Effects of Monetary Policy on Household Expectations: The Role of Homeownership★

Hie Joo Ahn[a], Shihan Xie[b], Choongryul Yang[c]

[a] *Federal Reserve Board*
[b] *University of Illinois at Urbana-Champaign*
[c] *Federal Reserve Board*

Abstract

We study the role of homeownership in the effectiveness of monetary policy on households' expectations based on individual-level microdata in the U.S. We find that homeowners lower their near-term inflation expectations and optimism about the labor market outlook in response to a rise in mortgage rates, while renters are less likely to do so. We further show that forward guidance shocks lead to similar differences between homeowners and renters. Our results suggest that homeowners pay attention to news on interest rates and adjust their expectations accordingly in a manner consistent with the intended effect of monetary policy. We characterize this empirical finding with a rational inattention model where mortgage payments create an incentive for homeowners to acquire information on monetary policy, unlike renters. This housing-driven endogenous attentiveness is the key mechanism behind the compelling empirical link among homeownership, attention, and the transmission of monetary policy.

Keywords: Inflation expectations, homeownership, rational inattention, monetary policy
JEL classification: D83, D84, E31, E52

★We would like to thank Andrew Figura, Rupal Kamdar, Wenting Song, Dan Vine, Johannes Wieland, and numerous seminar participants at the Federal Reserve Board, UC Irvine, Fudan FISF, Applied Time Series Econometrics Workshop at St. Louis Fed, 4th Behavioral Macroeconomics Workshop, 2022 KER-KAEA International Conference, SEM 2022, SETA 2022, SEA 2022, MEG 2022, MWM 2022, and California Macro Conference for helpful comments and suggestions. The views expressed herein are those of the authors, and do not reflect the views of the Federal Reserve Board or any person associated with the Federal Reserve System. First version: April 2022; This version: April 2024.

Email addresses: econ.hjahn@gmail.com (Hie Joo Ahn), shihanx@illinois.edu (Shihan Xie), choongryul.yang@frb.gov (Choongryul Yang)

1. Introduction

The success of monetary policy relies on how effectively the central bank's communication and policy implementation affect the expectations of economic agents. Forward guidance policy, for example, is designed to work through economic agents' expectations at the zero lower bounds when standard policy instruments are constrained. However, recent empirical studies find that the Federal Reserve's communication about monetary policy has little effect on the inflation expectations of households (*e.g.*, Lamla and Vinogradov 2019; Coibion et al. 2022; D'Acunto et al. 2022). Moreover, households in low-inflation countries even report that they are largely unaware of monetary policy announcements and the role of the central bank (*e.g.*, Coibion et al. 2018). This evidence suggests that the widely believed premise that household inflation expectations serve as one of the key transmission mechanisms in monetary models is not empirically well-grounded. This possibility questions the validity of common practice in theory and policy: the expectation-driven propagation of monetary policy shocks in macroeconomic models. In this context, it is crucial to revisit the premise that has been the backbone of the macroeconomic literature and policy.

Does monetary policy have meaningful effects on households' expectations? We answer this question *empirically* by establishing stylized facts about the responsiveness of households' expectations to monetary policy based upon *individual-level* data from the University of Michigan Surveys of Consumers (MSC). We focus on *homeownership* as the key contributor to attention heterogeneity, which determines the degree to which monetary policy affects households' expectations. To the best of our knowledge, none of the previous studies have investigated the responsiveness of households' expectations to monetary policy with a particular focus on homeownership based upon the individual-level data in the U.S.[1] This paper is the first one that provides empirical answers to this important question and builds a novel structural model of endogenous attention and heterogeneous households that characterizes the mechanism driving the empirical findings.

Why is homeownership important? Housing asset provides an incentive for households to actively acquire information on changes in interest rates owing to mortgage payments or refinancing opportunities. Meanwhile, such factors are not of immediate interest for the household finance of

[1]The recent literature (*e.g.*, Weber et al., 2022) documents the importance of economic agents' heterogeneity in expectation formation and the implications for monetary policy. However, none of the previous studies have examined the role of homeownership in the heterogeneous responsiveness of households' expectations to monetary policy shocks.

renters, and hence renters have less incentive to pay attention to news on interest-rate changes. This suggests that homeownership could be a primary determinant of information acquisition. As a result, homeowners will pay close attention to mortgage rates and adjust their macroeconomic expectations more responsively to monetary policy shocks than renters. The microdata from the MSC supports this hypothesis. Specifically, homeowners lower their one-year-ahead inflation expectations in response to a rise in 30-year mortgage rates, while renters are less likely to do so. This relationship, however, is not observed in the five-year ahead inflation expectations on average. The effects on longer-run inflation expectations are only salient in times of mortgage rate declines.

Notably, in response to a rise in mortgage rates, homeowners also reduce their optimism about labor market conditions more than renters do. In other words, homeowners lower their near-term inflation expectations and labor-market outlook facing an increase in mortgage rates. Furthermore, we show that homeowners respond similarly to forward guidance shocks, which have the strongest pass-through to 30-year mortgage rates among monetary policy tools.[2] This empirical evidence suggests that homeowners are attentive to the evolution of mortgage rates and adjust their economic outlook in a way that is consistent with the intended outcome of monetary policy.

The heterogeneous responses in expectations by homeownership status suggest that mortgage-holding is a potentially important transmission channel. Homeowners with mortgages likely have a strong incentive to pay attention to mortgage rate changes especially when seeking an opportunity to refinance. The refinancing motive is likely strong in times of declining mortgage rates. Since the MSC does not have information on mortgage status, we test the mortgage channel by exploiting the variations in refinancing motives. Consistent with the conjecture that homeowners have a stronger motive to pay attention when mortgage rate declines, we find that the sensitivity of homeowners' revisions in short-term inflation expectations is greater during those periods. Moreover, the sensitivity of individuals' inflation expectation revision also increases with the state-level intensity of refinancing activities.

We further provide direct corroborating evidence on the importance of the mortgage channel from several additional sources. Using data from the Federal Reserve Bank of New York's Survey

[2]Our evidence suggests that conditional on a demand shock like monetary policy shock, inflation expectations, and the labor market outlook are positively correlated. This finding, however, does not contradict the observation in Kamdar (2019) that unconditional expectations of inflation and labor markets are negatively correlated as if the associations reflected the consequence of a supply shock.

of Consumer Expectations (SCE), we analyze heterogeneity in responsiveness to mortgage rate changes. We find that homeowners, particularly those with mortgages, are significantly more sensitive to mortgage rate changes, due to the potential financial benefits of refinancing among other reasons.[3] This heightened awareness is mirrored in their understanding of monetary policy effects, as we illustrate using the Bank of England's surveys. To further support these findings, we develop a novel attentiveness indicator from the MSC and employ time-use data from the American Time Use Survey (ATUS) to show that homeowners spend more time on finance-related activities, enhancing their exposure to economic information. In short, evidence from additional sources reinforces our main hypothesis that the mortgage-holding channel plays an essential role in attentiveness to macroeconomic conditions.

The main finding seems to be inconsistent with the recent evidence based on surveys and experiments that points to little effect of monetary policy on economic agents' expectations formation (*e.g.*, Coibion et al. 2018, 2022; Lamla and Vinogradov 2019; D'Acunto et al. 2022). These studies show that households do not have a good understanding of monetary policy or the central bank's communication about the future policy path. Nonetheless, these findings do not necessarily contradict our empirical results. Though households may not know concepts like "Federal Reserve", "monetary policy", and "inflation target", they may have a solid understanding of the effect of interest-rate changes on their household finances and the overall economy. Households may have learned about it from their own experiences or conversations with people that they interact with such as loan officers. In other words, even if households have little knowledge of monetary policy, our findings suggest that some households have strong incentives to pay attention to changes in interest rates and revise their expectations accordingly. In this regard, we identify a novel mechanism for the heterogeneous transmission of monetary policy based on homeownership status.

Based on the empirical evidence, we develop a novel general equilibrium model with rationally inattentive renters and homeowners with mortgages. Our novel empirical findings are employed to discipline the structural model and serve as the foundation for quantitative analysis on the transmis-

[3] Relatedly, according to the special survey of SCE designed by Pfajfar and Winkler (2024), homeowners are more likely to check mortgage rates and do so more frequently compared to renters. However, this difference is not statistically significant when considering attention to the federal funds rate and news related to the Federal Reserve. This finding provides independent corroborating evidence for our main claim and helps reconcile discrepancies between our study and prior findings as we discuss later.

sion of forward guidance shocks. The purpose of this analysis is to characterize the mortgage-holding channel that serves as the key mechanism driving heterogeneous responses of homeowners and renters to monetary policy shocks. As homeowners endogenously pay more attention to mortgage-rate changes, they are better informed about interest rate changes and macroeconomic conditions. As a result, in response to an expansionary forward guidance shock, homeowners raise their consumption more than renters do when they re-optimize their consumption accordingly. This structural model sheds light on endogenous attention as the key mechanism behind our compelling empirical evidence. The model is flexible and versatile enough for us to analyze the consequence of secular changes in homeownership on the effectiveness of monetary policy and also the interacting effects of monetary policy and macroprudential policy targeting the housing market. All these analyses are entirely new in the literature.

This paper contributes to multiple strands of research.The first is growing literature on the effectiveness of monetary policy on economic agents' expectations (*e.g.*, Coibion et al. 2022; D'Acunto et al. 2022). Recent studies have found scant evidence for the effectiveness of the Fed's communication or monetary policy on economic agents' expectations, though some studies (*e.g.*, Hoffmann et al., 2021; Kryvtsov and Petersen, 2021) reach a different conclusion.[4] Different from the previous literature, we show that homeownership and mortgage holdings are crucial drivers of households' heterogeneity in attention and expectations. In this context, our research also speaks to the literature on the role of household heterogeneity in the transmission of monetary policy.[5]

Second, this paper contributes to research on expectation formation (*e.g.*, Carroll 2003; Coibion and Gorodnichenko 2015b). Studies have focused on the role of economic developments or individual attributes in the expectation of economic agents (*e.g.*, D'Acunto et al. 2023; Pedemonte et al. 2023). We emphasize that this paper links the aforementioned literature by uncovering the importance of homeownership and mortgage holdings in households' expectation formation and the transmission of monetary policy.

Our unique contributions include 1) providing empirical evidence on the importance of household heterogeneity in monetary policy transmission mechanism through inflation expectations, and

[4] Coibion et al. (2023) study the effect of forward guidance on consumers' expectations and find that information treatment about mortgage rate has strong effects on the treatment group's expectations on nominal rate expectations while it has little effect on their inflation expectations relative to the control group.

[5] See, for example, McKay et al. (2016), Cloyne et al. (2019), Bilbiie (2020), and Nord (2022) among others.

2) building an endogenous information acquisition model to explain this homeownership-driven heterogeneous attention motive and its consequences. This paper is closest to Claus and Nguyen (2020) but different for two primary reasons. First, we focus on households in the U.S., different from their focus—Australian households. Second, Claus and Nguyen do not consider how homeownership determines the sensitivity of inflation expectations to monetary policy shocks, which is the main focus of our paper.

The paper is composed of 7 sections. Section 2 introduces the data, and section 3 presents the empirical analyses. Section 4 explores the mechanism behind our main findings. Section 5 develops a model of rational inattentive households disciplined by our empirical findings. Section 6 discusses model mechanisms and performs sensitivity analyses. Section 7 concludes.

2. Data

This section describes the survey data and monetary policy shocks used in this paper. Our main analysis relies on household expectations from the Michigan Survey of Consumers (henceforth MSC). We offer corroborating evidence on households' attention heterogeneity using a rich set of additional surveys. For monetary policy shocks, we adopt the measure from Swanson (2021).

2.1. Measuring of household expectations

The MSC questionnaires are designed to track consumer attitudes and expectations. The survey has been conducted by telephone monthly since 1978 and constitutes a sample of over 500 households representative of the U.S. population. It contains demographic information such as respondents' education level, age, and household income. In 1990, the MSC started collecting information about respondents' homeownership, home value, and home price expectations. The MSC does not track all individual households over time. About 40% of the households who were interviewed six months ago are re-contacted. In our study, we focus on the post-1990 sample to exploit the information on homeownership and the repeated sample feature of the survey. Hence, the sample period of the main empirical analyses ranges from 1990:M1 through 2020:M12. The homeownership rate is about 75% in our sample.

We supplement our main analysis using several additional surveys to evaluate the transmission mechanisms. We now briefly summarize the surveys and will provide more detailed information on each dataset in our subsequent analysis. First, the Federal Reserve Bank of New York has implemented the Survey of Consumer Expectations (henceforth, SCE) since 2013. This survey has a special module on housing which provides more detailed information on consumers' mortgage holding status, as well as their housing and mortgage market expectations. Second, the Bank of England has implemented the Survey of Inflation Attitudes since 2001. This survey includes special questions on the public's opinions and awareness of the central bank's work, and its relation to inflation. Third, the Federal Reserve Bank of Cleveland has implemented a survey starting in 2021 that indirectly measures consumer inflation expectations at a weekly frequency (henceforth, ICIE). Fourth, the American Time Use Survey contains information on individuals' time spent on various daily activities. We use this information to validate the attention allocation heterogeneity across homeowners and renters. Lastly, we use McDash data to measure state-level refinancing intensity.

2.2. Monetary policy shocks and mortgage rate pass-through

We adopt measures of monetary policy shocks constructed by Swanson (2021). Three orthogonal factors of FOMC announcements capture changes in federal funds rate, forward guidance, and large scale asset purchases (LSAPs), respectively. We first analyze the pass-through of these shocks to the 30-year mortgage rate by considering the following specification at weekly frequency:

$$\Delta R_t = \alpha + \underset{(0.009)}{0.009}\ FedFunds_t + \underset{(0.008)}{0.024}\ ForwardGuidance_t + \underset{(0.017)}{0.027}\ LSAP_t + \sum_{j=1}^{3} \delta_j \Delta R_{t-j} + \epsilon_t, \quad (1)$$

where the dependent variable ΔR_t is a change in the 30-year mortgage rate over week t. The weekly monetary policy shocks are the estimated shocks around an FOMC meeting, if the meeting falls in week t, but are set to zero, otherwise. We control for three lags of changes in the mortgage rate as in Hamilton (2008).

The coefficients reported in Equation (1) measure the responsiveness of the mortgage rate to the three factors of monetary policy shocks. Newey-West standard errors are reported in the parenthesis. Both forward guidance and LSAP shocks have statistically significant pass-through to the mortgage rate. Given that forward guidance was active during the entire sample period while LSAP was adopted only after the Great Recession, we focus on the pass-through of forward guidance shock in our following analysis. Specifically, we aggregate forward guidance shocks to monthly frequency and normalize it to have the same standard deviation as ΔR_t^{Mort} for interpretability in our subsequent analysis. We will use $\Delta \tilde{R}_{t,FG}$ to denote forward guidance shocks hereafter.

3. Empirical investigation

We discuss our empirical strategies and provide evidence of the heterogeneous effects of monetary policy on homeowners' and renters' expectations through mortgage rate changes. Section 3.1 analyzes the effect of mortgage rate changes on the inflation expectations of homeowners and renters. Section 3.2 conducts similar analyses for households' labor market outlooks. Section 3.3 examines the responsiveness of interest-rate expectations.

3.1. Effects of mortgage-rate changes on households' inflation expectations

This section investigates how much homeowners and renters revise their inflation expectations in response to mortgage rate changes. For this empirical analysis, we employ the following model specification:

$$E_{i,t+6}^{h-yr} - E_{i,t}^{h-yr} = \alpha + \beta_1 \, homeowner_i \times \Delta R_t + \beta_2 \, renter_i \times \Delta R_t + \gamma Z_t + \delta X_{i,t} + \epsilon_{i,t}, \tag{2}$$

where $E_{i,t}^{h-yr}$ is respondent i's h-year-ahead inflation expectation for $h = 1, 5$ at time t from the MSC; $homeowner_i$ and $renter_i$ are dummies for homeowner and renter, respectively; ΔR_t is a change in 30-year mortgage rates during the past six months or changes in 30-year mortgage rate predicted by forward guidance shocks, and $X_{i,t}$ are controls for the respondent's demographic characteristics which include gender, education, birth cohort, homeownership, marriage status, region, and income quartiles, as well as the respondent's revisions in gas price expectations. We control for other macroeconomic conditions by including the changes in the unemployment rate and federal funds rate during the past six months as explanatory variables Z_t.[6]

This specification is based on the model by Coibion and Gorodnichenko (2015b) that analyzes the effect of oil price changes on inflation expectations, but there are a few differences. First, our model captures the different sensitivities of homeowners and renters to a change in interest rates. We control for households' revisions in gas price expectations to capture the confounding effects of oil price changes on household expectations. Second, we use a past change in interest rates to reflect the delayed effect of monetary policy due, for instance, to information rigidity, while Coibion and Gorodnichenko (2015b) consider a change in oil prices in the current period. Third, we explicitly control for additional observable individual characteristics.

[6] We consider mortgage rate changes over different horizons as robustness checks. In Appendix Table A.1, we show that our results are robust when we employ mortgage rate changes over the past three or nine months.

Table 1: Sensitivity of revisions in homeowners and renters' inflation expectations to changes in mortgage rates

	1-year ahead inflation expectations		5-year ahead inflation expectations	
Interactions	(1) ΔR_t	(2) $\Delta \tilde{R}_{t,FG}$	(3) ΔR_t	(4) $\Delta \tilde{R}_{t,FG}$
Homeowner (β_1)	-0.6852***	-0.7485***	-0.0816	-0.0060
	(0.1035)	(0.1017)	(0.0713)	(0.0703)
Renter (β_2)	-0.2257	-0.2292	-0.1254	0.0125
	(0.1954)	(0.1914)	(0.1458)	(0.1456)
Number of obs.	21,338	20,722	20,455	20,455
Adj. R^2	0.0386	0.0398	0.0194	0.0193
***F*-test** $(\beta_1 = \beta_2)$	4.44**	5.86**	0.07	0.01

Notes: This table reports the regression results from Equation (2). Dependent variables are the six-month change in the MSC's 12-month ahead inflation expectations (Columns (1) and (2)) and the six-month change in the MSC's 5-year ahead inflation expectations (Columns (3) and (4)). "Homeowner" and "Renter" indicate dummies for homeowner and renter respectively. Columns (1) and (3) report responses to changes in 30-year mortgage rate; Columns (2) and (4) report responses to forward guidance shocks. We control for the respondent's gender, education, birth cohort, homeownership, marriage status, region, income quartiles, and respondent's revisions in gas price expectations, as well as changes in the unemployment rate and federal funds rate during the past six months. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

Columns (1) of Table 1 reports the estimation results for inflation expectations in the next 12 months from the MSC. The coefficient on $homeowner_i$ is negative and statistically significant, while that on $renter_i$ is not. The F-test rejects the null hypothesis of these two coefficients being equal at a 5% significance level. This result suggests that homeowners take signals from changes in mortgage rates when projecting inflation a year ahead, while renters are less likely to do so. Homeowners likely make regular mortgage payments and consider refinancing their home loans. Therefore, homeowners may pay closer attention to the evolution of mortgage rates than renters do, because a change in mortgage rates likely has a direct effect on their household finances. This observation indicates that households do adjust their inflation expectations to interest rate changes to which they pay attention. We empirically test and verify this heterogeneous attention motive in Section 4.

Unlike the estimation results from one-year-ahead inflation expectations, households' five-year-ahead inflation expectations do not seem to respond to interest rate changes, regardless of homeownership status. As shown in Column (3) of Table 1, the coefficients on interest rate changes are close to zero and not statistically significant. Overall, households are less likely to change their long-run inflation expectations in response to a change in interest rates.[7]

[7] We show in Section 4.3 that homeowners revise lower their 5-year ahead inflation expectations with statistical

We next analyze how responsive households' inflation expectations are to monetary policy shocks by replacing ΔR_t in Equation (2) with forward guidance shock $\Delta\tilde{R}_{t,FG}$. The estimation results for households' inflation expectations is reported in Columns (2) and (4) Table 1. Column (2) shows that in the MSC, homeowners do strongly react to forward guidance shocks when revising short-term inflation expectations, while renters do not. This difference in responses is statistically significant at a 5% significance level. Consistent with the baseline result, none of the coefficients are statistically significant in predicting five-year-ahead inflation expectations (Column 4), suggesting that households' long-run inflation expectations are not responsive to news on monetary policy.

3.2. Effects of mortgage-rate changes on labor market outlooks

We investigate how interest rate changes affect households' expectations of labor market conditions. Suppose an interest rate increase also has negative effects on households' job market outlook. In that case, we can interpret that the interest rate change influences households' expectations in a way similar to a contractionary monetary policy and may reflect a consequence of monetary policy.

The main challenge in this analysis, however, is that expectations of labor market conditions are captured by categorical responses, unlike inflation expectations. Since we are chiefly interested in changes in expectations, we construct a binary variable that reflects the direction of expectation revisions. This variable takes the value 1 if an individual's unemployment outlook has "*improved*", and 0 otherwise.[8] We estimate the following linear regression model:

$$\mathcal{I}_{i,t} = \alpha_0 + \beta_1 \; homeowner_i \times \Delta R_t + \beta_2 \; renter_i \times \Delta R_t + \gamma Z_t + \delta X_{i,t} + \epsilon_{i,t}, \tag{3}$$

where $\mathcal{I}_{i,t}$ is a binary variable that takes the value 1 if individual i's unemployment outlook improved from time t to $t+6$. The regressors $homeowner_i$ and $renter_i$ are dummies for homeowner and renter, respectively; ΔR_t is a change in the mortgage rate or forward guidance shocks during the past six months. We include the same set of household-level controls and aggregate variables as Equation (2).

significance in response to a mortgage-rate cut. Effects of monetary policy on long-run inflation expectations have been studied in the context of *"re-anchoring of inflation expectations"*, and there are different views about the effectiveness (*e.g.*, Breckenfelder et al., 2016; Ciccarelli et al., 2017). Unlike our approach, the previous literature studies the consensus expectations data using time-series models. Nonetheless, our finding—null to small negative effects of monetary policy on long-run inflation expectations, but larger negative effects on short-term inflation expectations—is broadly in line with the finding of previous literature (*e.g.*, Diegel and Nautz, 2021).

[8] Appendix A.2 provides more details on the survey question and the construction of the variable.

Table 2: Sensitivity of revisions in homeowners and renters' unemployment outlook to changes in mortgage rates

	$\mathcal{I}$(Unemployment outlook improves)	
Interactions	(1) ΔR_t	(2) $\Delta\tilde{R}_{t,FG}$
Homeowner (β_1)	-0.0177**	-0.0290***
	(0.0077)	(0.0077)
Renter (β_2)	0.0205	-0.0130
	(0.0142)	(0.0139)
Number of obs.	24,474	23,881
Adj. R^2	0.0162	0.0168
***F*-test** ($\beta_1 = \beta_2$)	5.90**	1.08

Notes: This table reports the regression results from Equation (3). The dependent variable is a dummy that takes the value 1 if an individual's unemployment outlook improves over 6 months. "Homeowner" and "Renter" indicate dummies for homeowner and renter respectively. ΔR_t refers to the six-month change in interest rate. Columns (1) report responses to changes in 30-year mortgage rate; Columns (2) report responses to forward guidance shocks. We control for the respondent's gender, education, birth cohort, homeownership, marriage status, region, income quartiles, and respondent's revisions in gas price expectations, as well as changes in the unemployment rate and federal funds rate during the past six months. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

The coefficient estimates for unemployment outlook are reported in Table 2. Homeowners become less likely to anticipate that the labor market conditions will improve with a rise in the 30-year mortgage rate, while renters do not. We find similar results with forward guidance shocks as reported in the second column, even though the difference between homeowners and renters is not statistically significant. As a robustness check, we employ a multivariate logit regression model and reach the same conclusions. The results are reported in Appendix A.2.

3.3. Effects of mortgage-rate changes on interest rate expectations

We further examine the sensitivity of households' expectations of future interest rates to a recent interest-rate change as a channel through which the rate rise has contractionary effects on household expectations. Responses to the question on interest-rate expectation are also a categorical variable. Therefore, we employ Equation (3), but change the dependent variable accordingly.

We construct a binary variable that takes the value 1 if an individual expects interest rates to increase over the next 12 months, and 0 otherwise.[9] Next, we estimate Equation (3) using this binary variable as the dependent variable. The coefficient estimates for interest rates are reported in Table 3. When there is an increase in the interest rate, households are more likely to believe that interest

[9] Appendix A.3 provides more details on the survey question and the construction of the variable.

Table 3: Sensitivity of revisions in homeowners and renters' interest rate expectations to changes in mortgage rates

	$\mathcal{I}$(Interest rates go up)	
Interactions	(1) ΔR_t	(2) $\Delta\tilde{R}_{t,FG}$
Homeowner (β_1)	0.1475***	0.0708***
	(0.0074)	(0.0069)
Renter (β_2)	0.0621***	0.0648***
	(0.0097)	(0.0157)
Number of obs.	24,496	23,898
Adj. R^2	0.0551	0.0463
***F*-test** ($\beta_1 = \beta_2$)	59.14***	0.10

Notes: This table reports the regression results from Equation (3). The dependent variable is a dummy that takes the value 1 if interest rates are expected to go up. "Homeowner" and "Renter" indicate dummies for homeowner and renter respectively. ΔR_t refers to the six-month change in interest rate. Columns (1) report responses to changes in 30-year mortgage rate; Columns (2) report responses to forward guidance shocks. We control for the respondent's gender, education, birth cohort, homeownership, marriage status, region, income quartiles, and respondent's revisions in gas price expectations, as well as changes in the unemployment rate and federal funds rate during the past six months. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

rates will keep increasing in the future. In addition, the responsiveness of homeowners is larger than that of renters with statistical significance. As a robustness check, we employ a multivariate logit regression model and reach the same conclusions. The results are reported in Appendix A.3.

To summarize, homeowners adjust their short-run inflation expectations and labor market outlook in response to mortgage rate changes and forward guidance shocks, while renters are less likely to do so. Moreover, both homeowners and renters extrapolate interest rate changes. The extrapolation is stronger among homeowners than renters, and the difference in responsiveness is statistically significant for an increase in the mortgage rate. This channel of interest rate expectations reinforces the contractionary effects of an interest rate rise on homeowners' expectations.

4. Mechanisms

We explore the potential mechanisms in support of our main findings. Section 4.1 provides evidence based on special modules of NY Fed SCE. Section 4.2 provides international evidence based on surveys from the Bank of England. Section 4.3 examines the potential nonlinearity in the main results and its implications. Section 4.4 exploits heterogeneities in state-level refinancing activities. Section 4.5 summarizes additional survey-based evidence.

4.1. Evidence from NY Fed Survey of Consumer Expectations

This section provides evidence from special modules of the SCE. First, we conduct an analysis based on the housing survey which focuses on households' housing and mortgage market expectations. This special module has been conducted every February since 2014. Second, we briefly discuss evidence from a recent special module on how frequently households pay attention to economic and financial news.

4.1.1. SCE Housing Survey

Distinguished from the MSC and the main SCE, the housing module has information about households' mortgage holding status, recent refinancing plans, and their perception and forecasts of mortgage rates. Exploiting these features, we provide additional evidence that homeowners with mortgages pay more attention to mortgage rate changes than outright homeowners. In addition, households who recently refinanced their mortgages or have a plan to refinance their mortgage in the next 12 months have even more accurate mortgage rate perceptions and forecasts than other mortgage holders. This evidence supports our claim that mortgage holdings, refinancing motive in particular, provide incentives for households' attention to mortgage rates and general macroeconomic conditions.[10]

We examine to which extent mortgage holding and a near-term refinancing plan affect the accuracy of current mortgage rate perceptions and future mortgage rate projections. The housing module asks the survey respondents their perceived probability of mortgage refinancing in the next 12 months, and the data are available from 2014 to 2020. We consider the following regression:

$$\begin{aligned} FE^h_{i,t} =& \alpha_1 \times \mathbf{I}(\textit{owned outright})_{i,t} + \alpha_2 \times \mathbf{I}(\textit{owned mortgage})_{i,t} + \alpha_3 \times \mathbf{I}(\textit{refinanced last year})_{i,t} \\ &+ \alpha_4 \times \mathbf{I}(\textit{plan to refinance})_{i,t} + \xi_t + \delta X_{i,t} + \epsilon_{i,t}, \end{aligned}$$

where the dependent variable $FE^h_{i,t}$ is the absolute deviation of h-period ahead mortgage-rate projection relative to the realized values of the corresponding period for h =0 (current year), 1 (1-year ahead), and 3 (3-year ahead). The regressors of interests are four dummy variables, where $\mathbf{I}(\textit{owned outright})_{i,t}$ takes the value 1 if the individual is a homeowner but does not have any

[10] Appendix B.1 provides a more detailed description of the survey questionnaires. Specifically, Appendix Figure B.4 shows that homeowners with mortgages have the most accurate mortgage rate perceptions and forecasts in every wave of surveys.

Table 4: Mortgage rate forecast errors by homeownership status

	Errors in 30-year fixed rate mortgage		
	(1) Perceptions	(2) 1-year head	(3) 3-year ahead
Owned outright (α_1)	-0.4027***	-0.4514***	-0.3701***
	(0.0740)	(0.0731)	(0.0794)
Owned mortgage (α_2)	-0.8042***	-0.7326***	-0.6827***
	(0.0603)	(0.0607)	(0.0671)
Refinanced last year (α_3)	-0.0775*	-0.1040***	-0.0566
	(0.0459)	(0.0566)	(0.0559)
Plan to refinance (α_4)	-0.1291***	-0.1092***	-0.0674
	(0.0400)	(0.0453)	(0.0788)
Year FE	Y	Y	Y
Demographic FE	Y	Y	Y
Number of obs.	7,446	7,404	7,315
Adj. R^2	0.1265	0.1291	0.1173

Notes: This table reports the regression results from Equation (4.1.1). Dependent variables in Columns (1) - (3) are mortgage rate perception errors, 1-year ahead forecast errors, and 3-year ahead forecast errors. The baseline is renters. "Owned outright" and "Owned mortgage" indicate dummies for homeowners without or with mortgages respectively. We control for year and demographic fixed effects. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

outstanding mortgages or home equity loans; $\mathbf{I}(\textit{owned mortgage})_{i,t}$ takes the value 1 if the individual is a homeowner with mortgages or home equity loans; $\mathbf{I}(\textit{refinanced last year})_{i,t}$ equals one if the individual refinanced during the last year; $\mathbf{I}(\textit{plan to refinance})_{i,t}$ equals one if the individual i has a non-trivial probability of refinancing (greater than 20 percent) in the next 12 months.

The baseline of this regression is renters. We control for year fixed effects (ξ_t) and other demographic fixed effects ($X_{i,t}$) including age, education, income, numeracy, and region. We consider three age groups (younger than 40, 40-60, and 61 and over); three education groups (high-school graduation; some college and associate degree; college graduation or higher); three income groups (<50K; 50-100K; 100K+).

Table 4 shows that homeowners with mortgages or other home equity loans have the most accurate mortgage perceptions or forecasts over all horizons, followed by homeowners without any home loans. Overall, homeowners have better knowledge of mortgage rates compared to renters. Moreover, among mortgage holders, those who refinanced during the past year or plan to refinance in the next 12 months have even better mortgage perceptions or 1-year ahead forecasts.

To sum up, we interpret the accuracy of households' perception and prediction of mortgage rates as reflecting the degree of attention to mortgage rates. Our evidence from the SCE housing module strongly supports the mortgage channel in explaining attention heterogeneity.

4.1.2. SCE Special Module on households' attention to macroeconomic news

The SCE special module captures how frequently households pay attention to economic and financial news. This one-time special survey is designed by Pfajfar and Winkler (2024) and conducted by the Federal Reserve Bank of New York in June 2023.[11] The special module allows us to directly observe how frequently an individual checks macroeconomic news and to analyze the extent to which homeownership and mortgage holdings affect households' attention to interest rate changes.[12]

According to the survey, homeowners are more likely to check mortgage rates than renters and also check mortgage rates more frequently than renters do. This result is primarily driven by homeowners with mortgages, while outright homeowners' attention to mortgage rates is not as strong. Notably, the difference between homeowners and renters is not statistically significant for federal funds rate and news on the Federal Reserve. Homeownership and mortgage holdings are important factors in households' attention to mortgage rates.

Furthermore, homeownership and attention to bond yields reduce the difference in inflation forecasts from those of professional forecasters. Considering professional forecasters are better informed on macroeconomic conditions and hence produce more accurate inflation, the reduction in forecast differentials between the two groups implies homeownership helps households to be better informed of macroeconomic conditions. Again, attention to federal funds rate and news on the Federal Reserve does not have statistically significant effects on reducing the forecast differentials between households and professional forecasters.

All told, relative to renters homeowners are more likely to be better informed of macroeconomic conditions and to have an information set closer to that of professional forecasters through their attention to mortgage rates and interest rates related to homeownership.

[11] The description of the special module is from Pfajfar and Winkler (2024), and the associated empirical evidence is from the companion paper, Ahn et al. (2024). We provide the summary of main findings from Ahn et al. (2024) that serves as the corroborating evidence for our main claim. See Appendix B.2 for details on the survey.

[12] Relative to the MSC, one caveat of the special module is that the survey was conducted only in June 2023, and hence the survey does not allow us to evaluate revisions of households' macroeconomic expectations in response to forward guidance shocks or mortgage rate changes.

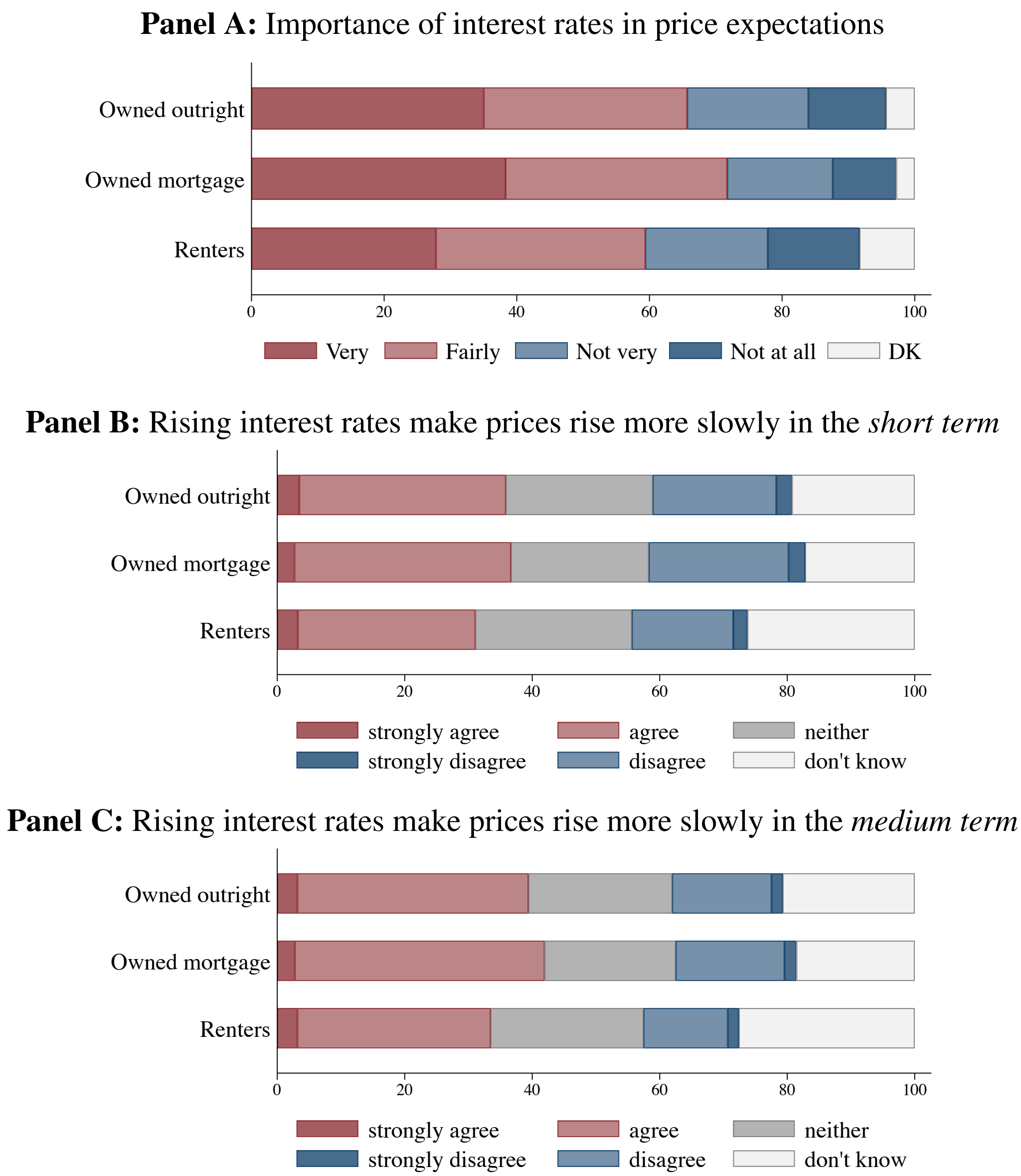
4.2. Evidence from Bank of England Survey of Inflation Attitudes

As additional corroborating evidence, we now look at households in the U.K.— a country with a mortgage structure similar to the United States. We show that, like US homeowners, UK homeowners are more likely to understand the intended consequences of monetary policy. British households primarily use fixed-rate mortgages or variable-rate mortgages. Unlike fixed-rate mortgages in the U.S. that fix the interest rate until maturity, fixed-rate mortgages in the UK typically only fix the interest rate for the first 2 or 5 years and start floating afterward. Therefore, UK homeowners have similar, if not stronger, incentives to pay attention to mortgage rates compared to US homeowners.

The Bank of England has been running a quarterly survey to assess public attitudes toward inflation, and opinions and awareness about the central bank's work since 2001. The survey includes questions on (1) inflation perceptions and expectations; (2) knowledge of interest rates; and is occasionally supplemented with questions on (3) the relationship between interest rates and price changes. The survey includes basic demographic information of the respondents including homeownership and mortgage holdings.

Specifically, we analyze three questions that provide a qualitative but direct assessment of respondents' knowledge of the causal relationship between interest rate changes and inflation dynamics. Figure 1 reports responses to these questions. Panel A summarizes responses to the question on "*How important is the current level of interest rates in your expectations about price changes?*". The results show that homeowners, especially mortgage-payers, are more likely to form inflation expectations based on current interest rates. Next, we analyze to what extent respondents agree with the statement that "*rising interest rates make prices rise more slowly in the short or medium term*". The results on short and medium terms are summarized in Panel B and C respectively. We find that homeowners, especially mortgage-payers, are more likely to agree that rising interest rates make prices rise more slowly in both the short and medium runs. In other words, like US homeowners, UK homeowners are more likely to understand the intended consequences of monetary policy, i.e., interest rate increases will lower inflation.

Figure 1: BOE's Inflation Attitudes Survey



Notes: Panel A documents responses to the question, "*How important is the current level of interest rates in your expectations about price changes?*" Panel B documents responses to the question, "How strongly do you agree or disagree: *Rising interest rates make prices rise more slowly in the short term*?" Panel C documents responses to the question, "How strongly do you agree or disagree: *Rising interest rates make prices rise more slowly in the medium term*?"

Source: Bank of England Inflation Attitudes Survey.

4.3. Asymmetric effects of mortgage-rate changes on household expectations

This section examines the asymmetric effects of mortgage rate changes on households' inflation expectations. Homeowners with mortgages may seek opportunities to refinance their mortgages with lower rates. Therefore, homeowners have more incentive to pay attention to mortgage-rate declines. Given that MSC does not contain information on mortgage status, we investigate the mortgage-holding channel through refinancing motive, which could lead to an asymmetric response of inflation expectations to mortgage-rage changes. Specifically, we expect larger sensitivity during mortgage rate declines than periods of mortgage rate rises.

We consider the following specification which is a variant of Equation (2) in order to separate the effects of increases and decreases in mortgage rates:

$$
\begin{aligned}
E^{h-yr}_{i,t+6} - E^{h-yr}_{i,t} =& \alpha + \beta_1 \text{ homeowner}_i \times \Delta R_t \times I^+_t + \beta_2 \text{ homeowner}_i \times \Delta R_t \times I^-_t \\
& + \beta_3 \text{ renter}_i \times \Delta R_t \times I^+_t + \beta_4 \text{ renter}_i \times \Delta R_t \times I^-_t + \gamma Z_t + \delta X_{i,t} + \epsilon_{i,t},
\end{aligned}
$$

where I^+_t (I^-_t) is a dummy variable indicating an increase (decrease) in the mortgage rate. For ΔR_t, we consider a change in 30-year mortgage (ΔR^{Mort}_t) and forward guidance shocks. The larger negative and statistically significant coefficient on $homeowner \times I^-_t$ than that on $homeowner \times I^+_t$ suggests the refinancing motive of homeowners is in effect. We estimate this model with the MSC data including the same set of household-level controls and aggregate variables as our main empirical specification.

Table 5 reports the estimation result.[13] Overall, the estimation result supports the refinancing motive as an important factor driving the sensitivity of homeowners' inflation expectations to mortgage-rate changes. Homeowners' short-term inflation expectations respond to mortgage rate declines with statistical significance, while the coefficient's statistical significance disappears with mortgage rate increases (Column 1). The F-test rejects the null hypothesis that homeowners' responses to the increase or decrease in mortgage rates are the same at a 5% significance level. Asymmetric responses are also observed for long-term inflation expectations (Column 3). We reach similar conclusions when we look at forward guidance shocks (Columns 2 and 4). However, renters' inflation expectations are quite different. They do not respond to either increase or decrease in mortgage rates with statistical differences.

The observed asymmetric sensitivity of homeowners' inflation expectations to a change in mortgage rates and monetary policy offers new insight into the effectiveness of monetary policy—

[13] Our baseline results are based on mortgage rate increases or decreases over the past six months. We consider mortgage rate changes over different horizons as robustness checks. In Appendix Table A.2, we show that our results are robust when we employ mortgage rate changes over the past three or nine months.

Table 5: Asymmetric effects of mortgage-rate changes

	1-year ahead inflation expectations		5-year ahead inflation expectations	
Interactions	(1) ΔR_t	(2) $\Delta \tilde{R}_{t,FG}$	(3) ΔR_t	(4) $\Delta \tilde{R}_{t,FG}$
Homeowner$\times I_t^+$ (β_1)	-0.2971	-0.6880***	0.1398	0.1258
	(0.1868)	(0.1524)	(0.1412)	(0.1054)
Renter$\times I_t^+$ (β_2)	-0.0379	0.0167	0.1648	0.1551
	(0.3431)	(0.2830)	(0.2810)	(0.2218)
Homeowner$\times I_t^-$ (β_3)	-1.0020***	-0.8057***	-0.2669**	-0.1138
	(0.2024)	(0.1406)	(0.1268)	(0.0926)
Renter$\times I_t^-$ (β_4)	-0.4264	-0.4219	-0.4104	-0.1109
	(0.4293)	(0.2614)	(0.2994)	(0.1949)
Number of obs.	21,338	20,772	20,731	20,455
Adj. R^2	0.0388	0.0397	0.0190	0.0194
***F*-test** ($\beta_1 = \beta_3$)	4.46**	0.31	3.19*	2.98*

Notes: This table reports the regression results from Equation (4.3). Dependent variables are the six-month change in the MSC's 12-month ahead inflation expectations (Columns (1) and (2)) and the six-month change in the MSC's 5-year ahead inflation expectations (Columns (3) and (4)). "Homeowner" and "Renter" indicate dummies for homeowner and renter respectively. I_t^+ and I_t^- indicate dummies for periods of increase and decrease in 30-year mortgage rates respectively. Columns (1) and (3) report responses to changes in 30-year mortgage rate; Columns (2) and (4) report responses to forward guidance shocks. We control for the respondent's gender, education, birth cohort, homeownership, marriage status, region, income quartiles, and respondent's revisions in gas price expectations, as well as unemployment rate and federal funds rate changes during the past six months. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

the mortgage channel may be a key driver of unequal effects of monetary policy on households' expectations.

4.4. State-level refinancing activities

In this section, we provide further evidence that households in states with more intensive refinancing activities are more responsive to monetary policy shocks in their expectation revisions. To this end, we combine data on state-level mortgage refinances and outstanding loans from McDash with MSC. We use the McDash data from 2006 since the coverage of state-level refinance data has improved significantly from the mid-2000s.

We first construct the variable of *refinancing intensity* as the ratio of mortgage-refinance counts to total loans outstanding for each state for each month. Unfortunately, we do not observe whether a household owns mortgages or not in MSC, so we use the state-level variations as a proxy for individual propensity for refinancing. We consider the following model:

$$E_{i,t+6}^{h-yr} - E_{i,t}^{h-yr} = \alpha + \beta_1 \, \Delta R_t + \beta_2 \Delta \; refinance_{i,t} + \beta_3 \; \Delta refinance_{i,t} \times \Delta R_t + \gamma Z_t + \delta X_{i,t} + \epsilon_{i,t}, \quad (4)$$

Table 6: Sensitivity of revisions in households' inflation expectations to changes in mortgage rates and the state-level refinance intensity

Coefficient	1-year ahead inflation expectations (1) ΔR_t	1-year ahead inflation expectations (2) $\Delta \tilde{R}_{t,FG}$	5-year ahead inflation expectations (3) ΔR_t	5-year ahead inflation expectations (4) $\Delta \tilde{R}_{t,FG}$
β_1	-0.5832***	-0.5509***	-0.0701	0.0185
	(0.1057)	(0.0924)	(0.0750)	(0.0663)
β_2	-0.4913	0.6472*	0.0974	0.3846
	(0.3982)	(0.3650)	(0.2907)	(0.2573)
β_3	-3.5158***	-1.5239**	-1.3508***	-0.7265
	(0.7128)	(0.7686)	(0.4954)	(0.5208)
Number of obs.	20,344	20,344	20,048	20,048
Adj. R^2	0.0424	0.0415	0.0200	0.0196

Notes: This table reports the regression results from Equation (4). Dependent variables are the six-month change in the MSC's 12-month ahead inflation expectations (Columns (1) and (2)) and the six-month change in the MSC's 5-year ahead inflation expectations (Columns (3) and (4)). Columns (1) and (3) report responses to changes in 30-year mortgage rate; Columns (2) and (4) report responses to forward guidance shocks. We control for the respondent's gender, education, birth cohort, homeownership, marriage status, region, income quartiles, and respondent's revisions in gas price expectations, as well as unemployment rate and federal funds rate changes during the past six months. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

Source: MSC, McDash and authors' calculation.

where $E_{i,t}^{h-yr}$ is respondent i's h-year-ahead inflation expectation for $h = 1, 5$ at time t from the MSC; $refinance_{i,t}$ captures the refinancing intensity of the state where individual i resides at time t; ΔR_t is a change in 30-year mortgage rates during the past six months or forward guidance shocks. We include the same set of controls, $X_{i,t}$ and Z_t, as our baseline specification, Equation (2).

Table 6 reports the estimation results. The coefficient β_3, capturing the interacting effects of monetary policy and refinancing intensity, is statistically significant in the short-term inflation expectations (Columns 1 and 2). In the states where the refinancing activity increases, households take a stronger signal about monetary policy from mortgage rate changes when revising their short-term inflation expectations. The additional effects of mortgage-rate changes likely come from homeowners, since homeowners carry mortgages and refinance their home loans.[14] For the long-run expectations, the coefficients of mortgage rate changes (β_1) are not statistically significant with both mortgage-rate changes (Columns 3 and 4). The interacting effects captured by β_3 are also negative, though smaller in magnitude and weaker in statistical significance relative to the short-term inflation

[14] Increased refinance activity may further motivate renters to pay attention to mortgage rates and housing markets, potentially raising the overall mortgage-rate sensitivity to households' inflation expectations.

expectations. As shown in Column (3), the statistical significance of β_3 survives only for the model with mortgage-rate changes.

To summarize, the effects of monetary policy reflected on mortgage rate changes are larger in a state with higher refinancing intensity. This evidence again supports our conclusion that mortgage-holding is an important channel through which households pay attention to monetary policy and macroeconomic conditions when forming their inflation expectations.

4.5. Additional survey-based evidence

We provide further corroborating evidence on the attention heterogeneity between homeowners and renters. First, in Appendix B.3, we show that homeowners pay more attention to news on interest rates when assessing the overall macroeconomic conditions. For this, we construct a new indicator of attentiveness based on the microdata from the MSC. According to the indicator, homeowners pay more attention to news on interest rates than renters do.

Second, in Appendix B.4, we use the American Time Use Survey (ATUS) to show that homeowners spend more time on finance-related activities that likely expose them to information on interest rates and macroeconomic conditions. Time spent on particular activities during a day can be interpreted as an individual's effort or attention to such activities. In this context, time spent on finance-related activities– such as checking financial markets and researching investments– serves as a measure of households' attentiveness to financial markets and macroeconomic developments. In sum, our main finding is also supported by the ATUS– the microdata independent of the MSC, confirming the main conclusion and the key mechanism.

Third, in Appendix B.5, we examine the inflation forecast accuracy of different age groups from ICIE. We find that consumers in the age group that are most likely to be homeowners with mortgages have the most accurate inflation perceptions and forecasts, suggesting that they likely pay more attention to inflation than others.

5. A general equilibrium model with rationally inattentive homeowners and renters

In this section, we develop a general equilibrium model featuring rationally inattentive homeowners and renters. The model is disciplined using the novel empirical evidence of Section 3 and serves as the foundation for quantitative analysis on the transmission of forward guidance shocks.

Our primary focus in this analysis is twofold: first, we investigate how rational inattention induces heterogeneous responses in expectations among homeowners and renters following a forward guidance shock; second, we explore the policy and welfare implications of attention heterogeneity within the model framework. Specifically, we examine the consumption responses of homeowners and renters to a forward guidance shock and quantify the welfare costs associated with such shocks in an economy with rationally inattentive agents.

5.1. Environment

Our model extends the framework of the New Keynesian model with mortgage markets as developed in Garriga et al. (2021) by introducing rationally inattentive homeowners and renters, who optimally choose their attention levels considering the associated cost. The rational inattention aspect of our model draws from Maćkowiak and Wiederholt (2023) and Afrouzi and Yang (2021). Within this economy, we consider three types of households (homeowners, renters, and mortgage lenders), alongside construction and non-construction firms. The central bank implements monetary policy by setting the nominal interest rate according to a standard Taylor rule.

Our primary focus in this model is to explore heterogeneous attention dynamics among homeowners and renters. To simplify our analysis, we assume that only homeowners and renters face attention costs, while mortgage lenders, firms, and the central bank operate under full information rational expectations.

5.1.1. Homeowners

There are a measure λ^o of homeowners index by i who maximize their lifetime utility,

$$\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t\left(u\left(C^o_{i,t},S^o_{i,t}\right)-\omega\mathbb{I}(y^o_{i,t};\{\xi^o_{i,\tau}\}_{\tau\leq t}|\mathcal{I}^o_{i,t-1})\right)\Big|\mathcal{I}^o_{i,-1}\right]$$

subject to a budget constraint

$$C^o_{i,t}+Q_tX_{i,t}+P^s_tS^o_{i,t}+b^o_{i,t}+\frac{\psi_{b^o}}{2}\left(b^o_{i,t}\right)^2=W_tN^o+\frac{R_{t-1}}{\Pi_t}b^o_{i,t-1}+P^s_tS_{i,t}+L^o_{i,t}-M^o_{i,t}$$

where $C^o_{i,t}$ is consumption, $X_{i,t}$ is purchases of new housing, Q_t is the real housing price, $S^o_{i,t}$ is the owner-occupied housing services, P^s_t is the price of housing rental services, $b^o_{i,t}$ is real bond holding, N^o is fixed labor supply, W_t is the real wage, R_t is nominal interest rate, Π_t is aggregate inflation, $S_{i,t}$ is the total sales of housing services, $L^o_{i,t}$ is new real mortgage borrowing, $M^o_{i,t}$ is real mortgage payment on outstanding debt, and $\omega \mathbb{I}(y^o_{i,t}; \{\xi^o_{i,\tau}\}_{\tau \le t} | \mathcal{I}^o_{i,t-1})$ is the total cost of attention observing signal $y^o_{i,t}$ about all the relevant states for homeowners up to time t, $\{\xi^o_{i,\tau}\}_{\tau \le t}$, given the information set $\mathcal{I}^o_{i,t-1}$ in which we will discuss in detail in Section 5.2.

The existing stock of housing, $H_{i,t}$, accumulates as $H_{i,t} = (1-\delta) H_{i,t-1} + X_{i,t}$. We assume that the total housing services are produced from the housing stock with a linear technology ($S_{i,t} = H_{i,t}$). We also assume a quadratic portfolio adjustment cost, ψ_{b^o}, à la Schmitt-Grohé and Uribe (2003), to ensure stationary bond holdings in the equilibrium.

The homeowner purchases new housing with a mortgage loan, $L^o_{i,t}$, at the loan-to-value ratio θ, $L^o_{i,t} = \theta Q_t X_{i,t}$. Denoting by $D^o_{i,t-1}$ the outstanding real mortgage debt of the homeowner at the beginning of period t, the nominal mortgage payments the homeowner has to make in period t are given by $M^o_{i,t} = \left(R^M_{t-1} - 1 + \gamma\right) \frac{D^o_{i,t-1}}{\Pi_t}$ where $R^M_t - 1$ is the interest rate of outstanding debt, and γ is the amortization rate.[15] The outstanding mortgage debt D^o_t evolves as $D^o_{i,t} = (1-\gamma) D^o_{i,t-1} \frac{1}{\Pi_t} + L^o_{i,t}$. Lastly, we consider a fixed mortgage rate as our baseline such that $R^M_t = (1-\phi^o_t) R^M_{t-1} + \phi^o_t R^F_t$ where $\phi^o_t = \frac{L^o_t}{D^o_t}$ is the ratio of newly initiated loans to the total mortgage debt carrying over to the beginning of next period and R^F_t is the mortgage rate for the new loan.[16]

5.1.2. Renters

There are a measure λ^r of rationally inattentive renters index by i who maximize lifetime utility,

$$\mathbb{E}\left[\sum_{t=0}^{\infty} \beta^t \left(u\left(C^r_{i,t}, S^r_{i,t}\right) - \omega \mathbb{I}(y^r_{i,t}; \{\xi^r_{i,\tau}\}_{\tau \le t} | \mathcal{I}^r_{i,t-1})\right) \Big| \mathcal{I}^r_{i,-1}\right]$$

subject to a budget constraint, $C^r_{i,t} + P^s_t S^r_{i,t} + b^r_{i,t} = W_t N^r + \frac{R_{t-1}}{\Pi_t} b^r_{i,t-1}$, where $C^r_{i,t}$ is consumption, $S^r_{i,t}$ is the renter-occupied housing services, $b^r_{i,t}$ is real bond holding, and N^r is fixed labor supply.[17] Lastly, $\omega \mathbb{I}(y^r_{i,t}; \{\xi^r_{i,\tau}\}_{\tau \le t} | \mathcal{I}^r_{i,t-1})$ is the total cost of attention observing signal $y^r_{i,t}$ about all the relevant states for renters up to time t, $\{\xi^r_{i,\tau}\}_{\tau \le t}$, given the information set $\mathcal{I}^r_{i,t-1}$ in which we will

[15] As indicated by Garriga et al. (2021), a constant amortization rate implies geometrically declining mortgage payments, unlike standard mortgage contracts. We make this assumption for computational simplicity. A similar formulation is considered in Woodford (2001) with longer-term government debt.

[16] In our baseline model, we assume a fixed mortgage rate, consistent with the prevalence of fixed-rate mortgages in the US (approximately 92% according to the 2019 Survey of Consumer Finances). In Section 6, we conduct a sensitivity analysis by considering an adjustable mortgage rate ($R^M_t = R_t$) to explore alternative scenarios.

[17] Unlike homeowners, we assume that renters are not subject to a bond adjustment cost, which allows them to smooth their consumption through the bond market sufficiently. This assumption also simplifies the computational challenges associated with the renters' attention problem.

discuss in detail in Section 5.2.

5.1.3. Mortgage lenders

There are a measure λ^l of mortgage lenders indexed by i who maximize their lifetime utility,

$$\mathbb{E}_0\left[\sum_{t=0}^{\infty}\beta^t u\left(C_{i,t}^l\right)\right]$$

subject to a budget constraint

$$C_{i,t}^l + b_{i,t}^l + \frac{\psi_{b^l}}{2}\left(b_{i,t}^l\right)^2 + L_{i,t}^l = W_t N^l + W_t^H N^{l,H} + \frac{R_{t-1}}{\Pi_t} b_{i,t-1}^l + M_{i,t}^l + \Phi_{i,t}^l + \Phi_{i,t}^{l,H} - T_{i,t}$$

where $C_{i,t}^l$ is consumption, $b_{i,t}^l$ is (real) bond holding, $N^{l,H}$ is fixed labor supply for the housing construction sector, W_t^H is the wage rate of the housing construction sector, $L_{i,t}^l$ is new real mortgage lending, $M_{i,t}^l$ is receipts of real mortgage payments from outstanding debt, and $T_{i,t}$ is a lump-sum tax collected by a government. We assume that this household owns firms and gets the real profit distributions from both the non-construction ($\Phi_{i,t}^l$) and construction sectors ($\Phi_{i,t}^{l,H}$).

5.1.4. Firms

Construction firms. There is a representative construction firm in a competitive market which produce housing investment X_t^F to maximize its profit $\Phi_t^H = \frac{Q_t}{P_t}X_t^F - \frac{W_t^H}{P_t}N_t^{F,X}$, using a linear production function $X_t^F = N_t^{F,X}$. Then, the firm's optimality condition implies $Q_t = W_t^H$.

Non-construction firms. In the non-construction sector, there are final goods producers and intermediate goods producers. Final goods producers in the perfectly competitive market produce aggregate output Y_t by combining a continuum of differentiated intermediate goods, indexed by $i \in [0,1]$, using the CES aggregator given by $Y_t = \left(\int_0^1 \left(Y_t\left(i\right)\right)^{\frac{\varepsilon-1}{\varepsilon}} di\right)^{\frac{\varepsilon}{\varepsilon-1}}$ where $\varepsilon > 1$ is the elasticity of substitution across intermediate goods. The corresponding optimal price index P_t for the final good is defined as $P_t = \left(\int_0^1 \left(P_t\left(i\right)\right)^{1-\varepsilon} di\right)^{\frac{1}{1-\varepsilon}}$ where $P_t\left(i\right)$ is the price of intermediate good i and the optimal demand for good i is $Y_t\left(i\right) = \left(\frac{P_t(i)}{P_t}\right)^{-\varepsilon} Y_t$.

A measure of monopolistically competitive intermediate goods firms, indexed by i, produce output using the linear production function $Y_t\left(i\right) = N_t^F\left(i\right)$ and set prices according to a standard Calvo friction. Flow (real) profits are given by $\Phi_t\left(i\right) = \frac{P_t(i)}{P_t}Y_t\left(i\right) - \frac{W_t}{P_t}N_t^F\left(i\right)$, and the profit maximization problem of firms that get to adjust prices is given by

$$\max_{\left\{P_t^*\right\}} \sum_{s=0}^{\infty}\left(\alpha\beta\right)^s \frac{\Lambda_{t+s}}{\Lambda_t}\left[P_t^* - W_{t+s}\right]\left(\frac{P_t^*}{P_{t+s}}\right)^{-\varepsilon} Y_{t+s}.$$

where α is the Calvo price stickiness index, Λ_t is the marginal utility of nominal income for mortgage lenders, and P_t^* is the optimal price.

5.1.5. Monetary policy, resource constraint, and equilibrium

The monetary rule is of the feedback type with "smoothing", given by $R_t = R_{t-1}^{\rho} \Pi_t^{(1-\rho)\phi_\pi} \varepsilon_{R,t-k}$ where $\log \varepsilon_{R,t-k} \sim N(0, \sigma_R^2)$ is a forward guidance shock announced k-period ahead.

Given wages, nominal interest rate, and prices, labor, bond, and good markets are clear in equilibrium. Notice that given fixed labor supply, we have $\lambda^o N^o + \lambda^r N^r + \lambda^l N^l = \int_0^1 N_t^F(i)di$ and $\lambda^l N^l = N_t^{F,X}$. Moreover, given housing prices, housing service rental prices, and mortgage rates, housing, and mortgage markets are clear in equilibrium, i.e., $X_t^F = \int_0^{\lambda^o} X_{i,t}^o di$, $\int_0^{\lambda^o} S_{i,t} di = \int_0^{\lambda^o} S_{i,t}^o di + \int_0^{\lambda^r} S_{i,t}^r di$, and $\int_0^{\lambda^l} x_{i,t}^l di = \int_0^{\lambda^o} x_{i,t}^o di \equiv x_t$ for $x \in \{M, L, D\}$.

Let $C_t^k = \int_0^{\lambda^k} C_{i,t}^k di$ and $b_t^k = \int_0^{\lambda^k} b_{i,t}^k di$ for each $k \in \{o, r, l\}$. Define economy-wide consumption as $C_t = \lambda^l C_t^l + \lambda^o C_t^o + \lambda^r C_t^r$. Notice that, in equilibrium, $\int_0^{\lambda^l} \Phi_{i,t}^l di = \int_0^1 \Phi_t(i) di$. Then, we can derive an aggregate resource constraint given by $C_t + \frac{\psi_{bl}}{2} \left(b_t^l\right)^2 + \frac{\psi_{bo}}{2} \left(b_t^o\right)^2 + \frac{\psi_{br}}{2} \left(b_t^r\right)^2 + T_t = Y_t$ where $T_t = \int_0^{\lambda^l} T_{i,t} di$ is aggregate lump-sum tax. We assume that the government takes the real profit distributions from mortgage lenders in the form of the lump-sum tax ($T_t = \int_0^1 \Phi_t(i) di$) to isolate the effects of profit distributions on mortgage lenders' optimal intertemporal decisions. Also, by aggregating firms' production functions, we can derive aggregate outputs $Y_t^F = \int_0^1 Y_t(i)\, di = Y_t \Xi_t$ where the price dispersion, Ξ_t, is given by $\Xi_t = (1-\alpha)\left(p_t^*\right)^{-\varepsilon} + \alpha \left(\Pi_t\right)^{\varepsilon} \Xi_{t-1}$. Lastly, we derive the law of motions of inflation $\Pi_t^{1-\varepsilon} = (1-\alpha)\left(p_t^* \Pi_t\right)^{1-\varepsilon} + \alpha$.[18]

5.2. Computing the equilibrium with rationally inattentive homeowners and renters

Solving dynamic rational inattention problems involving numerous state variables poses significant computational challenges. To address this complexity and achieve equilibrium within our model framework, we introduce two simplifying assumptions that streamline the model structure. First, we assume households have log utilities: $u(C^l) = \log(C^l)$ and $u(C^i, S^i) = \log(C^i) + \psi \log(S^i)$ for $i \in \{o, r\}$ where ψ is the utility factor for housing rental services for homeowners and renters. Second, we assume full depreciation of housing accumulation ($\delta = 1$). Although atypical, this choice significantly streamlines our model by eliminating the need to track an endogenous state variable

[18] All model details and the solution algorithm can be found in Appendix D.

(H_{t-1}). Given our primary interest in examining heterogeneous attention among homeowners and renters, this simplification provides a practical benchmark that enhances computational traceability.

We contrast our baseline model featuring rationally inattentive homeowners and renters with a counterpart model assuming full-information rational expectations. In the full-information model, all economic agents, including homeowners and renters, possess complete knowledge. To solve this model, we log-linearize their first-order conditions and other equilibrium conditions at the non-stochastic steady state, yielding standard log-linear equilibrium conditions (see Appendix C). This solution is referred to as the full information equilibrium. The baseline model with rationally inattentive homeowners and renters maintains identical equilibrium conditions to the full information model, with the exception of differences in optimal attention and allocation choices made by homeowners and renters.

Let h denote the household type where $h = o$ for homeowners and $h = r$ for renters. At the beginning of period t, the rationally inattentive household i wakes up with its initial information set, $\mathcal{I}^h_{i,t-1}$. Then it chooses optimal signals, $y^h_{i,t}$, from a set of available signals subject to the cost of information, which is linear in Shannon's mutual information function, $\mathbb{I}(y^h_{i,t}; \{\xi^h_{i,\tau}\}_{\tau \leq t} | \mathcal{I}^h_{i,t-1})$ where $\{\xi^h_{i,\tau}\}_{\tau \leq t}$ is a set of all relevant state variables for household i whose type is $h \in \{o, r\}$ including all prices and interest rates up until time t. Denote ω as the marginal cost of information processing, a fraction of the steady-state consumption. Household i forms a new information set, $\mathcal{I}^h_{i,t} = \mathcal{I}^h_{i,t-1} \cup y^h_{i,t}$, and uses it for optimal decisions.

To solve the households' attention problem, we begin by approximating the expected sum of households' utility at the non-stochastic steady state using a log-quadratic approximation approach. This approximation allows us to derive an expression for the expected discounted sum of utility losses incurred when actions of household i deviate from those maximizing utility under full information in each period. Subsequently, we formulate the decision problems for both homeowners and renters as standard linear quadratic Gaussian (LQG) dynamic rational inattention problems (DRIPs). In this framework, the objective function is quadratic in households' actions and state vector, the state vector follows linear dynamics with Gaussian innovations, and the information cost is linear in Shannon's mutual information. Our formulation of the DRIP aligns with that of Afrouzi and Yang (2021). Detailed derivations of both homeowners' and renters' DRIPs are provided in Appendix D.1 and Appendix D.2. Additionally, Appendix D.3 outlines the procedure for obtaining

Table 7: Model calibration

	Value	Description	Targets / Sources
Panel A. Households			
β	$0.96^{1/4}$	Time preference	Quarterly frequency
ψ	0.75	Housing services utility	Steady-state ratio of housing to non-housing consumption (BEA)
λ^l	0.25	Share of lenders	Steady-state ratio of non-housing consumption to disposable income
λ^o	0.50	Share of homeowners	2/3 of homeownership ratio (U.S. Census Bureau)
λ^r	0.25	Share of renters	2/3 of homeownership ratio (U.S. Census Bureau)
θ	0.8	Loan-to-value ratio	The 50^{th} percentile original loan-to-value ratio (FR Y-14M)
γ	0.1	Mortgage amortization rate	Steady-state household debt-to-GDP ratio (US Financial Account)
ψ_b^l	0.01	Lender's portfolio adjustment cost	Assigned
ψ_b^o	0.01	Homeowner's portfolio adjustment cost	Assigned
ω	0.125 $\times 10^{-3}$	Marginal cost of attention	Heterogeneous responses in inflation expectations ($\hat{\beta}_1 - \hat{\beta}_2$ in Column (2) of Table 1)
Panel B. Firms			
ε	5.0	Elasticity of substitution across firms	Steady-state markup (25%)
α	0.75	Calvo price stickiness parameter	Garriga et al. (2021)
Panel C. Monetary Policy			
ρ	0.56	Interest rate smoothing	Carvalho et al. (2021)
ϕ_π	2.0	Interest rate response to inflation	Carvalho et al. (2021)
σ_R	0.0042	S.D. of forward guidance shock	Swanson (2021)

Notes: This table shows model parameter values used for our baseline simulation. See Section 5.3 for details.

numerical solutions for the equilibrium involving rationally inattentive homeowners and renters.[19]

5.3. Calibration and parameterization

Table 7 presents our calibration. The model is calibrated at a quarterly frequency with a time discount factor of $\beta = 0.96^{1/4}$. We set the utility factor of housing rental services (ψ) to 0.75 to match the steady-state housing to non-housing personal consumption expenditure ratio of 4.71. The population share of mortgage lenders (λ^l) is assumed to be 0.25 to match the steady-state ratio of non-housing consumption expenditure to disposable income, which is 0.6. We then set the population share of homeowners (λ^o) to 0.5 and renters (λ^r) to 0.25, corresponding to a recent homeownership ratio of 2/3.[20]

[19] Recent theoretical works emphasizing the role of mortgages in monetary shock transmission often highlight refinancing motives (e.g., Eichenbaum et al. (2022) and Garriga et al. (2017)). We acknowledge that our model does not incorporate a refinancing motive for computational simplicity. Unlike previous studies employing full information rational expectations models, our approach is based on a model of rational inattention within a linear-quadratic-Gaussian framework, which currently does not accommodate nonlinear constraints required for studying refinancing motives. We view the incorporation of the refinancing channel in a model with rationally inattentive homeowners as a potential avenue for future research to enrich the transmission mechanisms of monetary policy.

[20] This calibration aligns with the finding that approximately 40% of U.S. households have mortgages, as indicated by the 2019 Survey of Consumer Finances.

The loan-to-value ratio (θ) is set to 0.8, consistent with the median original loan-to-value ratio reported in FR Y-14M. The mortgage amortization rate (γ) is chosen to be 0.1 to match the steady-state household debt-to-GDP ratio of 0.53. We assume small bond adjustment cost parameters for both mortgage lenders (ψ_{b^l}) and homeowners (ψ_{b^o}) of 0.01, which falls within a reasonable range used in the literature.[21] We set the elasticity of substitution across intermediate producers to be five ($\varepsilon = 5$), corresponding to a recent estimate of an average markup of 25 percent. The Calvo parameter is chosen as $\alpha = 0.75$, consistent with Garriga et al. (2021).

We recover the marginal cost of attention parameter ω through our main empirical regression. Specifically, for a given ω, we simulate our model with 400 homeowners and 200 renters for 1,000 periods, and run the empirical regression specified in Equation (2) using the simulated data. We determine the value of ω that aligns with the heterogeneous responses in inflation expectations observed among homeowners and renters following a forward guidance shock (as indicated by $\hat{\beta}_1 - \hat{\beta}_2$ in Column (2) of Table 1). Our calibrated marginal cost of attention parameter implies $\omega = 0.125 \times 10^{-3}$ units of the steady-state level of consumption. To assess the validity of the recovered attention costs, we perform a regression of average forecast errors on average forecast revisions in inflation using the simulated data, following the framework suggested by Coibion and Gorodnichenko (2015a). Our estimated coefficient, $\hat{\beta} = 2.3$, exceeds their estimate of 1.2 using Survey of Professional Forecasters data, suggesting a greater level of inattentiveness among households compared to professional forecasters

Lastly, for model parameters related to monetary policy, we rely on recent estimates. Specifically, we set the persistence of the nominal interest rate (ρ) to 0.56 and the parameter of the interest rate feedback to inflation (ϕ_π) to 2.0, in line with estimates from Carvalho et al. (2021). The standard deviation of forward guidance shocks (σ_R) is determined by computing the standard deviation of quarterly averages of the shock series as reported in Swanson (2021).

5.4. IRFs to a forward guidance shock

We examine the effects of a forward guidance shock that reduces the four-quarter ahead nominal interest rate by one standard deviation. As shown in Figure 2, this announcement triggers increases

[21] For example, Schmitt-Grohé and Uribe (2003) uses a value of 0.00074 for the portfolio adjustment cost parameter, whereas Cantore and Freund (2021) uses 0.07.

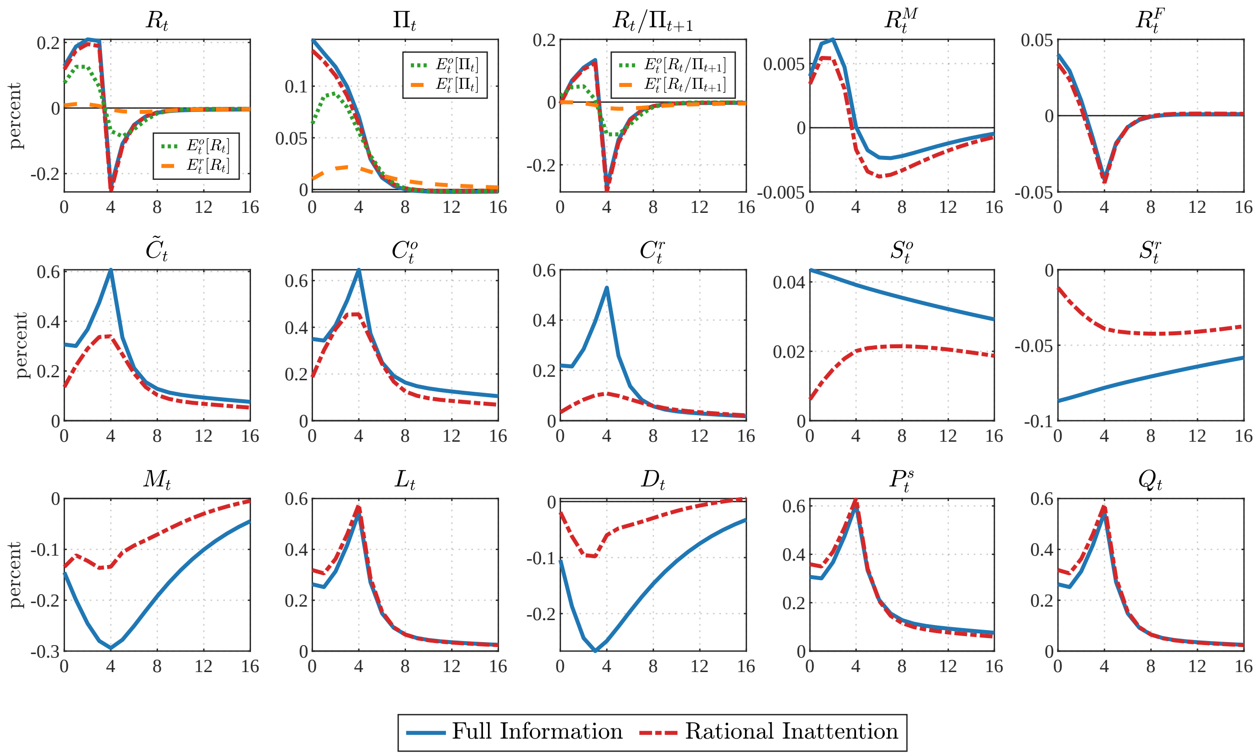


Figure 2: Model impulse responses to a 1 S.D. 4-quarter ahead forward guidance shock

Notes: This figure reports the model impulse responses to a forward guidance shock that lowers the 4-quarter ahead interest rate by one standard deviation. The solid blue lines plot the case of full information rational expectations. The dot-dashed red lines plot the case under rational inattention. The dotted green lines and dashed yellow lines in the top left three panels plot the interest rate or inflation expectations of homeowners and renters respectively. $\tilde{C}_t = \lambda^o C_t^o + \lambda^r C_t^r$ is aggregate consumption for both homeowners and renters. The impulse responses of all other model variables are shown in Appendix Figure D.5.

in inflation and consumption under both full information and rational inattention settings. However, with rationally inattentive homeowners and renters, the responses in expectations regarding nominal and real interest rates (top left and middle panels) as well as inflation (top second panel) are more subdued compared to the responses under the full information model.

Notably, under rational inattention, homeowners have a stronger incentive to pay attention to a forward guidance shock, as news of future interest rate changes impacts mortgage rates and inflation, subsequently influencing their real income through changes in real mortgage payments as shown in the log-linearized real mortgage payment equation: $m_t^o = \frac{1}{1-\beta(1-\gamma)} r_{t-1}^M + d_{t-1} - \pi_t$. Consequently, homeowners' inflation expectations exhibit greater sensitivity to a forward guidance shock compared to renters, whose expectations show more sluggish adjustments.

As households gradually absorb news on the changes in interest rates, their consumption responses are correspondingly smaller compared to the full information benchmark (middle left three panels). Additionally, the effects on housing market activities—including housing service (S_t^o and S_t^r), mortgage borrowing (m_t), and housing debt (d_t)—are relatively muted.. Overall, forward guidance is less effective under the rational inattention model compared to the full information benchmark. Notably, homeowners exhibit greater responsiveness to forward guidance shocks than renters, primarily due to the mortgage holding channel.

Our model provides theoretical support for the empirical findings of Coibion et al. (2023). Through large-scale randomized controlled trials (RCTs), they observe that information about future interest rates has similar and offsetting effects on interest rate and inflation expectations, resulting in limited pass-through into perceived real rates. This aligns closely with the mechanism outlined in our model under rational inattention. Furthermore, our model predicts that mortgage rates exert a stronger influence on homeowners' perceptions of interest rates, leading to more pronounced changes in perceived real rates, thus corroborating their empirical findings.

Our model implications resonate with the findings of McKay et al. (2016) and Bilbiie (2020), who demonstrate that the potent effects of forward guidance can be attenuated under incomplete market settings. In their models, agents face the risk of hitting borrowing constraints, leading to stronger precautionary motives and a discounted Euler equation that dampens the real effects of forward guidance policies. In our framework, agents exhibit reduced responsiveness to forward guidance due to limited attention. Specifically, renters have less incentive to pay attention to interest rates, resulting in minimal effects of future interest rate changes on their consumption.

5.5. Welfare implications: heterogeneous inflation expectations and monetary policy responses

We define our measure of implicit welfare cost for a household of type $i \in \{o, r\}$, μ^i, as

$$\sum_{t=0}^{\infty} \beta^t \left(u((1+\mu^i)C_t^{i,RI}, S_t^{i,RI}) - \omega \mathbb{I}(y_t^i; \{\xi_\tau^i\}_{\tau \le t} | \mathcal{I}_{t-1}^i) \right) = \sum_{t=0}^{\infty} \beta^t u(\bar{C}^i, \bar{S}^i)$$

where $\{C_t^{i,FI}, S_t^{i,FI}\}$ are type-i household's optimal consumption and housing services choices under the full information rational expectations model, and $\{C_t^{i,RI}, S_t^{i,RI}\}$ are the time path of type-i household's consumption and housing services under the rational inattention frictions. Notice that $\omega \mathbb{I}(y_t^i; \{\xi_\tau^i\}_{\tau \le t} | \mathcal{I}_{t-1}^i)$ is the period-t cost of attention for household type-i. Here μ^i captures the welfare costs, measured as the fraction of equivalent consumption loss, for households i given the

Table 8: Welfare Costs: Baseline Analysis

Households	(A) Total welfare costs (μ^i)	(B) Welfare costs under full-information	(C) Welfare gains from under-reaction	(D) Costs of attention
Homeowner	0.2415	0.0065	0.0020	0.2370
Renter	0.0389	0.0005	0.0004	0.0388

Notes: This table shows the implicit welfare costs in responses to forward guidance shocks under rational inattention. Note that (A) = (B) - (C) + (D). See Equation (5) for the decomposition.

series of monetary policy forward guidance shocks. With the log separable preferences, we can rewrite the welfare cost as

$$\log\left(1+\mu^i\right) = \underbrace{(1-\beta)\left(\frac{1}{1-\beta}u(\bar{C}^i,\bar{S}^i) - \sum_{t=0}^{\infty}\beta^t u(C_t^{i,FI},S_t^{i,FI})\right)}_{\text{Welfare costs under the full-information model}} \tag{5}$$

$$\underbrace{-\,(1-\beta)\left(\sum_{t=0}^{\infty}\beta^t u(C_t^{i,RI},S_t^{i,RI}) - \sum_{t=0}^{\infty}\beta^t u(C_t^{i,FI},S_t^{i,FI})\right)}_{\text{Welfare gains from under-reaction}} + \underbrace{\sum_{t=0}^{\infty}\beta^t \omega \mathbb{I}(y_t^i;\{\xi_\tau^i\}_{\tau\le t}|\mathcal{I}_{t-1}^i)}_{\text{Cost of attention}}.$$

We simulate the model for 1000 periods with forward guidance shocks and compute the welfare costs using Equation (5). To interpret the results, we further decompose the welfare costs into three pieces. The first piece represents the costs under the full information model, which arise due to the business cycle fluctuations. The second piece measures gains from under-reaction of households' consumption and housing services choices to forward guidance shocks due to rational inattention. As shown in the second row of Figure 2, consumption and housing service fluctuate less under rational inattention compared to full information. The last piece is information acquisition costs.

Table 8 shows the results. Under the presence of the mortgage channel, homeowners' consumption responses are always more sensitive to interest rate changes. Therefore, welfare costs of business cycles driven by forward guidance shocks are larger for homeowners than renters even under the full information model (see Column B). Overall, the welfare costs are larger for homeowners mostly due to the cost of information acquisition (see Column D). As homeowners have strong incentives to pay close attention to interest rates and mortgage rates, their informational costs are larger than renters. The heterogeneous efforts in information acquisition over business cycles are outcomes of households' optimal choices. This is also consistent with our empirical findings that homeowners spend significantly more amount of time on financial management and purchasing financial services.

6. Model mechanisms and sensitivity analyses

In this section, we perform sensitivity analyses to provide additional insights into the consequences of changing the homeownership ratio and mortgage market access.[22]

6.1. Lowering homeownership ratio

Motivated by the recent discussions on the declining homeownership ratio in the U.S., we first employ our model to consider its implications on the effectiveness of monetary policy (*e.g.*, Paz-Pardo, 2024). We conduct two experiments by lowering homeownership ratios from 0.67 to 0.55 and 0.6 respectively, and show the IRFs in Appendix Figure E.6. As the share of homeowners in the economy decreases, the effectiveness of the forward guidance policy decreases mainly for two reasons. First, the expectation channel is weakened due to the larger share of renters who pay less attention to the monetary policy. Second, the direct transmission through the mortgage channel is weakened given the smaller share of homeowners participating in the mortgage market. Overall, the expansionary effects of forward guidance shocks become less powerful with a declining homeownership ratio. Appendix Table E.9 shows the welfare costs with different homeownership ratios. The benefits of acquiring more information are lower as the economy becomes less sensitive to the forward guidance with the smaller share of homeowners. Both homeowners and renters decide to pay lower costs to acquire information than the baseline economy, leading to smaller total welfare costs of forward guidance shocks.

6.2. Mortgage accessibility

We study the interaction between macro-prudential policy and monetary policy by considering changes in loan-to-value (LTV) ratio θ. Appendix Figure E.7 shows the IRFs under different LTV ratios. When the LTV constraints are tightened, homeowners cannot borrow as much as they could.

[22] In Appendix E, we provide further sensitivity analyses on the effects of the expected-augmented Taylor rule and different horizons of forward guidance.

As a result, the forward guidance policy became less effective in boosting the economy through the mortgage channel. Appendix Table E.10 presents the welfare analysis. As forward guidance policy becomes less effective in stimulating the economy, both homeowners and renters are less motivated to pay information acquisition costs. As a result, the total welfare costs are also smaller in the model with lower LTVs than in the baseline model. Since lowering LTV makes housing less affordable in general, the overall effects on the economy are very similar to the case of lowering homeownership ratios.

6.3. Adjustable-rate mortgage (ARM) vs fixed-rate mortgage (FRM)

In the U.S., about 92 percent of mortgage loans are FRMs, but in other countries, like the U.K. and Canada, ARMs are more popular. In this experiment, we compare the effectiveness of forward guidance in economies with ARM ($R_t^M = R_t$) vs. FRM. As shown in Appendix Figure E.8, housing-related loans are much more responsive to forward guidance shocks under ARM, while the responses of consumption and housing services are much muted. As homeowners have a much stronger incentive to keep track of mortgage rates under ARM, the welfare costs of forward guidance on homeowners are much higher compared to FRM, primarily driven by increasing information acquisition costs (Appendix Table E.11). The welfare costs for renters, in contracts, are smaller under ARM due to more muted responses in consumption and housing services.

7. Conclusion

This paper focuses on homeownership and mortgage holdings as the crucial factors of households' expectation formation and the propagation of monetary policy. Based on the microdata from MSC, along with the battery of independent external evidence, we show that households learn about macroeconomic conditions and monetary policy from mortgage rate changes and news related to homeownership, and adjust their macroeconomic expectations accordingly. This evidence sheds light on housing-driven endogenous attention as the key mechanism behind our novel empirical findings. To characterize the key mechanism and further analyze the heterogeneous effects of monetary policy on homeowners and renters, we build a general equilibrium model with rationally inattentive households, which is entirely new in the literature. We show that in response to an expansionary forward guidance shock, homeowners with mortgages raise their consumption more than renters do, because homeowners are better informed of the path of monetary policy through their attention to mortgage rates and reoptimize their consumption accordingly. We further demonstrate that this novel structural model is versatile enough for us to analyze the consequences of declining homeownership on the effectiveness of monetary policy as well as the interaction between macroprudential policy and monetary policy.

References

Afrouzi, H., Yang, C., 2021. Dynamic rational inattention and the Phillips curve. CESifo Working Paper No. 8840. CESifo.

Ahn, H.J., Pfajfar, D., Winkler, F., 2024. Frequency of households' information acquisition and macroeconomic perceptions. mimeo .

Bilbiie, F.O., 2020. The new keynesian cross. Journal of Monetary Economics 114, 90–108.

Breckenfelder, J., De Fiore, F., Andrade, P., Karadi, P., Tristani, O., 2016. The ECB's asset purchase programme: an early assessment. Working Paper Series 1956. European Central Bank.

Cantore, C., Freund, L.B., 2021. Workers, capitalists, and the government: fiscal policy and income (re)distribution. Journal of Monetary Economics 119, 58–74.

Carroll, C.D., 2003. Macroeconomic expectations of households and professional forecasters. The Quarterly Journal of Economics 118, 269–298.

Carvalho, C., Nechio, F., Tristão, T., 2021. Taylor rule estimation by ols. Journal of Monetary Economics 124, 140–154.

Ciccarelli, M., García, J.A., Montes-Galdón, C., 2017. Unconventional monetary policy and the anchoring of inflation expectations. Working Paper Series 1995. European Central Bank.

Claus, E., Nguyen, V.H., 2020. Monetary policy shocks from the consumer perspective. Journal of Monetary Economics 114, 159–173.

Cloyne, J., Ferreira, C., Surico, P., 2019. Monetary policy when households have debt: New evidence on the transmission mechanism. The Review of Economic Studies 87, 102–129.

Coibion, O., Georgarakos, D., Gorodnichenko, Y., Weber, M., 2023. Forward guidance and household expectations. Journal of the European Economic Association 21, 2131–2171.

Coibion, O., Gorodnichenko, Y., 2015a. Information rigidity and the expectations formation process: A simple framework and new facts. American Economic Review 105, 2644–78.

Coibion, O., Gorodnichenko, Y., 2015b. Is the phillips curve alive and well after all? inflation expectations and the missing disinflation. American Economic Journal: Macroeconomics 7, 197–232.

Coibion, O., Gorodnichenko, Y., Kamdar, R., 2018. The formation of expectations, inflation, and the phillips curve. Journal of Economic Literature 56, 1447–91.

Coibion, O., Gorodnichenko, Y., Weber, M., 2022. Monetary policy communications and their effects on household inflation expectations. Journal of Political Economy 130, 1537–1584.

D'Acunto, F., Hoang, D., Weber, M., 2022. Managing households' expectations with unconventional policies. The Review of Financial Studies 35, 1597–1642.

D'Acunto, F., Malmendier, U., Weber, M., 2023. What do the data tell us about inflation expectations?, in: Bachmann, R., Topa, G., van der Klaauw, W. (Eds.), Handbook of Economic Expectations. Academic Press, pp. 133–161.

Del Negro, M., Giannoni, M.P., Patterson, C., 2023. The forward guidance puzzle. Journal of Political Economy Macroeconomics 1, 43–79.

Diegel, M., Nautz, D., 2021. Long-term inflation expectations and the transmission of monetary policy shocks: Evidence from a svar analysis. Journal of Economic Dynamics and Control 130, 104192.

Eichenbaum, M., Rebelo, S., Wong, A., 2022. State-dependent effects of monetary policy: The refinancing channel. American Economic Review 112, 721–61.

Garriga, C., Kydland, F.E., Šustek, R., 2017. Mortgages and Monetary Policy. The Review of Financial Studies 30, 3337–3375.

Garriga, C., Kydland, F.E., Šustek, R., 2021. MoNK: Mortgages in a new-keynesian model. Journal of Economic Dynamics and Control 123, 104059.

Hajdini, I., Knotek, E.S., Leer, J., Pedemonte, M., Rich, R., Schoenle, R., 2024. Indirect consumer inflation expectations: Theory and evidence. Journal of Monetary Economics , 103568.

Hamilton, J.D., 2008. Daily monetary policy shocks and new home sales. Journal of Monetary Economics 55, 1171–1190.

Hoffmann, M., Moench, E., Pavlova, L., Schultefrankenfeld, G., 2021. The effects of the ECB's new inflation target on private households' inflation expectations. Research Brief. Bundesbank.

Kamdar, R., 2019. The inattentive consumer: Sentiment and expectations. working paper .

Kryvtsov, O., Petersen, L., 2021. Central bank communication that works: Lessons from lab experiments. Journal of Monetary Economics 117, 760–780.

Lamla, M.J., Vinogradov, D.V., 2019. Central bank announcements: Big news for little people? Journal of Monetary Economics 108, 21–38.

Maćkowiak, B., Wiederholt, M., 2023. Rational inattention and the business cycle effects of productivity and news shocks. Working Paper Series 2827. European Central Bank.

Malmendier, U., Nagel, S., 2015. Learning from inflation experiences. The Quarterly Journal of Economics 131, 53–87.

McKay, A., Nakamura, E., Steinsson, J., 2016. The power of forward guidance revisited. American Economic Review 106, 3133–58.

Nord, L., 2022. Who cares about inflation? endogenous expectation formation of heterogeneous households. mimeo .

Paz-Pardo, G., 2024. Homeownership and portfolio choice over the generations. American Economic Journal: Macroeconomics 16, 207–37.

Pedemonte, M., Toma, H., Verdugo, E., 2023. Aggregate implications of heterogeneous inflation expectations: the role of individual experience. Working Paper 23-04. Federal Reserve Bank of Cleveland.

Pfajfar, D., Winkler, F., 2024. Monetary Policy Attitudes and Expectations of U.S. Households. mimeo .

Schmitt-Grohé, S., Uribe, M., 2003. Closing small open economy models. Journal of International Economics 61, 163–185.

Swanson, E.T., 2021. Measuring the effects of federal reserve forward guidance and asset purchases on financial markets. Journal of Monetary Economics 118, 32–53.

Weber, M., D'Acunto, F., Gorodnichenko, Y., Coibion, O., 2022. The subjective inflation expectations of households and firms: Measurement, determinants, and implications. Journal of Economic Perspectives 36, 157–84.

Woodford, M., 2001. Fiscal requirements for price stability. Journal of Money, Credit and Banking 33, 669–728.

Appendix For Online Publication

Appendix A. Supplementary Empirical Results

Appendix A.1. Robustness Checks: Different Interest Rate Change Horizons

Appendix Table A.1: Robunestness Check: sensitivity of revisions in homeowners and renters' inflation expectations to changes in mortgage rates

	1-year ahead inflation expectations		5-year ahead inflation expectations	
Interactions	(1) ΔR_t	(2) $\Delta \tilde{R}_{t,FG}$	(3) ΔR_t	(4) $\Delta \tilde{R}_{t,FG}$
Panel A. Mortgage rate changes over past 3 months				
Homeowner (β_1)	-0.8128***	-0.5158***	0.0006	-0.0000
	(0.1488)	(0.1326)	(0.1027)	(0.0910)
Renter (β_2)	-0.2955	0.0900	-0.3416	-0.2089
	(0.2781)	(0.2537)	(0.2141)	(0.1842)
Number of obs.	21,338	20,722	20,731	20,455
Adj. R^2	0.0373	0.0355	0.0185	0.0188
***F*-test** ($\beta_1 = \beta_2$)	2.73*	4.47**	2.14	1.06
Panel B. Mortgage rate changes over past 9 months				
Homeowner (β_1)	-0.6991***	-0.5628***	-0.2143***	-0.0014
	(0.0909)	(0.0812)	(0.0637)	(0.0564)
Renter (β_2)	-0.3138*	-0.1253	-0.1613	0.0147
	(0.1672)	(0.1477)	(0.1318)	(0.1141)
Number of obs.	21,338	20,722	20,455	20,455
Adj. R^2	0.0402	0.0402	0.0195	0.0193
***F*-test** ($\beta_1 = \beta_2$)	4.34**	6.94***	0.14	0.02

Notes: This table reports the regression results from Equation (2). Dependent variables are the six-month change in the MSC's 12-month ahead inflation expectations (Columns (1) and (2)) and the six-month change in the MSC's 5-year ahead inflation expectations (Columns (3) and (4)). "Homeowner" and "Renter" indicate dummies for homeowner and renter respectively. ΔR_t refers to changes in interest rate over the past 3 months (Panel A) or 9 months (Panel B). Columns (1) and (3) report responses to changes in 30-year mortgage rate; Columns (2) and (4) report responses to the changes in 30-year mortgage rate predicted by forward guidance shocks. We control for the respondent's demographic fixed effects including gender, education, birth cohort, homeownership, marriage status, region, income quartiles, and respondent's revisions in gas price expectations, as well as macroeconomic conditions including changes in the unemployment rate and federal funds rate during the past three or nine months. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

Appendix Table A.2: Robustness check: asymmetric effects of mortgage-rate changes

Interactions	1-year ahead inflation expectations (1) ΔR_t	(2) $\Delta\tilde{R}_{t,FG}$	5-year ahead inflation expectations (3) ΔR_t	(4) $\Delta\tilde{R}_{t,FG}$
Panel A. Mortgage rate changes over past 3 months				
Homeowner$\times I_t^+$ (β_1)	-0.0355	0.1165	0.3755**	0.1827
	(0.2512)	(0.2340)	(0.1833)	(0.1648)
Renter$\times I_t^+$ (β_2)	-0.2424	0.9153**	-0.0385	-0.0183
	(0.4446)	(0.4351)	(0.3703)	(0.3581)
Homeowner$\times I_t^-$ (β_3)	-1.7390***	-0.8726***	-0.4401**	-0.1017
	(0.3251)	(0.1725)	(0.2147)	(0.1130)
Renter$\times I_t^-$ (β_4)	-0.4452	-0.3388	-0.7665	-0.3081
	(0.6799)	(0.3239)	(0.4706)	(0.2233)
Number of obs.	21,338	20,772	20,731	20,455
Adj. R^2	0.0365	0.0363	0.0187	0.0188
***F*-test** $(\beta_1 = \beta_3)$	11.89***	10.62***	5.73**	1.93
Panel B. Mortgage rate changes over past 9 months				
Homeowner$\times I_t^+$ (β_1)	-0.1354	-0.7726***	-0.0042	-0.0317
	(0.1643)	(0.1208)	(0.1223)	(0.0871)
Renter$\times I_t^+$ (β_2)	0.3100	-0.0904	-0.0484	0.0753
	(0.3156)	(0.2012)	(0.2539)	(0.1620)
Homeowner$\times I_t^-$ (β_3)	-1.2258***	-0.3642***	-0.4094***	0.0226
	(0.1871)	(0.1206)	(0.1238)	(0.0847)
Renter$\times I_t^-$ (β_4)	-1.0032	-0.1051	-0.2946	-0.0289
	(0.3825)	(0.2166)	(0.2952)	(0.1645)
Number of obs.	21,338	20,772	20,731	20,455
Adj. R^2	0.0409	0.0404	0.0195	0.0192
***F*-test** $(\beta_1 = \beta_3)$	12.93***	5.23**	3.70*	0.18

Notes: This table reports the regression results from Equation (4). Dependent variables are the six-month change in the MSC's 12-month ahead inflation expectations (Columns (1) and (2)) and the six-month change in the MSC's 5-year ahead inflation expectations (Columns (3) and (4)). ΔR_t refers to changes in interest rate over the past 3 months (Panel A) or 9 months (Panel B). "Homeowner" and "Renter" indicate dummies for homeowner and renter respectively. I_t^+ and I_t^- indicate dummies for periods of increase and decrease in 30-year mortgage rates respectively. Columns (1) and (3) report responses to changes in 30-year mortgage rate; Columns (2) and (4) report responses to the changes in 30-year mortgage rate predicted by forward guidance shocks. We control for the respondent's demographic fixed effects including gender, education, birth cohort, homeownership, marriage status, region, income quartiles, and respondent's revisions in gas price expectations, as well as macroeconomic conditions including changes in the unemployment rate and federal funds rate during the past three or six months. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

Appendix A.2. Additional analysis: effects of mortgage-rate changes on labor market outlooks and future business conditions

In this appendix, we conduct an additional analysis of the effects of mortgage rate changes on labor market outlooks. In the MSC, for example, the question on expectations of joblessness in the next 12 months is postulated as follows:

> *How about people out of work during the coming 12 months—do you think that there will be more unemployment than now, about the same, or less?*
>
> 1. More unemployment
> 3. About the same
> 5. Less unemployment

We construct a categorical variable that reflects the direction of expectation revisions. This variable has three outcomes—*improved, unchanged*, and *worsened*. If the numeric value of the response in the original question increases, we regard the expectation to have "*improved*." If the numeric value decreases, we interpret the expectation to have "*worsened*." If the numeric value stays the same, we assign "*unchanged*."

With the constructed categorical variable capturing households' revision of unemployment expectations, we run a multivariate *logit* regression to examine how a change in the interest rate six months ago affects the revision. The model is specified as follows:

$$\log\left(\frac{p_{ik,t}}{p_{ij,t}}\right) = \alpha_0 + \beta_1\, homeowner_i \times \Delta R_t + \beta_2\, renter_i \times \Delta R_t + \gamma Z_t + \delta X_{i,t} + \epsilon_{i,t}, \quad \text{(A.1)}$$

where $p_{ik,t}$ is the probability that household i's response is $k \in \{$"*improved*","*worsened*"$\}$ from period t to $t+6$, and $p_{ij,t}$ is the probability that household i's response is $j =$ "*unchanged*" from period t to $t+6$. The regressors $homeowner_i$ and $renter_i$ are dummies for homeowner and renter, respectively; ΔR_t is a change in the mortgage rate or changes in mortgage rate predicted by forward guidance shocks during the past six months. We include the same set of household-level controls and aggregate variables as Equation (2). We treat the response "*unchanged*" as the base category and estimate the probability of household i to respond "*improved*" or "*worsened*" relative to that of household i to respond "*unchanged*." The coefficient estimates are reported in Table A.3.

To make the results more interpretable, we compute the marginal probabilities of households to change their unemployment expectations and display the probabilities in Figure A.1. As depicted by the downward-sloping lines in the top-left panel, households become less likely to expect that the labor market conditions will improve, when 30-year mortgage rates rise. Consistent with this observation, households become more likely to anticipate that the labor market conditions

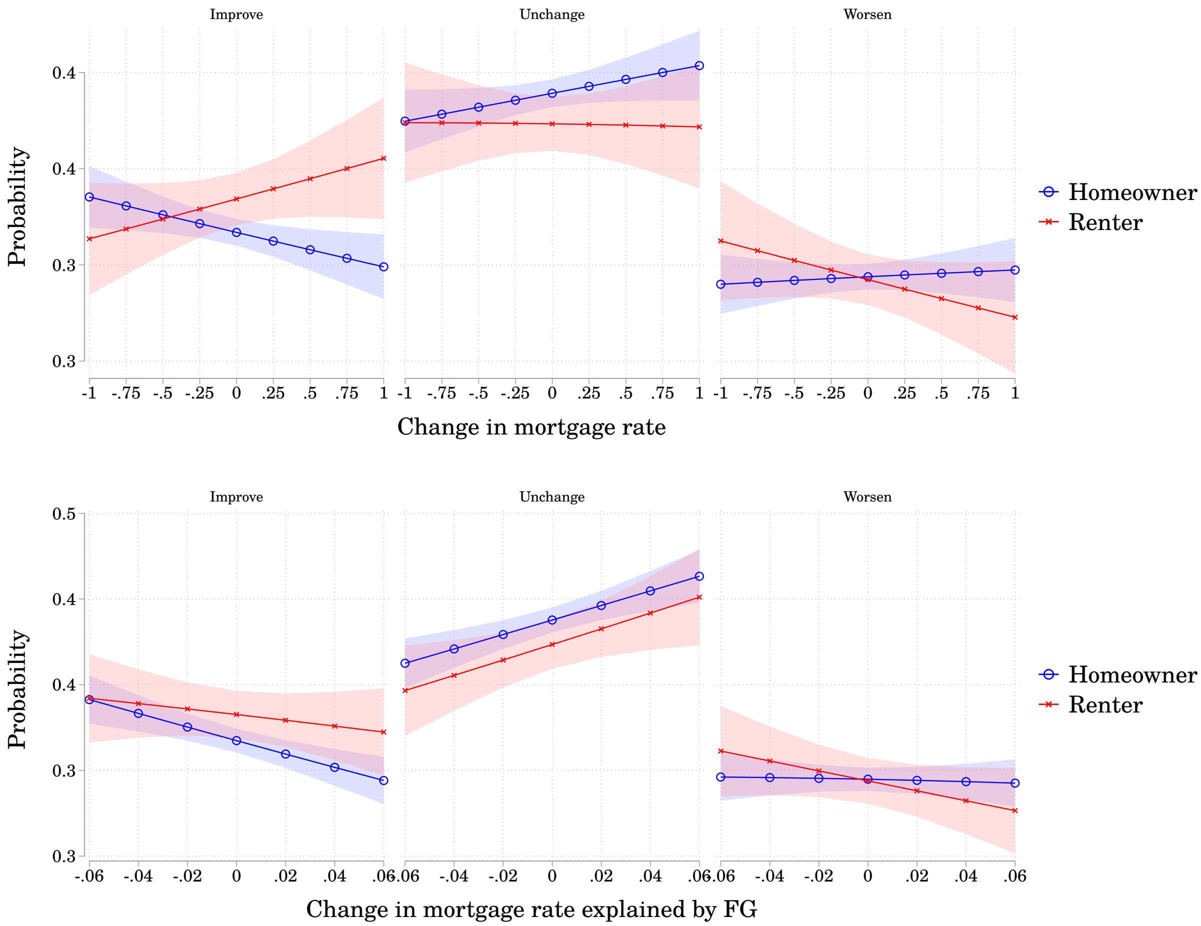
Appendix Table A.3: Sensitivity of revisions in homeowners and renters' unemployment expectations to changes in interest rates

Interactions	(1) ΔR_t	(2) $\Delta \tilde{R}_{t,FG}$
Panel A. Unemployment: Improve		
Renter (α_1)	1.100**	1.089**
	(0.046)	(0.046)
Homeowner×ΔR_t (β_1)	0.908**	0.094***
	(0.036)	(0.051)
Renter×ΔR_t (β_2)	1.068	0.179*
	(0.076)	(0.170)
Panel B. Unemployment: Worsen		
Renter (α_1)	1.037	1.034
	(0.044)	(0.045)
Homeowner×ΔR_t (β_1)	0.977	0.307**
	(0.039)	(0.171)
Renter×ΔR_t (β_2)	0.936	0.110**
	(0.071)	(0.113)
Number of obs.	24,483	23,890
Pseudo R^2	0.0108	0.0111

Notes: This table reports the multinomial logit regression results from Equation (3). Dependent variables are the log of the probability that unemployment rate will be improved (Panel A) or worsened (Panel B) in the next six months relative to the probability that unemployment rate will be unchanged in the next six months. "Homeowner" and "Renter" indicate dummies for homeowner and renter respectively. The coefficients are reported in relative-risk ratios. ΔR_t and $\Delta \tilde{R}_{t,FG}$ refer to the six-month change in 30-year mortgage rate and forward guidance shocks respectively. We control for the respondent's demographic fixed effects including gender, education, birth cohort, homeownership, marriage status, region, income quartiles, and respondent's revisions in gas price expectations, as well as macroeconomic conditions including changes in the unemployment rate and federal funds rate during the past six months. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

will deteriorate with a rise in the 30-year mortgage rate, as indicated by the upward-sloping lines (top right panel). However, we find statistically significant differences in the optimistic revisions between homeowners and renters (top left panel) but not in the pessimistic revisions (top right panel). Homeowners lower their optimism more in response to an increase in the mortgage rate than renters do. We find similar results with changes in the mortgage rate predicted by forward guidance shocks as reported in the lower panel.

To examine the contractionary effect of interest-rate changes on overall economic conditions, we also consider expectations on future business conditions as dependent variables. As shown in Table A.4 and Figure A.2, our main conclusion remains robust.



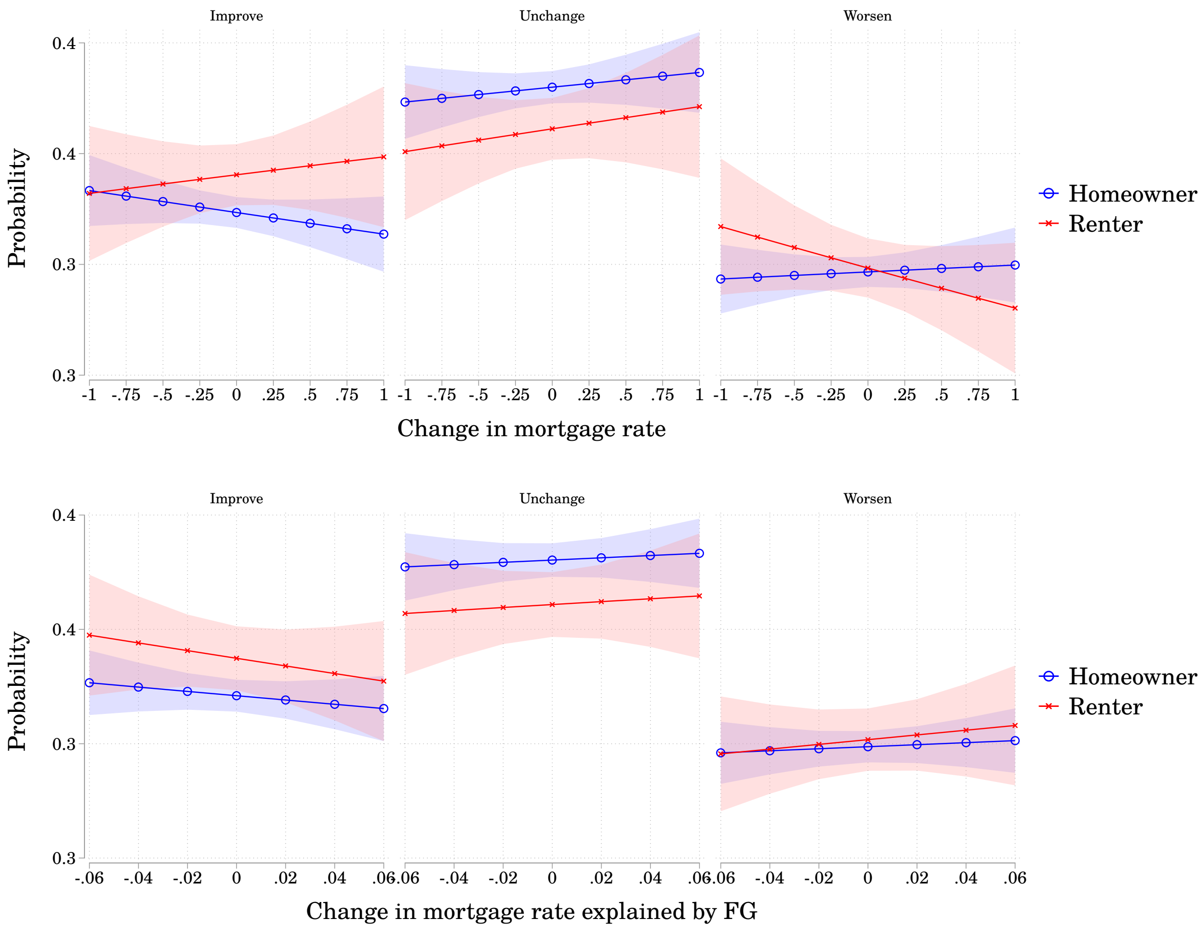
Appendix Figure A.1: Marginal probability of changes in household expectations of unemployment

Notes: This figure reports the marginal probabilities of changes in household expectations of unemployment to changes in mortgage rates. The explanatory variable considered is the changes in the 30-year mortgage rate (top panel) and forward guidance shocks (bottom panel). The results are calculated based on the estimates of the logit regression results from Equation (A.1) as reported in Online Appendix Table A.3. We control for the respondent's gender, education, birth cohort, homeownership, marriage status, region, income quartiles, and respondent's revisions in gas price expectations, as well as unemployment rate and federal funds rate changes during the past six months. Shaded areas represent 95% confidence intervals.

Appendix Table A.4: Sensitivity of revisions in homeowners and renters' expectations on future business conditions to changes in interest rates

Interactions	(1) ΔR_t	(2) $\Delta \tilde{R}_{t,FG}$
Panel A. Future Business Conditions: Improve		
Renter (α_1)	1.108**	1.108**
	(0.046)	(0.047)
Homeowner$\times\Delta R_t$ (β_1)	0.953	0.652
	(0.038)	(0.358)
Renter$\times\Delta R_t$ (β_2)	1.000	0.505
	(0.072)	(0.494)
Panel B. Future Business Conditions: Worsen		
Renter (α_1)	1.058	1.064
	(0.046)	(0.047)
Homeowner$\times\Delta R_t$ (β_1)	0.99	1.023
	(0.873)	(0.569)
Renter$\times\Delta R_t$ (β_2)	0.913	1.190
	(0.069)	(1.202)
Number of obs.	24,024	23,434
Pseudo R^2	0.0105	0.0104

Notes: This table reports the multinomial logit regression results from Equation (3). Dependent variables are the log of the probability that future business conditions will be improved (Panel A) or worsened (Panel B) in the next six months relative to the probability that future business conditions will be unchanged in the next six months. "Homeowner" and "Renter" indicate dummies for homeowner and renter respectively. The coefficients are reported in relative-risk ratios. ΔR_t and $\Delta \tilde{R}_{t,FG}$ refer to the six-month change in 30-year mortgage rate and forward guidance shocks respectively. We control for the respondent's demographic fixed effects including gender, education, birth cohort, homeownership, marriage status, region, income quartiles, and respondent's revisions in gas price expectations, as well as macroeconomic conditions including changes in the unemployment rate and federal funds rate during the past six months. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.



Appendix Figure A.2: Marginal probability of changes in household expectations of future business conditions

Notes: This figure reports the marginal probabilities of changes in household expectations of future business conditions to changes in mortgage rates over the past six months. The explanatory variable considered is the changes in the 30-year mortgage rate (top panel) and forward guidance shocks (bottom panel). The results are calculated based on the estimates of the logit regression results from Equation (A.1). We control for the respondent's gender, education, birth cohort, homeownership, marriage status, region, income quartiles, and respondent's revisions in gas price expectations, as well as unemployment rate and federal funds rate changes during the past six months. Shaded areas represent 95% confidence intervals.

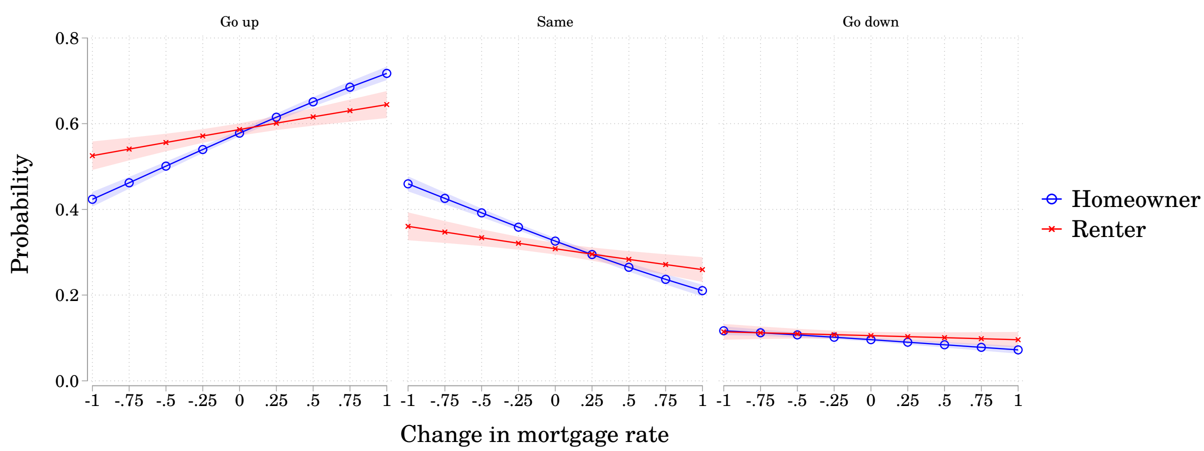
Source: Authors' calculation.

Appendix A.3. Additional analysis: effects of mortgage-rate changes on interest rate expectations

We conduct additional analysis of the effects on interest rate expectations by employing the same specification (A.1), but change the dependent variable to expectations of future interest rates. The question on interest rate expectations is postulated as follows:

> *No one can say for sure, but what do you think will happen to interest rates for borrowing money during the next 12 months—will they go up, stay the same, or go down?*
>
> 1. Go up
> 3. Stay the same
> 5. Go down

We treat the response *"stay the same"* as the base category and estimate the probability of household i responding *"go up"* or *"go down"* relative to that of household i responding *"the same"*. Therefore, in the dependent variable, $p_{ik,t}$ is the probability that household i's response is $k =$*go up/go down*, and $p_{ij,t}$ is the probability that household i's response is $j =$*stay the same*.



Appendix Figure A.3: Marginal probability of household expectations of interest rates

Notes: This figure reports the marginal probabilities of household expectations of 1-year ahead interest rates to past changes in interest rates. The explanatory variable considered is the changes in the 30-year mortgage rate. The results are calculated based on the estimates of the logit regression results from Equation (A.1) as reported in Column (1) of Table A.5. We control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Shaded areas represent 95% confidence intervals. The confidence bands are so narrow that they do not clearly show through to the figures.

Figure A.3 displays the marginal probability estimates. The coefficient estimates are reported in Table A.5. When there is an increase in the interest rate, households become more optimistic about

Appendix Table A.5: Sensitivity of revisions in homeowners and renters' expectations on future interest rates to changes in interest rates

Interactions	(1) ΔR_t	(2) $\Delta \tilde{R}_{t,FG}$
Panel A. Interest rate increase		
Renter (α_1)	1.073^{*}	1.087^{**}
	(0.042)	(0.043)
Homeowner$\times\Delta R_t$ (β_1)	1.945^{***}	107.451^{***}
	(0.073)	(54.050)
Renter$\times\Delta R_t$ (β_2)	1.312^{***}	67.566^{***}
	(0.092)	(63.626)
Panel B. Interest rate decrease		
Renter (α_1)	1.164^{**}	1.141^{**}
	(0.076)	(0.043)
Homeowner$\times\Delta R_t$ (β_1)	1.139^{**}	$7.6181.087^{**}$
	(0.067)	(6.074)
Renter$\times\Delta R_t$ (β_2)	1.071	4.214
	(0.503)	(5.697)
Number of obs.	24,505	23,907
Pseudo R^2	0.0444	0.0392

Notes: This table reports the multinomial logit regression results from Equation (3). Dependent variables are the log of the probability that interest rate will increase (Panel A) or decrease (Panel B) in the next six months relative to the probability that interest rate will stay the same in the next six months. "Homeowner" and "Renter" indicate dummies for homeowner and renter respectively. The coefficients are reported in relative-risk ratios. ΔR_t and $\Delta \tilde{R}_{t,FG}$ refer to the six-month change in 30-year mortgage rate and changes in forward guidance shocks respectively. We control for the respondent's demographic fixed effects including gender, education, birth cohort, homeownership, marriage status, region, income quartiles, and respondent's revisions in gas price expectations, as well as macroeconomic conditions including changes in the unemployment rate and federal funds rate during the past six months. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

future interest rate rises but become less likely to believe that the interest rate would either stay the same or go down. The upside revisions to the belief in an interest rate increase are larger than the downside revisions to the belief in either an unchanged or decreased interest rate. In addition, the responsiveness of homeowners is larger than that of renters with statistical significance. Similar to the case of other expectations, the upward revisions of homeowners are the largest when there is a rise in the mortgage rate. Again, the difference in the upward revision between homeowners and renters is also the greatest.

Appendix B. Additional Survey Evidence

Appendix B.1. SCE Housing Survey

The SCE Housing Survey identifies homeowners' mortgage status with the following question:

> *Do you have any outstanding loans against the value of your home, including all mortgages, home equity loans, and home equity lines of credit?*

(1) Yes, mortgage(s) only

(2) Yes, home equity loans/lines of credit only

(3) Yes, both mortgage(s) and home equity loans/lines of credit

(4) No.

We consider individuals whose responses are (1) - (3) as homeowners with mortgages and those with response (4) as outright homeowners. According to the housing module, about 67 percent of homeowners carry mortgages and 33 percent are outright homeowners.

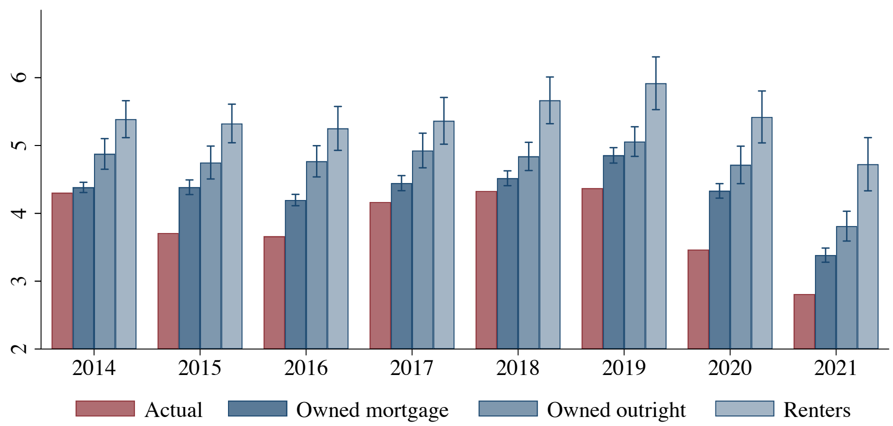
Moreover, for homeowners, the housing module also asks whether they recently refinanced their mortgages and their probability of refinancing their current mortgages in the next 12 months. In addition, the module contains information on households' knowledge about current and future mortgage rates. Concerning knowledge of current mortgage rates and expectations about future mortgage rates, the survey asks the following questions:

- *"What do you think is the average interest rate (for all borrowers) on a new 30-year fixed-rate mortgage as of today?"*
- *"What do you think is the average interest rate (for all borrowers) on a new 30-year fixed-rate mortgage one year from today?"*

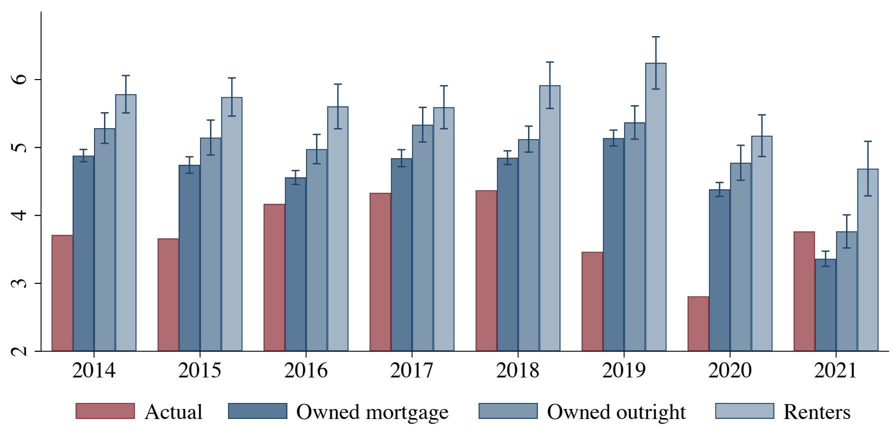
Figure B.4 reports the mortgage rate perceptions and forecasts by homeownership and mortgage holding status. Panel A displays the perception of current 30-year mortgage rates along with the actual 30-year mortgage rates. Homeowners, particularly those with mortgages, have a more accurate perception of current mortgage rates, compared to the realized 30-year mortgage rates. Panel B displays one-year-ahead forecasts of 30-year mortgage rates along with the realized 30-year mortgage rates. Again, homeowners with mortgages have the most accurate mortgage rate expectations followed by outright homeowners. One exception is 2021, when outright homeowners' forecasts essentially match the realized mortgage rates, whereas those with mortgages produced lower forecasts. In particular, renters produce the most inaccurate perceptions of mortgage rates for the current year and forecasts of future mortgage rates.

Appendix Figure B.4: Accuracy of Perceived and Predicted Current Mortgage Rates by Homeownership Status (SCE housing module)

Panel A. Perception of Current Mortgage Rates



Panel B. Forecast of mortgage rates 1 year ahead



Notes: Panel A documents responses to the survey question, "What do you think is the average interest rate (for all borrowers) on a new 30-year fixed-rate mortgage as of today?" Panel B documents responses to the survey question "What do you think is the average interest rate (for all borrowers) on a new 30-year fixed rate mortgage one year from today?

Source: Survey of Consumer Expectations, Housing Module.

Appendix B.2. SCE Special Module on households' attention to macroeconomic news

The sample of the SCE special module is composed of 2,155 individuals who are nationally representative and have participated in the main SCE survey. The special module asks the survey respondents about their frequency of information acquisition about various economic and financial news and variables. The topic includes six different interest rates including mortgage interest rates and federal funds rate, and six economic news including stock market prices, news on inflation, and that on the Federal Reserve. For each topic, the survey asks the respondent whether the person checks the information (1) daily, (2) weekly, (3) monthly, (4) quarterly, (5) yearly, (6) not at all or (7) has no knowledge about it. The last two categories are used to measure the extensive margin of information acquisition. The extensive margin captures whether an individual checks the news on a particular topic: It takes value 0 if the response is either "not at all" or "has no knowledge about it, or takes value 1, otherwise. The survey contains the basic socioeconomic attributes of survey participants including homeownership status. In addition, the respondents in the sample are matchable with the main SCE survey and a subset of the sample is also matchable with the SCE housing survey.

Appendix B.3. Attention to news on interest rates

This section provides direct evidence that homeowners pay more attention to news on interest rates based on newly constructed indicators. We construct several variables to measure households' attention toward news on interest rates using the MSC. First, we consider how interest rates directly affect households' home-buying and home-selling attitudes.[23] The variable $HomeBuy_{it}$ ($HomeSell_{it}$) takes value 1 if the household's home-buying (home-selling) attitude is affected by interest rate-related reasons and 0 otherwise. These measures suggest that interest rate is a primary reason affecting households' home-buying and home-selling attitudes. On average, over 45 percent of households reported interest rates being a factor affecting their home-buying attitudes and the fraction is about 15 percent for home-selling.

Our next measure is based on whether a household recalls any news on interest rates related to changes in business conditions. The variable $Business_{it}$ takes value 1 if the household recalls at least one change related to interest rates and 0 otherwise. Therefore, $Business_{it}$ is an indicator variable for whether an individual household pays attention to news on interest rates related to business conditions. Based on our sample, about 4.5 percent of the households recalled news on interest rates related to business conditions.

Our last measure is based on whether a household identifies interest rates as a factor driving personal finances. The variable $Finance_{it}$ takes value 1 if the household selects at least one reason related to interest rates and 0 otherwise. Therefore, $Finance_{it}$ is an indicator variable for whether an individual household pays attention to interest rates related to personal finances. Based on our sample, about 0.11 percent of the households mentioned interest rates being a factor affecting their personal financial conditions.

We consider the following linear regression model:

$$Y_{it} = \alpha + \beta_1 \text{homeowner}_{it} + \delta X_{it} + \zeta_t + \epsilon_{it} \tag{B.1}$$

[23] Notice that these questions are designed to assess general home-buying or home-selling attitudes, not the respondents' attitude towards buying or selling houses for their own use.

Appendix Table B.6: Homeownership and attention to news on interest rates

Dependent variables	(1) HomeBuy	(2) HomeSell	(3) Business	(4) Finance
Homeowner	0.0850***	0.0416***	0.0074***	0.0006***
	(0.0031)	(0.0022)	(0.0013)	(0.0.0002)
Demographic FE	Y	Y	Y	Y
Year-month FE	Y	Y	Y	Y
Number of obs.	153,347	145,268	156,098	156,098
Adj. R^2	0.1567	0.0997	0.0368	0.0037

Notes: This table reports the estimates of β_1's from Equation (B.1). The dependent variables are dummies indicating whether news on interest rates affects the respondent's home-buying attitudes (Column 1), home-selling attitude (Column 2), perception of business conditions (Column 3), and personal finances (Column 4). "Homeowner" indicates a dummy for the respondent being a homeowner. We control for the respondent's gender, education, birth cohort, homeownership, marriage status, region, income quartiles, and time-fixed effects. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

where $Y_{it} = \{HomeBuy_{it};\ HomeSell_{it};\ Business_{it};\ Finance_{it}\}$. The control variables X_{it} are respondent's demographic fixed effects including gender, education, birth cohort, marriage status, region, and income quartiles, which is the same set of fixed effects in our baseline specification. We include time-fixed effects ζ_t to control for aggregate business cycles. A statistically positive coefficient for the *homeowner* dummy suggests that homeowners pay more attention to interest rates compared to renters.

Table B.6 reports the coefficient estimates. Columns (1) and (2) show that homeowners have a significantly higher probability of reporting interest rates as one of the reasons affecting their home-buying and home-selling attitudes respectively. Column (3) reveals that homeowners are more likely to recall news on interest rates related to changes in business conditions. Column (4) suggests that the same result holds for personal finances. In summary, this evidence shows that homeowners pay more attention to information on interest rates and are more likely to use this information in their assessments of macroeconomic conditions.

Appendix B.4. Evidence from American Time Use Survey

This section provides corroborating evidence that homeowners are more attentive to macroeconomic developments than renters based on analysis with ATUS. The ATUS collects data on the time that an individual spends on various activities during the day. The sample of ATUS is from the eighth outgoing rotation group of the Current Population Survey. Therefore, each individual in the ATUS is surveyed once. The ATUS has information on an individual's time spent on finance-related activities, which is a natural measure of households' attentiveness to financial markets and macroeconomic developments. In addition, the ATUS has respondents' socio-economic characteristics including homeownership and other demographic attributes. Therefore, the data allow us to analyze the association between homeownership and attentiveness to economic conditions. The ATUS is a monthly survey beginning in 2003. Hence, the sample period of our analysis with ATUS is from 2003:M1 to 2020:M12.

We consider two types of activities, "financial management" and "purchasing financial and banking services", to measure their attention to macroeconomic developments. Activities in financial management include trading and checking stocks, researching investments, paying mortgages, checking cryptocurrency or bitcoin balance, and so on. Activities in purchasing financial and banking services include applying for a loan or mortgage, talking to/with a loan officer, meeting with a stockbroker, insurance agent, bank manager, etc[24]

We consider the following linear regression model:

$$Y_i = \alpha + \beta_1 \text{homeowner}_i + \delta X_i + \epsilon_i \tag{B.2}$$

where $Y_i = \{\text{Time}_i;\ E_i;\ N_i\}$. Time_i is individual i's time spent on financial management, E_i denotes the indicator of respondent i's participating in the activity, and N_i is minutes spent for financial management conditional on reporting nonzero minutes for the activity. Notice that E_i is the extensive margin of financial management which takes value 1, if an individual reports a nonzero minute for financial management, but is zero, otherwise. The notation N_i is the intensive margin and takes always a positive value. Individual characteristics, denoted by X_i, include gender (female), age (16-24, 55 and over), race (white), education (high-school graduation or less, some college and associate degree), labor force status (unemployment and out of the labor force).[25]

Table B.7 reports the coefficient estimates. Being a homeowner raises the probability of engaging in financial management and also time spent on financial management among those who engage in the activity with statistical significance (Panel A). Similar results are obtained if we replace the dependent variable with time spent for purchasing financial and banking services (Panel B). This result suggests that homeowners are more likely to engage in activities that expose them to current macroeconomic conditions and interest rates and also to spend more time on these activities. All told, this direct evidence from ATUS confirms that homeowners tend to pay more attention to overall macroeconomic conditions than renters, corroborating why homeowners' expectations of the macroeconomy are more sensitive to interest-rate changes than others.

[24]The ATUS may understate time spent on financial management and purchasing financial and banking services because the ATUS surveys the respondent's primary activity only. If an individual checks stock prices while working or watching TV, this activity may be classified as "*working*" or "*TV watching*."

[25]We consider a linear probability model for the extensive margin as the baseline. We further consider a *logit* and *probit* model for the extensive margin, but the overall conclusion is the same as that from the linear probability model. Our results are robust once we control for occupation, region, and/or time-fixed effects.

Appendix Table B.7: Homeownership and time spent on finance-related activities

Dependent variable	(1) Extensive (E_i)	(2) Intensive (N_i)	(3) Time (Time_i)
Panel A. Financial management			
Homeowner	0.0076***	4.6085***	0.5331***
	(0.0010)	(1.7788)	(0.0810)
Number of obs.	219,368	8,583	219,368
R^2	0.0084	0.0366	0.0064
Panel B. Purchasing financial and banking services			
Homeowner	0.0029***	0.6366***	0.0636***
	(0.0010)	(0.7869)	(0.0228)
Number of obs.	219,368	5,618	219,368
R^2	0.0020	0.0366	0.0008

Notes: This table reports the estimates of β_1's from Equation (B.2). Panel A shows the results when we use time spent on financial management as the dependent variable. Panel B shows the results when we use time spent on purchasing financial banking services as the dependent variable. In Column (1), we use the indicator of respondents participating in the activity (extensive margin). In Column (2), we use minutes spent for the activity conditional on reporting nonzero minutes for the activity (intensive margin). Lastly, in Column (3), we use the total time spent on the activity. "Homeowner" indicates a dummy for the respondent being a homeowner. We control for the respondents' gender, age, race, education, and labor force status. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

Appendix B.5. Evidence from the Indirect Consumer Inflation Expectations

Hajdini et al. (2024) propose a new indirect way to measure consumers' expectations for inflation over the next 12 months based on indirect utility theory and a novel survey. The survey asks a representative sample of about 20,000 adults in the US about how their incomes would have to change to make them equally well off relative to their current situation such that they could buy the same amount of goods and services as they can today. For the question, the individuals in the sample receive consumers' expectations about the developments in the prices of goods and services during the next 12 months. This survey is conducted weekly and is implemented through Morning Consult's proprietary survey infrastructure.

The data have limited disaggregate information. Unfortunately, information on home ownership and mortgage-holding status is not available. However, the data have inflation expectations by four age groups–18-34; 35-44; 45-64; and over 65. Given the data limitation, we use the grouped age information to infer the effect of homeownership on the degree of attention to macroeconomic conditions and monetary policy. Individuals aged 18-34 are likely to be renters, those aged 35-44 and 45-64 are likely to be current buyers or homeowners with mortgages, and those aged 65+ are likely to be homeowners without mortgages.

We use errors in current inflation perceptions and inflation forecasts to proxy the degree of attention to macroeconomic news. We examine whether individuals who are likely to be homeowners

Appendix Table B.8: Root mean squared deviations from CPI inflation of current month and one-year ahead by age (percentage point)

	18-34	35-44	45-64	65+
[1] Current month (t)	2.28	1.48	1.57	2.11
[2] One-year ahead (t+12)	2.75	1.69	0.98	0.97

Note: The perception error is the difference between reported inflation forecasts and year-over-year percent change in headline CPI of the current month. The sample period for the perception accuracy spans from 13-Feb-21 to 30-Dec-23. The CPI data are available through December 2023, so our analyses end in 30-Dec-23. The prediction error is the difference between reported inflation forecasts and year-over-year percent changes in headline CPI 12 months from the current month. The sample period for the perception accuracy spans from 13-Feb-21 to 29-Dec-22.
Source: CEBRA website (https://cebra.org/indirect-consumer-inflation-expectations)

and those who are likely to hold mortgages have better inflation perceptions and forecasts than others.

We compare the weekly inflation expectations in the next 12 months against the year-over-year CPI inflation of the current month (t) and 12 months ahead (t+12). The current-month price changes are also considered, although the CPI inflation one year ahead should be the right point of comparison. This is because Hajdini et al. (2024) note that the ICIE largely reflects current inflation expectations. The sample period of this analysis is from 13-Feb-21 to 30-Dec-23.

Table B.8 reports the root-mean-squared deviations from the CPI inflation of the current month and one year ahead by age. The first row reports the deviations from the current CPI inflation. The average difference is smallest among individuals aged 35-44, followed by individuals aged 45-64. The average deviation from the current-month inflation is quite large among individuals aged 65 and over. The second row reports the deviations from the CPI inflation 1 year ahead. The average difference is the smallest in the group aged 45 and over. Individuals aged 45-64 have weekly inflation expectations, of which the differences from the current and one-year-ahead CPI inflation are consistently small, relative to other age groups. Considering that this age group is likely to be homeowners and to hold mortgages, we tentatively interpret that homeowners, particularly those with mortgages, are likely to pay more attention to inflation than others.

However, one caveat of this analysis is that we do not separate the cohort effects capturing individuals' inflation experiences, which is important in the formation of inflation expectations (Malmendier and Nagel, 2015). Since the data have limited information on households' attributes, controlling for the individual inflation experiences is not feasible. Including more comprehensive individual attributes in the analyses on high-frequency inflation expectations can be pursued in future research.

Appendix C. A full-information rational expectations model

In this appendix, we present the equilibrium conditions of the model with full information rational expectations.

Appendix C.1. A system of nonlinear equilibrium conditions

- Homeowner

$$\psi C_t^o = P_t^s S_t^o \tag{C.1}$$

$$1 + \psi_{b^o} b_t^o = \beta R_t E_t \left[\frac{C_t^o}{C_{t+1}^o} \frac{1}{\Pi_{t+1}} \right] \tag{C.2}$$

$$\begin{aligned} \frac{P_t^s}{Q_t} - (1-\theta) &= \beta E_t \left[\frac{C_t^o}{C_{t+1}^o} \frac{1}{\Pi_{t+1}} \left(\left(\frac{P_{t+1}^s}{Q_{t+1}} - 1 \right) (1-\gamma) + \theta R_t^M \right) \right] \\ &- \theta C_t^o \left\{ (1-\phi_t^o) \frac{\mu_t}{D_t^o} \left(R_t^F - R_{t-1}^M \right) - \beta (1-\gamma) E_t \left[\frac{\mu_{t+1}}{D_{t+1}^o} \frac{1}{\Pi_{t+1}} \left(R_{t+1}^F - R_t^M \right) \right] \right\} \end{aligned} \tag{C.3}$$

$$\mu_t = \begin{cases} 0 & \text{if ARM} \\ \beta E_t \left[\left(1 - \phi_{t+1}^o\right) \mu_{t+1} - \frac{D_t^o}{\Pi_{t+1}} \frac{1}{C_{t+1}^o} \right] & \text{if FRM} \end{cases} \tag{C.4}$$

$$D_t^o = (1-\gamma) \frac{D_{t-1}^o}{\Pi_t} + L_t^o \tag{C.5}$$

$$M_t^o = \left(R_{t-1}^M - 1 + \gamma \right) \frac{D_{t-1}^o}{\Pi_t} \tag{C.6}$$

$$L_t^o = \theta Q_t H_t \tag{C.7}$$

$$\phi_t^o = \frac{L_t^o}{M_t^o} \tag{C.8}$$

$$C_t^o + P_t^s S_t^o + Q_t H_t + b_t^o + \frac{\psi_{b^o}}{2} (b_t^o)^2 = W_t N^o + \frac{R_{t-1}}{\Pi_t} b_{t-1}^o + P_t^s S_t + L_t^o - M_t^o \tag{C.9}$$

- Renter

$$1 = \beta R_t E_t \left[\frac{C_t^r}{C_{t+1}^r} \frac{1}{\Pi_{t+1}} \right] \tag{C.10}$$

$$\psi C_t^r = P_t^s S_t^r \tag{C.11}$$

- Mortgage lender

$$1+\psi_{b^l} b_t^l = \beta R_t E_t \left[\frac{C_t^l}{C_{t+1}^l} \frac{1}{\Pi_{t+1}} \right] \tag{C.12}$$

$$C_t^l + b_t^l + \frac{\psi_{b^l}}{2} \left(b_t^l\right)^2 + L_t^l = W_t N^l + W_t^H N^{l,H} + \frac{R_{t-1}}{\Pi_t} b_{t-1}^l + M_t^l + \Phi_t^l - T_t \tag{C.13}$$

$$\Lambda_{t,t+1} = \frac{C_t^l}{C_{t+1}^l} \frac{1}{\Pi_{t+1}} \tag{C.14}$$

$$\begin{aligned} &\frac{1}{C_t^l} - \beta R_t^M E_t \left[\frac{1}{C_{t+1}^l} \frac{1}{\Pi_{t+1}} \right] = \frac{\mu_t^l}{D_t^l} \left(R_t^F - R_{t-1}^M \right) \left(1 - \phi_t^l\right) \\ &- \beta \left(1-\gamma\right) E_t \left[\frac{\mu_{t+1}^l}{D_{t+1}^l} \frac{1}{\Pi_{t+1}} \left(R_{t+1}^F - R_t^M \right) \right] \end{aligned} \tag{C.15}$$

$$\mu_t^l = \begin{cases} 0 & \text{if ARM} \\ \beta E_t \left[\frac{D_t^l}{C_{t+1}^l} \frac{1}{\Pi_{t+1}} + \mu_{t+1}^l \left(1 - \phi_{t+1}^l\right) \right] & \text{if FRM} \end{cases} \tag{C.16}$$

$$\phi_t^l = \frac{L_t^l}{M_t^l} \tag{C.17}$$

- Construction firm

$$Q_t = W_t^H \tag{C.18}$$

- Non-construction firm

$$p_t^* = \frac{\varepsilon}{\varepsilon - 1} \frac{Z_{1,t}}{Z_{2,t}} \tag{C.19}$$

$$Z_{1,t} = W_t Y_t + \alpha \beta E_t \left[\Lambda_{t,t+1} Z_{1,t+1} \left(\Pi_{t+1}\right)^{\varepsilon+1} \right] \tag{C.20}$$

$$Z_{2,t} = Y_t + \alpha \beta E_t \left[\Lambda_{t,t+1} Z_{2,t+1} \left(\Pi_{t+1}\right)^{\varepsilon} \right]. \tag{C.21}$$

- Equilibrium and market clearing:

$$\lambda^o H_t = \lambda^l \bar{N}^{l,H} \tag{C.22}$$

$$\lambda^o S_t = \lambda^o S_t^o + \lambda^r S_t^r \tag{C.23}$$

$$S_t = H_t \tag{C.24}$$

$$0 = \lambda^l b_t^l + \lambda^o b_t^o + \lambda^r b_t^r \tag{C.25}$$

$$C_t = \lambda^l C_t^l + \lambda^o C_t^o + \lambda^r C_t^r \tag{C.26}$$

$$Y_t = C_t + \frac{\psi_b}{2}\left(\lambda^l \left(b_t^l\right)^2 + \lambda^o \left(b_t^o\right)^2 + \lambda^r \left(b_t^r\right)^2\right) + \lambda^l T_t \tag{C.27}$$

$$\bar{N} = Y_t \Xi_t \tag{C.28}$$

$$\Xi_t = (1-\alpha)\left(p_t^*\right)^{-\varepsilon} + \alpha \left(\Pi_t\right)^{\varepsilon} \Xi_{t-1} \tag{C.29}$$

$$\Pi_t^{1-\varepsilon} = (1-\alpha)\left(p_t^* \Pi_t\right)^{1-\varepsilon} + \alpha \tag{C.30}$$

$$\lambda^l L_t^l = \lambda^o L_t^o \tag{C.31}$$

$$\lambda^l M_t^l = \lambda^o M_t^o \tag{C.32}$$

$$\lambda^l D_t^l = \lambda^o D_t^o \tag{C.33}$$

$$\lambda^l \Phi_t^l = \int \left(\frac{P_t(i)}{P_t} Y_t(i) - w_t N_t^F(i)\right) di = Y_t - w_t \bar{N} \tag{C.34}$$

$$T_t = \Phi_t^l \tag{C.35}$$

and

$$\bar{N} = \lambda^l N^l + \lambda^o N^o + \lambda^r N^r$$

- Monetary policy and mortgage rates

$$\frac{R_t}{\bar{R}} = \left(\frac{R_t}{\bar{R}}\right)^{\rho} \left(\frac{\Pi_t}{\bar{\Pi}}\right)^{(1-\rho)\phi_\pi} \exp\left(\varepsilon_{t-k}\right) \tag{C.36}$$

$$R_t^M = \begin{cases} R_t & \text{if ARM} \\ \left(1-\phi_t^o\right) R_{t-1}^M + \phi_t^o R_t^F & \text{if FRM} \end{cases} \tag{C.37}$$

- 37 Variables and 37 equations
  - Real allocations: (13 variables)

$$\left\{C_t^l, C_t^o, C_t^r, C_t, S_t^o, S_t^r, S_t, H_t, Y_t, \Phi_t^l, T_t, \lambda_{2t}, \lambda_{2t}^l\right\}$$

  - Bonds: (3 variables)

$$\left\{b_t^l, b_t^o, b_t^r\right\}$$

  - Prices and interest rates: (13 variables)

$$\left\{P_t^s, Q_t R_t, R_t^M, R_t^F, W_t, W_t^H, \Pi_t, p_t^*, Z_{1,t}, Z_{2,t}, \Xi_t, \Lambda_{t,t+1}\right\}$$

– Mortgages: (8 variables)

$$\left\{M_t^l, L_t^l, D_t^l, \phi_t^l, M_t^o, L_t^o, D_t^o, \phi_t^o\right\}$$

Appendix C.2. Non-stochastic steady-states

In this subsection, we define a non-stochastic steady-state equilibrium of the baseline model. We first fix $\bar{N} = 0.3$, $\bar{N}^l = 0.8\bar{N}$, and $\bar{N}^{l,H} = 0.2\bar{N}$ which implies about 5% or workers work for construction sector. We consider the model with zero net inflation steady-state ($\Pi \bar{=} 1$). Then, Equations (C.19), (C.20), (C.21), (C.19), and (C.19) imply that $\bar{p}^* = 1$, $\bar{\Xi} = 1$, $\bar{W} = \frac{\varepsilon-1}{\varepsilon}$, $\bar{Z}_1 = \frac{1}{1-\alpha\beta}\bar{W}\bar{Y}$, and $\bar{Z}_2 = \frac{1}{1-\alpha\beta}\bar{W}$ where $\bar{Y} = \bar{N}$ from Equation (C.28). Also, from Equations (C.27), (C.34) and (C.35), we have $\bar{T} = \bar{\Phi}^l = \frac{1}{\lambda^l}\left(1 - \bar{W}\right)\bar{N}$ and $\bar{C} = \bar{Y} - \lambda^l \bar{T}$.

We assume the steady-state consumption for homeowners and renters are the same ($\bar{C}^o = \bar{C}^r = \bar{C}^{or}$) and the steady-state bond holdings are zero ($\bar{b}^o = \bar{b}^r = \bar{b}^l = 0$). We calibrate the population share of mortgage lenders λ^l to match the ratio of personal consumption expenditure (PCE) excluding housing services to disposable income ratio ($\frac{\bar{C}^{or}}{\bar{W}\bar{N}}$) of 0.59 observed in the data. First, observe that Equation C.22 implies the steady-state housing stock $\bar{H} = \frac{\lambda^l}{\lambda^o}\bar{N}^{l,H}$. Note that we set $\lambda^o = \frac{2}{3}\left(1 - \lambda^l\right)$ to match the 2/3 of homeownership ratio observed in data. Also, from Equation (C.24), we have $\bar{S} = \bar{H}$. Then, we take the ratio of PCE excluding housing services to PCE housing services ($\frac{\bar{C}^{or}}{\bar{S}} = 4.7$) from the data and set $\bar{C}^{or} = \frac{\bar{C}^{or}}{\bar{S}}\bar{S} = \frac{\bar{C}^{or}}{\bar{S}}\frac{\lambda^l}{\lambda^o}\bar{N}^{l,H}$. Now, we find λ^l which satisfies $\frac{\bar{C}^{or}}{\bar{W}\bar{N}} = 0.59$. We get $\bar{C}^l = \frac{1}{\lambda^l}\bar{C} - \left(\frac{1-\lambda^l}{\lambda^l}\right)\bar{C}^{or}$ from Equation (C.26).

The steady-state nominal interest rates and mortgage rates are derived from Equations (C.2), (C.15), (C.37), $\bar{R} = \bar{R}^M = \bar{R}^F = \frac{1}{\beta}$.

Then, from Equation (C.3), we have the steady-state rent-to-price ratio of 1 ($\bar{P}^s = \bar{Q}$).

Now, we calibrate ψ to match $\frac{\bar{C}^{or}}{\bar{S}} = 4.7$ as following. First, from mortgage lenders' budget constraint (C.13) and Equations (C.31) and (C.32), we get

$$\begin{aligned}
\bar{C}^l &= \bar{W}N^l + \bar{W}^H N^{l,H} + M^l - \bar{L}^l \\
&= \bar{W}N^l + \bar{W}^H N^{l,H} + \frac{\lambda^o}{\lambda^l}\bar{M}^o - \frac{\lambda^o}{\lambda^l}\bar{L}^o \\
&= \bar{W}N^l + \frac{\lambda^o}{\lambda^l}\left(1 + \frac{\theta}{\gamma}\left(\frac{1}{\beta} - 1\right)\right)\bar{Q}\bar{H}
\end{aligned}$$

where we use Equations (C.5), (C.6), (C.7), (C.18), and (C.22) to derive the last equality. From this, we can get $\bar{Q}$. Second, from Equations (C.1), (C.11), and (C.23), we can get

$$\psi = \frac{\lambda^o}{1 - \lambda^l}\frac{\bar{Q}}{\frac{\bar{C}^o}{\bar{S}}}.$$

Then, we get $\bar{S}^o = \bar{S}^r = \psi \frac{\bar{C}^o}{\bar{P}^s}$, $\bar{L}^o = \theta \bar{Q} \bar{H}$, $\bar{D}^o = \frac{1}{\gamma} \bar{L}^o$ and $\bar{M}^o = \left(\frac{1}{\beta} - 1 + \gamma \right) \bar{D}^o$. Then, using the homeowners' budget constraint (C.9), we get

$$
\begin{aligned}
N^o &= \frac{1}{\bar{W}} \left(\bar{C}^o + \bar{P}^S \bar{S}^o - \bar{L}^o + \bar{M}^o \right), \\
N^r &= \frac{1}{\lambda^r} \bar{N} - \frac{1}{\lambda^r} \left(\lambda^l N^l + \lambda^o N^o \right).
\end{aligned}
$$

Lastly, Equations (C.8) and (C.17) imply that $\bar{\phi}^o = \bar{\phi}^l = \frac{\gamma}{\frac{1}{\beta} - 1 + \gamma}$, and Equations (C.4) and (C.16) imply that

$$
\bar{\mu}^o = \begin{cases} 0 & \text{if ARM} \\ -\frac{\beta}{1-\beta(1-\gamma)} \frac{\bar{D}^o}{\bar{C}^o} & \text{if FRM} \end{cases}
$$

$$
\bar{\mu}^l = \begin{cases} 0 & \text{if ARM} \\ \frac{\beta}{1-\beta(1-\gamma)} \frac{\bar{D}^l}{\bar{C}^l} & \text{if FRM} \end{cases}
$$

Appendix C.3. A system of log-linearized model equilibrium conditions

In this subsection, we derive the equilibrium conditions for the log-linearized model. We denote small letters as the log deviation from its steady-state ($x_t = \log X_t - \log \bar{X}$).

- Homeowner

$$
c_t^o = p_t^s + s_t^o \tag{C.38}
$$

$$
\psi_{b^o} b_t^o = c_t^o - E_t c_{t+1}^o + r_t - E_t \pi_{t+1} \tag{C.39}
$$

$$
\frac{1}{\theta} \left(p_t^S - q_t \right) = \begin{cases} c_t^o - E_t c_{t+1}^o + r_t^M - E_t \pi_{t+1} + \beta \frac{1-\gamma}{\theta} E_t \left[p_{t+1}^S - q_{t+1} \right] & \text{if ARM} \\ c_t^o - E_t c_{t+1}^o + r_t^M - E_t \pi_{t+1} + \beta \frac{1-\gamma}{\theta} E_t \left[p_{t+1}^S - q_{t+1} \right] & \\ -\frac{1-\gamma}{1-\beta(1-\gamma)} \left(r_{t-1}^M - r_t^F - \beta E_t \left[r_t^M - r_{t+1}^F \right] \right) & \text{if FRM} \end{cases} \tag{C.40}
$$

$$
d_t = (1-\gamma)(d_{t-1} - \pi_t) + \gamma l_t^o \tag{C.41}
$$

$$
m_t^o = \frac{\frac{1}{\beta}}{\frac{1}{\beta} - 1 + \gamma} r_{t-1}^M + d_{t-1} - \pi_t \tag{C.42}
$$

$$
l_t^o = q_t + h_t \tag{C.43}
$$

$$
\begin{aligned}
&\bar{C}^o c_t^o + \bar{P}^s \bar{S}^o (p_t^s + s_t^o) + \bar{Q} \bar{H} (q_t + h_t) + b_t^o = \bar{W} N^o w_t + \frac{1}{\beta} b_{t-1}^o + \bar{P}^s \bar{S} (p_t^s + s_t) \\
&+ \bar{L}^o l_t^o - \bar{M}^o m_t^o
\end{aligned} \tag{C.44}
$$

- Renter

$$0 = c_t^r - E_t c_{t+1}^r + r_t - E_t \pi_{t+1} \tag{C.45}$$

$$c_t^r = p_t^s + s_t^r \tag{C.46}$$

- Lender

$$\psi_{b^l} b_t^l = c_t^l - E_t c_{t+1}^l + r_t - E_t \pi_{t+1} \tag{C.47}$$

$$0 = \begin{cases} r_t^M - r_t^F & \text{if ARM} \\ c_t^l - E_t c_{t+1}^l + r_t^M - E_t \pi_{t+1} + \frac{1-\gamma}{1-\beta(1-\gamma)} \left(r_t^F - r_{t-1}^M - \beta E_t r_{t+1}^F - r_t^M \right) & \text{if FRM} \end{cases} \tag{C.48}$$

$$\bar{C}^l c_t^l + b_t^l + \bar{L}^l l_t^l = \bar{W} N^l w_t + \bar{W}^H N^{l,H} w_t^H + \frac{1}{\beta} b_{t-1}^l + \bar{M}^l m_t^l + \bar{\Phi}^l \Phi_t^l - \bar{T} T_t \tag{C.49}$$

- Firms

$$w_t^H = q_t \tag{C.50}$$

$$\pi_t = \beta E_t \pi_{t+1} + \frac{(1-\omega)(1-\omega\beta)}{\omega} w_t \tag{C.51}$$

- Equilibrium and market clearing:

$$h_t = 0 \tag{C.52}$$

$$\lambda^o \bar{S} s_t = \lambda^o \bar{S}^o s_t^o + \lambda^r \bar{S}^r s_t^r \tag{C.53}$$

$$s_t = h_t \tag{C.54}$$

$$0 = \lambda^l b_t^l + \lambda^o b_t^o + \lambda^r b_t^r \tag{C.55}$$

$$\bar{C} c_t = \lambda^l \bar{C}^l c_t^l + \lambda^o \bar{C}^o c_t^o + \lambda^r \bar{C}^r c_t^r \tag{C.56}$$

$$\bar{Y} y_t = \bar{C} c_t + \lambda^l \bar{T} \tilde{T}_t \tag{C.57}$$

$$y_t = 0 \tag{C.58}$$

$$l_t^l = l_t^o \tag{C.59}$$

$$m_t^l = m_t^o \tag{C.60}$$

$$\tilde{\Phi}_t^l = -\frac{\bar{W}}{1-\bar{W}} w_t \tag{C.61}$$

$$\tilde{T}_t = \tilde{\Phi}_t^l \tag{C.62}$$

- Monetary policy and mortgage rates

$$r_t = \rho^R r_{t-1} + \left(1 - \rho^R\right) \phi_\pi \pi_t + \varepsilon_{t-k} \tag{C.63}$$

$$r_t^M = \begin{cases} r_t & \text{if ARM} \\ (1-\gamma)\, r_{t-1}^M + \gamma R_t^F & \text{if FRM} \end{cases} \tag{C.64}$$

- 27 Variables and 27 equations
  - Real allocations: (11 variables)

$$\left\{c_t^l, c_t^o, c_t^r, c_t, s_t^o, s_t^r, s_t, h_t, y_t, \tilde{\Phi}_t^l, \tilde{T}_t\right\}$$

  - Bonds: (3 variables)

$$\left\{b_t^l, b_t^o, b_t^r\right\}$$

  - Prices and interest rates: (8 variables)

$$\left\{p_t^s, q_t r_t, r_t^M, r_t^F, w_t, w_t^H, \pi_t\right\}$$

  - Mortgages: (5 variables)

$$\left\{m_t^l, l_t^l, m_t^o, l_t^o, d_t^o\right\}$$

Appendix D. The baseline model with rationally inattentive homeowners and renters

In this section, we derive decision problems for rationally inattentive homeowners and renters. We formulate the dynamic rational inattention problem (DRIP) of homeowners and renters in a Linear-Quadratic-Gaussian (LQG) setup to use the solution method developed in Afrouzi and Yang (2021). The approach used to derive the DRIP of homeowners and renters in an LQG setup parallels that of Maćkowiak and Wiederholt (2023).

Appendix D.1. Second-order approximation for homeowner's utility

Notice that a homeowner's problem is as follows (we omit an individual i-index for a notation simplicity):

$$\max_{\left\{C_t^o, S_t^o, b_t^o, L_t^o, D_t^o,\right\}} E_0 \sum_{t=0}^{\infty} \beta^t u\left(C_t^o, S_t^o\right)$$

subject to

$$C_t^o + P_t^s S_t^o + b_t^o + \frac{\psi_{b^o}}{2}\left(b_t^o\right)^2 = W_t N^o + \frac{R_{t-1}}{\Pi_t} b_{t-1}^o + \frac{1}{\theta}\left(\frac{P_t^s}{Q_t} - (1-\theta)\right) L_t^o$$
$$- \left(R_{t-1}^M - 1 + \gamma\right) \frac{D_{t-1}^o}{\Pi_t}$$
$$R_t^M = \left(1 - \frac{L_t^o}{D_t^o}\right) R_{t-1}^M + \frac{L_t^o}{D_t^o} R_t^F$$
$$D_t^o = (1-\gamma)\frac{D_{t-1}^o}{\Pi_t} + L_t^o$$

First, using the constraints for the optimization problem to substitute for consumption and housing services in the utility function and expressing all variables in terms of log deviations from the non-stochastic steady state yields the following expression for the period utility of the homeowner in period t:

$$\begin{aligned}
f\left(\chi_t^o, z_t^o\right) = \log \Bigg\{ & \bar{w}\bar{N}^o \exp\left(w_t\right) + \bar{R}\exp\left(r_{t-1} - \pi_t\right) b_{t-1}^o + \frac{1}{\theta}\bar{D}^o\left(\exp\left(p_t^s - q_t\right) - (1-\theta)\right)\exp\left(d_t^o\right) \\
& - \bar{D}^o\left(\frac{1-\gamma}{\theta}\left(\exp\left(p_t^s - q_t\right) - 1\right) + \bar{R}^M \exp\left(r_{t-1}^M\right)\right)\exp\left(d_{t-1}^o - \pi_t\right) \\
& - \bar{p}^S \bar{S}^o \exp\left(p_t^S + s_t^o\right) - b_t^o - \frac{\psi_b}{2}\left(b_t^o\right)^2 \Bigg\} + \psi\left(s_t^o + \log\left(\bar{S}^o\right)\right) \\
& - \frac{1}{1-\beta(1-\gamma)}\frac{\bar{D}^o}{\bar{C}^o}\exp\left(\mu_t^o\right)\Big((1-\gamma)\exp\left(d_{t-1}^o - d_t^o - \pi_t\right)\left(\exp\left(r_{t-1}^M\right) - \exp\left(r_t^F\right)\right) \\
& + \exp\left(r_t^F\right) - \exp\left(r_t^M\right)\Big)
\end{aligned}$$

where $\chi_t^o = \left(b_t^o, d_t^o s_t^o, \mu_t\right)'$ denotes a set of choice variables and $z_t^o = \left(\pi_t, w_t, p_t^s, q_t, r_{t-1}, r_{t-1}^M r_t^F\right)$ denotes a set of state variables at time t. Let $\varrho_t = \left(\chi_t^o, z_t^o, 1\right)'$.

Now, define

$$g\left(\left\{\chi_{t-1}^o, z_t^o\right\}_{t\geq 0}\right) = \sum_{t=0}^{\infty}\beta^t f\left(\chi_t^o, \chi_{t-1}^o, z_t^o\right).$$

Suppose that homeowner knows in period -1 its initial bond holdings (b_{-1}^o) and debt holdings (d_{-1}^o) and $s_{-1}^o = \mu_{-1} = 0$. Suppose also that there exist two constants $\delta < 1/\beta$ and such that, for each period $t \geq 0$, for all $m, n \in \{1, 2, \cdots, 11\}$, and for $\tau = 0, 1$,

$$E_{-1}\left|\varrho_{m,t}\varrho_{n,t+\tau}\right| < \delta^t A.$$

Then, Proposition 3 in Appendix of Maćkowiak and Wiederholt (2023) implies that after the second-order Taylor approximation of f at the non-stochastic steady state, the loss in expected utility when the law of motion for the actions differs from the law of motion for the optimal actions under perfect information is given by

$$\sum_{t=0}^{\infty} \beta^t E_{-1} \left[\frac{1}{2} \left(\chi_t^o - \chi_t^{o,*} \right)' \Theta_0^o \left(\chi_t^o - \chi_t^{o,*} \right) + \left(\chi_t^o - \chi_t^{o,*} \right)' \Theta_1^o \left(\chi_{t+1}^o - \chi_{t+1}^{o,*} \right) \right]$$

where Θ_0^o is defined as the Hessian matrix of second derivatives of g with respect to χ_t^o evaluated at the non-stochastic steady state and divided by β^t,$\Theta_1^o$is defined as the Hessian matrix of second derivatives of g with respect to χ_t^o and χ_{t+1}^oevaluated at the non-stochastic steady state and divided by β^t,and the process $\{\chi_t^{o,*}\}$ is defined as the sequence of actions that the homeowner would take if it had perfect information in each period $t \geq 0$. In our setup of homeowner's problem, Θ_0^o and Θ_1^o are given by:

$$\Theta_0^o = \begin{pmatrix} -\frac{\psi_b}{\bar{C}^o} - \left(\frac{1}{\bar{C}^o}\right)^2 \left(1 + \frac{1}{\beta}\right), & \left(\frac{1}{\bar{C}^o}\right)^2 \bar{D}^o \left(1 + \frac{1}{\beta}\right), & -\frac{\psi}{\bar{C}^o}, & 0 \\ \left(\frac{1}{\bar{C}^o}\right)^2 \bar{D}^o \left(1 + \frac{1}{\beta}\right), & -\left(\frac{\bar{D}^o}{\bar{C}^o}\right)^2 \left(1 + \frac{1}{\beta}\right), & \psi \frac{\bar{D}^o}{\bar{C}^o}, & 0 \\ -\frac{\psi}{\bar{C}^o}, & \psi \frac{\bar{D}^o}{\bar{C}^o}, & -\psi\left(1 + \psi\right), & 0 \\ 0, & 0, & 0, & 0 \end{pmatrix}$$

$$\Theta_1^r = \begin{pmatrix} \left(\frac{1}{\bar{C}^o}\right)^2, & -\left(\frac{1}{\bar{C}^o}\right)^2 \bar{D}^o, & \frac{\psi}{\bar{C}^o} & 0, \\ -\left(\frac{1}{\bar{C}^o}\right)^2 \bar{D}^o, & \left(\frac{\bar{D}^o}{\bar{C}^o}\right)^2, & -\psi \frac{\bar{D}^o}{\bar{C}^o} & 0, \\ 0, & 0, & 0 & 0, \\ 0, & 0, & 0 & 0, \end{pmatrix}.$$

Also, the optimal actions under perfect information, $\{\chi_t^{o,*}\}_{t=0}^{\infty}$, is defined by the initial condition $\chi_{-1}^{o,*} = \left(b_{-1}^o, d_{-1}^o, 0, 0\right)'$ and the optimality condition

$$E_t \left[\theta_0^o + \Theta_{-1}^o \chi_{t-1}^{o,*} + \Theta_0^o \chi_t^{o,*} + \Theta_1^o \chi_{t+1}^{o,*} + \Phi_0^o z_t^o + \Phi_1^o z_{t+1}^o \right] = 0$$

where θ_0^o is the vector of first derivatives of g w.r.t. χ_t^o at the non-stochastic steady state, Θ_{-1}^o is the matrix of second derivatives of g w.r.t. χ_t^o and χ_{t-1}^o at the non-stochastic steady state, Φ_0^o is the matrix of second derivatives of g w.r.t. χ_t^o and z_t^o at the non-stochastic steady state, and Φ_1^o is the matrix of second derivatives of g w.r.t. χ_t^o and z_{t+1}^o at the non-stochastic steady state. In our setup, these objects are defined as follows:

$$
\Theta_{-1}^{o} = \begin{pmatrix}
\frac{1}{\beta}\left(\frac{1}{\bar{C}^{o}}\right)^{2}, & -\frac{1}{\beta}\left(\frac{1}{\bar{C}^{o}}\right)^{2}\bar{D}^{o}, & 0, & 0 \\
-\frac{1}{\beta}\left(\frac{1}{\bar{C}^{o}}\right)^{2}\bar{D}^{o}, & \frac{1}{\beta}\left(\frac{\bar{D}^{o}}{\bar{C}^{o}}\right)^{2}, & 0, & 0 \\
\frac{1}{\beta}\frac{\psi}{\bar{C}^{o}}, & -\frac{1}{\beta}\psi\frac{\bar{D}^{o}}{\bar{C}^{o}}, & 0, & 0 \\
0, & 0, & 0, & 0
\end{pmatrix}
$$

$$
\Theta_{0}^{o} = \begin{pmatrix}
-\left\{\frac{\psi_b}{\bar{C}^{o}} + \left(\frac{1}{\bar{C}^{o}}\right)^{2}\left(1+\frac{1}{\beta}\right)\right\}, & \left(\frac{1}{\bar{C}^{o}}\right)^{2}\bar{D}^{o}\left(1+\frac{1}{\beta}\right), & -\frac{\psi}{\bar{C}^{o}} & 0, \\
\left(\frac{1}{\bar{C}^{o}}\right)^{2}\bar{D}^{o}\left(1+\frac{1}{\beta}\right), & -\left(\frac{\bar{D}^{o}}{\bar{C}^{o}}\right)^{2}\left(1+\frac{1}{\beta}\right), & \psi\frac{\bar{D}^{o}}{\bar{C}^{o}} & 0, \\
-\frac{\psi}{\bar{C}^{o}}, & \psi\frac{\bar{D}^{o}}{\bar{C}^{o}}, & -\psi\left(1+\psi\right) & 0, \\
0, & 0, & 0 & 0,
\end{pmatrix}
$$

$$
\Theta_{1}^{o} = \begin{pmatrix}
\left(\frac{1}{\bar{C}^{o}}\right)^{2}, & -\left(\frac{1}{\bar{C}^{o}}\right)^{2}\bar{D}^{o}, & \frac{\psi}{\bar{C}^{o}} & 0, \\
-\left(\frac{1}{\bar{C}^{o}}\right)^{2}\bar{D}^{o}, & \left(\frac{\bar{D}^{o}}{\bar{C}^{o}}\right)^{2}, & -\psi\frac{\bar{D}^{o}}{\bar{C}^{o}} & 0, \\
0, & 0, & 0 & 0, \\
0, & 0, & 0 & 0,
\end{pmatrix}
$$

$$
\Phi_{0}^{o} = \begin{pmatrix}
\frac{1}{\beta}\left(\frac{1}{\bar{C}^{o}}\right)^{2}\bar{D}^{o}, & \left(\frac{1}{\bar{C}^{o}}\right)^{2}\bar{\varpi}\bar{N}^{o}, & \left(\frac{1}{\bar{C}^{o}}\right)^{2}\left(\frac{\gamma}{\theta}\bar{D}^{o}-\psi\bar{C}^{o}\right), & -\left(\frac{1}{\bar{C}^{o}}\right)^{2}\frac{\gamma}{\theta}\bar{D}^{o}, & 0, & -\frac{1}{\beta}\left(\frac{1}{\bar{C}^{o}}\right)^{2}\bar{D}^{o}, & 0 \\
-\frac{1}{\beta}\left(\frac{\bar{D}^{o}}{\bar{C}^{o}}\right)^{2}, & -\left(\frac{1}{\bar{C}^{o}}\right)^{2}\bar{D}^{o}\bar{\varpi}\bar{N}^{o}, & \left(\frac{1}{\theta}+\psi\right)\frac{\bar{D}^{o}}{\bar{C}^{o}}-\frac{\gamma}{\theta}\left(\frac{\bar{D}^{o}}{\bar{C}^{o}}\right)^{2}, & -\frac{1}{\theta}\frac{\bar{D}^{o}}{\bar{C}^{o}}+\frac{\gamma}{\theta}\left(\frac{\bar{D}^{o}}{\bar{C}^{o}}\right)^{2}, & 0, & \frac{1}{\beta}\frac{\bar{D}^{o}}{\bar{C}^{o}}\left(\frac{\bar{D}^{o}}{\bar{C}^{o}}+\frac{\beta(1-\gamma)}{1-\beta(1-\gamma)}\right), & -\frac{(1-\gamma)}{1-\beta(1-\gamma)}\frac{\bar{D}^{o}}{\bar{C}^{o}} \\
\frac{1}{\beta}\psi\frac{\bar{D}^{o}}{\bar{C}^{o}}, & \psi\frac{1}{\bar{C}^{o}}\bar{\varpi}\bar{N}^{o} & -\psi\left(1+\psi-\frac{\gamma}{\theta}\frac{\bar{D}^{o}}{\bar{C}^{o}}\right), & -\psi\frac{\bar{D}^{o}}{\bar{C}^{o}}\frac{\gamma}{\theta}, & 0, & -\frac{1}{\beta}\psi\frac{\bar{D}^{o}}{\bar{C}^{o}} & 0 \\
0, & 0, & 0, & 0, & 0, & -\frac{1}{\beta}\left(\frac{\beta(1-\gamma)}{1-\beta(1-\gamma)}\right)\frac{\bar{D}^{o}}{\bar{C}^{o}}, & -\frac{\gamma}{1-\beta(1-\gamma)}\frac{\bar{D}^{o}}{\bar{C}^{o}}
\end{pmatrix}
$$

$$
\Phi_{1}^{o} = \begin{pmatrix}
-\frac{1}{\bar{C}^{o}}-\frac{1}{\beta}\left(\frac{1}{\bar{C}^{o}}\right)^{2}\bar{D}^{o}, & -\left(\frac{1}{\bar{C}^{o}}\right)^{2}\bar{\varpi}\bar{N}^{o}, & -\left(\frac{1}{\bar{C}^{o}}\right)^{2}\left(\frac{\gamma}{\theta}\bar{D}^{o}-\psi\bar{C}^{o}\right), & \left(\frac{1}{\bar{C}^{o}}\right)^{2}\frac{\gamma}{\theta}\bar{D}^{o}, & \frac{1}{\bar{C}^{o}}, & \frac{1}{\beta}\left(\frac{1}{\bar{C}^{o}}\right)^{2}\bar{D}^{o}, & 0 \\
\frac{\bar{D}^{o}}{\bar{C}^{o}}+\left(\frac{\bar{D}^{o}}{\bar{C}^{o}}\right)^{2}\frac{1}{\beta}, & \left(\frac{1}{\bar{C}^{o}}\right)^{2}\bar{D}^{o}\bar{\varpi}\bar{N}^{o}, & \frac{\bar{D}^{o}}{\bar{C}^{o}}\left(\frac{\gamma}{\theta}\frac{\bar{D}^{o}}{\bar{C}^{o}}-\beta\left(\frac{1-\gamma}{\theta}\right)-\psi\right), & -\frac{\bar{D}^{o}}{\bar{C}^{o}}\left(\frac{\gamma}{\theta}\frac{\bar{D}^{o}}{\bar{C}^{o}}-\beta\left(\frac{1-\gamma}{\theta}\right)\right), & 0, & -\frac{\bar{D}^{o}}{\bar{C}^{o}}\left(1+\frac{1}{\beta}\frac{\bar{D}^{o}}{\bar{C}^{o}}+\frac{\beta(1-\gamma)}{1-\beta(1-\gamma)}\right), & \frac{\beta(1-\gamma)}{1-\beta(1-\gamma)}\frac{\bar{D}^{o}}{\bar{C}^{o}} \\
0, & 0, & 0, & 0, & 0, & 0 & 0 \\
0, & 0, & 0, & 0, & 0, & \frac{1}{1-\beta(1-\gamma)}\frac{\bar{D}^{o}}{\bar{C}^{o}}, & 0
\end{pmatrix}.
$$

Then, we now have

$$
E_t\left[\Theta_{-1}^{o}\begin{pmatrix} b_{t-1}^{o,*} \\ d_{t-1}^{o,*} \\ \mu_{t-1}^{o,*} \\ s_{t-1}^{o,*} \end{pmatrix} + \Theta_{0}^{o}\begin{pmatrix} b_{t}^{o,*} \\ d_{t}^{o,*} \\ \mu_{t}^{o,*} \\ s_{t}^{o,*} \end{pmatrix} + \Theta_{1}^{o}\begin{pmatrix} b_{t+1}^{o,*} \\ d_{t+1}^{o,*} \\ \mu_{t+1}^{o,*} \\ s_{t+1}^{o,*} \end{pmatrix} + \Phi_{0}^{o}\begin{pmatrix} \pi_t \\ p_t^{s} \\ q_t \\ r_{t-1} \\ r_{t-1}^{M} \\ r_{t-1}^{F} \end{pmatrix} + \Phi_{1}^{o}\begin{pmatrix} \pi_{t+1} \\ p_{t+1}^{s} \\ q_{t+1} \\ r_t \\ r_t^{M} \\ r_t^{F} \end{pmatrix}\right] = 0. \tag{D.1}
$$

Notice that from the log-linearized budget constraint of homeowner, we can derive the homeowner's consumption in the full information model as follows:

$$\bar{C}^o c_t^* = \frac{1}{\beta} b_{t-1}^{o,*} - b_t^{o,*} - \bar{D}^o \left(\frac{1}{\beta} d_{t-1}^{o,*} - d_t^{o,*} \right) + \varpi \bar{N}^o w_t + \frac{\gamma}{\theta} \bar{D}^o \left(p_t^s - q_t \right) - \psi \bar{C}^o \left(s_t^{o,*} + p_t^s \right) - \frac{1}{\beta} \bar{D}^o \left(r_{t-1}^M - \pi_t \right).$$

Then, we can derive each entry of the matrix equation (D.1) as follows:

- The first entry is

$$\psi_b b_t^{o,*} = c_t^* - c_{t+1}^* + r_t - \pi_{t+1}$$

- The second entry

$$\begin{aligned} \frac{1}{\theta} \left(p_t^s - q_t \right) = c_t^* - c_{t+1}^* + \left(r_t^M - \pi_{t+1} \right) + \beta \frac{1-\gamma}{\theta} \left(p_{t+1}^s - q_{t+1} \right) \\ - \frac{1-\gamma}{1-\beta(1-\gamma)} \left(\left(r_{t-1}^M - r_t^F \right) - \beta \left(r_t^M - r_{t+1}^F \right) \right) \end{aligned}$$

- The third entry

$$s_t^{o,*} + p_t^s = c_t^*$$

- The fourth entry

$$r_t^M = (1-\gamma) r_{t-1}^M + \gamma r_t^F$$

Now we have

$$c_t^{o,*} = \frac{1}{\bar{C}^o} \left[\frac{1}{\beta} b_{t-1}^{o,*} - b_t^{o,*} - \bar{D}^o \left(\frac{1}{\beta} d_{t-1}^{o,*} - d_t^{o,*} \right) + \frac{\gamma}{\theta} \bar{d} \left(p_t^s - q_t \right) + \varpi \bar{N}^o w_t - \frac{1}{\beta} \bar{D}^o \left(r_{t-1}^M - \pi_t \right) - \bar{C}^o \psi \left(s_t^o + p_t^s \right) \right] \tag{D.2}$$
$$c_{t+1}^{o,*} = \frac{1}{\bar{C}^o} \left[\frac{1}{\beta} b_t^{o,*} - b_{t+1}^{o,*} - \bar{D}^o \left(\frac{1}{\beta} d_t^{o,*} - d_{t+1}^{o,*} \right) + \frac{\gamma}{\theta} \bar{d} \left(p_{t+1}^s - q_{t+1} \right) + \varpi \bar{N}^o w_{t+1} - \frac{1}{\beta} \bar{D}^o \left(r_t^M - \pi_{t+1} \right) - \bar{C}^o \psi \left(s_{t+1}^{o,*} + p_{t+1}^s \right) \right]$$

Then,

$$\psi_b b_t^{o,*} = c_t^{o,*} - c_{t+1}^{o,*} + \left(r_t - \pi_{t+1} \right) \tag{D.3}$$
$$\frac{1}{\theta} \left(p_t^s - q_t \right) = c_t^{o,*} - c_{t+1}^{o,*} + \beta \frac{1-\gamma}{\theta} \left(p_{t+1}^s - q_{t+1} \right) + \left(r_t^M - \pi_{t+1} \right) - \frac{1-\gamma}{1-\beta(1-\gamma)} \left(\left(r_{t-1}^M - r_t^F \right) - \beta \left(r_t^M - r_{t+1}^F \right) \right) \tag{D.4}$$
$$c_t^{o,*} = s_t^{o,*} + p_t^s \tag{D.5}$$

Then, combine Equation (D.5) with Equation (D.2) to get

$$(1+\psi) c_t^{o,*} = \frac{1}{\bar{C}^o} \left[\frac{1}{\beta} b_{t-1}^{o,*} - b_t^{o,*} - \bar{D}^o \left(\frac{1}{\beta} d_{t-1}^* - d_t^* \right) + \frac{\gamma}{\theta} \bar{D}^o \left(p_t^s - q_t \right) + \varpi \bar{N}^o w_t - \frac{1}{\beta} \bar{d} \left(r_{t-1}^M - \pi_t \right) \right]$$

which implies

$$\bar{C}^o\left(1+\psi\right)\sum_{s=t}^{t+N}\beta^{s-t}c_s^{o,*}=\frac{1}{\beta}\left(b_{t-1}^{o,*}-\bar{D}^o d_{t-1}^{o,*}\right)-\frac{1}{\beta}\bar{d}\left(r_{t-1}^M-\pi_t\right)$$
$$-\beta^N\left(b_{t+N}^{o,*}-\bar{D}^o d_{t+N}^{o,*}\right)+\beta^N\bar{d}\left(r_{t+N}^M-\pi_{t+N+1}\right)$$
$$+\frac{\gamma}{\theta}\bar{d}\sum_{s=t}^{t+N}\beta^{s-t}\left(p_s^S-q_s\right)+\bar{\omega}\bar{N}^o\sum_{s=t}^{t+N}\beta^{s-t}w_s-\bar{d}\sum_{s=t}^{t+N}\beta^{s-t}\left(r_s^M-\pi_{s+1}\right).$$

Taking the expectation $E_t\left[\cdot\right]$ and the limit as $N\to\infty$ and using the transversality condition, we get

$$\bar{C}^o\left(1+\psi\right)\sum_{s=t}^{\infty}\beta^{s-t}E_t\left[c_s^{o,*}\right]=\frac{1}{\beta}\left(b_{t-1}^{o,*}-\bar{D}^o d_{t-1}^{o,*}\right)-\frac{1}{\beta}\bar{d}\left(r_{t-1}^M-\pi_t\right)$$
$$+\bar{D}^o\sum_{s=t}^{\infty}\beta^{s-t}E_t\left[\frac{\gamma}{\theta}\left(p_s^S-q_s\right)-\left(r_s^M-\pi_{s+1}\right)\right]+\bar{\omega}\bar{N}^o\sum_{s=t}^{\infty}\beta^{s-t}E_t w_s \quad \text{(D.6)}$$

Now, using Equation (D.3) and the law of iterated expectations, we get

$$\begin{aligned}
c_t^{o,*}&=c_t^{o,*}\\
c_{t+1}^{o,*}&=c_t^{o,*}+\left(r_t-\pi_{t+1}\right)-\psi_b b_t^{o,*}\\
c_{t+2}^{o,*}&=c_t^{o,*}+\left(r_t-\pi_{t+1}\right)-\psi_b b_t^{o,*}+\left(r_{t+1}-\pi_{t+2}\right)-\psi_b b_{t+1}^{o,*}\\
c_{t+3}^{o,*}&=c_t^{o,*}+\left(r_t-\pi_{t+1}\right)-\psi_b b_t^{o,*}+\left(r_{t+1}-\pi_{t+2}\right)-\psi_b b_{t+1}^{o,*}+\left(r_{t+2}-\pi_{t+3}\right)-\psi_b b_{t+2}^{o,*}\\
&\vdots
\end{aligned}$$
$$\sum_{s=t}^{\infty}\beta^{s-t}E_t\left[c_s^{o,*}\right]=\frac{1}{1-\beta}c_t^{o,*}+\frac{\beta}{1-\beta}\sum_{s=t}^{\infty}\beta^{s-t}E_t\left[\left(\left(r_s-\pi_{s+1}\right)-\psi_b b_s^{o,*}\right)\right]$$

Then, combine Equation (D.3) and (D.4) to get

$$\begin{aligned}
\sum_{s=t}^{\infty}\beta^{s-t}E_t\left[c_s^{o,*}\right]&=\frac{1}{1-\beta}c_t^{o,*}+\frac{\beta}{1-\beta}\sum_{s=t}^{\infty}\beta^{s-t}E_t\left[\left(\left(r_s-\pi_{s+1}\right)-\psi_b b_s^{o,*}\right)\right]\\
&=\frac{1}{1-\beta}c_t^{o,*}-\frac{\beta}{1-\beta}\sum_{s=t}^{\infty}\beta^{s-t}E_t\left[\frac{1}{\theta}\left(p_s^s-q_s\right)-\beta\frac{1-\gamma}{\theta}\left(p_{s+1}^s-q_{s+1}\right)\right]\\
&+\frac{\beta}{1-\beta}\sum_{s=t}^{\infty}\beta^{s-t}E_t\left[\left(r_s^M-\pi_{s+1}\right)-\frac{1-\gamma}{1-\beta\left(1-\gamma\right)}\left(\left(r_{s-1}^M-r_s^F\right)-\beta\left(r_s^M-r_{s+1}^F\right)\right)\right]
\end{aligned} \quad \text{(D.7)}$$

Then, by combining Equations (D.6) and (D.7), we have

$$\left(b_t^{o,*}-\bar{D}^o d_t^{o,*}\right)-\left(b_{t-1}^{o,*}-\bar{D}^o d_{t-1}^{o,*}\right)=\bar{\omega}\bar{N}^o\left(w_t-\left(1-\beta\right)\sum_{s=t}^{\infty}\beta^{s-t}E_t w_s\right)-\bar{D}^o\left(r_{t-1}^M-\pi_t\right)$$

$$+\left(\frac{\gamma}{\theta}\bar{D}^{o}-\bar{C}^{o}\beta\frac{1-\gamma}{\theta}\left(1+\psi\right)\right)\left(p_{t}^{s}-q_{t}\right)$$
$$+\left(\bar{D}^{o}\left(1-\beta\right)+\bar{C}^{o}\beta\left(1+\psi\right)\right)\sum_{s=t}^{\infty}\beta^{s-t}E_{t}\left[\left(r_{s}^{M}-\pi_{s+1}\right)-\frac{\gamma}{\theta}\left(p_{s}^{S}-q_{s}\right)\right]$$
$$-\bar{C}^{o}\left(1+\psi\right)\frac{\beta\left(1-\gamma\right)}{1-\beta\left(1-\gamma\right)}\sum_{s=t}^{\infty}\beta^{s-t}E_{t}\left[\left(r_{s-1}^{M}-r_{s}^{F}\right)-\beta\left(r_{s}^{M}-r_{s+1}^{F}\right)\right]$$

Then, we now have a system of four equations

$$\psi_{b}b_{t}^{o,*}=\frac{1}{\theta}\left(p_{t}^{s}-q_{t}\right)+\left(r_{t}-\pi_{t+1}\right)-\beta\frac{1-\gamma}{\theta}\left(p_{t+1}^{s}-q_{t+1}\right)-\left(r_{t}^{M}-\pi_{t+1}\right)$$
$$+\frac{1-\gamma}{1-\beta\left(1-\gamma\right)}\left(\left(r_{t-1}^{M}-r_{t}^{F}\right)-\beta\left(r_{t}^{M}-r_{t+1}^{F}\right)\right)$$

$$\left(b_{t}^{o,*}-\bar{D}^{o}d_{t}^{o,*}\right)-\left(b_{t-1}^{o,*}-\bar{D}^{o}d_{t-1}^{o,*}\right)=\bar{w}\bar{N}^{o}\left(w_{t}-\left(1-\beta\right)\sum_{s=t}^{\infty}\beta^{s-t}E_{t}w_{s}\right)-\bar{D}^{o}\left(r_{t-1}^{M}-\pi_{t}\right)$$
$$+\left(\frac{\gamma}{\theta}\bar{D}^{o}-\bar{C}^{o}\beta\frac{1-\gamma}{\theta}\left(1+\psi\right)\right)\left(p_{t}^{s}-q_{t}\right)$$
$$+\left(\bar{D}^{o}\left(1-\beta\right)+\bar{C}^{o}\beta\left(1+\psi\right)\right)\sum_{s=t}^{\infty}\beta^{s-t}E_{t}\left[\left(r_{s}^{M}-\pi_{s+1}\right)-\frac{\gamma}{\theta}\left(p_{s}^{S}-q_{s}\right)\right]$$
$$-\bar{C}^{o}\left(1+\psi\right)\frac{\beta\left(1-\gamma\right)}{1-\beta\left(1-\gamma\right)}\sum_{s=t}^{\infty}\beta^{s-t}E_{t}\left[\left(r_{s-1}^{M}-r_{s}^{F}\right)-\beta\left(r_{s}^{M}-r_{s+1}^{F}\right)\right]$$

$$\frac{1}{\beta}\left(b_{t-1}^{o,*}-\bar{D}^{o}d_{t-1}^{o,*}\right)-\left(b_{t}^{o,*}-\bar{D}^{o}d_{t}^{o,*}\right)-\bar{C}^{o}\left(1+\psi\right)s_{t}^{o,*}=-\frac{\gamma}{\theta}\bar{d}\left(p_{t}^{s}-q_{t}\right)-\bar{w}\bar{N}^{o}w_{t}+\frac{1}{\beta}\bar{d}\left(r_{t-1}^{M}-\pi_{t}\right)$$
$$+\bar{C}^{o}\left(1+\psi\right)p_{t}^{s}$$

and

$$r_{t}^{M}=\left(1-\gamma\right)r_{t-1}^{M}+\gamma r_{t}^{F},$$

which characterizes the homeowner's optimal allocations under the full information rational expectations.

Now, we can use a change of variables approach to derive a DRIP which is applicable to solution method in Afrouzi and Yang (2021). Formally, we use Proposition 4 of the appendix in MW (2023) to show that

$$\sum_{t=0}^{\infty}\beta^{t}\left[\frac{1}{2}\left(\chi_{t}^{o}-\chi_{t}^{o,*}\right)'\Theta_{0}^{o}\left(\chi_{t}^{o}-\chi_{t}^{o,*}\right)+\left(\chi_{t}^{o}-\chi_{t}^{o,*}\right)'\Theta_{1}^{o}\left(\chi_{t+1}^{o}-\chi_{t+1}^{o,*}\right)\right]$$
$$=\sum_{t=0}^{\infty}\beta^{t}\left[\frac{1}{2}\left(\tilde{x}_{t}^{o}-\tilde{x}_{t}^{o,*}\right)'\tilde{\Theta}^{o}\left(\tilde{x}_{t}^{o}-\tilde{x}_{t}^{o,*}\right)\right].$$

In our model setup,

$$\tilde{x}_t^o - \tilde{x}_t^{o,*} = \begin{pmatrix} \left(b_t^o - b_t^{o,*}\right) \\ \left(b_t^o - b_t^{o,*}\right) - \bar{d}\left(d_t - d_t^*\right) - \left(\left(b_{t-1}^o - b_{t-1}^{o,*}\right) - \bar{d}\left(d_{t-1} - d_{t-1}^*\right)\right) \\ \frac{1}{\beta}\left(\left(b_{t-1}^o - b_{t-1}^{o,*}\right) - \bar{d}\left(d_{t-1} - d_{t-1}^*\right)\right) - \left(\left(b_t^o - b_t^{o,*}\right) - \bar{d}\left(d_t - d_t^*\right)\right) \\ \quad -\bar{C}^o\left(1+\psi\right)\left(s_t^o - s_t^{o,*}\right) \end{pmatrix}$$

and

$$\tilde{\Theta}^o = \begin{pmatrix} -\frac{\psi_b}{\bar{C}^o}, & 0 & 0 \\ 0, & -\left(\frac{1}{1+\psi}\right)\frac{1}{\beta}\left(\frac{1}{\bar{C}^o}\right)^2, & 0 \\ 0, & 0, & -\left(\frac{\psi}{1+\psi}\right)\left(\frac{1}{\bar{C}^o}\right)^2 \end{pmatrix}.$$

To show this, the the loss in expected utility when the law of motion for the actions differs from the law of motion for the optimal actions under perfect information is given by:

$$\begin{aligned}
&\frac{1}{2}\left(\chi_t^o - \chi_t^{o,*}\right)' \Theta_0^o \left(\chi_t^o - \chi_t^{o,*}\right) + \left(\chi_t^o - \chi_t^{o,*}\right)' \Theta_1^o \left(\chi_{t+1}^o - \chi_{t+1}^{o,*}\right) \\
=& -\frac{1}{2}\frac{\psi_b}{\bar{C}^o}\left(\tilde{x}_{1,t}^o - \tilde{x}_{1,t}^{o,*}\right)^2 \\
&-\frac{1}{2}\left(\frac{1}{1+\psi}\right)\left(\frac{1}{\bar{C}^o}\right)^2\left(\tilde{x}_{2,t+1}^o - \tilde{x}_{2,t+1}^{o,*}\right)^2 \\
&-\frac{1}{2}\left(\frac{\psi}{1+\psi}\right)\left(\frac{1}{\bar{C}^o}\right)^2\left(\tilde{x}_{3,t}^o - \tilde{x}_{3,t}^{o,*}\right)^2 \\
&+\frac{1}{2}\left(\frac{1}{1+\psi}\right)\left(\frac{1}{\bar{C}^o}\right)^2\left[\left(\left(b_{t+1}^o - b_{t+1}^{o,*}\right) - \bar{D}^o\left(d_{t+1}^o - d_{t+1}^{o,*}\right)\right)^2 - \frac{1}{\beta}\left(\left(b_t^o - b_t^{o,*}\right) - \bar{D}^o\left(d_t^o - d_t^{o,*}\right)\right)^2\right] \\
&+\frac{1}{2}\left(\frac{\psi}{1+\psi}\right)\frac{1}{\beta}\left(\frac{1}{\bar{C}^o}\right)^2\left[\left(\left(b_t^o - b_t^{o,*}\right) - \bar{D}^o\left(d_t^o - d_t^{o,*}\right)\right)^2 - \frac{1}{\beta}\left(\left(b_{t-1}^o - b_{t-1}^{o,*}\right) - \bar{D}^o\left(d_{t-1}^o - d_{t-1}^{o,*}\right)\right)^2\right] \\
&-\frac{\psi}{1+\psi}\left(\frac{1}{\bar{C}^o}\right)^2\left[\left(\left(b_t^o - b_t^{o,*}\right) - \bar{D}^o\left(d_t^o - d_t^{o,*}\right)\right)\left(\tilde{x}_{3,t+1} - \tilde{x}_{3,t+1}^*\right)\right] \\
&+\frac{\psi}{1+\psi}\left(\frac{1}{\bar{C}^o}\right)^2\left[\frac{1}{\beta}\left(\left(b_{t-1}^o - b_{t-1}^{o,*}\right) + \bar{D}^o\left(d_{t-1}^o - d_{t-1}^{o,*}\right)\right)\left(\tilde{x}_{3,t} - \tilde{x}_{3,t}^*\right)\right] \\
&-\frac{\psi}{1+\psi}\left(\frac{1}{\bar{C}^o}\right)^2\left[\left(\left(b_t^o - b_t^{o,*}\right) - \bar{D}^o\left(d_t^o - d_t^{o,*}\right)\right)\left(\tilde{x}_{3,t+1} - \tilde{x}_{3,t+1}^*\right)\right] \\
&+\frac{\psi}{1+\psi}\left(\frac{1}{\bar{C}^o}\right)^2\left[\frac{1}{\beta}\left(\left(b_{t-1}^o - b_{t-1}^{o,*}\right) + \bar{D}^o\left(d_{t-1}^o - d_{t-1}^{o,*}\right)\right)\left(\tilde{x}_{3,t} - \tilde{x}_{3,t}^*\right)\right]
\end{aligned}$$

Then, using $\tilde{x}_{2,0} - \tilde{x}_{2,0}^* = \left(b_0^o - b_0^{o,*}\right) - \bar{d}\left(d_0 - d_0^*\right)$

$$\sum_{t=0}^{T}\beta^t\left[\frac{1}{2}\left(\chi_t^o - \chi_t^{o,*}\right)' \Theta_0^o \left(\chi_t^o - \chi_t^{o,*}\right) + \left(\chi_t^o - \chi_t^{o,*}\right)' \Theta_1^o \left(\chi_{t+1}^o - \chi_{t+1}^{o,*}\right)\right]$$

$$
\begin{aligned}
&= \sum_{t=0}^{T} \beta^t \left[-\frac{1}{2} \frac{\psi_b}{\bar{C}^o} \left(\tilde{x}^o_{1,t} - \tilde{x}^{o,*}_{1,t} \right)^2 - \frac{1}{2} \left(\frac{1}{1+\psi} \right) \left(\frac{1}{\bar{C}^o} \right)^2 \frac{1}{\beta} \left(\tilde{x}^o_{2,t} - \tilde{x}^{o,*}_{2,t} \right)^2 - \frac{1}{2} \left(\frac{\psi}{1+\psi} \right) \left(\frac{1}{\bar{C}^o} \right)^2 \left(\tilde{x}^o_{3,t} - \tilde{x}^{o,*}_{3,t} \right)^2 \right] \\
&\quad - \beta^T \frac{1}{2} \left(\frac{1}{1+\psi} \right) \left(\frac{1}{\bar{C}^o} \right)^2 \frac{1}{\beta} \left(\tilde{x}^o_{2,T+1} - \tilde{x}^{o,*}_{2,T+1} \right)^2 \\
&\quad + \beta^T \frac{1}{2} \left(\frac{1}{1+\psi} \right) \left(\frac{1}{\bar{C}^o} \right)^2 \left[\left((b^o_{T+1} - b^{o,*}_{T+1}) - \bar{d} \left(d^o_{T+1} - d^{o,*}_{T+1} \right) \right)^2 \right] \\
&\quad + \beta^T \frac{1}{2} \left(\frac{\psi}{1+\psi} \right) \frac{1}{\beta} \left(\frac{1}{\bar{C}^o} \right)^2 \left[\left((b^o_T - b^{o,*}_T) - \bar{d} \left(d^o_T - d^{o,*}_T \right) \right)^2 \right] \\
&\quad - \beta^T \frac{\psi}{1+\psi} \left(\frac{1}{\bar{C}^o} \right)^2 \left[\left((b^o_T - b^{o,*}_T) - \bar{d} \left(d^o_T - d^{o,*}_T \right) \right) \left(\tilde{x}_{3,T+1} - \tilde{x}^*_{3,T+1} \right) \right]
\end{aligned}
$$

Taking the expectation and taking the limit as $T \to \infty$,

$$
\begin{aligned}
&\sum_{t=0}^{\infty} \beta^t \left[\frac{1}{2} \left(\chi^o_t - \chi^{o,*}_t \right)' \Theta^o_0 \left(\chi^o_t - \chi^{o,*}_t \right) + \left(\chi^o_t - \chi^{o,*}_t \right)' \Theta^o_1 \left(\chi^o_{t+1} - \chi^{o,*}_{t+1} \right) \right] \\
&= \sum_{t=0}^{\infty} \beta^t \left[-\frac{1}{2} \frac{\psi_b}{\bar{C}^o} \left(\tilde{x}^o_{1,t} - \tilde{x}^{o,*}_{1,t} \right)^2 - \frac{1}{2} \left(\frac{1}{1+\psi} \right) \frac{1}{\beta} \left(\frac{1}{\bar{C}^o} \right)^2 \left(\tilde{x}^o_{2,t} - \tilde{x}^{o,*}_{2,t} \right)^2 - \frac{1}{2} \left(\frac{\psi}{1+\psi} \right) \left(\frac{1}{\bar{C}^o} \right)^2 \left(\tilde{x}^o_{3,t} - \tilde{x}^{o,*}_{3,t} \right)^2 \right] \\
&= \sum_{t=0}^{\infty} \beta^t \left[\frac{1}{2} \left(\tilde{x}^o_t - \tilde{x}^{o,*}_t \right)' \tilde{\Theta}^o \left(\tilde{x}^o_t - \tilde{x}^{o,*}_t \right) \right]
\end{aligned}
$$

where

$$
\tilde{\Theta}^o = \begin{pmatrix} -\frac{\psi_b}{\bar{C}^o}, & 0 & 0 \\ 0, & -\left(\frac{1}{1+\psi} \right) \frac{1}{\beta} \left(\frac{1}{\bar{C}^o} \right)^2, & 0 \\ 0, & 0, & -\left(\frac{\psi}{1+\psi} \right) \left(\frac{1}{\bar{C}^o} \right)^2 \end{pmatrix}
$$

and

$$
\begin{aligned}
\tilde{x}^{o,*}_t &= \begin{pmatrix} b^{o,*}_t \\ \left(b^{o,*}_t - \bar{d} d^*_t \right) - \left(b^{o,*}_{t-1} - \bar{d} d^*_{t-1} \right) \\ \frac{1}{\beta} \left(b^{o,*}_{t-1} - \bar{d} d^*_{t-1} \right) - \left(b^{o,*}_t - \bar{d} d^*_t \right) - \bar{C}^o \left(1+\psi \right) s^{o,*}_t \end{pmatrix} \\
&= \begin{pmatrix} \frac{1}{\psi_b} \left[\frac{1}{\theta} \left(p^s_t - q_t \right) + \left(r_t - r^M_t \right) - \beta \frac{1-\gamma}{\theta} \left(p^s_{t+1} - q_{t+1} \right) + \frac{1-\gamma}{1-\beta(1-\gamma)} \left(\left(r^M_{t-1} - r^F_t \right) - \beta \left(r^M_t - r^F_{t+1} \right) \right) \right] \\ \bar{w} \bar{N}^o \left(w_t - (1-\beta) \sum_{s=t}^{\infty} \beta^{s-t} E_t w_s \right) - \bar{D}^o \left(r^M_{t-1} - \pi_t \right) + \left(\frac{\gamma}{\theta} \bar{D}^o - \bar{C}^o \beta \frac{1-\gamma}{\theta} \left(1+\psi \right) \right) \left(p^s_t - q_t \right) \\ \quad + \left(\bar{D}^o (1-\beta) + \bar{C}^o \beta (1+\psi) \right) \sum_{s=t}^{\infty} \beta^{s-t} E_t \left[\left(r^M_s - \pi_{s+1} \right) - \frac{\gamma}{\theta} \left(p^S_s - q_s \right) \right] \\ \quad - \bar{C}^o \left(1+\psi \right) \frac{\beta(1-\gamma)}{1-\beta(1-\gamma)} \sum_{s=t}^{\infty} \beta^{s-t} E_t \left[\left(r^M_{s-1} - r^F_s \right) - \beta \left(r^M_s - r^F_{s+1} \right) \right] \\ -\frac{\gamma}{\theta} \bar{d} \left(p^s_t - q_t \right) - \bar{w} \bar{N}^o w_t + \frac{1}{\beta} \bar{d} \left(r^M_{t-1} - \pi_t \right) + \bar{C}^o \left(1+\psi \right) p^s_t \end{pmatrix}
\end{aligned}
$$

$$
\begin{aligned}
c^{o,*}_t &= \frac{1}{(1+\psi)\bar{C}^o} \left[\frac{1}{\beta} b^{o,*}_{t-1} - b^{o,*}_t - \bar{D}^o \left(\frac{1}{\beta} d^*_{t-1} - d^*_t \right) + \frac{\gamma}{\theta} \bar{D}^o \left(p^s_t - q_t \right) + \bar{w} \bar{N}^o w_t - \frac{1}{\beta} \bar{D}^o \left(r^M_{t-1} - \pi_t \right) \right] \\
c^{o,*}_t &= s^{o,*}_t + p^s_t
\end{aligned}
$$

Appendix D.2. Second-order approximation for homeowner's utility

Notice that a renter's problem is as follows (we omit an individual i-index for a notation simplicity):

$$\begin{aligned}&\max E_0 \sum \beta^t u\left(C_t^r, S_t^r\right)\\&\text{s.t. } C_t^r + p_t^S S_t^r + b_t^r = w_t N_t^r + \frac{R_{t-1}}{\Pi_t} b_{t-1}^r\end{aligned}$$

First, using the budget constraint for the renter's optimization problem to substitute for consumption and housing services in the utility function and expressing all variables in terms of log-deviations from the non-stochastic steady state yields the following expression for the period utility of the homeowner in period t:

$$\begin{aligned}f\left(\chi_t^r, z_t^r\right) = \log &\left(\bar{w}\exp\left(w_t\right)\bar{N}^r + \bar{R}\exp\left(r_{t-1}-\pi_t\right)b_{t-1}^r - \bar{p}^S\bar{S}^r\exp\left(p_t^S + s_t^r\right) - b_t^r\right)\\&+\psi\left(s_t^r + \log\left(\bar{S}^r\right)\right)\end{aligned}$$

where $\chi_t^r = \left(b_t^r, S_t^r\right)'$ and denotes a set of choice variables and $z_t^r = \left(\pi_t, w_t, p_t^s, r_{t-1}\right)$ denotes a set of state variables at time t. Let $\varrho = \left(\chi_t^r, z_t^r, 1\right)'$.

Now, define

$$g\left(\left\{\chi_{t-1}^r, z_t^r\right\}_{t\geq 0}\right) = \sum_{t=0}^{\infty}\beta^t f\left(\chi_t^r, \chi_{t-1}^r, z_t^r\right).$$

Suppose that renter knows in period -1 its initial bond holdings (b_{-1}^r). Suppose also that there exist two constants $\delta < 1/\beta$ and such that, for each period $t \geq 0$, for all $m, n \in \{1, 2, \cdots, 11\}$, and for $\tau = 0, 1$,

$$E_{-1}\left|\varrho_{m,t}\varrho_{n,t+\tau}\right| < \delta^t A.$$

Then, Proposition 3 of MW (2023) appendix implies that after the second-order Taylor approximation of f at the non-stochastic steady state, the loss in expected utility when the law of motion for the actions differs from the law of motion for the optimal actions under perfect information is given by

Optimal actions under perfect information: $\left\{\chi_t^{r,*}\right\}_{t=0}^{\infty}$ with a initial condition $\chi_{-1}^{r,*} = \left(b_{-1}^r, 0\right)'$ and

$$E_t\left[\theta_0^r + \Theta_{-1}^r\chi_{t-1}^{r,*} + \Theta_0^r\chi_t^{r,*} + \Theta_1^r\chi_{t+1}^{r,*} + \Phi_0^r z_t^r + \Phi_1^r z_{t+1}^r\right] = 0$$

where θ_0^r is the vector of first derivatives of g w.r.t. χ_t^r at the non-stochastic steady state, Θ_{-1}^r is the matrix of second derivatives of g w.r.t. χ_t^r and χ_{t-1}^r at the non-stochastic steady state, Φ_0^r is the matrix of second derivatives of g w.r.t. χ_t^r and z_t^r at the non-stochastic steady state, and Φ_1^r is the matrix of second derivatives of g w.r.t. χ_t^r and z_{t+1}^r at the non-stochastic steady state. In our setup, these objects are defined as follows:

$$\Theta_{-1}^r = \begin{pmatrix} \frac{1}{\beta}\left(\frac{1}{\bar{C}^r}\right)^2, & 0 \\ \frac{1}{\beta}\frac{\psi}{C_t^r}, & 0 \end{pmatrix}$$

$$\Theta_0^r = \begin{pmatrix} -\left(\frac{1}{\bar{C}^r}\right)^2\left(1+\frac{1}{\beta}\right), & -\frac{\psi}{\bar{C}^r} \\ -\frac{\psi}{\bar{C}^r}, & -\psi\left(1+\psi\right) \end{pmatrix}$$

$$\Theta_1^r = \begin{pmatrix} \left(\frac{1}{\bar{C}^r}\right)^2, & \frac{\psi}{\bar{C}^r} \\ 0, & 0 \end{pmatrix}$$

$$\Phi_0^r = \begin{pmatrix} 0, & \left(\frac{1}{\bar{C}^r}\right)^2\bar{\varpi}\bar{N}^r, & -\frac{\psi}{\bar{C}^r}, & 0 \\ 0, & \psi\frac{1}{\bar{C}^r}\bar{\varpi}\bar{N}^r, & -\psi\left(1+\psi\right), & 0 \end{pmatrix}$$

$$\Phi_1^r = \begin{pmatrix} -\frac{1}{\bar{C}^r}, & -\left(\frac{1}{\bar{C}^r}\right)^2\bar{\varpi}\bar{N}^r, & \frac{\psi}{\bar{C}^r}, & \frac{1}{\bar{C}^r} \\ 0, & 0, & 0, & 0 \end{pmatrix}$$

Then, we now have

$$E_t\left[\Theta_{-1}^r\begin{pmatrix} b_{t-1}^{r,*} \\ s_{t-1}^{r,*}\end{pmatrix} + \Theta_0^r\begin{pmatrix} b_t^{r,*} \\ s_t^{r,*}\end{pmatrix} + \Theta_1^r\begin{pmatrix} b_{t+1}^{r,*} \\ s_{t+1}^{r,*}\end{pmatrix} + \Phi_0^r\begin{pmatrix}\pi_t \\ p_t^s \\ r_{t-1}\end{pmatrix} + \Phi_1^r\begin{pmatrix}\pi_{t+1} \\ q_{t+1} \\ r_t\end{pmatrix}\right] = 0 \tag{D.8}$$

Notice that from the log-linearized budget constraint of renter, we can derive the renter's consumption in the full information model as follows:

$$c_t^{r,*} = \frac{1}{\bar{C}^r}\left[\frac{1}{\beta}b_{t-1}^{r,*} - b_t^{r,*} + \bar{\varpi}\bar{N}^r w_t - C_t^r\psi\left(p_t^s + s_t^{r,*}\right)\right]$$

Then, we can derive each entry of the matrix equation (D.8) as follows:

- The first entry is
$$0 = c_t^{r,*} - c_{t+1}^{r,*} + \left(r_t - \pi_{t+1}\right)$$

- The second entry is

$$\bar{C}^r\left(s_t^r + p_t^s\right) = \frac{1}{\beta}b_{t-1}^r - b_t^r + \bar{\varpi}\bar{N}^r w_t - \bar{C}^r\psi\left(s_t^r + p_t^s\right)$$

Now we have

$$c_t^{r,*} = \frac{1}{\bar{C}^r}\left[\frac{1}{\beta}b_{t-1}^{r,*} - b_t^{r,*} + \varpi\bar{N}^r w_t - C_t^r\psi\left(p_t^s + s_t^{r,*}\right)\right] \tag{D.9}$$

$$c_{t+1}^{r,*} = \frac{1}{\bar{C}^r}\left[\frac{1}{\beta}b_t^{r,*} - b_{t+1}^{r,*} + \varpi\bar{N}^r w_{t+1} - C_t^r\psi\left(p_{t+1}^s + s_{t+1}^{r,*}\right)\right]$$

Then,

$$0 = c_t^{r,*} - c_{t+1}^{r,*} + (r_t - \pi_{t+1}) \tag{D.10}$$

$$c_t^{r,*} = s_t^{r,*} + p_t^s \tag{D.11}$$

Then, combine Equation (D.11) with Equation (D.9) to get

$$\bar{C}^r\left(1+\psi\right)c_t^{r,*} = \frac{1}{\beta}b_{t-1}^{r,*} - b_t^{r,*} + \varpi\bar{N}^r w_t$$

which implies

$$\bar{C}^r\left(1+\psi\right)\sum_{s=t}^{t+N}\beta^{s-t}c_s^{r,*} = \frac{1}{\beta}b_{t-1}^{r,*} + \varpi\bar{N}^r\sum_{s=t}^{t+N}\beta^{s-t}w_s - \beta^N b_{t+N}^{r,*}.$$

Taking the expectation $E_t\left[\cdot\right]$ and the limit as $N \to \infty$ and using the transversality condition, we get

$$\bar{C}^r\left(1+\psi\right)\sum_{s=t}^{\infty}\beta^{s-t}E_t\left[c_s^{r,*}\right] = \frac{1}{\beta}b_{t-1}^{r,*} + \varpi\bar{N}^r\sum_{s=t}^{t+N}\beta^{s-t}w_s \tag{D.12}$$

Then, using Equation (D.10) and the law of iterated expectations, we get

$$\begin{aligned}
c_t^{r,*} &= c_t^{r,*}\\
c_{t+1}^{r,*} &= c_t^{r,*} + (r_t - \pi_{t+1})\\
c_{t+2}^{r,*} &= c_t^{r,*} + (r_t - \pi_{t+1}) + (r_{t+1} - \pi_{t+2})\\
c_{t+3}^{r,*} &= c_t^{r,*} + (r_t - \pi_{t+1}) + (r_{t+1} - \pi_{t+2}) + (r_{t+2} - \pi_{t+3})\\
&\vdots\\
\sum_{s=t}^{\infty}\beta^{s-t}E_t\left[c_s^{r,*}\right] &= \frac{1}{1-\beta}c_t^{r,*} + \frac{\beta}{1-\beta}\sum_{s=t}^{\infty}\beta^{s-t}E_t\left[r_s - \pi_{s+1}\right]
\end{aligned}$$

$$0 = c_t^{r,*} - E_t c_{t+1}^{r,*} + (r_t - E_t\pi_{t+1})$$

$$c_t^{r,*} = s_t^{r,*} + p_t^s$$
$$\bar{C}^r c_t^{r,*} = \frac{1}{(1+\psi)}\left(\frac{1}{\beta} b_{t-1}^{r,*} - b_t^{r,*} + \bar{w}\bar{N}^r w_t\right)$$

Then, we now have a system of two equations

$$\frac{1}{\beta} b_{t-1}^{r,*} - b_t^{r,*} - \bar{C}^r (1+\psi) s_t^{r,*} = \bar{C}^r (1+\psi) p_t^s - \bar{w}\bar{N}^r w_t$$

$$b_t^{r,*} - b_{t-1}^{r,*} = \bar{w}\bar{N}^r \left(w_t - (1-\beta) \sum_{s=t}^{t+N} \beta^{s-t} w_s \right) + \bar{C}^r (1+\psi) \beta \sum_{s=t}^{\infty} \beta^{s-t} E_t \left[r_s - \pi_{s+1} \right]$$

which characterizes the renter's optimal allocations under the full information rational expectations.

Now, we can use a change of variables approach to derive a DRIP which is applicable to solution method in Afrouzi and Yang (2021). Formally, we use Proposition 4 of the appendix in MW (2023) to show that

$$\begin{aligned}
&\sum_{t=0}^{\infty} \beta^t \left[\frac{1}{2} \left(\chi_t^r - \chi_t^{r,*}\right)' \Theta_0^r \left(\chi_t^r - \chi_t^{r,*}\right) + \left(\chi_t^r - \chi_t^{r,*}\right)' \Theta_1^r \left(\chi_{t+1}^r - \chi_{t+1}^{r,*}\right) \right] \\
=&\sum_{t=0}^{\infty} \beta^t \left[\frac{1}{2} \left(\tilde{x}_t^r - \tilde{x}_t^{r,*}\right)' \tilde{\Theta}^r \left(\tilde{x}_t^r - \tilde{x}_t^{r,*}\right) \right].
\end{aligned}$$

In our model setup,

$$\tilde{x}_t^r - \tilde{x}_t^{r,*} = \begin{pmatrix} \left(b_t^r - b_t^{r,*}\right) - \left(b_{t-1}^r - b_{t-1}^{r,*}\right) \\ \frac{1}{\beta}\left(b_{t-1}^r - b_{t-1}^{r,*}\right) - \left(b_t^r - b_t^{r,*}\right) - \bar{C}^r (1+\psi) \left(s_t^r - s_t^{r,*}\right) \end{pmatrix}$$

and

$$\tilde{\Theta}^r = \begin{pmatrix} -\left(\frac{1}{1+\psi}\right) \frac{1}{\beta} \left(\frac{1}{\bar{C}^r}\right)^2 & 0 \\ 0 & -\frac{\psi}{1+\psi} \left(\frac{1}{\bar{C}^r}\right)^2 \end{pmatrix}.$$

To show this, the the loss in expected utility when the law of motion for the actions differs from the law of motion for the optimal actions under perfect information is given by:

$$\begin{aligned}
&\frac{1}{2} \left(\chi_t^r - \chi_t^{r,*}\right)' \Theta_0^r \left(\chi_t^r - \chi_t^{r,*}\right) + \left(\chi_t^r - \chi_t^{r,*}\right)' \Theta_1^r \left(\chi_{t+1}^r - \chi_{t+1}^{r,*}\right) \\
=&-\frac{1}{2} \left(\frac{1}{1+\psi}\right) \left(\frac{1}{\bar{C}^r}\right)^2 \left(\tilde{x}_{1,t+1}^r - \tilde{x}_{1,t+1}^{r,*}\right)^2 \\
&-\frac{1}{2} \left(\frac{\psi}{1+\psi}\right) \left(\frac{1}{\bar{C}^r}\right)^2 \left(\tilde{x}_{2,t}^r - \tilde{x}_{2,t}^{r,*}\right)^2
\end{aligned}$$

$$+\frac{1}{2}\left(\frac{1}{1+\psi}\right)\left(\frac{1}{\bar{C}^r}\right)^2\left[(b^r_{t+1}-b^{r,*}_{t+1})^2-\frac{1}{\beta}(b^r_t-b^{r,*}_t)^2\right]$$
$$+\frac{1}{2}\left(\frac{\psi}{1+\psi}\right)\frac{1}{\beta}\left(\frac{1}{\bar{C}^r}\right)^2\left[(b^r_t-b^{r,*}_t)^2-\frac{1}{\beta}(b^r_{t-1}-b^{r,*}_{t-1})^2\right]$$
$$-\frac{\psi}{1+\psi}\left(\frac{1}{\bar{C}^r}\right)^2\left[(b^r_t-b^{r,*}_t)\left(\tilde{x}^r_{2,t+1}-\tilde{x}^{r,*}_{2,t+1}\right)-\frac{1}{\beta}(b^r_{t-1}-b^{r,*}_{t-1})\left(\tilde{x}^r_{2,t}-\tilde{x}^{r,*}_{2,t}\right)\right]$$

Then, using $\tilde{x}_{2,0}-\tilde{x}^*_{2,0}=b^o_0-b^{o,*}_0$

$$\sum_{t=0}^{T}\beta^t\left[\frac{1}{2}(\chi^r_t-\chi^{r,*}_t)'\,\Theta^r_0\,(\chi^r_t-\chi^{r,*}_t)+(\chi^r_t-\chi^{r,*}_t)'\,\Theta^r_1\,(\chi^r_{t+1}-\chi^{r,*}_{t+1})\right]$$
$$=\sum_{t=0}^{T}\beta^t\left[-\frac{1}{2}\left(\frac{1}{1+\psi}\right)\frac{1}{\beta}\left(\frac{1}{\bar{C}^r}\right)^2\left(\tilde{x}^r_{1,t}-\tilde{x}^{r,*}_{1,t}\right)^2-\frac{1}{2}\frac{\psi}{1+\psi}\left(\frac{1}{\bar{C}^r}\right)^2\left(\tilde{x}^r_{2,t}-\tilde{x}^{r,*}_{2,t}\right)^2\right]$$
$$-\beta^T\frac{1}{2}\left(\frac{1}{1+\psi}\right)\frac{1}{\beta}\left(\frac{1}{\bar{C}^r}\right)^2\left(\tilde{x}^r_{1,T+1}-\tilde{x}^{r,*}_{1,T+1}\right)^2$$
$$+\beta^T\frac{1}{2}\left(\frac{1}{1+\psi}\right)\left(\frac{1}{\bar{C}^r}\right)^2(b^r_{T+1}-b^{r,*}_{T+1})^2$$
$$+\beta^T\frac{1}{2}\left(\frac{\psi}{1+\psi}\right)\frac{1}{\beta}\left(\frac{1}{\bar{C}^r}\right)^2(b^r_T-b^{r,*}_T)^2$$
$$-\beta^T\frac{\psi}{1+\psi}\left(\frac{1}{\bar{C}^r}\right)^2(b^r_T-b^{r,*}_T)\left(\tilde{x}^r_{2,T+1}-\tilde{x}^{r,*}_{2,T+1}\right)$$

Taking the expectation and taking the limit as $T\to\infty$,

$$\sum_{t=0}^{\infty}\beta^t\left[\frac{1}{2}(\chi^r_t-\chi^{r,*}_t)'\,\Theta^r_0\,(\chi^r_t-\chi^{r,*}_t)+(\chi^r_t-\chi^{r,*}_t)'\,\Theta^r_1\,(\chi^r_{t+1}-\chi^{r,*}_{t+1})\right]$$
$$=\sum_{t=0}^{\infty}\beta^t\left[-\frac{1}{2}\left(\frac{1}{1+\psi}\right)\frac{1}{\beta}\left(\frac{1}{\bar{C}^r}\right)^2\left(\tilde{x}^r_{1,t}-\tilde{x}^{r,*}_{1,t}\right)^2-\frac{1}{2}\frac{\psi}{1+\psi}\left(\frac{1}{\bar{C}^r}\right)^2\left(\tilde{x}^r_{2,t}-\tilde{x}^{r,*}_{2,t}\right)^2\right]$$
$$=\sum_{t=0}^{\infty}\beta^t\left[\frac{1}{2}(\tilde{x}^r_t-\tilde{x}^{r,*}_t)'\,\tilde{\Theta}^r\,(\tilde{x}^r_t-\tilde{x}^{r*}_t)\right]$$

where

$$\tilde{\Theta}^r=\begin{pmatrix}-\left(\frac{1}{1+\psi}\right)\frac{1}{\beta}\left(\frac{1}{\bar{C}^r}\right)^2 & 0\\ 0 & -\frac{\psi}{1+\psi}\left(\frac{1}{\bar{C}^r}\right)^2\end{pmatrix}$$

and

$$\tilde{x}_t^{r,*} = \begin{pmatrix} b_t^{r,*} - b_{t-1}^{r,*} \\ \frac{1}{\beta} b_{t-1}^{r,*} - b_t^{r,*} - \bar{C}^r (1+\psi) s_t^{r,*} \end{pmatrix}$$
$$= \begin{pmatrix} \varpi \bar{N}^r \left(w_t - (1-\beta) \sum_{s=t}^{t+N} \beta^{s-t} w_s \right) + \bar{C}^r (1+\psi) \beta \sum_{s=t}^{\infty} \beta^{s-t} E_t \left[r_s - \pi_{s+1} \right] \\ \bar{C}^r (1+\psi) p_t^s - \varpi \bar{N}^r w_t \end{pmatrix}$$

$$\bar{C}^r c_t^{r,*} = \frac{1}{(1+\psi)} \left(\frac{1}{\beta} b_{t-1}^{r,*} - b_t^{r,*} + \varpi \bar{N}^r w_t \right)$$

Appendix D.3. Solution algorithm

1. Let $\mathbf{U}_t = \left(\varepsilon_t, \varepsilon_{t-1}, \varepsilon_{t-2}, \cdots, \varepsilon_{t-T}\right)'$. Then, as in Afrouzi and Yang (2021), we define an MA representation of the state space for the homeowner's problem as:

$$\mathbf{U}_t = \mathbf{A} \mathbf{U}_{t-1} + \mathbf{Q} \varepsilon_t$$

   where $\mathbf{A} = \mathbf{M} = \begin{pmatrix} \mathbf{0}_{1\times T}, & 0 \\ \mathbf{I}_{T\times T}, & \mathbf{0}_{T\times 1} \end{pmatrix}$ is a shift matrix and $\mathbf{Q} = \mathbf{e}_1$ is a $(T+1\times 1)$ vector whose first element is one and others are zero.

2. We start by gussing $\left\{\pi_t, p_t^s, q_t, r_t^F\right\}$ as follows:

$$\begin{aligned} \pi_t &= \mathbf{G}_{\pi}' \mathbf{U}_t \\ p_t^s &= \mathbf{G}_{p^s}' \mathbf{U}_t \\ q_t &= \mathbf{G}_q' \mathbf{U}_t \\ r_t^F &= \mathbf{G}_{R^F}' \mathbf{U}_t \end{aligned}$$

   Then, we get $\mathbf{G}_w, \mathbf{G}_R, \mathbf{G}_{R^M}$ as follows:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa w_t$$
$$\mathbf{G}_w = \frac{1}{\kappa} \left(\mathbf{I} - \beta \mathbf{M}' \right) \mathbf{G}_{\pi}$$

   where $\mathbf{I}$ is an identify matrix and $\kappa = \frac{(1-\omega)(1-\omega\beta)}{\omega}$.

$$\begin{aligned} r_t &= \rho^R r_{t-1} + \left(1 - \rho^R\right) \phi_{\pi} \pi_t + \varepsilon_{t-k} \\ &= (\mathbf{I} - \mathbf{M})^{-1} \left(\phi_{\pi} \mathbf{G}_{\pi} + \mathbf{M}^k \mathbf{e}_1 \right)' \mathbf{U}_t \\ &= \mathbf{G}_R' \mathbf{U}_t \end{aligned}$$

and

$$\begin{aligned} r_t^M &= (1-\gamma)\, r_{t-1}^M + \gamma r_t^F \\ &= \mathbf{G}_{R^M}' \mathbf{U}_t \end{aligned}$$

where

$$\mathbf{G}_{R^M} = \left(\frac{1}{\gamma}\mathbf{I} - \frac{1-\gamma}{\gamma}\mathbf{M}\right)^{-1} \mathbf{G}_{R^F}$$

3. Solve rational inattention problem for homeowners:

   (a) Homeowner's problem can be written as

$$\begin{aligned} &\min \sum_{t=0}^{\infty} \beta^t \left[\frac{1}{2}\left(\tilde{x}_t^o - \tilde{x}_t^{o,*}\right)' \tilde{\Theta}^o \left(\tilde{x}_t^o - \tilde{x}_t^{o,*}\right)\right] + \lambda \sum_{t=0}^{\infty} \mathbf{I}\left(\tilde{x}_t^o; \tilde{x}_t^{o,*} | \tilde{x}^{o,t-1}\right) \\ &s.t. \tilde{x}_t^{o,*} = \mathbf{G}_o' \mathbf{U}_t \\ &\quad \mathbf{U}_t = \mathbf{M}\mathbf{U}_{t-1} + \mathbf{e}_1 \varepsilon_t \\ &\quad x_t^o = \mathbb{E}\left[\tilde{x}_t^{o,*} | \mathcal{I}_t^o\right] \\ &\quad \tilde{x}^{o,t} = \tilde{x}^{o,t-1} \cup \tilde{x}_t^o \end{aligned}$$

   Notice that in our setup,

$$\frac{1}{2}\left(\tilde{x}_t^o - \tilde{x}_t^{o,*}\right)' \tilde{\Theta}^o \left(\tilde{x}_t^o - \tilde{x}_t^{o,*}\right) = \frac{1}{2}\left(\mathbf{U}_{t|t} - \mathbf{U}_t\right)' \mathbf{G}_o \tilde{\Theta}^o \mathbf{G}_o' \left(\mathbf{U}_{t|t} - \mathbf{U}_t\right)$$

   (b) Then, as shown in Lemma 2.4 a of Afrouzi and Yang (2021), the DRIP for homeowner can be written as

$$\begin{aligned} &\min \sum \beta^t \left[tr\left(\Omega^o \Sigma_{t|t}^o\right) + \omega \ln\left(\left|\Sigma_{t|t-1}^o\right|\right) - \omega \ln\left(\left|\Sigma_{t|t}^o\right|\right)\right] \\ &s.t. \Sigma_{t+1|t}^o = \mathbf{M}\Sigma_{t|t}^o \mathbf{M}' + \mathbf{e}_1 \mathbf{e}_1' \\ &\quad \Sigma_{t|t-1}^o - \Sigma_{t|t}^o \succeq 0 \end{aligned}$$

   where $\Sigma_{t|t}^o = var\left(\mathbf{U}_t | \mathcal{I}_t^o\right)$ is the posterior covariance matrix given information set $\mathcal{I}_t$ for homeowner, $\Sigma_{t|t-1}^o = var\left(\mathbf{U}_t | \mathcal{I}_{t-1}^o\right)$ is the prior covariance matrix, $\succeq$ denotes positive semidefiniteness, and $\Omega^o = \mathbf{G}_o \tilde{\Theta}^o \mathbf{G}_o'$ is the benefit matrix where

$$\tilde{\Theta} = \begin{pmatrix} -\frac{\psi_b}{\bar{C}^o}, & 0 & 0 \\ 0, & -\left(\frac{1}{1+\psi}\right)\frac{1}{\beta}\left(\frac{1}{\bar{C}^o}\right)^2, & 0 \\ 0, & 0, & -\left(\frac{\psi}{1+\psi}\right)\left(\frac{1}{\bar{C}^o}\right)^2 \end{pmatrix}.$$

(c) The optimal action under the full information satisfies

$$\begin{aligned} \tilde{x}_t^{o,*} &= \begin{pmatrix} b_t^{o,*} \\ \left(b_t^{o,*} - \bar{d}d_t^*\right) - \left(b_{t-1}^{o,*} - \bar{d}d_{t-1}^*\right) \\ \frac{1}{\beta}\left(b_{t-1}^{o,*} - \bar{d}d_{t-1}^*\right) - \left(b_t^{o,*} - \bar{d}d_t^*\right) - \bar{C}^o\left(1+\psi\right)s_t^{o,*} \end{pmatrix} \\ &= \begin{pmatrix} \frac{1}{\psi_b}\left[\frac{1}{\theta}\left(p_t^s - q_t\right) - \beta\frac{1-\gamma}{\theta}\left(p_{t+1}^s - q_{t+1}\right) + \left(r_t - r_t^M\right) + \frac{1-\gamma}{1-\beta(1-\gamma)}\left(\left(r_{t-1}^M - r_t^F\right) - \beta\left(r_t^M - r_{t+1}^F\right)\right)\right] \\ \varpi\bar{N}^o\left(w_t - (1-\beta)\sum_{s=t}^{\infty}\beta^{s-t}E_t w_s\right) - \bar{D}^o\left(r_{t-1}^M - \pi_t\right) + \left(\frac{\gamma}{\theta}\bar{D}^o - \bar{C}^o\beta\frac{1-\gamma}{\theta}\left(1+\psi\right)\right)\left(p_t^s - q_t\right) \\ \quad + \left(\bar{D}^o\left(1-\beta\right) + \bar{C}^o\beta\left(1+\psi\right)\right)\sum_{s=t}^{\infty}\beta^{s-t}E_t\left[\left(r_s^M - \pi_{s+1}\right) - \frac{\gamma}{\theta}\left(p_s^S - q_s\right)\right] \\ \quad -\bar{C}^o\left(1+\psi\right)\frac{\beta(1-\gamma)}{1-\beta(1-\gamma)}\sum_{s=t}^{\infty}\beta^{s-t}E_t\left[\left(r_{s-1}^M - r_s^F\right) - \beta\left(r_s^M - r_{s+1}^F\right)\right] \\ \frac{1}{\beta}\bar{D}^o\left(r_{t-1}^M - \pi_t\right) - \frac{\gamma}{\theta}\bar{D}^o\left(p_t^s - q_t\right) - \varpi\bar{N}^o w_t + \bar{C}^o\left(1+\psi\right)p_t^s \end{pmatrix}. \end{aligned}$$

which implies that

$$\tilde{x}_t^{o,*} = \mathbf{G}_o'\mathbf{U}_t$$

where

$$\begin{aligned} \mathbf{G}_o\left(:,1\right) =& \frac{1}{\psi_b}\Bigg\{\frac{1}{\theta}\left(\left(\mathbf{I} - \beta\left(1-\gamma\right)\mathbf{M}'\right)\left(\mathbf{G}_{p^s} - \mathbf{G}_q\right)\right) \\ & + \left(\left(\mathbf{G}_R - \mathbf{G}_{R^M}\right) + \frac{1-\gamma}{1-\beta\left(1-\gamma\right)}\left(\left(\mathbf{M}\mathbf{G}_{R^M} - \mathbf{G}_{R^f}\right) - \beta\left(\mathbf{G}_{R^M} - \mathbf{M}'\mathbf{G}_{R^f}\right)\right)\right)\Bigg\} \\ \mathbf{G}_o\left(:,2\right) =& \varpi\bar{N}^o\left(\mathbf{I} - \left(1-\beta\right)\left(\mathbf{I} - \beta\mathbf{M}'\right)^{-1}\right)\mathbf{G}_w - \bar{D}^o\left(\mathbf{M}\mathbf{G}_{R^M} - \mathbf{G}_\pi\right) \\ & + \left(\frac{\gamma}{\theta}\bar{D}^o - \bar{C}^o\beta\frac{1-\gamma}{\theta}\left(1+\psi\right)\right)\left(\mathbf{G}_{p^s} - \mathbf{G}_q\right) \\ & + \left(\bar{D}^o\left(1-\beta\right) + \bar{C}^o\beta\left(1+\psi\right)\right)\left(\mathbf{I} - \beta\mathbf{M}'\right)^{-1}\left(\left(\mathbf{G}_R - \mathbf{M}'\mathbf{G}_\pi\right) - \frac{\gamma}{\theta}\left(\mathbf{G}_{p^s} - \mathbf{G}_q\right)\right) \\ & - \bar{C}^o\left(1+\psi\right)\frac{\beta\left(1-\gamma\right)}{1-\beta\left(1-\gamma\right)}\left(\mathbf{I} - \beta\mathbf{M}'\right)^{-1}\left(\left(\mathbf{M}\mathbf{G}_{R^M} - \mathbf{G}_{R^F}\right) - \beta\left(\mathbf{G}_{R^M} - \mathbf{M}'\mathbf{G}_{R^F}\right)\right) \\ \mathbf{G}_o\left(:,3\right) =& -\frac{\gamma}{\theta}\bar{d}\left(\mathbf{G}_{p^s} - \mathbf{G}_q\right) - \varpi\bar{N}^o\mathbf{G}_w + \frac{1}{\beta}\bar{d}\left(\mathbf{M}\mathbf{G}_R - \mathbf{G}_\pi\right) + \bar{C}^o\left(1+\psi\right)\mathbf{G}_{p^s} \end{aligned}$$

(d) As $\tilde{\Theta}$ matrix is a diagonal, we know that the optimal action under the rational inattention satisfies

$$\tilde{x}_t^o = \mathbf{G}_o'\mathbf{U}_{t|t}$$

where $\mathbf{U}_{t|t} = \mathbb{E}\left[\mathbf{U}_t|\mathcal{I}_t^o\right]$. From this, we can get $\{\mathbf{G}_{b^o}, \mathbf{G}_{d^o}, \mathbf{G}_{s^o}\}$

$$
\begin{aligned}
b_t^o &= \mathbf{G}_o\left(:,1\right)' \mathbf{U}_{t|t} = \mathbf{G}_{b^o}' \mathbf{U}_t \\
d_t &= \frac{1}{\bar{d}}\left(\mathbf{G}_{b^o} - \left(\mathbf{I} - \mathbf{M}\right)^{-1} \mathbf{X}' \mathbf{G}_o\left(:,2\right)\right)' \mathbf{U}_t = \mathbf{G}_{d^o}' \mathbf{U}_t \\
s_t^o &= \frac{1}{\bar{C}^o\left(1+\psi\right)}\left[\left(\frac{1}{\beta}\mathbf{M} - \mathbf{I}\right)\left(\mathbf{G}_{b^o} - \bar{d}\mathbf{G}_d\right) - \mathbf{X}'\mathbf{G}_o\left(:,3\right)\right]' \mathbf{U}_t = \mathbf{G}_{s^o}' \mathbf{U}_t
\end{aligned}
$$

Note that using the Kalman updating equation, we get

$$
\begin{aligned}
\mathbf{U}_{t|t} &= \left(\mathbf{I} - \mathbf{K}\mathbf{Y}'\right)\mathbf{U}_{t|t-1} + \mathbf{K}\mathbf{Y}'\mathbf{U}_t \\
&= \left(\mathbf{I} - \mathbf{K}\mathbf{Y}'\right)\mathbf{A}\mathbf{U}_{t-1|t-1} + \mathbf{K}\mathbf{Y}'\mathbf{U}_t \\
&= \left\{\left(\mathbf{I} - \mathbf{K}\mathbf{Y}'\right)\mathbf{A}\right\}^2 \mathbf{U}_{t-2|t-2} + \left(\mathbf{I} - \mathbf{K}\mathbf{Y}'\right)\mathbf{A}\mathbf{K}\mathbf{Y}'\mathbf{U}_{t-1} + \mathbf{K}\mathbf{Y}'\mathbf{U}_t \\
&\vdots \\
&= \mathbf{K}\mathbf{Y}'\mathbf{U}_t + \left(\mathbf{I} - \mathbf{K}\mathbf{Y}'\right)\mathbf{A}\mathbf{K}\mathbf{Y}'\mathbf{M}'\mathbf{U}_t + \left\{\left(\mathbf{I} - \mathbf{K}\mathbf{Y}'\right)\mathbf{A}\right\}^2 \mathbf{K}\mathbf{Y}'\left(\mathbf{M}'\right)^2 \mathbf{U}_t + \cdots \\
&= \sum_{j=0}^{\infty}\left\{\left(\mathbf{I} - \mathbf{K}\mathbf{Y}'\right)\mathbf{A}\right\}^j \mathbf{K}\mathbf{Y}'\left(\mathbf{M}'\right)^j \mathbf{U}_t \\
&= \mathbf{X}^o \mathbf{U}_t
\end{aligned}
$$

where $\mathbf{K} = \Sigma_{-1}^o \mathbf{Y}\left(\mathbf{Y}'\Sigma_{-1}^o\mathbf{Y} + \Sigma_z\right)^{-1}$ is the implied Kalman gain, Σ_{-1}^o is the steady-state prior covariance matrix, and $\mathbf{Y}$ is the signal matrix from homeowner's DRIP. With this, we also get $\mathbf{G}_{c^o}$ using

$$
\begin{aligned}
c_t^o &= s_t^o + \mathbb{E}_t^o\left[p_t^s|\mathcal{I}_t\right] \\
\mathbf{G}_{c^o}'\mathbf{U}_t &= \mathbf{G}_{s^o}'\mathbf{U}_t + \mathbf{G}_{p^s}'\mathbf{U}_{t|t} \\
\mathbf{G}_{c^o} &= \mathbf{G}_{s^o} + \mathbf{X}^{o'}\mathbf{G}_{p^s}.
\end{aligned}
$$

4. Solve rational inattention problem for renters:

   (a) Renter's problem can be written as

$$
\begin{aligned}
&\min \sum_{t=0}^{\infty} \beta^t \left[\frac{1}{2}\left(\tilde{x}_t^r - \tilde{x}_t^{r,*}\right)' \tilde{\Theta}^r \left(\tilde{x}_t^r - \tilde{x}_t^{r,*}\right)\right] + \lambda \sum_{t=0}^{\infty} \mathbf{I}\left(\tilde{x}_t^r; \tilde{x}_t^{r,*}|\tilde{x}^{r,t-1}\right) \\
&s.t. \tilde{x}_t^* = \mathbf{G}_r'\mathbf{U}_t \\
&\quad \mathbf{U}_t = \mathbf{M}\mathbf{U}_{t-1} + \mathbf{e}_1\varepsilon_t \\
&\quad x_t^r = \mathbb{E}\left[\tilde{x}_t^{r,*}|\mathcal{I}_t^r\right]
\end{aligned}
$$

$$\tilde{x}^{r,t} = \tilde{x}^{r,t-1} \cup \tilde{x}_t^r$$

Note that

$$\frac{1}{2}\left(\tilde{x}_t^r - \tilde{x}_t^{r,*}\right)' \tilde{\Theta}\left(\tilde{x}_t^r - \tilde{x}_t^{r,*}\right) = \frac{1}{2}\left(\mathbf{U}_{t|t} - \mathbf{U}_t\right)' \mathbf{G}_r \tilde{\Theta}^r \mathbf{G}_r' \left(\mathbf{U}_{t|t} - \mathbf{U}_t\right)$$

(b) Then, as shown in Lemma 2.4 of Afrouzi and Yang (2021), the DRIP for renter can be written as

$$\begin{aligned}
&\min \sum \beta^t \left[tr\left(\Omega^r \Sigma_{t|t}^r\right) + \omega \ln\left(\left|\Sigma_{t|t-1}^r\right|\right) - \omega \ln\left(\left|\Sigma_{t|t}^r\right|\right)\right] \\
&s.t. \Sigma_{t+1|t}^r = \mathbf{M}\Sigma_{t|t}^r \mathbf{M}' + \mathbf{e}_1 \mathbf{e}_1' \\
&\quad \Sigma_{t|t-1}^r - \Sigma_{t|t}^r \geq 0
\end{aligned}$$

where $\Sigma_{t|t}^r = var\left(\mathbf{U}_t | \mathcal{I}_t^r\right)$ is the posterior covariance matrix given information set $\mathcal{I}_t$ for renter, $\Sigma_{t|t-1}^r = var\left(\mathbf{U}_t | \mathcal{I}_{t-1}^r\right)$ is the prior covariance matrix, $\succeq$ denotes positive semidefiniteness, and $\Omega^r = \mathbf{G}_r \tilde{\Theta}^r \mathbf{G}_r'$ is the benefit matrix where

$$\tilde{\Theta}^r = \begin{pmatrix} -\left(\frac{1}{1+\psi}\right)\frac{1}{\beta}\left(\frac{1}{\bar{C}^r}\right)^2 & 0 \\ 0 & -\frac{\psi}{1+\psi}\left(\frac{1}{\bar{C}^r}\right)^2 \end{pmatrix}$$

(c) The optimal action under the full information satisfies

$$\begin{aligned}
\tilde{x}_t^{r,*} &= \begin{pmatrix} b_t^{r,*} - b_{t-1}^{r,*} \\ \frac{1}{\beta} b_{t-1}^{r,*} - b_t^{r,*} - \bar{C}^r (1+\psi) s_t^{r,*} \end{pmatrix} \\
&= \begin{pmatrix} \varpi \bar{N}^r \left(w_t - (1-\beta)\sum_{s=t}^{t+N} \beta^{s-t} w_s\right) + \bar{C}^r (1+\psi) \beta \sum_{s=t}^{\infty} \beta^{s-t} E_t\left[r_s - \pi_{s+1}\right] \\ \bar{C}^r (1+\psi) p_t^s - \varpi \bar{N}^r w_t \end{pmatrix}
\end{aligned}$$

which implies that

$$\tilde{x}_t^{r,*} = \mathbf{G}_r' \mathbf{U}_t$$

where

$$\begin{aligned}
\mathbf{G}_r(:,1) &= \varpi \bar{N}^r \left(\mathbf{I} - (1-\beta)\left(\mathbf{I} - \beta \mathbf{M}'\right)^{-1}\right) \mathbf{G}_w \\
&\quad + \bar{C}^r (1+\psi) \beta \left(\mathbf{I} - \beta \mathbf{M}'\right)^{-1} \left[\mathbf{G}_R - \mathbf{M}' \mathbf{G}_\pi\right] \\
\mathbf{G}_r(:,2) &= \bar{C}^r (1+\psi) \mathbf{G}_{p^s} - \varpi \bar{N}^r \mathbf{G}_w
\end{aligned}$$

(d) As $\tilde{\Theta}$ matrix is a diagonal, we know that the optimal action under the rational inattention satisfies

$$\tilde{x}_t^r = \mathbf{G}_r'\mathbf{U}_{t|t}$$

where $\mathbf{U}_{t|t} = \mathbb{E}\left[\mathbf{U}_t|\mathcal{I}_t^r\right]$. From this, we can get $\{\mathbf{G}_{b^r}, \mathbf{G}_{s^r}, \mathbf{G}_{c^r}\}$:

$$\begin{aligned}
b_t^r &= \left[(\mathbf{I}-\mathbf{M})^{-1}\mathbf{X}'\mathbf{G}_r(:,1)\right]'\mathbf{U}_t \\
&= \mathbf{G}_{b^r}'\mathbf{U}_t \\
s_t^r &= \frac{1}{\bar{C}^r(1+\psi)}\left[\left(\frac{1}{\beta}\mathbf{M}-\mathbf{I}\right)\mathbf{G}_{b^r} - \mathbf{X}'\mathbf{G}_r(:,2)\right]'\mathbf{U}_t \\
&= \mathbf{G}_{s^r}'\mathbf{U}_t
\end{aligned}$$

Note that using the Kalman updating equation, we get

$$\begin{aligned}
\mathbf{U}_{t|t} &= \left(\mathbf{I}-\mathbf{K}\mathbf{Y}'\right)\mathbf{U}_{t|t-1} + \mathbf{K}\mathbf{Y}'\mathbf{U}_t \\
&= \left(\mathbf{I}-\mathbf{K}\mathbf{Y}'\right)\mathbf{A}\mathbf{U}_{t-1|t-1} + \mathbf{K}\mathbf{Y}'\mathbf{U}_t \\
&= \left\{\left(\mathbf{I}-\mathbf{K}\mathbf{Y}'\right)\mathbf{A}\right\}^2\mathbf{U}_{t-2|t-2} + \left(\mathbf{I}-\mathbf{K}\mathbf{Y}'\right)\mathbf{A}\mathbf{K}\mathbf{Y}'\mathbf{U}_{t-1} + \mathbf{K}\mathbf{Y}'\mathbf{U}_t \\
&\vdots \\
&= \mathbf{K}\mathbf{Y}'\mathbf{U}_t + \left(\mathbf{I}-\mathbf{K}\mathbf{Y}'\right)\mathbf{A}\mathbf{K}\mathbf{Y}'\mathbf{M}'\mathbf{U}_t + \left\{\left(\mathbf{I}-\mathbf{K}\mathbf{Y}'\right)\mathbf{A}\right\}^2\mathbf{K}\mathbf{Y}'\left(\mathbf{M}'\right)^2\mathbf{U}_t + \cdots \\
&= \sum_{j=0}^{\infty}\left\{\left(\mathbf{I}-\mathbf{K}\mathbf{Y}'\right)\mathbf{A}\right\}^j\mathbf{K}\mathbf{Y}'\left(\mathbf{M}'\right)^j\mathbf{U}_t \\
&= \mathbf{X}^r\mathbf{U}_t
\end{aligned}$$

where $\mathbf{K} = \Sigma_{-1}^o\mathbf{Y}\left(\mathbf{Y}'\Sigma_{-1}^o\mathbf{Y}+\Sigma_z\right)^{-1}$ is the implied Kalman gain, Σ_{-1}^o is the steady-state prior covariance matrix, and $\mathbf{Y}$ is the signal matrix from renter's DRIP. With this, we also get $\mathbf{G}_{c^r}$ using

$$\begin{aligned}
c_t^r &= s_t^r + E_t^r\left[p_t^s\right] \\
&= \mathbf{G}_{s^r}'\mathbf{U}_t + \mathbf{G}_{p^s}'\mathbf{X}^r\mathbf{U}_t \\
&= \mathbf{G}_{c^r}'\mathbf{U}_t
\end{aligned}$$

5. Then, get the lender's equilibrium allocations using the market clearing conditions:

$$b_t^l = -\frac{1}{\lambda^l}\left(\lambda^o b_t^o + \lambda^r b_t^r\right)$$

$$c_t^l = \frac{1}{\lambda^l \bar{C}^l} \left(\bar{C} c_t - \lambda^o \bar{C}^o c_t^o - \lambda^r \bar{C}^r c_t^r \right)$$

$$\begin{aligned}
\mathbf{G}_{b^l} &= -\frac{1}{\lambda^l} \left(\lambda^o \mathbf{G}_{b^o} + \lambda^r \mathbf{G}_{b^r} \right) \\
\mathbf{G}_{c^l} &= \frac{1}{\lambda^l \bar{C}^l} \left(\lambda^o \mathbf{G}_c - \lambda^o \bar{C}^o \mathbf{G}_{c^o} - \lambda^r \bar{C}^r \mathbf{G}_{c^r} \right)
\end{aligned}$$

6. Update new p_t^s, q_t, π_t, r_t^F using the remaining equilibrium conditions. From lender's optimal conditions and the Taylor rule,

$$\begin{aligned}
\psi_b b_t^l &= C_t^l - E_t \left[C_{t+1}^l \right] + R_t - E_t \left[\pi_{t+1} \right] \\
\bar{C}^l C_t^l + b_t^l + \bar{l} l_t &= \bar{w} N^l w_t + \frac{1}{\beta} b_{t-1}^l + \bar{m} m_t + \bar{\mathbf{\Phi}} \mathbf{\Phi}_t^l - \bar{T} T_t \\
R_t &= \rho^R R_{t-1} + \left(1 - \rho^R \right) \phi_\pi \pi_t + \varepsilon_t \\
l_t &= q_t + H_t \\
H_t &= 0,
\end{aligned}$$

we update

$$\begin{aligned}
\mathbf{G}_R^{new} &= \psi_{b^l} \mathbf{G}_{b^l} - \left(\mathbf{I} - \mathbf{M}' \right) \mathbf{G}_{c^l} + \mathbf{M}' \mathbf{G}_\pi \\
\mathbf{G}_\pi^{new} &= \frac{1}{(1 - \rho^R)\, \phi_\pi} \left(\left(\mathbf{I} - \rho^R \mathbf{M} \right) \mathbf{G}_R^{new} - \mathbf{e}_1 \right) \\
\mathbf{G}_q^{new} &= \frac{1}{\bar{l}} \left(\bar{w} \left(N^l - \frac{1}{1 - \bar{w}} \bar{\mathbf{\Phi}} \right) \mathbf{G}_w + \left(\frac{1}{\beta} \mathbf{M} - \mathbf{I} \right) \mathbf{G}_{b^l} + \bar{m} \mathbf{G}_m - \bar{C}^l \mathbf{G}_{c^l} \right)
\end{aligned}$$

Also, from

$$\begin{aligned}
C_t^o &= E_t^o p_t^s + S_t^o \\
C_t^r &= E_t^r p_t^s + S_t^r \\
\lambda^o \bar{S} S_t &= \lambda^o \bar{S}^o S_t^o + \lambda^r \bar{S}^r S_t^r,
\end{aligned}$$

we have

$$\begin{aligned}
0 &= \lambda^o \bar{S}^o \left(C_t^o - E_t^o p_t^s \right) + \lambda^r \bar{S}^r \left(C_t^r - E_t^o p_t^s \right) \\
\mathbf{G}_{p^s} &= \left(\lambda^o \bar{S}^o \mathbf{X}_o' G_{p^s} + \lambda^r \bar{S}^r \mathbf{X}_r' \right)^{-1} \left(\lambda^o \bar{S}^o \mathbf{G}_{c^o} + \lambda^r \bar{S}^r \mathbf{G}_{c^r} \right).
\end{aligned}$$

Lastly, we update the mortgage rates using

$$0 = c_t^l - E_t c_{t+1}^l + r_t^M - E_t \pi_{t+1} + \frac{1-\gamma}{1-\beta(1-\gamma)} \left(r_t^F - r_{t-1}^M - \beta E_t r_{t+1}^F - r_t^M \right)$$
$$r_t^M = (1-\gamma) r_{t-1}^M + \gamma r_t^F$$

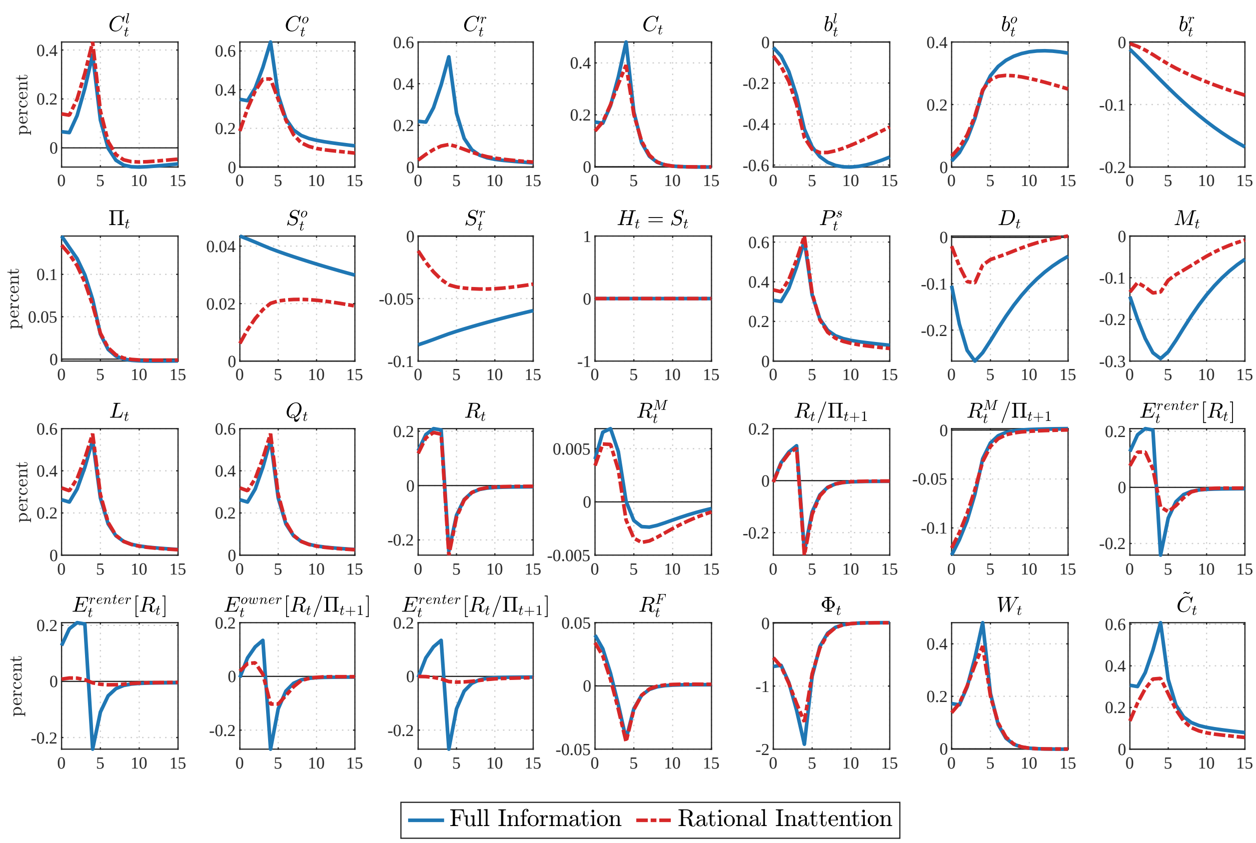
such that

$$\mathbf{G}_{R^M}^{new} = \left(\frac{1}{\gamma}\mathbf{I} - \frac{1-\gamma}{\gamma}\mathbf{M} \right)^{-1} \mathbf{G}_{R^F}^{new}$$

where

$$\left(\mathbf{I} - \beta \mathbf{M}'\right) \mathbf{G}_{R^F}^{new} = \left(\mathbf{M} - \beta \mathbf{I}\right) \mathbf{G}_{R^M} - \frac{1-\beta(1-\gamma)}{1-\gamma} \left(\left(\mathbf{I} - \mathbf{M}'\right) \mathbf{G}_{c^l} + \mathbf{G}_{R^M} - \mathbf{M}'\mathbf{G}_\pi \right).$$

Appendix D.4. Model impulse responses to a forward guidance shock



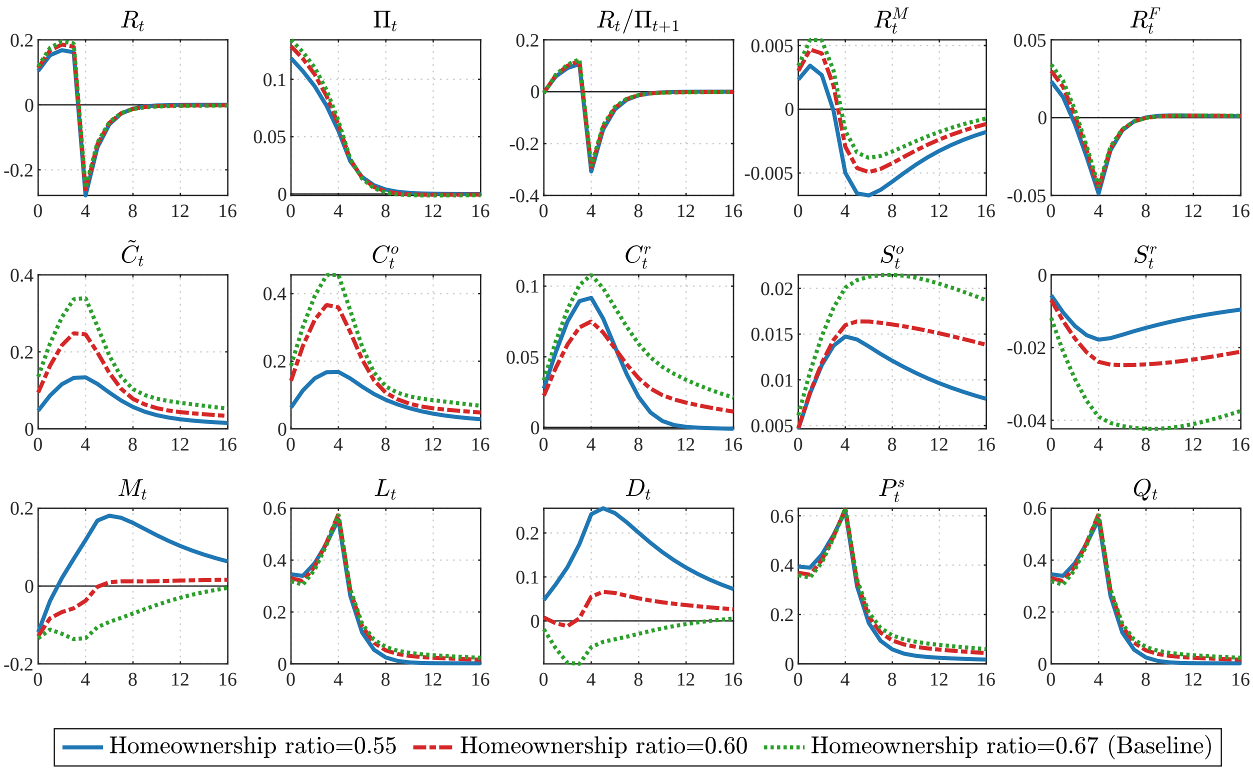
Appendix Figure D.5: Model impulse responses to a 1 S.D. 4-period ahead forward guidance shock

Notes: This figure reports the model impulse responses to a forward guidance shock that lowers the 4-period ahead interest rate by one standard deviation. The solid blue lines plot the case of full information rational expectations. The dot-dashed red lines plot the case under rational inattention.

Appendix E. Model sensitivity analyses

In this appendix, we provide more details on the model sensitivity analyses and discuss two additional analyses.

Appendix E.1. Lowering homeownership ratio



Appendix Figure E.6: Model impulse responses to a 1 S.D. 4-period ahead forward guidance shock by different homeownership ratio

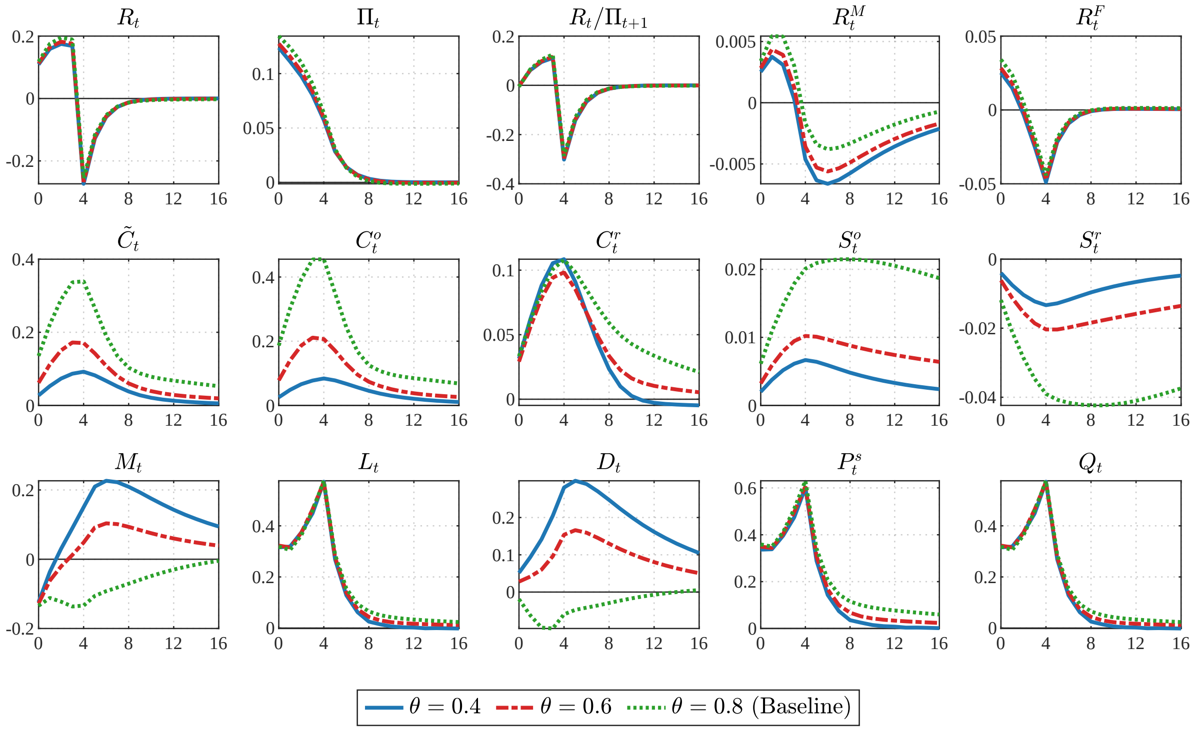
Notes: This figure reports the model impulse responses to a forward guidance shock that lowers the 4-period ahead interest rate by one standard deviation under rational inattention. The solid blue lines plot the case with a homeownership ratio of 0.55. The dot-dashed red lines plot the case with a homeownership ratio of 0.60. The dotted green lines plot the baseline case with a homeownership ratio of 0.67.

Appendix Table E.9: Welfare Costs by Homeownership Ratios

Households	(A) Total welfare costs (μ^i)	(B) Welfare costs under full-information	(C) Welfare gains from unresponsiveness	(D) Costs of attention
Panel A. Homeownership ratio= 0.67 *(Baseline)*				
Homeowner	0.2415	0.0065	0.0020	0.2370
Renter	0.0389	0.0005	0.0004	0.0388
Panel B. Homeownership ratio= 0.60				
Homeowner	0.1436	0.0062	0.0028	0.1402
Renter	0.0230	0.0009	0.0007	0.0228
Panel C. Homeownership ratio= 0.55				
Homeowner	0.0457	0.0058	0.0039	0.0438
Renter	0.0248	0.0012	0.0009	0.0245

Notes: This table shows the implicit welfare costs in economies with different homeownership ratios in responses to forward guidance shocks under rational inattention. Panels A, B, and C represent economies with homeownership ratios of 0.67 (baseline), 0.60, and 0.55 respectively. Note that Columns (A) = (B) - (C) + (D). See Equation (5) for the decomposition.

Appendix E.2. Mortgage accessibility



Appendix Figure E.7: IRFs to a 1 S.D. 4-period ahead forward guidance shock by different LTV ratios (θ)

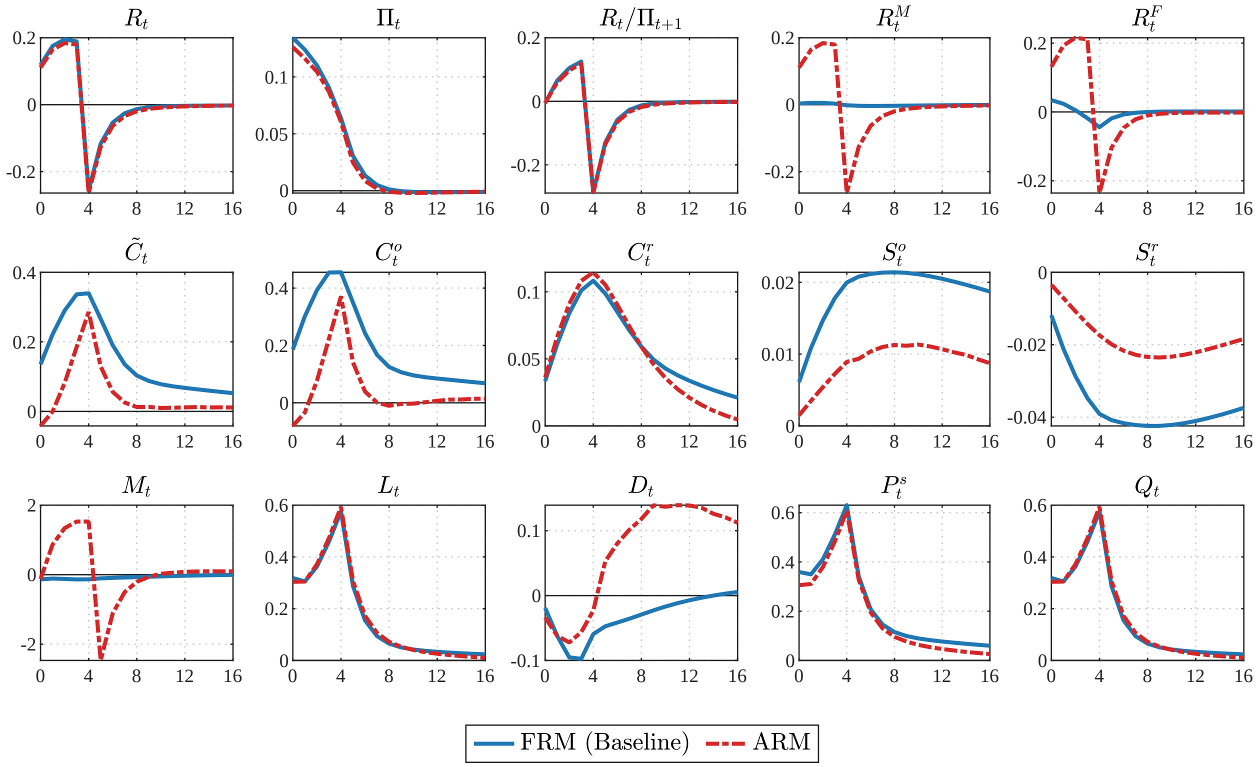
Notes: This figure reports the model impulse responses to a forward guidance shock that lowers the 4-period ahead interest rate by one standard deviation under rational inattention. The solid blue lines plot the case with a LTV ratio of 40%. The dot-dashed red lines plot the case with a LTV ratio of 60%. The dotted green lines plot the baseline case with a LTV ratio of 80%.

Appendix Table E.10: Welfare Costs by LTV Ratios

Households	(A) Total welfare costs (μ^i)	(B) Welfare costs under full-information	(C) Welfare gains from unresponsiveness	(D) Costs of attention
Panel A. $\theta = 0.8$ (Baseline)				
Homeowner	0.2415	0.0065	0.0020	0.2370
Renter	0.0389	0.0005	0.0004	0.0388
Panel B. $\theta = 0.6$				
Homeowner	0.0662	0.0053	0.0032	0.0641
Renter	0.0290	0.0008	0.0005	0.0287
Panel C. $\theta = 0.4$				
Homeowner	0.0215	0.0041	0.0032	0.0207
Renter	0.0310	0.0011	0.0008	0.0307

Notes: This table shows the implicit welfare costs in economies with different LTV ratios in responses to forward guidance shocks under rational inattention. Panel A - C represents economies with LTV ratios of 80% (baseline), 60%, and 40% respectively. Note that Columns (A) = (B) - (C) + (D). See Equation (5) for the decomposition.

Appendix E.3. ARM vs FRM



Appendix Figure E.8: IRFs to a 1 S.D. 4-period ahead forward guidance shock under FRM vs. ARM

Notes: This figure reports the model impulse responses to a forward guidance shock that lowers the 4-period ahead interest rate by one standard deviation under rational inattention. The solid blue lines plot the baseline case with fixed-rate mortgages (FRM). The dot-dashed red lines plot the case with adjustable-rate mortgages (ARM).

Appendix Table E.11: Welfare Costs: ARM vs FRM

Households	(A) Total welfare costs (μ^i)	(B) Welfare costs under full-information	(C) Welfare gains from unresponsiveness	(D) Costs of attention
Panel A. Fixed rate mortgage				
Homeowner	0.2415	0.0065	0.0020	0.2370
Renter	0.0389	0.0005	0.0004	0.0388
Panel B. Adjustable rate mortgage				
Homeowner	0.7467	0.0041	0.003	0.7456
Renter	0.0352	0.0012	0.0008	0.0349

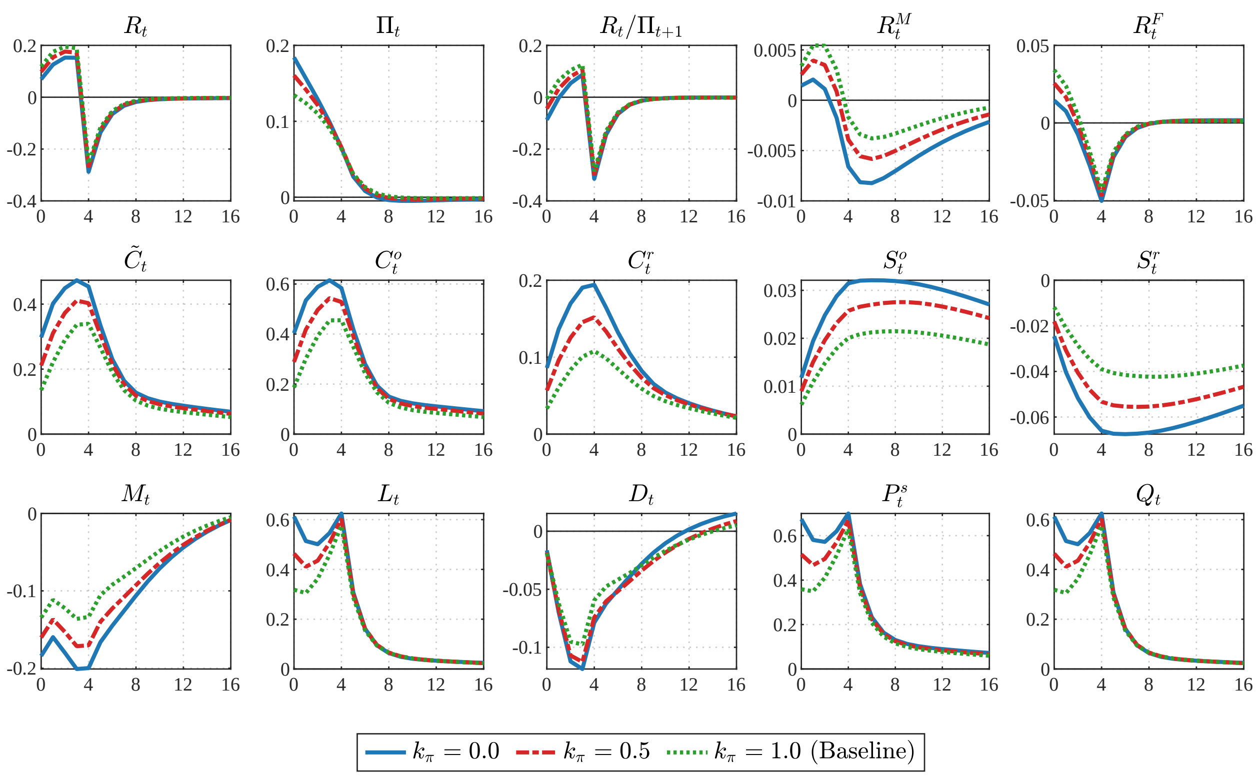
Notes: This table shows the implicit welfare costs in economies with different mortgage structures in responses to forward guidance shocks under rational inattention. Panel A represents the baseline economy with flexible-rate mortgages (FRM). Panel B represents the economy with adjustable-rate mortgages (ARM). Note that Columns (A) = (B) - (C) + (D). See Equation (5) for the decomposition.

Appendix E.4. Expectation-Augmented Taylor rules

To understand the optimal design of monetary policy in the presence of the mortgage channel, we consider the following modified Taylor rule where the central bank responds to actual inflation and the average inflation expectations:

$$\hat{R}_t = \rho\hat{R}_{t-1} + (1-\rho)\phi_\pi \left(k_\pi \pi_t + (1-k_\pi)\bar{E}_t[\pi_t]\right) + \varepsilon_{R,t-4}$$

where $\bar{E}_t[\pi_t]$ is the average inflation expectations across homeowners and renters and k_π is the relative weight on the actual inflation rate in the Taylor rule. As shown in Figure E.9, the policy becomes more stimulative when the central bank places more weight on inflation expectations. Since the average inflation expectations under-react to shocks compared to the actual inflation rate, the policy becomes more dovish when targeting expectations. As a result, inflation and consumption responses are stronger with a lower k_π. In terms of welfare, a lower k_π leads to much more volatile responses in households' consumption and housing services choices. Consequently, the welfare costs increase with the more intensive efforts on information acquisition (see Table E.12).



Appendix Figure E.9: Model impulse responses to a 1 S.D. 4-period ahead forward guidance shock with the central bank response to inflation expectations

Notes: This figure reports the model impulse responses to a forward guidance shock that lowers the 4-period ahead interest rate by one standard deviation under rational inattention. The solid blue lines plot the case where the central bank only responds to inflation expectations. The dot-dashed red lines plot the case where the central bank places equal weights on actual inflation and inflation expectations. The dotted green lines plot the baseline case where the central bank only responds to actual inflation.

Appendix Table E.12: Welfare Costs: Expectation-Augmented Taylor Rules

Households	(A) Total welfare costs (μ^i)	(B) Welfare costs under full-information	(C) Welfare gains from unresponsiveness	(D) Costs of attention
Panel A. $k_\pi = 1.0$ (Baseline)				
Homeowner	0.2415	0.0065	0.0020	0.2370
Renter	0.0389	0.0005	0.0004	0.0388
Panel B. $k_\pi = 0.5$				
Homeowner	0.2931	0.0065	0.0010	0.2876
Renter	0.0521	0.0005	0.0003	0.0519
Panel C. $k_\pi = 0.0$				
Homeowner	0.3398	0.0065	0.0002	0.3335
Renter	0.0637	0.0005	0.0003	0.0634

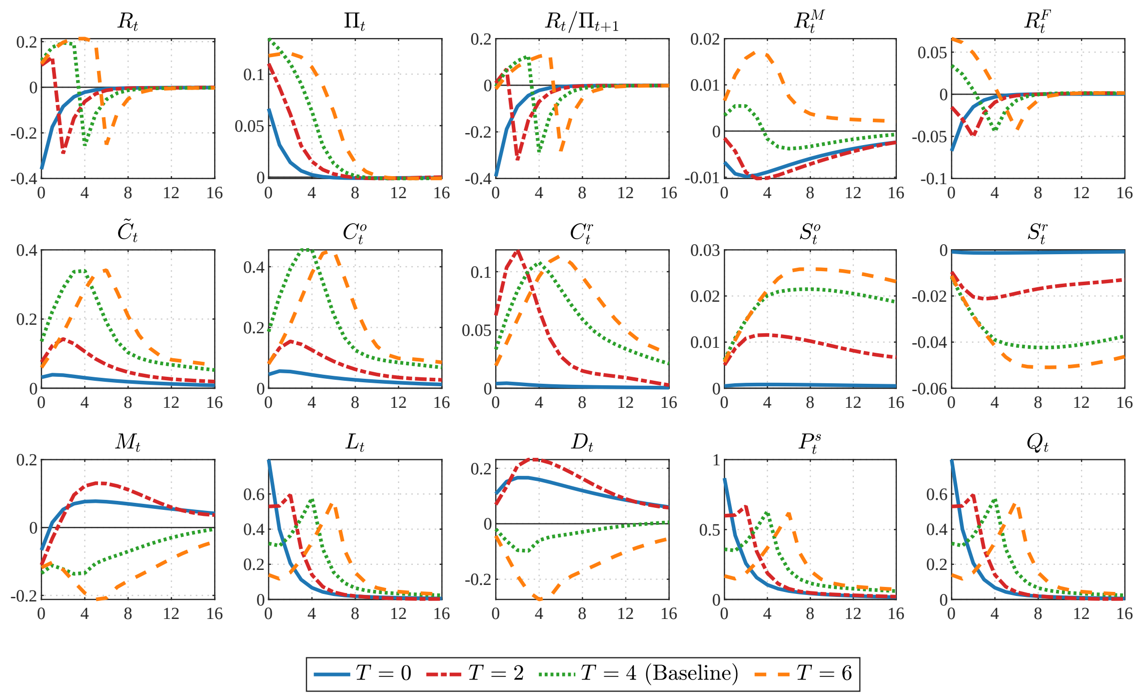
Notes: This table shows the implicit welfare costs in economies with different Taylor rules in responses to forward guidance shocks under rational inattention. Panel A is the baseline case where the central bank only responds to actual inflation. Panel B is based on the case where the central bank places equal weights on actual inflation and inflation expectations. Panel C is based on the case where the central bank only responds to inflation expectations. Note that Columns (A) = (B) - (C) + (D). See Equation (5) for the decomposition.

Appendix E.5. Forward guidance horizons

Our final exercise considers the sensitivity of forward guidance shocks over different targeting horizons. Notice that the linearized Taylor rule is given by

$$\hat{R}_t = \rho \hat{R}_{t-1} + (1-\rho)\phi_\pi \pi_t + \varepsilon_{R,t-T}$$

where T is the forward guidance horizon. In this exercise, we consider $T = 0, 2, 4, 6$ to examine how the forward guidance horizons affect the economy in this model. In general, forward guidance becomes more expansionary in consumption and inflation as the target horizon increases (Figure E.10). This is consistent with common predictions of forward guidance in full information rational expectations models, known as the forward guidance puzzle (e.g., Del Negro et al. 2023; Bilbiie 2020). However, the power of forward guidance is smaller with rationally inattentive households compared to the economy with full-information rational expectations. The limited attention leads to a weaker pass-through of the future interest rate cut into the economy. As for welfare costs, the economy becomes more volatile as the power of forward guidance increases with horizons. Consequently, information acquisition costs increase with horizons, especially for homeowners.



Appendix Figure E.10: IRFs to a 1 S.D. forward guidance shock with different forward guidance horizons

Notes: This figure reports the model impulse responses to a forward guidance shock over different horizons. The solid blue lines plot the case where the forward guidance lowers the current period interest rate. The dot-dashed red lines plot the case where the forward guidance lowers the 2-period ahead interest rate. The dotted green lines plot the baseline case where the forward guidance lowers the 4-period ahead interest rate. The dashed yellow lines plot the case where the forward guidance lowers the 6-period ahead interest rate.

Appendix Table E.13: Welfare Costs by Forward Guidance Horizons

Households	(A) Total welfare costs (μ^i)	(B) Welfare costs under full-information	(C) Welfare gains from unresponsiveness	(D) Costs of attention
Panel A. $T = 0$				
Homeowner	0.0280	0.0034	0.0028	0.0274
Renter	0.0023	0.0007	0.0007	0.0023
Panel B. $T = 2$				
Homeowner	0.0492	0.0055	0.0038	0.0475
Renter	0.0403	0.0008	0.0006	0.0401
Panel C. $T = 4$ (Baseline)				
Homeowner	0.2415	0.0066	0.0020	0.2370
Homeowner	0.0389	0.0005	0.0004	0.0388
Panel D. $T = 6$				
Homeowner	0.2561	0.0065	0.0015	0.2511
Renter	0.0412	0.0001	0	0.0411

Notes: This table shows the implicit welfare costs in responses to forward guidance shocks over different horizons. Panel A is based on the case where the forward guidance lowers the current period interest rate. Panel B is based on the case where the forward guidance lowers the 2-period ahead interest rate. Panel C is the baseline case where the forward guidance lowers the 4-period ahead interest rate. Panel D is based on the case where the forward guidance lowers the 6-period ahead interest rate. See Equation (5) for the decomposition.