Monetary Policy and Homeownership: Empirical Evidence, Theory, and Policy Implications*

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Abstract

We study the interplay between monetary policy and housing tenure decisions and how this channel affects monetary policy transmission in the business cycle. We show that monetary policy shocks are an important driver of fluctuations in the aggregate rate of homeownership in the United States, accounting for as much as 35% of its long-run variation. We also provide empirical evidence that monetary policy affects housing tenure choice decisions at the household level and affects housing supply for rental and ownership. We propose a standard two-agent New Keynesian model extended with a housing tenure decision and adjustment costs on housing supply to account for these empirical facts. Using the model, we show that homeownership is a relevant channel of monetary policy transmission and entails redistributive implications. Furthermore, we find that a monetary authority that reacts to price indexes that include housing rents, such as the consumer price index, generates excess price and output volatility.

JEL classification codes: E31, E43, R21.

Keywords: Monetary policy; Homeownership; Housing rents and housing prices; Inflation dynamics; Housing tenure; "Price puzzle".

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1 Introduction

"Like others, I think the recent inflation data are moderately encouraging. I continue to see risks. If you're not satiated with risks, I'll add one more, which is that if the housing market really weakens and people go back to renting, we could get the same phenomenon that we saw last year, by which rents are driven up and we get an effect working through shelter costs. So I agree with those who still view the risk to inflation as being tilted to the upside."

— Ben Bernanke, *Meeting of the Federal Open Market Committee on August 7, 2007*

By the end of the 20^{th} century, housing as a topic was so irrelevant for macroeconomics that, as noted by Piazzesi and Schneider (2016) in the 1999 *Handbook of Macroeconomics* there was no reference to it. Since then, and primarily motivated by the 2007 housing bust in the United States, there has been a boom in research looking at different aspects of housing and how these aspects may matter for the macroeconomy. However, the literature has overlooked one area of the housing market: the interplay between monetary policy and housing tenure decisions which, as we will show in this paper, plays a significant role in the transmission of monetary policy to the real economy and to the monetary policy itself.

This paper studies the interplay between monetary policy and homeownership decisions and how this interplay affects the transmission of monetary policy. The motivation for this question comes from a result in Dias and Duarte (2019) showing that the aggregate homeownership rate responds strongly to monetary policy. In the current paper, we want to expand on this finding and understand (i) how important monetary policy is for fluctuations in homeownership, (ii) why monetary policy affects homeownership, and (iii) whether there are implications for optimal monetary policy through this channel.

To measure the relative importance of monetary policy shocks for homeownership fluctuations, we use aggregate data and estimate a proxy structural vector autoregression (SVAR) and a structural vector moving average (SVMA) identifying the monetary policy shocks with high-frequency external instruments[1]: Jarociński and Karadi (2020) and Miranda-Agrippino and Ricco (2021). We estimate a SVMA model because it allows us to estimate an upper bound for the relative importance of the monetary policy shock for homeownership rate dynamics without assuming invertibility, as shown by Plagborg-Møller and Wolf (2021a). We find that monetary policy shocks are an important driver of fluctuations in the aggregate rate of homeownership in the United States, accounting for as much as 35% of the long-run variation of this variable.

[1] Both of these instruments, unlike previous high-frequency monetary policy instruments, separate the effect on interest rates that is due to pure monetary policy surprises from the effect on interest rates that is due to new information about the Feds view of the economy.

We then resort to the American Housing Survey (AHS) microdata to provide empirical evidence that monetary policy affects housing tenure choice decisions at the household level and affects housing supply for rental and ownership. At the household level, we estimate simple logit models in which the dependent variable measures transition from renting to owning or from owning to renting. We find that in response to a 25 basis points contractionary policy shock, the rate of transition from renting to homeownership falls by about 16.6% and the rate of transition from homeownership to renting increases by 6.1%. At the housing unit level, we find that monetary policy surprises affect the tenure status of houses. Hence, we find that monetary policy shocks also affect the relative supply of housing for ownership and renting. Specifically, we find that the housing supply for rental increases relative to ownership when interest rates rise unexpectedly.

We propose a standard two-agent New Keynesian model extended with a housing tenure decision and adjustment costs on housing supply to account for our empirical findings. We calibrate the model to match a set of data moments related to long-run dynamics. We then evaluate the model by comparing its impulse response functions to the untargeted empirical counterpart obtained from the proxy SVAR. The calibrated model matches the empirical monetary transmission to the selected variables well. The key mechanism behind the monetary transmission to homeownership rate is as follows. A positive interest-rate surprise increases the cost of borrowing to finance a house purchase. A higher cost for purchasing a house incentivizes the marginal borrower to rent instead of owning. From a housing demand perspective, as more borrowers switch to renting, the aggregate demand for renting rises driven through this extensive margin adjustment. At the same time, from a housing supply perspective, landlords observing higher rents respond by investing in housing stock for renting. However, because of adjustment costs, the supply of rental housing responds less than proportionally to the increase in demand for renting. As a consequence, housing rents increase in equilibrium.

The new homeownership channel of monetary policy transmission we uncover in this paper brings new dimensions on how monetary policy has redistributive consequences. First and foremost, monetary policy shocks generate redistribution between homeowners and renters by affecting the price-to-rent ratio. Secondly, we find that borrowers are worse-off when facing positive monetary policy shocks relative to savers. The reason is that borrowers face increased costs to finance a house purchase, and savers, by owning the housing stock for renting, benefit from higher house rents revenue.

Last but not least, we find that the homeownership channel has implications for monetary policy. We find that a monetary authority that reacts to price indexes that include housing rents, such as consumer price indexes, generates unnecessary excess price and output volatility. Since the response of housing rents to monetary policy shocks goes in the opposite direction of all other nominal final goods prices, the consumer price index falls less than actual inflation. The latter makes the interest rate adjustment towards the steady state slower. The monetary authority needs to be more aggressive to push the persistent inflation down as measured by the CPI. Hence, targeting the CPI leads to higher volatility in the economy than when the monetary authority targets inflation measures that exclude rents/shelter.

Literature. The paper contributes to three large strands of the literature: the literature on monetary policy transmission, the literature on housing and macroeconomics, and the literature on the determinants of housing tenure choices. We contribute to the literature on monetary policy transmission by introducing and studying a new channel of monetary policy. [2] The literature on the channels of transmission of monetary policy is pervasive and dynamic, with new channels being proposed regularly. As summarized in Mishkin (1996), the more *traditional* channels of monetary policy include the interest rate channel, the exchange rate channel, the equity price channel, and the credit channel. More recently, however, new channels have been identified. Examples of these more *novel* channels of monetary policy are the risk-taking channel (examples of papers discussing this channel include Jiménez et al. (2014), Bruno and Shin (2015), and Morais et al. (2019)), the deposits channel (Drechsler et al. (2017)), and the floating rate channel (examples of papers discussing this channel include Garriga et al. (2017), Ippolito et al. (2018)).

There has also been recent work linking monetary policy transmission to features of the housing market, and our paper is mainly related to this area of the literature. For instance, using the Euro Area area as a lab, Corsetti et al. (2021) shows that the strength of monetary transmission strongly correlates with the country's homeownership rate and the fraction of adjustable rate mortgage contracts. Also, using U.S. data, Beraja et al. (2019) and Eichenbaum et al. (2018) note that the effect of monetary policy in the economy through the refinancing of mortgages, which usually results in mortgage payment savings for borrowers, depends on the distribution of savings in the economy and how much people can save in total by refinancing. The results in these two papers imply that monetary policy is path-dependent, meaning that the effect of today's monetary policy shocks may depend on the history of shocks. Another implication of these two papers is that the effect of monetary policy through the mortgage refinancing channel is heterogeneous and time-varying, with the potential gains from refinancing varying across agents and over time. Hedlund

[2] As in Bernanke and Gertler (1995), we think of a transmission channel of monetary policy as being *a set of factors and institutional features of the economy that amplify and propagate conventional interest rate effects*.

et al. (2017) model the joint distribution of housing and mortgage debt in the context of a heterogeneous New Keynesian model to study how monetary policy shocks transmit through the housing market. Their main results are that housing prices are relevant for aggregate consumption dynamics. Monetary policy has asymmetric effects on economic activity, with responses to contractionary shocks being stronger than expansionary monetary policy shocks, and that monetary policy is more effective in a high-loan-to-value environment.

In a more empirical contribution, Cloyne et al. (2019) show that monetary policy transmission at the household level depends on the housing tenure status of the household, with the critical difference coming from the effects on consumption of outright homeowners (those without any mortgage) and of homeowners with a mortgage or renters. We contribute to this literature by showing that monetary policy affects households' tenure choice decisions and that frictions in housing supply for ownership and renting affect the relative price of houses and rents. We show that when monetary policy loosens (tightens), more (less) households move from renting to owning and that fewer (more) households move from owning to renting. This result is consistent with the aggregate homeownership rate increasing (decreasing) after an expansionary (contractionary) monetary policy shock, as we showed in previous work (Dias and Duarte (2019)). One consequence of these effects on house prices and rents is that shelter-related expenses, either mortgage payments or rents, change for some households, affecting the income available for consumption of non-shelter goods or services. One noteworthy difference in our work relative to that of Cloyne et al. (2019) is that we find housing rents increase in response to a contractionary monetary policy shock, while they find housing rents fall. A possible explanation for this different finding most probably stems from the different datasets used. While they use microdata at the household level, we use aggregate data. This paper focuses on aggregate housing rents because they constitute a significant component of CPI, thus affecting inflation dynamics.

We also contribute to the literature on housing and macroeconomics by proposing a model that allows studying the implications of changes in the aggregate level of homeownership for business cycle dynamics. The literature on housing and macroeconomics is also extensive, covering many aspects of how housing interacts with the overall macroeconomy. An excellent summary of this literature is that of Piazzesi and Schneider (2016). Within this literature, our paper is closest to Iacoviello (2005) and Iacoviello and Neri (2010), but with a key difference in how the supply of housing for renting and for ownership is modeled. In terms of the modeling choices we make, our approach is similar[3] to contemporary and

[3]To generate a distribution of homeowners and renters, we also embed the household heterogeneity in a single family using the assumption of market completeness within the family. This simplifying trick is

separate work by Greenwald (2018). While Greenwald (2018) focuses on how the structure of the mortgage market influences the propagation of macroeconomic shocks, whereas we are primarily interested in how monetary policy propagates through its effects on housing tenure decisions. Unlike most of the literature on housing and macroeconomics, in our paper, we consider a fractional housing market where transaction costs and nominal rigidities prevent the supply of housing for rental and ownership from adjusting for demand.[4] With this fractional housing supply market, the price of houses in the short run can be different from the discounted value of rents, which means that there may be fluctuations in the house price-to-rent ratio in the short run.

In addition to the modeling contribution, we also contribute to the literature on housing and macroeconomics by providing estimates of the importance of monetary policy shocks for fluctuations in the homeownership rate. Using the methodology of Plagborg-Møller and Wolf (2021a), we estimate that monetary policy shocks can account for as much as 35% of the long-run variation in the homeownership rate. To put this value in perspective, Plagborg-Møller and Wolf (2021a) estimate that monetary policy shocks account for close to 0% of the variation in consumer price growth. Our application estimates that monetary policy shocks can account for at most 30% of the variation of consumer price growth, but this result depends on the monetary policy instrument used. Using the Miranda-Agrippino and Ricco (2021) instrument, we find much lower importance of monetary policy shocks for consumer price growth variation, which is more in line with the results in Plagborg-Møller and Wolf (2021a). As such, our results show that monetary policy is likely to be at least as important for fluctuations in the aggregate homeownership rate as it is for the rate of inflation. To the extent that monetary policy transmission depends on the level of homeownership, our paper shows that the effectiveness of monetary policy may depend on the history of monetary policy shocks.

We also contribute to the literature on the determinants of housing tenure arrangements by providing evidence that monetary policy is one driver of the choice between owning or renting a home. This literature focuses typically on structural factors such as tax regimes or life-cycle motives as forces driving the choice between owning or renting - see for example Henderson and Ioannides (1983) or Weiss (1978). We contribute to this literature by providing a factor that can explain fluctuations in the timing of housing tenure decisions (for

suggested by Ragot (2018).

[4]One paper that also allows for a fractional housing is Sommer et al. (2013). In this paper, the authors carefully model the U.S. housing market to study the effects of fundamentals on house prices and rents. Sommer et al. (2013)' model is richer than ours, but this higher richness comes at the cost of not being as tractable as ours and therefore either impossible or very difficult to use for the analysis of business cycle dynamics. Another paper that shows how segmented makers affect housing price dynamics is Greenwald and Guren (2021).

example, why specific cohorts of the population transitioned from renting to ownership than other cohorts) but also provides a source of fluctuations in rents, which, as shown in Sinai and Souleles (2005), can be an essential factor for households choosing to own instead of renting.

Finally, the model we propose can explain the ″price puzzle″ (Sims (1992)) through the procyclical effect of monetary policy on housing rents. Namely, with rents moving in the same direction of interest rates, and because the shelter component of the consumer price index (or personal consumption expenditures index) is based chiefly on the price of rents [5], it is possible to see in the short run a rise (decline) in consumer prices when interest rates rise (decline). As such, for specific parameterizations of the model, the rise in housing rents following a contractionary monetary policy shock can be sufficiently high to offset the decline in the prices of other goods or services. In such a case, the aggregate consumer price index (not inflation as defined in the model) may rise in response to a contractionary monetary policy shock (i.e., the ″price puzzle″).

Layout. The rest of the paper is organized as follows: in section 2 we provide empirical evidence on the effect of monetary policy on the level of aggregate homeownership and on the effect of monetary policy on the decision to own or rent. In section 3 we present a model that can account for the main empirical patterns shown in section 2. Section 4 describes the calibration of the model and evaluates it through comparison with the empirical results obtained in 2. Section 5 presents the results on interest rate transmission, the redistributive implications, and the consequences for monetary policy. Finally, in section 6, we conclude.

2 Empirical Evidence of the Effect of Monetary Policy on the Aggregate Homeownership Rate and on Housing Tenure Decisions

In this section, we use U.S. aggregate-, household-, and housing-unit-level data to provide empirical evidence of the effects of monetary policy on the aggregate homeownership rate and show that monetary policy affects aggregate homeownership rate by affecting housing tenure choice decisions.

[5] Directly through the cost of rental housing or indirectly through the way rents from the rental market are used to calculate the owner's equivalent rent

2.1 Monetary Policy and the Homeownership Rate - Evidence from Aggregate U.S. data

We first use U.S. aggregate data to analyze how monetary policy affects the aggregate homeownership rate in the U.S. economy and how important it is for this variable. This analysis takes the results in Dias and Duarte (2019) as the starting point and expands on them. We first introduce the relevant methodologies and then present and discuss the results.

2.1.1 Methodology

To identify the effects of monetary policy on the variables of interest, we use a proxy SVAR model and a SVMA model with instrumental variables. This part will first discuss the monetary policy instrument we use and then present the two econometric methodologies.

Instruments. To identify the effect of monetary policy on key variables of interest, we use two leading high-frequency monetary policy instruments. The first one is the instrument developed by Jarociński and Karadi (2020) and the second one is the instrument constructed by Miranda-Agrippino and Ricco (2021). Unlike previous high-frequency monetary policy instruments, both of these instruments separate the effect on interest rates due to pure monetary policy surprises from the effect on interest rates that is due to new information about the Fed's view of the economy. To separate the monetary news from economic outlook news embedded in the Fed's communications, Jarociński and Karadi (2020) simultaneously look at high-frequency movements in interest rates and equity prices during a narrow window of time (10 minutes before and 20 minutes after the communication) around the Fed's policy announcement. These authors' idea is that news about monetary policy and news about the state of the economy have distinct effects on interest rates and equity prices. While a pure monetary shock has a negative correlation with equity prices – when monetary policy loosens, *ceteris paribus*, equity prices rise, and vice-versa –, information about the economy shock makes interest rates and equity prices move in the same direction – when interest rates fall because the Fed perceives a negative economic outlook, then equity prices are also expected to decline because equity prices are supposed to reflect future profits which correlate positively with the performance of the economy, and vice versa. With a similar objective to that of Jarociński and Karadi (2020), but using a different approach, the instrument proposed by Miranda-Agrippino and Ricco (2021) instead isolates the pure monetary surprises from the information channel by projecting market-based monetary surprises around policy announcements on their lags and on the central banks' information set formed by the Greenbook forecasts.

These two monetary policy instruments are widely used in the macroeconomics literature, and, therefore, we do not expand much on the details of the two instruments' construction. The reader interested in the details underlying the construction and justification for the validity of these instruments can find this information in Jarociński and Karadi (2020) and in Miranda-Agrippino and Ricco (2021). However, it is helpful in formally defining the external instrument and how it helps identify monetary policy shocks, as doing so will help with the discussions of the econometric methodologies we use.

For a variable Z_t to be a valid instrument, it must simultaneously meet the relevance and exogeneity conditions:

1. **Relevance**: $E[\epsilon_{i,t} Z_t] \neq 0$
2. **Exogeneity**: $E[\epsilon_{j,t} Z_t] = 0 \;\forall\; i \neq j$

Additionally, it is also useful to express the instrument as a (linear) function of the structural shock and measurement error, as done in Plagborg-Møller and Wolf (2021a):

$$Z_t = \alpha \epsilon_{i,t} + \sigma_v \nu_t \tag{1}$$

With $\alpha \neq 0$, $\sigma_v \geq 0$, and ν_t a white noise random variable. The expression in equation 1 will be particular relevant for the discussion of the forecast variance decomposition methodology.

Proxy SVAR Model. We use a proxy structural vector autoregressive model to study the dynamic effects of a monetary policy shock on the variables of interest. A structural vector autoregressive (SVAR) for Y_t, an $n \times 1$ vector of observable time series variables, with p lags is written as follows:

$$Y_t = A_0 + A_1 Y_{t-1} + A_2 Y_{t-2} + ... + A_p Y_{t-p} + H\varepsilon_t. \tag{2}$$

This expression can be re-written in a more succinct way by using the lag-operator notation:

$$A(L)Y_t = H\varepsilon_t, \tag{3}$$

In equation 3, $A(L) = I_n - \sum_{l=0}^{p} A_l(L^l)$ and each matrix $A_l(L^l)$, for $l \geq 1$, is an $n \times n$ matrix of coefficients associated with lag l, H is an $n \times n$ matrix of impact coefficients, and

ε_t is a vector of n structural shocks. This equation characterizes all the dynamics of the variables in the model. As usual, the structural shocks are assumed to have a linear effect on the variables included in the model and to be uncorrelated at all leads and lags.

Our goal is to separate the effects of monetary policy shocks on the variables Y_t in the model while controlling for any possible policy/feedback rule and other co-movements in the data. The elements in matrix H are the contemporaneous effect of a change in the structural shock associated with that matrix element. For example, column j of matrix H corresponds to the contemporaneous effect of structural shock j on each variable included in the vector Y_t. For ease of notation, as in Stock and Watson (2012), we assume that the monetary policy shock corresponds to the first column of H, and we denote it as H_1.

Given the definitions above, we can re-write the model in its structural vector moving average formulation:

$$Y_t = A(L)^{-1} H \varepsilon_t \tag{4}$$

Following equation 4, the impulse response function (IRF) of Y_t to a monetary policy shock is given by

$$Y_t = A(L)^{-1} H_1 \tag{5}$$

All the parameters in $A(L)$ can be obtained by estimating equation 2 by ordinary least squares (OLS). Note that matrix H is not directly estimable by OLS, and with OLS, we can only estimate the reduced form innovations $\eta_t = H\varepsilon_t$. To identify the monetary policy shocks that are included in η_t, we use the external instrument based on high-frequency identification of shocks approach as in Gertler and Karadi (2015) (with the obvious difference that we use the more refined monetary policy instruments of Jarociński and Karadi (2020) and Miranda-Agrippino and Ricco (2021)), which combines the external instrument approach to identification of structural shocks as in Stock and Watson (2012) and Mertens and Ravn (2013) with high frequency event studies around monetary policy announcements as in Kuttner (2001), Gurkaynak et al. (2005), Hamilton (2008), and Campbell et al. (2012). This approach will provide us with an estimate of the parameters in H_1, which we then use to identify the monetary policy shocks and the corresponding IRFs of all the variables in Y_t to a monetary policy shock. All the details on the exact procedure can be found in Gertler and Karadi (2015).

Dynamic Variance Decomposition Using SVMA Models with Instrumental Variables. To understand the relative importance of different structural shocks for the dynamics of a variable of interest, we could have used the same proxy SVAR model that we just discussed to compute the forecast error variance decomposition. However, as argued in Plagborg-Møller and Wolf (2021a), the results based on this approach would be highly dependent on certain assumptions, such as the invertibility of the model. The forecast variance decomposition methodology proposed by Plagborg-Møller and Wolf (2021a) allows us to estimate bounds for the importance of monetary policy shocks on variables of interest without having to make many assumptions on the underlying economic model.

Plagborg-Møller and Wolf (2021a)'s approach to measure the relative importance of a structural shock for the dynamics of a particular macroeconomic variable is intuitively simple but reasonably tricky to present concisely. Therefore, we only present the main ideas behind the method and refer the reader to the original paper for a more detailed exposition of the methodology and its implementation.

As a starting point, and for simplicity of exposition, following the exposure of the methodology in Plagborg-Møller and Wolf (2021a), we follow Plagborg-Møller and Wolf (2021a) and assume that SVMA representation of equation 4 has no dynamics and expand it by separating the structural shock $\epsilon_{1,t}$ from the other structural shocks.

$$Y_t = \Theta_{\cdot,1,0}\varepsilon_{1,t} + \sum_{j=2}^{n_\epsilon} \Theta_{\cdot,j,0}\varepsilon_{j,t} \tag{6}$$

Based on the expression in 6, the forecast variance ratio can be written as:

$$FVR_{i,0} = 1 - \frac{Var[Y_{i,t}|\epsilon_{1,t}]}{Var[Y_{i,t}]} = \frac{\Theta_{i,1,0}^2}{Var[Y_{i,t}]} \tag{7}$$

The expression for $FVR_{i,0,}$ can be re-written as a function of the instrument Z_t (defined in equation 1):

$$FVR_{i,0} = \frac{1}{\alpha^2}\frac{Cov[Y_{i,t}, Z_t]^2}{Var[Y_{i,t}]} \tag{8}$$

While equation 8 provides an exact expression for the forecast variance ratio based on the observed instrument, because the estimation of α is infeasible, it is impossible to provide a point estimate of the forecast variance ratio. Plagborg-Møller and Wolf (2021a)'s key contribution is to show that, under the assumption that a valid instrument for the shock of interest exists and that it is possible to express the variables Y_t as in 6, it is possible to construct informative bounds on the true forecast variance ratio.

To arrive at the lower bound for the true forecast error variance ratio, Plagborg-Møller and Wolf (2021a) note that $\alpha^2 \leq Var(Z_t) = \alpha^2 + \sigma_v^2$. This inequality implies that the quality of the instrument, measured by the signal-to-noise ratio $\frac{\alpha^2}{\sigma_v^2}$, will determine how tight or wide the lower bound for the true forecast variance ratio is. It is easy to see that $\alpha^{-2} \geq$

$(Var(Z_t) = \alpha^2 + \sigma_v^2)^{-1}$, and if $\sigma_v = 0$ (case of a perfect instrument) , then this lower bound exactly estimates α, whereas if σ_v is very large, the signal-to-noise ratio becomes very small pushing the lower bound of forecast variance ratio towards zero.

To derive the upper bound for the true forecast error variance ratio, Plagborg-Møller and Wolf (2021a) make the point that, the most that the variables included in Y_t can explain of Z_t (in the sense of a linear projection) is bounded above by what the structural shock $\epsilon_{1,t}$ can explain of the instrument Z_t (this is a theoretical upper bound as the structural shock is not observed). That is, the explained sum of squares of a linear projection of $\epsilon_{1,t}$ on Z_t is exactly α^2, and, any linear projection of Y_t on $\epsilon_{1,t}$ will be at most as high as α^2. More formally, this means that $Var\{E[Z_t|Y_t]\} \leq \alpha^2$, and, consequently, $\alpha^{-2} \leq Var\{E[Z_t|Y_t]\}^{-1}$. When the model is invertible, that is, when the variables in Y_t perfectly span the structural shocks, then the inequality binds and $\alpha^{-2} = Var\{E[Z_t|Y_t]\}^{-1}$.

Plagborg-Møller and Wolf (2021a) expand on these insights to entirely derive upper and lower bounds for a more general case, which allows for rich dynamics of the variables. In the empirical application, we use the more general formulation of the interval estimation for the forecast variance ratios (and the corresponding confidence intervals). We refer the reader to the original paper for more details on the full methodology.

2.1.2 Results and Discussion

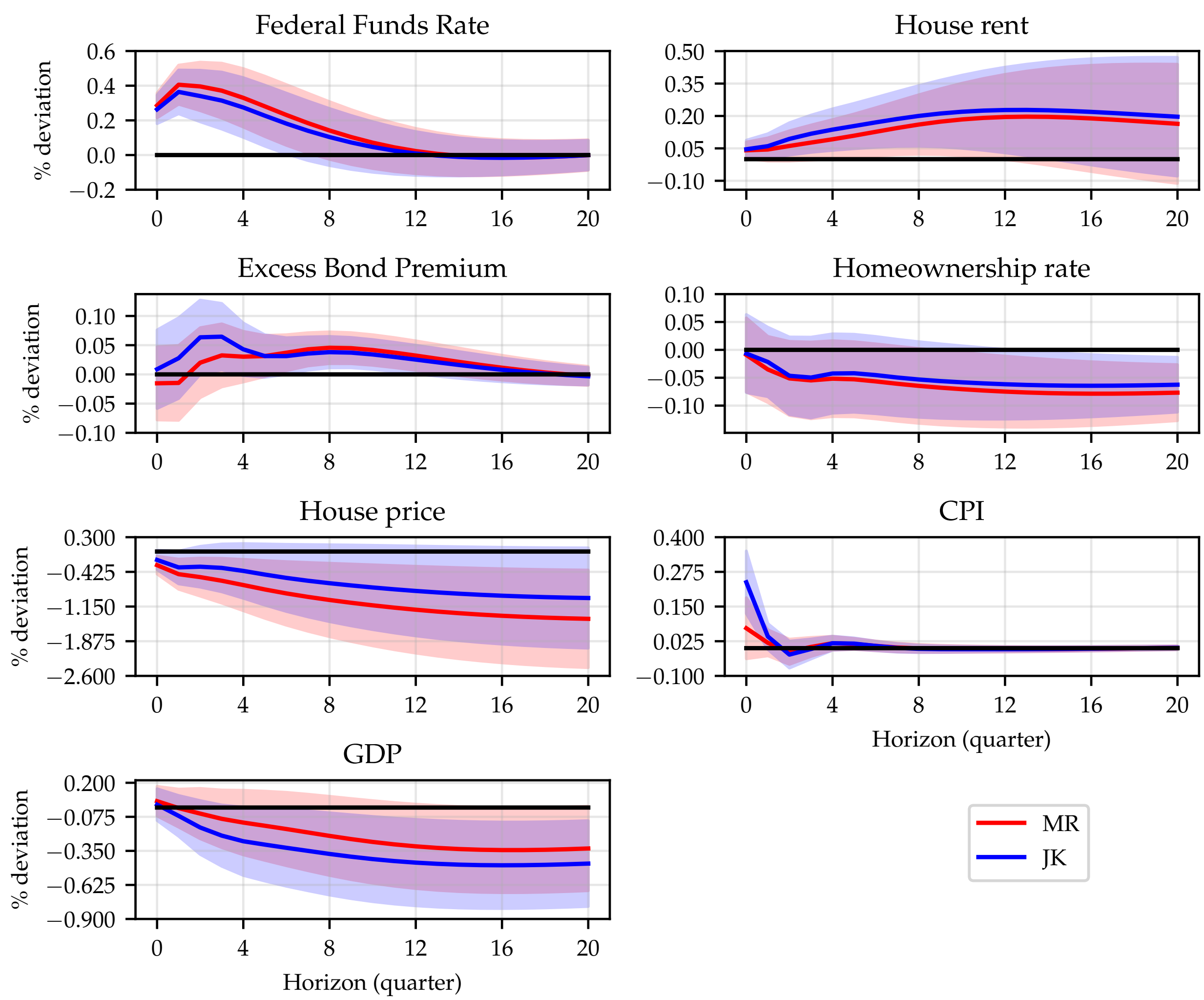
Having presented the most relevant aspects of the methodology we use, we now turn to the results. In Figure 1, we show the estimated impulse response functions of the variables included in the VAR model – the federal funds rate, house rents, excess bond premium, the homeownership rate, house prices, consumer prices measured by the CPI, and GDP – to a 25 bps contractionary monetary policy shock. Except for the federal funds rate, the excess bond premium and the homeownership rate, all variables are in log differences. For the latter, the impulse responses presented in Figure 1 are the cumulative ones. The results in this Figure are not new as we had obtained very similar results in previous work (Dias and Duarte (2019)). However, it is reassuring to see that the results are robust to using new monetary policy instruments – the first one proposed by Jarociński and Karadi (2020) and the second instrument is the one proposed by Miranda-Agrippino and Ricco (2021) – that account for the information channel contained in monetary policy announcements relative to results based the instrument of Gertler and Karadi (2015). The latter does not separate the pure monetary policy channel from the information channel of monetary policy. It is also reassuring to see that, as shown in Figure 1 the two monetary policy instruments yield qualitatively and quantitatively similar results.[6] Because the focus of the paper is on the effects of monetary policy on homeownership and housing tenure choices, and the results for the other variables are standard in the literature, we focus discussion on the results in the Figure that pertain to the effect of monetary policy on the homeownership rate, house rents, and house prices. As we had found in previous work, when the Fed unexpectedly tightens monetary policy, the homeownership rate declines and stays persistently lower for several years. At the same time, housing rents initially increase before adjusting down after some years. As for house prices, as shown previously, these decline after the monetary authority tightens its monetary policy. Altogether, we interpret these three results as evidence that monetary policy affects housing tenure choice decisions by affecting the relative cost of ownership relative to renting – in the following subsection, we use household- and housing unit-level data to test this hypothesis more formally.

Monetary policy affects mortgage rates, which can affect the cost of buying and owning a house. If the changes in demand for housing, due to changes in mortgage rates, do not cause house prices to adjust automatically and assuming some stickiness in housing rents (which is empirically verified, as shown by Gallin and Verbrugge (2019)), there will be temporary fluctuations in the house price-to-rent ratio. These fluctuations can result in households switching from renting to owning or owning to renting. Monetary policy also affects income / real economic activity, as shown in Figure 1, which can also lead to fluctuations in the house price-to-rent ratio if households have a preference for owning and as their income changes. With higher (lower) income, possibly as a result of loosening (tightening) monetary policy conditions, households may decide to own (rent) instead of renting (owning). We do not take a stand on which channel is relatively more important. We just acknowledge that both channels can help explain the effect of monetary policy on homeownership, housing prices and rents.

For the other variables included in the model – the federal funds rate, the excess bond premium, GDP growth, and the growth rate of the consumer price index – our results are in line with those in the literature. In the case of the growth rate of the consumer price index, albeit with a lower magnitude in the case of the Miranda-Agrippino and Ricco (2021) instrument, the estimated impulse response functions show an initial increase in prices in response to a monetary policy shock (i.e., "price puzzle"). However, we are not too concerned with this result because, as discussed in Ramey (2016), small differences in the sample and identification can give rise to differences in the initial response of the

[6] In Appendix C we show results based on local projections using a proxy VAR model to identify the structural shocks. As expected, given the results of Plagborg-Møller and Wolf (2021b) showing the equivalence between LP regressions and VAR models, the two methodologies yield very similar quantitative and qualitative results. Also, in this case, the results do not depend on the instrument used.

Figure 1: Impulse Response Functions of Select Macroeconomic Variables to a 25 bps Monetary Policy Shock



Note: The Figure shows the estimated impulse responses of the different variables included in the analysis to a 25 bps contractionary U.S. monetary policy shock. The results in the Figure are based on the proxy-SVAR methodology described in section 2, using the two alternative monetary policy instruments, that of Miranda-Agrippino and Ricco (2021) (in red), and that of Jarociński and Karadi (2020) (in blue) that were also described in section 2. Both instruments isolate the pure monetary surprises from the information content present in the Fed's communications. The solid lines are the impulse-response function point estimates, while the shaded areas are the 68% confidence intervals. The confidence intervals were computed from 1,000 draws using a parametric bootstrap as proposed in Stock and Watson (2018).

consumer price index to monetary policy shocks.

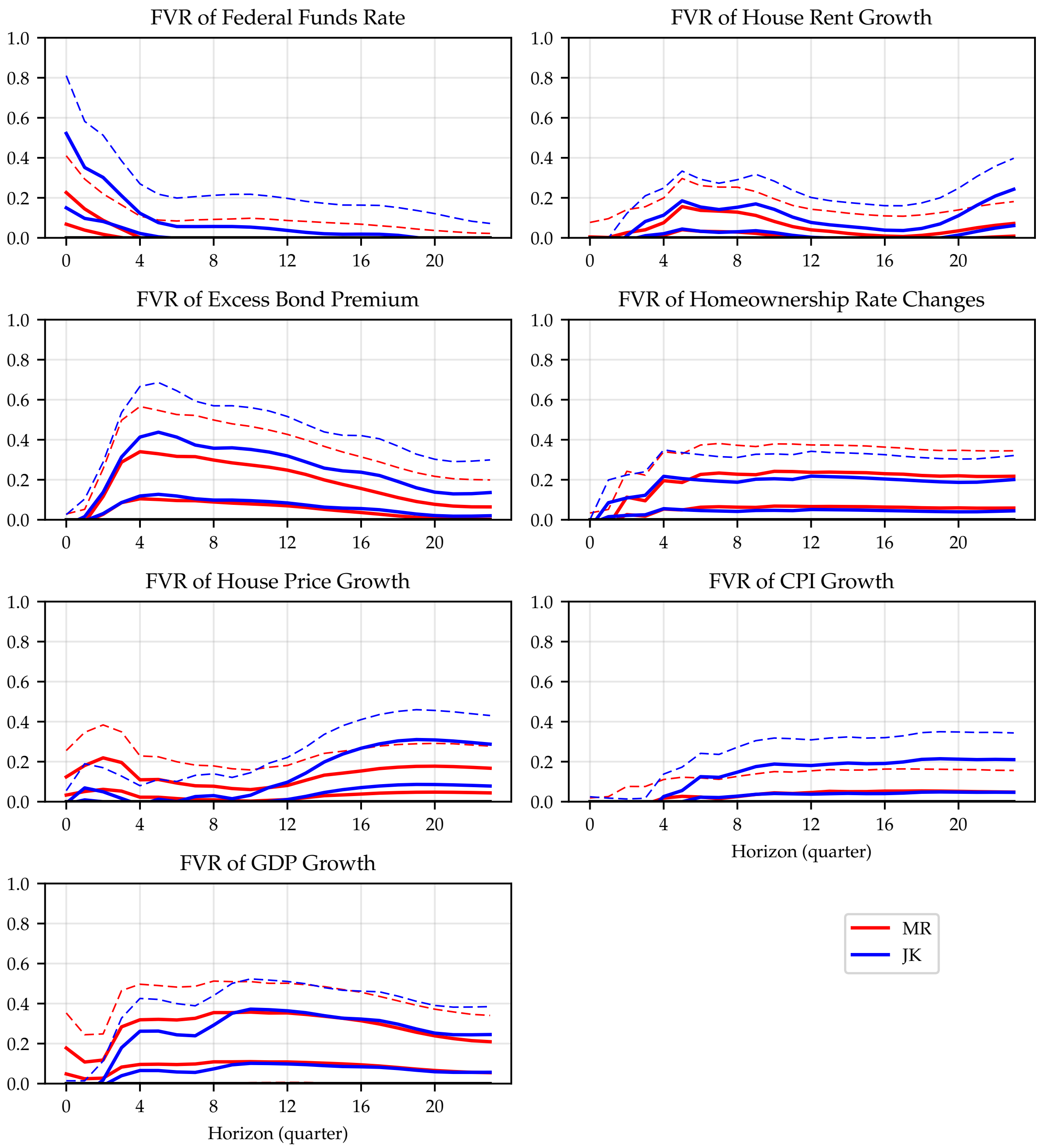
While Figure 1 shows that the homeownership rate, house prices, and housing rents respond strongly to monetary policy shocks, it is also important to know how much monetary policy shocks contribute to the variation in these variables. To answer this question, we use the dynamic variance decomposition methodology of Plagborg-Møller and Wolf (2021a) that we summarized earlier. The results of this decomposition are shown in Figure 2.[7]

We estimate that monetary policy shocks are an important driver of fluctuations in these two variables for house prices and house rents. In the short-run (in the first 1.5 years after the shock), monetary policy shocks can explain up to 30 percent of variations in rents, whereas in the medium-run (after 1.5 years), monetary policy shocks can explain as much as 40 percent of fluctuations in house prices. As for the homeownership rate, we estimate that monetary policy shocks account for at least 5 percent of the variation of this variable, both in the short and the medium run, but that this share may be as high as 30 percent. This result is significant because the homeownership rate tends to be a relatively slow-moving variable which is, as our results suggest, highly influenced by monetary policy shocks. To the extent that anticipating or delaying homeownership has welfare consequences for individuals, the Fed should consider this channel when conducting monetary policy. In addition, there may also be redistributive effects between renters and homeowners that the central bank should be aware of when deciding monetary policy.

The results for the excess bond premium are the same as those found for these variables by Plagborg-Møller and Wolf (2021a). For GDP, we estimate that monetary policy shocks can be responsible for as much as 40 percent of the fluctuations in the rate of GDP growth - Plagborg-Møller and Wolf (2021a) obtained a similar result for industrial production. Unlike what Plagborg-Møller and Wolf (2021a) found for the rate of growth of the CPI when using the Jarociński and Karadi (2020) monetary policy shocks instrument, we estimate that monetary policy shocks can account for as high as 30 percent of fluctuation in the rate of growth of the CPI. However, when using the Miranda-Agrippino and Ricco (2021) monetary policy shock instrument, we estimate that monetary policy accounts for less than 5 percent of fluctuations in the rate of growth of the CPI, a result that is much more similar to the findings of Plagborg-Møller and Wolf (2021a). The results for the rate of growth of the CPI are that using one monetary policy instrument or the other made a difference for the results. The fed funds rate is another variable for which we found substantial differences in results depending on the monetary policy instrument used. In particular, while based on the Jarociński and Karadi (2020) monetary policy shocks can explain close to 60 percent of the fed funds rate variation in the short run, based on the Miranda-Agrippino and Ricco (2021) monetary policy shock, monetary policy shocks are at most responsible for 20 per-

[7] In Appendix C we show the forecast error variance decomposition results based on the proxy VAR model that we used to obtain the impulse response functions shown in Figure 1. Overall, the two methodologies yield similar qualitative results.

Figure 2: Contribution of U.S. Monetary Policy Shocks to the Dynamic Variance of Select Macroeconomic Variables



Note: the Figure shows the forecast variance ratio of the different variables included in the analysis to a U.S. monetary policy shock based on the dynamic variance decomposition methodology of Plagborg-Møller and Wolf (2021a). The results are based in two alternative monetary policy instruments, that of Miranda-Agrippino and Ricco (2021) (in red) and that of Jarociński and Karadi (2020) (in blue). Both instruments isolate the pure monetary surprises from the information content present in the Fed's communications. The solid lines report the point estimates and the dashed lines the 90% confidence intervals for the identified sets of forecast variance across different variables and forecast horizons. The confidence intervals were computed from 1,000 draws using a bootstrap procedure as proposed in Kilian and Lütkepohl (2017).

cent of the variation in the fed funds rate in the short run. While understanding what may be driving these differences in the results is important, it is beyond the scope of our paper, and therefore we leave it for future research. At the same time, the most important results for this paper, namely those concerning the homeownership rate, housing rents, and house prices, the two instruments yield qualitatively and quantitatively very similar results.

2.2 Monetary Policy and Housing Tenure Choice Decisions - Evidence from Household- and Housing Unit-Level Data

2.2.1 Data

We use the national American Housing Survey (AHS) data to test whether monetary policy affects housing tenure decisions. This survey is conducted by the U.S. Census every two years (in odd-numbered years) between May and September. This survey follows a sample of housing units and collects information on characteristics of the housing unit and the people (or household) living in that housing unit (in the case that the housing unit is not vacant). One key characteristic of the housing unit is its tenure status. That is, whether that house is owned by the person living in it or whether it is a rental. We will also know whether a specific household is renting or is a homeowner with this information. Because the survey follows the same housing unit over time, it will be straightforward to study the effect of monetary policy on the housing unit tenure status. This information at the unit level means that the AHS data are very well suited for studying the effect of monetary policy on housing supply. However, at the household level, it will be more challenging to study the effect of monetary policy on that household's decision to rent or own the house they are living in because the survey does not track households over time. As such, we will not know if the household living in a particular housing unit is the same household that was living in that housing unit in the previous period — in other words, the data at the household level is not a panel, but just a pooled cross-section. While the survey does not track households over time, it collects information on whether the household changed tenure status in the previous 12 months. Even if not ideal, this information still allows us to estimate the effect of monetary policy on the probability of a household switching from renting to owning and from owning to renting.

The AHS data are available at a biennial frequency from 1973 to 2019. However, in our empirical exercises, we only use 1993 to 2015. We restrict the sample to start in 1993 and end in 2015 because the monetary policy instrument we use, the high-frequency monetary instrument constructed by Jarociński and Karadi (2020), is only available for the period 1992 to 2016. In Appendix A we provide detailed information on the data we use and how we constructed the different variables.

An alternative source for studying housing tenure transitions is the Panel Study of Income Dynamics database. Bachmann and Cooper (2014) use this database to study housing tenure transitions in the U.S. market and compare their results to those obtained with the AHS database, and they report that the empirical patterns observed with the two databases are broadly similar. We chose to use the AHS database because it simultaneously allows us to study housing tenure decisions at the household level and changes in housing unit type - from rental to ownership and vice versa. One key difference between our study and that of Bachmann and Cooper (2014) is that these authors mostly look at transitions during the business cycle, whereas we look explicitly at housing tenure and housing unit type transitions related to changes in monetary policy.

For the microdata analysis, we use the high-frequency monetary surprises shock constructed by Jarociński and Karadi (2020) as our monetary policy shock variable because of the more extended sample[8]. Because the AHS data are bi-annual, we constructed a bi-annual monetary policy shock. In constructing the bi-annual monetary policy shock, we considered the fact that the AHS is conducted between May and September and summed the quarterly Jarociński and Karadi (2020) monetary policy shocks from the fourth quarter of the year $t-2$ to the third quarter of year t.

$$MP_t^{JK} = \sum_{q=-7}^{q=0} MP_{t,q}^{JK,quarterly} \tag{9}$$

For example, the monetary policy shock measure for 2005 is the sum of all the quarterly monetary policy shocks between 2003:Q4 and 2005:Q3 (8 quarters in total).

We use the separate regressions as additional controls information on household characteristics, namely the head of household age and household income, and the U.S. region where the housing is located.

2.2.2 Methodology

To study the effect of monetary policy on the household's tenure decisions, we estimate simple logit models in which the dependent variable measures transition from renting to owning or from owning to renting. In the case of the rent-to-own transition, the dependent variable is an indicator variable equal to 1 if the household is currently a homeowner but was a renter before, and 0 if the household is currently a homeowner and was also a homeowner before. In the case of the own-to-rent transition, the dependent variable is an

[8] While the Miranda-Agrippino and Ricco (2021) instrument sample ends in 2009, the Jarociński and Karadi (2020) instrument ends in 2016.

indicator variable equal to 1 if the household is currently a renter but was a homeowner before, and 0 if the household is currently a renter and was also a renter before.

The estimated equations are the following:

$$\begin{aligned} Prob(HH_{i,t} = owner | HH_{i,t-1} = renter) = Logit(\alpha + \beta MP_t^{JK} + \theta D_{i,t}) \\ Prob(HH_{i,t} = renter | HH_{i,t-1} = owner) = Logit(\lambda + \gamma MP_t^{JK} + \delta D_{i,t}) \end{aligned} \tag{10}$$

$$\begin{aligned} Prob(HH_{i,t} = owner | HH_{i,t-1} = renter) = Logit(\alpha + \sum \beta_j MP_t^{JK} * d_{i,t} + \theta D_{i,t}) \\ Prob(HH_{i,t} = renter | HH_{i,t-1} = owner) = Logit(\lambda + \sum \gamma_j MP_t^{JK} * d_{i,t} + \delta D_{i,t}) \end{aligned} \tag{11}$$

In equations 10 and 11, the function Logit(.) is the standardized logit function $\frac{exp(.)}{1+exp(.)}$, $D_{i,t} = \{d_{i,t}^{region}, d_{i,t}^{age\ ter}, d_{i,t}^{inc\ quar}\}$ are indicator variables for the U.S. region where the housing unit is located ($d_{i,t}^{region}$), the age tercile ($d_{i,t}^{age\ ter}$), or the income quartile ($d_{i,t}^{inc\ quar}$) the household belongs to.[9] Equation 11 is estimated separately for the interactions between the monetary policy shock and the region the household lives in, the age tercile the the head of household belongs to, and the income quartile the household belongs to. The results pertaining to equation 10 are shown in Table 1, while the results pertaining to equation 11 are shown in Tables 2, 4, and 5, respectively.

To study the effect of monetary policy on the housing unit's tenure status, we run simple linear regressions, either applied to individual housing unit information or aggregated data on housing unit tenure status. In the case of individual housing unit information, we can control for time-invariant housing unit characteristics by using fixed effects in the regression. The models we estimate are the following:

$$Y_{i,t} = \alpha + \beta MP_t^{JK} + \delta_i + \epsilon_{i,t} \tag{12}$$

$$S_{j,t} = \gamma + \lambda MP_t^{JK} + \kappa_j + \epsilon_{j,t} \tag{13}$$

$$S_t = \gamma + \lambda MP_t^{JK} + \epsilon_t \tag{14}$$

In equation 12, the dependent variable is an indicator variable that takes the value 1 if the housing unit is a rental unit and 0 if not, δ_i are housing unit fixed effects, and $\epsilon_{i,t}$ is an

[9]The head of household age terciles and household income quartiles are based on the sample distribution of ages and incomes within each cohort of the AHS survey.

error term. In equations 13 and 14, the dependent variables are the share of housing units that are rental units in the region and period and the share of housing units that are rental units in the aggregate, respectively. In equation 13, κ_j are region fixed effects and $\epsilon_{j,t}$ is an error term; in equation 14, ϵ_t is an error term.

2.2.3 Results

We now turn to the discussion of the results, starting with those in Table 1. The first four columns in this Table show the effect of a monetary policy shock on the probability of a household transitioning from a renter to a homeowner in the previous 12 months. The last four columns in the Table show the effect of a monetary policy shock on the probability of a household having transitioned from a homeowner to a renter in the previous 12 months. In columns (1) and (5), the results do not control for any household characteristic or location of the housing unit. The results in columns (2) through (4) and (6) through (8) incrementally add controls for household characteristics and location of the housing unit.

The results based on aggregate data in the previous sub-section showed that, in response to a contractionary monetary policy shock, house prices decline, rents increase, but at the same time, homeownership declines. To explain these results, we conjectured that when monetary conditions tighten, the relative costs of owning relative to renting increase, which drives people away from homeownership and into renting. The results in Table 1 are consistent with this mechanism, albeit not always statistically significant, especially in the case of own-to-rent transitions.[10] According to the results of Table 1, when monetary conditions tighten (loosen), it is less (more) likely that a renter becomes a homeowner and more (less) likely that a homeowner becomes a renter. Also, note that the results are sensible concerning household characteristics, namely household age and income. According to the results in this Table, younger households are more likely to both transition from being a renter to being a homeowner and from being a homeowner to being a renter. The higher likelihood of a younger household adjusting its tenure status is in line with the idea that younger households are more likely to make changes to their lifestyle and are still in the process of stabilizing their careers. The pattern is evident in the case of income, with higher-income households being more likely to become homeowners and less likely to become renters. Finally, there are some regional differences in the transition rates from renting to owning and from owning to renting, but no noticeable pattern.

To see whether there are noticeable regional differences in the way monetary policy

[10] Bachmann and Cooper (2014) found the own-to-rent transitions to be mostly acyclical, but in our results for the effect of monetary policy on the transitions from owning to renting, we still find them to be numerically in line with our expectation, despite not being statistically significant.

Table 1: Probability of a household changing housing tenure and monetary policy shocks

Variables	Probability of becoming owner				Probability of becoming renter			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MP Shock	-0.704	-0.709	-0.846	-0.821	0.241	-0.062	0.253	0.249
	(0.560)	(0.538)	(0.490)*	(0.487)*	(0.403)	(0.474)	(0.476)	(0.459)
2^{nd} age tercile		-0.091	-0.082	-0.062		-1.468	-1.384	-1.388
		(0.035)**	(0.026)***	(0.024)**		(0.049)***	(0.040)***	(0.040)***
3^{rd} age tercile		-0.613	-0.182	-0.141		-2.113	-2.551	-2.557
		(0.040)***	(0.054)***	(0.049)***		(0.083)***	(0.090)***	(0.089)***
2^{nd} income quartile			1.047	1.065			-0.764	-0.770
			(0.037)***	(0.038)***			(0.027)***	(0.027)***
3^{rd} income quartile			1.904	1.953			-1.580	-1.592
			(0.041)***	(0.042)***			(0.033)***	(0.032)***
4^{th} income quartile			2.618	2.727			-2.277	-2.310
			(0.041)***	(0.040)***			(0.030)***	(0.026)***
Midwest				0.661				0.009
				(0.062)***				(0.032)
South				0.626				0.083
				(0.069)***				(0.063)
West				0.158				0.506
				(0.077)**				(0.052)***
Constant	-2.036	-1.871	-3.260	-3.702	-2.614	-1.452	-0.237	-0.376
	(0.141)***	(0.134)***	(0.147)***	(0.136)***	(0.116)***	(0.131)***	(0.139)*	(0.115)***
N	193,718	193,718	193,718	193,718	384,183	384,183	384,183	384,183

Note: The Table shows results of logit regressions in which the dependent variable in columns (1)-(3) is a dummy variable that takes the value 1 if the household switched from renting to owning a house between in the 12 months prior to the survey interview and 0 if it the household continues to rent; and, the dependent variable in columns (4)-(6) is a dummy variable that takes the value 1 if the household switched from owning to renting a house in the 12 months prior to the survey interview and 0 if the household continues to own the house it lives in; the monetary policy shock was constructed with the high-frequency monetary shock instrument of Jarociński and Karadi (2020). Data are biannual from 1995 to 2015. Standard errors clustered by period in parentheses. *, **, and *** denote statistical significance at 10%, 5%, and 1%.

affects households tenure choice decisions, we extended the results of Table 1 by allowing the effect of monetary policy to vary with the region where the household lives – these results are shown in Table 2. While there is heterogeneity across regions, similar to the case with regional dummies, we do not see any particular pattern in the results. This result, however, could be due to the statistical model being non-linear, which makes some of the comparisons less straightforward. Similar to what we did before, we translate the results in Table 2 into marginal effects of monetary policy shock on the transition probabilities from rent to own and own to rent in the four regions - these results are shown in Table 3.

To give some sense of the economic importance of the results in Table 1 and in Table 2, we use the results in columns (1) and (5) and columns (1) and (3) of these two tables, respectively, to calculate the effect of a 25 basis points monetary policy shock (this is about the size of the standard deviation of monetary policy shocks in our sample) on the respective

Table 2: Probability of a household changing housing tenure and monetary policy shocks - interaction with U.S. region

Variables	Prob. of becoming owner (1)	(2)	Prob. of becoming renter (3)	(4)
MP Shock*U.S. East	-0.682	-0.762	0.259	0.234
	(0.614)	(0.549)	(0.331)	(0.454)
MP Shock*U.S. Midwest	-0.645	-0.771	0.297	0.262
	(0.582)	(0.465)*	(0.345)	(0.438)
MP Shock*U.S. South	-0.784	-0.824	0.247	0.245
	(0.599)	(0.521)	(0.415)	(0.452)
MP Shock*U.S. West	-0.622	-0.910	0.172	0.251
	(0.535)	(0.518)*	(0.468)	(0.573)
Midwest	0.483	-0.062	0.225	-1.388
	(0.057)***	(0.024)**	(0.033)***	(0.041)***
South	0.484	-0.142	0.341	-2.557
	(0.059)***	(0.049)***	(0.066)***	(0.089)***
West	0.271	1.065	0.543	-0.770
	(0.073)***	(0.037)***	(0.042)***	(0.027)***
2^{nd} age tercile		1.953		-1.592
		(0.042)***		(0.032)***
3^{rd} age tercile		2.727		-2.310
		(0.040)***		(0.026)***
2^{nd} income quartile		0.660		0.011
		(0.080)***		(0.039)
3^{rd} income quartile		0.621		0.084
		(0.080)***		(0.063)
4^{th} income quartile		0.147		0.507
		(0.096)		(0.060)***
Constant	-2.371	-3.697	-2.921	-0.377
	(0.153)***	(0.141)***	(0.090)***	(0.116)***
N	193,718	193,718	384,183	384,183

Note: The Table shows results of logit regressions in which the dependent variable in columns (1) and (2) is a dummy variable that takes the value 1 if the household switched from renting to owning a house between in the 12 months prior to the survey interview and 0 if it the household continues to rent; and, the dependent variable in columns (3) and (4) is a dummy variable that takes the value 1 if the household switched from owning to renting a house in the 12 months prior to the survey interview and 0 if the household continues to own the house it lives in; the monetary policy shock was constructed with the high-frequency monetary shock instrument of Jarociński and Karadi (2020). Data are biannual from 1995 to 2015. Standard errors clustered by period in parentheses. *, **, and *** denote statistical significance at 10%, 5%, and 1%.

probabilities of becoming an owner or becoming a renter. In Table 3, columns (1) and (5) correspond to an estimated baseline average transition from renting to owning and from owning to renting, respectively. Using the results of Tables 1 and 2, we then estimate the effect of a 25 basis point monetary policy shock on these transition probabilities, these results

Table 3: Marginal effect of a monetary policy shock on the rent-to-own and own-to-rent transition probabilities

Region	Rent to Own				Own to Rent			
	No MP shock (1)	MP shock= 25 bps (2)	Marginal effect (3)	Percent change (4)	No MP shock (5)	MP shock= 25 bps (6)	Marginal effect (7)	Percent change (8)
East	8.49%	7.06%	-1.44%	-16.9%	5.14%	5.47%	0.33%	6.5%
Midwest	13.09%	11.05%	-2.04%	-15.6%	6.33%	6.83%	0.50%	7.9%
South	7.55%	6.16%	-1.39%	-18.4%	3.78%	4.01%	0.23%	6.1%
West	6.09%	5.21%	-0.88%	-14.5%	4.60%	4.80%	0.19%	4.2%
U.S.	11.54%	9.62%	-1.91%	-16.6%	6.82%	7.24%	0.42%	6.1%

Note: The Table shows the effect of a 25 basis points monetary policy shock on the transition probabilities from renting to owning the home the household lives in and from owning to renting it. The results in the table are based on the results in columns (1) and (5) in Table 1 and columns (1) and (3) in Table 2. Columns (3) and (7) are obtained by subtracting columns (2), (1), (6) and (5), respectively; columns (4) and (8) are obtained by dividing columns (3) and (1) and (7) and (5), respectively.

are shown in columns (2) and (6). The marginal effect of the 25 basis point shock on the transition from renting to owning and from owning to renting are shown in columns (3) and (7), respectively. Columns (4) and (8) translate the marginal effect results in columns (3) and (7) into percentage changes relative to the no-shock baseline case. The results in this Table show that, on average, absent any monetary policy shock, about 11.5% of renters become owners every year. About 6.8% of owners become renters in our sample.[11] When monetary policy conditions tighten by 25 basis points, about 9.6% of renters become owners and about 7.2% of owners become renters. These results imply that in response to a 25 basis points contractionary policy shock, the rate of transitions from renting to homeownership falls by about 16.6% and the rate of transition from homeownership to renting increases by 6.1%.[12] There are also some regional differences regarding the percentage changes in the transitions probabilities, but these are relatively small.

Because the effects on the decision to transition from renting to owning or from owning to renting are likely to depend on the household head's age or income, we also consider interactions of the monetary policy shocks with the household's age and the income. The results for the interactions with the age of the household head are shown in Table 4, while

[11] While it is difficult to make a straight comparison between our results for average housing tenure transition rates and those of Bachmann and Cooper (2014) because of differences in the data, due to differences of how transitions are calculated, and differences in the sample period, the results in Table 3 are broadly in line with results fromBachmann and Cooper (2014). Namely, Bachmann and Cooper (2014) estimate that within a 2-year period close to 7% of housing transitions are between ownership and rental and our results in Table 3 give a transition rate of about 8% – this number is the sample size weighted average of the values in the bottom row of columns (1) and (5) in Table 3.

[12] The 16.6% and 6.1% figures are obtained by $\frac{9.6\%}{11.5\%} - 1$ and $\frac{7.2\%}{6.8\%} - 1$, respectively.

Table 4: Probability of a household changing housing tenure and monetary policy shocks - interaction with the head of household age

Variables	Prob. of becoming owner (1)	Prob. of becoming renter (2)
MP Shock*1^{st} age tercile	-0.903	-0.239
	(0.477)*	(0.592)
MP Shock*2^{nd} age tercile	-0.932	0.295
	(0.535)*	(0.466)
MP Shock*3^{rd} age tercile	-0.409	1.197
	(0.524)	(0.458)***
2^{nd} age tercile	-0.066	-1.351
	(0.033)**	(0.040)***
3^{rd} age tercile	-0.103	-2.455
	(0.049)**	(0.074)***
2^{nd} income quartile	1.064	-0.775
	(0.037)***	(0.027)***
3^{rd} income quartile	1.954	-1.594
	(0.042)***	(0.033)***
4^{th} income quartile	2.729	-2.308
	(0.040)***	(0.026)***
Midwest	0.661	0.009
	(0.063)***	(0.032)
South	0.626	0.083
	(0.069)***	(0.063)
West	0.158	0.506
	(0.078)**	(0.051)***
Constant	-3.708	-0.408
	(0.134)***	(0.108)***
N	193,718	384,183

Note: The Table shows results of logit regressions in which the dependent variable in column (1) is a dummy variable that takes the value 1 if the household switched from renting to owning a house between in the 12 months prior to the survey interview and 0 if it the household continues to rent; and, the dependent variable in column (2) is a dummy variable that takes the value 1 if the household switched from owning to renting a house in the 12 months prior to the survey interview and 0 if the household continues to own the house it lives in; the monetary policy shock was constructed with the high-frequency monetary shock instrument of Jarociński and Karadi (2020). Data are biannual from 1995 to 2015. Standard errors clustered by period in parentheses. *, **, and *** denote statistical significance at 10%, 5%, and 1%.

for the interaction with the household income are shown in Table 5. Starting with the results in Table 4, they show there is important heterogeneity, with the transition to owning of younger households and the transition of older households being more responsive to monetary policy shocks, relative to the other age groups. In the case of the interaction of monetary policy shocks with the household income, results in Table 5 show that, con-

Table 5: Probability of a household changing housing tenure and monetary policy shocks - interaction with household income

Variables	Prob. of becoming owner (1)	Prob. of becoming renter (2)
MP Shock*1st income quartile	-1.048	0.459
	(0.546)*	(0.404)
MP Shock*2nd income quartile	-0.999	0.157
	(0.470)**	(0.454)
MP Shock*3rd income quartile	-0.657	0.242
	(0.458)	(0.512)
MP Shock*4th income quartile	-0.685	-0.074
	(0.571)	(0.715)
2nd age tercile	-0.061	-1.389
	(0.024)**	(0.041)***
3rd age tercile	-0.140	-2.557
	(0.049)***	(0.089)***
2nd income quartile	1.069	-0.793
	(0.045)***	(0.040)***
3rd income quartile	1.985	-1.609
	(0.044)***	(0.051)***
4th income quartile	2.757	-2.347
	(0.041)***	(0.031)***
Midwest	0.661	0.009
	(0.062)***	(0.032)
South	0.626	0.084
	(0.069)***	(0.063)
West	0.158	0.506
	(0.078)**	(0.052)***
Constant	-3.722	-0.359
	(0.139)***	(0.122)***
N	193,718	384,183

Note: The Table shows results of logit regressions in which the dependent variable in column (1) is a dummy variable that takes the value 1 if the household switched from renting to owning a house between in the 12 months prior to the survey interview and 0 if it the household continues to rent; and, the dependent variable in columns (2) is a dummy variable that takes the value 1 if the household switched from owning to renting a house in the 12 months prior to the survey interview and 0 if the household continues to own the house it lives in; the monetary policy shock was constructed with the high-frequency monetary shock instrument of Jarociński and Karadi (2020). Data are biannual from 1995 to 2015. Standard errors clustered by period in parentheses. *, **, and *** denote statistical significance at 10%, 5%, and 1%.

cerning transitions from renting to owning and from owning to renting, households in the bottom half of the distribution are more sensitive to monetary policy shocks than households in the top half of the income distribution. While we do not plan to capture all these heterogeneous effects with the model we propose in the next section, these results already hint that, through its effects on housing tenure choice decisions, monetary policy will have heterogeneous effects on households depending on their age and income levels.

Table 6: Effect of monetary policy shocks on housing unit tenure status

Variables	Prob. of becoming rental		Δ Rental share (percent)			
	(1)	(2)	(3)	(4)	(5)	(6)
MP Shock	0.040	0.004	6.00	6.00	4.09	6.00
	(0.018)*	(0.012)	(1.51)***	(1.56)***	(2.89)	(1.15)***
MP Shock*U.S. Midwest		0.044			2.14	
		(0.016)**			(2.21)	
MP Shock*U.S. South		0.046			1.09	
		(0.012)***			(1.80)	
MP Shock*U.S. West		0.047			4.40	
		(0.014)***			(3.67)	
R^2	0.82	0.82	0.16	0.16	0.17	0.21
N	504,220	504,220	44	44	44	11
House unit FE	Y	Y	N	N	N	N
Region FE	N	N	N	Y	Y	N
Data	House unit	House unit	U.S. Regional	U.S. Regional	U.S. Regional	U.S. Aggregate

Note: The Table shows results of OLS regressions in which: the dependent variable in columns (1) and (2) is a dummy variable that takes the value 1 if the housing unit is a rental and 0 if it is owner-occupied; the dependent variable in columns (3), (4), and (5) is the change in the average share of rental housing units in the sample by year and U.S. Census region (Northeast, South, Midwest, and West); the dependent variable in column (6) is the change in the average share of housing units in the sample that are rentals by year and for the whole U.S. economy; the monetary policy shock was constructed with the high-frequency monetary shock instrument of Jarociński and Karadi (2020). Data are biannual from 1995 to 2015. Standard errors, in parentheses, for results in columns (1) and (2) are clustered by housing unit and period; standard errors for results in columns (3), (4), and (5) are clustered by period and adjusted for serial correlation (Driscoll and Kraay (1998)); standard errors for results in column (6) are robust to heteroskedasticity and serial correlation. *, **, and *** denote statistical significance at 10%, 5%, and 1%.

As shown in the previous section, monetary policy affects the relative price of houses *vis-à-vis* renting, and this result is expected to be driven by a change in the relative demand of the two types of housing tenure arrangements that is not fully offset by a change in the supply of the two types of housing. The results discussed thus far in this sub-section show that monetary policy affects the relative demand of owned homes relative to renting, which agrees with the effects on the relative prices of houses and renting that we presented in the previous sub-section.

The last set of results we want to discuss before presenting a model consistent with our empirical results are those related to the effect of monetary policy on housing unit's tenure type or the effect of monetary policy on the supply of housing for homeownership *vis-à-vis* for renting. We answer this question by using the housing unit data we described earlier to estimate models 12, 13), and 14. These results are shown in Table 6 – columns (1) and (2) show the results for the individual housing unit, while columns (3), (4), (5), and (6) show results based on the aggregation of the individual housing unit at the U.S. region and the

U.S. as a whole. Starting with column (1) in Table 6, which shows the average effect across the U.S. economy of a monetary policy shock on the probability of a given housing unit becoming a rental unit, we see that a contractionary monetary policy shock makes it more likely that a housing unit becomes a rental (relative to its average status that is controlled by the housing unit fixed effect). This result shows that, as could be expected, it becomes more desirable for some housing units for ownership to be transformed into rental units because a contractionary monetary policy shock leads to higher rents lower house prices. This result just confirms that the housing market responds to incentives.

Column (2) in the same Table shows the results by region, indicating some regional heterogeneity. While housing units in the East region do not respond much to monetary policy shocks, tighter monetary policy conditions make it more likely for housing units in the Midwest, South, and West regions to become rental. The results in columns (3) through (6) in Table 6, which are based on aggregated data, show similar results to those based on individual housing unit data and provide a sense of the aggregate effects of monetary policy on the relative stock of rental units. While the results in Table 6 provide a good idea of how monetary policy affects the relative supply of housing units. A caveat is that these results are only based on existing housing units, and they do not consider that new housing units can be produced. For short time horizons, however, changes in the relative supply of housing for homeownership and rental should not be driven by new construction, but this will be an important channel at longer time horizons. In sum, our results show that monetary policy affects the relative supply of rentals *vis--vis* houses for ownership. However, these effects are not significant enough to prevent temporary changes in the house-to-rent ratio. As such, monetary policy has an important bearing on housing tenure choice decisions.

The empirical results of this section clearly show that monetary policy is an important driver of fluctuations in the aggregate homeownership rate and that these fluctuations are due to the effect of monetary policy on the relative prices of homeownership *vis-à-vis* renting. An obvious question is why this matters. In the next section, we propose a two-agent New Keynesian model that can replicate the main empirical results shown in this section. With the model in hand, we then use it to study the implications of these empirical findings to better understand monetary policy transmission through the housing tenure choice channel and the implications for optimal monetary policy.

3 Theory

To account for the empirical results discussed in the previous section, we propose a two-agent New Keynesian model in which agents decide whether to own or rent based on the relative price of the two housing tenure options. The model builds on existing models that include a housing sector, such as those of Iacoviello (2005) and Iacoviello and Neri (2010), and extend them by incorporating a segmented housing market. Specifically, there is a housing tenure choice at the household level and a housing supply sector with landlords who can buy houses and rent them subject to adjustment costs. This section shows that it is precisely the interaction between housing tenure decisions and the housing supply that can generate price-to-rent responses to monetary policy shocks like the ones we observe in the data.

3.1 The environment

The economy is set in discrete-time and features two types of families — borrowers and savers — each populated by a continuum of infinitely-lived households with measure one. The savers have full access to credit markets and behave as Ricardian agents. The borrowers face a collateral constraint along the lines of work by Campbell and Hercowitz (2005), Iacoviello (2005), Iacoviello and Neri (2010), and Calza et al. (2013). Hence, the borrowers borrowing limit is a function of the value of their house. In our theoretical environment, the borrowers find themselves against the borrowing constraint at all times. Consequently, they are assumed to behave in a ”hand-to-mouth” fashion. Also, the borrower's family households differ in their preferences concerning owning a house: they receive extra utility from these services for the same quantity of housing services if they own a house instead of renting one. Motivated by our empirical findings in Table 5, we assume that the housing tenure choice is only relevant for the borrowers.[13]

We assume a fixed total housing stock. Real estate brokers provide housing rental services buying them from landlords and selling them with a markup. The brokers are the source of rigidity in housing rents. The landlords buy/sell housing stock for owning and rent it to the brokers, subject to adjustment costs. The latter can be motivated by higher maintenance costs for renting, less favorable tax treatment relative to owning, and the necessity of rehabilitation work. These housing stock adjustment costs are the source of housing market segmentation in our model.

Finally, in terms of the supply of final goods, we assume that wholesale firms produce

[13]This assumption does not affect the qualitative nature of how the tenure choice channel affects the monetary policy transmission dynamics. It only has quantitative implications.

them with a constant return to scale technology that uses the labor of both agents (borrowers and savers) as its only inputs. Consumers buy the final good from retailers, who sell the wholesale goods with a markup but can only adjust the prices of their goods at random times. Therefore, retailers are a source of nominal rigidity in this economy. We assume that savers own all types of firms in the economy. The savers' problem is standard. The savers, the wholesalers and the retailers' problems are the same as in Iacoviello (2005). The only difference is that the savers in our model also own the brokers and landlords.

3.2 Households

All households get utility from consuming the final good and housing services and dislike working.[14] The instantaneous utility function is given by

$$u(c,h,L) = \ln c + \frac{h^{1-\phi}}{1-\phi} - \frac{L^{\eta}}{\eta}.$$

Borrowers

Each household of the borrower's family can choose to own or rent a house every period. As discussed previously, we also assume that borrowers-households are heterogeneous regarding their utility from owning the house. We assume that owners have higher utility for a given house size than renters, and we denote the difference by ρ_i for household i. We assume that, every period, each household receives an i.i.d. draw ρ_i from cdf $F(\rho)$. Also, inspired by the work of Ragot (2018), we assume that each household in the borrower's family trade a complete set of contracts for consumption and housing services within their own family, providing perfect insurance against idiosyncratic risk. The borrowers' social planner problem is one of maximizing the following lifetime utility function:

$$E_0 \sum_{t=0}^{\infty} (\beta')^t \left\{ \int_0^1 \ln c_t^i + (1 - I_t^i) \left(j^r \frac{(h_t^i)^{1-\phi^r}}{1-\phi^r} \right) + I_t^i \left(j^o \frac{(h_t^i)^{1-\phi^o}}{1-\phi^o} + \rho_t^i \right) - \frac{(L_t^i)^{\eta}}{\eta} di \right\},$$

where E_0 is the expectation operator conditional on time zero information, $\beta \in (0,1)$ is the discount factor, c_t^i is consumption of borrower i at time t, $I_t^i \in \{0,1\}$ is an indicator function that takes the value of 1 if borrower i decides to own and zero if she decides to rent, h_t^i denotes housing services, ρ_i is the extra utility i.i.d. draw from $F(\rho)$ that agent i receives when owning a house and L_t^i are hours of work, subject to

[14]We assume utility is separable in money balances, which results in the quantity of money having no implications for the rest of the model and, therefore, are ignored.

$$\begin{aligned}\int_0^1 c_t^i + I_t^i q_t \Delta h_t^i + (1-I_t^i) h_t^i l_t + b_{t-1}^i \frac{R_{t-1}}{\pi_t} di &= \int_0^1 b_t^i + w_t' L_t^i di \\ b_t^i \leq I_t^i E_t \left[m q_{t+1} h_t^i \frac{\pi_{t+1}}{R_t} \right],\end{aligned}$$

where q_t, l_t, R_t, π_t, w_t', m and b_t^i denote the real housing price, real housing rent, gross nominal interest rate, gross inflation rate, real wage, loan-to-value ratio and borrowing in real terms, respectively.

Proposition 1. *Assuming a parameter space that allows an interior solution, if ρ_i are i.i.d. draws from a continuous cdf $F(\rho)$ with a non-negative support, then:*

(i) a single cutoff rule is the optimal housing tenure choice, where $\bar{\rho}_t$ is the individual draw of the borrower who, given prices, is indifferent between owning or renting a house. Therefore, households with $\rho_t^i > \bar{\rho}_t$ choose to own a house, while those with $\rho_t^i < \bar{\rho}_t$ decide to rent a house. Consequently, in each period the share of homeowners is given by $\alpha_t = 1 - F(\bar{\rho}_t)$;

(ii) the consumption and hours of work allocations are the same across all borrowers;

(iii) housing services and bond holdings allocations, although different between homeowners and renters, will be the same across renters and homeowners.

According to Proposition 1[15], the problem of the borrowers' social planner can be rewritten as:

$$\max_{c_t', h_t^o, h_t^r, b_t^o, b_t^r, L_t'} E_0 \sum_{t=0}^{\infty} (\beta')^t \left\{ \ln c_t' + \alpha_t \left(j^o \frac{(h_t^o)^{1-\phi^o}}{1-\phi^o} \right) + (1-\alpha_t) \left(j^r \frac{(h_t^r)^{1-\phi^r}}{1-\phi^r} \right) - \frac{(L_t')^\eta}{\eta} \right\},$$

subject to

$$c_t' + \alpha_t q_t h_t^o - \alpha_{t-1} q_t h_{t-1}^o + (1-\alpha_t) l_t h_t^r + \alpha_{t-1} b_{t-1}^o \frac{R_{t-1}}{\pi_t} = \alpha_t b_t^o + w_t' L_t' \quad (15)$$

$$b_t^o \leq E_t \left[m q_{t+1} h_t^o \frac{\pi_{t+1}}{R_t} \right] \quad (16)$$

$$b_t^r = 0, \quad (17)$$

[15]The proof of Proposition 1 can be found in section B of the Online Appendix.

where the share of homeowners is given by:

$$\alpha_t = 1 - F(\bar{\rho}_t) \tag{18}$$

$$\text{with} \quad \bar{\rho}_t = u((c_t')^*, (h_t^r)^*, (L_t')^*) - u((c_t')^*, (h_t^o)^*, (L_t')^*) \tag{19}$$

The star superscript in equation 19 denote that these are optimal allocations given prices and distributions of homeowners and renters. These optimal allocations are the ones used by each household to decide whether they should rent or own a house. First, the borrowers first order condition with respect to L_t' is given by

$$(L_t')^{\eta-1} = \frac{w_t'}{c_t'} \tag{20}$$

Second, the first order conditions with respect to h_t^o, h_t^r and b_t^o when combined with those related to consumption are the following:

$$\alpha_t j^o (h_t^o)^{-\phi^o} = \frac{\alpha_t q_t}{c_t^o} - E_t\left[\frac{\alpha_t q_{t+1}\beta'}{c_{t+1}^o} - \lambda_t m q_{t+1}\pi_{t+1}\right] \tag{21}$$

$$j^r (h_t^r)^{-\phi^r} = \frac{l_t}{c_t^r} \tag{22}$$

$$\frac{\alpha_t}{c_t^o} = E_t\left[\beta'\alpha_t \frac{R_t}{c_{t+1}^o \pi_{t+1}}\right] + \lambda_t R_t \tag{23}$$

The aggregate demand of borrowers that are homeowners is given by:

$$h_t' = \alpha_t h_t^o \tag{24}$$

Savers

In our setting, the savers' problem is standard. These agents do not need to choose between owning or renting; we assume they own a house and simply have to maximize their lifetime utility given the resources that are available to them:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\ln c_t + j \ln h_t - \frac{(L_t)^\eta}{\eta}\right),$$

subject to

$$c_t + q_t(h_t - h_{t-1}) + b_t \frac{R_{t-1}}{\pi_t} = b_t + w_t L_t + F_t. \tag{25}$$

In equation 25, F_t are lump-sum profits received from brokers, landlords, and retailers.

The first order conditions are given by:

$$\frac{1}{c_t} = \beta E_t\left[\frac{R_t}{c_{t+1}\pi_{t+1}}\right] \tag{26}$$

$$\frac{q_t}{c_t} = \frac{j}{h_t} + \beta E_t\left[\frac{q_{t+1}}{c_{t+1}}\right] \tag{27}$$

$$L_t^{\eta-1} = \frac{w_t}{c_t} \tag{28}$$

3.3 Housing supply

A crucial component of our model is housing supply. In this sub-section, we describe how the supply side of housing operates in our model. We assume that the total stock of housing is fixed and has value $\bar{H}$. The total stock of housing is then split into a part that is for ownership, H_t^o, and another part that is for rent, H_t^r, with $\bar{H} = H_t^o + H_t^r$. While we assume that the total housing stock is fixed, the mix of housing stock available for owning can change over time, but these changes are subject to adjustment costs. The landlords are the ones making the housing stock mix adjustment. To adjust the housing stock mix, landlords either buy housing stock that is available for owning and rent it or sell housing stock that was available for rent. Finally, we assume that housing rents are sticky. As renting contracts duration is typically longer than a single period, we assume that only a fraction of these contracts changes prices every period.[16] To model this rent stickiness, we assume there are real estate brokers that buy housing services from the landlords and sell them at a markup to households. The markup can be motivated by management costs and real estate brokers' fees. We describe the landlords' problem in more detail before describing the real estate brokers' problem.

Landlords

There is a unit mass of landlords that own the housing stock for renting. They competitively rent each unit of their housing stock for l_t^L to real estate brokers that resell the housing services at $l_t = X_t^r l_t^L$, where X_t^r is the brokers' markup. They invest/disinvest by buying/selling housing stock and converting it into renting stock. However, when they invest/disinvest, they face adjustment costs. In particular, we assume that the adjustment

[16]The assumption of sticky rents is in line with empirical observation, as shown in Gallin and Verbrugge (2019). However, in contrast to Gallin and Verbrugge (2019), whose main objective was to explain why rents were sticky, we assumed a simple model of rent stickiness that assumes that only a fraction of housing rents can be adjusted every period as in a standard Calvo price setting assumption. This simplification should not have material implications for our results.

costs depend on the size of the investment relative to the current stock of renting housing and that they are convex. The adjustment costs are given by

$$\zeta_t = \psi \left(\frac{I_t^r}{H_{t-1}^r} \right)^2 q_t \frac{H_{t-1}^r}{2} \tag{29}$$

In our model, the convex adjustment costs are motivated by transaction and construction costs faced by landlords. One example of transaction costs that a landlord faces when buying a house is the taxes levied. Moreover, landlords need to pay for maintenance and rehabilitation expenses when placing a house for renting.

Consider the problem of a landlord that owns the capital stock for renting H_{t-1}^R at time t. The representative landlord's problem is to

$$\max_{I_t^r, H_t^r} E_0 \sum_{t=0}^{\infty} \Lambda_t \left(\frac{l_t}{X_t^r} H_t^r - q_t I_t^r - \psi \left(\frac{I_t^r}{H_{t-1}^r} \right)^2 q_t \frac{H_{t-1}^r}{2} \right)$$

subject to

$$H_t^r = I_t^r + H_{t-1}^r \tag{30}$$

where $\Lambda_t = \prod_{\tau=0}^{t} \frac{\pi_\tau}{R_{\tau-1}}$ is the saver's relevant discount factor. Given that the total housing stock is fixed, the housing stock for owning is given by

$$H_t^o = \bar{H}_t - H_t^r. \tag{31}$$

The first-order conditions of the landlords for I_t^r and H_t^r are given by

$$\mu_t = q_t + \psi q_t \frac{I_t^r}{H_{t-1}^r} \tag{32}$$

$$\mu_t = \frac{l_t}{X_t^r} + E_t \left[\frac{\pi_{t+1}}{R_t} \frac{\psi}{2} q_{t+1} \left(\frac{I_{t+1}^r}{H_t^r} \right)^2 + \frac{\pi_{t+1}}{R_t} \mu_{t+1} \right] \tag{33}$$

In equations 32 and 33, μ_t is the Lagrangian multiplier associated with the law of motion of the housing for renting stock. This quantity is the shadow value of the constraint, which corresponds to how much the landlord would value having the constraint relaxed.

Note that, in the steady state, the landlord behavior will ensure that the price of housing is nothing but the present value of all future housing rents: $q = \frac{l}{X_{ss}^r (1-\beta)}$. In the short run, though, there may be deviations from this no-arbitrage condition because of two reasons: adjustment costs and rent stickiness. The adjustment costs and price stickiness will prevent housing prices from equal to future rents' present value. On the one hand, since housing prices are not sticky, but rents are, the sluggish adjustment of rents will imply that there will be deviations from the no-arbitrage condition in the short run. On the other hand, adjustment costs will also prevent the housing for renting stock from adjusting fast enough when faced with different demand conditions, contributing to deviations from the no-arbitrage condition between ownership and renting in the short run.

Real estate brokers

We introduce sticky prices in the housing rental sector by assuming monopolistic competition at the broker level and implicit costs of adjusting nominal prices following Calvo-style contracts. Real estate brokers rent the landlords' housing stock, differentiate it at no cost, and rent them at a markup over the marginal cost. The CES aggregates of these housing services are converted back into homogeneous housing services by households. Each period, a fraction $1-\theta^r$ of real estate brokers set prices optimally, while a fraction θ^r cannot do so. These assumptions deliver the following housing-rental Phillips curve:

$$\pi_t^l = \pi_t \frac{l_t}{l_{t-1}} \tag{34}$$

$$\ln \pi_t^l = \beta E_t \ln \pi_{t+1}^l - \kappa^r \ln \frac{X_t^r}{X_{ss}^r} \tag{35}$$

where π_t^l is the gross nominal housing rent inflation and $\kappa^r = (1-\theta^r)(1-\beta\theta^r)/\theta^r$.

3.4 Final goods sector

The final goods sector has two types of firms, competitive wholesale firms that produce wholesale goods and monopolistic competitive retailers who sell the goods to consumers. There are two types of final goods firms in the model to introduce price rigidity in the consumption sector.

Wholesalers

Wholesale firms hire labor to produce wholesale goods. They solve:

$$\max \frac{Y_t}{X_t} - w_t L_t - w_t' L_t' \tag{36}$$

where X_t above is the markup of final goods over wholesale goods. The production technology is:

$$Y_t = A_t L_t^{\nu} (L_t')^{1-\nu}. \tag{37}$$

The first-order conditions of the wholesalers are

$$w_t = \nu \frac{Y_t}{L_t X_t} \tag{38}$$

$$w_t' = (1-\nu) \frac{Y_t}{L_t' X_t}. \tag{39}$$

Retailers

Retailers face monopolistic competition and implicit costs of adjusting nominal prices following Calvo-style contracts (this is a similar assumption to how real estate brokers can adjust housing rents). Retailers buy wholesale goods Y_t from wholesale firms at price P_t^w in a competitive market, differentiate the goods at no cost, and sell them at a markup $X_t = P_t / P_t^w$ over the marginal cost. The CES aggregates of these goods are converted into homogeneous consumption goods by households. A fraction of retailers θ can set prices optimally each period, while a fraction $1-\theta$ cannot choose prices optimally. These assumptions deliver the following consumption-sector Phillips curve:

$$\ln \pi_t = \beta E_t \ln \pi_{t+1} - \kappa \ln \frac{X_t}{X_{ss}} \tag{40}$$

where $\kappa = (1-\theta)(1-\beta\theta)/\theta$.

3.5 Consumer price index

In our model there are two goods that are consumed: final goods and housing services. The inflation rate of a consumer price index that follows the price changes of both goods is given by:

$$\ln CPI_t = (1-\omega) \ln \pi_t^l + \omega \ln \pi_t, \tag{41}$$

where ω is the steady-state consumption share of total expenditure.

3.6 Interest rate rule

As is standard in this literature, the monetary authority sets the gross nominal interest rate according to a Taylor rule:

$$R_t = R_{t-1}^{r_R} CPI_{t-1}^{(1-r_R)r_\pi} \left(\frac{Y_{t-1}}{Y_{ss}}\right)^{(1-r_R)r_Y} R_{ss}^{1-r_R} \epsilon_t^R \tag{42}$$

where R_{ss} and Y_{ss} are the steady-state real interest rate and output, respectively. The rule allows for interest rate inertia via the parameter $r_R > 0$. Also, the interest rate reacts to past CPI inflation and output. The strength of these reactions is determined by r_π and r_Y, respectively. Finally, ϵ_t^R is a white noise shock that captures interest rate surprises.

3.7 Equilibrium

The equilibrium in this economy is a sequence of allocations $\{c_t', h_t', L_t', h_t^r, h_t^o, \alpha_t, \rho_t, c_t, h_t, b_t, b_t^o, b_t^r, L_t, H_t^o, H_t^r, I_t^r, Y_t, \zeta_r\}_{t=0}^{\infty}$ and a sequence of values $\{w_t', w_t, q_t, l_t, \pi_t, CPI_t, R_t, \pi_t^l, X_t, X_t^r, \mu_t, \lambda_t\}_{t=0}^{\infty}$ satisfying equations (15) - (42) and the following market conditions[17]

$$\text{Goods market:} \quad c_t + c_t' = Y_t - \zeta_t \tag{43}$$

$$\text{Housing rental market:} \quad H_t^r = (1-\alpha_t) h_t^r \tag{44}$$

$$\text{Housing homeownership market:} \quad H_t^o = h_t + h_t', \tag{45}$$

given $\{h_{-1}, h_{-1}', \alpha_{-1}, P_{-1}, R_{-1}\}$ and the sequence of monetary shocks $\{e_t^R\}_{t=0}^{\infty}$, together with the relevant transversality conditions.

3.8 Model Solution

The model is solved using a second-order perturbation method around the steady state. The second-order approximation in our model is crucial since, to choose between owning or renting a house, agents need to compare the utility they get from owning a house with that of renting. It is well known that first-order approximations (see Kim and Kim (2003)) give inaccurate solutions to welfare analysis because they miss second moments.

[17] The bonds market is suppressed because of Walras law.

4 Calibration and Model Evaluation

In this section, we calibrate the model so that it matches a set of data moments, most of which are related to long-run dynamics, and evaluate the model by comparing its impulse response functions to their untargeted empirical counterpart estimated with a proxy SVAR in section 2. We emphasize that the calibration does not target the empirical impulse response functions, thus providing a credible test to our theory.

4.1 Calibration

The calibrated parameter values are presented in Table 7. For the heterogeneous extra utility received when owning a house distribution $F(\rho)$, we choose the uniform functional form, so that $\rho_t^i \sim U(0, b)$. As a consequence, the share of borrowers that are homeowners is given by:

$$\alpha_t = 1 - \frac{\bar{\rho}_t}{b}. \tag{46}$$

In terms of preferences, we set the discount factor of savers $\beta = 0.99$ as is standard to match a quarterly interest rate of around 1%. As for the discount factor of the borrowers, we follow Iacoviello and Neri (2010) and set $\beta' = 0.97$. This value is also very close to the one calibrated in Greenwald (2018). We set the savers' housing preference $j = 0.04$ to match the housing stock to GDP ratio of 1.35. The renters' and homeowners' housing preferences essentially regulate the steady-state housing share of total expenditure, so we set $j^r = 0.08$ and $j^o = 0.24$ to match the average housing weight in total expenditures in the CPI in 2019. The other housing preferences parameters ϕ^o and ϕ_r are the inverse price elasticity of intensive-margin demand for homeowners and renters housing, respectively. For the homeowners we set this elasticity $\phi^o = 1$ as in Iacoviello (2005), Iacoviello and Neri (2010) and Greenwald (2018), while for renters we set $\phi^r = 2$ based on Albouy et al. (2016), which estimates this inverse price elasticity to be somewhere between 1.5 and 2.24. We calibrate $\eta = 2$ so that the inverse Frisch elasticity is set to 1, as is standard in the literature. Given that we only model the homeownership decision for the borrowers, we set the upper bound of the uniform distribution $b = 0.45$ to match the U.S. average homeownership rate of hand-to-mouth agents reported in Kaplan et al. (2014) of approximately 50%. According to Kaplan et al. (2014) findings, the share of hand-to-mouth agents is approximately 32%, implying that hand-to-mouth households who rent a house amount to 16% of the population. The average homeownership rate in the U.S. between 1983 and 2019 is approximately 65%, which means 35% of the households rent a house. Hence, 19% of the households rent a house but do not face liquidity constraints. In our model, we abstract from these agents because we assume that they have preferences towards owning that are far from the indifferent agent, thus yielding the impact of monetary surprises on housing tenure decision negligible. Thus, in the model, we focus on explaining changes in the aggregate homeownership in response to monetary policy shocks rate solely coming from changes in the hand-to-mouth households' housing tenure choices.

Next, we turn to the calibration of parameters related to the housing sector. We set the parameter regulating the adjustment costs of the housing stock mix $\psi = 0.8$ to match the housing supply response to a 25 basis points average surprise over two years estimated from the AHS microdata. As reported in column 5 of Table 6, we find that the rental share increases by approximately four percentage points in response to a positive 100 basis points monetary policy shock. Consequently, a positive shock of 25 basis points corresponds to an increase of 1 percentage point in the rental share. With $\psi = 0.8$, a permanent shock of 25 basis points in the interest rate over two years gives a response in the rental share that matches our empirical findings. We set the share of real estate brokers that cannot adjust rents $\theta^r = 0.83$ to match the share of rents that do not change in 6 months reported in Table 1 of Gallin and Verbrugge (2019). The landlords first-order conditions in the steady-state imply that $q_t = l_t/(X^r_{ss}(1-\beta))$. We use this condition to calibrate $X^r_{ss} = 2.2$ such that we match the U.S. average price-to-rent ratio of 11.4. The loan-to-value ration $m = 0.85$ is taken from Iacoviello and Neri (2010) and Greenwald (2018), and the total housing stock is normalized to 1.

For the final goods sector, we set the Calvo fairy parameter $\theta = 0.84$ as in Iacoviello and Neri (2010). We follow Iacoviello and Neri (2010) and Kaplan et al. (2014) and set the savers labor income share $\nu = 0.79$. The retailers markup is calibrated to $X_{ss} = 1.15$ as in Iacoviello and Neri (2010), and the TFP parameter A is set such that output at the steady state is normalized to 1.

Finally, for the Taylor rule, we follow Iacoviello and Neri (2010) and set the steady-state inflation $CPI_{ss} = \pi_{ss} = 1$, the interest rate smoothing parameter $r_R = 0.7$, the response to output gap parameter $r_Y = 0.13$ and the response to inflation parameter $r_\pi = 1.5$.

4.2 Model evaluation

In this section, we evaluate the model by comparing the responses of selected variables to a monetary policy shock in the model and proxy SVAR presented in section 2.1.2. This comparison provides a credible test to our proposed theory because the calibration of the model does not target the empirical impulse response functions estimated in the proxy

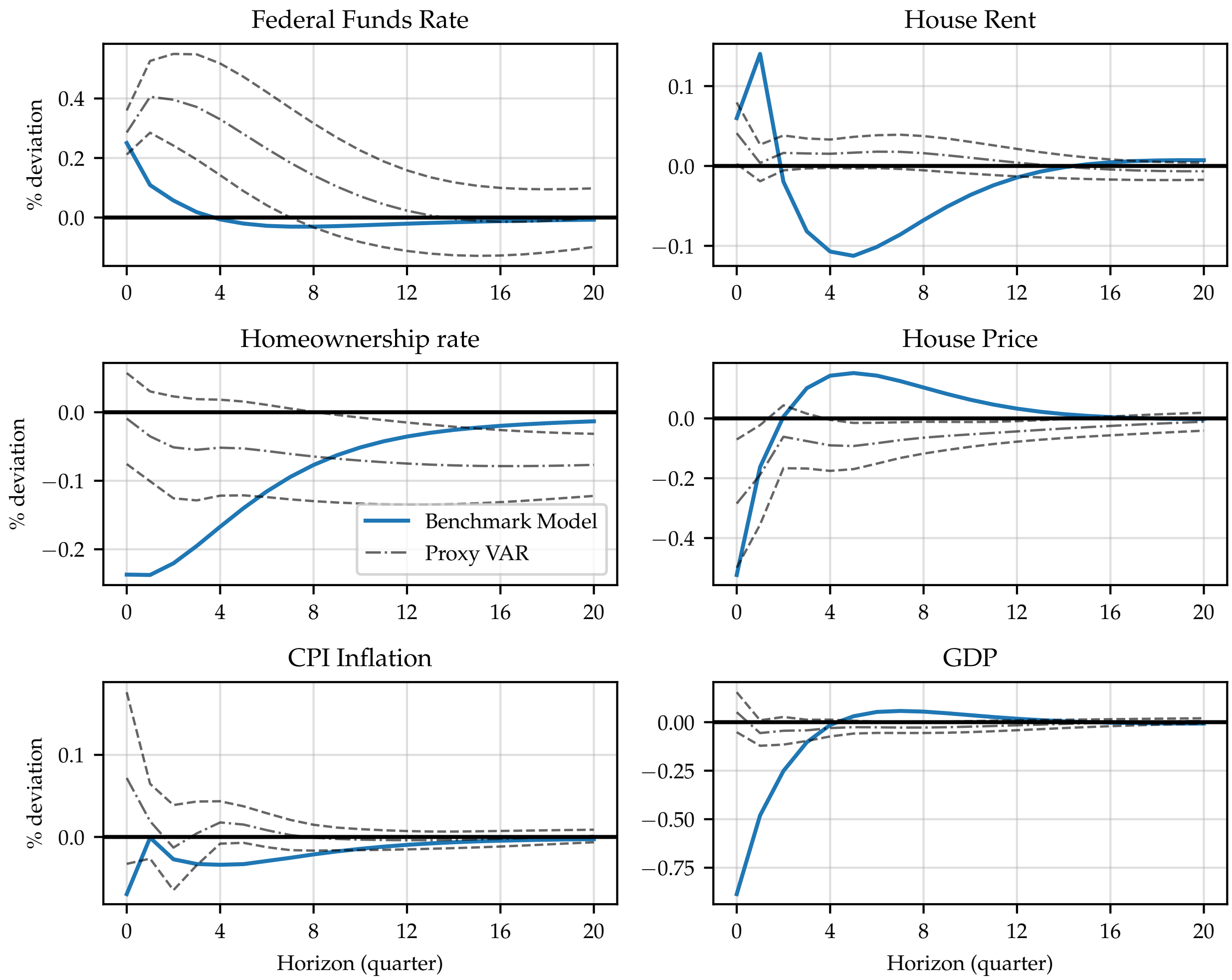
Table 7: Parameter Values: Baseline Calibration

Parameter	Name	Value	Internal	Target/Source
Preferences				
β	Saver discount factor	0.99	Y	Standard
β'	Borr. discount factor	0.97	N	Iacoviello and Neri (2010)
j	Saver housing preference	0.04	Y	Housing stock to GDP ratio of 1.35, Iacoviello and Neri (2010)
j^r	Borr. that rents housing preference	0.08	N	Renters housing share of total expenditure in CPI
j^o	Borr. that owns housing preference	0.24	N	Homeown. with outstd. mortgage housing share of total expenditure in CPI
η	Labor disutility	2	N	Standard
ϕ^r	Inv. price elasticity of intensive-margin demand for rental housing	2	N	Albouy et al. (2016), Howard and Liebersohn (2021) estimates range = $[1.5, 2.24]$
ϕ^o	Inv. price elasticity of intensive-margin demand for homeowner housing	1	N	Iacoviello (2005), Iacoviello and Neri (2010), Greenwald (2018)
b	Upper limit of owning extra services	0.45	Y	U.S. average homeownership rate of hand-to-mouth households in Kaplan et al. (2014): 50%, $\alpha_{ss} = 0.5$
Housing sector				
ψ	Rental housing stock adjustment cost	0.8	Y	Increase in rental units share two years after a 25bps monetary policy shock (Table 6, column 4)
X^r_{ss}	Rental brokers markup	2.2	Y	Zillow, U.S. average price-to-rent ratio, $q_{ss}/(l_{ss} * 4) = 11.4$
θ^r	Rents stickiness	0.83	N	Gallin and Verbrugge (2019)
m	Loan-to-value ratio	0.85	N	Iacoviello and Neri (2010), Greenwald (2018)
$\bar{H}$	Total housing stock	1	N	Normalization
Final goods sector				
θ	Price stickiness	0.84	N	Iacoviello and Neri (2010)
ν	Savers labor income share	0.79	N	Iacoviello and Neri (2010), Kaplan et al. (2014)
X_{ss}	Retailers markup	1.15	N	Iacoviello and Neri (2010)
A	TFP	1.057	Y	$Y_{ss} = 1$
Monetary policy				
π_{ss}	Steady state inflation	1	N	Iacoviello and Neri (2010)
r_R	Taylor rule smoothing	0.7	N	Iacoviello and Neri (2010)
r_Y	Taylor rule (GDP)	0.13	N	Iacoviello and Neri (2010)
r_π	Taylor rule (CPI)	1.5	N	Standard

SVAR. Moreover, except for the housing supply dynamic response, the calibration of the model only targets long-run data moments.

In Figure 3, we show how the model transmission of monetary policy shocks to the

Figure 3: Model vs. untargeted Proxy SVAR impulse response functions



Note: the Figure shows how the model responses to a monetary policy shock of 25 basis points compare to the untargeted empirical responses estimated in the Proxy SVAR. The dashed lines report the 68% confidence intervals for the proxy SVAR impulse response functions.

federal funds rate, house rents, homeownership rate[18], house price, CPI inflation and GDP compare with that of the Proxy SVAR. The model matches the empirical monetary transmission to the selected variables well, especially qualitatively. Broadly consistent with our empirical findings, the model predicts that the homeownership rate and house price fall while house rent rises following a contractionary monetary policy surprise. In the benchmark calibration of the model, the rise in rents is not enough to generate a "price puzzle" as observed in the proxy SVAR. In any case, the response of CPI in our model is small and

[18]To compute changes in the homeownership rate for the hand-to-mouth agents based on Kaplan et al. (2014), as discussed in the calibration section. A 1 p.p. change in the share of borrowers-homeowners α_t corresponds to a 0.32 p.p. change in the homeownership rate.

close to the proxy SVAR.

Quantitatively, the match of the model with the empirical results could be improved. In particular, for GDP, the initial response of the model is much larger than that obtained from the proxy SVAR. One common way in the literature to improve this fit is to introduce habit formation into households preferences as in Iacoviello and Neri (2010). In our benchmark model, we do not include habit formation and other specifications that could improve the model fit because: (i) the focus of this paper is in understanding the mechanisms involved in the homeownership channel of monetary transmission; and (ii) we want to have the impulse responses untargeted in the calibration of the model. For our purpose, a more stripped-down environment makes the illustration of the mechanisms sharper.

5 The Housing Tenure Choice Channel of Monetary Policy Transmission

In this section, first, we present the results on interest rate transmission. Second, we show that there are novel redistributive implications of monetary policy. Third, we discuss how the housing tenure choice channel has consequences for monetary policy.

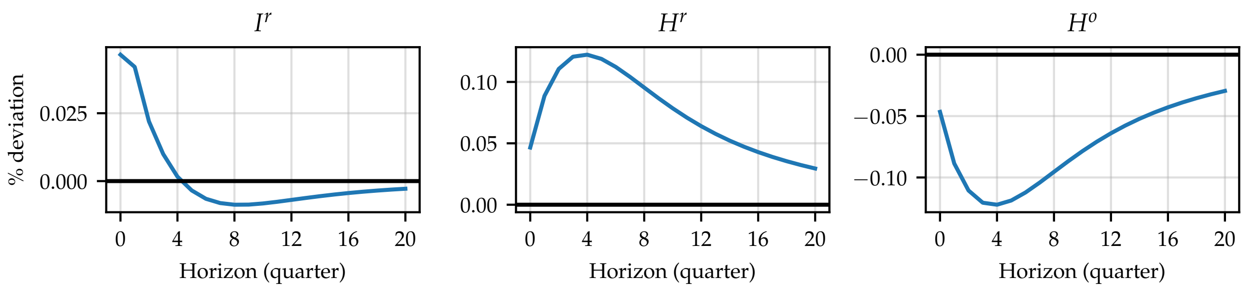
5.1 Interest Rate Transmission

Having calibrated and evaluated the model, we now discuss the transmission of monetary policy shocks in the benchmark calibration. As shown in Figure 3, a positive interest rate surprise depresses house prices and the homeownership rate while it increases the house rents. The key mechanism generating for such price-to-rent dynamics is as follows.

Key Mechanism. A positive interest-rate surprise increases the cost of borrowing to finance a house purchase, which incentivizes the marginal borrower to rent instead of owning. From a housing demand perspective, as more borrowers switch to renting, the aggregate demand for renting rises driven through this extensive margin adjustment. At the same time, from a housing supply perspective, landlords observing higher rents respond by investing in housing stock for renting. However, because of adjustment costs, the supply of rental housing responds less than proportionally to the increase in demand for renting. As a consequence, housing rents increase in equilibrium.

In Figure 4, we show that indeed, as expected, the housing supply for renting H^r increases in response to the unexpected interest rate hike. Given that the total housing stock is fixed, housing supply for homeownership decreases in the same proportion. Hence, the supply response makes house prices and rents adjust less than they would in an environment with nonexistent housing supply adjustments. By determining the level of housing market segmentation, it becomes clear that the housing adjustment costs play a crucial role in the key mechanism. We discuss this in more detail in the following subsection. However, before doing so, we study how the housing tenure choice channel affects the monetary policy transmission to macroeconomic aggregates.

Figure 4: Model Impulse Response Functions of Housing Supply Variables to a Monetary Policy Shock

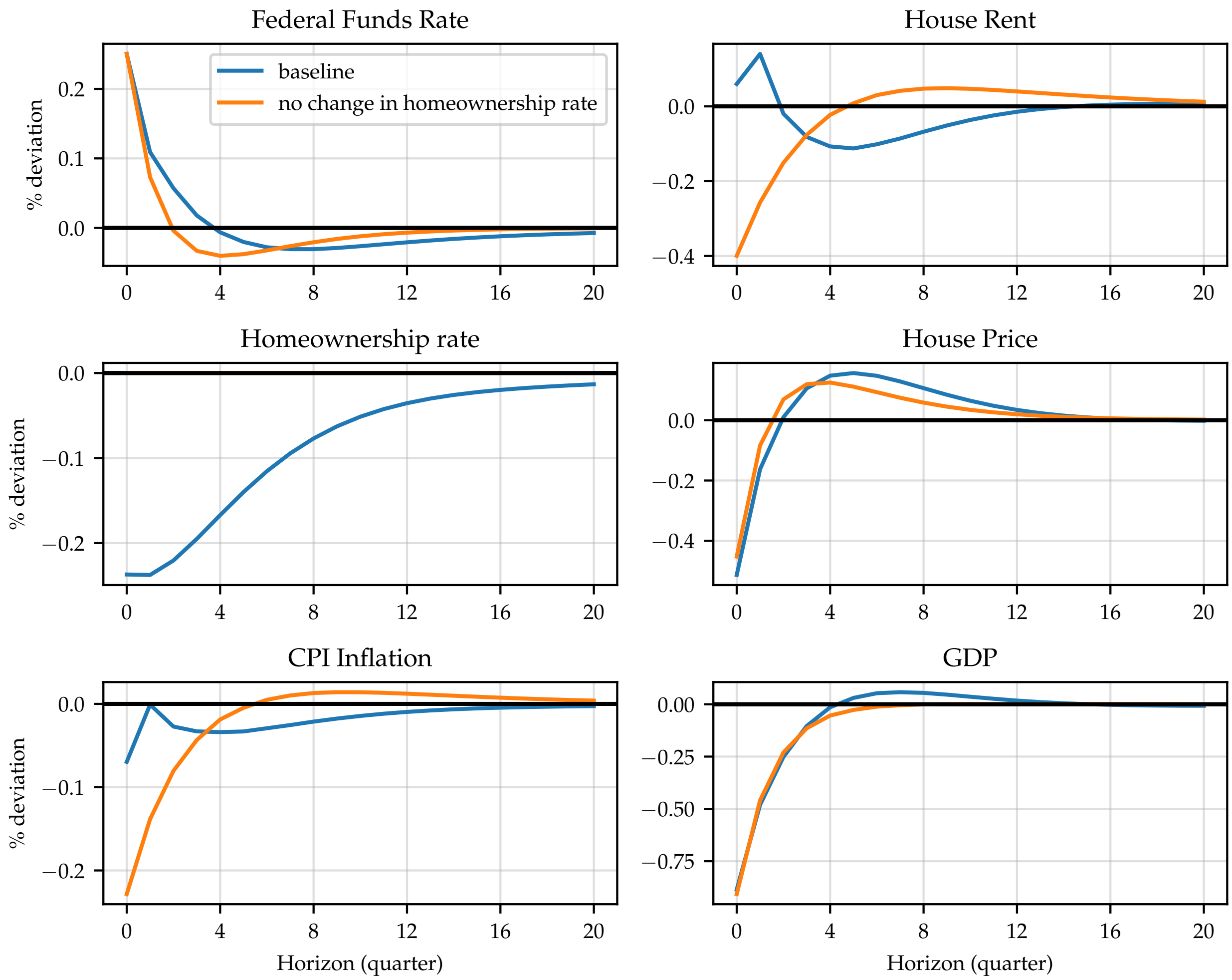


Note: this Figure shows the housing supply variables responses to a 25 basis points positive shock in the nominal interest rate in the benchmark calibration of the model.

How does the housing tenure choice channel changes the shape of monetary transmission? In Figure 5 we show how the responses of the macroeconomic aggregates change when we shut down the housing tenure channel in our baseline model. We shut it down by keeping the distribution of homeowners fixed and eliminating the housing adjustment costs. We conclude that, except for output, the monetary transmission to all macroeconomic aggregates is affected by the housing tenure channel. The homeownership rate by construction is not allowed to move, and because of that and because there are no adjustment costs, housing rents instead of rising now fall. For the same reasons, house prices fall less now. House rent falling makes the CPI drop by more, which allows the interest rate to fall faster after the same shock. Finally, the response is similar in both scenarios in terms of output. Taking stock of our previous discussion, we find that the homeownership channel of monetary policy transmission plays a significant role in inflation dynamics and a smaller one in output. However, as we will show later, the minor role in aggregate output hides relevant composition changes because of redistributive effects. Next, we focus on the role of adjustments costs in accounting for the housing tenure choice channel.

The Role of Housing Adjustment Costs. If the adjustment costs are infinite, then housing markets are entirely segmented. Therefore, housing rents increase while house prices

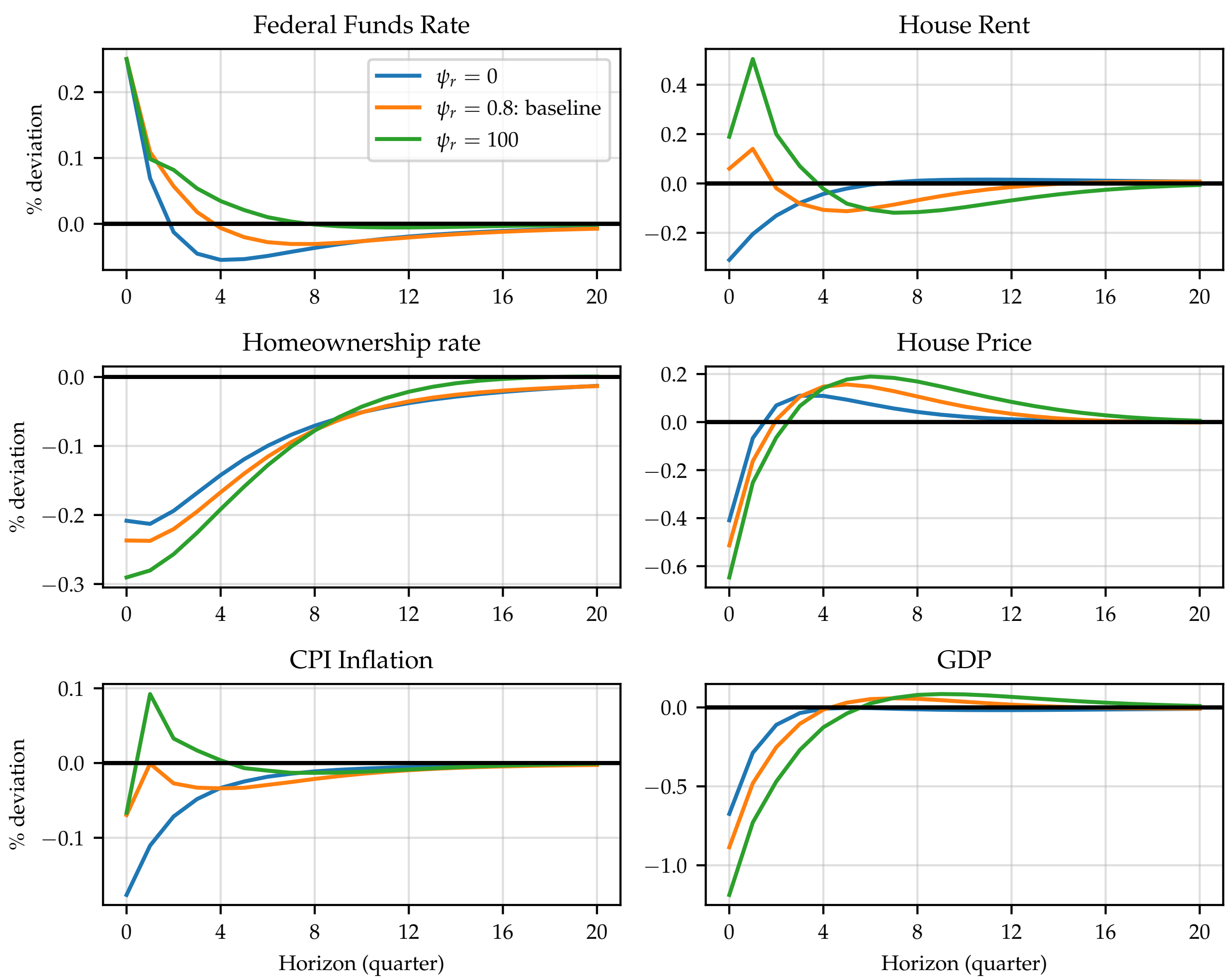
Figure 5: Importance of housing tenure choice for monetary transmission



Note: this Figure shows the dynamics responses of macroeconomic aggregates to a 25 basis points positive shock in the nominal interest rate in the baseline calibration and in an alternative calibration in which the homeowner ship rate is constant and the adjustment costs are zero $\psi_r = 0$.

fall even more in equilibrium as the housing supply does not respond to rents. Consequently, consumption drops more for those that would-be renters in any event. At the same time, given higher rents, fewer borrowers can avoid paying higher mortgage payments in equilibrium. However, savers get more profits as rents increase even more. In Figure 6 we show how the monetary transmission differs for different values of the adjustment cost parameter ψ. Indeed, as expected, housing rents react more the higher are the adjustment costs. Also, note that the housing price falls by more with higher adjustment costs as now there is less demand for housing for owning from landlords. In terms of aggregate economic activity, the effect of higher adjustment costs on borrowers is higher than that on savers, which results in output falling more under higher adjustment costs than when adjustment costs are lower. While in our model, we only have two types of agents, borrowers and savers, which are homogeneous for the whole economy, in reality, housing market characteristics are very heterogeneous across the United States. Taking these results for the effects of adjustment costs at face value suggests that, in cities or states where adjusting the housing stock mix is more costly, the real effects of monetary policy will be higher.

Figure 6: Impulse responses of macroeconomic aggregates with different adjustment costs



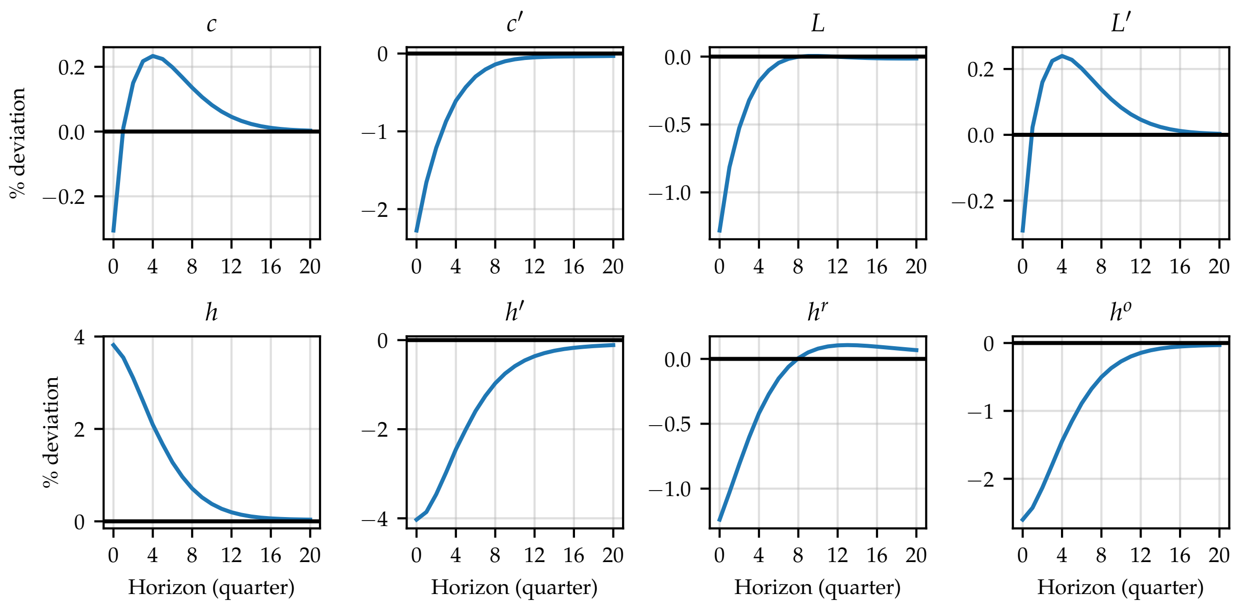
Note: this Figure shows the responses of macroeconomic aggregates to a 25 basis points positive shock in the nominal interest rate for the baseline and for two alternative scenarios in which the adjustment cost parameter is set to $\psi_r = 0$ and $\psi_r = 100$.

5.2 Redistributive Implications

The housing tenure channel of monetary policy transmission brings to light new redistributive implications between borrowers and savers and between homeowners and renters.

We start by comparing the welfare changes between borrowers and savers. In Figure 7, we show that borrowers' consumption drops relatively more than savers', their housing services drop while savers rise, and their labor supply falls by less than that of savers. Given that the households derive utility from consumption and housing services and disutility from hours worked, these results imply that borrowers unambiguously are worse-off than savers. In panel (a) of Figure 8 we show that this is the case. In fact, because of lower house prices coupled with a positive income effect coming from higher interest rates and house rent, savers increase their holdings of housing services so much that their welfare increases relative to the steady state.

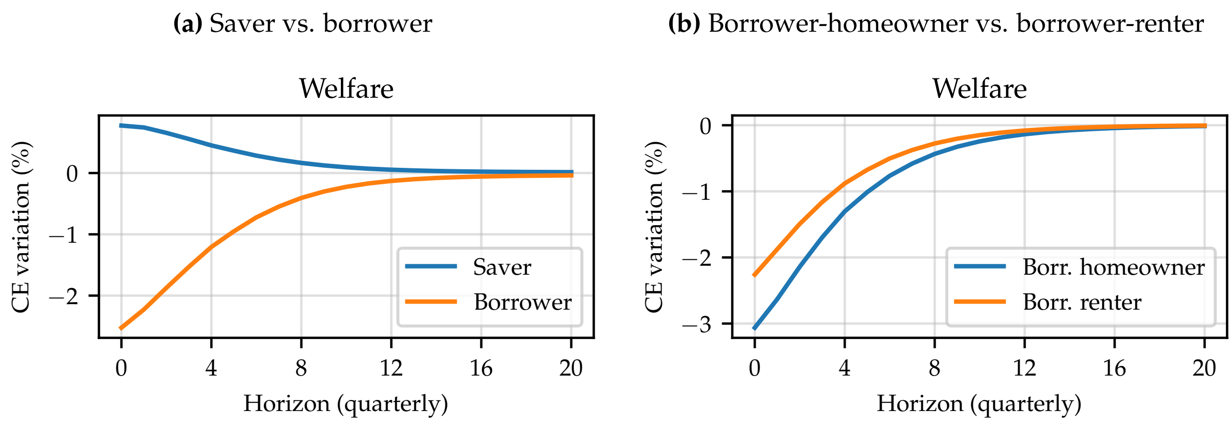
Figure 7: Impact of monetary policy shock on selected variables in the benchmark calibration of the model



Note: this Figure shows the dynamic responses of borrowers and savers allocations to a 25 basis points positive surprise in nominal interest rate.

Turning to borrowers-homeowners and borrowers-savers, since their consumption and labor supply responses are the same, the welfare difference between them stems from differences in their respective housing services responses. In Figure 7, we see that housing services fall by more for homeowners than for renters. This result is driven by the collateral constraint that gets tighter when house prices fall, thus further depressing homeowners' demand for housing. Reflecting what we just described, the welfare of borrowers-homeowners falls by more than the welfare of borrowers-renters (see panel (b) of Figure 8).

Figure 8: Impact of monetary policy shock on welfare across agents

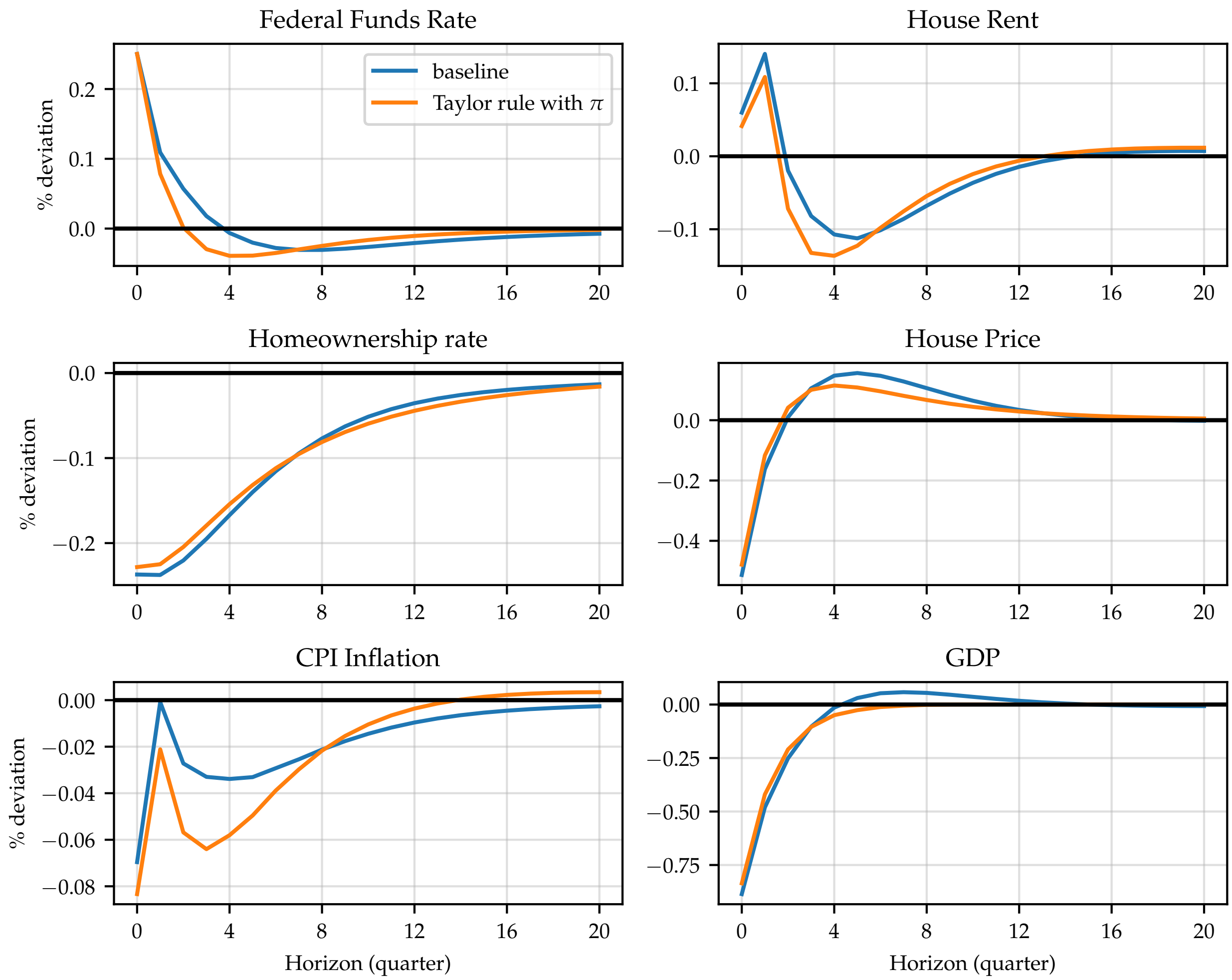


Note: panel (a) shows the welfare change, measures in consumption equivalent variation, for borrowers and savers, following a contractionary monetary policy shock of 25 basis points; panel (b) shows the welfare change for borrowers-homeowners and borrowers-savers following the same shock as in panel (a).

5.3 Consequences for Monetary Policy

As briefly mentioned before, the response of housing rents to monetary policy shocks, which goes in the opposite direction of all other nominal final goods prices, generates a smaller reaction of the consumer price index. The latter makes the interest rate adjustment towards the steady state slower as the monetary authority needs to be more aggressive to push the persistent inflation down as measured by the CPI. Hence, targeting the CPI leads to higher volatility in the economy than when the monetary authority targets inflation measures that exclude rents/shelter. To isolate this effect, we report in Figure 9 how the monetary transmission to macroeconomic aggregates would look like if the monetary authority only reacted to consumer prices nominal inflation π—in our model, π captures the monetary value of goods and services perfectly. We conclude that not responding to housing rents makes the interest rate fall faster, making output fall by less and recover faster to the steady state, while inflation, as measured by the CPI also falls by more.

Figure 9: Impulse responses when monetary authority reacts to π



Note: this Figure shows the response of macroeconomic aggregates to a monetary policy shock in the baseline calibration and modified version of the baseline in which the Taylor rule reacts to final consumption goods only π instead of CPI.

6 Conclusion

This paper studies the interplay between monetary policy and housing tenure decisions and how it affects monetary policy transmission. We show that monetary policy shocks are an essential driver of fluctuations in the aggregate rate of homeownership in the United States. They explain as much as 35% of the long-run variation of this variable. We find this aggregate result is microfounded as we also provide empirical evidence that monetary policy affects housing tenure choice decisions at the household level. We propose a standard two-agent New Keynesian model extended with a housing tenure decision and adjustment costs on housing supply to account for these empirical facts. We show that the model predictions align well with the empirical facts. We find that the housing tenure choice channel has significant implications for monetary policy transmission in terms of its overall impact, redistributive effects and optimal design.

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Online Appendix for "Monetary Policy and Homeownership: Empirical Evidence, Theory, and Policy Implications"

A Data description

A.1 Aggregate U.S. Data

In the aggregate data analysis portion of this paper, we use several publicly available macroeconomic variables. The table below lists and defines all these variables and provides the corresponding sources.

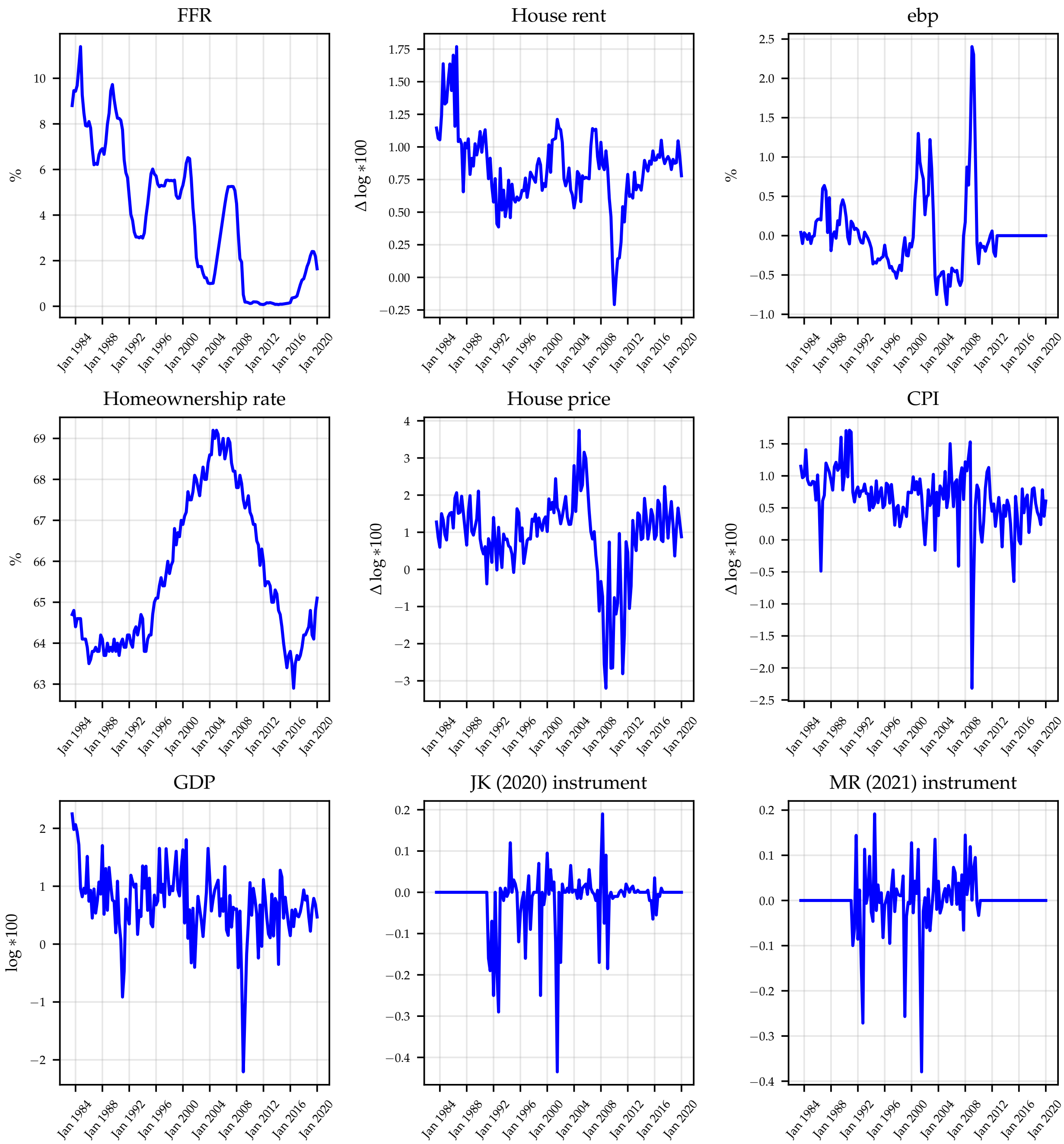
Table A1: Aggregate macroeconomic data

Series	Source	Series Description	Sample
U.S. GDP	FRED	Quarterly data, Seasonally Adjusted	1981:Q1 - 2017:Q4
One-Year Rate	Own calculation	Quarterly average of the one-year rate monthly data, Seasonally Adjusted	1981:Q1 - 2017:Q4
Housing Prices (USSTHPI)	FRED	All-Transactions House Price Index for the United States, Index 1980:Q1=100, Not Seasonally Adjusted	1981:Q1 - 2017:Q4
Housing Rents	Own calculation	Quarterly average of the housing rents monthly data, Seasonally Adjusted	1981:Q1 - 2017:Q4
Homeownership Rate (RSAHORUSQ156SN)	FRED	Homeownership Rate for the United States, Percent, Seasonally Adjusted	1981:Q1 - 2017:Q4
Excess Bond Premium		Gilchrist and Zakrajšek (2012)	1990:Q1 - 2012:Q4
JK monetary policy shock	Jarociński and Karadi (2020)	high frequency monetary policy shock instrument that separates monetary policy developments from economic outlook information from the Fed's communications	1990:Q1 - 2016:Q4
MR monetary policy shock	Miranda-Agrippino and Ricco (2021)		1990:Q1 - 2009:Q4

A.2 Annual Housing Survey Data

With the exception of the monetary policy shock, all the data underlying the analysis of household tenure status and housing unit type transitions come from the publicly available Annual Housing Survey database that is compiled by the U.S. Census Bureau. This database has two main surveys, the national and the metro area, and it covers a very large of aspects relating to U.S. household living arrangements and characteristics of the U.S.

Figure A1: Macroeconomic Variables and Instruments Time Series



Note: this Figure shows the time series data for all the variables and external instruments (Jarociński and Karadi (2020) and Miranda-Agrippino and Ricco (2021)) used in the estimation of the Proxy SVAR.

housing stock. For the analysis in this paper, we only used a small subset of variables which we list and describe how they were used in Table A2.

Table A2: Data from AHS database used in the analysis

Variable used in analysis	Definition	Used variable(s) from AHS database
Housing unit type	Indicator variable for the housing unite tenure status. This variable takes the value 1 if the housing unit is deemed for rental and 0 if deemed for ownership. Other types of housing unit tenure status (e.g. "Occupied without payment of rent") were excluded from the sample.	"tenure" for years 1995, 1997, 1999, 2001, 2003, 2005, 2007, 2009, 2011, 2013, and 2015
Rent-to-own transition	Indicator variable taking the value 1 if the household living in the housing unit was renting 1 year before and owns now, and the value 0 if the household was owning 1 year before and is owning now	"xaten" for year 1995; "xten" for years 1997, 1999, 2001, 2003, 2005, 2007, 2009, 2011, 2013; "mgv1type" for year 2015. Combined with variable "tenure", which provides information on current housing unit type
Own-to-rent transition	Indicator variable taking the value 1 if the household living in the housing unit owned the house it lived itn 1 year before and rents now, and the value 0 if the household was renting 1 year before and is renting now.	"xaten" for year 1995; "xten" for years 1997, 1999, 2001, 2003, 2005, 2007, 2009, 2011, 2013; "mgv1type" for year 2015. Combined with variable "tenure", which provides information on current housing unit type
Age tercile	Indicator variables taking the value 1 if the head of household's age falls in a given age tercile for the sample of heads of household in a given year, and 0 otherwise.	"age" for years 1995, 1997, and 1999; "hhage" for years 2001, 2003, 2005, 2007, 2009, 2011, 2013, and 2015
Income quartile	Indicator variables taking the value 1 if the housedhold's income falls in a given income quartile for the sample of heads of household in a given year, and 0 otherwise.	"zinc2" for years 1995, 1997, 1999, 2001, 2003, 2005, 2007, 2009, 2011, and 2013; "hincp" for year 2015
Region	Indicator variables taking the value 1 if housing unit is located in one of U.S. four administrative regions as defined by the U.S. Census Bureau: East, Midwest, South, and West.	"region" for years 1995, 1997, 1999, 2001, 2003, 2005, 2007, 2009, 2011, and 2013; "division" for year 2015

Note: the AHS database is available online here and the definition of each of the variables in the database can be found here.

B Proof of Proposition 1

Start with the borrowers' social planner problem of maximizing:

$$E_0 \sum_{t=0}^{\infty} (\beta')^t \left\{ \int_0^1 \ln c_t^i + (1 - I_t^i) \left(j^r \frac{(h_t^i)^{1-\phi^r}}{1-\phi^r} \right) + I_t^i \left(j^o \frac{(h_t^i)^{1-\phi^o}}{1-\phi^o} + \rho_t^i \right) - \frac{(L_t^i)^\eta}{\eta} di \right\},$$

where E_0 is the expectation operator conditional on time zero information, $\beta \in (0, 1)$ is the discount factor, c_t^i is consumption of borrower i at time t, $I_t^i \in \{0,1\}$ is an indicator function that takes the value of 1 if borrower i decides to own and zero if she decides to rent, h_t^i denotes housing services, ρ_i is the extra utility i.i.d. draw from $F(\rho)$ that agent i receives when owning a house and L_t^i are hours of work, subject to

$$\begin{aligned}\int_0^1 c_t^i + I_t^i q_t \Delta h_t^i + (1-I_t^i) h_t^i l_t + b_{t-1}^i \frac{R_{t-1}}{\pi_t} di &= \int_0^1 b_t^i + w_t' L_t^i di \\ b_t^i \leq I_t^i E_t \left[m q_{t+1} h_t^i \frac{\pi_{t+1}}{R_t} \right],\end{aligned}$$

where q_t, l_t, R_t, π_t, w_t', m and b_t^i denote the real housing price, real housing rent, gross nominal interest rate, gross inflation rate, real wage, loan-to-value ratio and borrowing in real terms, respectively.

The first order condition with respect to c_t^i is

$$\frac{1}{c_t^i} = \gamma_t, \tag{47}$$

where γ_t is the Lagrange multiplier associated with the budget constraint. This condition implies that the optimal consumption is the same for all households. Let us denote this consumption by c_t'. Next, the first order for L_t^i is the following:

$$(L_t^i)^{\eta-1} = \frac{w_t}{c_t'}. \tag{48}$$

This condition implies that optimal hours worked will also be the same for all households. Hence, conditions 47 and 48 prove result (ii) of Proposition 1. Finally the first order condition for h_t^i is given by:

$$\begin{cases} j^o (h_t^i)^{-\phi^o} = \frac{q_t}{c_t'} - E_t \left(\beta' \frac{q_{t+1}}{c_{t+1}'} + \lambda_t m_t q_{t+1} \pi_{t+1} \right) & \text{if } I_t = 1 \\ j^r (h_t^i)^{-\phi^r} = \frac{l_t}{c_t'} & \text{if } I_t = 0 \end{cases} \tag{49}$$

where λ_t is the Lagrange multiplier of the borrowing constraint. This last condition implies that the optimal housing services allocation h_t^o wil l be the same across all homeowners $I_t = 1$, and that the optimal housing services allocation h_t^r will be the same across all of those who rent $I_t = 0$. However, depending on house prices and rents, the housing allocations can be different between homeowners and renters. With this, we prove result (iii) of Proposition 1. We now turn to prove result (iii). In each period, the borrowers' social planner will have each household i owning a house instead of renting if and only if she receives higher instantaneous utility from it than otherwise:

$$I_t = \begin{cases} 1 & \text{if and only if} \quad j^o \frac{(h_t^i)^{1-\phi^o}}{1-\phi^o} + \rho_t^i > j^r \frac{(h_t^i)^{1-\phi^r}}{1-\phi^r} \\ 0 & \text{otherwise.} \end{cases} \tag{50}$$

Assuming a parameter space that allows an interior solution: $j^r \frac{(h_t^i)^{1-\phi^r}}{1-\phi^r} > j^o \frac{(h_t^i)^{1-\phi^o}}{1-\phi^o}$. Because ρ_t^i is drawn from a continuous cdf $F(\rho)$ with a non-negative support there will be a unique $\bar{\rho}_t$ that makes a household indifferent between owning and renting, for the parameter space in which. Therefore, households with $\rho_t^i > \bar{\rho}_t$ choose to own a house, while those with $\rho_t^i < \bar{\rho}_t$ decide to rent a house. Hence, the share of homeowners will be given by $\alpha_t = 1 - F(\bar{\rho}_t)$.

C Robustness Checks

C.1 Local Projections

Jordà (2005) introduced the local projections (LP) method as an alternative to VAR models for the purpose of studying the dynamic effects of shocks on variables of interest. As shown in Plagborg-Mller and Wolf (2021), LP and VAR estimators are simply two dimension reduction techniques with common estimand but different finite-sample properties. As also discuss in Miranda-Agrippino and Ricco (2021), the different finite-samples are mostly related to a bias-variance trade-off, particularly at longer horizons: LP provide lower bias but higher variance when compared with VAR estimators. For the sake of robustness, we show how the dynamic responses of monetary shocks look like when estimating them via LP. The identification of the shocks in the LP is the same as in the VAR. In Figure C1 we show that the results remain the same as the ones obtained from the VAR presented in subsection 2.1.2 of the main text.

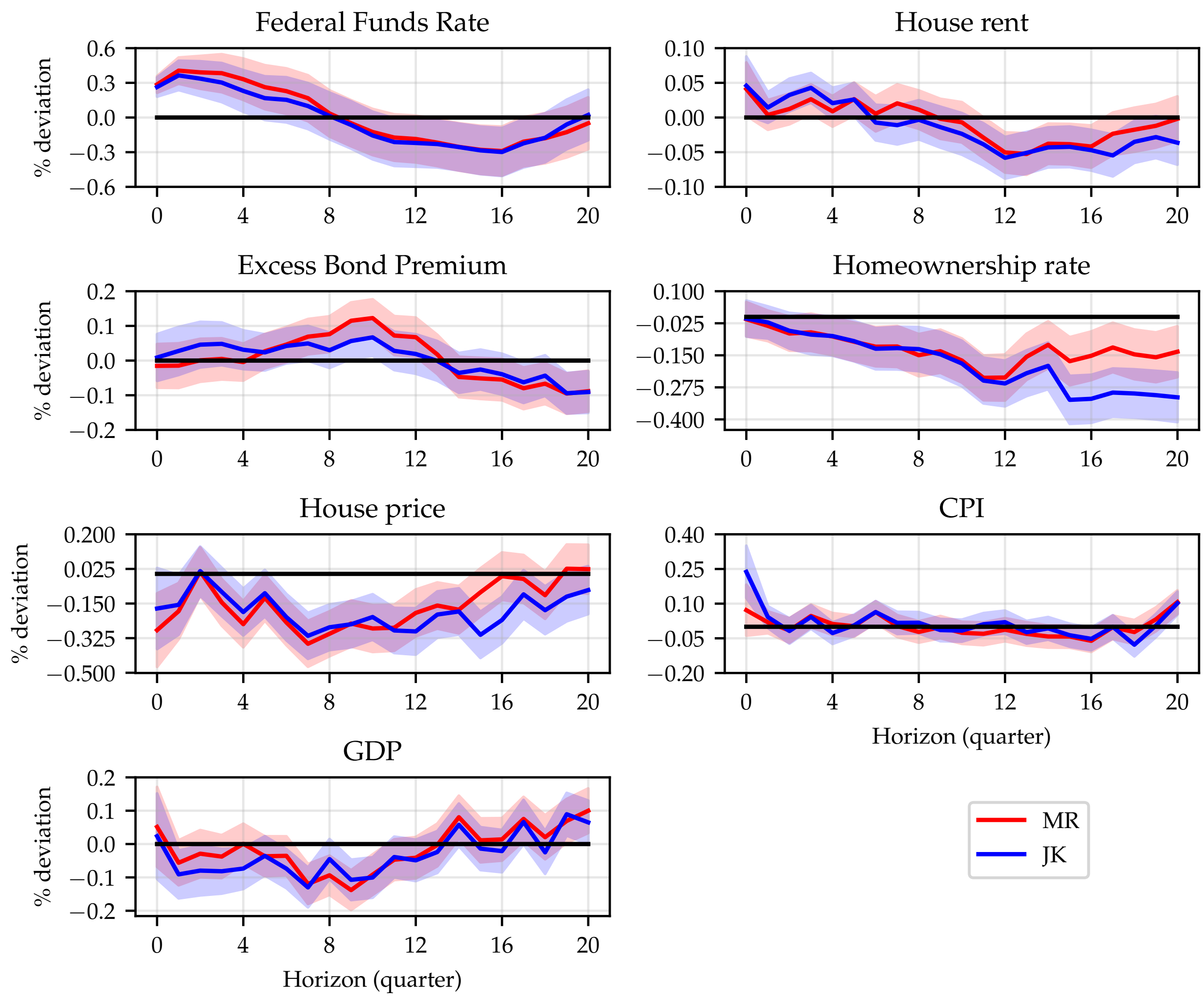
C.2 FEVD based on proxy SVAR

This Figure shows the forecast error variance decomposition (FEVD) estimates from the Proxy SVAR assuming invertibility.

C.3 The Role of House Rents Stickiness for Monetary Policy Transmission

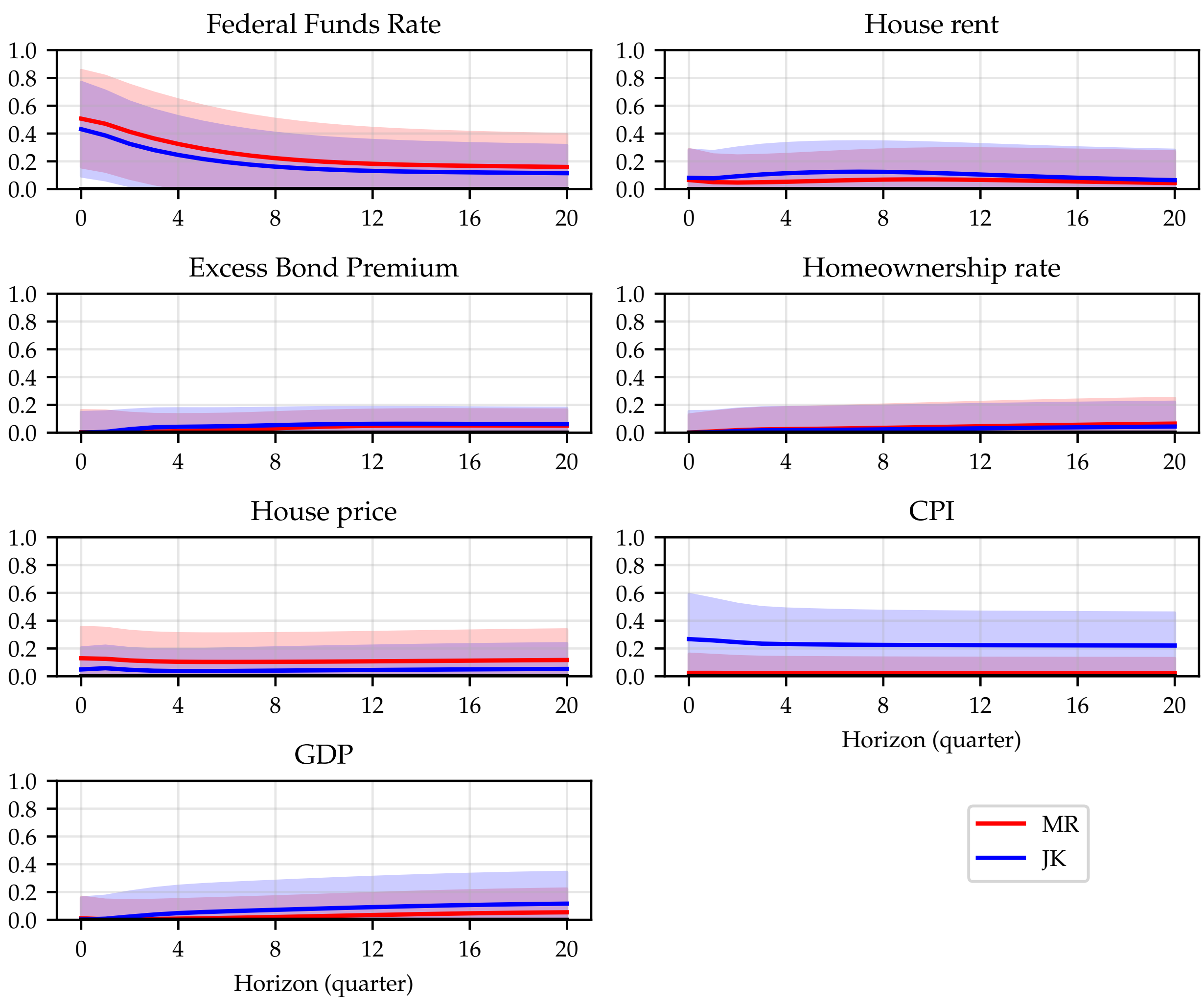
We show here thee effect of rent stickiness on the transmission of monetary policy. As shown in Figure C3, the degree of rent stickiness has important implications for the transmission of monetary policy in our model. If rents are less sticky, housing rents increase by more in response to a contractionary monetary policy shock, thereby affecting renters by more and making it more difficult for borrowers to transitioning from onwership to renting as a way of escaping higher mortgage payments. All of which contribute to lowering borrowers' aggregate consumption. However, when rents are more flexible, rents can increase without paying any adjustment costs which boosts the profits that go to savers by more. Indeed, in case of more flexible rents the added profits more than compensate the fall in the borrowers' aggregate consumption and output falls by less.

Figure C1: Impulse Response Functions of Select Macroeconomic Variables to a 25 bps Monetary Policy Shock Using Local Projections



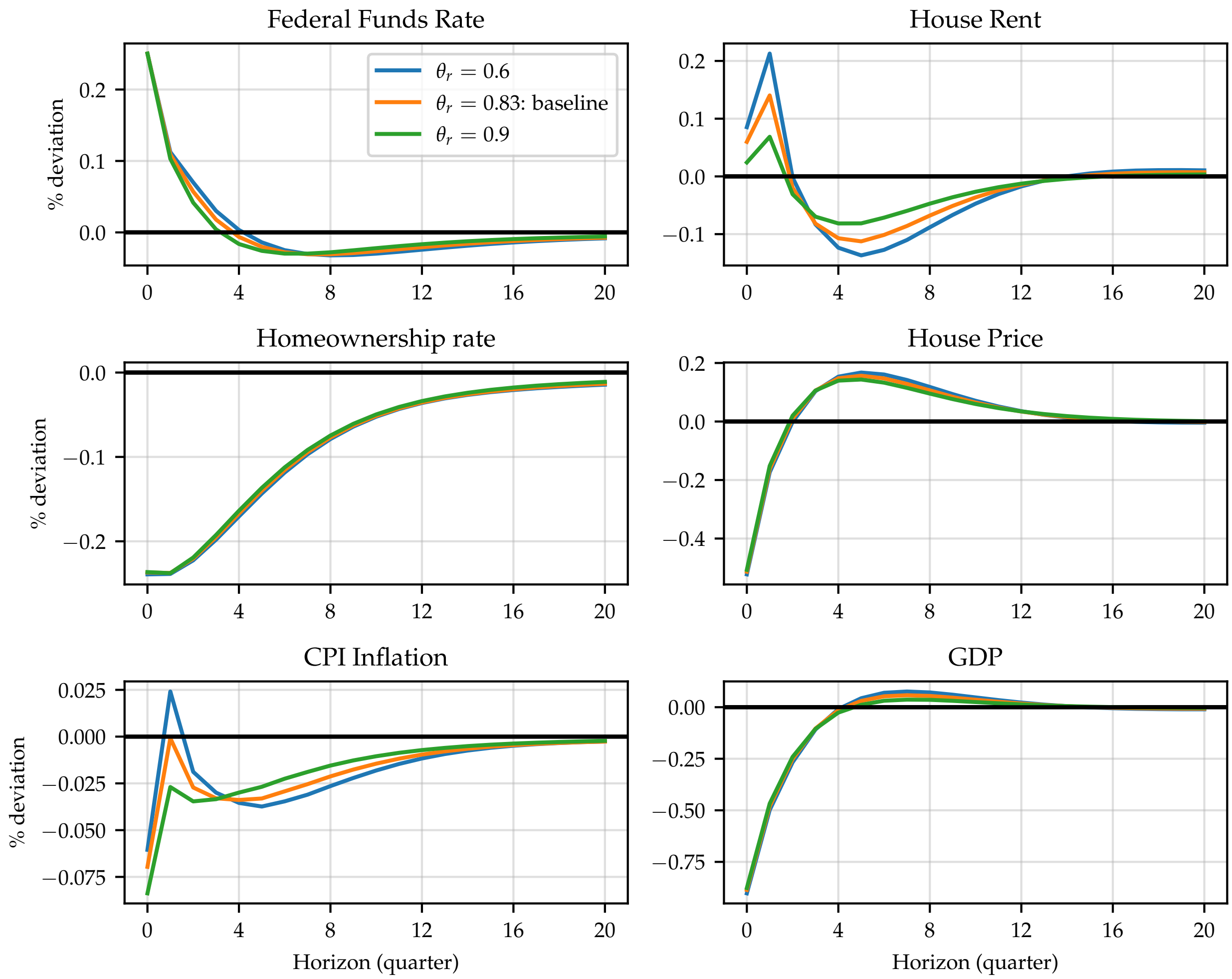
Note: results in the figure are based on the local projections method (Jordà (2005)) combined with the proxy VAR approach to identify the impact effects of the monetary shock on the variables of interest (Miranda-Agrippino and Ricco (2021)); the monetary policy shock instrument used for the results displayed in red is that of Miranda-Agrippino and Ricco (2021) and the instrument used for those reported in blue is that of Jarociński and Karadi (2020) coming from their the poor man's sign restriction approach. Both instruments isolate the pure monetary surprises from the information content present in the Fed's communications. The solid lines report the impulse response functions point estimates, while the shaded areas report the 68% confidence intervals. The confidence intervals were computed from 1,000 draws using a parametric bootstrap as proposed in Stock and Watson (2018).

Figure C2: Contribution of Monetary Policy Shocks to the Forecast Error Variance of Select Macroeconomic Variables



Note: the forecast error variance decomposition of the monetary policy shock results in the figure are based on the proxy SVAR described in the methodology section of the paper; the monetary policy shock instrument used for the results displayed in red is that of Miranda-Agrippino and Ricco (2021) and the instrument used for those reported in blue is that of Jarociński and Karadi (2020) coming from their the poor man's sign restriction approach. Both instruments isolate the pure monetary surprises from the information content present in the Fed's communications. The solid lines report the point estimates, while the shaded areas report the 90% confidence intervals. The confidence intervals were computed from 1,000 draws using a parametric bootstrap as proposed in Stock and Watson (2018).

Figure C3: Impulse responses with stickiness in housing rents



Note: this Figure shows the responses of macroeconomic aggregates to a 25 basis points positive shock in the nominal interest rate for the baseline and for two alternative scenarios in which the Calvo fairy parameter in the real estate brokers sector is set to $\theta_r = 0.6$ and $\theta_r = 0.9$.