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Abstract

This article investigates the relationship between residential investment, asset inflation, and macroeconomic dynamics based on the US post-deregulation case (1992-2019). To do so, we estimate a vector error correction model (VECM) to asses the relevance of real interest rate of real estate. Our results report that housing own interest rate explains residential investment growth rate considerably.

Keywords: Real Estate; own interest rate; Vector Error Correction Model; Sraffian supermultiplier.

1 Introduction

The Sraffian supermultiplier (SSM) model presented by Serrano (1995) establishes a prominent role for non-capacity creating autonomous expenditures in the theoretical ground. A current trend among empirical research on demand-led growth agenda is to test its relevance and stability. Freitas and Dweck (2013) present a growth accounting decomposition and show the relevance of those expenditures to describe the Brazilian GDP growth rate between 1970-2005. Braga (2018) shows evidence that economic growth and induced investment are governed by unproductive expenditures in Brazilian economy from 1962 to 2015. For the US, Girardi and Pariboni (2016) show that autonomous expenditures do cause long-run effects on the growth rate. Girardi and Pariboni (2018) bring evidence that autonomous expenditures determine the investment share on GDP for twenty OECD countries. Haluska, Braga, and Summa (2019) employ Granger-causality tests to assess the stability of the SSM for the US (1987-2017). They find: (i) causality goes from autonomous expenditures to the marginal propensity to invest; (ii) induced investment share has a higher temporal persistence and presents slow and statistically significant adjustment rate to demand growth, as described by the SSM.

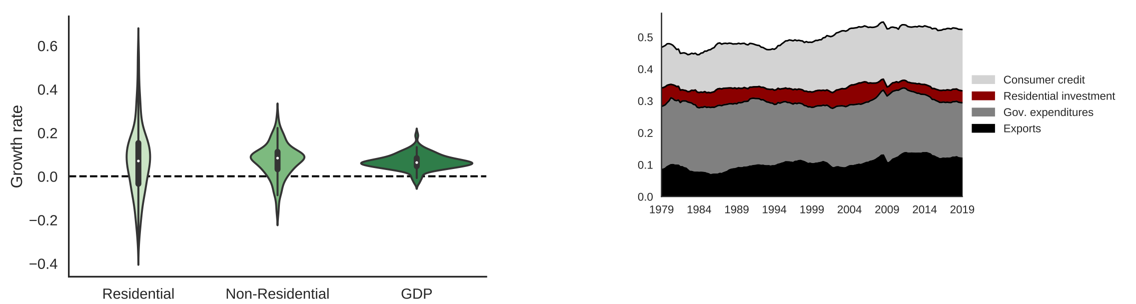
Nevertheless, there still is a lack of studies on the role of residential investment in particular. Except for Green (1997) and Leamer (2007) — which shows the relevance of this expenditure to US business cycle at least since the post-war period —, most of those studies were published after the Great Recession (2008-2009)[1]. Our main objective is to assess the determinants of residential investment growth rate in a Sraffian supermultiplier-friendly framework as proposed by Teixeira (2015). In Section 2, we present some stylized facts for the US economy highlighting the relevance of residential investment. Next, in Section 3, we will present and compare different macroeconometric models that explicitly incorporate residential investment. In Section 4, we estimate a bi-dimensional vector error-correction model (VECM) using time-series data for the US economy from 1992 onward to test the houses' own interest rate presented by Teixeira (2015). Section 5 offers some concluding remarks.

We find residential investment growth rate and houses' own interest rate to be cointegrated. We also find that that long-run causality goes unidirectionally from houses' own interest rate to residential investment growth rate, as expected. The results for all tests are provided in Appendix A. In summary, the findings provided in Section 4 appear to support the relevance of houses' own interest rate in determining residential investment while the other way round does not occur.

1 More precisely, Leamer (2007, p. 8) argues that the US business cycles can be characterized as follows: "*[f]irst homes, then cars, and last business equipment*".

Figure 1. Housing's Particular Stylized Facts

(a) Selected growth rate distribution (1947-2019) (b) Autonomous expenditures share on GDP (US, 1979-2019)



Source: U.S. Bureau of Economic Analysis, Authors' Elaboration

2 Housing Dynamics and Business Cycle in the US Economy

Among aggregate demand expenditures, non-residential investment is one of the most examined (at least) between heterodox macroeconomists. As a consequence, the relevance of other (autonomous) expenditures on macroeconomic dynamics has been underestimated (Brochier and Macedo e Silva, 2017). Residential investment, on the other hand, is not as studied by the literature despite being one of the most volatile expenditure (see Figure 1a). Moreover, however small its share on GDP is (see Figure 1b), it does not imply that it has negligible effects on the business cycle. In this section, we argue that this little attention that residential investment receives is not compatible with its relevance for the US. Furthermore, we show that this significance is not restricted to the recent housing crisis.

It is worth mentioning the novelty of Green (1997) and Leamer (2007) — revisited in Leamer (2015) and by Fiebiger and Lavoie (2018) — when shedding light on the relevance of residential investment even before of the Great Recession. More precisely, Green (1997) reports that residential investment leads — more than firms' investment — the business cycle. However, argues that this result does not imply a causal relationship:

> [P]erhaps residential investment, like stock prices and interest rates, is a good predictor of GDP because it is a series that reflects **forward-looking behavior**. Presumably households will not increase their expenditures on housing unless they expect to prosper in the future. Building a house is a natural mechanism for doing this. Thus, the series can do a good job of predicting GDP **without necessarily causing GDP** (Green, 1997, p. 267, ephasis added).

Despite paying attention to non-capacity creating autonomous expenditure, Green (1997), restricts its relevance as temporal precedence indicator. Leamer (2007), on the other hand, reports a causal relationship between housing and GDP. In summary, states that residential investment implies a higher durable goods consumption, that is, the US business cycle is a "consumer cycle".

Next, we present Figure 2 in order to depict the relation between housing and business cycle in which each cycle is represented in a different panel[2]. The vertical axis represents residential investment-GDP ratio and the horizontal axis represents the rate of capacity utilization as a proxy for business cycle. Economic recovery is generally characterized residential investment growing faster than GDP — with the 1991-2000 period being a particular case. As a consequence of this higher growth rate, is the increase of both residential investment share on GDP and capacity utilization. Following the Sraffian supermultiplier growth model, we conclude that increase of non-residential investment is the result of capital stock adjustment principle. This increase implies GDP to grow faster than residential investment, therefore reducing both its share on GDP and capacity utilization ratio. Finally, as a result of economic

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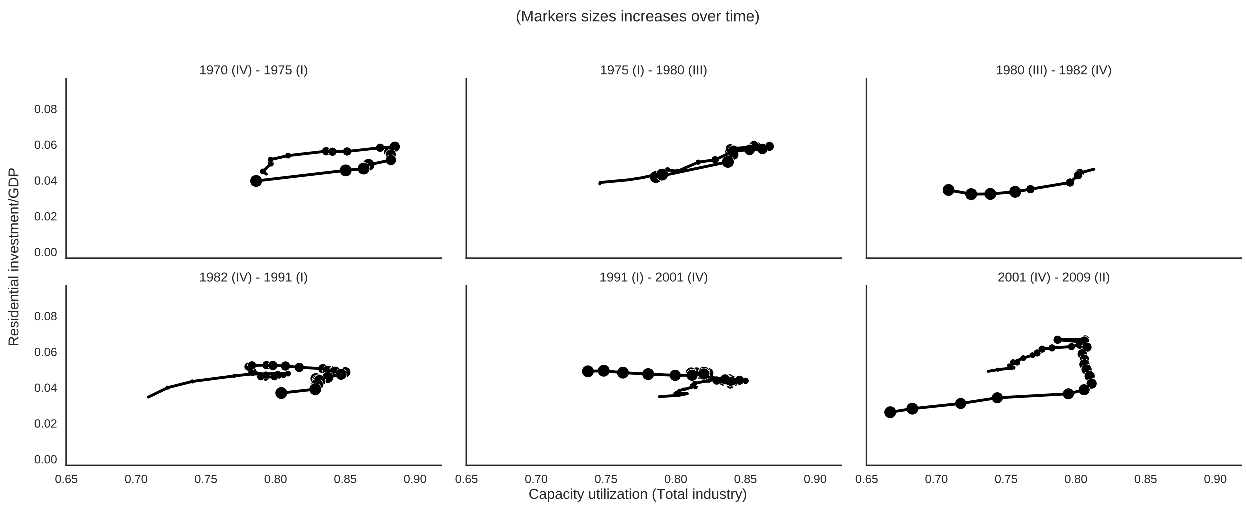
burst, capacity utilization ratio falls and the cycle.

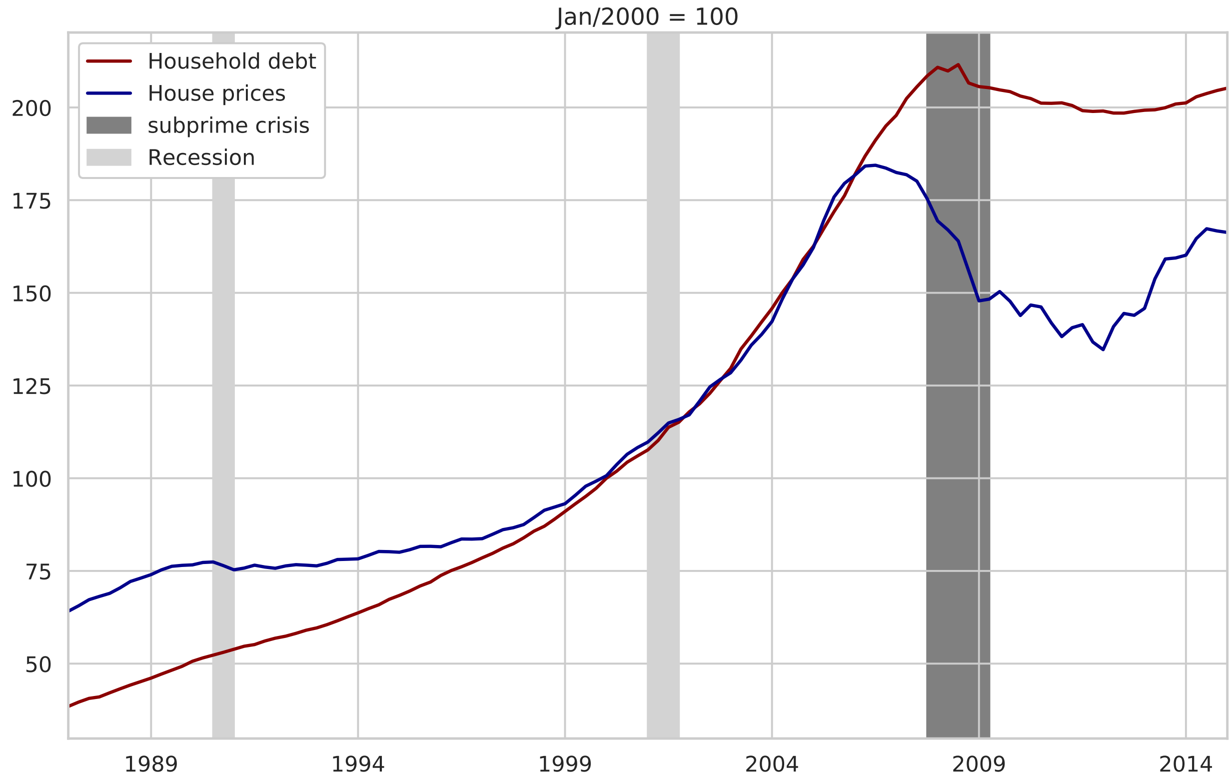
Figure 2. Residential investment share on GDP VS. capacity utilization during recessions



Source: Authors' Elaboration

There is also an indirect relation between housing and aggregate demand. Real estate constitutes a significant portion of household wealth so houses serves as collateral to borrowing (Teixeira, 2012). As a consequence of US institutional arrangement, households — especially the poorest ones — could increase their indebtedness as houses prices went up (see Figure 3) as a way to "realize" capital gains without selling their homes during house bubble of the 2000s (Teixeira, 2015). Therefore, real estate inflation and durable goods consumption are connected and has relevant consequences for business cycle. Zezza (2008) and Barba and Pivetti (2009), for example, report that credit-financed consumption was one of the main drivers of economic growth before the Great Recession.

Figure 3. Household indebtedness and house prices dynamics (jan/2000=100)



Source: U.S. Bureau of Economic Analysis, Authors' Elaboration

This relation between households indebtedness and real estate inflation has other relevant implications. The first is the gap between assets and liabilities in the course of the Great Recession. This dynamic is due both to the housing prices burst (post-2005) and to the insensitivity of households' financial commitments. In other words, real estate (assets) has a market value while debt (liabilities) has a contractual one, thus, households net worth decreases onset of the subprime crisis. Therefore, the second implication is the sharp reduction in the net worth of the poorest households in absolute and relative terms (see Figure 4).

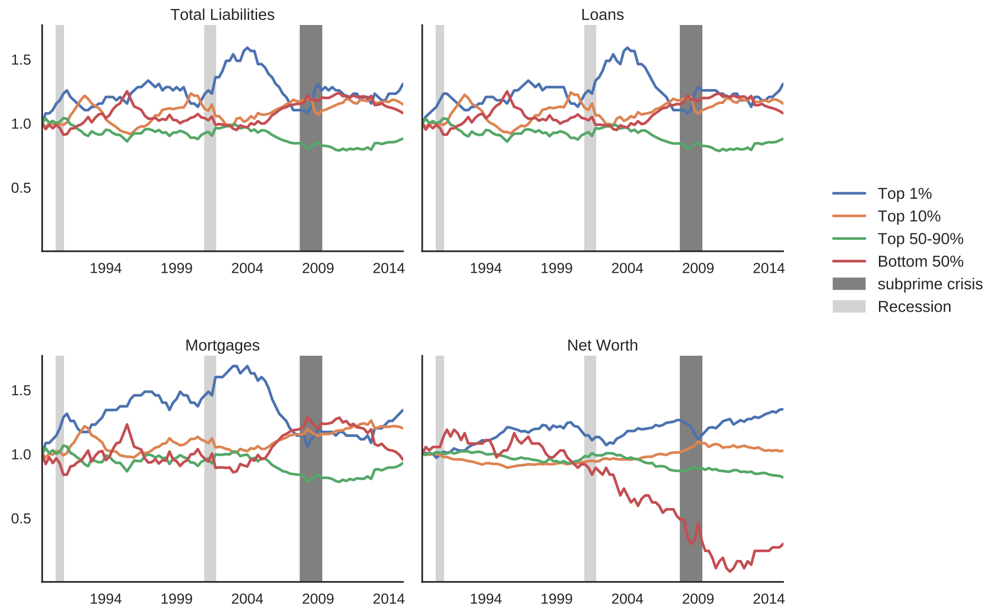
In summary, we conclude that housing is relevant to understand the specificity of US business cycle. On the following section, we analyze how econometric literature has dealt with the topic. More precisely, we evaluate macroeconometric works according to its compatibility with Sraffian supermultiplier growth model.

3 Review of the Macroeconometric Literature

It worth noting that most papers that includes residential investment has failed to treat it macroeconomically, restricting it to microeconomic and regional issues (Arestis and Karakitsos, 2008). However, after the burst of the US housing bubble, there have been a growing attention in the macroeconomic implications of residential investment. In this context, we analyze the macroeconometric literature that explicitly includes housing to evaluate the determinants of its growth rate. Each model will be analyzed according to the compatibility with demand-led growth agenda as well as the possibility of including asset bubbles.

In this sense, Poterba (1984) contribution stands out once it does not assume instantly convergence of real estate supply to the desired level. Furthermore, this theoretical frame considers residential investment as induced positively by house prices. Despite the novelty, this work does not include asset bubbles. In this context, Arestis and González-Martínez (2015) update Poterba (1984) framework by estimating an autoregressive distributed lag

Figure 4. Liabilities evolution by wealth percentile (1989/07=1)



Source: US Census Bureau (2017), Authors' Elaboration

(ARDL) model for 17 OECD countries. In summary, they conclude that residential investment depends mainly on disposable income. This result would question the possibility of treating housing as an autonomous expenditure and jeopardize the analysis from the Sraffian supermultiplier perspective. However, the authors themselves find that this result is not statistically significant for the US in which real house prices and the volume of banking credit are the main determinant of residential investment. In this sense, this result allows considering housing as a non-capacity creating autonomous expenditure.

Alternatively, Huang, Li, Liow, and Zhou (2018) assess both Leamer (2007) hypotheses related to residential investment (prediction and causality). To do so, they estimate a Structural Vector Autoregressive (SVEC) model with wavelets transformation for some OECD countries They find residential investment is not only as monetary policy transmission channel, but it also has temporally distinct effects on business cycle. In the short-run, housing is more predictive while house prices have a bigger influence in the long-run[3]. These distinct temporal influence of housing occurs due to the large wealth effect in the long-run while credit and collateral effect are more relevant in the short-run. Regarding the causal relationship described by Leamer (2007), Huang et al. (2018) report inconclusive results for all countries due to their institutional heterogeneity[4], but remains valid for the US. Despite the inconclusive results on fluctuations, they find that the variables associated with residential investment (house prices, real mortgage rate — deflated by a general price index — and bank spread) lead the business cycle.

Despite clarifying some macroeconomics implications of housing on the business cycle, the results reported above are centered on supply side variables. Gauger and Coxwell Snyder (2003), on the other hand, evaluate the consequences of deregulation of depository institutions throughout the 1980s. To do so, they estimate a VECM between monetary aggregates (M2), GDP, residential investment and alternate between short-term government bonds and long-term mortgage interest rates. They report an increasing contribution of long-term mortgages interest rate over resident investment variance after those institutional chances mentioned above:

> The findings for the two interest rates give valuable information to evaluate results in other studies.

3 More precisely, Huang et al. (2018) also conclude that residential investment prediction increases with its share on GDP.
4 However, Huang et al. (2018) claim that for most G7 countries, residential investment at least amplify the business cycle.

> Results here suggest that use of a short-term FFR and post-deregulation data may lead to conclusions that 'interest rate shocks are much less important after deregulation.' The fuller state of evidence here indicates that interest rate shocks remain important post-deregulation; however, now it is the long-term rate shocks that carry more information for housing sector movements (Gauger and Coxwell Snyder, 2003, p. 346)

It worth noting that Gauger and Coxwell Snyder (2003) work reports other two interesting results: (i) GDP level is determined — as Sraffian supermultiplier suggests — by residential investment and both expenditures share a common long-term trend; (ii) show some relevant institutional changes in real estate market.

Figure 5 illustrates item (ii) mentioned above in which we mark some reforms that occurred due to the savings and loans crisis throughout the 80's and early 90's. This institutional changes — notably Financial Institutions Reform, Recovery, and Enforcement Act (FIRREA) in 1989 and Federal Deposit Insurance Corporation Improvement Act (FDICIA) in 1991 — increased the credit volume to households[5][6]. As a consequence, real estate finance has increased considerably in the following periods.

Although Gauger and Coxwell Snyder (2003) emphasize the relevance of long-term mortgages interest rate in residential investment dynamics, this procedure is not appropriate once policy rate is determined by monetary aggregates. Thus, such a proposal is incompatible with modern macroeconomic theory in which policy rate is an exogenous variable determined through a decision-making process (Lavoie, 2014, p. 230–256).

One way to include residential investment in demand-led growth agenda without incurring problems mentioned above is the houses' own interest rate proposed by Teixeira (2015). In summary, this particular real interest rate depicts both debt service and capital gains effects in households' net worth. On the following section, we discuss this proposal in further details and then evaluate its relevance in a macroeconometric model.

4 Macroeconometric analysis

4.1 Houses' own interest rate and residential investment growth rate in the US Economy

This subsection aims to describe the relationship between residential investment growth rate (g_{I_h}) and houses' own interest rate (own) proposed by Teixeira (2015). Next, we will present the hypothesis to be tested on the Section 4.2. To demonstrate this relationship, the mortgage interest rate (r_{mo}) is deflated by the real estate inflation (π) as follows:

5 Moysich (1997) argues that this consequence stems from the different regulation of S&L compared to commercial banks. The financial deregulation of the 1980s encouraged speculation in other sectors, especially real estate. As a consequence, engendered a banking run, increasing overall credit volume, which, however, was followed by the S&L crisis:

> Clearly, competition from savings and loans did not cause the various crises experienced by the commercial banking industry during the 1980s; these crises would have occurred regardless of the thrift situation. But the channeling of large volumes of deposits into high-risk institutions that speculated in real estate development did create marketplace distortions (Moysich, 1997, p. 168)

Therefore, the increase in credit volume cannot be dissociated from speculation with real estate.

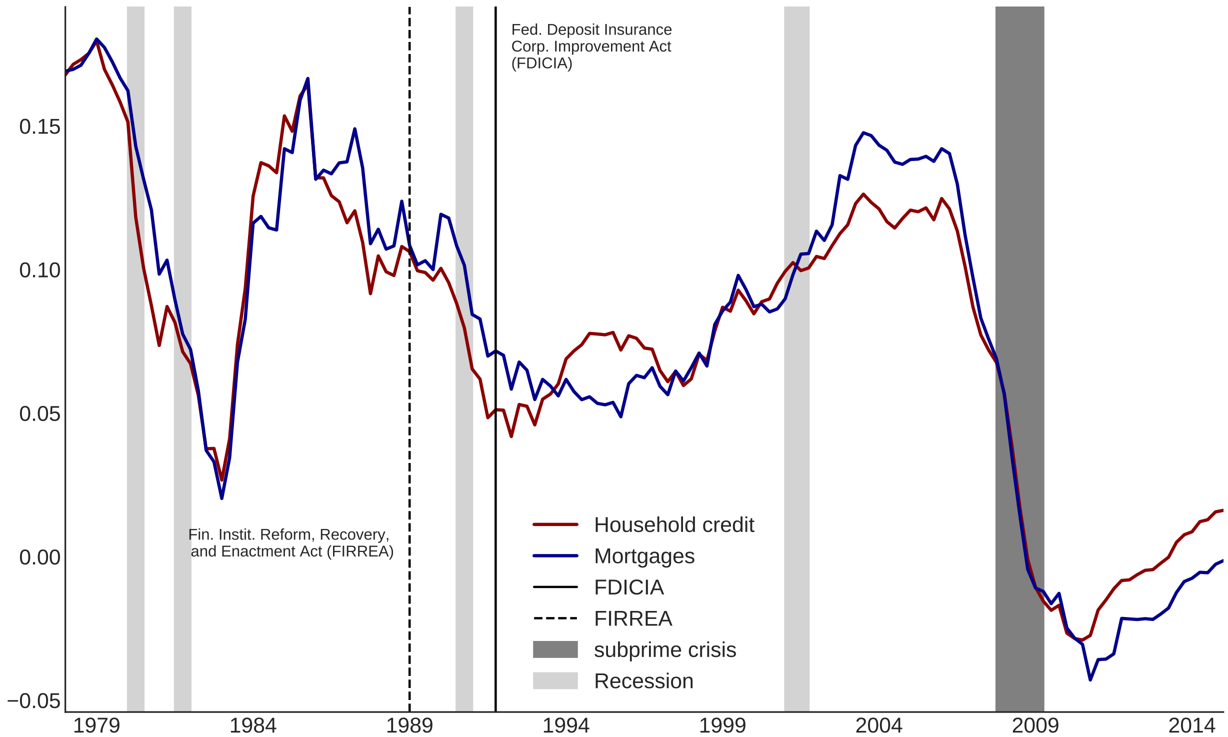
6 According to Moysich (1997), had two main objectives: (i) Recapitalize the bank insurance fund and; (ii) Reform the deposit guarantee system and bank regulation to minimize taxpayer in the event of bank collapse (Mishkin, 1997). Moysich (1997, p. 170) describe banking operation before FDICIA as follows:

> Legislation for S&Ls was driven by the public policy goal of encouraging home ownership. It began with the Federal Home Loan Bank Act of 1932, which established the Federal Home Loan Bank System as a source of liquidity and low-cost financing for S&Ls.

and the implications after its implementation is depicted as:

> Prior to the act's passage, the FDIC and the Federal Savings and Loan Insurance Corporation provided 100 percent *de facto* deposit insurance at almost all failed banks. The FDIC did so by comparing bids to acquire the entire bank (including all its deposits) with the cost of liquidating the bank, which generally produced the result that covering all deposits was less expensive (FDIC 2003, chap. 2). FDICIA sought to change this process by mandating least-cost resolution, which required consideration of all possible resolution methods (FDIC 2003, chap. 2) (Wall, 2010, p. iii)

Figure 5. Mortgage and Consumer credit growth rate (1979-2019)



Source: U.S. Bureau of Economic Analisys, Authors' elaboration

$$g_{I_h} = \phi_0 - \phi_1 \cdot \overbrace{\left(\frac{1 + r_{mo}}{1 + \pi} - 1\right)}^{own}$$

$$g_{I_h} = \phi_0 - \phi_1 \cdot own \tag{1}$$

where ϕ_0 represents long-term determinants (*e.g.* demographic factors, housing and credit policies, etc.) while ϕ_1 captures the demand for real estate arising from expectations of capital gains resulting from speculation with the existing dwellings stock.

This particular real interest rate is the most relevant for households since the holders of an asset take their price into account in the decision-making process since its variation can generate capital gains/losses (Teixeira, 2015, p. 114). In other words, the mortgage interest rate captures debt service for investors — in this case, households — while the real estate inflation allows incorporating changes in equity. Therefore, this own interest rate stands for the real cost in real estate from buying real estate (Teixeira, 2015, p. 53).

Figure FIGURE shows how this deflation procedure is more adequate than a general price index — as Fair (2013, p. 143–6) does — to describe the housing dynamics. It worth noting that during a houses' bubble period, it is real estate inflation that governs own's interest rate dynamics. Therefore, the lower this rate is, the greater the capital gains (in real estate) for speculating with real estate will be. This negative relation between houses' own interest rate and residential investment is shown in Figure FIGURE in which this particular real interest rate has been gradually decreased over the real estate boom (2002-5).

Despite shedding light on some relevant relationships, Teixeira (2015) proposition was not evaluated econometrically and this will be done in Section 4.2. To do so, we assume the following long-run relationship:

$$g_{I_h t} = \phi_0 - \phi_1 \cdot own_t \tag{2}$$

therefore, if these time-series are cointegrated, we model the short-run adjustment process through the following VECM:

$$\begin{cases} \Delta own_t = \delta_1 + \alpha_1 \left(g_{I_{h_{t-1}}} - \phi_0 + \phi_1 \cdot own_{t-1} \right) + \sum_{i=1}^{N=4} \beta_{1,i} \cdot \Delta g_{I_{h_{t-i}}} + \sum_{i=1}^{N=4} \gamma_{1,i} \cdot \Delta own_{t-i} + \varepsilon_{t,1} \\ \Delta g_{Z_t} = \delta_2 + \alpha_2 \left(g_{I_{h_{t-1}}} - \phi_0 + \phi_1 \cdot own_{t-1} \right) + \sum_{i=1}^{N=4} \beta_{2,i} \cdot \Delta g_{I_{h_{t-i}}} + \sum_{i=1}^{N=4} \gamma_{2,i} \cdot \Delta own_{t-i} + \varepsilon_{t,2} \end{cases} \tag{3}$$

where δ_s indicate linear trend in the series (level); α_{is} are the error correction coefficients ; β_s e γ_s are coefficients associated with lagged g_{I_h} and own respectively and; ε_s are the residual. According to Teixeira (2015), the expected results are depicted in Table 1 below:

Table 1. Summary of expected results of the macroeconometric model

Expected Result	**Econometric Meaning**	**Economic Meaning**
1. $\varepsilon \sim I0$	Stationary residuals indicates cointegration relationship	Series share a common long-run trend
2. $\alpha_1 = 0$	own is weakly exogenous compered to g_{I_h}	own dynamics is not affected by previous equilibrium deviation
3. $\alpha_2 < 0$	Own interest rate Granger-causes residential investment growth rate	g_{I_h} dynamics is not affected by previous equilibrium deviation
4. $\phi_1 > 0$	Series share a common negative long-run relationship	Own interest rate affects residential investment growth rate negatively
5. $\phi_0 < 0$	Real estate demand for non-speculation reasons is statistically significant	Real estate demand associated with institutional particularities and demographic changes affects residential investment growth rate positively
6. $\gamma_{2,is} < 0$	Residential investment growth rate coefficient is statistically significant	Own interest rate affects g_{I_h} in the short-run
7. $\beta_{1,is} = 0$	g_{I_h} effects over own interest rate is not statistically significant	g_{I_h} effects over own interest rate is negligible since dwellings stock is much bigger than residential investment (flow)

Source: Authors' elaboration

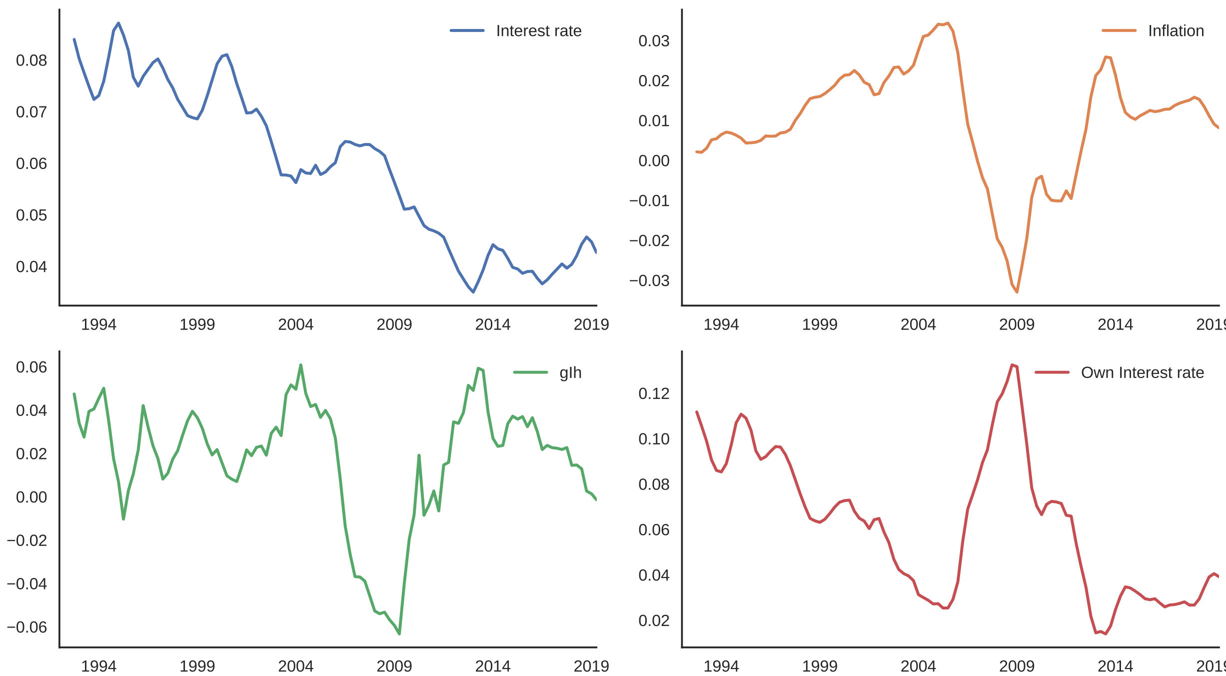
4.2 Data and estimation strategy

In this section, we employ a model to test if real estate inflation describes residential investment growth rate dynamics[7]. Our sample period (1992:Q1 to 2019:Q1) starts after institutional changes (FDIC e FIRREA) due to the Savings and Loans crisis (see Table 4 in appendix A for some related structural breaks). We rely on the following quarterly seasonally adjusted data: (i) 30-Year fixed mortgage interest rate (MORTGAGE30US, resampled by end of period), private residential investment (PRFI, growth rate as percent change from the previous quarter) and Case-Shiller home price index (CSUSHPISA, resampled by end of period).

7 Scripts are available under request.

Next, we applied Yeo and Johnson (2000) transformation since these series are quite volatile. The reason for using this procedure instead of Box and Cox (1964) transformation it can be applied to non-positive values. Then, we employ standard unit root tests (see Table 3 in appendix A) as well as Johansen (1991) procedure to assess whether houses' own interest rate and residential investment growth rate share a common long-run trend (see Table 5 in appendix A). Our series are cointegrated at 5% significance level which allows us to estimate a error correction model and evaluate the previous hypothesis (Enders, 2014).

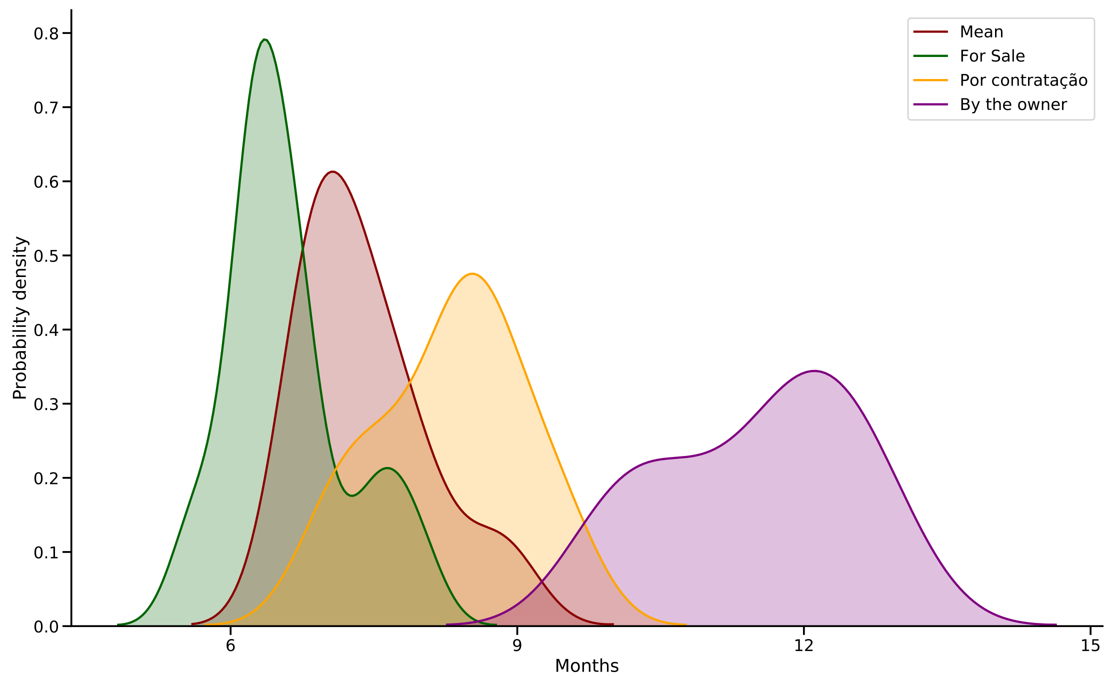
Figure 6. Time-series with Yeo and Johnson (2000) transformation



Source: U.S. Bureau of Economic Analysis, Authors' elaboration

The next step is to define the order of lags. According to usual information criteria, both first and forth lags are eligible (see Table 6 in appendix A). Although parsimonious, the choice of the first lag has no empirical support. Considering the average construction time (from approval to completion), we should include at least the second in order to incorporate homes built for capital gains purposes which only take place once the construction is completed (see Figure 7).

Figure 7. Average construction time (approval to completion) of properties for a family unit by construction purposes except manufactured houses (1976-2018)



Source: Survey of Construction (SOC), Authors' elaboration

This procedure, however, it is not enough to determine the model order. Since residential investment (flow) is significantly smaller than dwelling ()existing stock), the price variation effect is verified even when the construction is unfinished. We argue that this price effect is a result of future real estate inflation. Such dynamic would be captured by the **expected** houses' own interest rate. However, such series does not exist. So, we use lagged houses' own interest rate as a first approximation to the expected one[8].

In order to display the relation between lagged own interest rate and current residential investment growth rate, Figure 8 depicts one variable of interest against the other variable lagged according to lags that minimize the information criteria (1 and 4 respectively)[9]. This simple procedure allows checking if there is any relationship between the expected own interest rate (in this case, lagged effective rate) and residential investment growth rate[10]. In the same Figure, we verify that the inverse relationship, that is, from residential investment to own interest rate, does not occur. The lack of relationship in the opposite direction reflects a dynamics already mentioned before. Since residential investment (flow) is much lower than the existing stock of dwellings, it is expected that such relationship does not exist. In summary, speculation with the dwellings stock generates inflation of these assets, which affects the construction of new houses (flow) and not the other way round[11].

8 This procedure is similar to Keynes (1937) "practical theory of the future" in which decision-making process for buying a new property depends on expectations/conventions based on past observations. In summary, in the absence of a series for the expected own interest rate, the lag of this variable will be used as a proxy for the future one.

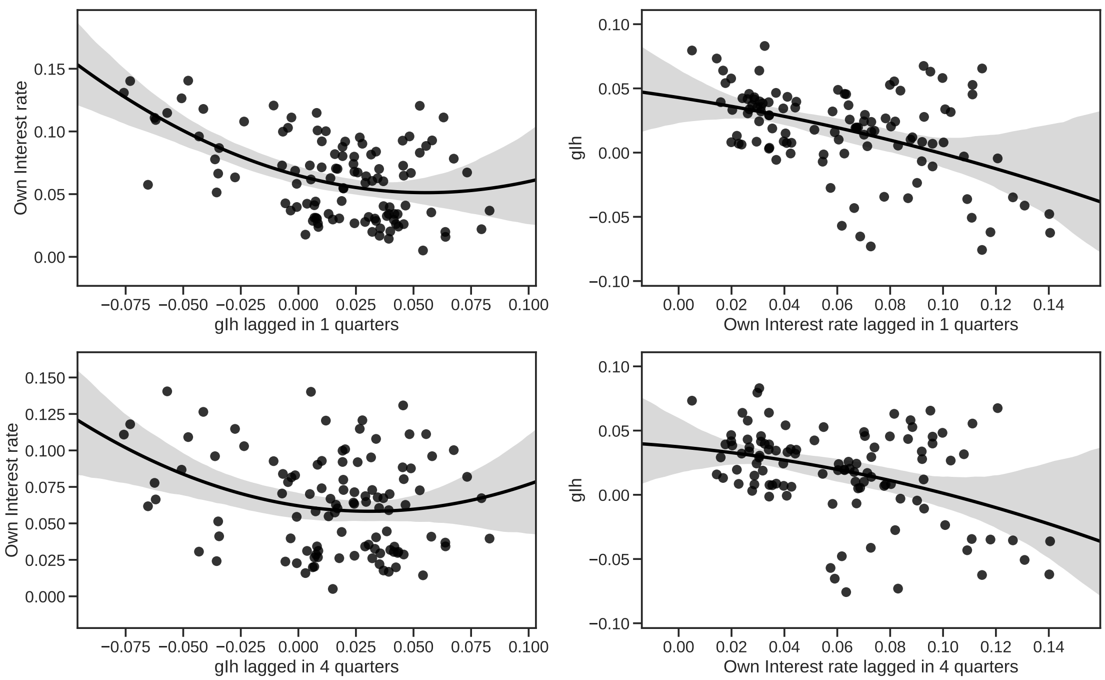
9 Similar plot can be seen in Girardi and Pariboni (2015, p. 16).

10 In order to consider non-linearities, we presented quadratic regression between variables of interest.

11 It is worth noting a particular aspect of house price formation: land scarcity. As a consequence, speculation with residences is, in the end, speculation with land (the only scarce resource involved in its production) and, therefore, it is relevant for speculation with the dwellings stock. Leamer (2007, p. 349, emphasis added) points out this particularity as follows:

> It's not the structure that has a volatile price; **it's the land**. Where there is plenty of buildable land, the response to an increase is demand for homes is mostly to build more, not to increase prices. Where there is little buildable land, the response to an increase in demand for homes is mostly a price increase, sufficient to discourage buyers enough to reequilibrate the supply and demand.

Figure 8. Dispersion between houses' own interest rate and residential investment growth: lags selected based on information criteria



Source: Authors' elaboration

From this theoretical and econometric discussion of model order specification, we estimate a VEC with four lags (see Table 2)[12]. Figure 9 displays an inspection of the residuals while Table 7 in Appendix A presents a few residual tests to check the model's specification. On the following subsection, we analyze if our estimation supports the hypothesis presented in Table 1 above.

4.3 Estimation results

According to parameters presented in Table 2, we find statistically significant cointegration coefficients for both equations. Therefore, both variables share a (negative) long-run trend (validating hypotheses 1 and 4). The short-term relationship between own and g_{Ih} ($\beta_{1,is}$ coefficients) are not statistically significant at 5%[13]. In addition, coefficients $\gamma_{2,s}$ are negative and statistically significant at 5%, supporting hypothesis 6 (see Table 2). We also find statistically significant coefficients related to demand for properties for non-speculative reasons (ϕ_0), validating proposition 5. On the other hand, the error correction parameter is statistically significant only for the residential investment growth rate equation. In this sense, own is weakly exogenous compared to g_{I_h} while houses' own interest rate Granger-causes g_{I_h}, supporting the hypothesis (2) and (3). In conclusion, our estimation results are in line with the hypothesis presented above and can be summarized as follows: houses' own interest rate determines — but is not determined by — residential investment growth rate and these variables present a negative long-term relationship (are cointegrated).

Figure 10 display the forescas error variance decomposition (FEVD) which reports houses own interest rate in describing residential investment growth rate dynamics[14]. We report that own interest rate has depicted g_{Ih} — while

12 In addition to being theoretically based, this lag also generates homocedastic residuals without serial auto-correlation (see Table 7 in Appendix A).
13 The expected result (7) can also be validated from the inspection of Table 2 in which only the fourth lag of own interest rate equation is statistically significant.
14 It is important to note that the number of variables (two) used generates similar of a Structural VEC, which means that Choleski's decomposition

Table 2. Estimation parameters

Equation: own	**coef**	**std err**	**z**	**P$>\|$z$\|$**	**[0.025**	**0.975]**
δ_1	-1.632e-05	4.4e-05	-0.371	0.710	-0.000	6.98e-05
$\gamma_{1,1}$ ($L_1\,own$)	0.0381	0.111	0.342	0.732	-0.180	0.256
$\beta_{1,1}$ ($L_1 g_{I_h}$)	0.0738	0.083	0.887	0.375	-0.089	0.237
$\gamma_{1,2}$ ($L_2\,own$)	-0.0032	0.110	-0.029	0.977	-0.218	0.212
$\beta_{1,2}$ ($L_2 g_{I_h}$)	0.1115	0.082	1.366	0.172	-0.048	0.272
$\gamma_{1,3}$ ($L_3\,own$)	0.0757	0.118	0.642	0.521	-0.156	0.307
$\beta_{1,3}$ ($L_3 g_{I_h}$)	0.1080	0.069	1.563	0.118	-0.027	0.243
$\gamma_{1,4}$ ($L_4\,own$)	0.2649	0.119	2.230	0.026***	0.032	0.498
$\beta_{1,4}$ ($L_4 g_{I_h}$)	0.0583	0.054	1.089	0.276	-0.047	0.163
Equation: g_{I_h}	**coef**	**std err**	**z**	**P$>\|$z$\|$**	**[0.025**	**0.975]**
δ_2	-0.0003	6.96e-05	-3.848	0.000***	-0.000	-0.000
$\gamma_{2,1}$ ($L_1\,own$)	-0.1747	0.176	-0.991	0.322	-0.520	0.171
$\beta_{2,1}$ ($L_2 g_{I_h}$)	-0.4203	0.132	-3.191	0.001***	-0.678	-0.162
$\gamma_{2,2}$ ($L_2\,own$)	-0.9997	0.174	-5.752	0.000***	-1.340	-0.659
$\beta_{2,2}$ ($L_1 g_{I_h}$)	-0.4596	0.129	-3.555	0.000***	-0.713	-0.206
$\gamma_{2,3}$ ($L_3\,own$)	-0.5863	0.187	-3.137	0.002***	-0.953	-0.220
$\beta_{2,3}$ ($L_3 g_{I_h}$)	-0.1991	0.109	-1.820	0.069*	-0.414	0.015
$\gamma_{2,4}$ ($L_4\,own$)	-0.5350	0.188	-2.844	0.004***	-0.904	-0.166
$\beta_{2,4}$ ($L_4 g_{I_h}$)	-0.2444	0.085	-2.885	0.004***	-0.411	-0.078
Error correction	**coef**	**std err**	**z**	**P$>\|$z$\|$**	**[0.025**	**0.975]**
α_1	-0.0232	0.071	-0.328	0.743	-0.162	0.116
α_2	-0.4245	0.112	-3.784	0.000***	-0.644	-0.205
Cointegration relationship	**coef**	**std err**	**z**	**P$>\|$z$\|$**	**[0.025**	**0.975]**
$\phi_{1,1}$	1.0000	0	0	0.000***	1.000	1.000
$\phi_{1,2}$	1.2835	0.149	8.599	0.000***	0.991	1.576
ϕ_0	-0.1131	0.009	-12.528	0.000**	-0.131	-0.095

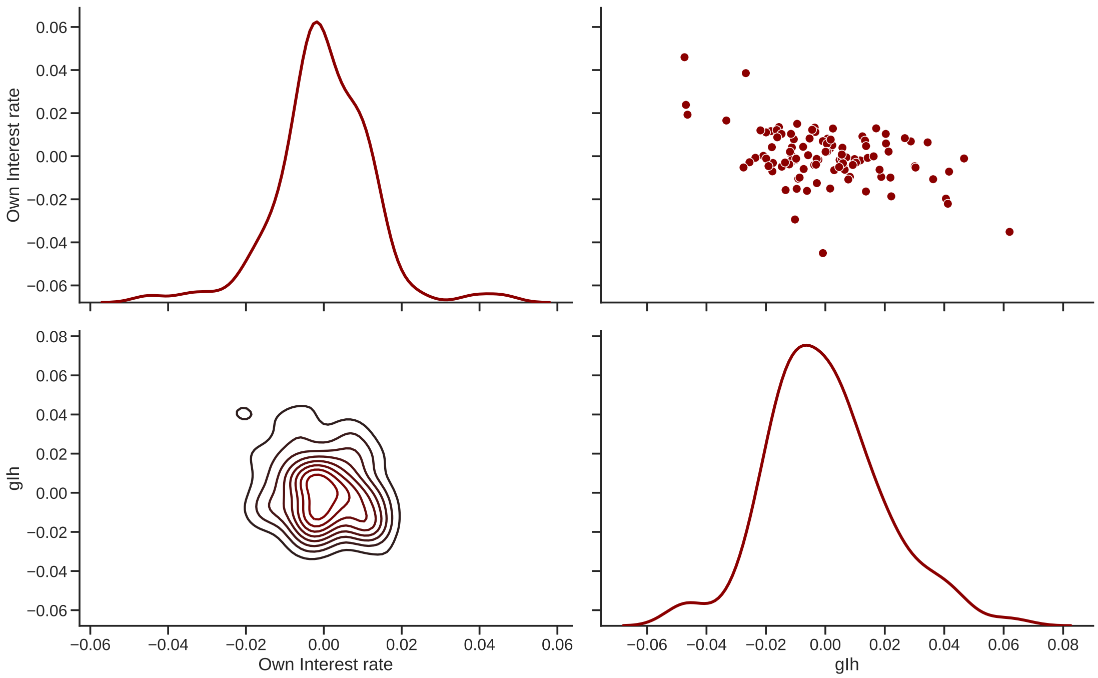
(*) Statistically significant at 10%; (**) Statistically significant at 5%; (***) Statistically significant at 1%.

Source: Authors' elaboration

the reverse is not valid — since the first quarter. In addition, we find that such contribution is growing and greater than 50% beyond the third quarter. Therefore, houses' own interest rate is explained mainly by itself and explains g_{I_h} considerably.

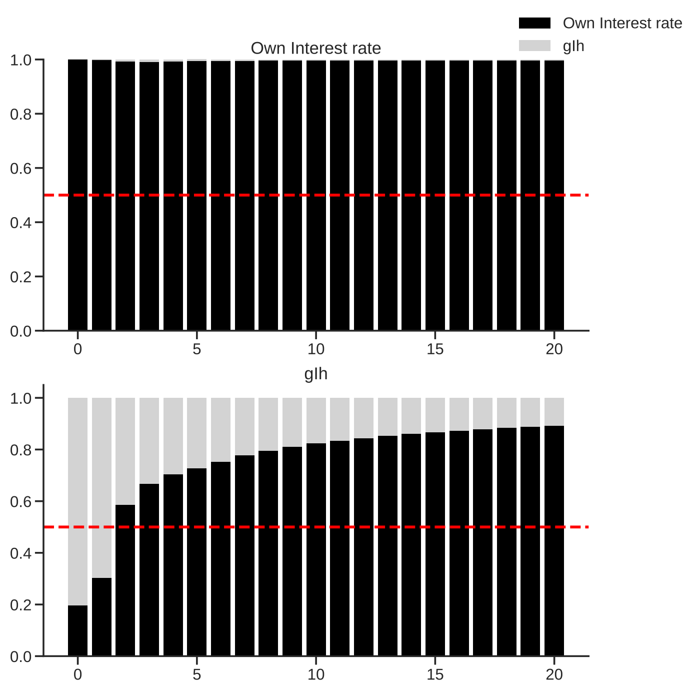
is sufficient to analyze the (orthogonalized) impulse response function.

Figure 9. Inspection of estimation residuals



Source: Authors' elaboration

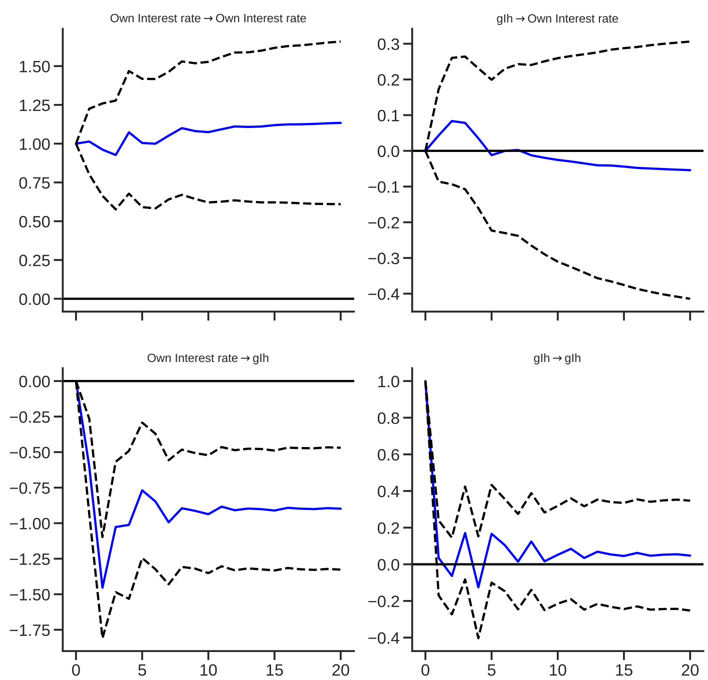
Figure 10. Forecast error variance decomposition (FEVD)



Source: Authors' elaboration

Next, we analyze the orthoganilized impulse response function (Figure 11). In summary, we report a stable system since the increase in g_{I_h} on itself are dampened over time while equivalent shock on own interest rate has a non-explosive permanent effect. On the other hand, an increase in g_{I_h} has a null effect over own. The most relevant result reported in Figure 11 is the considerable and lasting negative effect due to an increase in own interest rate over g_{I_h}, validating Teixeira (2015) proposition. In short, our results shows that an increase in mortgage interest rate (equivalent to an increase in houses' own interest rate) has a negative and persistent effect on residential investment growth rate while an increase in real estate inflation has an opposite effect.

Figure 11. Orthogonalized Impulse Response Function



Source: Authors' elaboration

In summary, our estimation reports that houses' own interest rate has a prominent role in describing residential investment growth rate dynamics. It is worth noting that despite the amplitude of VEC order, the estimated model is quite parsimonious in terms of the number of variables. Thus, considering its parsimony and robustness, we conclude that our estimation depicts residential investment growth rate satisfactorily. On the following section we present some concluding remarks.

5 Concluding Remarks

In this article, we present a residential investment growth rate specification compatible with the Srrafian supermultiplier model. To do so, we estimate a bi-dimension VEC evaluate Teixeira (2015) proposal. We report: (i) Houses' own interest rate (own) and residential investment growth rate (g_{I_h}) share a common long-run trend; (ii) g_{I_h} effects over own are negligible and; (iii) own interest rate has a negative effect on g_{I_h} and is its main determinant (see Figure 10). Besides being parsimonious, our estimations does not show residuals serial autocorrelation and heteroscedasticity. Thus, our results are quite satisfactory.

It remains to contrast our findings with those obtained by Arestis and González-Martínez (2015). It worth remembering that one of the authors' hypotheses is that residential investment depends on disposable income (is induced expenditure). However, the authors themselves find that such results are not statistically significant for the US. Therefore, we can compare this result with our model. Despite the differences, some results of the model are in line with those of Arestis and González-Martínez (2015). Among them, house prices relevance in determining residential investment dynamics for the US. However, they report insignificant coefficients for mortgages nominal interest rate, that is, the opposite conclusion of our model.

In conclusion, we report lack of work analyzing residential investment in a Sraffian supermultiplier-friendly framework in the macroeconometric literature. Our estimation supports houses' own interest rate relevance in describing residential investment growth rate for the US as depicted by Teixeira (2015). Thus, our proposal differs from the usual empirical literature by: (i) considering housing as a non-capacity creating autonomous expenditure; (ii) reporting that mortgage interest rates are relevant to describe long-run residential investment dynamics; and notably (iii) including asset bubble through houses own interest rate.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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A Statistical Appendix

In this appendix we report several tests: unit root tests on our variables of interest, Structural break test, Johansen procedure and hypothesis tests on residuals. The time-series of residential investment growth rate, mortgage interest rate and real estate inflation are all taken using Yeo and Johnson (2000) transformation. As shown in Table 3, the null of a unit root in the first differences of the series is overwhelmingly rejected.

COMENTAR OUTRAS TABELAS.

Table 3. Unit root tests

Variable		**ADF**[a]		**Zivot Andrews**[b]		**Phillips Perron**[a]		**KPSS**[c]	
		Statistic	p-value	Statistic	p-value	Statistic	p-value	Statistic	p-value
Residential investment (g_{I_h})	level	-3.333	0.013	-4.439	0.139	-6.165	0.000	0.181	0.309
	first difference	-7.155	0.000	-7.739	0.000	-20.346	0.000	0.106	0.558
Real estate inflation	level	-2.671	0.079	-4.871	0.043	-2.704	0.073	0.148	0.395
	first difference	-4.680	0.000	-6.122	0.001	-11.340	0.000	0.059	0.819
Houses' own interest rate	level	-2.330	0.162	-4.203	0.237	-2.425	0.135	0.690	0.014
	first difference	-5.087	0.000	-6.340	0.000	-10.408	0.000	0.062	0.804
Mortgage interest rate	level	-3.638	0.027	-4.494	0.215	-3.604	0.030	0.081	0.264
	first difference	-8.050	0.000	-8.144	0.000	-11.127	0.000	0.034	0.962

[a] H0: has a unit root.
[b] H0: has a unit root and a structural break.
[c] H0: series is weakly stationary.

Source: Authors' elaboration

Table 4. Structural break test

Variable	Break	Chow test[a]	
		Statistic	p-value
Residential investment (g_{I_h})	1991/Q3	5.1147	0.0254
	2005/Q4	7.286	0.007881
	2010/Q3	6.1013	0.01481
Own interest rate	1991/Q3	63.453	7.487e-13
	1996/Q3	107.47	<2.2e-16
	2001/Q2	78.378	5.662e-15
	2006/Q1	20.68	1.236e-05
	2011/Q1	78.969	4.663e-15
Mortgage interest rate	1991/Q3	124.35	<2.2e-16
	1997/Q1	199.25	<2.2e-16
	2002/Q1	301.18	<2.2e-16
	2009/Q4	172.97	<2.2e-16
Real estate inflation	1997/Q3	1.5508	0.2153
	2005/Q4	23.49	3.569e-06
	2011/Q3	4.4981	0.03586

[a] H0: There is no structural break.

Source: Authors' elaboration

Table 5. Cointegration test

Model specification	Hypothesis	Johansen Procedure[a]	
		Statistic	critical value (5%)
g_{I_h}, **Own interest rate**	$r = 0$	22.51	19.96
	$r = 1^*$	2.91	9.24
g_{I_h}, **Inflation and Mortgage interest rate**	$r = 0$	46.05	34.91
	$r = 1^*$	15.08	19.96
	$r = 2$	6.44	9.24
g_{I_h}, **Inflation and exogenous mortgages interest rate**	$r = 0$	36.88	19.96
	$r = 1^*$	7.87	9.24

(a) Using trace test with constant for the 5th lag (according to AIC criteria). (*) Indicates the selected rank that implies cointegration.

Source: Authors' elaboration

Table 6. Selection model order (* indicates the minimum)

	AIC	BIC	FPE	HQIC
0	-13.86	-13.71	9.553e-07	-13.80
1	-14.71	-14.46*	4.102e-07	-14.61
2	-14.72	-14.38	4.038e-07	-14.58
3	-14.74	-14.29	3.983e-07	-14.56
4	-14.88	-14.34	3.442e-07	-14.66*
5	-14.89*	-14.24	3.425e-07*	-14.63
6	-14.84	-14.09	3.612e-07	-14.54
7	-14.82	-13.97	3.696e-07	-14.47
8	-14.77	-13.82	3.891e-07	-14.38
9	-14.75	-13.71	3.961e-07	-14.33
10	-14.70	-13.56	4.189e-07	-14.24
11	-14.67	-13.43	4.308e-07	-14.17
12	-14.63	-13.29	4.535e-07	-14.08
13	-14.66	-13.22	4.406e-07	-14.08
14	-14.63	-13.09	4.582e-07	-14.00
15	-14.59	-12.95	4.806e-07	-13.92

Source: Authors' elaboration

Table 7. Hypothesis tests on residuals

		Statistic	**p-value**
Serial autocorrelation[a]	System	54.51	0.093
Homoscedasticity[b]	own	1.863	0.175
	g_{I_h}	3.080	0.082
Normality[c]	System	46.64	0.000

[a] Adjusted Portmanteau tested until up to 15th *lag*. H0: autocorrelations up to the selected lag equal zero.
[b] ARCH-LM test. H0: Residuals are homoscedastic.
[c] Jarque-Bera test. H0: data generated by normally-distributed process.

Source: Authors' elaboration