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

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Abstract

We study the role of homeownership in the effectiveness of monetary policy on households' expectations. Empirically, we find that homeowners revise down their near-term inflation expectations and their optimism about future labor market conditions in response to a rise in mortgage rates, while renters are less likely to do so. We further show that the monetary-policy component of mortgage-rate changes creates the difference in expectation revisions between homeowners and renters. This result suggests that homeowners are attentive to news on interest rates and adjust their expectations accordingly in a manner consistent with the intended effect of monetary policy. We characterize these findings using a rational inattention model with two types of households–homeowners and renters.

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1 Introduction

The effectiveness of monetary policy critically and increasingly depends on whether the policy can affect economic agents' expectations. For this reason, the central bank strives to communicate its future policy path as clearly as possible so that monetary policy can preemptively prevent the risk of running the economy persistently overheated or slack. However, recent studies find that the Fed's communication about monetary policy has little effect on the expectations of households (e.g., Lamla and Vinogradov 2019; Coibion, Gorodnichenko and Weber 2022; D'Acunto, Hoang and Weber 2022). Another strand of studies finds that central bank communication does change the behavior and expectations of economic agents (e.g., Hoffmann, Moench, Pavlova and Schultefrankenfeld 2021; Kryvtsov and Petersen 2021). It is still unclear whether monetary policy affects economic agents' expectations of future economic conditions, as it is intended to do. If it does, through what channel does monetary policy influence the expectation formation?

This paper concerns the effect of monetary policy on households' expectations and the role of household heterogeneity in its effectiveness. We pay attention to homeownership as the key heterogeneity, because homeowners and renters have different incentives to acquire information on changes in interest rates. Homeowners may make regular mortgage payments or consider refinancing their mortgages, and hence changes in interest rates likely have direct effects on their household finances. In this regard, homeowners have more incentives to pay close attention to news on interest rates and the economy than renters do. Relatedly, Grundl and Kim (2019) find that households who receive newsletters on home loans and mortgage refinancing make more informed decisions on their household finances than those who do not. This evidence suggests that homeowners may have more access to information on interest rates than renters do. All told, when it comes to economic expectations, homeowners may be better informed of news on interest-rate changes and monetary policy than renters.

We empirically investigate how responsive expectations of homeowners and renters are to interest-rate changes and monetary policy shocks with microdata from the University of Michigan Surveys of Consumers (MSC) and the Survey of Consumer Expectations (SCE). We find that homeowners lower their inflation expectations one- to three- years ahead 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 longer-run inflation expectations. Additionally, in response to a rise in mortgage rates, homeowners reduce their optimism about labor market conditions more, and are more likely to expect interest-rate rises in the future than renters. We further show that monetary policy shocks pass through to 30-year mortgage rates with statistical significance, and homeowners respond particularly to the portion of mortgage rate changes driven by monetary policy shocks.[1] We also consider the 30-year T-bond rate and federal funds rate, but the sensitivity of expectations to mortgage-rate changes exhibits the largest difference between homeowners and renters. All the empirical evidence indicates that homeowners are attentive to the evolution of mortgage rates and adjust their economic outlook in a way that is consistent with the intended consequences of monetary policy.

What explains the heterogeneous response of inflation expectations to interest rate changes by homeownership status? One potential explanation is the refinancing motive. Homeowners holding mortgages likely have a strong incentive to pay attention to mortgage rate changes to seek an opportunity to refinance their mortgage with a lower rate. Considering that more than 60% of U.S. homeowners carry a mortgage, the refinancing motive may be the key driver of the strong responsiveness of homeowners' expectations to the rate changes.[2] Consistent with this conjecture, we find that the sensitivity of homeowners' revisions in short-term inflation expectations is larger to a decrease in mortgage rate than to an increase in the rate.

We offer corroborating evidence for our main claim based upon the American Time Use Survey. Time spent on finance-related activities is a natural measure of households' attentiveness to financial markets and macroeconomic developments. We find that homeowners are more likely to engage in finance-related activities such as checking financial markets and researching investments that likely expose them to current macroeconomic conditions and interest rates, and also spend more on these activities than renters.

Our findings seem to be inconsistent with the recent evidence based on surveys and exper-

[1] Notice that our evidence suggests that conditional on a demand shock like a 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 on inflation and labor markets are negatively correlated, as if the associations reflected the consequence of a supply shock.

[2] Recent studies highlight the refinancing motive as an important transmission channel of monetary policy (e.g., Amromin, Bhutta and Keys, 2020; Berger, Milbradt, Tourre and Vavra, 2021; Wong, 2021; Eichenbaum, Rebelo and Wong, 2022).

iments that points to little effect of monetary policy on economic agents' expectations (e.g., Coibion, Gorodnichenko and Kamdar 2018; Lamla and Vinogradov 2019; Coibion et al. 2022; D'Acunto et al. 2022). These studies show that economic agents—households in particular—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 result. 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 respond to a survey that they do not know about monetary policy, this response does not necessarily mean that households do not pay attention to a change in interest rates and do not understand the consequences to future macroeconomic conditions.

We characterize our main empirical findings with a simple two-period rational inattention model with a particular focus on the association between inflation expectations and interest-rate changes. Facing uncertainty about future economic fundamentals, including inflation and interest rates, households acquire costly information to optimize their consumption and housing choices. Households are composed of homeowners and renters. A homeowner, after purchasing a house with a home loan, pays mortgage interest each period, while a renter pays a fixed rent and trades a one-period nominal bond. Since homeowners value housing services in their utility, changes in goods' prices affect the relative price of housing, which has a substitution effect on their consumption. This additional substitution effect is absent from the renters' problem. Therefore, homeowners' beliefs about inflation respond more strongly to interest rate variations than renters' beliefs. All told, homeownership creates differences in the incentive to acquire information, and hence results in heterogeneity in the sensitivity of inflation expectations to interest rate changes between homeowners and renters.

This paper contributes to multiple strands of research. First, there is growing literature regarding the effectiveness of monetary policy on economic agents' expectations (e.g., Cavallo, Cruces and Perez-Truglia 2017; Coibion et al. 2022; D'Acunto et al. 2022; Coibion, Gorodnichenko

and Weber 2021).[3] The majority of recent research finds little evidence for the effectiveness of the Fed's communication or monetary policy in guiding economic agents' expectations, though some studies including Hoffmann et al. (2021) and Kryvtsov and Petersen (2021) reach a different conclusion. This paper also speaks to the literature on determinants of expectation formation (e.g., Carroll 2003; Coibion and Gorodnichenko 2015; Bauer 2015; Stillwagon 2018; Kilian and Zhou 2021). Recent studies focus on the role of economic developments or individual attributes in the expectation of economic agents (e.g., Kuchler and Zafar 2019; Armona, Fuster and Zafar 2019; D'Acunto, Hoang, Paloviita and Weber 2019; D'Acunto, Malmendier, Ospina and Weber 2021; D'Acunto, Malmendier and Weber 2022). Our paper bridges these strands of literature by shedding light on the importance of homeownership in the effectiveness of monetary policy on households' expectation formation. In this regard, this paper is closest to Claus and Nguyen (2020), but is different from it in two respects.[4] First, we focus on households in the United States, while Claus-Nguyen's analysis concerns 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 rest of this paper is organized as follows. Section 2 introduces the data adopted for our empirical study. Section 3 presents the empirical analyses. Section 4 explores the potential mechanism behind our main findings and checks the robustness of results. Section 5 discusses a model of rational inattentive households that is designed to explain our empirical findings. Section 6 concludes.

2 Data

This section describes measures of household expectations and monetary policy shocks used in this paper. As noted earlier, our data on household expectations come from the MSC and SCE. Both datasets have been popularly used in the literature to study household expectations. For

[3] For instance, D'Acunto et al. (2022) find that household expectations are affected by unconventional fiscal policy, not forward guidance, and argue that policies aimed at households directly are not effective because households do not understand them.

[4] Adelino, Schoar and Severino (2018) investigate the effect of expectations about housing prices on homeownership, which is different from our focus—the effect of homeownership on expectations.

monetary policy shocks, we adopt the measure from Bu, Rogers and Wu (2021).[5] The sample period of the empirical analyses ranges from 1990:M1 through 2020:M12.

2.1 Measures 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 has a long time series but does not track 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.

The SCE is a monthly survey conducted by the Federal Reserve Bank of New York that focuses on expectations about inflation, labor market conditions, and household finance. With data starting in June 2013, this internet-based survey constitutes a sample of about 1,300 nationally representative households. Survey respondents participate consecutively for up to 12 months. The survey measures household expectations using two different approaches. First, respondents report their expected growth rate of the variable of interest over a specified time horizon. Second, for certain variables such as inflation, income growth, and unemployment, respondents report the probability they assign to a percentage change in the respective variable. Based on this information, a generalized beta distribution is estimated to characterize the distribution that each survey participant perceives about changes in each variable. In our study, we use the mean of this distribution as a measure of household expectations. In this survey, homeowners are those who indicate that they own their primary residence and renters are those who do not. Only a small fraction of renters, about 1.2% of all respondents, indicate that own other homes.[6]

[5] We also consider Swanson (2021) for robustness checks in the appendix.

[6] Appendix Table B.1 shows the summary statistics for the homeownership rate and the average inflation expectations by homeownership status.

2.2 Measures of monetary policy shocks

We select measures of monetary policy shocks that are available for the sample period including the post-zero lower bound (ZLB) period. During the ZLB period, monetary policy has become more multidimensional with the adoption of unconventional monetary policy tools. A common approach in the literature is the high-frequency identification method that focuses on movements in asset prices in a narrow window around Federal Open Market Committee (FOMC) meetings. These FOMC meeting announcements usually contain both central bank information effect and monetary policy shocks. For this reason, we adopt the unified measure of monetary policy shocks proposed by Bu et al. (2021) that contains no significant information effect (BRW shock henceforth).

3 Empirical investigation

Section 3.1 analyzes the effect of interest rate changes on inflation expectations of homeowners and renters. Section 3.2 conducts similar analyses for households' expectations of labor market conditions. Section 3.3 examines the responsiveness of interest-rate expectations to changes in interest rates. Section 3.4 explores the extent to which monetary policy shocks account for households' expectations via the interest-rate channel.

3.1 The effect of interest-rate changes on households' inflation expectations

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

$$E_{i,t+6}^{h-yr} - E_{i,t}^{h-yr} = \alpha + \beta_1 \; homeowner_i \times \Delta R_t + \beta_2 \; renter_i \times \Delta R_t + \delta X_{i,t} + \epsilon_{i,t}, \tag{3.1}$$

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 interest rates during the past six months, and $X_{i,t}$ are controls for the respondent's

characteristics which include gender, education, birth cohort, and income. For ΔR_t, we consider changes in the 30-year fixed mortgage rate, the federal funds rate, and the 30-year T-bond rate.

This specification is based on the model by Coibion and Gorodnichenko (2015) that analyzes the effect of oil price changes on inflation expectations. There are a few differences between our model and Coibion and Gorodnichenko's. First, our model has terms that capture the different sensitivities of homeowners and renters to a change in interest rates as a replacement of the argument capturing the effect of oil-price changes in Coibion and Gorodnichenko's model. 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 (2015) consider a change in oil prices in the current period. Third, we explicitly control for additional observable individual characteristics.

Panel A of Table 1 reports the estimation results for inflation expectations in the next 12 months from the MSC. As shown in the first column, the coefficient on $homeowner_i$ is negative and statistically significant, while that on $renter_i$ is not statistically significant. 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. Meanwhile, both homeowners' and renters' coefficients on changes in the 30-year T-bond rate are negative and statistically significant. Considering loan interest rates are closely associated with the 30-year T-bond rate, this result may reflect that homeowners and renters have loans to pay off and thus pay attention to news on the interest rate. This observation indicates that households do adjust their inflation expectations to interest rate changes to which they pay attention.[7]

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 by Panel B of Table 1, the coefficients on interest rate changes

[7]Quite differently, we do not observe a similar association between a change in the federal funds rate and households' one-year-ahead inflation expectations. Rather, homeowners' coefficient is positive and statistically significant. One potential explanation for the difference is that homeowners may take a different signal from the federal funds rate. Homeowners may infer information about future inflation from a rise in the federal funds rate, which is often referred to as the information effect (Nakamura and Steinsson, 2018).

Table 1: SENSITIVITY OF REVISIONS IN HOMEOWNERS AND RENTERS' INFLATION EXPECTATIONS TO CHANGES IN INTEREST RATES

Interactions	(1) ΔR_t^{Mort}	(2) ΔR_t^{FFR}	(3) $\Delta R_t^{T\text{-}bond}$
Panel A. Michigan Survey of Consumers (1-year ahead inflation expectations)			
Homeowner×ΔR_t (β_1)	-0.246***	0.118**	-0.285***
	(0.062)	(0.046)	(0.061)
Renter×ΔR_t (β_2)	-0.151	0.00961	-0.289**
	(0.114)	(0.087)	(0.115)
Number of obs.	50,834	50,834	50,834
R^2	0.0140	0.0138	0.0143
Panel B. Michigan Survey of Consumers (5-year ahead inflation expectations)			
Homeowner×ΔR_t (β_1)	-0.0176	0.0468	-0.0585
	(0.051)	(0.034)	(0.050)
Renter×ΔR_t (β_2)	0.00269	-0.0837	-0.0474
	(0.107)	(0.077)	(0.107)
Number of obs.	48,842	48,842	48,842
R^2	0.0107	0.0107	0.0107

Notes: This table reports the regression results from Equation (3.1). Dependent variables are the six-month change in the MSC's 12-month ahead inflation expectations (Panel A) and the six-month change in the MSC's 5-year ahead inflation expectations (Panel B). "Homeowner" and "Renter" indicate dummies for homeowner and renter respectively. ΔR_t refers to the six-month change in interest rate. We use the 30-year mortgage rate in Column (1), the Federal Funds Rate in Column (2), and the 30-year Treasury Bond rate in Column (3). We control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

Sources: Authors' calculation.

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.

We further examine the robustness of empirical results based on the SCE. The model specification is as follows:

$$E_{i,t+6}^{h-yr} - E_{i,t}^{h-yr} = \alpha_i + \beta_1 \text{ homeowner}_i \times \Delta R_t + \beta_2 \text{ renter}_i \times \Delta R_t + \epsilon_{i,t}, \tag{3.2}$$

where $E_{i,t}^{h-yr}$ is respondent i's h-year ahead inflation expectation for $h = 1,3$ at time t and α_i captures individual fixed-effects. As households participate in the survey repeatedly for up to 12 months, we employ the individual fixed effect α_i to absorb the individual heterogeneity.

The estimation results are documented in Table 2. Homeowners lower their three-year-ahead

Table 2: SENSITIVITY OF REVISIONS IN HOMEOWNERS AND RENTERS' INFLATION EXPECTATIONS TO CHANGES IN INTEREST RATES

Interactions	(1) ΔR_t^{Mort}	(2) ΔR_t^{FFR}	(3) $\Delta R_t^{T\text{-}bond}$
Panel A. NY Fed Survey of Consumer Expectations (1-year ahead inflation expectations)			
Homeowner×ΔR_t (β_1)	-0.212	-0.385*	-0.279**
	(0.130)	(0.226)	(0.124)
Renter×ΔR_t (β_2)	-0.278	0.389	-0.408
	(0.309)	(0.431)	(0.281)
Number of obs.	42,081	42,081	42,081
R^2	0.0001	0.0002	0.0003
Panel B. NY Fed Survey of Consumer Expectations (3-year ahead inflation expectations)			
Homeowner×ΔR_t (β_1)	-0.257*	-0.301	-0.197
	(0.134)	(0.214)	(0.127)
Renter×ΔR_t (β_2)	-0.257	0.236	-0.283
	(0.294)	(0.469)	(0.268)
Number of obs.	42,183	42,183	42,183
R^2	0.0002	0.0001	0.0001

Notes: This table reports the regression results from Equation (3.2). Dependent variables are the six-month change in the SCE's 1-year ahead inflation expectations (Panel A) and the six-month change in the SCE's 3-year ahead inflation expectations (Panel B). "Homeowner" and "Renter" indicate dummies for homeowner and renter respectively. ΔR_t refers to the six-month change in interest rate. We use the 30-year mortgage rate in Column (1), the Federal Funds Rate in Column (2), and the 30-year Treasury Bond rate in Column (3). We employ the individual fixed effects to control the individual heterogeneity. Robust standard errors (clustered at the individual-level) are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

Sources: Authors' calculation.

inflation expectations to a rise in 30-year mortgage rate with statistical significance (Panel A). In addition, homeowners revise down their one-year-ahead inflation expectations in response to a rise in the 30-year T-bond rate and the federal funds rate (Panel B). None of the coefficients capturing renters' responsiveness are statistically significant. To summarize, the evidence based on the SCE clearly shows that homeowners pay attention to interest-rate changes and revise their inflation expectations accordingly, while renters are less likely to do so.

All told, homeowners are attentive to developments in mortgage rates and T-bond rates, as if a rise in the interest rates is a contractionary macroeconomic factor. However, renters are less likely to do so. The empirical findings imply that households pay attention to interest rate changes about which they have an incentive to acquire information.

3.2 How do expectations on labor market conditions react to interest-rate changes?

This section investigates to what extent interest rate changes affect households' expectations of labor market conditions. If an interest rate increase also has negative effects on households' job market outlook, we can interpret that the interest rate change influences households' expectations in a way similar to a contractionary monetary policy and, furthermore, may actually reflect a consequence of monetary policy.

The main challenge, however, in this analysis is that expectations of labor market conditions are captured by categorical responses, unlike inflation expectations. 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

Since we are chiefly interested in changes in expectations, 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:

$$\log\left(\frac{p_{ik,t}}{p_{ij,t}}\right) = \alpha_0 + \alpha_1\ renter_i + \beta_1\ homeowner_i \times \Delta R_t + \beta_2\ renter_i \times \Delta R_t + \delta X_{i,t} + \epsilon_{i,t}, \qquad (3.3)$$

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

Table 3: SENSITIVITY OF REVISIONS IN HOMEOWNERS AND RENTERS' UNEMPLOYMENT EXPECTATIONS TO CHANGES IN INTEREST RATES

Interactions	(1) ΔR_t^{Mort}	(2) ΔR_t^{FFR}	(3) $\Delta R_t^{T\text{-}bond}$
Panel A. Unemployment: Improve			
Renter (α_1)	1.090***	1.086***	1.080***
	(0.025)	(0.025)	(0.025)
Homeowner×ΔR_t (β_1)	0.814***	0.874***	0.872***
	(0.017)	(0.013)	(0.019)
Renter×ΔR_t (β_2)	0.863***	0.914***	0.877***
	(0.030)	(0.022)	(0.031)
Panel B. Unemployment: Worsen			
Renter (α_1)	1.043*	1.042*	1.043*
	(0.025)	(0.025)	(0.025)
Homeowner×ΔR_t (β_1)	1.032	1.119***	1.014
	(0.022)	(0.017)	(0.022)
Renter×ΔR_t (β_2)	1.028	1.159***	1.012
	(0.036)	(0.031)	(0.037)
Number of obs.	59,917	59,917	59,917
R^2	0.0022	0.0035	0.0016

Notes: This table reports the logit regression results from Equation (3.3). 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. ΔR_t refers to the six-month change in interest rate. We use the 30-year mortgage rate in Column (1), the Federal Funds Rate in Column (2), and the 30-year Treasury Bond rate in Column (3). The coefficients are reported in terms of relative risk ratios. We control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

Sources: Authors' calculation.

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 interest rate during the past six months; $X_{i,t}$ are controls for individual characteristics. 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 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 1. As depicted by the downward-sloping lines in the top-left panel, households become less likely

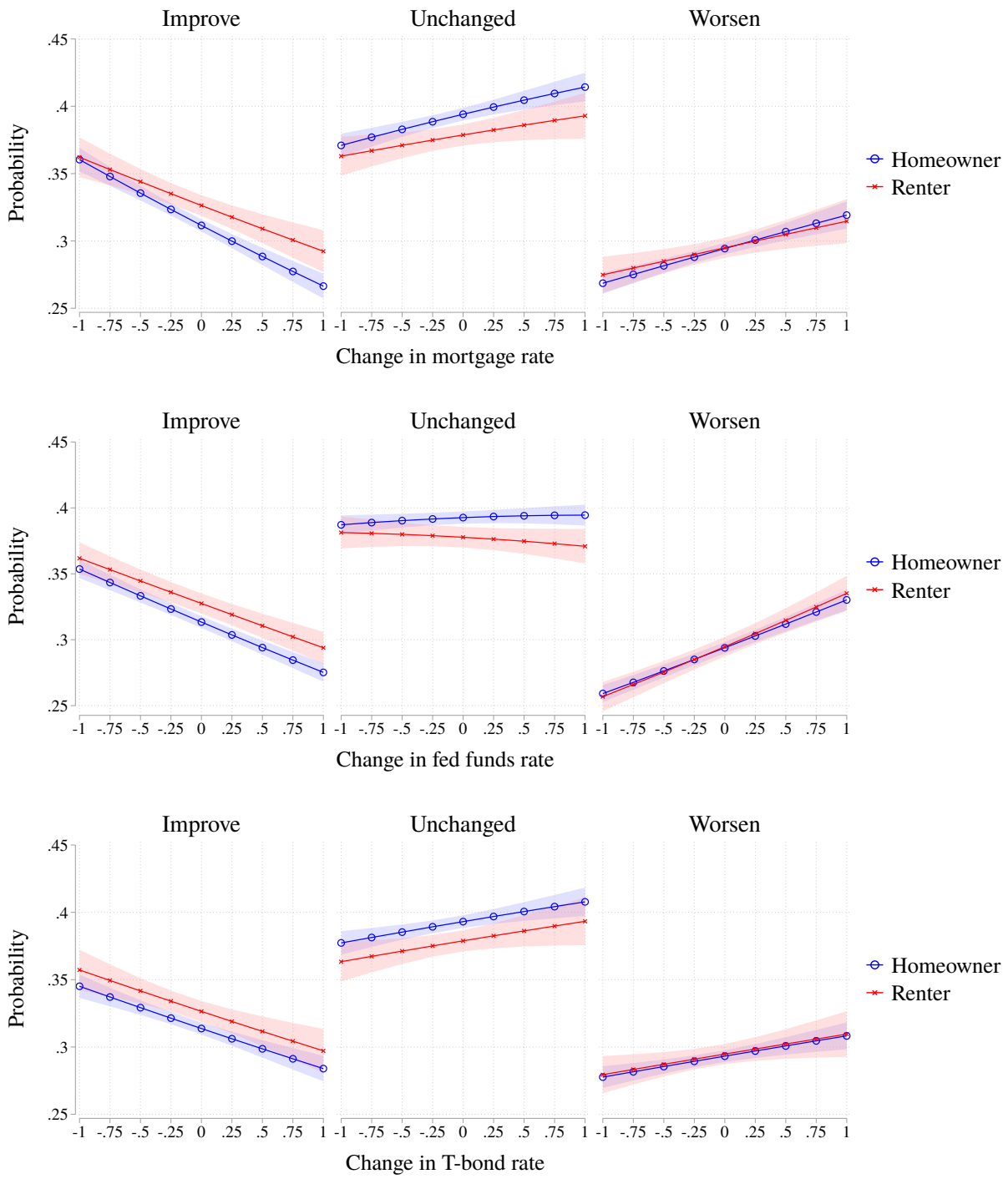

Figure 1: MARGINAL PROBABILITY OF CHANGES IN HOUSEHOLD EXPECTATIONS OF UNEMPLOYMENT

Notes: This figure reports the marginal probabilities of changes in household expectations of unemployment to changes in interest rates. The interest rates considered from top to bottom are the 30-year mortgage rate, federal funds rate, and 30-year T-bond rate. The results are calculated based on the estimates of the logit regression results from Equation (3.3) as reported in Table 3. We control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Shaded areas represent 95% confidence intervals.

Source: Authors' calculation.

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 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 revise down their optimism more in response to an increase in the mortgage rate than renters do. We find similar results with changes in the federal funds rate and the 30-year T-bond rate (middle and bottom panels). Nonetheless, the sensitivity of reduced optimism between homeowners and renters exhibits the largest difference, when conditioned on a change in 30-year mortgage rates.

To summarize, households become less optimistic about labor market outlook, when there is a rise in interest rates. The decreased optimism is stronger among homeowners than renters, and the difference between the two groups is largest with an increase in mortgage rates. Combined with the evidence on inflation expectations, the empirical result indicates that a rise in mortgage rates particularly influences homeowners' macroeconomic expectations in a way similar to a monetary policy shock.

3.3 How do expectations on future interest rates respond to recent changes in interest rates?

In this section, we further investigate the sensitivity of households' expectations of future interest rates to a past interest-rate change. We examine this sensitivity as a potential channel through which the rate rise has persistent contractionary effects on household expectations. Responses to the question on interest-rate expectation are also a categorical variable. Therefore, we employ specification (3.3) without constructing a new categorical variable.[8] 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?*

[8] Notice that we are interested in expectations on future interest rate not the revisions of expectations unlike the previous analyses. For this reason, we use the categorical data as they are.

Table 4: SENSITIVITY OF HOMEOWNERS AND RENTERS' EXPECTATIONS ON FUTURE INTEREST RATES TO CHANGES IN INTEREST RATES

Interactions	(1) ΔR_t^{Mort}	(2) ΔR_t^{FFR}	(3) $\Delta R_t^{T\text{-}bond}$
Panel A. Interest rate increase			
Renter (α_1)	1.153***	1.177*	1.171***
	(0.016)	(0.016)	(0.016)
Homeowner×ΔR_t (β_1)	2.015***	1.757***	1.618***
	(0.025)	(0.016)	(0.019)
Renter×ΔR_t (β_2)	1.481***	1.361***	1.348***
	(0.031)	(0.021)	(0.028)
Panel B. Interest rate decrease			
Renter (α_1)	1.398***	1.414***	1.355***
	(0.030)	(0.030)	(0.028)
Homeowner×ΔR_t (β_1)	0.590***	0.589***	0.676***
	(0.012)	(0.007)	(0.012)
Renter×ΔR_t (β_2)	0.704***	0.638***	0.766***
	(0.022)	(0.013)	(0.024)
Number of obs.	168,201	168,201	168,201
R^2	0.0243	0.0390	0.0014

Notes: This table reports the logit regression results from Equation (3.3). 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. ΔR_t refers to the six-month change in interest rate. We use the 30-year mortgage rate in Column (1), the Federal Funds Rate in Column (2), and the 30-year Treasury Bond rate in Column (3). The coefficients are reported in terms of relative risk ratios. We control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively. This table reports the estimates of Equation (3.3) on outcomes of unemployment.

Sources: Authors' calculation.

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 *"stay 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*.

Table 4 reports the parameter estimates. Figure 2 displays the marginal probability estimates. When there is a rise in the interest rate, households become more likely to expect 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 are larger than the downside revisions to a same or declining

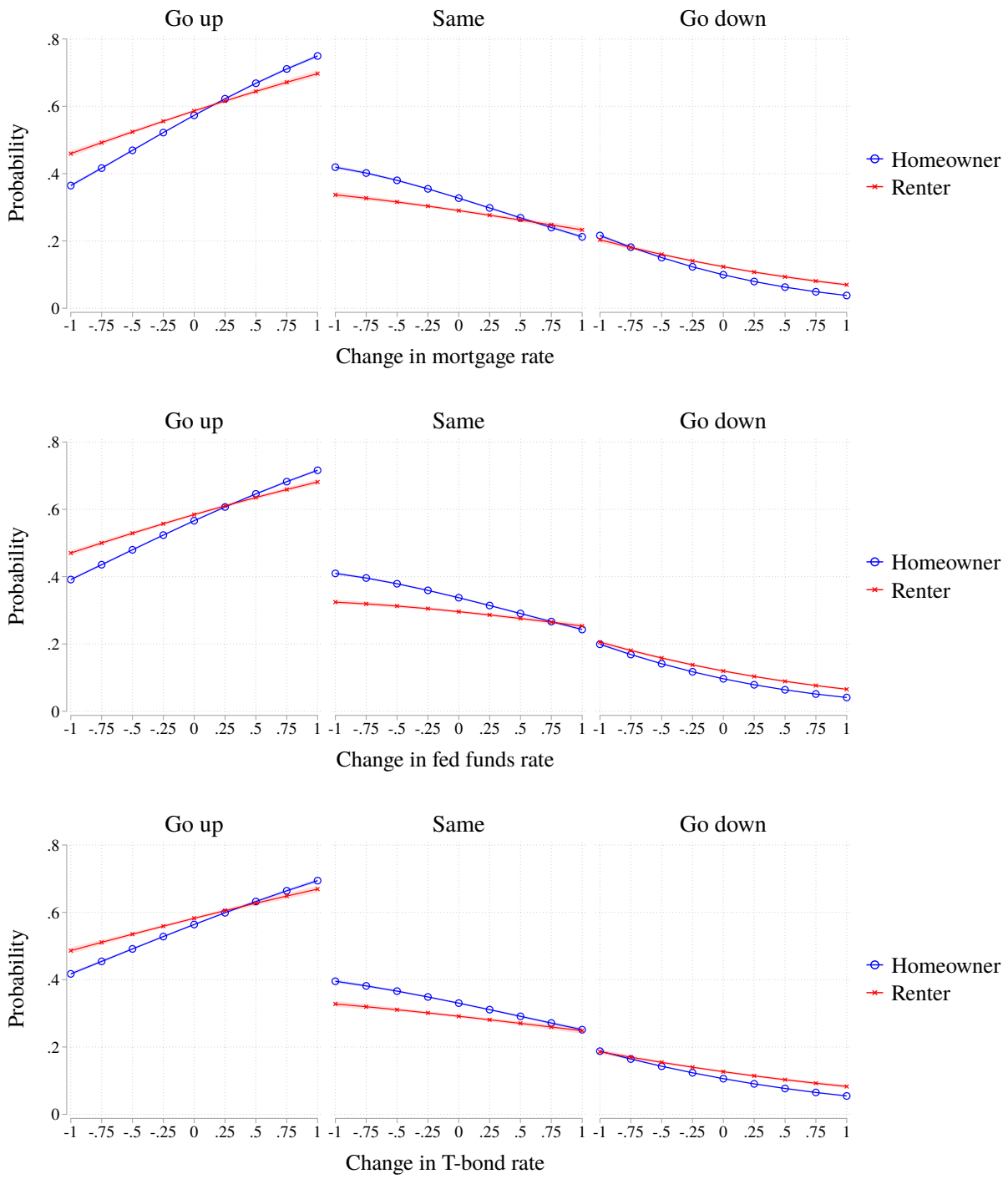

Figure 2: MARGINAL PROBABILITY OF HOUSEHOLD EXPECTATIONS OF INTEREST RATES

Notes: This figure reports the marginal probabilities of household expectations of 1-year ahead interest rates to past changes in interest rates. The interest rates considered are the 30-year fixed mortgage rates, federal funds rates, and 30-year T-bond rates. The results are calculated based on the estimates of the logit regression results from Equation (3.3) as reported in Table 4. 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.

Source: Authors' calculation.

interest rate. This observation implies a persistent contractionary effect of interest rate hikes on household expectations.

Notably, the responsiveness of homeowners is larger than that of renters with statistical significance. Similar to the earlier results, the difference in upward revision between homeowners and renters is also the largest when conditioned on a change in 30-year mortgage rates. The empirical findings provide a partial explanation for contractionary effects of rises in interest rates—mortgage rates, in particular—on households' expectations, with a larger effect on homeowners than on renters.

3.4 Pass-through of monetary policy shocks to households' expectations

The empirical evidence in the previous sections points to the possibility that an interest rate change influences households' inflation expectations in a way similar to a monetary policy shock. In this section, we evaluate the extent to which monetary policy shocks account for the empirical evidence. We particularly focus on the 30-year mortgage rate and the 30-year T-bond rate, because households' one-year-ahead inflation expectations from the MSC have statistically significant negative associations with the interest rates.

Notice that there are factors other than monetary policy that create changes in the 30-year T-bond rate and the 30-year mortgage rate. Examples include risk premiums, the future economic outlook, and housing market conditions. However, these factors have opposite effects on households' inflation expectations. To illustrate, a rise in the interest rate, if driven by monetary tightening or rises in default risks, lowers inflation expectations. Quite differently, an increased interest rate driven by a rosier economic outlook raises inflation expectations.[9] In this context, the negative associations between interest rate changes and households' inflation expectations capture the net outcomes of multiple sources, with the contractionary (former) effects being stronger than the expansionary (latter) effects. Therefore, it is ex-ante unclear how monetary policy shocks would influence households' expectations through the interest-rate channels.

[9] Increased housing demand can also raise mortgage rates and, at the same time, households' expectations of inflation via an increase in the cost of owner-occupied housing, among others. Meanwhile, a rise in the mortgage rate due to contractionary monetary policy or increased default risk in housing markets can lower inflation expectations.

Table 5: RESPONSES OF INTEREST RATES TO MONETARY POLICY SHOCKS

Dependent variable	(1) ΔR_t^{Mort}	(2) $\Delta R_t^{T\text{-}bond}$	(3) ΔR_t^{Mort}	(4) $\Delta R_t^{T\text{-}bond}$
Unified shock	0.532***	-0.001	0.870**	0.007
	(0.183)	(0.156)	(0.396)	(0.301)
Sample period	1991–2019	1991–2019	2013–2019	2013–2019
Number of obs.	1,299	1,334	340	350
R^2	0.0214	0.0059	0.0695	0.0149

Notes: This table reports the regression results from Equation (3.4). Dependent variables are the weekly change in the 30-year mortgage rate in Columns (1) and (3) and the weekly change in the 30-year Treasury Bond rate in Columns (2) and (4). The sample period is from April 1991 to July 2019 for the estimates reported in Columns (1) and (2). The sample period for the estimates in Columns (3) and (4) is from 2013 onward. Newey-West robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

Sources: Authors' calculation.

To investigate to what extent information on monetary policy contained in the interest rate changes affects households' inflation expectations, we first analyze the pass-through of monetary policy shocks to the 30-year mortgage rate and the 30-year T-bond rate.[10] We then examine the responsiveness of households' inflation expectations to the monetary policy component of interest rate changes.

Consider the following high-frequency specifications, with interest rate changes at a weekly frequency:

$$\Delta R_{t+1} = \alpha + \beta_1 \ \textit{Unified Shock}_t + \sum_{j=1}^{3} \delta_j \Delta R_{t-j} + \epsilon_t \tag{3.4}$$

where the dependent variable ΔR_t is a change in the interest rate over week t, and *Unified Shock* refers to the monetary policy shock from Bu et al. (2021). The weekly monetary policy shocks are the estimates around an FOMC meeting, if the meeting falls in week t, but are set to zero, otherwise. The coefficients of interest are β's, which measure the responsiveness of the interest rate to a monetary policy shock. We control for three lags of changes in the interest rate.

Table 5 documents the coefficient on the unified shock. Changes in the mortgage rate have a statistically significant positive correlation with the unified shock (Column 1), while changes in the T-bond rate do not (Column 2). As shown in Columns 3 and 4, we arrive at a similar result,

[10] We do not consider the federal funds rate, because the interest rate has an ambiguous effect on inflation expectations as shown in Tables 1 and 2.

Table 6: SENSITIVITY OF REVISIONS IN HOMEOWNERS AND RENTERS' INFLATION EXPECTATIONS TO CHANGES IN INTEREST RATES PREDICTED BY MONETARY POLICY SHOCK

	Michigan Survey (MSC)		**NY Fed Survey (SCE)**	
Dependent variable	(1) 1-year	(2) 5-year	(3) 1-year	(4) 3-year
Homeowner×ΔR_t (β_1)	-2.749***	-0.717	0.881	-0.631
	(0.687)	(0.489)	(1.119)	(1.121)
Renter×ΔR_t (β_2)	-0.193	0.009	1.386	1.304
	(1.399)	(1.144)	(2.417)	(2.259)
Number of obs.	43,434	42,240	38,775	38,861
R^2	0.0137	0.0096	0.0000	0.0001

Notes: This table reports the regression results from Equations (3.1) and (3.2). Dependent variables are the six-month changes in the MSC's 1-year ahead inflation expectations (Column (1)), the 5-year ahead inflation expectations (Column (2)), the SCE's 1-year ahead inflation expectations (Column (3)), and the SCE's 3-year ahead inflation expectations (Column (4)). "Homeowner" and "Renter" indicate dummies for homeowner and renter respectively. ΔR_t refers to the six-month change in interest rate. We use the 30-year mortgage rate predicted by the unified shock from Bu et al. (2021). In Columns (1) and (2), we control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Robust standard errors are reported in the parenthesis. In Columns (3) and (4), we employ the individual fixed effects to control the individual heterogeneity. Robust standard errors (clustered at the individual-level) are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.
Sources: Authors' calculation.

even if we narrow the sample period to the post-2013 era—the sample period of the SCE. In sum, a monetary policy shock passes through to the 30-year mortgage rate with statistical significance, while the pass-through is unclear for the 30-year T-bond rate.

With the coefficient estimates in Table 5, we recover the portions of changes in the 30-year mortgage rate attributable to monetary policy shocks. Let $\Delta\tilde{R}^{Mort}_{t,brw}$ denote changes in the mortgage rate predicted by the unified shock.[11] With the predicted values, we now analyze how responsive households' expectations of inflation and real economic activities are to the information on monetary policy contained in the mortgage rate. For this analysis, we replace ΔR^{Mort}_t in Equations (3.1) and (3.2) with the corresponding predicted value.

The estimation result for households' inflation expectations is documented in Table 6. Column 1 shows that in the MSC, homeowners do strongly react to news on monetary policy reflected in the interest rate changes when revising short-term inflation expectations. Consistent with the baseline result, none of the coefficients are statistically significant in predicting five-

[11] We do not report the estimation result with $\Delta\tilde{R}^{T\text{-}bond}_{t,brw}$, because the coefficient of shock from Bu et al. (2021) is small and not statistically significant.

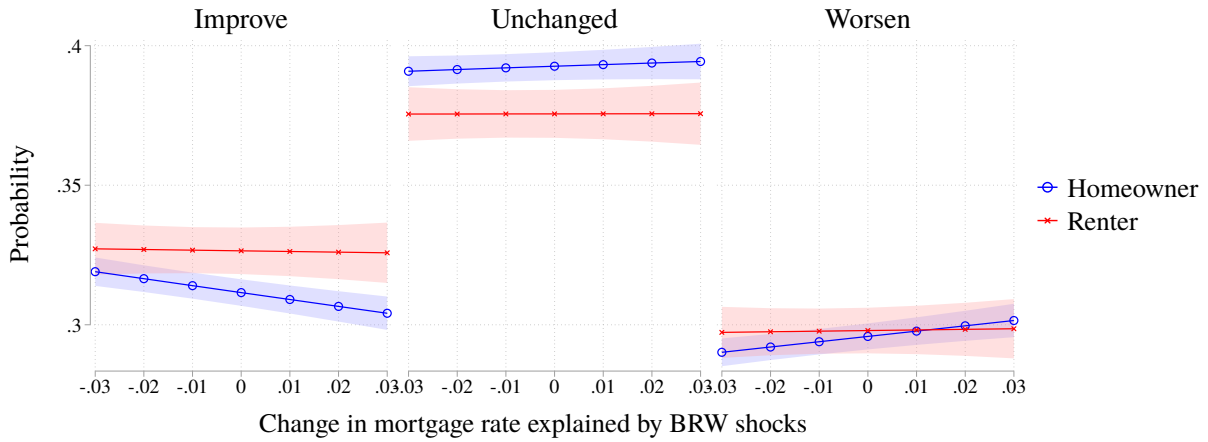

Figure 3: MARGINAL PROBABILITY OF CHANGES IN HOUSEHOLD EXPECTATIONS OF UNEMPLOYMENT

Notes: This figure reports the marginal probabilities of changes in household expectations of unemployment to changes in interest rates explained by monetary policy shocks. The explanatory variable considered is the 30-year mortgage rate predicted by the unified shock from Bu et al. (2021). The results are calculated based on the estimates of the logit regression results from Equation (3.3) as reported in Column (1) of Appendix Table B.2. We control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Shaded areas represent 95% confidence intervals.

Source: Authors' calculation.

year-ahead inflation expectations (Column 2), suggesting that households' long-run inflation expectations are not responsive to news on monetary policy. However, none of the coefficients are statistically significant based upon the SCE (Columns 3 and 4).

Next, we show the estimation result for households' expectations of labor market conditions. For interpretability, we report the marginal probability of households changing their expectations of future unemployment in Figure 3.[12] Strikingly, renters do not revise down their optimism on labor market outlook in response to the monetary policy component of mortgage-rate changes, while homeowners do. The different responsiveness between the two groups is statistically significant.

To summarize, monetary policy shocks pass through to the 30-year mortgage rate with statistical significance. Homeowners, taking signals from the monetary policy component or mortgage-rate changes, adjust their macroeconomic expectations accordingly, while renters are less likely to do so. All told, homeowners are attentive to news on monetary policy reflected on mortgage rates, but the evidence is weak for renters.

[12]The logit regression results are reported in Column (1) of Appendix Table B.2.

4 Mechanism and Robustness

Section 4.1 examines the potential nonlinearity in the main result, and its implications. Section 4.2 provides corroborating evidence based upon the American Time Use Survey. Section 4.3 checks the robustness of our main empirical results.

4.1 Asymmetric effects of mortgage-rate changes on households' expectations

This section examines the asymmetric effects of mortgage-rate changes on households' inflation expectations. Homeowners holding mortgages would keep seeking an opportunity to refinance their mortgages with lower rates. Therefore, homeowners have more incentive to pay attention to mortgage-rate declines, and hence are likely to make more informed predictions about future inflation in times of declining mortgage rates. In other words, attention heterogeneity due to the refinancing motive could lead to an asymmetric response of inflation expectations to mortgage-rage changes—specifically, larger sensitivity in times of declining mortgage rates than in times of rising mortgage rates.[13]

We consider the following specification which is a variant of Equation (3.1) in order to separate the effects of increases and decreases in mortgage rates:

$$\begin{aligned} E^{h-yr}_{i,t+6} - E^{h-yr}_{i,t} = \alpha &+ \beta_1 \text{ homeowner}_i \times \Delta R_t \times I^+_t + \beta_2 \text{ homeowner}_i \times \Delta R_t \times I^-_t \\ &+ \beta_3 \text{ renter}_i \times \Delta R_t \times I^+_t + \beta_4 \text{ renter}_i \times \Delta R_t \times I^-_t + \delta X_{i,t} + \epsilon_{i,t}, \end{aligned} \tag{4.1}$$

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 a change in the mortgage rate attributed to monetary policy 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

[13] Several recent works highlight that this refinancing motive would be important for the transmission of monetary policy (e.g., Amromin, Bhutta and Keys, 2020; Berger, Milbradt, Tourre and Vavra, 2021; Wong, 2021; Eichenbaum, Rebelo and Wong, 2022. Relatedly, Barnichon and Matthes (2016) argue that contractionary monetary policy has a significantly stronger effect on the economy than expansionary policy.

Table 7: ASYMMETRIC EFFECTS OF MORTGAGE-RATE CHANGES

	1-year ahead inflation expectations		5-year ahead inflation expectations	
Interactions	(1) ΔR_t^{Mort}	(2) $\Delta \tilde{R}_{t,brw}^{Mort}$	(3) ΔR_t^{Mort}	(4) $\Delta \tilde{R}_{t,brw}^{Mort}$
Homeowner$\times I_t^+$	-0.1072	-1.6605*	0.0653	-0.0392
	(0.1243)	(0.9614)	(0.1116)	(0.7199)
Renter$\times I_t^+$	-0.5835***	1.5777	-0.4370**	-0.0577
	(0.1870)	(1.9134)	(0.1816)	(1.5933)
Homeowner$\times I_t^-$	-0.3293***	-3.7813***	-0.0564	-1.3554**
	(0.1078)	(0.9699)	(0.8270)	(0.6578)
Renter$\times I_t^-$	0.1756	-1.8928	0.3443**	0.0668
	(0.1739)	(2.0247)	(0.1541)	(1.6436)
Number of obs.	50,834	43,434	48,842	42,240
R^2	0.0144	0.0138	0.0111	0.0096

Notes: This table reports the regression results from Equation (4.1). 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 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 the unified shock from Bu et al. (2021). We control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

Source: Authors' calculation.

controls for our main empirical specification.

Table 7 reports the estimation result. Overall, the estimation result supports the refinancing motive as an important factor driving the sensitivity of homeowners' inflation expectations to mortgage-rate changes. Homeowners' inflation expectations—both short-term and long-term—respond to the monetary-policy component of mortgage-rate declines more than they do to that of mortgage-rate rises (Columns 2 and 4). In line with this result, homeowners' short-term inflation expectations increase to a decline in mortgage rates with statistical significance, while the coefficient's statistical significance disappears to a rise in mortgage rates (Column 1). For long-term inflation expectations, homeowners' asymmetric sensitivity to the mortgage-rate change is unclear (Column 3). However, strikingly, homeowners raise their long-term inflation expectations with statistical significance in response to a drop in mortgage rates caused by monetary policy shocks. In summary, a drop in mortgage rate driven by monetary policy raises homeowners' inflation expectations in the long run as well as in the short run.

Quite differently, renters' inflation expectations respond more strongly to an increase in mortgage rate, and are not driven by monetary policy shocks. While renters do not have an

incentive to refinance, they might worry about a higher mortgage rate as potential home-buyers, leading their expectations to respond more strongly to the rate hikes than to the rate cuts.

The observed asymmetric sensitivity of homeowners' inflation expectations to a change in mortgage rates and monetary policy offers new insight about the effectiveness of monetary policy. This analysis suggests that homeownership and homeowners' refinancing motive may be a key driver of unequal effects of monetary policy on households' expectations.

4.2 Evidence from American Time Use Survey

This section provides corroborating evidence for the greater attentiveness of homeowners to the macroeconomic developments than that of renters based upon the American Time Use Survey (hereafter, ATUS).

Here, we provide brief explanations on the survey and the variables used for the empirical analysis.[14] The ATUS collects data on the time that an individual spends for various activities during a 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 is a monthly survey, which began from 2003. Hence, the sample period of our empirical analysis is from 2003:M1 to 2020:M12.

The ATUS has information about an individual's time spent on finance-related activities, which is a natural measure of households' attentiveness to financial markets and macroeconomic developments. Specifically, the ATUS has data on time spent on financial management and purchasing financial and banking services. Activities on financial management include trading and checking stocks, researching investments, paying mortgages, checking cryptocurrency or bitcoin balance, and so on. Activities on 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. In addition, the ATUS has respondents' socio-economic characteristics including homeownership as well as demographic attributes. Therefore, the data allow us to analyze the association between homeownership and attentiveness to developments in financial markets and the macroeconomy.[15]

[14] For interested readers on the ATUS used for other research, see, for example, Mukoyama, Patterson and Şahin (2018) and Ahn and Shao (2021).

[15] The ATUS may understate time spent on financial management and purchasing financial and banking services,

Table 8: 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 (4.2).
Source: Authors' calculation.

We consider the following linear regression model:

$$Y_i = \alpha + \beta_1 \text{homeowner}_i + \delta X_i + \epsilon_i \tag{4.2}$$

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. It 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).[16]

Table 8 reports the coefficient estimates. Being a homeowner raises the probability of en-

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*."

[16]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.

gaging in financial management and also time spent for financial management among those who engage in the activity with statistical significance (Panel A). Essentially, 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.

4.3 Robustness checks

This section outlines the robustness of empirical results. The details are found in the appendix. First, we control for house-price expectations to examine the possibility that differences in households' inflation expectations just reflect house-price expectations. Even if we do so, the main result is robust as documented in Appendix Table B.3. Second, we consider different horizons of interest-rate changes. In our baseline specification, we employ changes in interest rate during the past six months. Instead, we adopt interest-rate changes during the past three-months or nine-months. As shown in Appendix Tables B.4 and B.5, our main result on the heterogeneous response of inflation expectations to interest-rate changes still survives regardless.[17] However, the empirical relationship becomes weaker, if the horizon of interest-rate changes becomes the past twelve months or longer. Third, we replace expectations on unemployment conditions with those on future business conditions to examine the contractionary effect of interest-rate changes on overall economic conditions. As shown in Appendix Table B.6 and Figure B.5, our main conclusion remains robust.

We employ an alternative measure 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. Each of three

[17] Similarly, we also find that the different horizons of interest rate changes do not change our conclusion on the heterogeneous responses of unemployment expectations (Appendix Figures B.1 and B.2) and those of 1-year ahead interest rate expectations (Appendix Figures B.3 and B.4).

measures from Swanson (2021) is correlated with the BRW estimate.[18] Appendix Table B.7 documents the coefficients on the federal funds rate, forward guidance, and the LSAP shocks. We recover the portions of changes in the 30-year mortgage rate and T-bond rate attributable to forward guidance and LSAP shocks. With the predicted values, we estimate the responsiveness of households' expectations of inflation (Appendix Table B.8) and real economic activities (Appendix Table B.2 and Appendix Figure B.6) to the information on monetary policy contained in the mortgage rate and T-bond rate. In summary, our results are robust to this alternative measure of monetary policy shocks.

5 Model

In this section, we provide a structural model that explains our empirical findings with a focus on inflation expectations. The structural model is designed to characterize the two findings: First, homeowners revise down their inflation expectations to a rise in interest rate more than renters do; Second, homeowners have a more incentive to pay attention to news on interest-rate changes but renters do not.

We build a two-period partial equilibrium model of rationally inattentive consumers who are either a homeowner or a renter. The homeowner makes a once-and-for-all house purchase and consumes housing services while the renter does not make a decision on housing purchase, but rents it.[19]

5.1 Homeowner

Suppose there are two periods, with time denoted by $t = 0, 1$. In each period, the homeowner is endowed with a fixed real income, w, and consumes C_t^o for $t = 0, 1$. In time 0, the homeowner

[18] The two types of shock estimates capture the different components of monetary policy changes. During the pre-ZLB period, the BRW shock has a correlation of 0.44 with the federal-funds-rate factor, and a correlation of 0.45 with the forward-guidance factor. The correlation between BRW shock and forward guidance factor increases to 0.55 in the post-ZLB period, while the correlation with federal-funds-rate shock drops close to zero. The BRW shock has low correlations with the LSAP factor either pre- or post-ZLB period.

[19] This assumption is without loss of generality. Though homeowners may rent and renters may own a house, we do not consider it a representative case. For instance, in the MSC, homeowners are those who indicate that they currently own or are buying their home and renters are those who do not. Similarly, in the SCE, homeowners are those who indicate that they own their primary residence and renters are those who do not. Only a small fraction of renters, about 1.2% of all respondents, indicate that they own other homes.

makes a once-and-for-all house purchase, H, financing a fraction θ of the purchase with a loan and a fraction $1-\theta$ with homeowner's income. The loan can be used only for the housing purchase; the house lasts for $t=0,1$, then it fully depreciates. The lifetime utility of the homeowner is $u\left(C_0^o\right)+\beta u\left(C_1^o\right)+\left(1+\beta\right)v\left(H\right)$. The homeowner maximizes its utility by choosing C_0^o, C_1^o, and H, subject to budget constraints: $C_0^o+H=w+\frac{l}{P_0}$ and $C_1^o=w-\frac{m}{P_1}$, where $l=\theta P_0 H$ is the nominal value of the loan, $m=R^m l$ is nominal mortgage payments, R^m is the (gross) mortgage interest rate, P_t is aggregate price level, and $\Pi=\frac{P_1}{P_0}$ is the inflation rate.

We assume that the homeowner does not know the nominal mortgage rate and aggregate prices but may observe costly and noisy signal(s) about them given the informational cost, which we discuss later in further detail. This two-period problem is broken into three sequential steps: (1) obtain noisy signal(s), (2) commit to the amount of the housing purchase and the mortgage payment, and (3) consume so that the budget constraint binds.[20]

By combining the budget constraints into the homeowner's utility, we obtain the utility as a function of the choice variable, H, and the two unknown fundamentals, $\left\{R^m,\Pi\right\}$:

$$U\left(H,R^m,\Pi\right)=u\left(w-\left(1-\theta\right)H\right)+\beta u\left(w-\theta\left(\frac{R^m}{\Pi}\right)H\right)+\left(1+\beta\right)v\left(H\right).$$

We take the second-order Taylor approximation to the utility function around the nonstochastic steady state. At this steady state, the optimal housing purchase is denoted by $\bar{H}$ and solves the first order condition, $U_1\left(\bar{H},\bar{R}^m,\bar{\Pi}\right)=0$. Denote log-deviations with lower case variables (e.g., $h=\log H-\log\bar{H}$, $\pi=\log\Pi-\log\bar{\Pi}$, and $i^m=\log R^m-\log\bar{R}^m$). We assume that π and i^m are drawn from independent Gaussian distributions with mean zero and variance σ^2, implying that inflation and the mortgage rate have zero correlation under the model's true data-generating process. Let $\hat{u}\left(h,i^m,\pi\right)=U\left(\bar{H}e^h,\bar{R}^m e^{i^m},\bar{\Pi}e^{\pi}\right)=U\left(H,R^m,\Pi\right)$ denote the homeowner's utility function expressed in terms of log deviations and $\tilde{u}$ denote the second-order Taylor approximation of $\hat{u}$ at the steady-state:

$$\tilde{u}\left(h,i^m,\pi\right)=\hat{u}_1 h+\frac{1}{2}\hat{u}_{11}h^2+\hat{u}_{12}hi^m+\hat{u}_{13}h\pi+\text{terms independent of housing.}$$

[20]The timing implies the budget constraint will hold in the realizations of the unknowns, not just in expectations. This assumption is commonly used in the models of rationally inattentive households. See, for instance, Kamdar (2019).

Notice that $\hat{u}_1 = 0$ because the housing purchase is the choice variable, and $\hat{u}_{11} < 0$ with a standard convexity property of the utility function. Let $x = [i^m \ \ \pi]'$ denote the vector of the two unknowns. Then, we can rewrite the homeowner's utility function as $-h'Dh + x'Bh$ where $D = \frac{1}{2}|\hat{u}_{11}|$ and $B = [\hat{u}_{12} \ \ \hat{u}_{13}]'$. Given the homeowner's information set $\mathscr{S}$, the optimal housing choice is $h^* = \frac{D^{-1}B'}{2}\tilde{x}$ where $\tilde{x} = \mathbb{E}[x|\mathscr{S}]$. Lastly, we rewrite the utility function as

$$U = -\left(\frac{D^{-1}B'}{2}\mathbb{E}[x|\mathscr{S}] - \frac{D^{-1}B'}{2}x\right)' D\left(\frac{D^{-1}B'}{2}\mathbb{E}[x|\mathscr{S}] - \frac{D^{-1}B'}{2}x\right) = -(\tilde{x}-x)'\Omega^o(\tilde{x}-x),$$

where $\Omega^o = \frac{BD^{-1}B'}{4} = \frac{1}{2|\hat{u}_{11}|}\begin{pmatrix} \hat{u}_{12}^2 & \hat{u}_{12}\hat{u}_{13} \\ \hat{u}_{12}\hat{u}_{13} & \hat{u}_{13}^2 \end{pmatrix}$.

We assume the homeowner is rationally inattentive and chooses the housing purchase based on imperfect information about two unknowns in the economy. We model the cost of information processing as a linear function in Shannon's mutual information function. Let $H(X|Y)$ be a conditional entropy of a random variable of X given knowledge of Y. We define the flow cost of information with the information set $\mathscr{S} = \mathscr{S}_{-1} \cup s$ as $\lambda\mathbb{I}(x;\mathscr{S}|\mathscr{S}_{-1})$, where $\mathbb{I}(x;\mathscr{S}|\mathscr{S}_{-1}) = H(x|\mathscr{S}) - E[H(x|\mathscr{S})|\mathscr{S}_{-1}]$ is the reduction in uncertainty about unknown fundamentals that the homeowner experiences by observing a set of signals, s, given the homeowner's prior information set, $\mathscr{S}_{-1}$, and λ is the marginal cost of a bit of information. Because the homeowner's prior and posterior beliefs are both Gaussian, we can rewrite the homeowner's problem as choosing the posterior variance-covariance matrix about the unknown fundamentals, Σ^o, to maximize utility given the cost of information processing:

$$\max_{\Sigma^o \leq \Gamma} -(\tilde{x}-x)'\Omega^o(\tilde{x}-x) - \frac{\lambda}{2}\log\left|\Sigma^o\right|,$$

where $\Gamma = \sigma^2 I$ is the prior variance-covariance matrix.[21]

5.2 Renter

In each period, the renter is endowed with a fixed real income, w, and consumes C_t^r for $t = 0, 1$. Unlike the homeowner, the renter does not buy a house, but rents one with a constant rental

[21] Any n-dimensional normally distributed vector has entropy $\frac{n}{2} + \frac{n}{2}\log(2\pi) + \frac{1}{2}\log|\Sigma|$ where Σ is the posterior variance-covariance matrix about the unknown fundamentals.

rate $\gamma_0 = \gamma_1 = \gamma$. Let $\tilde{w} = w - \gamma$ denote the rent-adjusted real income for the renter. At time 0, the renter trades a one-period nominal bond, B, with an exogenous nominal rate R. The renter maximizes lifetime utility, $u\left(C_0^r\right) + \beta u\left(C_1^r\right)$, by choosing C_0^r, C_1^r, and B, subject to budget constraints: $C_0^r + \frac{B}{P_0} = \tilde{w}$ and $C_1^r = \tilde{w} + R\frac{B}{P_1}$. We assume that the renter does not know the nominal rate and aggregate prices, but may observe costly and noisy signal(s) about them given the informational cost.

By combining budget constraints with the renter's utility, we obtain the utility as a function of the choice variable, C_0^r, and the two unknown fundamentals, $\{R, \Pi\}$:

$$U\left(C_0^r, R, \Pi\right) = u\left(C_0^r\right) + \beta u\left(\tilde{w} + \frac{R}{\Pi}\left(\tilde{w} - C_0^r\right)\right).$$

Denote log-deviations with lower case variables (e.g., $c_0^r = \log C_0^r - \log \bar{C}_0^r$ and $i = \log R - \log \bar{R}$). Similar to the homeowner's problem, we take the second-order Taylor approximation to the renter's utility around the non-stochastic steady state. Let $\breve{u}\left(c_0^r, i, \pi\right) = U\left(\bar{C}^r e^{c_0^r}, \bar{R}e^i, \bar{\Pi}e^{\pi}\right) = U\left(C_0^r, R, \Pi\right)$ denote the utility function expressed in terms of log deviations and let $\tilde{\breve{u}}$ denote the second-order Taylor approximation of $\breve{u}$ at the steady-state:

$$\tilde{\breve{u}}\left(c_0^r, i, \pi\right) = \breve{u}_1 h + \frac{1}{2}\breve{u}_{11}(c_0^r)^2 + \breve{u}_{12}c_0^r i + \breve{u}_{13}c_0^r \pi + \text{terms independent of } c_0^r.$$

The renter is also rationally inattentive and chooses consumption based on imperfect information about two unknowns in the economy. Let $x^r = [i \;\; \pi]'$ denote the vector of the two unknowns for the renter. After incorporating the cost of information processing as a linear function in Shannon's mutual information function, the renter's problem can be expressed as choosing the posterior variance-covariance matrix, Σ^r, to solve the following:

$$\max_{\Sigma^r \leq \Gamma} -\left(\tilde{x}^r - x^r\right)' \Omega^r \left(\tilde{x}^r - x^r\right) - \frac{\lambda}{2}\log\left|\Sigma^r\right|,$$

where $\Gamma = \sigma^2 I$ is the prior variance-covariance matrix and $\Omega^r = \frac{1}{2|\breve{u}_{11}|}\begin{pmatrix} \breve{u}_{12}^2 & \breve{u}_{12}\breve{u}_{13} \\ \breve{u}_{12}\breve{u}_{13} & \breve{u}_{13}^2 \end{pmatrix}$.

5.3 Solution

To derive an analytical solution of the rational inattention problems, we assume that the homeowner has a log utility in consumption and housing, $u(C) + v(H) = \log C + \log H$, and the renter also has a log utility in consumption: $u(C^r) = \log C^r$. We also assume that the nominal rate is identical to the mortgage rate, $i = i^m$, implying that both interest rates perfectly co-move, and have zero correlation with inflation under the model's true data-generating process.

We solve the rational inattention problems using a recently developed solution method (e.g., Kamdar 2019; Kőszegi and Matějka 2020; Afrouzi and Yang 2021). For a symmetric matrix $\mathbf{X}$ with spectral decomposition $\mathbf{X} = \mathbf{UDU}'$, we define $\text{Max}(\mathbf{X}, \lambda) = \mathbf{U}\max(\mathbf{D}, \lambda)\mathbf{U}'$ where $\max(\mathbf{D}, \lambda)$ operates on every element on the diagonal. Then, as shown in Afrouzi and Yang (2021), the optimal posterior covariance matrix, Σ^i, is characterized by the following policy function:

$$\Sigma^i = \lambda\sigma^2\left[\text{Max}\left(\sigma^2\Omega^i, \lambda\right)\right]^{-1} \text{ for } i \in \{o, r\},$$

For $i \in \{o, r\}$, the spectral decomposition of a matrix $\sigma^2\Omega^i$ shows one positive eigenvalue, $\Lambda_1^i > 0$, and another zero eigenvalue, $\Lambda_2^i = 0$. We set the marginal cost of information, λ, to satisfy $\Lambda_1^o = \sigma^2\frac{\hat{u}_{12}^2}{|\hat{u}_{11}|} > \lambda$ and $\Lambda_1^r = \sigma^2\frac{\check{u}_{12}^2}{|\check{u}_{11}|} > \lambda$.[22] In this case, both the homeowner and the renter choose to observe one signal along the corresponding first dimension.

We characterize the optimal posterior means of the agents' belief using Bayesian updating. The following proposition compares the response of the agents' inflation expectations with an exogenous change in the interest rate.

Proposition. *Let $\tilde{\pi}^o$ and $\tilde{\pi}^r$ be inflation expectations of the homeowner and the renter, respectively. Then, if $\beta > \frac{1}{2}$,*

$$\frac{\partial\tilde{\pi}^o}{\partial i} < \frac{\partial\tilde{\pi}^r}{\partial i} < 0.$$

Proof. The homeowner's optimal posterior mean belief of inflation is

$$\tilde{\pi}^o = \left(1 - \frac{\lambda|\hat{u}_{11}|}{\sigma^2\hat{u}_{12}^2}\right)\left[-i + \pi + \sigma z^o\right] = \left(1 - \frac{\lambda}{\sigma^2}\left(\frac{1+\beta}{2\beta^2}\right)\right)\left[-i + \pi + \sigma z^o\right].$$

[22] In Appendix A., we derive the second derivatives of the homeowner's and the renter's utility function.

where $z^o \sim \mathcal{N}\left(0, \frac{\lambda}{\Lambda_1^o - \lambda}\right)$ is the homeowner's rational inattention error. Similarly, the renter's inflation expectation can be expressed as follows:

$$\tilde{\pi}^r = \left(1 - \frac{\lambda |\check{u}_{11}|}{\sigma^2 \check{u}_{12}^2}\right)\left[-i + \pi + \sigma z^r\right] = \left(1 - \frac{\lambda}{\sigma^2}\left(\frac{1+\beta}{\beta}\right)\right)\left[-i + \pi + \sigma z^r\right]$$

where $z^r \sim \mathcal{N}\left(0, \frac{\lambda}{\Lambda_1^r - \lambda}\right)$ is the renter's rational inattention error. Then, if $\beta > \frac{1}{2}$, $\frac{\partial \tilde{\pi}^o}{\partial i} < \frac{\partial \tilde{\pi}^r}{\partial i} < 0$. □

Consistent with our empirical findings, the model implies that the homeowner's inflation expectations are more sensitive to a change in interest rates than the renter's inflation expectations. Because, at time 0, both homeowner and renter make their intertemporal saving decision on nominal assets (housing for the homeowner and a one-period nominal bond for the renter), they have an incentive to acquire information about inflation.[23] Notice that the changes in inflation affect the relative price of housing, which has a substitution effect on consumption for the homeowner, because homeowners value housing services in their utility. This additional substitution effect is absent from the renter's problem. If both the homeowner and the renter are sufficiently patient ($\beta > \frac{1}{2}$), then this additional substitution effect gives a stronger incentive for the homeowner to pay attention to the unknown fundamentals compared with the renter.[24] This finding implies that an exogenous increase in interest rates reduces the homeowner's inflation expectations more than the renter's expectations.

6 Conclusion

This paper investigates the role of household heterogeneity in the effectiveness of monetary policy on households' expectations with a particular focus on homeownership. The survey data suggest that homeowners revise down their expectations of inflation and the labor-market

[23] While we focus on the different incentives to acquire information about inflation and assume that the marginal cost of information, λ, is identical for both types of households, one might think of a case where the homeowner has a smaller cost than the renter due to either other household characteristics (e.g., education and income) or the greater availability of news related with interest rates (e.g., mortgage newsletters). This case, however, is only likely to strengthen our results as the homeowner will acquire more information about inflation with a lower marginal cost of information.

[24] This relationship can be easily found when we compare the homeowner's benefit matrix, $\Omega^o = \beta\left(\frac{\beta}{1+\beta}\right)\begin{pmatrix} 1 & -1 \\ -1 & 1 \end{pmatrix}$, with the renter's benefit matrix, $\Omega^r = \frac{1}{2}\left(\frac{\beta}{1+\beta}\right)\begin{pmatrix} 1 & -1 \\ -1 & 1 \end{pmatrix}$.

outlook in the near term in response to a rise in long-term mortgage rates or T-bond rates, while renters are less likely to do so. We find that the monetary-policy component of mortgage-rate changes drives the contractionary effect on homeowners' expectations. We interpret this result to suggest that homeowners are attentive to news on interest rates and revise their expectations accordingly in a manner consistent with the intended effect of monetary policy.

We characterize these findings using a rational inattention model with an information acquisition cost where homeowners making mortgage payments have an incentive to pay attention to news on interest rates and, hence, adjust their expectations in response to a change in interest rates more than renters do. Our results imply that the macroeconomic effects of monetary policy may depend on the distribution of household homeownership status in the economy. A fully-fledged general equilibrium model may be able to address the macroeconomic effects of monetary policy and its welfare implications for households. We leave the extended analyses for future research.

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Appendix For Online Publication

The appendix is composed of a section on the theory (Section Appendix A.) and a section on the supplementary empirical results (Section Appendix B.).

Appendix A. Second Derivatives of Consumer Utility Functions

In this appendix, we derive second derivatives of consumers' utility function, which are necessary for our main theoretical results.

Homeowner Recall the homeowner's utility function:

$$u\left(C_0^o\right)+\beta u\left(C_1^o\right)+\left(1+\beta\right)v\left(H\right)=\log C_0^o+\beta\log C_1^o+\left(1+\beta\right)\log H.$$

By combining the budget constraints, $C_0^o+H=w+\frac{l}{P_0}$ and $C_1^o=w-\frac{m}{P_1}$ with $l=\theta P_0 H$ and $m=R^m l$, we get the utility as a function of the choice variable, H, and the two unknown fundamentals, $\{R^m,\Pi\}$:

$$U\left(H,R^m,\Pi\right)=\log\left(w-\left(1-\theta\right)H\right)+\beta\log\left(w-\theta\left(\frac{R^m}{\Pi}\right)H\right)+\left(1+\beta\right)\log H.$$

The utility function written in log-deviations from its steady-state is:

$$\begin{aligned}\hat{u}\left(h,i^m,\pi\right)&=U\left(\bar{H}e^h,\bar{R}^m e^{i^m},\bar{\Pi}e^{\pi}\right)\\&=\log\left(w-\left(1-\theta\right)\bar{H}e^h\right)+\beta\log\left(w-\theta\left(\frac{\bar{R}^m e^{i^m}}{\bar{\Pi}e^{\pi}}\right)\bar{H}e^h\right)+\left(1+\beta\right)\log\bar{H}e^h.\end{aligned}$$

The optimal housing choice, h, satisfies the following first-order condition:

$$\frac{\left(1-\theta\right)\bar{H}e^h}{w-\left(1-\theta\right)\bar{H}e^h}+\beta\frac{\theta\left(\frac{\bar{R}^m e^{i^m}}{\bar{\Pi}e^{\pi}}\right)\bar{H}e^h}{w-\theta\left(\frac{\bar{R}^m e^{i^m}}{\bar{\Pi}e^{\pi}}\right)\bar{H}e^h}=\left(1+\beta\right).$$

Notice that using the budget constraints, we get the steady-state real mortgage rate, $\frac{\bar{R}^m}{\bar{\Pi}}=\frac{1-\theta}{\theta}$. Then, the steady-state housing choice is $\bar{H}=\frac{w}{2(1-\theta)}$.

The second-order approximation of $\hat{u}$ with respect to housing evaluated at the steady-state

is:

$$\begin{aligned}\hat{u}_{11} &= -\frac{(1-\theta)\bar{H}}{w-(1-\theta)\bar{H}}\left(\frac{w}{w-(1-\theta)\bar{H}}\right)-\beta\frac{\theta\left(\frac{\bar{R}^m}{\bar{\Pi}}\right)\bar{H}}{w-\theta\left(\frac{\bar{R}^m}{\bar{\Pi}}\right)\bar{H}}\left(\frac{w}{w-\theta\left(\frac{\bar{R}^m}{\bar{\Pi}}\right)\bar{H}}\right)\\ &= -2\left(1+\beta\right).\end{aligned}$$

The second-order approximation of $\hat{u}$ with respect to housing and mortgage rate evaluated at the steady-state is:

$$\hat{u}_{12} = -\beta\frac{\theta\left(\frac{\bar{R}^m}{\bar{\Pi}}\right)\bar{H}}{\left(w-\theta\left(\frac{\bar{R}^m}{\bar{\Pi}}\right)\bar{H}\right)^2}w = -2\beta$$

Similarly, the second-order approximation of $\hat{u}$ with respect to housing and inflation evaluated at the steady-state is:

$$\hat{u}_{13} = \beta\frac{\theta\left(\frac{\bar{R}^m}{\bar{\Pi}}\right)\bar{H}w}{\left(w-\theta\left(\frac{\bar{R}^m}{\bar{\Pi}}\right)\bar{H}\right)^2} = 2\beta.$$

This implies that $\hat{u}_{12} = -\hat{u}_{13}$ and the product of the two will be a negative number.

Renter Recall the renter's utility function:

$$u\left(C_0^r\right)+\beta u\left(C_1^r\right) = \log C_0^r+\beta\log C_1^r.$$

By combining the budget constraints, $C_0^r+\frac{B}{P_0} = \tilde{w}$ and $C_1^r = \tilde{w}+R\frac{B}{P_1}$, we get the utility as a function of the choice variable, C_0^r, and the two unknown fundamentals, $\{R,\Pi\}$:

$$U\left(C_0^r,R,\Pi\right) = \log\left(C_0^r\right)+\beta\log\left(\tilde{w}+\frac{R}{\Pi}\left(\tilde{w}-C_0^r\right)\right).$$

The utility function written in log-deviations from its steady-state is:

$$\begin{aligned}\check{u}\left(c_0^r,i,\pi\right) &= U\left(\bar{C}_0^r e^{c_0^r},\bar{R}e^i,\bar{\Pi}e^\pi\right)\\ &= \log\left(\bar{C}_0^r e^{c_0^r}\right)+\beta\log\left(\tilde{w}+\frac{\bar{R}e^i}{\bar{\Pi}e^\pi}\left(\tilde{w}-\bar{C}_0^r e^{c_0^r}\right)\right).\end{aligned}$$

The optimal housing choice, c_0^r, satisfies the following first-order condition:

$$1 = \beta\frac{\frac{\bar{R}e^i}{\bar{\Pi}e^\pi}\bar{C}_0^r e^{c_0^r}}{\tilde{w}+\frac{\bar{R}e^i}{\bar{\Pi}e^\pi}\left(\tilde{w}-\bar{C}_0^r e^{c_0^r}\right)}$$

Notice that using the budget constraints, we get the steady-state consumption, $\bar{C}^r = \tilde{w}$. Then, the steady-state housing choice is $\frac{\bar{R}}{\bar{\Pi}} = \frac{1}{\beta}$.

The 2nd-order approximation of $\hat{u}$ with respect to housing evaluated at the steady-state is:

$$\check{u}_{11} = -\beta \frac{\frac{\bar{R}}{\bar{\Pi}} \bar{C}_0^r}{\tilde{w} + \frac{\bar{R}}{\bar{\Pi}} \left(\tilde{w} - \bar{C}_0^r\right)} \left[\frac{\tilde{w} + \frac{\bar{R}}{\bar{\Pi}} \tilde{w}}{\tilde{w} + \frac{\bar{R}}{\bar{\Pi}} \left(\tilde{w} - \bar{C}_0^r\right)} \right] = -\frac{1+\beta}{\beta}$$

The 2nd-order approximation of $\hat{u}$ with respect to housing and mortgage rate evaluated at the steady-state is:

$$\check{u}_{12} = -\beta \frac{\frac{\bar{R}}{\bar{\Pi}} \bar{C}_0^r}{\tilde{w} + \frac{\bar{R}}{\bar{\Pi}} \left(\tilde{w} - \bar{C}_0^r\right)} \left(\frac{\tilde{w}}{\tilde{w} + \frac{\bar{R}}{\bar{\Pi}} \left(\tilde{w} - \bar{C}_0^r\right)} \right) = -1$$

Similarly, the second-order approximation of $\hat{u}$ with respect to housing and inflation evaluated at the steady-state is:

$$\check{u}_{13} = \beta \frac{\frac{\bar{R}}{\bar{\Pi}} \bar{C}_0^r}{\tilde{w} + \frac{\bar{R}}{\bar{\Pi}} \left(\tilde{w} - \bar{C}_0^r\right)} \left(\frac{\tilde{w}}{\tilde{w} + \frac{\bar{R}}{\bar{\Pi}} \left(\tilde{w} - \bar{C}_0^r\right)} \right) = 1.$$

This implies that $\hat{u}_{12} = -\hat{u}_{13}$ and the product of the two will be a negative number.

Appendix B. Supplementary Empirical Results

Appendix Table B.1: HOMEONWERSHIP RATES AND DIFFERENCES IN INFLATION EXPECTATIONS ACROSS HOMEOWNERS AND RENTERS

	(1) MSC	(2) SCE
Homeownership rate	75%	74%
Differences in inflation expectations: $E^{homeowner} - E^{renter}$		
− 1-year ahead inflation expectations	-0.342***	-0.282***
	(0.025)	(0.033)
− 3-year ahead inflation expectations		-0.249***
		(0.034)
− 5-year ahead inflation expectations	-0.458***	
	(0.021)	

Notes: This table reports homeownership rates and the average differences in inflation expectations between homeowners and renters from the Michigan Surveys of Consumers (Column (1)) and the NY Fed Survey of Consumer Expectations (Column (2)).

Appendix Table B.2: SENSITIVITY OF REVISIONS IN HOMEOWNERS AND RENTERS' UNEMPLOYMENT EXPECTATIONS TO CHANGES IN INTEREST RATES

Interactions	(1) $\Delta\tilde{R}^{Mort}_{t,brw}$	(2) $\Delta\tilde{R}^{Mort}_{t,LF}$	(3) $\Delta\tilde{R}^{T\text{-}bond}_{t,LF}$
Panel A. Unemployment: Improve			
Renter (α_1)	1.090***	1.076***	1.071***
	(0.027)	(0.025)	(0.025)
Homeowner×ΔR_t (β_1)	0.788***	0.820***	0.904***
	(0.021)	(0.021)	(0.022)
Renter×ΔR_t (β_2)	0.788***	0.857***	0.912**
	(0.036)	(0.035)	(0.037)
Panel B. Unemployment: Worsen			
Renter (α_1)	1.057**	1.053**	1.054**
	(0.027)	(0.025)	(0.026)
Homeowner×ΔR_t (β_1)	1.039	1.049*	1.022
	(0.028)	(0.026)	(0.025)
Renter×ΔR_t (β_2)	1.023	1.022	0.902
	(0.048)	(0.044)	(0.019)
Number of obs.	51764	55641	55641
R^2	0.0024	0.0021	0.0014

Notes: This table reports the logit regression results from Equation (3.3). 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. ΔR_t refers to the six-month change in interest rate. We use the 30-year mortgage rate predicted by the unified shock from Bu et al. (2021) in Column (1), the 30-year mortgage rate predicted by the LSAP and forward guidance shocks from Swanson (2021) in Column (2), and the 30-year Treasury Bond rate predicted by the LSAP and forward guidance shocks from Swanson (2021) in Column (3). The coefficients are reported in terms of relative risk ratios. We control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

Appendix Table B.3: ROBUSTNESS CHECK ON SENSITIVITY OF REVISIONS IN HOMEOWNERS' INFLATION EXPECTATIONS TO INTEREST-RATE CHANGES BY CONTROLLING FOR HOUSE PRICE EXPECTATIONS

Interactions	Baseline	(1) ΔR_t^{Mort}	(2) ΔR_t^{FFR}	(3) $\Delta R_t^{T\text{-}bond}$
Michigan Survey of Consumers (1-year ahead inflation expectations)				
House price expectations	-0.030***	-0.030***	-0.029***	-0.030***
	(0.006)	(0.006)	(0.006)	(0.006)
ΔR_t		-0.489***	0.431***	-0.262***
		(0.097)	(0.071)	(0.085)
Number of obs.	14071	14071	14071	14071
R^2	0.0129	0.0146	0.0155	0.0135

Notes: This table reports the estimates of β_1 from Equation (3.1) using inflation expectations of homeowners in the next 12 months in the MSC. House price expectations over the next year are included as an additional explanatory variable.

Appendix Table B.4: ROBUSTNESS CHECK ON SENSITIVITY OF REVISIONS IN HOMEOWNERS AND RENTERS' INFLATION EXPECTATIONS TO INTEREST-RATE CHANGES OF THE PAST 3 MONTHS

Interactions	(1) ΔR_t^{Mort}	(2) ΔR_t^{FFR}	(3) $\Delta R_t^{T\text{-}bond}$
Panel A. Michigan Survey of Consumers (1-year ahead inflation expectations)			
Homeowner×ΔR_t (β_1)	-0.339***	0.203***	-0.316***
	(0.085)	(0.042)	(0.083)
Renter×ΔR_t (β_2)	-0.146	0.038	-0.367**
	(0.096)	(0.125)	(0.143)
Number of obs.	50834	50834	50834
R^2	0.0140	0.0138	0.0141
Panel B. Michigan Survey of Consumers (5-year ahead inflation expectations)			
Homeowner×ΔR_t (β_1)	0.013	0.071	-0.057
	(0.071)	(0.035)	(0.070)
Renter×ΔR_t (β_2)	-0.08	-0.077	-0.172
	(0.119)	(0.105)	(0.121)
Number of obs.	48842	48842	48842
R^2	0.0107	0.0107	0.0107

Notes: This table reports the regression results from Equation (3.1). Dependent variables are the six-month change in the MSC's 12-month ahead inflation expectations (Panel A) and the six-month change in the MSC's 5-year ahead inflation expectations (Panel B). "Homeowner" and "Renter" indicate dummies for homeowner and renter respectively. ΔR_t refers to the change in interest rate over the past three months. We use the 30-year mortgage rate in Column (1), the Federal Funds Rate in Column (2), and the 30-year Treasury Bond rate in Column (3). We control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

Appendix Table B.5: ROBUSTNESS CHECK ON SENSITIVITY OF REVISIONS IN HOMEOWNERS AND RENTERS' INFLATION EXPECTATIONS TO INTEREST-RATE CHANGES OF THE PAST 9 MONTHS

Interactions	(1) ΔR_t^{Mort}	(2) ΔR_t^{FFR}	(3) $\Delta R_t^{T\text{-}bond}$
Panel A. Michigan Survey of Consumers (1-year ahead inflation expectations)			
Homeowner×ΔR_t (β_1)	-0.202***	0.068**	-0.202***
	(0.048)	(0.030)	(0.083)
Renter×ΔR_t (β_2)	-0.181**	-0.045	-0.213**
	(0.078)	(0.052)	(0.143)
Number of obs.	50834	50834	50834
R^2	0.0141	0.0138	0.0141
Panel B. Michigan Survey of Consumers (5-year ahead inflation expectations)			
Homeowner×ΔR_t (β_1)	-0.053	0.026	-0.085**
	(0.041)	(0.025)	(0.042)
Renter×ΔR_t (β_2)	-0.051	-0.067	-0.019
	(0.066)	(0.044)	(0.121)
Number of obs.	48842	48842	48842
R^2	0.0107	0.0107	0.0107

Notes: This table reports the regression results from Equation (3.1). Dependent variables are the six-month change in the MSC's 12-month ahead inflation expectations (Panel A) and the six-month change in the MSC's 5-year ahead inflation expectations (Panel B). "Homeowner" and "Renter" indicate dummies for homeowner and renter respectively. ΔR_t refers to the change in interest rate over the past nine months. We use the 30-year mortgage rate in Column (1), the Federal Funds Rate in Column (2), and the 30-year Treasury Bond rate in Column (3). We control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

Appendix Table B.6: SENSITIVITY OF REVISIONS IN HOMEOWNERS AND RENTERS' EXPECTATIONS ON FUTURE BUSINESS CONDITIONS TO CHANGES IN INTEREST RATES

Interactions	(1) ΔR_t^{Mort}	(2) ΔR_t^{FFR}	(3) $\Delta R_t^{T\text{-}bond}$
Panel A. Future Business Conditions: Improve			
Renter (α_1)	1.040^{*}	1.0045^{*}	1.044^{*}
	(0.025)	(0.025)	(0.025)
Homeowner$\times\Delta R_t$ (β_1)	0.878^{***}	0.881^{***}	0.916^{***}
	(0.019)	(0.013)	(0.020)
Renter$\times\Delta R_t$ (β_2)	0.875^{***}	0.897^{***}	0.946
	(0.031)	(0.022)	(0.034)
Panel B. Future Business Conditions: Worsen			
Renter (α_1)	1.070^{***}	1.070^{***}	1.070^{***}
	(0.026)	(0.025)	(0.026)
Homeowner$\times\Delta R_t$ (β_1)	1.000	1.018	1.034
	(0.022)	(0.016)	(0.023)
Renter$\times\Delta R_t$ (β_2)	1.010	1.034	1.036
	(0.036)	(0.027)	(0.038)
Number of obs.	58791	58791	58791
R^2	0.0017	0.0022	0.0014

Notes: This table reports the logit regression results from Equation (3.3). 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. ΔR_t refers to the six-month change in interest rate. We use the 30-year mortgage rate in Column (1), the Federal Funds Rate in Column (2), and the 30-year Treasury Bond rate in Column (3). The coefficients are reported in terms of relative risk ratios. We control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

Appendix Table B.7: RESPONSES OF INTEREST RATES TO MONETARY POLICY SHOCKS

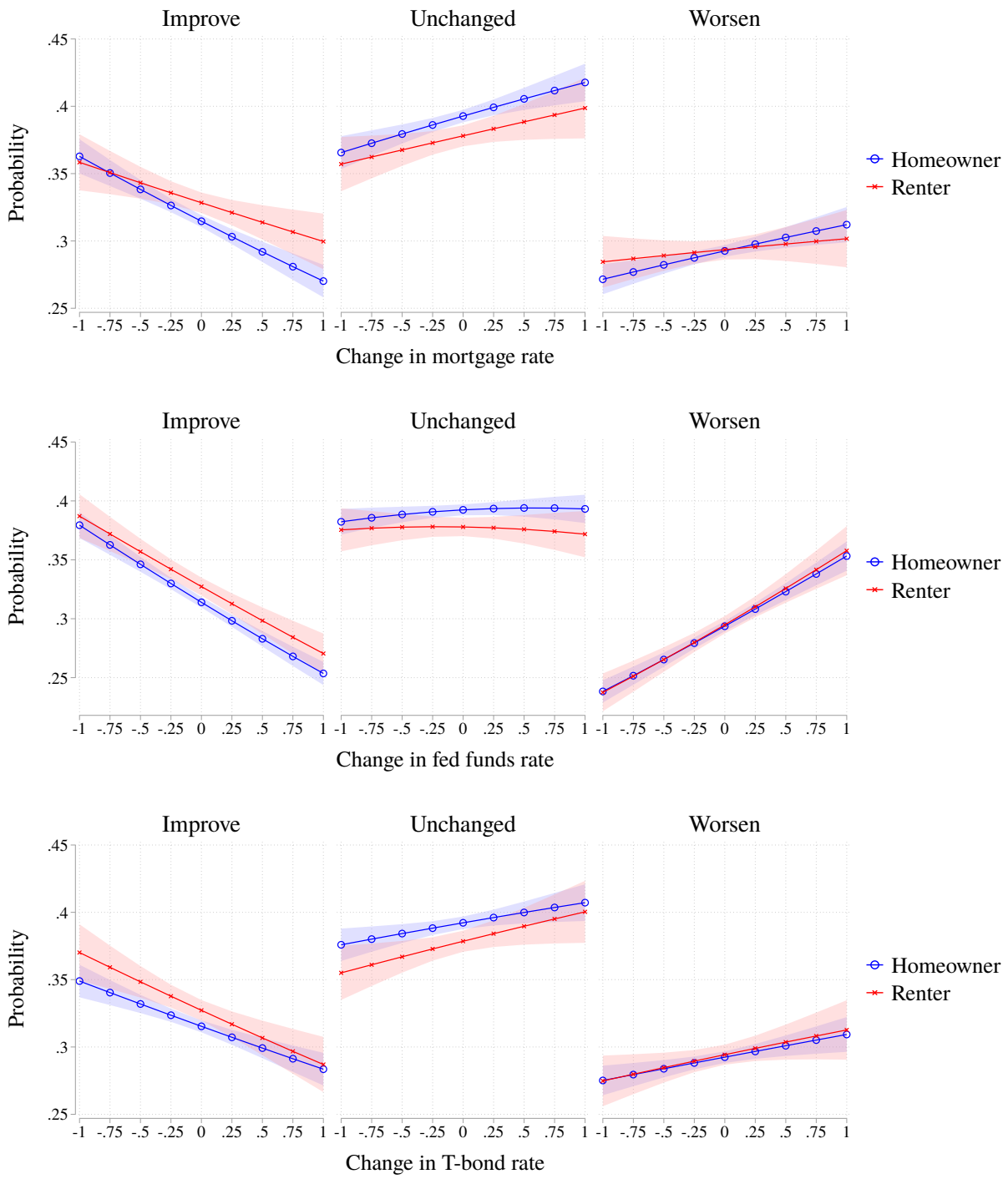
Dependent variable	(1) ΔR_t^{Mort}	(2) $\Delta R_t^{T\text{-}bond}$	(3) ΔR_t^{Mort}	(4) $\Delta R_t^{T\text{-}bond}$
Federal Funds	0.009	-0.004	-0.069	0.048
	(0.009)	(0.007)	(0.043)	(0.043)
Forward Guidance	0.024***	0.007	0.031***	0.024**
	(0.008)	(0.005)	(0.011)	(0.009)
LSAP	0.027***	0.026**	0.095**	0.028*
	(0.017)	(0.012)	(0.039)	(0.015)
Sample period	1991–2019	1991–2019	2013–2019	2013–2019
Number of obs.	1416	1464	330	342
R^2	0.0273	0.0112	0.1492	0.0373

Notes: This table reports the regression results when we use the monetary policy shocks identified in Swanson (2021). Dependent variables are the weekly change in the 30-year mortgage rate in Columns (1) and (3) and the weekly change in the 30-year Treasury Bond rate in Columns (2) and (4). The sample period is from April 1991 to July 2019 for the estimates reported in Columns (1) and (2). The sample period for the estimates in Columns (3) and (4) is from 2013 onward. Newey-West robust standard errors are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.

Appendix Table B.8: SENSITIVITY OF REVISIONS IN HOMEOWNERS AND RENTERS' INFLATION EXPECTATIONS TO CHANGES IN INTEREST RATES PREDICTED BY MONETARY POLICY SHOCK

Interactions	(1) $\Delta\tilde{R}^{Mort}_{t,LF}$	(2) $\Delta\tilde{R}^{T\text{-}bond}_{t,LF}$
Panel A. Michigan Survey of Consumers (1-year ahead inflation expectations)		
Homeowner×ΔR_t (β_1)	-4.523***	-4.341***
	(0.606)	(1.027)
Renter×ΔR_t (β_2)	-3.500***	-2.988
	(1.212)	(2.156)
Number of obs.	47008	47008
R^2	0.0143	0.0134
Panel B. Michigan Survey of Consumers (5-year ahead inflation expectations)		
Homeowner×ΔR_t (β_1)	-0.417	-0.455
	(0.505)	(0.723)
Renter×ΔR_t (β_2)	0.273	2.249
	(0.969)	(1.768)
Number of obs.	45622	45622
R^2	0.0105	0.0106
Panel C. NY Fed Survey of Consumer Expectations (1-year ahead inflation expectations)		
Homeowner×ΔR_t (β_1)	-1.329	-2.641
	(1.058)	(1.756)
Renter×ΔR_t (β_2)	-0.730	2.056
	(2.248)	(3.421)
Number of obs.	37258	37258
R^2	0.0000	0.0000
Panel D. NY Fed Survey of Consumer Expectations (3-year ahead inflation expectations)		
Homeowner×ΔR_t (β_1)	-2.170**	-4.743***
	(1.028)	(1.672)
Renter×ΔR_t (β_2)	-0.889	-0.609
	(2.235)	(3.426)
Number of obs.	37337	37337
R^2	0.0001	0.0003

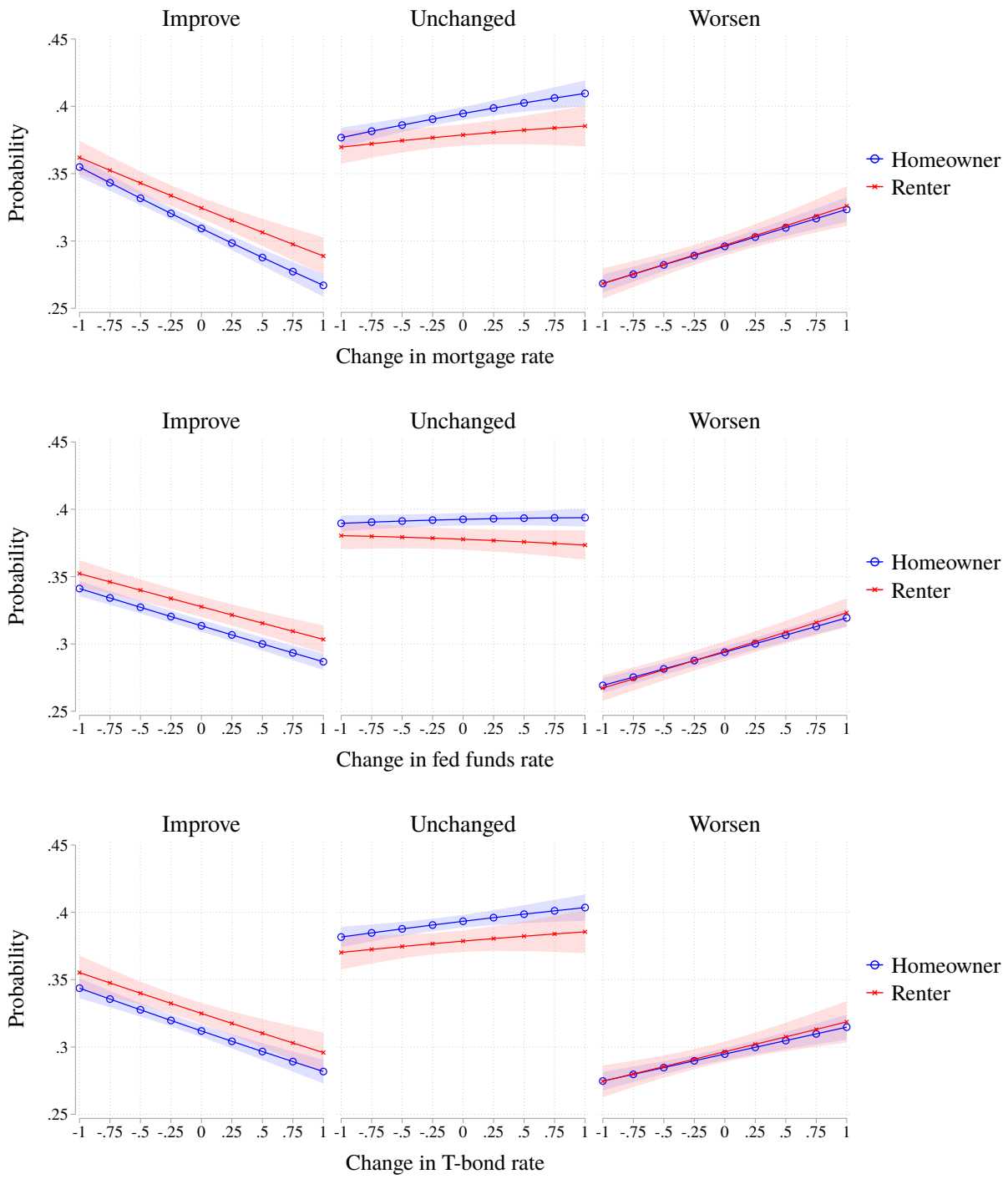
Notes: This table reports the regression results from Equations (3.1) and (3.2). Dependent variables are the six-month changes in the MSC's 1-year ahead inflation expectations (Panel A), the 5-year ahead inflation expectations (Panel B), the SCE's 1-year ahead inflation expectations (Panel C), and the SCE's 3-year ahead inflation expectations (Panel D). "Homeowner" and "Renter" indicate dummies for homeowner and renter respectively. ΔR_t refers to the six-month change in interest rate. We use the 30-year mortgage rate predicted by the LSAP and forward guidance shocks from Swanson (2021) in Column (1), and the 30-year Treasury Bond rate predicted by the LSAP and forward guidance shocks from Swanson (2021) in Column (2). In Panel A and B, we control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Robust standard errors are reported in the parenthesis. In Panel C and D, we employ the individual fixed effects to control the individual heterogeneity. Robust standard errors (clustered at the individual-level) are reported in the parenthesis. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.



Appendix Figure B.1: ROBUSTNESS CHECK ON MARGINAL PROBABILITY OF CHANGES IN HOUSEHOLD EXPECTATIONS OF UNEMPLOYMENT (INTEREST-RATE CHANGES OF THE PAST 3 MONTHS)

Notes: This figure reports the marginal probabilities of changes in household expectations of unemployment to changes in interest rates over the past three months. The interest rates considered from top to bottoms are 30-year mortgage rates, federal funds rate, and 30-year T-bond rates. The results are calculated based on the estimates of the logit regression results from Equation (3.3). We control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Shaded areas represent 95% confidence intervals.

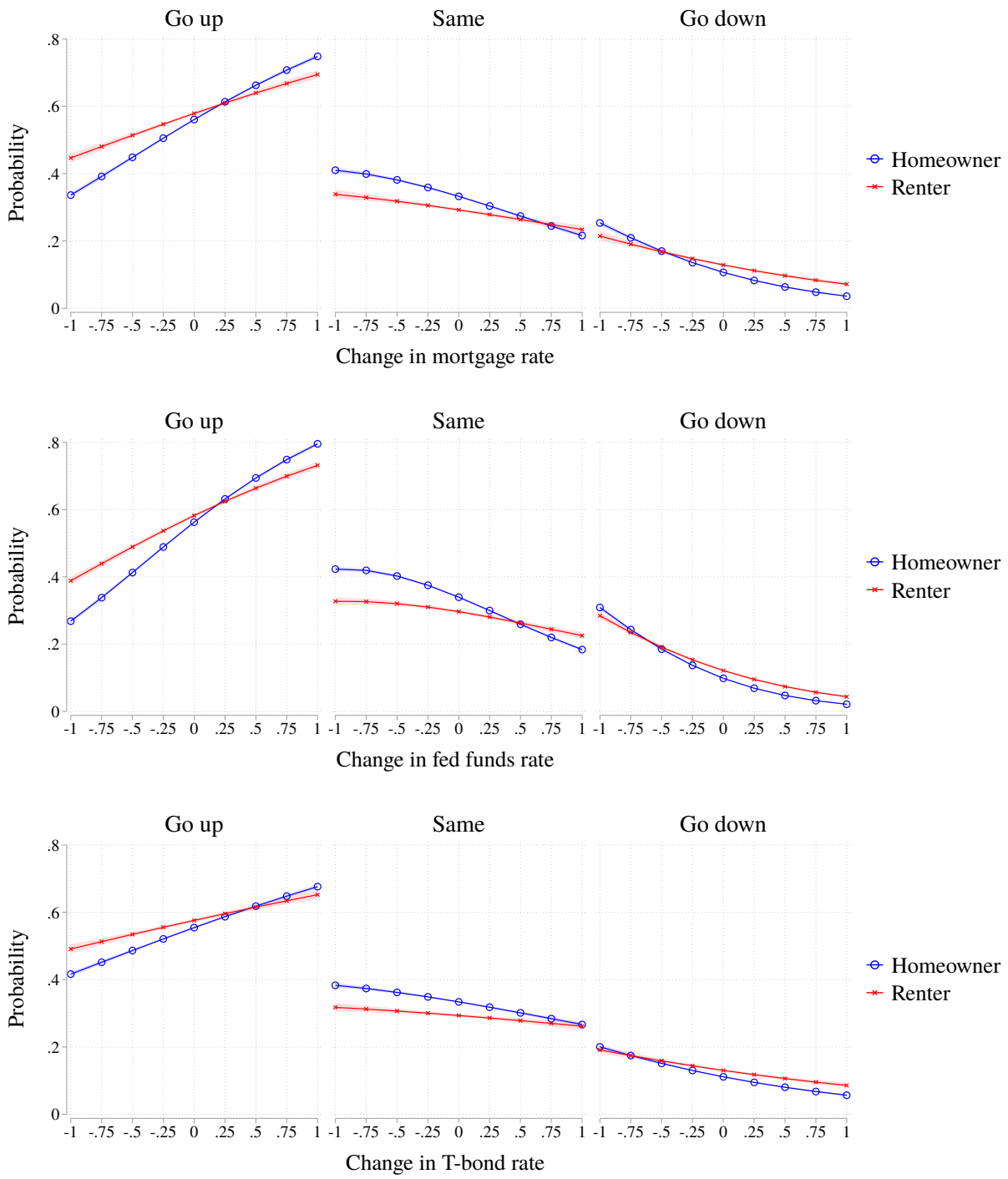
Source: Authors' calculation.



Appendix Figure B.2: ROBUSTNESS CHECK ON MARGINAL PROBABILITY OF CHANGES IN HOUSEHOLD EXPECTATIONS OF UNEMPLOYMENT (INTEREST-RATE CHANGES OF THE PAST 9 MONTHS)

Notes: This figure reports the marginal probabilities of changes in household expectations of unemployment to changes in interest rates over the past nine months. The interest rates considered from top to bottom are 30-year mortgage rates, federal funds rates, and 30-year T-bond rates. The results are calculated based on the estimates of the logit regression results from Equation (3.3). We control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Shaded areas represent 95% confidence intervals.

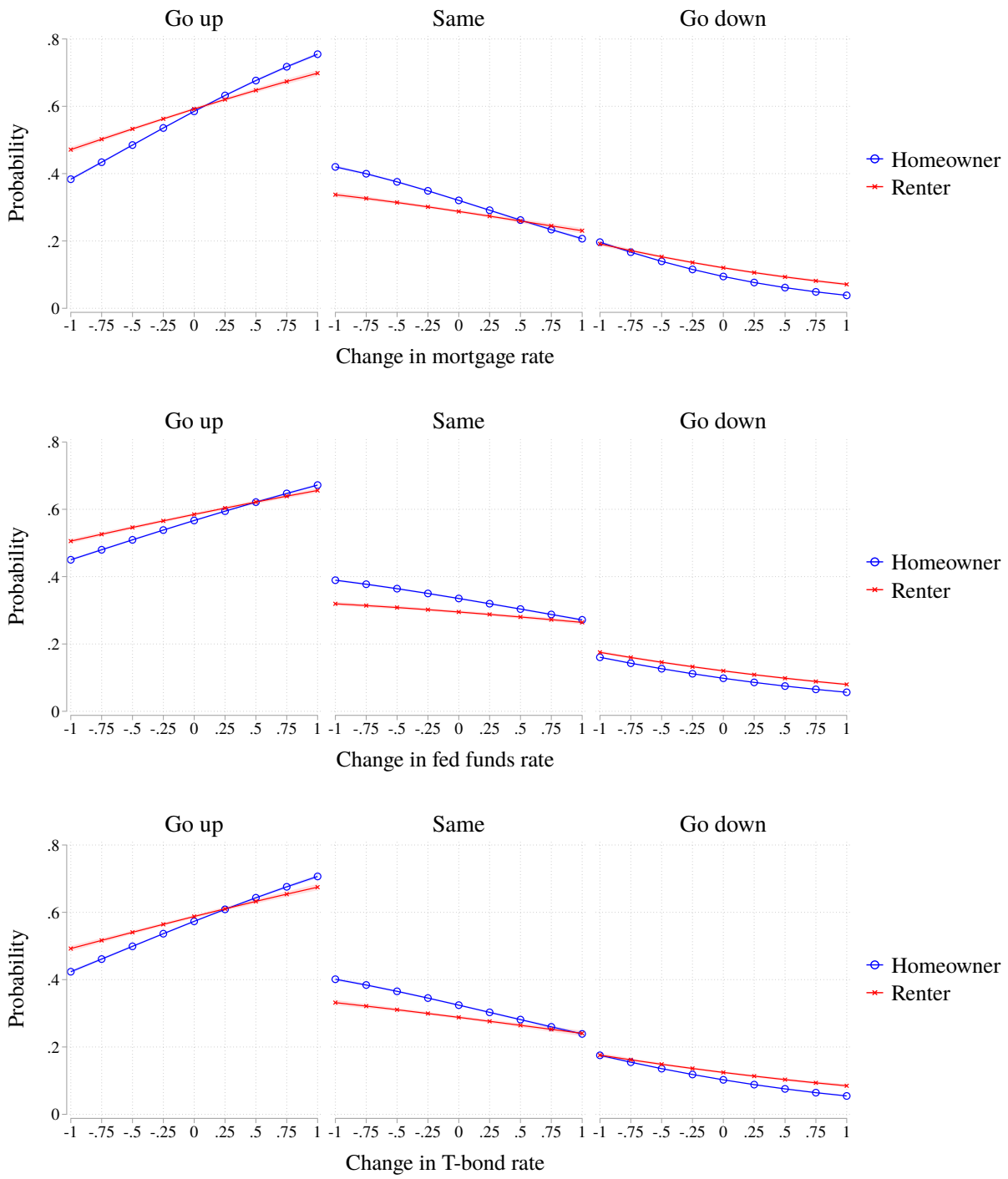
Source: Authors' calculation.



Appendix Figure B.3: ROBUSTNESS CHECK ON MARGINAL PROBABILITY OF HOUSEHOLD EXPECTATIONS OF INTEREST RATES (INTEREST-RATE CHANGES OF THE PAST 3 MONTHS)

Notes: This figure reports the marginal probabilities of changes in household expectations of 1-year-ahead interest rates to changes in interest rates over the past three months. The interest rates considered from top to bottom are 30-year mortgage rates, federal funds rates, and 30-year T-bond rates. The results are calculated based on the estimates of the logit regression results from Equation (3.3). We control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Shaded areas represent 95% confidence intervals.

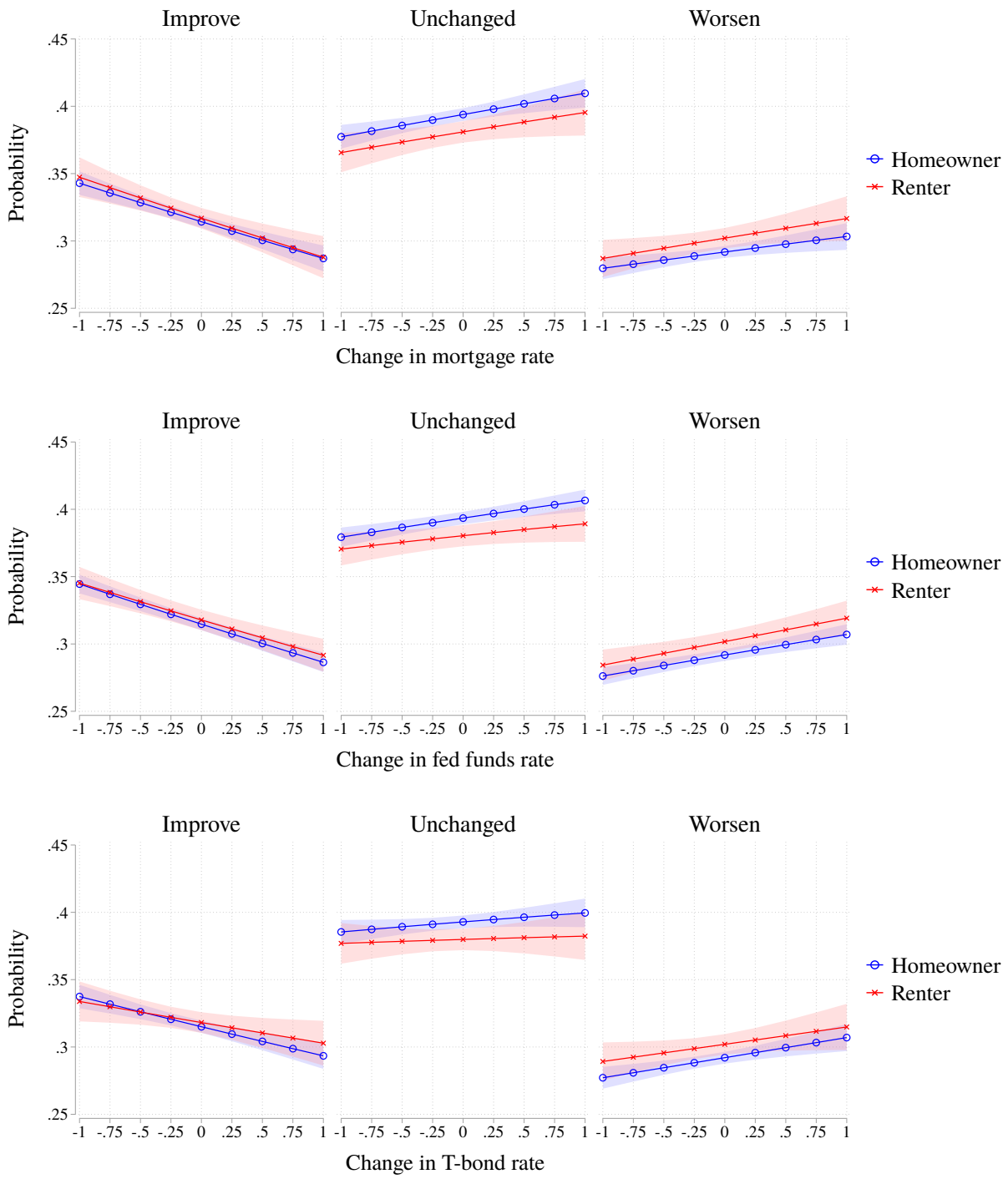
Source: Authors' calculation.



Appendix Figure B.4: ROBUSTNESS CHECK ON MARGINAL PROBABILITY OF HOUSEHOLD EXPECTATIONS OF INTEREST RATES (INTEREST-RATE CHANGES OF THE PAST 9 MONTHS)

Notes: This figure reports the marginal probabilities of changes in household expectations of 1-year-ahead interest rates to changes in interest rates over the past nine months. The interest rates considered from top to bottom are 30-year mortgage rates, federal funds rates, and 30-year T-bond rates. The results are calculated based on the estimates of the logit regression results from Equation (3.3). We control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Shaded areas represent 95% confidence intervals.

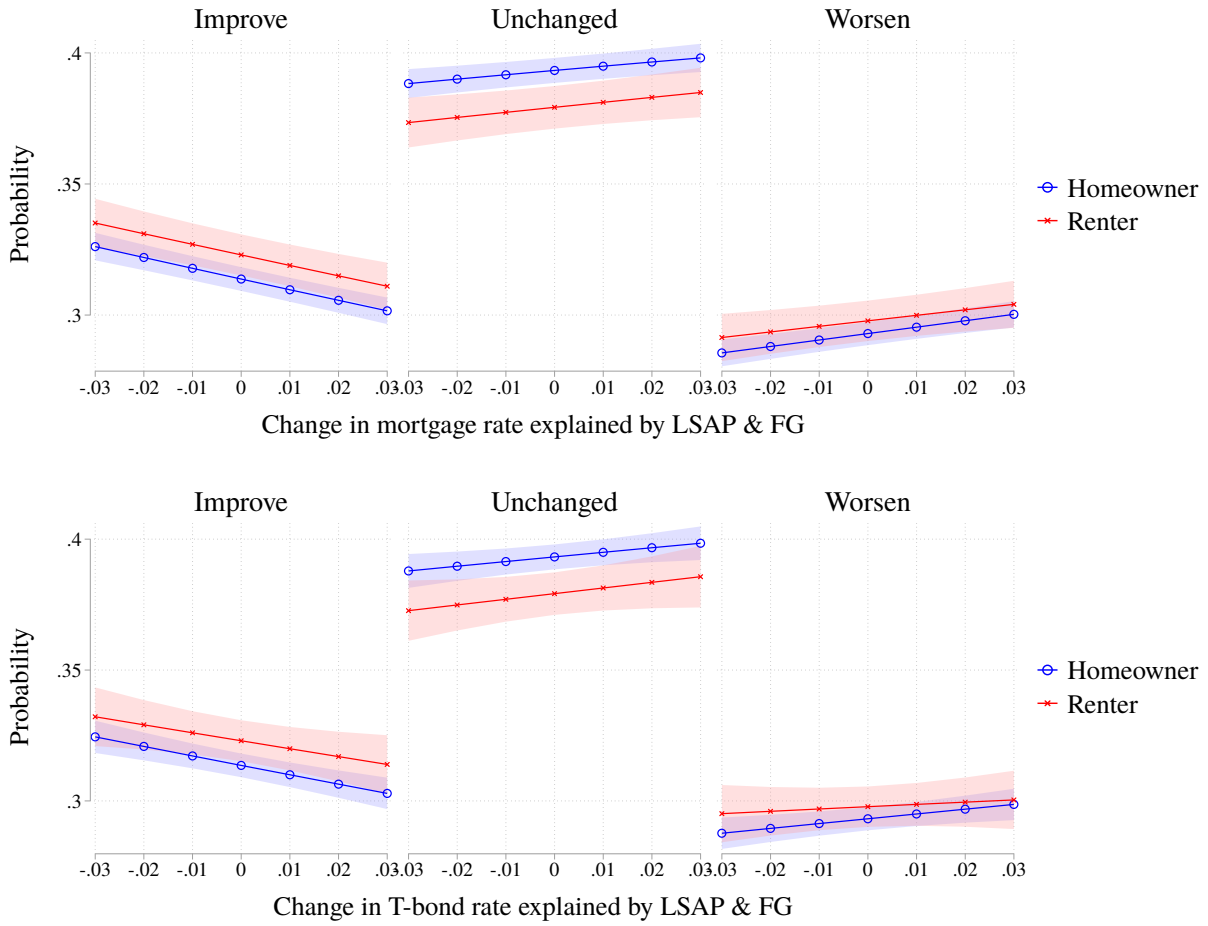
Source: Authors' calculation.



Appendix Figure B.5: 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 interest rates over the past six months. The interest rates considered from top to bottom are 30-year mortgage rates, federal funds rates, and 30-year T-bond rates. The results are calculated based on the estimates of the logit regression results from Equation (3.3). We control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Shaded areas represent 95% confidence intervals.

Source: Authors' calculation.



Appendix Figure B.6: 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 interest rates explained by monetary policy shocks. Explanatory variables considered in the top and bottom are the 30-year mortgage rate predicted by the LSAP and forward guidance shocks from Swanson (2021), and the 30-year Treasury Bond rate predicted by the LSAP and forward guidance shocks from Swanson (2021). The results are calculated based on the estimates of the logit regression results from Equation (3.3) as reported in Column (2) and (3) in Appendix Table B.2. We control for the observed survey respondents' characteristics, including gender, education, birth cohort, and the level of income. Shaded areas represent 95% confidence intervals.

Source: Authors' calculation.