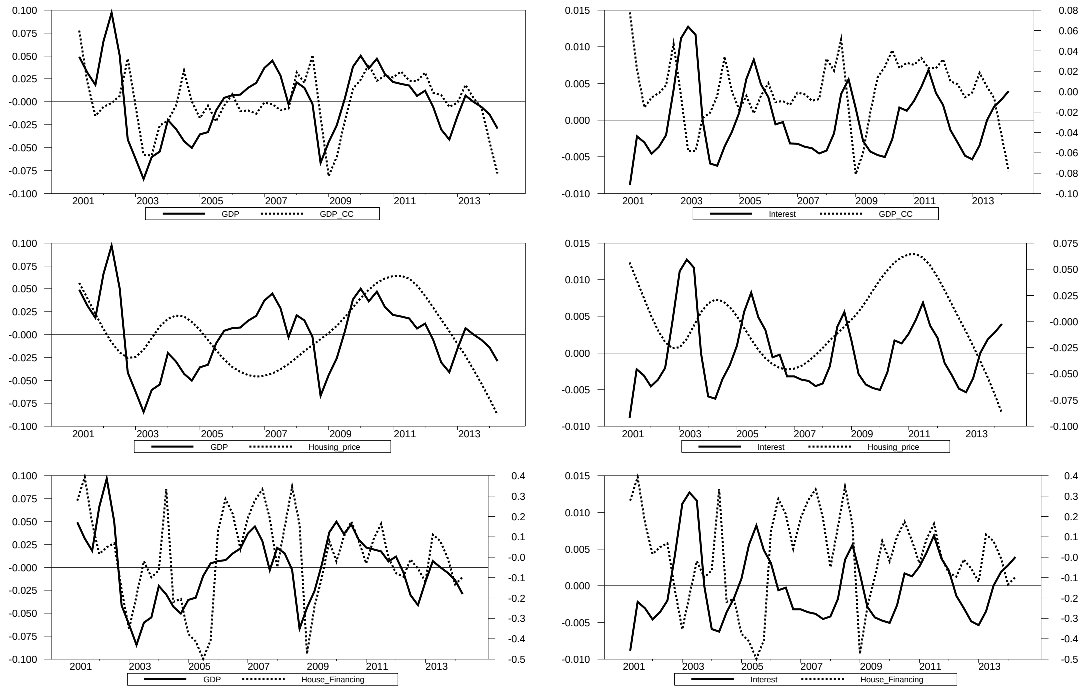

Figure 2: Housing Market Series

Note: Housing market variables and aggregate real GDP are in logs and HP filtered ($\lambda = 1600$). The nominal interest rate is HP filtered only.

4 The Dynamics of Housing Market

In this section we present the dynamics of the Brazilian housing market after productivity, monetary and housing prices shocks. The analysis is based on the impulse response functions obtained from our baseline SVAR model with sign restrictions previously exposed. Figure 3 summarizes our findings.

In response to a productivity shock that raises aggregate output and lowers inflation and interest rate, the housing sector output displays a humped-shaped response staying above its steady-state value even after the sign restriction is relaxed. Housing financing reacts positively for 2 years to unexpected increases in productivity. Additionally, housing prices also increase in response to higher aggregate productivity. Although this last result would be expected in comparison with the theoretical impulse responses, the housing supply is fixed in the model. Then, in theory, the prices would rise to clear the housing market. However, our empirical results points to increases in supply, demand and prices in the housing sector.

The pro-cyclicity of housing sector suggests a positive spillover effect from the aggregate economy to the housing sector. The intuition is that in the boom phase of the business cycle, there is an increase in housing demand and given the low elasticity of housing supply in the short run, housing prices must increase. These results are standard in the housing literature echoing, for example, Iacoviello (2005), Iacoviello and Neri (2010) and Ko (2011), which also find such positive effects of productivity shock on housing markets. However, only the latter also presents a persistent effect on the housing prices.

Another focus of our discussion is on the dynamics of housing market in response to monetary policy shocks. The contemporaneous effect of an increase in nominal interest rates is not statistically significant, in spite of the negative effect in the next quarters. Housing production show a negative persistent response after 2 years, while the prices show similar dynamics even sooner. The housing financing displays negative transient effect 2 and 3 quarters after the contractionary monetary shock. Since this variable reflects the demand for housing services, this results is in line with the theory. As the nominal interest rate increases, households face higher borrowing costs and hence reduce their housing demand.

These results are consistent with the literature which suggests that a contractionary monetary policy affects the housing market through a negative impact on residential investment and also through the credit channel. Higher interest rates worsens credit conditions and reduces the demand for housing financing, housing supply and housing prices (Bernanke and Gertler, 1995; Iacoviello, 2002; Erceg and Levin, 2006; Vargas-Silva, 2008; Monacelli, 2009; Aspachs-Bracons and Rabanal, 2011). Similarly, Mendonça et al. (2011) find evidence that a decline in housing financing in response to higher nominal interest rates in Brazil. Therefore we add to the literature evidence suggesting that housing prices negatively respond to deteriorating credit conditions, revealing the importance of the relationship between monetary policy, especially its effects on credit conditions, and housing prices in Brazil.

Lastly we analyze the dynamics of supply and demand of housing to exogenous variations to its price that are orthogonal to business cycle movements due to either productivity shocks or monetary policy shocks. Column 3 in Figure 3 shows increases in prices of housing tend to be persistent lasting more than 2 years. As expected, the con-

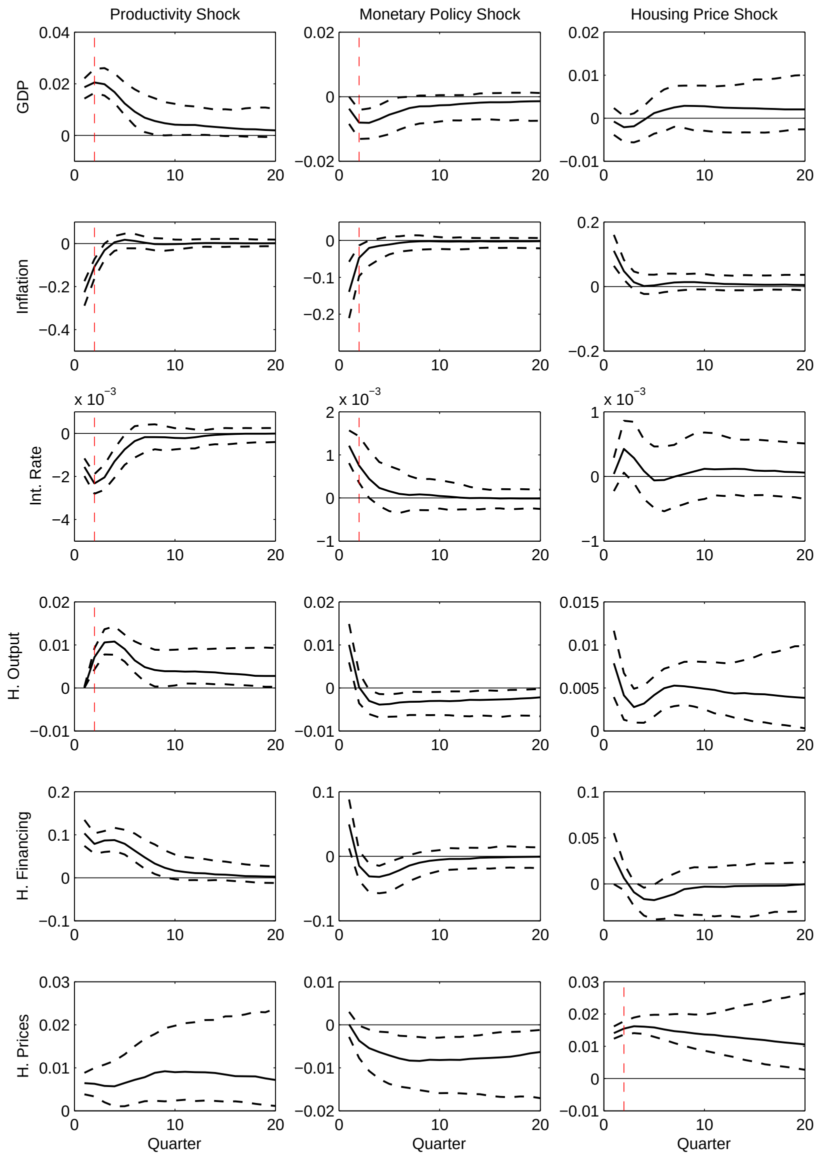

Figure 3: Empirical IRF: Baseline Model

Note: The solid line depicts the median response, while the dashed lines represent the 68% confidence interval. The vertical line represents the sign restriction horizon $k = 3$ quarters.

struction sector reacts positively and persistently to increases housing prices. However, a initial positive effect on the housing financing is also observed. Our results are similar to those obtained by Aspachs-Bracons and Rabanal (2011) for the Spanish case. They highlighted that higher housing prices has fueled an expansion in residential investment in Spain and that there was a positive spillover effect to the rest of the economy, with an expansion in private consumption and real GDP. Even though, we do not have quarterly data on residential investment, we would expect the same kind of behavior in Brazil. The result that a positive housing price shock leads to a persistent increase in housing output in Brazil may offer a complementary explanation for the recent dynamics of the housing sector in Brazil.

4.1 The Source of Dynamics

We continue our discussion by disentangling the sources of variation in housing market variables through a Forecast Error Variance Decomposition analysis. In this way, we decompose the dynamics of housing output, housing financing and housing prices resulting from the three shocks analyzed above up to 5 years after the shock in one year intervals. The results are presented in Table 4. Note that housing output (i.e. civilian construction GDP), is most explained by productivity shocks. The importance of this shock ranges from roughly 33% in one year to 27% in 5 years. In longer horizons, monetary policy shock and housing price shocks increase their share. At the 20^{th} quarter horizon, monetary policy explains 9% of housing GDP variance, while housing prices explain 10% at the same horizon.

Changes in productivity are the main factor explaining housing financing as well. Nonetheless, only 22% of housing financing variance is explained by productivity shocks. The second most important factor is the monetary policy which explains roughly 12% of the demand for housing services. Housing prices shocks are also an important factor but its movements explain only 5 to 8 per cent of housing financing.

Regarding these results, it is important to notice that the effects of a restrictive monetary policy can be felt not only by those who aspire to financing but also by those who already have. For the former, increases in interest rates, which results in increases in the cost of mortgage, would mean a barrier to entry, reducing the likelihood (or interest) for financing, while for the latter, this would mean an increase in the actual cost of financing, and therefore increasing the share of family income committed to interest rates payment.

Table 4: Variance Decomposition of Housing Market Variables

	Quarters	Shocks		
		Productivity	Monetary Policy	Housing Prices
H. Output	4	33.15	6.56	5.32
	8	30.36	8.00	7.71
	16	28.32	9.16	9.92
	20	27.61	9.23	10.62
H. Financ.	4	21.02	12.46	5.43
	8	22.52	12.81	6.49
	16	22.27	12.89	7.60
	20	22.04	12.96	8.08
H. Prices	4	9.35	10.26	46.38
	8	11.60	11.47	38.45
	16	13.91	11.47	33.89
	20	14.40	11.55	33.02

In a context where the economy goes into recession this may trigger an increase in *default* in real estate financing. Moreover, when housing prices are falling and there is an increase in default, this could mean that increases in interest rates can potentially bring housing sector to bankruptcy. Given its importance, it could spillover on the aggregate economy. The recent crisis in the sub-prime market seems to offer a recent example.

The difference, however, is that the share of households with outstanding mortgages in Brazil is still low relatively to the US and other advanced economies, which reduces the probability of similar crisis in the short term. However, as the share of households with outstanding mortgages rises the conduct of monetary policy may have to take into account the effects of changing interest rates on the housing market dynamics.

Finally, productivity shocks explains from 9%, in one year horizon, to 14% in a five years horizon, of housing prices fluctuations in Brazil. Meanwhile, monetary policy shocks are responsible for 10% to 11% in the same time horizon, respectively. These results are important because they have been appointed as possible explanations for the recent behavior of housing prices in Brazil. However, we show that among the three shocks we consider, housing prices shocks that are orthogonal to business cycle movements caused either by productivity shocks or monetary policy shocks are responsible for 46%, in one year horizon, to 33%, in five years horizon, of housing prices movements in Brazil. These results are worthy of emphasis because they show evidence supporting the idea that higher housing prices in recent years were caused not only by an expansionary monetary policy and the boom phase of business cycles in Brazil, but also by shocks to housing prices due to "market sentiments". By that we mean unexpected movements in housing prices that are not related to business cycles.

4.2 Dynamics of the Remaining Variables

In this subsection we briefly discuss the consistency of our results by (i) analyzing the dynamics of the other variables in the model and; (ii) using different data housing prices. Then, firstly we note that after a productivity shock, real GDP increases and both inflation and the nominal interest rate fall. It is noteworthy that the responses are significant even after the sign restrictions are relaxed. Additionally, the empirical responses are in line with the results obtained using our DSGE model. In the model, a positive productive shock increases labor supply and boosts investment in physical capital. Consumption for the two types of households and entrepreneurs also increases. The effects of a monetary policy shock are also in accordance with our theoretical model. This shock delivers contractionary effects with a decline in output and inflation following a rise in the nominal interest rate.

Lastly, the median response of real GDP to housing prices is positive, although it is not statistically different from zero. The median response of inflation is negative at impact and then it becomes positive, while the response of the nominal interest rate is positive. In both cases, the responses are not statistically different from zero. Recall that in our DSGE model, a housing price shock raises aggregate output, while inflation falls at impact. After a few quarters, higher housing prices are translated into higher inflation and in response to this scenario, the central bank rises the nominal interest rate. Qualitatively these are the results we are observing empirically.

4.3 Robustness

In this section, we implement two complementary exercises to assess the robustness of our results obtained from the SVAR model. In the first, we replace the index of real estate prices used in our baseline model by an alternative index, and in the second we lower the time horizon for the sign restriction imposed to identify our structural shocks.

Recall that in our baseline specification we employ an index of real housing prices computed by the Brazilian Central Bank. This index is based of housing prices settled in mortgage contracts. Alternatively, we construct an index of real housing prices (IPH_t) based on from monthly observations of sale housing prices from Secovi-SP (Union of Housing Firms of São Paulo). A potential drawback of using the IPH is that it refers only to the city of São Paulo, which it lowers its potential as a proxy variable for the national compound. An alternative would be the index computed by the Foundation for Economic Research (FIPE) that covers main cities in Brazil, however that data only covers the period from 2010 to 2017, while the IPH_t covers the period from 2004 to 2017. However, we think IPH still can be used to assess the consistency of our results. The correlation between our IPH index and the one computed by FIPE is 0.99 in the data, hence we present the results using the IPH.[4]

The IPH_t was calculated in the Laspeyres index format, as adopted by FIPE. Secovi-SP makes available the number of new residential units sold (in units) and the revenue obtained from the sale (in millions of R\$ - the Brazilian currency) of the properties of each region of São Paulo, weighted by the number of dormitories. Based on this information, the average price and the housing price index of real estate sold in São Paulo were calculated. At each time period t, the IPH_t is calculated based on the following expression:

$$\text{IPH}_t = \frac{\sum(\bar{P}_{it} Q_{i0})}{\sum(\bar{P}_{i0} Q_{i0})} \tag{4}$$

Where $\bar{P}_{it}$ is the average price in the current time period; $\bar{P}_{i0}$ is the average price of the month taken as the basis; Q_{i0} is the new real estate quantity sold in the month taken as the base period and the i subscript represents the number of dormitories.

Figure 4 presents the results using the new housing price index. In general, they echo our baseline specification.

[4]In addition, São Paulo represents 39.2% of the national composite and expanded index of FIPE.

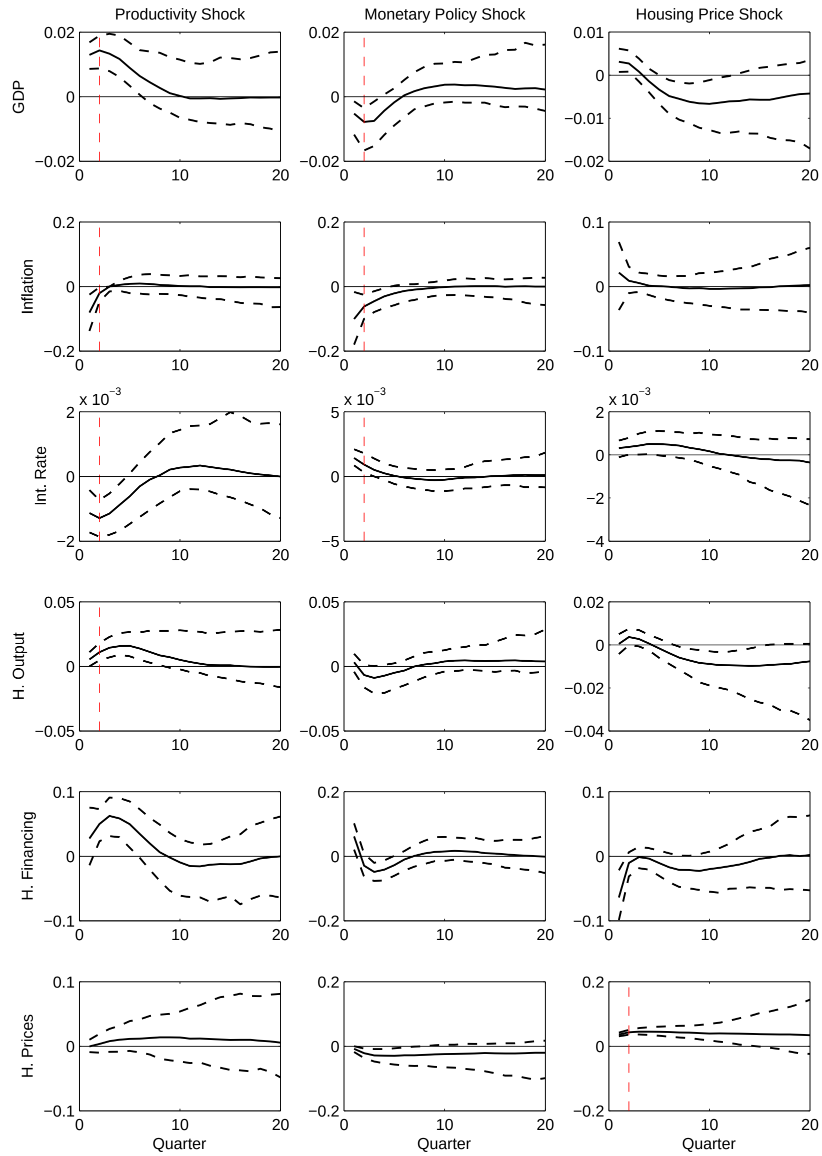

Figure 4: Empirical IRF:Alternative Housing Price Index

Note: The solid line depicts the median response, while the dashed lines represent the 68% confidence interval. The vertical line represents the sign restriction horizon $k = 3$ quarters.

We also investigate whether our baseline results are robust to imposing a lower time restriction to our IRFs. Figure 5 displays these results and they are in line with our baseline results.

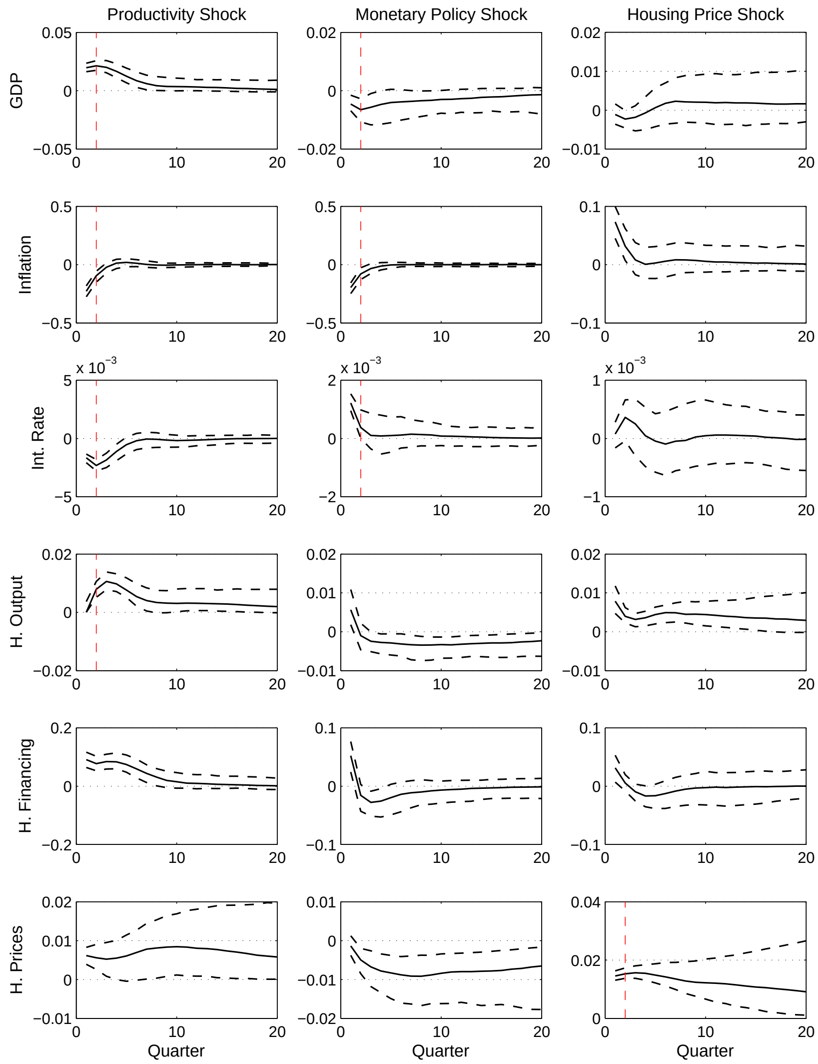

Figure 5: Empirical IRF:Lower restriction $k = 2$ quarters

Note: The solid line depicts the median response, while the dashed lines represent the 68% confidence interval. The vertical line represents the sign restriction horizon $k = 2$ quarters.

5 Conclusions

In this paper, we evaluate the dynamics of housing market after productivity, monetary and housing prices shocks. The results show that while housing supply and demand - measured by housing financing - are mainly driven by productivity shocks. Monetary policy plays an important role on the movements of housing market variables, especially housing financing and prices. Qualitatively, a contractionary monetary policy ought to reduce both supply and demand for housing services, having negative effect also in prices. The productivity shock produces opposite results. Lastly, shocks in housing prices driven by *market sentiments* have long lasting positive effects on housing production and only contemporaneous positive effects on housing financing. We also present evidence supporting the idea that higher housing prices in recent years were caused not only by an expansionary monetary policy and the boom phase of business cycles in Brazil, but also by shocks to housing prices ("market sentiments").

In sum, we point out that the effects of a restrictive monetary policy can be felt not only by those who aspire to financing but also by those who already have. A contractionary policy, reflected in higher interest rates, would have the effect of raising the cost of mortgage, reducing new funding and increasing the commitment of family income with mortgage interest payments. What is the lesson to be drawn from these results? The monetary authority must take into account the real estate sector behavior in their decision-making process.

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