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

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Abstract

We study the role of household heterogeneity in the effectiveness of monetary policy on households' expectations with a particular focus on homeownership. Empirically, we find that homeowners lower their near-term inflation expectations in response to an increase in mortgage rates, while renters are less likely to do so. We further show that the monetary-policy component of interest-rate rises drives the contractionary effect on homeowners' expectations. This observation 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, though they may not have a direct understanding of monetary policy. We characterize these findings using a rational inattention model 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 monetary policy shock more than renters do.

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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 too hot or with slack labor market conditions. 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 2019; D'Acunto, Hoang and Weber 2020). 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 investigates 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 research 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 about news on interest-rate changes and, potentially, monetary policy compared to with renters.

To verify this possibility, we empirically investigate how responsive expectations of homeowners and renters are to interest-rate changes and monetary policy shocks with micro data 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 mortgage rates, while renters are less likely to do so. We further show that homeowners respond particularly to the portion of interest-rate changes driven by monetary policy shocks, including innovations from unconventional monetary policy. This relationship, however, is not observed in the longer-run inflation expectations. Additionally, in response to an increase in interest rates, homeowners reduce their optimism about labor market conditions more, and revise up their perceived probability of future interest-rate rises further, than renters do. The responsiveness to mortgage-rate changes is larger than that to changes in the 30-year T-bond rate and federal funds rate, and also shows 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 to the rate changes in a way consistent with the intended consequences of monetary policy.[1]

Our findings seem to be inconsistent with the recent evidence based on surveys and experiments 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. 2019; D'Acunto et al. 2020). 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, they do not necessarily contradict each other. 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 informal conversations with whom they interact, including 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 changes in interest rates and do not understand the effects of interest-rate changes on future economic conditions.

We interpret the empirical findings with a simple two-period rational inattention model with a particular focus on the association between inflation expectations and interest-rate changes.

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

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, the changes in inflation affect the relative price of housing, which has a substitution effect on their consumption. This additional substitution effect is absent from renters' problem, and thus homeowners' beliefs about inflation respond more strongly to interest rate variation 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 a growing literature regarding the effectiveness of monetary policy on economic agents' expectations (e.g., Cavallo, Cruces and Perez-Truglia 2017; Coibion et al. 2019; D'Acunto et al. 2020; Coibion, Gorodnichenko and Weber 2021). 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.[2] 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 expectations 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 household heterogeneity—homeownership, in particular—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.[3] First, we focus on households in the United States, while Claus-Nguyen's analysis concerns Australian

[2] For instance, D'Acunto et al. (2020) find that household expectations are affected by unconventional fiscal policy, not forward guidance, and argue that polices aimed at households directly are not effective because households do not understand them.

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

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 and the estimates of monetary shocks adopted for our empirical study. Section 3 presents the empirical analyses. Section 4 discusses a model of rational inattentive households that is designed to explain our empirical findings. Section 5 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 monetary policy shocks, we adopt the measures from Bu, Rogers and Wu (2021) and Swanson (2021). 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 recontacted. 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.[4]

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. To capture these features, we adopt two measures of monetary policy shocks, (1) a unified measure of monetary policy shocks proposed by Bu et al. (2021) that contains no significant information effect (BRW shock henceforth), and (2) three orthogonal factors of FOMC announcements constructed by Swanson (2021) capturing changes in federal funds rate, forward guidance, and large scale asset purchases (LSAPs), respectively. The BRW estimate is correlated with each of three measures from Swanson (2021). However, the two 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

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

LSAP factor either pre- or post-ZLB period. In this paper, we show how different shocks affect household expectations differently over time.

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. Based on the empirical results, Section 3.4 explores the extent to which monetary policy shocks account for the link between changes in interest rates and those in households' expectations. Section 3.5 briefly discusses the robustness of empirical results.

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-yea-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 rate during the past six months, and $X_{i,t}$ are controls for the respondent's characteristics. For ΔR_t, we consider changes in 30-year mortgage rates, 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 effects 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 changes in interest rates as a replacement for the argument capturing the effect of oil-price changes in Coibion and Gorodnichenko's model. Second, we use past changes in interest rates to reflect the delayed effects of monetary policy

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***
	(0.058)	(0.042)	(0.058)
Renter×ΔR_t (β_2)	-0.151	0.00961	-0.289**
	(0.096)	(0.072)	(0.099)
Number of obs.	50834	50834	50834
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
	(0.049)	(0.035)	(0.049)
Renter×ΔR_t (β_2)	0.00269	-0.0837	-0.0474
	(0.080)	(0.061)	(0.083)
Number of obs.	48842	48842	48842
R^2	0.0107	0.0107	0.0107

Notes: This table reports the estimates of β's from Equation (3.1) using inflation expectations in the next 12 months and in the next 5 years from the MSC.

due, for instance, to information rigidity, while Coibion and Gorodnichenko (2015) consider changes 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 signal 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 interest rates than renters do, because a change in the interest rate 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. It may reflect that homeowners and renters have loans to pay off and thus pay

attention to news on interest rates. This observation indicates that households do adjust their inflation expectations to interest rate changes to which they pay attention.[5]

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 are close to zero and not statistically significant. Overall, households are less likely to change their long-run inflation expectations in response to the evolution of 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 from the SCE and α_i captures individual fixed-effects. As households participate in the survey repeatedly 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. Similar to the results from the MSC, homeowners lower their three-year-ahead inflation expectations when there is a rise in mortgage rates, unlike renters (Panel B). In addition, both homeowners and renters lower their one-year-ahead inflation expectations in response to a rise in the T-bond rate (Panel A). Unlike the observation based on the MSC, homeowners lower their one-year-ahead inflation expectations to a change in the federal funds rate with statistical significance.[6] Overall, homeowners' inflation expectations are sensitive to changes in all three interest rates with statistical significance, while renters' expectations are responsive only to a change in the 30-year T-bond rate. All told, the evidence based on the SCE also confirms the conclusion from the MSC.

To summarize, households are attentive to developments in interest rates and adjust their inflation expectations to an interest rate variation as if the rate change is a contractionary factor.

[5] Quite differently, we do not observe a similar association between changes in the federal funds rate and those in one-year-ahead inflation expectations. Rather, homeowners' coefficient is positive and statistically significant. One potential explanation for the difference is that homeowners may take different signals from short- and long-term interest rates. Homeowners may extract a signal about future inflation from a rise in the federal funds rate, while they expect contractionary effects from a rise in long-term interest rates.

[6] Considering the SCE began from 2013, the statistically significant correlation may capture homeowners' response to unconventional monetary policy reflected on federal funds rate.

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$\times\Delta R_t$ (β_1)	-0.212	-0.385*	-0.279*
	(0.124)	(0.193)	(0.115)
Renter$\times\Delta R_t$ (β_2)	-0.278	0.389	-0.408*
	(0.218)	(0.354)	(0.200)
Number of obs.	42081	42081	42081
R^2	0.0001	0.0002	0.0003
Panel B. NY Fed Survey of Consumer Expectations (3-year ahead inflation expectations)			
Homeowner$\times\Delta R_t$ (β_1)	-0.257*	-0.301	-0.197
	(0.129)	(0.201)	(0.119)
Renter$\times\Delta R_t$ (β_2)	-0.257	0.236	-0.283
	(0.227)	(0.367)	(0.208)
Number of obs.	42183	42183	42183
R^2	0.0002	0.0001	0.0001

Notes: This table reports the estimates of β's from Equation (3.2) using the mean of each respondent's 1-year and 3-year ahead inflation expectations from the NY Fed Survey of Consumer Expectations.

In particular, homeowners, unlike renters, take signal from mortgage interest rates when forming one- to three-year-ahead inflation expectations. 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?

The previous section highlights that households—homeowners, in particular—tend to lower their inflation expectations in response to a rise in long-term interest rates. Does this finding mean that a change in interest rates has an effect on inflation expectations similar to that of a contractionary monetary policy shock? To answer this question, 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, our

interpretation would be that the interest rate change influences households' expectations in a way similar to a monetary policy shock and, furthermore, may reflect a consequence of the monetary policy shock.

A main challenge, however, in this empirical analysis is that expectations of labor market conditions are captured by categorical responses, unlike inflation expectations, the responses about which are recorded as numerical values. Specifically, in the MSC, 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 changes in expectations. This variable has three outcomes—*improve, unchanged*, and *worsen*. 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 $k = improve/worsen$ from period t to $t+6$, and $p_{ij,t}$ is the probability that household i's response is $j = unchanged$ from period t to $t+6$. The regressors $homeowner_i$ and $renter_i$ are dummies for homeowner and renter, respectively; ΔR_t is a change in the 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

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$\times\Delta R_t$ (β_1)	0.814^{***}	0.874^{***}	0.872^{***}
	(0.017)	(0.013)	(0.019)
Renter$\times\Delta R_t$ (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$\times\Delta R_t$ (β_1)	1.032	1.119^{***}	1.014
	(0.022)	(0.017)	(0.022)
Renter$\times\Delta R_t$ (β_2)	1.028	1.159^{***}	1.012
	(0.036)	(0.031)	(0.037)
Number of obs.	59917	59917	59917
R^2	0.0022	0.0035	0.0016

Notes: This table reports the estimates of Equation (3.3) on outcomes of unemployment. The coefficients are reported in terms of relative risk ratios and "unchanged" is used as the base outcome.

the probability of household i to respond "*improve*" or "*worsen*" 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 panel, households become less likely to expect that the labor market conditions will improve, when mortgage rates increase. Consistent with this observation, households become more likely to anticipate that the labor market conditions will deteriorate, as indicated by the upward- sloping lines in the right panel. We also find statistically significant differences in the optimistic revisions of homeowners' and renters' expectations (top-left panel) but not in the pessimistic revisions (top-right panel). Homeowners' expectations are more sensitive to changes in mortgage rates, and thus are more likely to revise down their

optimism in response to an increase in the mortgage rate than renters are. We find similar results, when we replace mortgage rates with federal funds rates and T-bond rates (middle-bottom panels). Nonetheless, the reduced optimism from to a rise in the mortgage rate is larger than that from to a rise in the 30-year T-bond rate or the federal funds rate, and, at the same time, exhibits the largest difference between homeowners and renters.

To summarize, households become less optimistic about their labor market outlook when there is a rise in the long-term interest rate. The decreased optimism is stronger among homeowners than renters, and the difference in responsiveness is largest in the case of an increase in the mortgage rate. All this evidence, combined with the evidence on inflation expectations, indicates that an interest rate change influences households' expectations in a way similar to a monetary policy shock.

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

In this section, we further examine the sensitivity of households' expectations of future interest rates to a recent interest-rate change as a channel through which the rate rise has contractionary effects on household expectations. Responses to the question on interest-rate expectation are also a categorical variable. Therefore, we employ specification (3.3), but change the dependent variable accordingly. The question on interest rate expectations is postulated as follows:

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

We treat the response *"stay the same"* as the base category and estimate the probability of household i responding *"go up"* or *"go down"* relative to that of household i responding *"the*

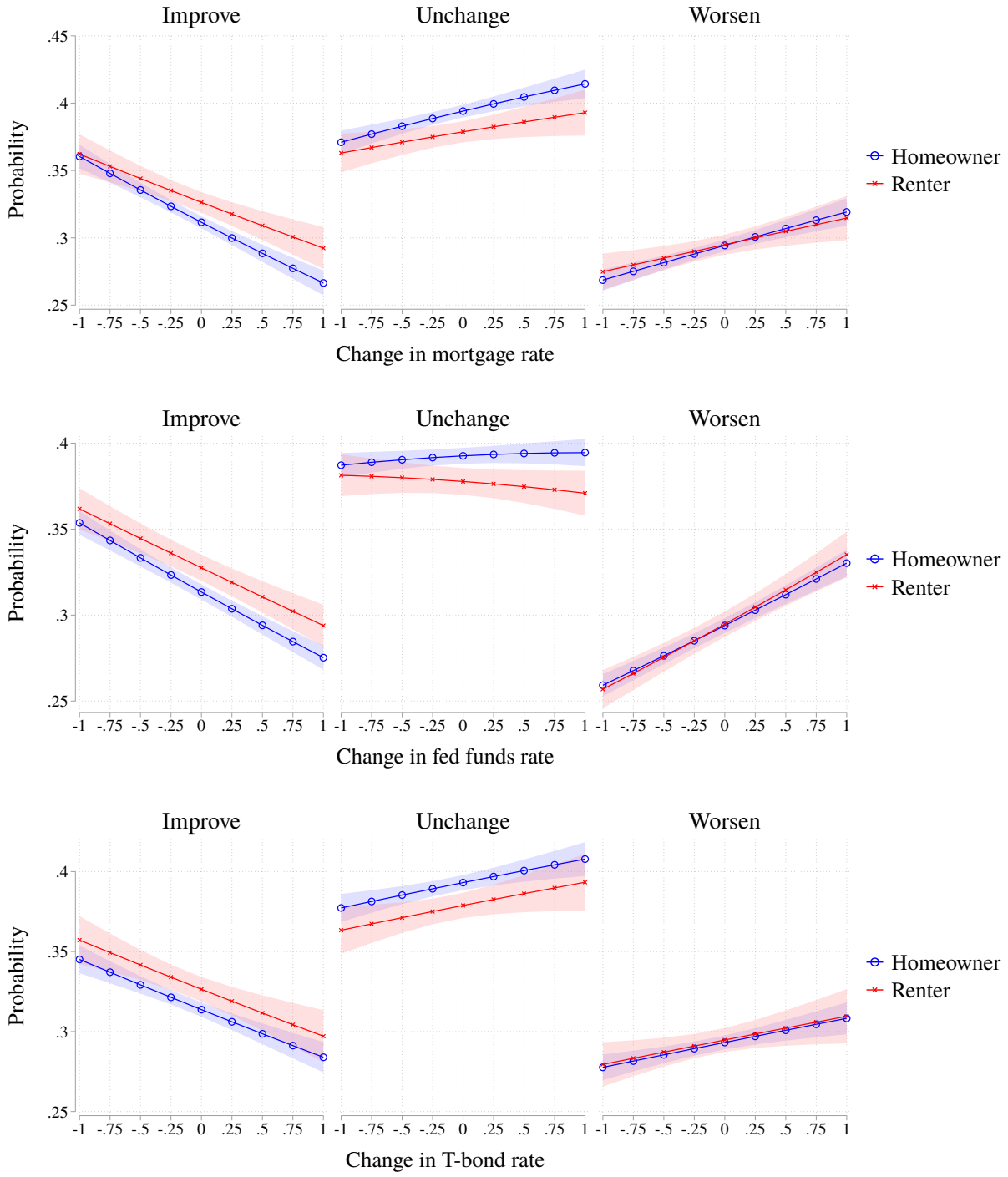

Figure 1: MARGINAL PROBABILITY OF CHANGES IN HOUSEHOLD EXPECTATIONS OF UNEMPLOYMENT

Notes: We report the marginal probabilities of changes in household expectations of unemployment to changes in interest rates. 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 Equation (3.3) as reported in Table 3.

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$\times\Delta R_t$ (β_1)	2.015^{***}	1.757^{***}	1.618^{***}
	(0.025)	(0.016)	(0.019)
Renter$\times\Delta R_t$ (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$\times\Delta R_t$ (β_1)	0.590^{***}	0.589^{***}	0.676^{***}
	(0.012)	(0.007)	(0.012)
Renter$\times\Delta R_t$ (β_2)	0.704^{***}	0.638^{***}	0.766^{***}
	(0.022)	(0.013)	(0.024)
Number of obs.	168201	168201	168201
R^2	0.0243	0.0390	0.0014

Notes: This table reports the estimates of Equation (3.3) on outcomes of interest rate expectations (go up, stay the same, go down). The coefficients are reported in terms of relative risk ratios and "stay the same" is used as the base outcome.

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

homeowners and renters is also the greatest.

To summarize, households raise their perceived probability of a future interest rate rise when there is an increase in the interest rate. The increased optimism is stronger among homeowners than renters, and the difference in responsiveness is largest for an increase in the mortgage rate. This channel of interest rate expectations provides a partial explanation for the significant contractionary effects of an interest rate rise 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 suggests 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 correlations. We particularly focus on mortgage rates and the 30-year T-bond rate, because households' one-year- ahead inflation expectations from the MSC have statistically significant associations with those interest rates.

Notice that there are factors other than monetary policy that create changes in the 30-year T-bond rate and mortgage rates. 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.[7] 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 possible that the effects of monetary policy on households' inflation expectations through the interest rate channel may be larger than those captured by the observed negative correlation.[8]

To investigate to what extent the information on monetary policy contained in interest rate

[7] Increased housing demand can 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.

[8] This is particularly so if risk premiums and monetary policy shocks move in opposite directions.

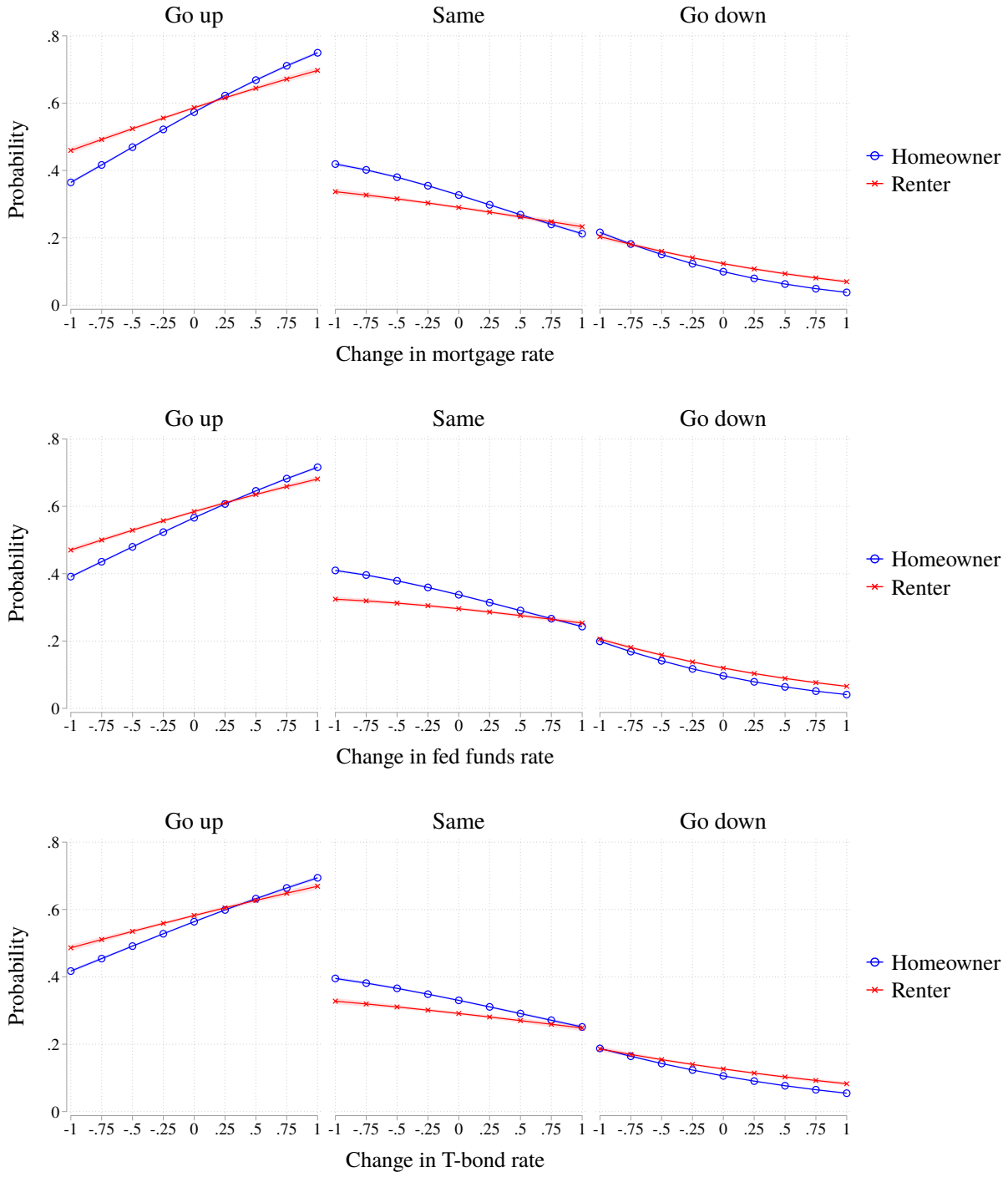

Figure 2: MARGINAL PROBABILITY OF HOUSEHOLD EXPECTATIONS OF INTEREST RATES

Notes: We report the marginal probabilities of household expectations of 1-year ahead interest rates to past changes in interest rates. The interest rates considered are e 30-year mortgage rates, federal funds rate, and 30-year T-bond rates. The results are calculated based on the estimates of Equation (3.3) as reported in Table 4. The confidence bands are so narrow that they do not clearly show through to the figures.

changes affects households' inflation expectations, we first analyze the pass-through of monetary policy shocks to interest rates. 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:

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

$$\Delta R_{t+1} = \alpha + \beta_1 \ \textit{FederalFunds}_t + \beta_2 \ \textit{ForwardGuidance}_t + \beta_3 \ \textit{LSAP}_t + \sum_{j=1}^{3} \delta_j \Delta R_{t-j} + \epsilon_t, \tag{3.5}$$

where the dependent variable ΔR_t is a change in the interest rate over week t. We consider (1) the unified monetary policy shock from Bu et al. (2021) in Equation (3.4) as *Unified Shock*, and (2) three components from Swanson (2021)—*FederalFunds*, *ForwardGuidance*, and *LSAP*—in Equation (3.5). The weekly monetary policy shocks are the estimated shocks around an FOMC meeting, if the meeting falls in week t, but are set to zero, otherwise. The coefficients of interest are β's, which measure the responsiveness of the interest rate to various measures of monetary policy shocks. We control for three lags of changes in the interest rate.

Table 5 documents the coefficients on the unified shock, the federal funds rate, forward guidance and the LSAP. Changes in the mortgage rate have a statistically significant positive correlation with the unified shock, forward guidance and the LSAP (Column 1). Meanwhile, changes in the T-bond rate have a statistically significant positive correlation only with the LSAP (Column 2). As shown in Columns 3 and 4, this result is robust, even if we narrow the sample period to the post-2013 era—the sample period of the SCE.[9] Overall, the pass-through of monetary policy shocks to mortgage rates and 30-year T-bond rates is statistically significant and robust. Notably, unconventional monetary policy such as forward guidance and the LSAP also has statistically significant effects on the interest rates.

With the coefficient estimates in Table 5, we recover the portions of changes in the 30-year T-bond rate and the mortgage rate attributable to monetary policy shocks. Let $\Delta \tilde{R}^{Mort}_{t,brw}$ denote

[9] One difference is that changes in the T-bond rate are positively correlated with the forward guidance in the later sample period, while the correlation with the LSAP is still positive but not statistically significant in the entire sample period.

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) $\Delta R_t^{T\text{-}bond}$
Panel A. Unified monetary policy shock from Bu et al. (2021)				
Unified shock	0.531***	-0.001	0.870***	0.007
	(0.156)	(0.1417)	(0.263)	(0.257)
Number of obs.	1299	1334	340	350
R^2	0.0214	0.0059	0.0695	0.0149
Panel B. Monetary policy shocks from Swanson (2021)				
Federal Funds	0.009	-0.004	-0.069	0.048
	(0.008)	(0.007)	(0.051)	(0.049)
Forward Guidance	0.024***	0.007	0.031***	0.024**
	(0.006)	(0.006)	(0.012)	(0.012)
LSAP	0.027***	0.026***	0.095***	0.028
	(0.011)	(0.010)	(0.019)	(0.018)
Number of obs.	1416	1464	330	342
R^2	0.0273	0.0112	0.1492	0.0373

Notes: Panel A reports the estimates of β_1 from Equation (3.4) using the monetary policy shocks identified in Bu et al. (2021). Panel B reports the estimates of β's from Equation (3.5) using the factors of monetary policy shocks identified in Swanson (2021). The sample period is from April 1991 to July 2019 for the estimates reported in Column (1) and (2). The sample period for the estimates in Column (3) and (4) is 2013 onward.

changes in the mortgage rate predicted by the unified shock from Bu et al. (2021). In addition, let $\Delta\tilde{R}_{t,LF}^{Mort}$ denote changes in the mortgage rate attributable to the LSAP and forward guidance, and let $\Delta\tilde{R}_{t,LF}^{T\text{-}bond}$ denote changes in the T-bond rate attributed to by the same components of monetary policy shocks. 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 T-bond rate and the mortgage rate. For this analysis, we replace ΔR_t^{Mort} or $\Delta R_t^{T\text{-}bond}$ in Equations (3.1) and (3.2) with the corresponding predicted values.

The estimation result for households' inflation expectations is documented in Table 6. Panel A shows that in the MSC, homeowners do strongly react to news on monetary policy reflected in interest rate changes when revising short-term inflation expectations. Among renters, only the coefficient on $\Delta\tilde{R}_{t,LF}^{Mort}$ is statistically significant. Renters are attentive to the monetary policy component in the mortgage rate, but are less attentive than homeowners are. Consistent with the

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

Interactions	(1) $\Delta\tilde{R}^{Mort}_{t,brw}$	(2) $\Delta\tilde{R}^{Mort}_{t,LF}$	(3) $\Delta\tilde{R}^{T\text{-}bond}_{t,LF}$
Panel A. Michigan Survey of Consumers (1-year ahead inflation expectations)			
Homeowner×ΔR_t (β_1)	-2.749***	-4.523***	-4.341***
	(0.667)	(0.603)	(0.995)
Renter×ΔR_t (β_2)	-0.193	-3.500***	-2.988
	(1.317)	(1.155)	(1.971)
Number of obs.	43434	47008	47008
R^2	0.0137	0.0143	0.0134
Panel B. Michigan Survey of Consumers (5-year ahead inflation expectations)			
Homeowner×ΔR_t (β_1)	-0.717	-0.417	-0.455
	(0.523)	(0.505)	(0.832)
Renter×ΔR_t (β_2)	0.009	0.273	2.249
	(1.026)	(0.969)	(1.661)
Number of obs.	42240	45622	45622
R^2	0.0096	0.0105	0.0106
Panel C. NY Fed Survey of Consumer Expectations (1-year ahead inflation expectations)			
Homeowner×ΔR_t (β_1)	0.881	-1.329	-2.641*
	(1.055)	(0.954)	(1.564)
Renter×ΔR_t (β_2)	1.386	-0.730	2.056
	(1.806)	(1.703)	(2.843)
Number of obs.	38775	37258	37258
R^2	0.0001	0.0001	0.0001
Panel D. NY Fed Survey of Consumer Expectations (3-year ahead inflation expectations)			
Homeowner×ΔR_t (β_1)	-0.631	-2.170**	-4.743***
	(1.110)	(1.004)	(1.646)
Renter×ΔR_t (β_2)	1.304	-0.889	-0.609
	(1.903)	(1.793)	(2.996)
Number of obs.	38861	37337	37337
R^2	0.0000	0.0003	0.0004

Notes: This table reports the estimates of β's from Equation (3.1) and (3.2) using changes in interest rates predicted by monetary policy shocks.

Table 7: 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 estimates of Equation (3.3) on outcomes of unemployment. The coefficients are reported in terms of relative risk ratios and "unchanged" is used as the base outcome.

baseline result, none of the coefficients are statistically significant in predicting five-year-ahead inflation expectations (Panel B of Table 6), again confirming that households' long-run inflation expectations are not responsive to news on monetary policy.

We reach a similar conclusion, if we instead base the analyses on the SCE. As shown in Panel D of Table 6, the monetary policy components of mortgage and T-bond rates ($\Delta\tilde{R}^{Mort}_{t,LF}$ and $\Delta\tilde{R}^{T\text{-}bond}_{t,LF}$) have statistically significant negative correlations with three-year-ahead inflation expectations of homeowners. However, none of the renters' coefficients are statistically significant. This result indicates that homeowners in the SCE do take signal about news on monetary policy from changes in long-term interest rates when revising their inflation expectations one to three years ahead.

Next, we report the estimation result for households' expectations of labor market conditions

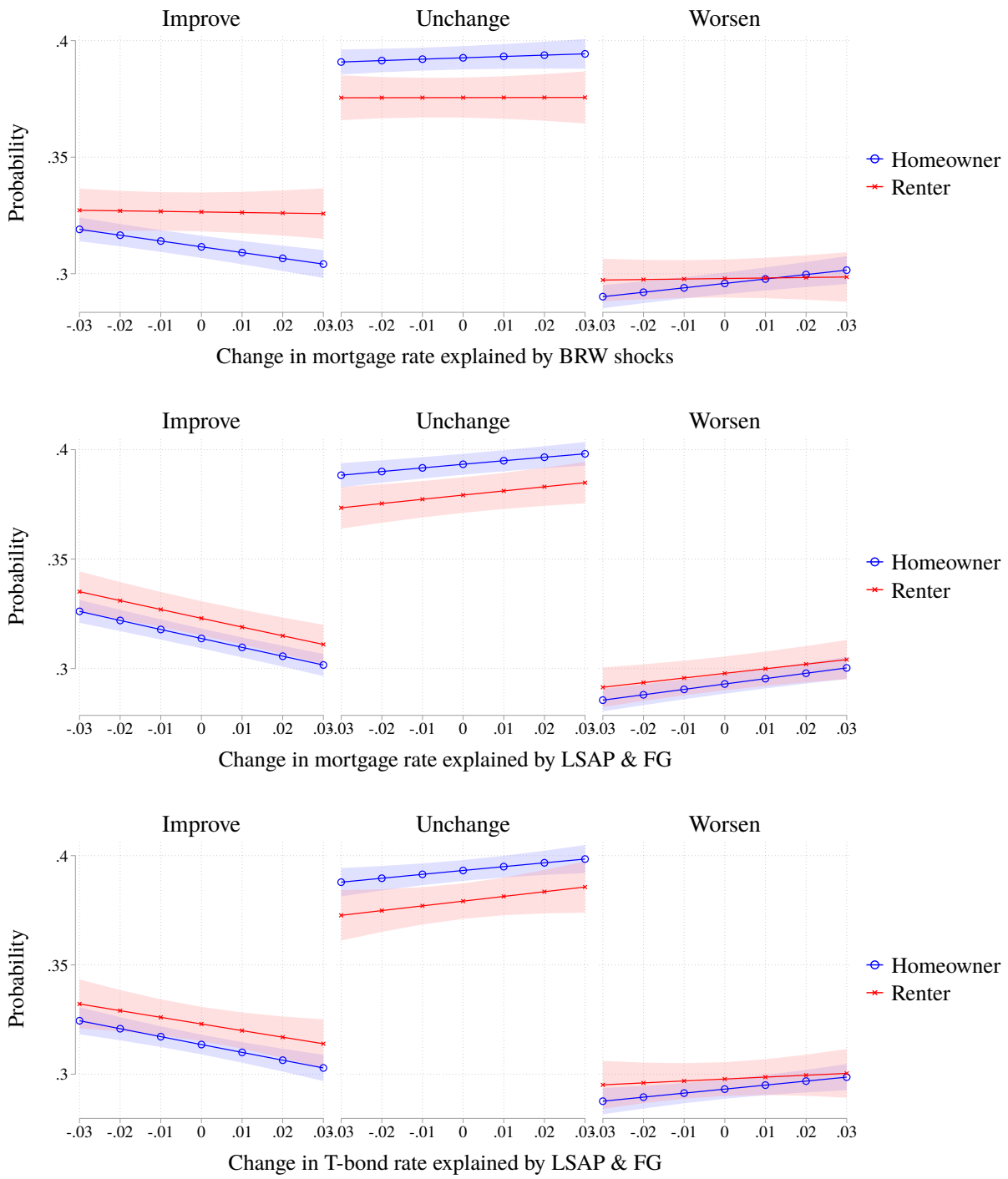

Figure 3: MARGINAL PROBABILITY OF CHANGES IN HOUSEHOLD EXPECTATIONS OF UNEMPLOYMENT

Notes: We report the marginal probabilities of changes in household expectations of unemployment to changes in interest rates explained by monetary policy shocks. The changes considered from top to bottoms are $\Delta\tilde{R}^{Mort}_{t,brw}$, $\tilde{R}^{Mort}_{t,LF}$, and $\tilde{R}^{T\text{-}bond}_{t,LF}$. The results are calculated based on the estimates of Equation (3.3) as reported in Table 7.

as documented in Table 7. For interpretability, we also report the marginal probability of households to change their expectations of unemployment in Figure 3 with a particular focus on the effects of $\Delta\tilde{R}^{Mort}_{t,brw}$, $\Delta\tilde{R}^{Mort}_{t,LF}$ and $\Delta\tilde{R}^{T\text{-}bond}_{t,LF}$. Overall, we find the result similar to that based on the raw interest rates. Households become less likely to expect that the unemployment situation will improve when interest rate changes driven by monetary policy shocks are positive. In addition, homeowners' expectations are more sensitive to changes in the mortgage rate attributable to the LSAP and forward guidance and thus are more likely to revise down their optimism in response to an increase in the mortgage rate driven by the LSAP and forward guidance than renters are.

To summarize, news on monetary policy passes through to 30-year T-bond rates and mortgage rates with statistical significance. Homeowners do take signal from the monetary policy components in interest rate changes and adjust their expectations of inflation and real economic activities, while renters are less likely to do so. The empirical evidence implies that homeowners are more likely to be attentive to news on monetary policy and its consequences for interest rate changes and the macroeconomy.

3.5 Robustness checks

This section outlines the robustness of empirical results. The details are found in the appendix. First, we consider different horizons of interest rate changes. In our baseline specification, we assume that households' expectations respond to changes in interest rate during the past six months. Instead, we employ changes in interest during the past three-months or nine-months. As shown in Appendix Tables B.3 and B.4, our main result on the heterogeneous response of inflation expectations to interest rate changes still survives regardless.[10] However, the empirical relationship becomes weaker with changes in interest rate during the past twelve months or longer. Second, we control for house-price expectations to consider the possibility that differences in households' inflation expectations mainly reflect house-price expectations. Nonetheless, the main result is robust as documented in Appendix Table B.2. Third, we replace expectations on unemployment conditions with those on future business conditions to examine

[10] 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).

the contractionary effect of interest-rate changes on overall economic conditions. As shown in Appendix Figure B.5, our main conclusion remains robust.

4 Model

So far, we have empirically shown that a rise in long-term interest rate lowers inflation expectations of households. The sensitivity is larger among homeowners than among renters, as homeowners are more attentive to news on interest-rate changes.

We further demonstrate that this likely captures the contractionary effects of monetary tightening by additionally investigating the association between interest-rate changes and expectations on labor market conditions. These observations suggest that homeowners pay attention to news on monetary policy more than renters do. This section provides a structural model where the negative association between households inflation expectations and interest-rate changes is larger among homeowners than among renters, because homeowners have more incentives to pay attention to news on interest-rate changes.

We build a two-period partial equilibrium model of rationally inattentive consumers who are either homeowner or renter. Homeowner makes once-and-for-all house purchase and consume housing services while the renter does not make a decision on housing purchase, but rents it.[11] The main purpose of the model is to demonstrate the channel through which homeownership status might affect heterogeneous responses of inflation expectations to an exogenous change in interest rates.

4.1 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 makes a once-and-for-all house purchase, H, financing a fraction θ of the purchase with a loan

[11] This assumption is without loss of generality. Though homeowners may rent and renters may own a house, we do not consider it as a representative case. For instance, in the MSC, homeowners are those who indicate that they currently own or is 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 own other homes.

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.[12]

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 haves 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:

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

[12]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

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

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.[13]

[13] 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.

4.2 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 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 $\check{u}\left(c_0^r, i, \pi\right) = U\left(\bar{C}^r e^{c_0^r}, \bar{R}e^i, \bar{\Pi}e^{\pi}\right) = U\left(C_0^r, R, \Pi\right)$ denote the utility function expressed in terms of log deviations and let $\tilde{\check{u}}$ denote the second-order Taylor approximation of $\check{u}$ at the steady-state:

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

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 $\Omega^r = \frac{1}{2|\check{u}_{11}|}\begin{pmatrix} \check{u}_{12}^2 & \check{u}_{12}\check{u}_{13} \\ \check{u}_{12}\check{u}_{13} & \check{u}_{13}^2 \end{pmatrix}$.

4.3 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 $\Lambda_1^r = \sigma^2\frac{\check{u}_{12}^2}{|\check{u}_{11}|} > \lambda$.[14] 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 $\beta > \frac{1}{2}$,*

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

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

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

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

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.[15] 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.[16] This finding implies that an exogenous increase in interest rates reduces the homeowner's inflation expectations more than the renter's expectations.

[15] 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 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 news letters). This case, however, is only likely to strength our results as the homeowner will acquire more information about inflation with a lower marginal cost of information.

[16] 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, $\Omega^r = \frac{1}{2}\left(\frac{\beta}{1+\beta}\right)\begin{pmatrix} 1 & -1 \\ -1 & 1 \end{pmatrix}$.

5 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 outlook in the near term in response to a rise in mortgage rates or long-term interest rates, while renters are less likely to do so. We find that the monetary-policy component of interest-rate rises 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 monetary policy shock more than renters do. Our results of the heterogeneous response in inflation expectations to monetary policy shocks imply that 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 extension and the analyses of such interesting issues for future research.

References

Adelino, Manuel, Antoinette Schoar, and Felipe Severino, "Perception of House Price Risk and Homeownership," Working Paper 25090, National Bureau of Economic Research 2018.

Afrouzi, Hassan and Choongryul Yang, "Dynamic Rational Inattention and the Phillips Curve," CESifo Working Paper No. 8840 2021.

Armona, Luis, Andreas Fuster, and Basit Zafar, "Home Price Expectations and Behaviour: Evidence from a Randomized Information Experiment," *Review of Economic Studies*, 2019, *86* (4), 1371–1410.

Bauer, Michael D., "Inflation Expectations and the News," *International Journal of Central Banking*, 2015, *11* (2), 1–40.

Bu, Chunya, John Rogers, and Wenbin Wu, "A unified measure of Fed monetary policy shocks," *Journal of Monetary Economics*, 2021, *118*, 331–349.

Carroll, Christopher D., "Macroeconomic Expectations of Households and Professional Forecasters," *The Quarterly Journal of Economics*, 2003, *118* (1), 269–298.

Cavallo, Alberto, Guillermo Cruces, and Ricardo Perez-Truglia, "Inflation Expectations, Learning, and Supermarket Prices: Evidence from Survey Experiments," *American Economic Journal: Macroeconomics*, 2017, *9* (3), 1–35.

Claus, Edda and Viet Hoang Nguyen, "Monetary policy shocks from the consumer perspective," *Journal of Monetary Economics*, 2020, *114* (C), 159–173.

Coibion, Olivier and Yuriy Gorodnichenko, "Is the Phillips Curve Alive and Well after All? Inflation Expectations and the Missing Disinflation," *American Economic Journal: Macroeconomics*, 2015, *7* (1), 197–232.

_ , _ , and Michael Weber, "Monetary Policy Communications and their Effects on Household Inflation Expectations," CESifo Working Paper Series 7464, CESifo 2019.

_ , _ , and _ , "Fiscal Policy and Households' Inflation Expectations: Evidence from a Randomized Control Trial," CESifo Working Paper Series 8905, CESifo 2021.

_ , _ , and Rupal Kamdar, "The Formation of Expectations, Inflation, and the Phillips Curve," *Journal of Economic Literature*, 2018, *56* (4), 1447–91.

D'Acunto, Francesco, Daniel Hoang, and Michael Weber, "Managing Households' Expectations with Unconventional Policies," NBER Working Papers 27399, National Bureau of Economic Research, Inc 2020.

_ , _ , Maritta Paloviita, and Michael Weber, "IQ, Expectations, and Choice," Research Discussion Papers 2/2019, Bank of Finland 2019.

_ , Ulrike Malmendier, and Michael Weber, "What Do the Data Tell Us About Inflation Expectations?," Working Paper 29825, National Bureau of Economic Research 2022.

_ , _ , Juan Ospina, and Michael Weber, "Exposure to Grocery Prices and Inflation Expectations," *Journal of Political Economy*, 2021, *129* (5), 1615–1639.

Grundl, Serafin and You Suk Kim, "Consumer mistakes and advertising: The case of mortgage refinancing," *Quantitative Marketing and Economics (QME)*, 2019, *17* (2), 161–213.

Hoffmann, Mathias, Emanuel Moench, Lora Pavlova, and Guido Schultefrankenfeld, "The effects of the ECB's new inflation target on private households' inflation expectations," Technical Report 43rd edition, Deutsche Bundesbank 2021.

Kamdar, Rupal, "The Inattentive Consumer: Sentiment and Expectations," *working paper*, 2019.

Kilian, Lutz and Xiaoqing Zhou, "The Impact of Rising Oil Prices on U.S. Inflation and Inflation Expectations in 2020-23," Working Papers 2116, Federal Reserve Bank of Dallas 2021.

Kőszegi, Botond and Filip Matějka, "Choice Simplification: A Theory of Mental Budgeting and Naive Diversification," *The Quarterly Journal of Economics*, 2020, *135* (2), 1153–1207.

Kryvtsov, Oleksiy and Luba Petersen, "Central bank communication that works: Lessons from lab experiments," *Journal of Monetary Economics*, 2021, *117*, 760–780.

Kuchler, Theresa and Basit Zafar, "Personal Experiences and Expectations about Aggregate

Outcomes," *Journal of Finance*, 2019, *74* (5), 2491–2542.

Lamla, Michael J. and Dmitri V. Vinogradov, "Central bank announcements: Big news for little people?," *Journal of Monetary Economics*, 2019, *108*, 21–38.

Stillwagon, Josh R., "TIPS and the VIX: Spillovers from Financial Panic to Breakeven Inflation in an Automated, Nonlinear Modeling Framework," *Oxford Bulletin of Economics and Statistics*, 2018, *80* (2), 218–235.

Swanson, Eric T, "Measuring the effects of Federal Reserve forward guidance and asset purchases on financial markets," *Journal of Monetary Economics*, 2021, *118*, 32–53.

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

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

The second-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

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	-0.342***	-0.282***
	(0.025)	(0.033)
3-year		-0.249***
		(0.034)
5-year	-0.458***	
	(0.021)	

Notes: This table reports homeownership rates and the average differences in inflation expectations between homeowners and renters from the MSC (Column (1)) and the SCE (Column (2)).

Table B.2: 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.

Table B.3: 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 estimates of β's from Equation (3.1) using inflation expectations in the next 12 months and in the next 5 years from the MSC. The interest rate change is over the past 3 months.

Table B.4: 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 estimates of β's from Equation (3.1) using inflation expectations in the next 12 months and in the next 5 years from the MSC. The interest rate change is over the past 9 months.

Table B.5: 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 estimates of Equation (3.3) on outcomes of future business conditions. The coefficients are reported in terms of relative risk ratios and "unchanged" is used as the base outcome.

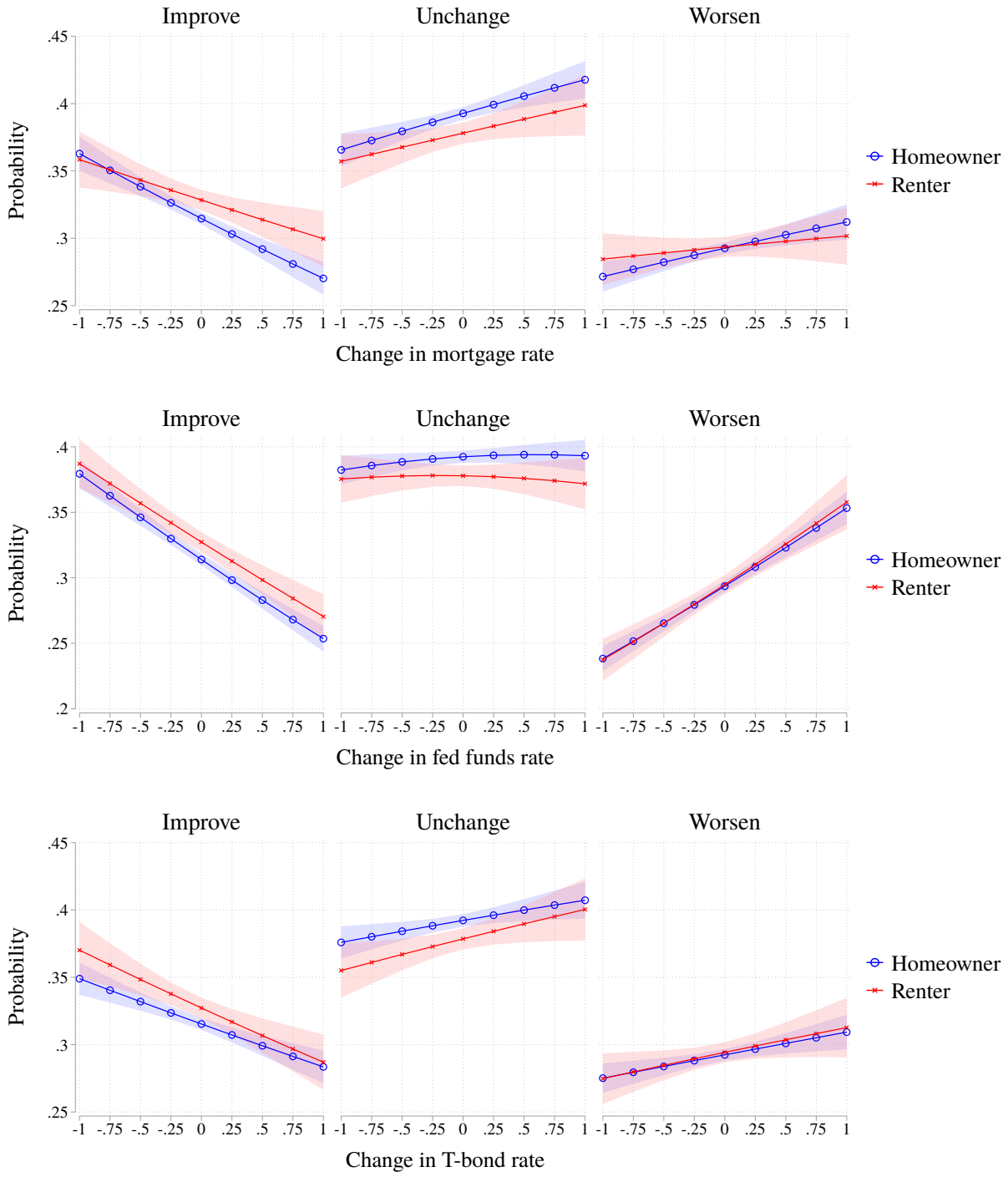

Figure B.1: ROBUSTNESS CHECK ON MARGINAL PROBABILITY OF CHANGES IN HOUSEHOLD EXPECTATIONS OF UNEMPLOYMENT (INTEREST-RATE CHANGES OF THE PAST 3 MONTHS)

Notes: We report the marginal probabilities of changes in household expectations of unemployment to changes in interest rates. 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 based on changes in interest rates over past 3 months.

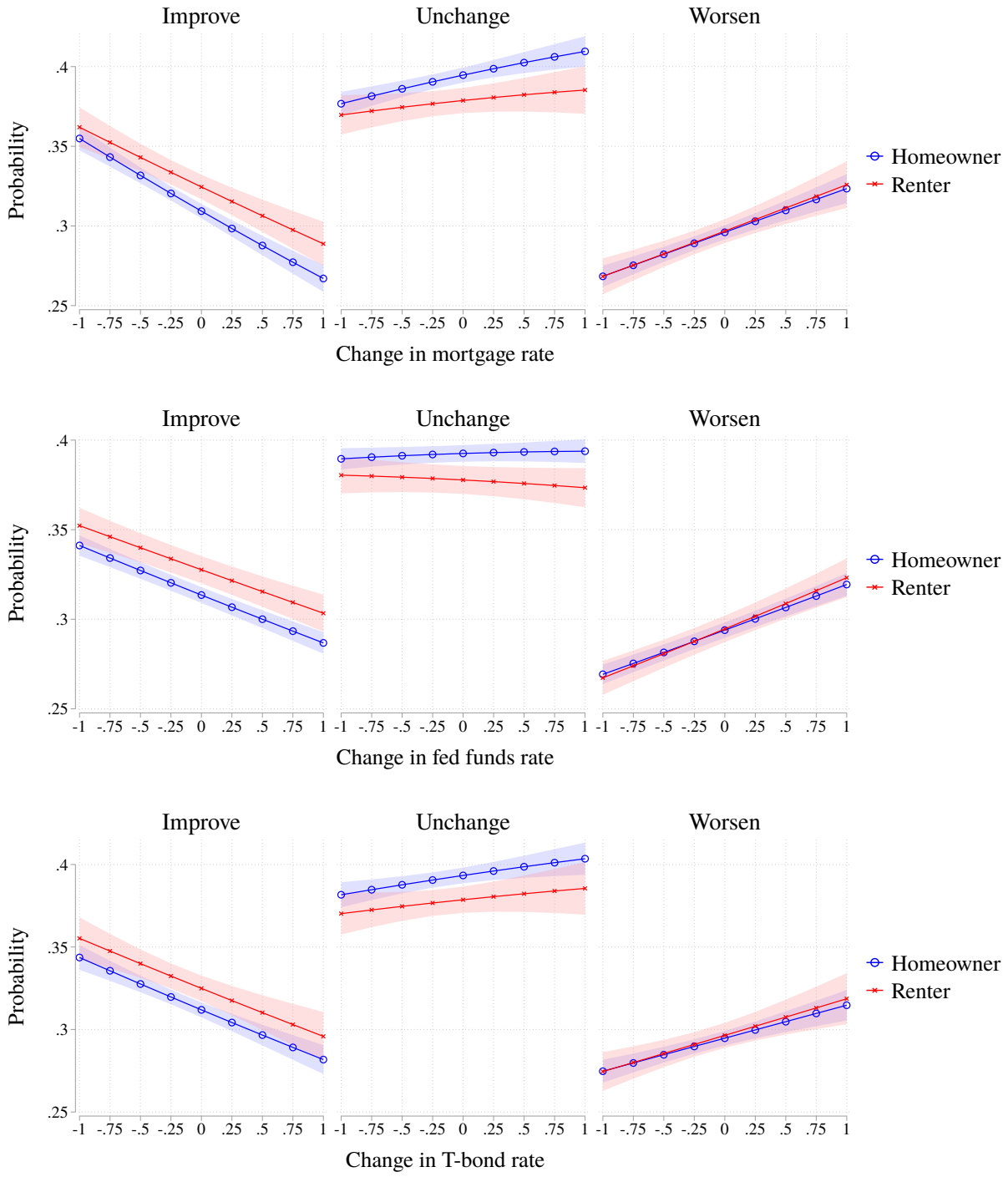

Figure B.2: ROBUSTNESS CHECK ON MARGINAL PROBABILITY OF CHANGES IN HOUSEHOLD EXPECTATIONS OF UNEMPLOYMENT (INTEREST-RATE CHANGES OF THE PAST 9 MONTHS)

Notes: We report the marginal probabilities of changes in household expectations of unemployment to changes in interest rates. 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 based on changes in interest rates over past 9 months.

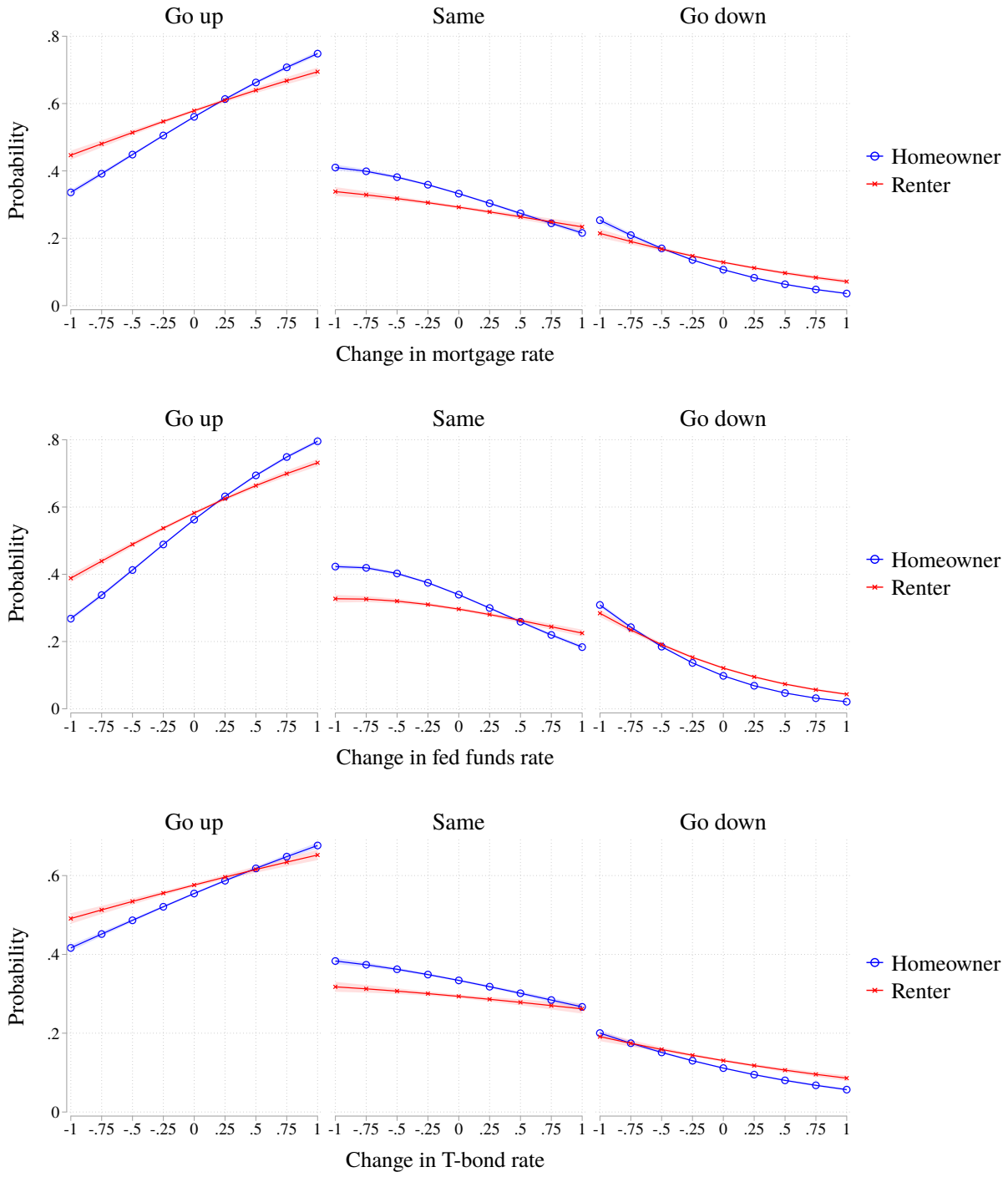

Figure B.3: ROBUSTNESS CHECK ON MARGINAL PROBABILITY OF HOUSEHOLD EXPECTATIONS OF INTEREST RATES (INTEREST-RATE CHANGES OF THE PAST 3 MONTHS)

Notes: We report the marginal probabilities of household expectations of 1-year ahead interest rates to past changes in interest rates. The interest rates considered are e 30-year mortgage rates, federal funds rate, and 30-year T-bond rates. The results are based on changes in interest rates over past 3 months.

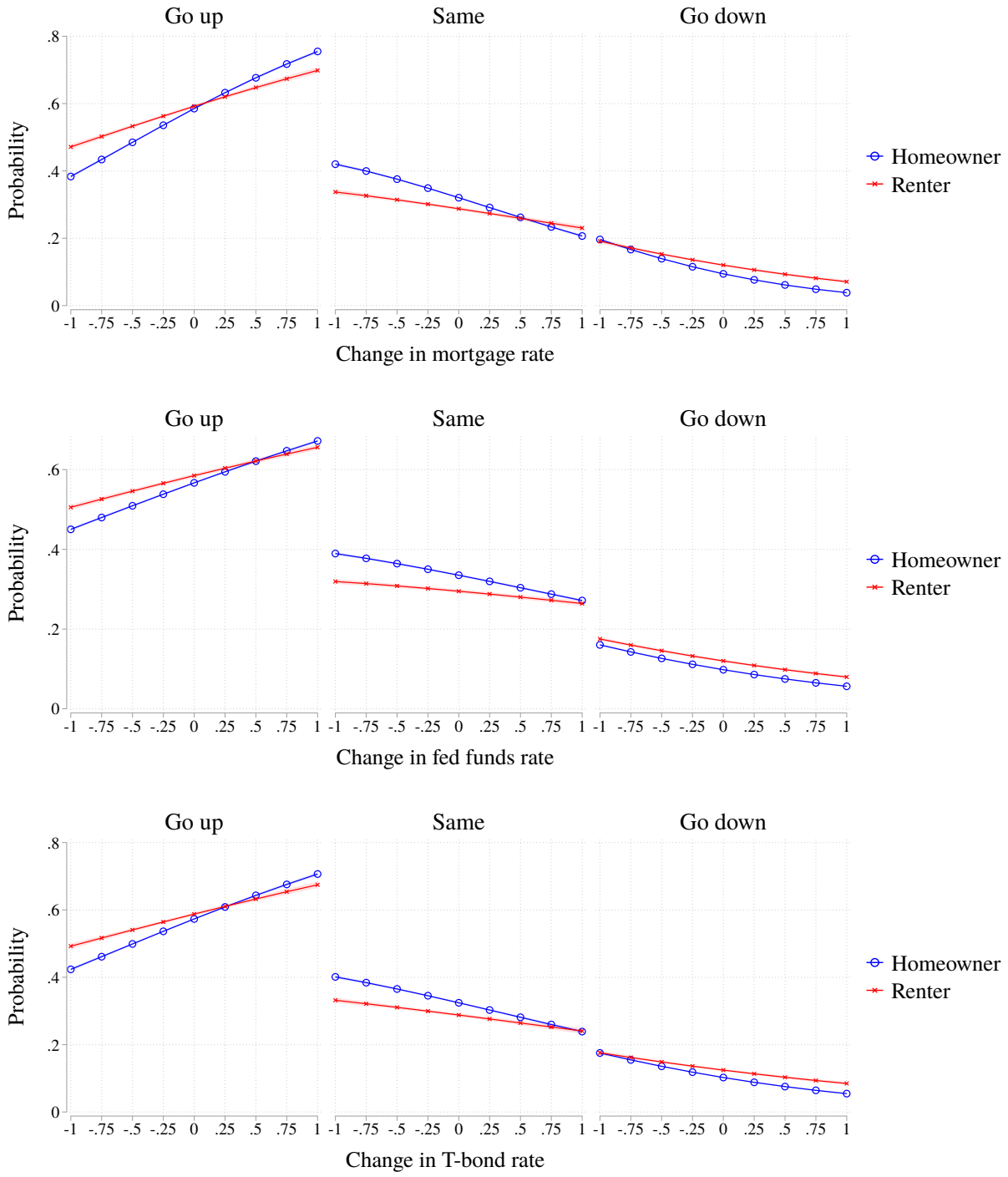

Figure B.4: ROBUSTNESS CHECK ON MARGINAL PROBABILITY OF HOUSEHOLD EXPECTATIONS OF INTEREST RATES (INTEREST-RATE CHANGES OF THE PAST 9 MONTHS)

Notes: We report the marginal probabilities of household expectations of 1-year ahead interest rates to past changes in interest rates. The interest rates considered are e 30-year mortgage rates, federal funds rate, and 30-year T-bond rates. The results are based on changes in interest rates over past 9 months.

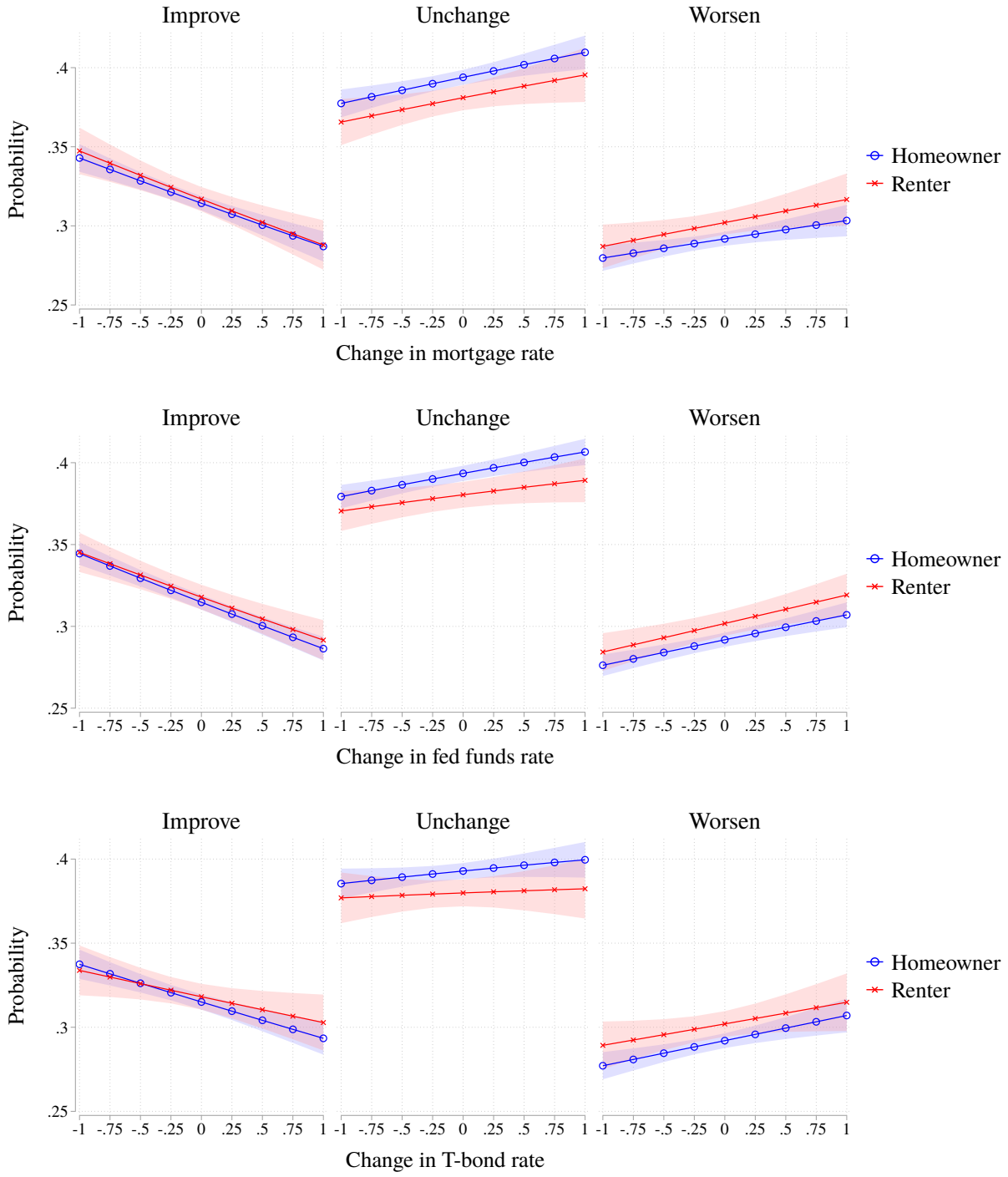

Figure B.5: MARGINAL PROBABILITY OF CHANGES IN HOUSEHOLD EXPECTATIONS OF FUTURE BUSINESS CONDITIONS

Notes: We report the marginal probabilities of changes in household expectations of future business conditions to changes in interest rates. 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 Equation (3.3) as reported in Table B.5.