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A tale of three prices: Monetary policy and autonomous consumption in the US☆

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ABSTRACT

This paper empirically assesses the role of monetary policy, real estate prices, housing rent, and consumer prices in the determination of autonomous consumption and output. To do this, six different Structural VAR models are estimated on US quarterly data for the period 1970-2020. The estimations suggest that: i. houses' own interest rate (which reflects the actual cost of buying a house) produces more persistent and statistically significant effects on autonomous consumption and on output than the real interest rate; ii. monetary policy transmission works through autonomous consumption, in particular via changes in housing prices; iii. autonomous consumption shocks trigger persistent and long-lasting effects on the output level. Last, when analysing separately the three price indexes considered, it is possible to observe the emergence of a price puzzle.

1. Introduction

As the epicentre of the ground breaking financial shock that led to the Global Financial Crisis, the housing market gradually attracted greater attention in academia and beyond. Nevertheless, even before the policy tools of the FED ended up on shaky grounds, a great amount of research has been produced within the mainstream to investigate the transmission channels of monetary policy. Bernanke and Gertler (1995), for instance, argue that finding a direct channel between monetary policy and output would require going "inside the black box", concluding that it is unclear how interest rates affect the real economy.

From a post-Keynesian perspective, the transmission channels of monetary policy, grounded in the downward sloping IS curve, have been challenged early in the days of heated debate among Cambridge UK/US scholars on the 'capital controversy'. In fact, a whole theoretical body grounded in the works of Sraffa (1960) and Garegnani (1970, 1978) has challenged the theoretical consistency of a downward-sloping investment demand curve through the possibility of re-switching of techniques, leading to the conclusion that investment only reacts to shifts in 'final demand'. Consequently, the link between interest rate and output can be attributed to autonomous components of demand, particularly autonomous consumption, which in turn affect investment (Deleidi, 2018). In fact, these linkages lie at the core of the endogenous money theory, according to which money supply is credit-led and demand-determined (Cesaratto, 2017; Cesaratto and Di Bucchianico, 2020; Dejuán and Dejuán-Bitriá, 2022).

Along these lines, the present contribution seeks to empirically assess the role of real estate prices, housing rent, consumer prices, and monetary policy in an amended autonomous consumption equation, in line with the Sraffian Supermultiplier (SSM, henceforth) approach (Serrano, 1995). To do this, six different Structural VAR (SVAR, henceforth) models are estimated on US quarterly data for the period 1970–2020. By using SVAR models, it is possible to identify exogenous autonomous consumption, price and monetary policy shocks. To do this, a recursive identification strategy is employed, based on a standard Cholesky decomposition, which is commonly used in the literature to

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isolate monetary policy shocks (e.g., Christiano et al. 1999; Castelnuovo and Surico 2010; Deleidi and Levrero, 2021; Cucciniello et al. 2022).[1] The novelties of this investigation are manifold : (i) confirming the hypotheses that houses' own interest rate (which reflects the actual cost of buying a house) produces more persistent and statistically significant effects on autonomous consumption and output than the real interest rate; (ii) confirming the hypotheses that monetary policy transmission works through autonomous consumption, in particular via changes in housing prices; (iii) verifying the persistence of the effect of autonomous consumption on output; (iv) assessing the dynamics of three prices (housing prices, rent prices, and overall consumer price index measured by the CPI).

The remainder of this paper is organized as follows. Section 2 highlights the differences between the New Consensus Model and the post-Keynesian framework regarding monetary policy tools and transmission mechanisms. Section 2 also provides a brief review of the empirical contributions that analysed the role of the real estate sector in output determination and monetary policy transmission, while emphasizing the gaps in the literature that this contribution seeks to fill through the theoretical elements of the amended autonomous consumption equation, which are then empirically tested. In Section 3, both data and methods employed are presented. In Section 4, the empirical findings of all estimated models are displayed and discussed, drawing some policy implications. Finally, Section 5 concludes.

2. Monetary policy and the role of housing prices and dwellings: A theoretical and empirical overview

This section first discusses monetary policy tools and their transmission mechanisms, with particular attention given to the distinctions between the New Consensus Model (NCM, henceforth) and the post-Keynesian (PK, henceforth) framework (in particular grounded in the Sraffian tradition). Given the significance of housing in the transmission of monetary policy, this section briefly reviews previous contributions that have investigated the role of the real estate sector in determining the business cycle and output trends. Subsequently, an amended version of the SSM autonomous consumption equation is presented, which serves as the foundation for the empirical estimations discussed in the following sections.

In practice, modern monetary policy framework uses an inflation target, controlled by the monetary authorities that no longer aim at controlling the supply of monetary aggregates.[2] In the US, the base rate is targeted as the overnight rate (Federal Funds Rate), which is the main instrument of the FED when it comes to controlling the spectrum of interest rates.[3] The shift towards this new policy framework is grounded in the NCM, which combines inflation targeting with the use of interest rate as the policy tool (i.e. the inflation targeting regime). This framework is grounded on three equations New Keynesian model composed of an IS curve, a Phillips curve, and an interest rate-based monetary policy rule (Taylor Rule). Notwithstanding the fact that the mainstream adopted a Taylor rule, which is an interest rate rule, too little has changed. This is in fact confirmed by Romer (2000), that argues that "[t]he main change is that it replaces [...] the money supply with [...] a simple interest rate rule". In this sense, as argued by Lavoie (2004, p.16), the NCM is still very much "old wine in new bottle". First, while relying on a long-run vertical Phillips-curve, the NCM is perfectly in line with the idea of a NAIRU (non-inflationary rate of unemployment), which can be summarized in the disappearance of a trade-off between inflation and activity level in the long run. As in the monetarist view, money ends up being neutral in the long run. Second, in the short run, the real effects of monetary policy are outlined in the IS curve.[4]

The success of inflation targeting will depend, in turn, on the transmission mechanisms of monetary policy that are grounded on the downward sloping Phillips-curve (in the short run) and on the sensitivity of investment to changes in the interest rate (the IS curve). In other words, changes in the interest rate must have a predictable impact on output (IS curve), which, in turn, needs to have a predictable impact on prices and inflation (Phillips Curve). Accordingly, it is important to identify the Phillips curve and the IS curve must be well-behaved. Both of the mechanisms can be found to have significant problems from a PK perspective. In fact, the cost of capital argument influencing investment has hardly found any empirical foundation, in the sense that it would appear to lag behind the reaction in the housing sector, and this is also in line with what New Keynesians find.[5]

From a PK perspective, authors from different strands have criticized the mechanisms of monetary policy transmission through the IS curve. If in fact, spending (and particularly business investments) is not sensitive to shifts in the interest rate, "very large reductions in the interest rate are necessary to offset the effects of even modest negative demand shocks" (Cynamon et al., 2013, p.9). This is justified by the fact that, according to the PK literature, money is credit-led and demand determined; loose monetary policy might thus be as 'pushing on string'.[6] The inverse also holds true, "unless interest rates are changed by drastic amounts (that may jeopardize the stability of the financial system)" (Kriesler and Lavoie, 2007, p.391).

PKs from a Sraffian background have also shown concern about the relationship between interest rates and investment: "neither economic theory nor the facts offer any compelling reason to think that investment is particularly interest-elastic. On the contrary, theory and facts both appear to refute the existence of any such elasticity" (Garegnani, 2015, p.113). Indeed, the challenge of the theoretical consistency of

[1] For a detailed review on SVAR models and the recursive identification strategy, the interested reader might refer to Ramey (2016) and Kilian and Lütkepohl (2017).

[2] The monetary policy management through interest rate setting is a rather recent phenomenon. In the US, for instance, since the early 1920s until the 1990s the reserve position doctrine prevailed (see Bindseil, 2004 for an in depth chronological review). Accordingly, until 1990, monetary policy was mainly conducted via open market operations, that would somewhat target reserves, impacting, in turn, the monetary aggregates via the money multiplier.

[3] The tight control of short-rates (especially in the case of private sector issued securities) may deviate from the target set by the central bank, particularly in turbulent times. In this sense, liquidity preference may affect the differentials relative to the base rate, but it certainly does not affect the central bank's determination of the latter as a discretionary policy tool in the hands of the monetary authority (Lavoie, 2014).

[4] The short run effects of monetary policy can also be challenged from a New Keynesian perspective if we take into account wage and price rigidities (Taylor, 1999).

[5] As argued by Sharpe and Suarez (2015, p.1): "[a] large body of empirical research offers mixed evidence, at best, for substantial interest-rate effects on investment". For instance, Bernanke and Gertler (1995) show that productive investment and output respond very slowly to monetary policy shocks. The authors also find that other expenditure components such as consumer durables and housing respond much faster.

[6] The first distinctive feature among PK scholars as regards monetary theory is undoubtedly the endogeneity of money. In particular, money-supply is demand-determined and credit-driven, depending on creditworthy demand for bank credit. While mainstream monetary theories tend to assume that the causality runs from deposits that allows creation of credit through the bank multiplier, for PKs the causality runs in the opposite direction, i.e. bank deposits are created in the occasion of bank credit concession. Accordingly, bank reserves are endogenous and credit-demand-determined, being a fraction of the amount of bank deposits. The concept of credit-driven money supply is also supported by several 'orthodox dissenters' (Lavoie, 2014), namely New Consensus authors, New Paradigm Keynesians, neo-Austrians, and Real-business Cycle scholars. Nevertheless, in these cases the 'accommodation principle' is a special case, and not the general case of endogenous money as in the PK framework. This is consistent with what Rochon (1999) has called 'credit-led but supply determined .

a downward-sloping investment demand curve lies in the very ground of the Sraffian approach (Sraffa, 1960; Garegnani, 1970; 1978) to the 'capital controversy'. The very possibility of reswitching of techniques invalidates this negative relation. As argued by Garegnani (2015), this would imply that in the long run changes in the stock of productive capacity adjust to the level of 'final demand'.

If empirical studies hardly find any evidence of a sensitivity of investment to shifts in the interest rate, then the question that remains is the following: what are the effects of monetary policy and its transmission mechanisms? (Krugman, 2018) points out to a similar track to the one found in Deleidi (2018) (i.e. that interest rates affect the economy mainly "through their effect on the housing market and the international value of the dollar"). Krugman continues arguing that "[a]ny direct effect on business investment is so small that it is hard even to see it in the data" and concludes arguing that what actually drives investment is market demand. This is in great accordance with what PKs, particularly Sraffians, have long advocated for. In fact, Garegnani (2015, p.122) pointed out that homebuilding is one of the sectors most affected by interest rate shocks: "[w]e have in fact seen that the interest rate can have a noticeable effect only in areas like homebuilding".

Contributing to the literature that advocates for a central role of housing in monetary policy management, a growing body of the PK literature incorporated the investigation of the so-called autonomous components of demand (in particular autonomous consumption which is mainly composed by private residential investment) into their analysis.[7] In fact, from a PK framework, if the principle of effective demand is valid both in the short and long run, the expenditure categories that do not create productive capacities and do not depend on the current level of income (the semi-autonomous components of demand) will determine the dynamics of the system (trend and cycle).

Along these lines, a branch of the literature on the SSM investigates how private residential investment not only drives the business cycle but also long-run growth. For instance, Pérez-Montiel and Pariboni (2022) use US data for the period 1960–2019 and show that the dynamics of residential investment drives output, whilst output has no significant effect on the dynamics of residential investment. Similarly, Teixeira and Petrini (2023) use numerical simulations of a stock-flow consistent model calibrated with US data and find that private residential investment not only leads the business cycle but also capital accumulation. In another contribution, Petrini and Teixeira (2022) use US data for the period 1992–2019 to investigate the determinants of private residential investment and find a long-run unidirectional negative link between houses' own-rate of interest and residential investment growth rate. Notwithstanding the above-mentioned literature has shown that permanent shocks in residential investment affect long-run output dynamics and that houses' own rate of interest negatively impacts the growth rate of private residential investment, the centrality of (semi-autonomous) demand in the transmission of monetary policy considering the role played by housing prices has not been successfully approached.[8] Therefore, this contribution seeks to build upon this recently growing literature.

In order to contemporaneously assess the transmission channels of monetary through semi-autonomous demand, which is affected in turn by the dynamics of housing prices, an amended version of the SSM autonomous consumption equation is presented in what follows.[9] Then, the theoretical relations discussed in this section, are empirically tested in Section 4. A consumption equation can be represented as follows:

$$C_t = C_t^y + C_t^a \tag{1}$$

Total consumption (1) is defined as the sum of induced consumption out of disposable income (C_t^y) and autonomous consumption (C_t^a). As shown in Eq. (2), the induced component (C_t^y) is dependent on the current level of income (Y_t), where c indicates the marginal propensity to consume ($0 \leq c < 1$).

$$C_t^y = cY_t \tag{2}$$

It is possible to split total autonomous consumption (Eq. (3)) into two main components, the first related to consumer credit and the second to housing dwellings. The first component is the sum of loans (consumer credit) minus the negative fraction of autonomous consumption related to consumer credit. More precisely, this negative fraction refers to the total of accumulated debt from consumer credit (D_t^L) multiplied by the propensity to consume (c) multiplied by the interest rate on loans for consumer credit (r) and by the percentage of principal repaid every period (ϕ). The second component can be decomposed into the sum of loans (real estate loans) minus the negative fraction. In the second component however, this negative fraction refers to the total mortgage debt (D_t^M) multiplied by the propensity to consume (c) multiplied by the interest rate on mortgages (r_m) and by the percentage of principal repaid every period(ψ).

$$TOTALC_t^a = Cc_t - c(r+\phi)D_t^L + RES_t - c(r_m+\psi)D_t^M \tag{3}$$

If the positive components are isolated as in Eq. (4), we have that the total amount of new autonomous consumption can be described simply as the sum of credit-financed consumption (Cc_t) and private residential investment (RES_t). Both components are a function of the so called 'own-interest rate' (FF_s), which is represented in Eq. (5).

$$C_t^a = Cc_t + RES_t = f(FF_s) = f(\overline{FF}, \pi_{residential}) \tag{4}$$

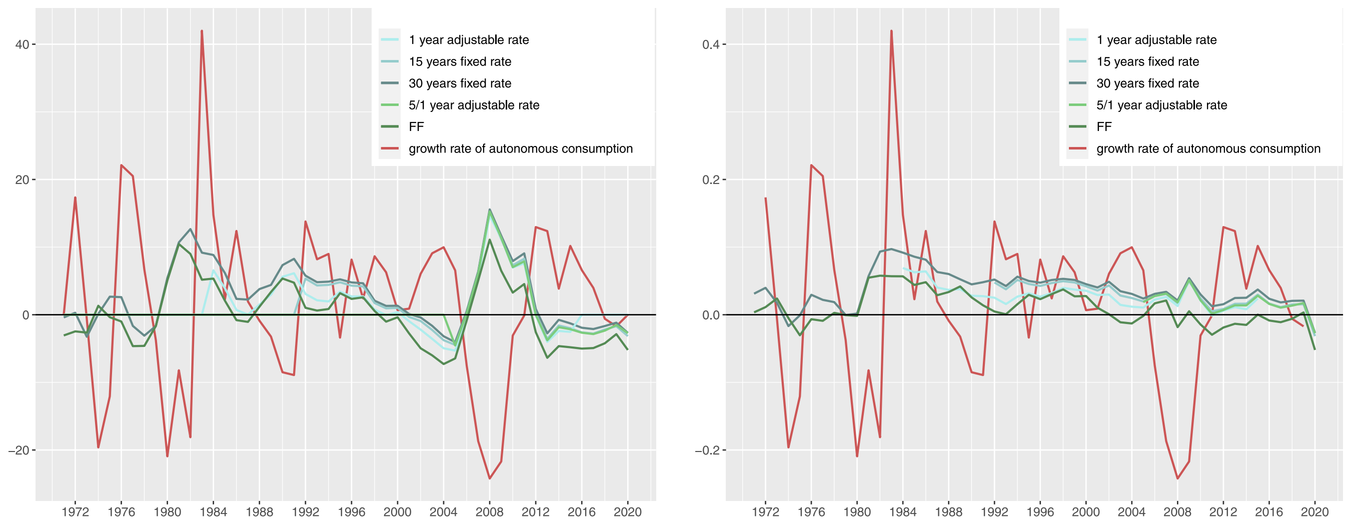
$$FF_s = \left(\frac{1+\overline{FF}}{1+\pi_{residential}}\right) - 1 \tag{5}$$

The own-interest rate of real estate (FF_s) is a function of the exogenously determined federal funds rate ($\overline{FF}$) and of profits from

[7] It ought to be noted that autonomous components of demand are theoretically defined by Serrano (1995) as those components that are neither financed by contractual incomes nor are able to create productive capacities. In particular, these components are related to discretionary or autonomous injection of purchasing power in the economy (Cesaratto et al., 2003), and, in this sense, are very much in the core of the literature on endogenous credit-led and demand-determined money supply (Cesaratto, 2017; Cesaratto and Di Bucchianico, 2020; Dejuán and Dejuán-Bitriá, 2022). In the empirical literature these expenditures include: (i) government expenditures, that are determined by policy decisions; (ii) exports, which depend on the level of foreign demand; (iii) autonomous consumption, that are financed in the credit market either via an endogenous money creation process or through accumulated wealth. In this contribution, the terms autonomous and semi-autonomous components (Kalecki, 1968; Fiebiger and Lavoie, 2019) are used interchangeably, in the sense that despite arguing that these components are independent from the current level of income, they should not be interpreted as 'manna from heaven'. Indeed, these variables may be affected by other macroeconomic variables. Monetary policy, for instance, can exert a certain degree of influence on the volume of credit borrowed by households (Pariboni, 2016; Deleidi, 2018; Deleidi and Mazzucato, 2019), which is the focus of this contribution.

[8] The role played by dwellings in determining business cycles and in the transmission channels of monetary policy have also been tackled by relying on the Real Business Cycle and New Keynesian frameworks. Both frameworks incorporated the short-run interest rate target as well as the endogenously determined (even though supply constrained) money supply in their approaches. However, in this literature authors either focus on the determination of cycles (see, among others, Green, 1997; Leamer, 2007, 2015), or on the transmission channels of monetary policy (see, among others, Bernanke and Gertler, 1995; Bernanke et al., 1999; Mishkin, 2007; Bjørnland and Jacobsen, 2010), without concomitantly discussing the two issues as well as neglecting their long-run implications.

[9] This amendment is greatly inspired by Teixeira (2015), Petrini and Teixeira (2022), and Teixeira and Petrini (2023), that incorporate the concept of houses' own-interest rate (Sraffa, 1932) in the determination of residential investment.



(a) Own Interest Rate and the Growth Rate of Autonomous Consumption (b) Real Interest Rate and the Growth Rate of Autonomous Consumption

Fig. 1. Growth Rate of Autonomous Consumption and the Spectrum of Interest Rates.
Source: FRED, BEA, author's representation.

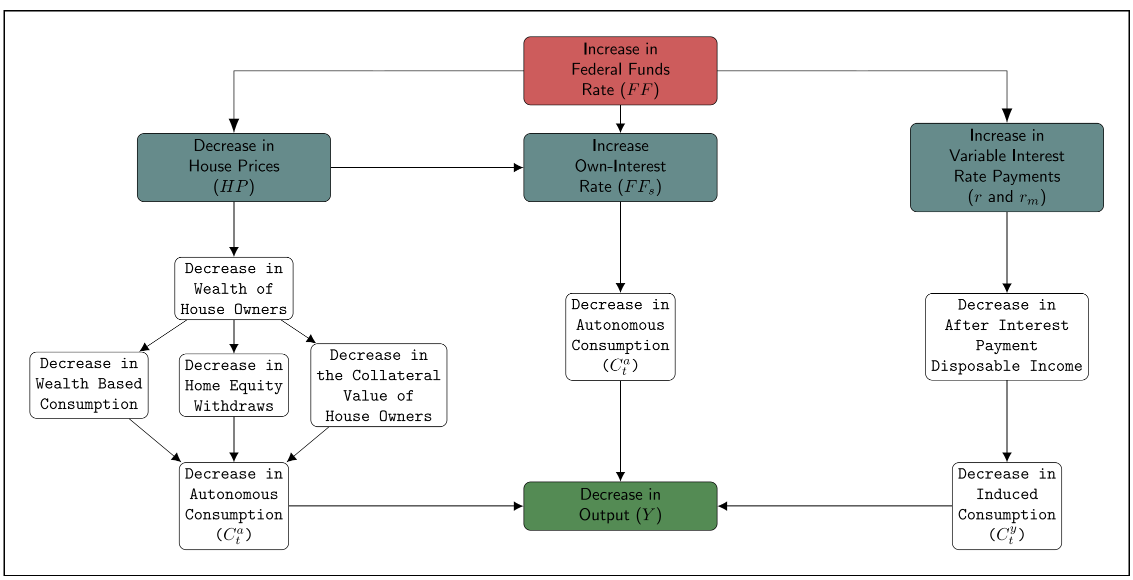


Fig. 2. Monetary policy: Effects and transmission mechanisms.
Source: Authors' elaboration.

real estate ($\pi_{residential}$).[10] The key role of this rate is related to the fact that "the owners of an asset, or those who intend to buy it, take price changes into account to speculate and obtain capital gains, or to prevent capital losses, and thus try to avoid reductions in their net worth" (Teixeira, 2015, p. 53, author's translation). Indeed, as illustrated in Fig. 1, autonomous consumption reacts to changes in the rate of interest adjusted using residential inflation (own rate of interest) and less due to changes in the real interest rate.[11] As argued by Leamer (2007), Teixeira (2015) and Fiebiger and Lavoie (2019), consumer durables follow movements in residential investment, therefore, the two variables are summed, as in Eq. (4), to obtain autonomous consumption (C_t^a). This is especially true in the US American case, where households (particularly in the years of the Great Moderation) have used home equity withdrawals (home equity extraction) to finance consumer credit.

[10] The Federal Funds rate is used as the base rate. Even tough mortgages are usually taken based on 30-years fixed rate, in normal times, all interest rates are a spectrum of the base rate. Hence, to avoid considering different rates, the base rate is taken as a benchmark. This is illustrated in Fig. 1.

[11] It is worth noting that this is only early evidence that autonomous consumption C_t^a is not only affected by the base-rate, but also by housing prices ($\pi_{residential}$). A more in-depth empirical analysis of the role of the interest rate (FF, FF_s, FF_{real}) as well as that of housing prices (HP) in the determination of autonomous consumption (CA) is presented in Section 4.

Fig. 2 illustrates the channels through which interest rate shocks may affect residential investment, consumer credit, and output. First, an increase in the base rate leads to a decrease in disposable income after interest payments, which in turn reduces induced consumption and ultimately decreases output. This first channel is known as the cash-flow channel, as it directly affects the amount of cash available for households to spend. The negative fraction of the autonomous consumption equation is related to this channel.[12] Second, an increase in the base rate results in an increase in the own-interest rate (FF_s), even if housing prices remain constant. This, in turn, reduces the demand for housing dwellings, consumer credit, and output. Third, the upward movement in the base rate can potentially lead to a decrease in housing prices.[13] This decrease in housing prices can further increase the own-interest rate, resulting in a stronger decline in dwellings, consumer credit, and ultimately output. The second and third channels are related to the so called credit demand channel, as higher own-interest rates (due to increased base rates or reduced housing prices) decrease the demand for loans for house purchases and consumer credit. Fourth, increases in the base rate that lead to lower housing prices can decrease the wealth of homeowners, thereby reducing the collateral value for credit-constrained borrowers, decreasing credit supply (the so called credit supply channel). The decline in wealth is also associated with a contraction in wealth-based consumption.[14]

3. Data and methodology

In this Section the data used in the estimation of the models is presented (Section 3.1), followed by a discussion of the methodology employed (Section 3.2).

3.1. Data

In order to estimate the SVAR models and assess the transmission channels of monetary policy, this contribution relies on quarterly time-series data (1970q1-2020q1) for the US, which is provided by the Federal Reserve Bank of St. Louis, the OECD, and the Bureau of Economic Analysis. In particular, the data is built using the Federal Funds rate (FF), the Federal Funds rate in real terms deflated using the CPI (FF_{real}), the own interest rate deflated using housing price inflation (FF_s), the housing price index (HP), the rent price index ($RENT$), the consumer price index (CPI), the housing price to consumer price ratio (HP_{ratio}), the sum of private residential investment and the flow of total consumer credit owned and securitized (autonomous consumption – CA), and GDP (Y).[15] Autonomous consumption and GDP are deflated using their corresponding deflators. Price indexes, autonomous consumption and GDP are used in log-levels.[16] All considered variables are seasonally adjusted. Variables and acronyms are summarized in Table 1.[17]

Table 1
Variables: Description and Acronyms.

Acronyms	Variables
FF	Federal Funds Rate
FF_{real}	Federal Funds Rate deflated using the CPI
FF_s	own rate of interest
HP	Housing Prices
RENT	Rent Prices
CPI	Consumer Price Index
HP_{ratio}	Housing Prices Ratio (HP/CPI)
$RENT_{ratio}$	Rent Prices Ratio ($RENT/CPI$)
CA	Autonomous Consumption (Private Residential Investment plus Consumer Credit)
Y	GDP

3.2. Methodology

To detect the transmission channels of monetary policy and assess the key role played by housing prices, this contribution relies on SVAR models. Before estimating a SVAR model, a reduced-form VAR is estimated (Eq. (6)):

$$y_t = c + \sum A_i y_{t-p} + u_t \tag{6}$$

where y_t is the $kx1$ vector of considered variables, c is the constant term, A_i is the kxk matrix of reduced-form coefficients and u_t is a $kx1$ vector composed by the error terms. The optimal lag length of the VAR is selected by minimizing the Akaike's Information Criterion (AIC).[18] Since $A_i = B_0{}^{-1} B_i$, and $u_t = B_0{}^{-1}\omega_t$, one can obtain the structural model (SVAR) as in Eq. (7):

$$B_0 y_t = c + \sum B_i y_{t-p} + \omega_t \tag{7}$$

where B_0 is the kxk non-singular matrix of contemporaneous relationships between the k variables in y_t, B_i is the kxk matrix of autoregressive slope coefficients, and ω_t is the $kx1$ structural innovation vector.

Therefore, to obtain a structural model in (7) an identification strategy needs to be imposed to the reduced-form VAR in Eq. (6). The identification of the structural model requires to impose restrictions on matrix B_0, usually retrieved from the economic theory (Kilian and Lütkepohl, 2017). Accordingly, six different models are set using a recursive identification based on the Cholesky Decomposition as summarized in the systems of Eq. (8), (9), (10), (11), (12), and (13) referring to Models 1, 2, 3, 4, 5, and 6 respectively.[19]

$$B_0 y_t = \begin{bmatrix} - & 0 & 0 \\ - & - & 0 \\ - & - & - \end{bmatrix} \begin{bmatrix} FF_s \\ CA \\ Y \end{bmatrix} \tag{8}$$

[12] From the cash-flow channel, many Post-Keynesians have analysed the income distribution effects that impact the overall multiplier and, consequently, output. This connection can be explained by the fact that interest income is typically distributed unequally, with higher-income and wealthier households often being the recipients, whom, according to the Keynesian tradition, tend to have a lower propensity to consume. For the consideration of interest on consumer debt on the measurement of poverty and inequality, the interested reader should refer to Pressman and Scott (2009, 2013, 2015). Even though, this contribution will empirically assess the other channels, focusing on autonomous consumption, we do not wish to disregard the cash-flow channel and its implications for income distribution.

[13] This is not equivalent of arguing that movements in the base rate are sufficient to impact housing prices. In fact, whereas a decrease can be assumed when interest rates increase, a boom in housing prices cannot be taken for granted in a scenario of low interest rates. Low interest rates are a necessary but not sufficient condition for booming housing prices, key factors could be financial institutions and regulation as well as demographic dynamics.

[14] This last channel is very debated both among PKs as well as in the mainstream since empirical tests related to the estimation of a marginal propensity to consume out of wealth hardly find any statistically significant coefficients.

[15] The time series for autonomous consumption was constructed following the methodology outlined in Girardi and Pariboni (2016). In this approach, the authors aggregate consumer credit with private residential investment to form the variable CA. This combination is justified by the fact that both expenditure categories are independent of current income and are typically funded by accumulated wealth or endogenous credit money.

[16] All variables are taken at levels to preserve any cointegrating or long-run relationship that may exist among them (Auerbach and Gorodnichenko, 2012; Kilian and Lütkepohl, 2017).

[17] Data sources with their respective weblinks can be found in Appendix A.

[18] Lag-length criteria and stability test for estimated VAR models are available upon request.

[19] In the restriction matrix '-' indicates an unrestricted parameter and '0' represents a zero restriction.

$$B_0 y_t = \begin{bmatrix} - & 0 & 0 \\ - & - & 0 \\ - & - & - \end{bmatrix} \begin{bmatrix} FF_{real} \\ CA \\ Y \end{bmatrix} \quad (9)$$

$$B_0 y_t = \begin{bmatrix} - & 0 & 0 & 0 \\ - & - & 0 & 0 \\ - & - & - & 0 \\ - & - & - & - \end{bmatrix} \begin{bmatrix} FF \\ HP_{ratio} \\ CA \\ Y \end{bmatrix} \quad (10)$$

$$B_0 y_t = \begin{bmatrix} - & 0 & 0 & 0 & 0 \\ - & - & 0 & 0 & 0 \\ - & - & - & 0 & 0 \\ - & - & - & - & 0 \\ - & - & - & - & - \end{bmatrix} \begin{bmatrix} FF \\ HP \\ CPI \\ CA \\ Y \end{bmatrix} \quad (11)$$

$$B_0 y_t = \begin{bmatrix} - & 0 & 0 & 0 & 0 \\ - & - & 0 & 0 & 0 \\ - & - & - & 0 & 0 \\ - & - & - & - & 0 \\ - & - & - & - & - \end{bmatrix} \begin{bmatrix} FF \\ HP_{ratio} \\ RENT_{ratio} \\ CA \\ Y \end{bmatrix} \quad (12)$$

$$B_0 y_t = \begin{bmatrix} - & 0 & 0 & 0 & 0 & 0 \\ - & - & 0 & 0 & 0 & 0 \\ - & - & - & 0 & 0 & 0 \\ - & - & - & - & 0 & 0 \\ - & - & - & - & - & 0 \\ - & - & - & - & - & - \end{bmatrix} \begin{bmatrix} FF \\ HP \\ RENT \\ CPI \\ CA \\ Y \end{bmatrix} \quad (13)$$

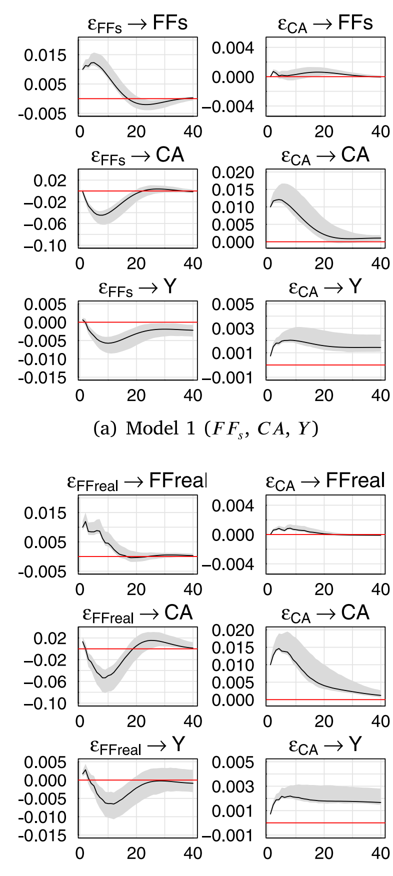
Following the PK endogenous monetary theory presented in Section 2, the first equation of the models assumes that the Federal Funds rate is exogenously set by the CB, implying that monetary policy can affect output and its components within the quarterly observation, while output may affect monetary policy with a delay. Subsequently, it is assumed that autonomous consumption (CA) contemporaneously affects the output level (Y), while output may influence CA with a delay. When considering separately housing, rent and consumer price indexes, it is assumed that prices affect the base rate contemporaneously but are only affected by it with a lag.[20] Moreover, it is assumed that housing prices affect rent contemporaneously, and that both rent and housing prices affect the CPI contemporaneously since housing is considered within the CPI. Finally, following the transmission channels of monetary policy discussed within the amended version of the autonomous consumption equation in the SSM, CA is assumed to follow movements in the interest rate and in housing prices, determining contemporaneously higher or lower GDP levels while not depending on the current level of the latter.

Once the SVAR is estimated, impulse responses functions (IRFs) are computed in order to assess the effect of monetary policy shocks on prices, autonomous consumption, and output. IRFs are reported with a 90 per cent confidence interval calculated through a 500 runs moving block bootstrap with respect to a 40-quarters time horizon. Finally, the forecast error variance decompositions (FEVDs) are computed to illustrate how much of the forecast error variance of each of the variables can be explained by shocks to the other variables.

4. Empirical findings

The empirical findings of Models 1, 2, 3, 4, 5, and 6 are reported in this Section, drawing particular attention to the analysis of IRFs and FEVDs. Fig. 3, 5, 7, 9, and 11 display elasticities of prices, autonomous consumption and output to changes on the shocked variables, whereas Fig. 4, 6, 8, 10, and 12 show the contributions from each individual shock as a portion of the total variability of each variable throughout time.

Starting by Fig. 3, it is possible to argue that the estimations of the IRFs suggest that the own interest rate (Fig. 3(a)) produces more persistent and statistically significant effects on autonomous consumption and on output than the real interest rate (Fig. 3(b)).[21] In fact, when analysing the contribution of each shock to the variabilities of autonomous consumption and output (Fig. 4), it is clear that a shock in the own-interest rate (Fig. 4(a)) explains a greater share of the variability of autonomous demand and output compared to the structural shock in the real interest rate (Fig. 4(b)). It is also worth noting that the FEVD of autonomous consumption validates the assumption of the SSM as regards autonomous demand components given that in all estimated models the variability of CA is barely affected by structural shocks in output.[22]



(a) Model 1 (FF_s, CA, Y)

(b) Model 2 (FF_{real}, CA, Y)

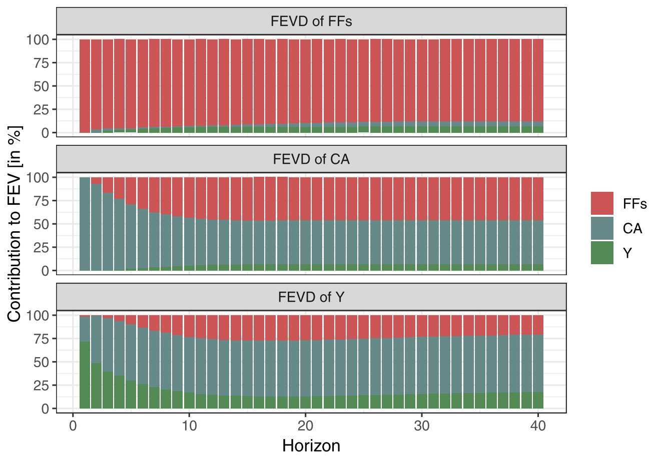
Fig. 3. Impulse Response Functions (IRFs), Models 1 and 2: Figures display IRFs of FF_s, FF_{real}, CA, and Y to monetary policy (ε_{FF_s} and $\varepsilon_{FF_{real}}$) and autonomous consumption shocks (ε_{CA}). Quarters on x-axis. Shaded grey area denotes 90% confidence bands calculated through m.b. bootstrapping (500 runs).
Source: Author's representation.

In order to analyse the separate effects of interest rate and prices on autonomous consumption and output, a successive step would be

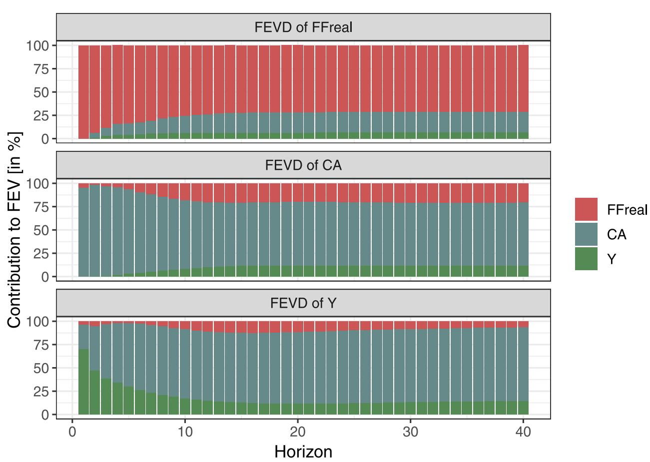
[20] As additional robustness check, all models have been estimated inverting the order of the variables in the identification matrix placing the Federal Funds rate at last following (Perotti, 2004) and the empirical literature on the transmission of monetary policy (Castelnuovo and Surico, 2010; Bjørnland and Jacobsen, 2010). The results of all six models letting interest rate react contemporaneously to output, autonomous consumption, and prices are very much in line with the estimations obtained using the identification strategies reported in ((8); (9); (10); (11); (12); and (13)). IRFs using this alternative ordering are available in Appendix B.

[21] It is worth noting that, whereas a positive shock in houses' own interest rate leads to a persistent and statistically significant negative effect in output, a positive shock in the real rate has only statistically significant negative effects in output until the 18th quarter. This result is, in fact, influenced by the response of autonomous consumption to shocks in these rates.

[22] The study of which autonomous component of demand is actually independent of the income level and to which extent (lagged and current values) is a further development of this contribution.



(a) FFs



(b) $FFreal$

Fig. 4. FEVD Models 1 and 2: Quarters on x-axis and Contribution to forecast error variance in % on y-axis.
Source: Author's representation.

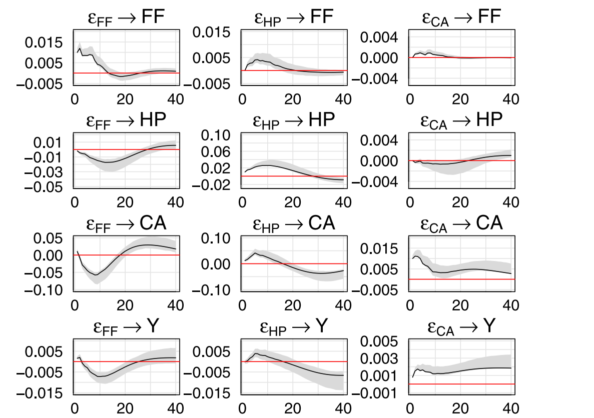


Fig. 5. Impulse Response Functions (IRFs), Model 3 (FF, HP_{ratio}, CA, Y): Figures display IRFs of FF, HP_{ratio}, CA, and Y to monetary policy (ε_{FF}), housing prices to CPI ratio ($\varepsilon_{HP_{ratio}}$), and autonomous consumption shocks (ε_{CA}). Quarters on x-axis. Shaded grey area denotes 90% confidence bands calculated through m.b. bootstrapping (500 runs).
Source: Author's representation.

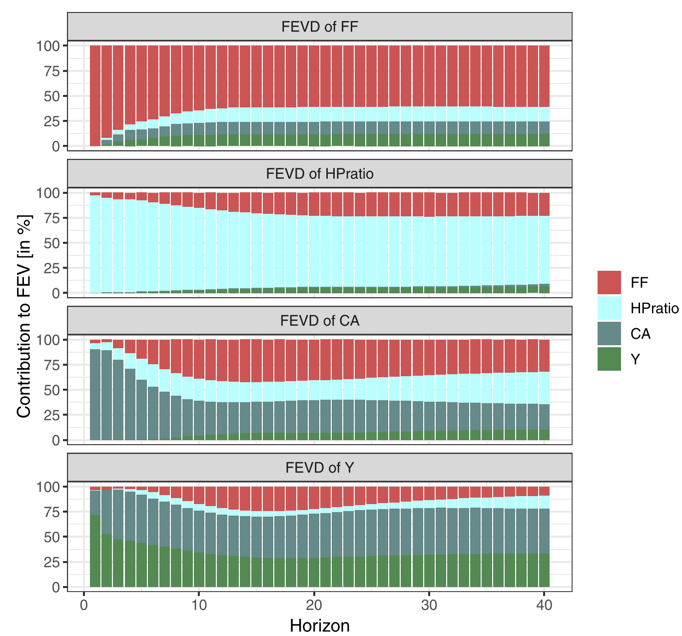


Fig. 6. FEVD Model 3 (FF, HP_{ratio}, CA, Y): Quarters on x-axis and Contribution to forecast error variance in % on y-axis..
Source: Author's representation.

to consider different variables for prices, relative prices and the base rate. Fig. 5, for instance, shows the IRFs of Model 3 that includes FF (the Federal Funds rate in nominal terms), HP_{ratio} (which is the ratio between housing prices and CPI), CA (autonomous consumption), and Y (output). A positive one percentage point increase in the base rate (FF) leads to a negative transitory movement in the housing prices to CPI ratio (HP_{ratio}), which leads to a negative movement in autonomous consumption (CA) and output (Y) until the shock in FF is reabsorbed. It is worth noting that a positive shock in the base rate leads to a statistically significant negative response in autonomous consumption, reaching its peak effect at approximately 5% across all estimated models. This finding indicates that autonomous consumption (CA) is highly sensitive to changes in interest rates, a result that is further supported by the results of the FEVDs. While the effect of a positive monetary policy shock on output (Y) follows a similar pattern to autonomous consumption (CA), its magnitude is about ten times smaller. This can be attributed to the fact that autonomous consumption represents a small share of GDP, averaging around 5%, primarily driven by private residential investment which accounts for approximately 95% of autonomous consumption. Moreover, the analysis of the FEVDs (Fig. 6) shows that the variability of autonomous consumption (CA) is mostly explained by shocks in the base rate (FF) and in the relative housing prices to CPI ratio (HP_{ratio}), confirming the previous results.

In order to assess the individual effects of housing prices (HP) and CPI separately, another model is estimated including both variables. Analysing the IRFs (Fig. 7), a contractionary monetary shock (increase in the FF) leads to a temporary slight decrease in housing prices (HP), a temporary significant increase in the CPI, a temporary decrease in autonomous consumption (CA) and in output (Y). Accordingly, it is possible to argue that while the monetary authority increases interest rates to control inflation, what they might actually get is an increase in the overall level of prices (CPI) which is accompanied by a drop in autonomous consumption and output passing through the housing market. This counter-intuitive effect of a contractionary monetary policy is commonly found in the empirical literature that investigates the effects of monetary policy (Gibson's Paradox).[23] In fact,

[23] For a historical overview of the debate on the Gibson's Paradox see Cucciniello et al. (2022) and Levrero (2023).

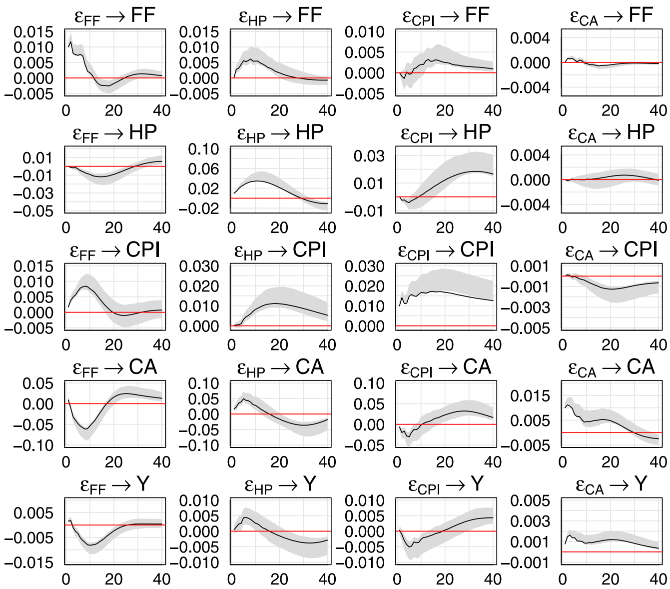


Fig. 7. Impulse Response Functions (IRFs), Model 4 (FF, HP, CPI, CA, Y): Figures display IRFs of FF, HP, CPI, CA, and Y to monetary policy (ε_{FF}), housing prices (ε_{HP}), consumer prices (ε_{CPI}), and autonomous consumption shocks (ε_{CA}). Quarters on x-axis. Shaded grey area denotes 90% confidence bands calculated through m.b. bootstrapping (500 runs).
Source: Author's representation.

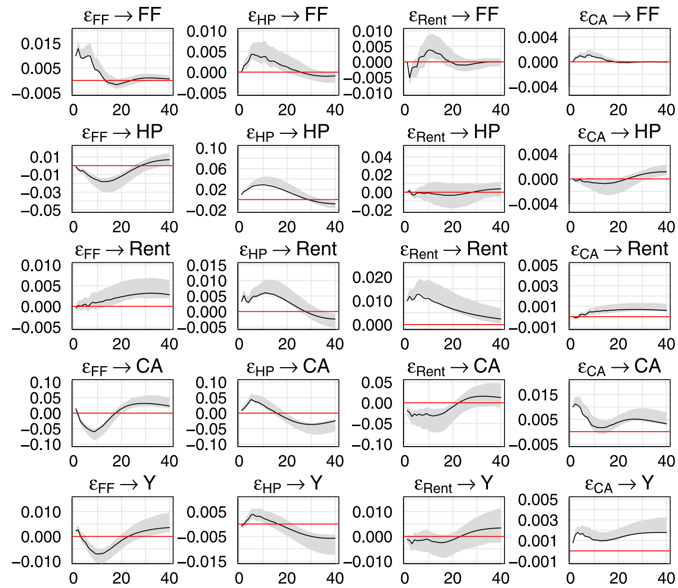


Fig. 9. Impulse Response Functions (IRFs), Model 5 (FF, HP_{ratio}, $RENT_{ratio}$, CA, Y): Figures display IRFs of FF, HP_{ratio}, $RENT_{ratio}$, CA, and Y to monetary policy (ε_{FF}), housing prices to CPI ratio ($\varepsilon_{HP_{ratio}}$), rent prices to CPI ratio ($\varepsilon_{RENT_{ratio}}$), and autonomous consumption shocks (ε_{CA}). Quarters on x-axis. Shaded grey area denotes 90% confidence bands calculated through m.b. bootstrapping (500 runs).
Source: Author's representation.

when analysing the results of the FEVDs (Fig. 8) we get that the variable that has its variability most dependent on shocks in the interest rate is exactly autonomous consumption.

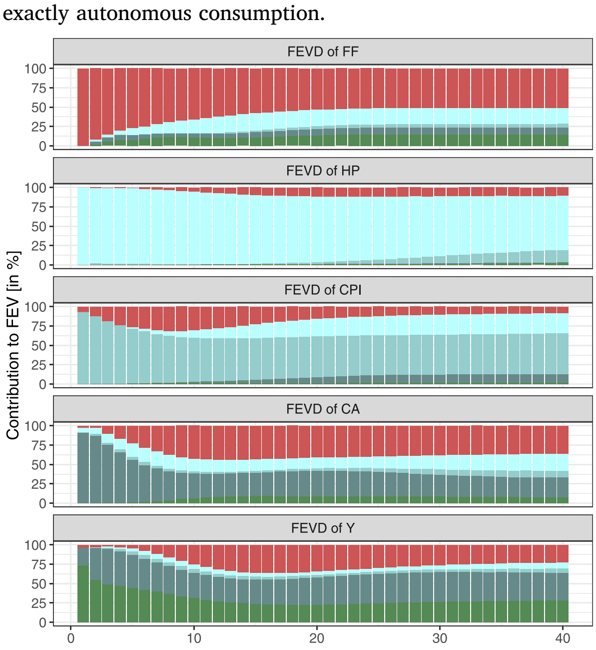


Fig. 8. FEVD Model 4 (FF, HP, CPI, CA, Y): Quarters on x-axis and Contribution to forecast error variance in % on y-axis.
Source: Author's representation.

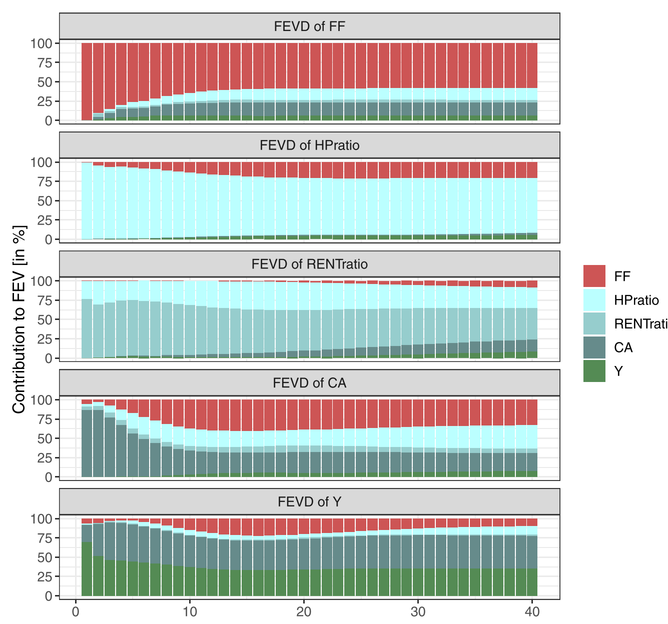


Fig. 10. FEVD Model 5 (FF, HP_{ratio}, $RENT_{ratio}$, CA, Y): Quarters on x-axis and Contribution to forecast error variance in % on y-axis.
Source: Author's representation.

Inspired by Dias and Duarte (2019) housing rent prices are included in the analysis in order to investigate the validity of the Gibson's Paradox found in the previous exercise. Estimating the IRFs of Model 5 (Fig. 9), its possible to see that an increase in the base rate leads to a temporary decrease in housing prices to CPI ratio (HP_{ratio}) that is accompanied by an increase the rent to CPI ratio ($RENT_{ratio}$) and temporary decrease in autonomous consumption and output that turns out positive after the 20th quarter. Analysing the FEVDs (Fig. 10), it is interesting to see that the variability of rent to CPI ratio ($RENT_{ratio}$) is much influenced by shocks in housing prices to CPI ratio (HP_{ratio}), whereas it is not much influenced by shocks in the interest rate.

In fact, when analysing the three price indexes separately, the chain of events is clearer. Calculating the IRFs of Model 6 (Fig. 11), a positive

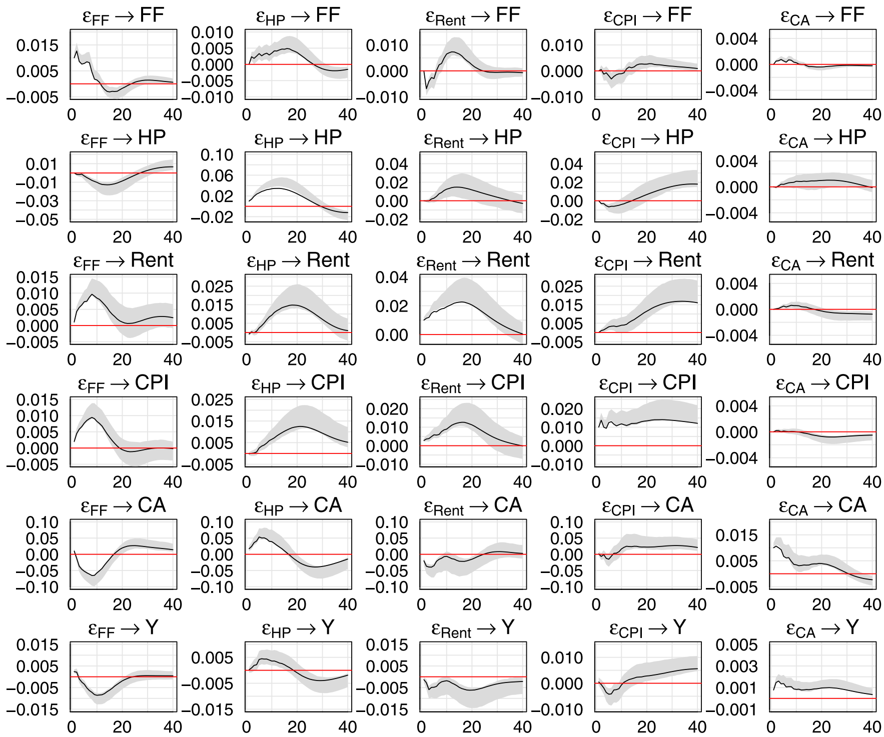


Fig. 11. Impulse Response Functions (IRFs), Model 6 (FF, HP, $RENT$, CPI, CA, Y): Figures display IRFs of FF, HP, $RENT$, CPI, CA, and Y to monetary policy (ε_{FF}), housing prices (ε_{HP}), rent prices (ε_{RENT}),consumer prices (ε_{CPI}), and autonomous consumption shocks (ε_{CA}). Quarters on x-axis. Shaded grey area denotes 90% confidence bands calculated through m.b. bootstrapping (500 runs).
Source: Author's representation.

shock in the base rate (FF) engenders a slightly negative response in housing prices (HP), a significant positive response in rent prices with a very similar response in the consumer price index (CPI) accompanied by a decrease in autonomous consumption (CA) and output (Y). Analysing the FEVDs (Fig. 12) it is possible to argue that whereas the variability of rent prices is much influenced by shocks in the interest rate, by itself, but also by housing prices and the overall price index, the variability of housing prices is basically not influenced by shocks in rent and very little influenced by shocks in the interest rate and in the CPI. In this sense, these results are very much in line with the arguments presented by Dias and Duarte (2019). Contrary to the movements in residential investment, housing rents have shown to increase due to a contractionary monetary policy shock. These movements might be explained by a decrease in the home-ownership rate and in rental vacancies which is a result of a decrease in residential investment (in this empirical test the biggest fraction of autonomous consumption).

Moreover, in all estimated models a positive shock in autonomous consumption produced positive, persistent, and statistically significant effects in the output level. Evidently, part of this effect might be explained by the persistent dynamics of positive shocks in autonomous consumption (i.e. a 1% positive shock in autonomous consumption engenders persistent dynamics in itself). Yet, these results are particularly striking, given that autonomous consumption exerts long-run effects on output even if estimated models allow for an endogenous Taylor-Rule-like monetary policy response to a demand shock.[24] These results are also consistent with Girardi et al. (2020) and challenge the NCM approach, according to which demand affects output only in the short run confined by the response of monetary policy.[25]

Lastly, having empirically discussed the channels through which monetary policy (in particular interest rate management by the monetary authority) affects output, some important patterns and issues

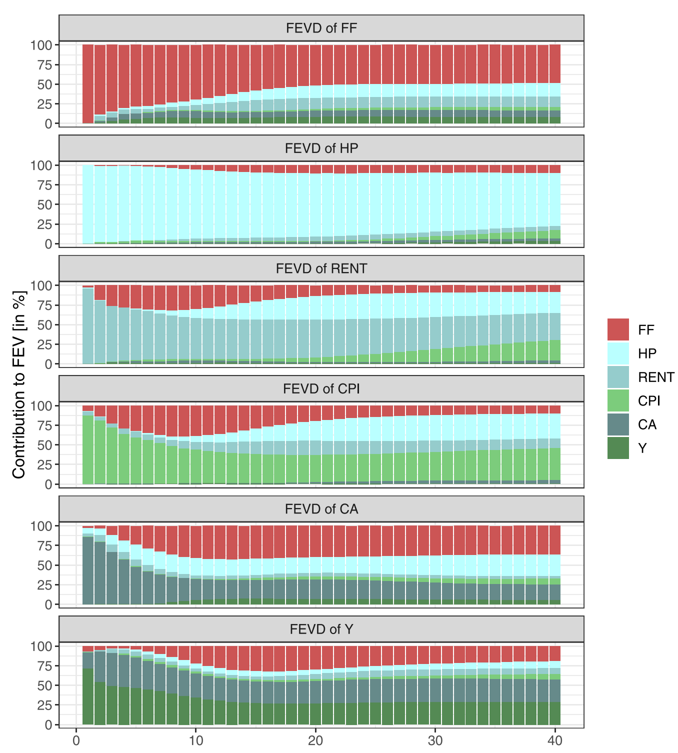


Fig. 12. FEVD Model 6 (FF, HP, $RENT$, CPI, CA, Y): Quarters on x-axis and Contribution to forecast error variance in % on y-axis.
Source: Author's representation.

[24] See Appendix B.
[25] I would like to thank an anonymous referee for pointing this out.

emerged. One striking pattern is the dynamic of rents, that even in the context of increasing interest rates (when housing prices and residential investment go down), tend to increase as a consequence of a decrease in home-ownership. It is clear from a comparison between supply and demand forces that if (on average) people rely more on rented dwellings, for a given supply, rent prices will tend to go up. However, it is also possible to explain such a mechanism by means of the alignment of returns from house property to the return from other types of financial and real investment. This last issue opens the scope for further research and cooperation between different areas of economic studies such as the study of wealth and income distribution, economic geography, and inclusive growth in a macro-framework. In fact, lower income households have a significantly lower home-ownership rate.[26] Accordingly, they are much more exposed to positive shifts in rent prices.

5. Concluding remarks

This paper revised the literature on monetary theory and monetary policy instruments, drawing particular attention to the role played by housing prices and dwellings. To incorporate the role of monetary policy and housing prices theoretically, this contribution introduces an amended version of the autonomous consumption function embedded in the SSM. Subsequently, to empirically assess the role of monetary policy, real estate prices, housing rent prices, and consumer prices, on autonomous consumption and output determination six different SVAR models are estimated.

The empirical findings suggest that the own interest rate (Sraffa, 1932; Teixeira, 2015; Petrini and Teixeira, 2022) produces more persistent and statistically significant effects on autonomous consumption and on output than the real interest rate. These findings also confirm the hypothesis that monetary policy transmission works through autonomous consumption (Deleidi, 2018), in particular, via changes in housing prices. Moreover, the persistence of autonomous consumption shocks restate the role played by these non-capacity creating demand components beyond the business cycle, in line with Pérez-Montiel and Pariboni (2022) and Girardi et al. (2020). Lastly, when analysing separately the three price indexes considered, it is possible to observe the emergence of a price puzzle. That is, a positive shock in the base rate leads to an increase in the overall consumer price index measured by the CPI. In this sense, it is possible to argue that a contractionary monetary policy shock has the opposite effects of its target (i.e., decreasing the inflation rate). These findings support the notion that the Gibson paradox is a product of economic theory rather than a ‘regime-specific phenomenon’ (Cucciniello et al., 2022).

In conclusion, in the context of recurring interest rate hikes, these empirical results stress the possibility of positive shifts in rent prices, opening a new path for the discussion of the linkages between monetary policy and distribution. Moreover, given the emergence of different dynamics of housing, rent and consumer prices and their underlying role in the determination of autonomous consumption and output, this empirical investigation finds a gap within the Classical Approach, which has not systematically discussed the movements in these market prices and their gravitation around their natural levels. These two issues are a successive step of this contribution.

Data availability

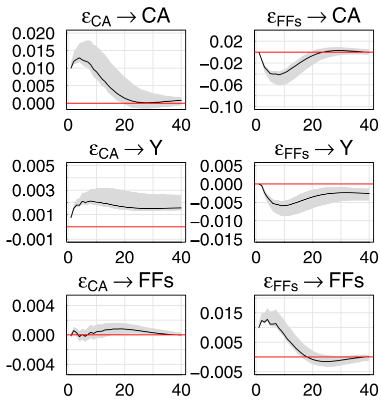
Data will be made available on request.

[26] For and in-depth analysis of the US economy based on the assets families own, which are also related to the possible motives behind their debts and their consecutive in impact on the income multiplier see Costantini and D'Ippoliti (2019).

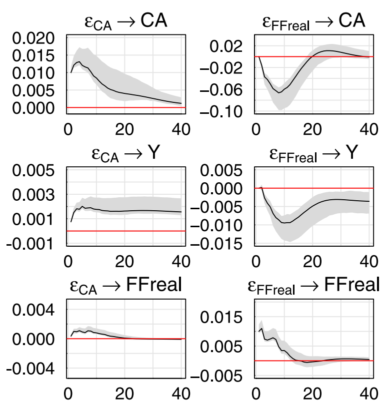
Appendix A. Data sources

- FF: Effective Federal Funds Rate, Quarterly Data, Federal Reserve Economic Data, Federal Reserve Bank of St. Louis.
  Available at: https://bit.ly/2VbSDcv
- X: Exports of goods and services in Billions of Dollars, Seasonally Adjusted, Quarterly Data, Bureau of Economic Analysis, NIPA Table 1.1.5.
  Available at: https://bit.ly/34DlOsj
  Deflated using the Implicit Price Deflator for Exports of goods and services, Seasonally Adjusted, Quarterly Data, Bureau of Economic Analysis, NIPA Table 1.1.9.
  Available at: https://bit.ly/2z6230N
- G: Government consumption expenditures and gross investment in Billions of Dollars, Seasonally Adjusted, Quarterly Data, Bureau of Economic Analysis, NIPA Table 1.1.5.
  Available at: https://bit.ly/34DlOsj
  Deflated using the Implicit Price Deflator for Government consumption expenditures and gross investment, Seasonally Adjusted, Quarterly Data, Bureau of Economic Analysis, NIPA Table 1.1.9.
  Available at: https://bit.ly/2z6230N
- CA: Autonomous Consumption (the sum of Private Residential Investment and Consumer Credit)
  - RES: Gross Private Residential Domestic Investment in Billions of Dollars, Seasonally Adjusted, Quarterly Data, Bureau of Economic Analysis, NIPA Table 1.1.5.
    Available at: https://bit.ly/34DlOsj
    Deflated using the Implicit Price Deflator for Gross Private Residential Domestic Investment, Seasonally Adjusted, Quarterly Data, Bureau of Economic Analysis, NIPA Table 1.1.9.
    Available at: https://bit.ly/2z6230N
  - CC: Flow of Total Consumer Credit Owned and Securitized in Billions of Dollars, Seasonally Adjusted, Quarterly Data, Federal Reserve Economic Data, Federal Reserve Bank of St. Louis.
    Available at: https://bit.ly/31xxNHw
    Deflated using the Implicit Price Deflator for Personal Consumption Expenditures, Seasonally Adjusted, Quarterly Data, Bureau of Economic Analysis, NIPA Table 1.1.9.
    Available at: https://bit.ly/2z6230N
- GDP: Gross Domestic Product in Billions of Dollars, Seasonally Adjusted, Quarterly Data, Bureau of Economic Analysis, NIPA Table 1.1.5.
  Available at: https://bit.ly/34DlOsj
  Deflated using the Implicit Price Deflator for Gross Domestic Product, Seasonally Adjusted, Quarterly Data, Bureau of Economic Analysis, NIPA Table 1.1.9.
  Available at: https://bit.ly/2z6230N
- HP: Nominal house price index covering the sales of newly-built and existing dwellings, Quarterly Data, OECD, Housing prices (indicator).
  Available at: https://bit.ly/3ybk3Re
- $RENT$: Housing rent price index, Quarterly Data, OECD, Inflation (CPI).
  Available at:https://bit.ly/3hu92ox
- CPI: Consumer Price Index, Quarterly Data, OECD, Housing prices (indicator).
  Available at:https://bit.ly/3uLlALW

Appendix B. IRFs alternative ordering (Taylor rule)



(a) Model 1 (CA, Y, FF_s)



(b) Model 2 (CA, Y, FF_{real})

Fig. B.13. Impulse Response Functions (IRFs), Models 1 and 2 Taylor Rule: Figures display IRFs of CA, Y, FF_s, and FF_{real}, to autonomous consumption (ε_{CA}) and monetary policy shocks (ε_{FF_s} and $\varepsilon_{FF_{real}}$). Quarters on *x*-axis. Shaded grey area denotes 90% confidence bands calculated through m.b. bootstrapping (500 runs).
Source: Author's representation.

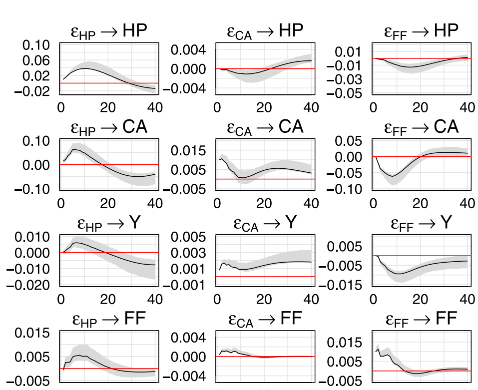


Fig. B.14. Impulse Response Functions (IRFs), Model 3 Taylor Rule (HP_{ratio}, CA, Y, FF): Figures display IRFs of HP_{ratio}, CA, Y, and FF to housing prices to CPI ratio ($\varepsilon_{HP_{ratio}}$), autonomous consumption (ε_{CA}), and monetary policy shocks (ε_{FF}). Quarters on *x*-axis. Shaded grey area denotes 90% confidence bands calculated through m.b. bootstrapping (500 runs)
Source: Author's representation.

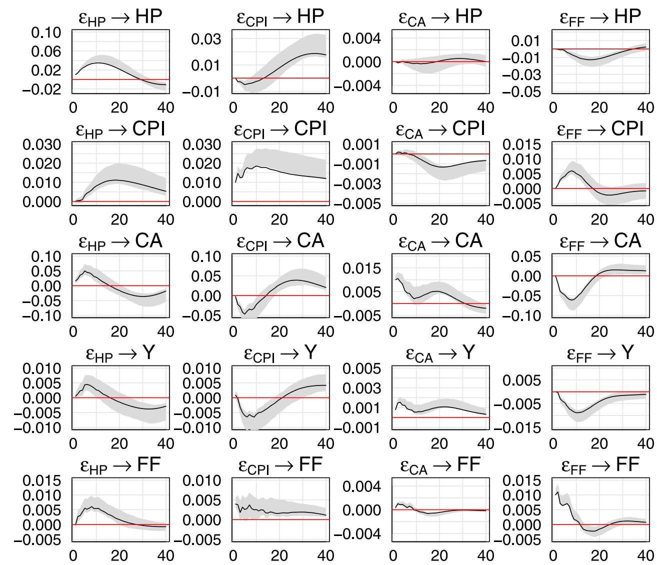


Fig. B.15. Impulse Response Functions (IRFs), Model 4 Taylor Rule (HP, CPI, CA, Y, FF): Figures display IRFs of HP, CPI, CA, Y, and FF to housing prices (ε_{HP}), consumer prices (ε_{CPI}), autonomous consumption (ε_{CA}), and monetary policy shocks (ε_{FF}). Quarters on *x*-axis. Shaded grey area denotes 90% confidence bands calculated through m.b. bootstrapping (500 runs).
Source: Author's representation.

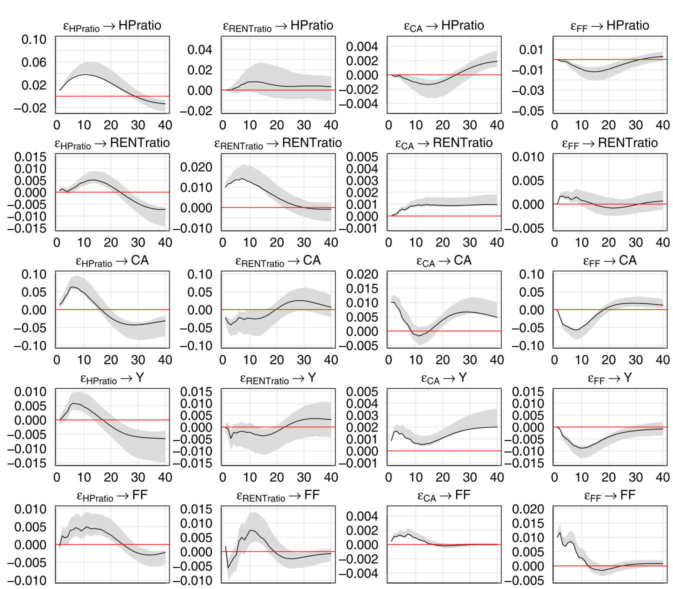


Fig. B.16. Impulse Response Functions (IRFs), Model 5 Taylor Rule (HP_{ratio}, $RENT_{ratio}$, CA, Y, FF): Figures display IRFs of HP_{ratio}, $RENT_{ratio}$, CA, Y, and FF to housing prices to CPI ratio ($\varepsilon_{HP_{ratio}}$), rent prices to CPI ratio ($\varepsilon_{RENT_{ratio}}$), autonomous consumption (ε_{CA}), and monetary policy shocks (ε_{FF}). Quarters on *x*-axis. Shaded grey area denotes 90% confidence bands calculated through m.b. bootstrapping (500 runs).
Source: Author's representation.

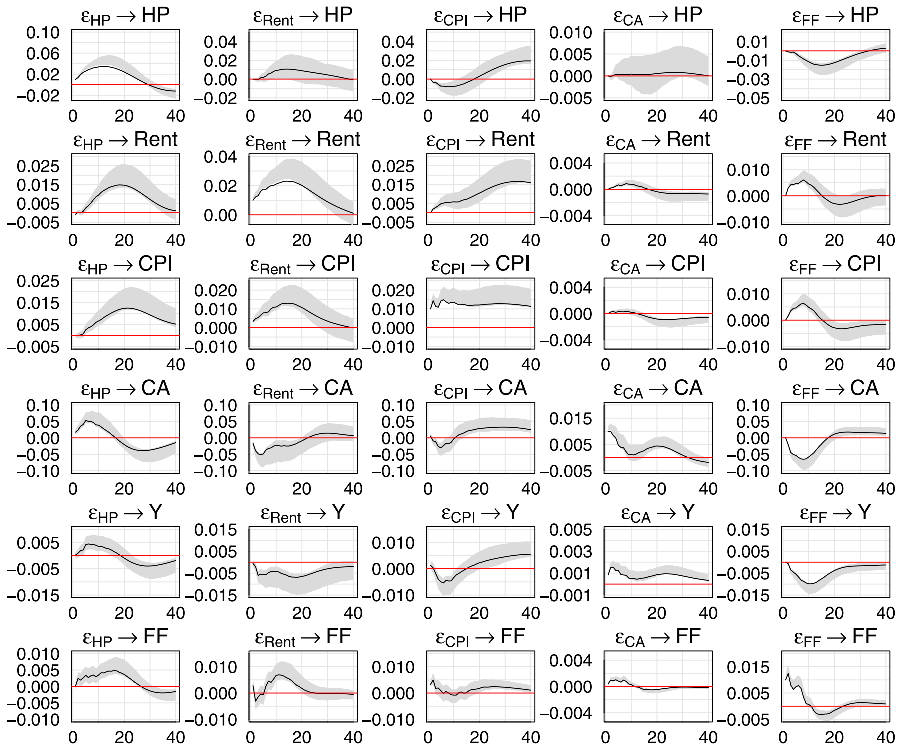


Fig. B.17. Impulse Response Functions (IRFs), Model 6 Taylor Rule (HP, $RENT$, CPI, CA, Y, FF): Figures display IRFs of HP, $RENT$, CPI, CA, Y, and FF to housing prices (ε_{HP}), rent prices (ε_{RENT}),consumer prices (ε_{CPI}), autonomous consumption (ε_{CA}), and monetary policy shocks (ε_{FF}). Quarters on x-axis. Shaded grey area denotes 90% confidence bands calculated through m.b. bootstrapping (500 runs).
Source: Author's representation.

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