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Abstract

We propose a new concept of monetary policy shocks: subjective monetary policy shocks. Using a unique survey on both consumption expenditures and forecasts of interest rates, we identify a cross-sectionally heterogeneous monetary policy shock at the micro level. We first distinguish between exogenous and endogenous interest rate changes and define the exogenous component as a subjective monetary policy shock for each household. We then estimate the impulse responses of consumption expenditures to a subjective monetary policy shock. We find the stark contrasts in the dynamics of consumption expenditures between borrowers and lenders; in response to an unexpected rise in interest rates, consumption expenditures by borrowers decrease, whereas those of asset holders increase. We also find large and quick responses of consumption expenditures when households are attentive to interest rates. Our findings support the theoretical prediction of not only heterogeneous agent New Keynesian models, but also behavioral macroeconomics under imperfect information.

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1 Introduction

Macroeconomic shocks work as idiosyncratic ones at the micro level. The statement has a double meaning. A fiscal policy shock works as an idiosyncratic one when a redistributional policy is implemented. A monetary policy policy shock also works as an idiosyncratic one when a redistributional policy is implemented.

Fiscal and monetary policy shocks are conceptually aggregate. They can also be considered idiosyncratic shocks. A monetary policy shock can be cross-sectionally heterogeneous. When we measure a monetary policy shock, researchers often rely on forecast errors about policy instruments (FF rates or overnight call rates). As forecasts are dispersed across forecasters, the disagreement yields cross-sectionally heterogeneous forecast errors. The cross-sectionally heterogeneous forecast error is considered as a micro monetary policy shocks for each consumer. We call it a subjective monetary policy shock at the micro level. The rationale behind the new measure of monetary policy shocks is to capture the micro-level monetary policy variations.

We propose a new concept of monetary policy shocks: a subjective monetary policy shock. Using a unique survey on both consumption expenditures and forecasts of interest rates, we identify a cross-sectionally heterogeneous monetary policy shock at the micro level. We first distinguish between exogenous and endogenous interest rate changes and define the exogenous component as a subjective monetary policy shock for each household. We estimate the impulse responses of consumption expenditures to a subjective monetary policy shock. We show that in response to an unexpected rise in interest rates, consumption expenditures by borrowers decrease, whereas those of asset holders increase. We also find large and quick responses of consumption expenditures when households are attentive to interest rates.

Our study makes the following four contributions. The first contribution is to introduce a new concept about monetary policy shocks: a subjective monetary policy shock at the micro level. The starting point for the new concept is identifying cross-sectionally heterogeneous monetary policy shocks. Dispersed forecasts on interest rates justify a subjective monetary policy shock. Some consumers consider a hike in policy rates as contractionary when the rate hike is larger than expected. Others consider a hike as expansionary when the rate hike is smaller than expected. The new measure contributes to identifying perception differences in monetary policy actions.

Second, such a subjective monetary policy shock may fill the gap between theoretical prediction and empirical evidence in consumption theory. Representative agent models predict that a consumption-saving behavior is generally in line with the permanent-income/life-cycle hypothesis. However, empirical evidence suggests that the situation is much more complex than what predicted by the conventional theories. Moreover, empirical evidence based on a micro-level policy shock contributes to uncovering the micro origins of macroeconomic phenomena.

Third, our approach does not employ high-frequency data or complex econometric methods, but depends only on a simple method involving linear regressions. We just compute forecast errors using a fixed-effect estimation, thus simplifying the identification of monetary policy shocks.

Fourth, our identification strategy to use survey data is effective under unconventional monetary policies. The survey data allow us to alleviate the "censored" problem (or the truncated problem) from the effective lower bound (ELB) of nominal interest rates: while (observed) nominal interest rates hardly become negative, their forecasts can be become negative (Ikeda et al., 2020; Mavroeidis, 2021). Furthermore, forecasts of interest rates, as well as macroeconomic variables, reflect the effectiveness of unconventional monetary policies, such as forward guidance, inflation targeting, and asset purchase programs. The unique survey on both interest rates and macroeconomic forecasts contributes to providing effective measures of monetary policy shocks even at the ELB.

Our study is related to three strands of the literature. First, it is related to studies identifying monetary policy shocks. Identifying monetary policy shocks and whether shocks have real effects are central questions in macroeconomics.[1] Contrary to the past literature using aggregate time-series or high-frequency data, our identification strategy depends on households' survey data on forecasts of interest rates and elicits a subjective monetary policy shock from forecast errors.[2] This straightforward yet original identification strategy is made possible by a unique household survey on interest rates as well as macroeconomic variables. To our knowledge, this is the first study to identify monetary policy shocks at the micro level.

Second, our approach is based on previous studies on information rigidity and behavioral macroeconomics. The full information rational expectations (FIRE) hypothesis assumes that every economic entity makes decisions using updated information sets. However, past studies strongly reject the FIRE hypothesis while supporting the perspectives of information rigidity and behavioral macroeconomics. In fact, economic agents are not always fully attentive to incoming news, rather, they are inattentive. In contrast to the FIRE hypothesis, even professional forecasters submit their forecasts based on old information sets (Andrade and Le Bihan, 2013).[3] This study sheds light

[1]Many prior studies have identified (un)conventional monetary policy shocks, beginning with Romer and Romer (2004) to Mavroeidis (2021).

[2]This approach was pioneered by Kuttner (2001) and Cochrane and Piazzesi (2002), and Bernanke and Kuttner (2005) and followed by Swanson (2006), Nakamura and Steinsson (2018), and Andrade and Ferroni (2021). Using high-frequency data, previous studies have defined monetary policy shocks as forecast errors, which are the differences between the policy rates priced in futures markets and the realized policy rates. Another approach in the literature measures monetary policy shocks using survey forecasts for policy rates (Romer and Romer, 2004; Honda and Kuroki, 2006). Auerbach and Gorodnichenko (2013) identify a fiscal policy shock using forecast errors of professional forecasters.

[3]Dupor et al. (2010) develop a model that integrates sticky prices and information and find that both rigidity types are present in the U.S. data. Coibion and Gorodnichenko (2012) and Coibion and Gorodnichenko (2015) provide broader

on the attentiveness of households to financial variables and examines whether attentiveness matters for the transmission mechanism of monetary policies. We provide evidence of heterogeneous effects of monetary policies among households under imperfect information.

Third, we build on a growing strand of research on households' subjective expectations (D'Acunto et al., 2021a; Malmendier and Nagel, 2016; Cavallo et al., 2017). Malmendier and Nagel (2016) find that lifetime experiences predict inflation expectations. Using subjective changes in inflation expectations, Crump et al. (2021) estimate the value of the elasticity of intertemporal substitution. Further, Andre et al. (2021) provide evidence on experts' beliefs about the effects of macroeconomic shocks. Kuchler and Zafar (2019) show that recent personal experiences influence the expectation formation about aggregate economic outcomes. We contribute to this research area by proposing a cross-sectionally heterogeneous monetary shock, paired with household-level expenditures, to estimate the causal effects of policy changes on consumption.[4]

The remainder of this paper is organized as follows: Section 2 presents a model to explain the transmission mechanism of monetary policy. Section 3 describes the survey used in our study. Section 4 introduces a subjective monetary policy shock. Section 5 presents the impulse responses. Section 6 discusses how only attentive households respond to monetary policies. Section 7 check the robustness of our results. Section 8 summarizes the main conclusions.

2 Model

This section presents the theoretical framework to describe how monetary policies influence the growth rate of consumption. Suppose that the utility function is isoelastic. The objective of the consumer is:

$$\max\ E_0 \sum_{k=0}^{\infty} \beta^t \frac{c_{t+k}^{1-\gamma} - 1}{1-\gamma},$$

where β denotes the discount factor and γ^{-1} is the elasticity of intertemporal substitution. We assume that consumers can borrow and save as much as needed at a real interest rate r. In this setting, the first-order conditions lead to the Euler equation:

$$E_t \left[\left(\frac{c_{t+1}}{c_t} \right)^{-\gamma} \beta(1 + r_{t+1}) \right] = 1. \tag{1}$$

evidence of information rigidity.

[4]Using administrative data in Norway, Holm et al. (2021) provide evidence on the cross-sectionally heterogeneous responses to a monetary policy shock. However, they use an aggregate shock.

Equation (1) simply indicates the theoretical predictions about the relationship between (real) interest rates and the growth rate of consumption. Suppose that a central bank decreases interest rates in an unexpected manner. If other variables are held constant, consumers change the intertemporal allocation of consumption and saving: they save less and spend more. The change in the intertemporal allocation entails greater current consumption, compared to future consumption. Thus, we can basically expect a negative relation between current consumption and changes in interest rates.

While the canonical macroeconomic model predicts that a decrease in interest rates *usually* induces greater current consumption, microeconomic models suggest that the consequences of changes in interest rates depend on which effect dominates: the substitution or the income effects. When the income effect dominates the substitution effect, a decrease in interest rates induces *less* current consumption. In this case, the correlation between current consumption and changes in interest rates is expected to be *positive*. On the other hand, when the substitution effect dominates the income effect, a decrease in interest rates induces *more* current consumption. In other words, there will be a negative correlation between the substitution and income effects. Therefore, it is difficult to predict the empirical results *ex ante* because the empirical evidence will provide the sum of the substitution and income effects.

However, the situation can be simplified when considering households with large loans. Suppose that such households face an unexpected hike in interest rates. A surprising rise in interest rates will increase the debt-servicing costs for them. Increased costs can be a negative income effect on current consumption. Consequently, not only the negative income effect but also the substitution effect will induce households to decrease current consumption in response to the surprising rise in interest rates. These two combined effects will result in a negative association between current consumption and a monetary policy shock. This is also the case for households with a fixed-rate loan, as such households will have fewer opportunities to refinance their loans than before when faced with an unexpected rise. In sum, we can expect monetary policy shocks to have a negative effect on consumption for households with loans. This situation also can be simplified when considering asset holders. Suppose that households have financial assets. A surprising rise in interest rates will increase cash flow from the assets. This can exert a positive income effect on current consumption. In this case, the positive income effect can dominate the substitution effect for asset holders. Therefore, we can expect monetary policy shocks to have positive effect on consumption for households with assets. In Section 4, we show the empirical strategy to use the subsamples from households with loans and those with financial assets.

3 Data

3.1 Consumers' forecasts on interest rates and updating frequency of the information sets

First, we summarize the survey data of consumer's forecasts of interest rates and show the basic statistics. We use a quarterly online survey of Japanese consumers from 2015Q4 to 2019Q4 to collect forecasts on 10-year interest rates after three and six months.[5] Every quarter, approximately 30,000 consumers provide an outlook of the levels of interest rates. We ask respondents to answer the following questions:

(A) Frequency of updating information on interest rates.

- "How often do you collect information on interest rates?"

(B) Outlook of the levels of interest rates.

- "What do you think will be the levels of interest rates after three and six months when you borrow money? Provide figures (%) for each month."

Regarding Question (A), respondents choose the most appropriate one from the following choices: (1) Almost every day, (2) Four or five times a week, (3) Twice or three times a week, (4) Once a week, (5) One or more times a week, (6) Twice or three times a month, (7) Once a month, (8) Once every two to three months, (9) Once in six months, (10) Once a year, (11) Less than once a year, and (12) Do not collect.

These questions can directly reveal consumers' forecasts of interest rates and the methods of consumers' information collection. First, the survey allows us to quantify consumers' forecasts of interest rates.[6] Using the survey, we compute the forecast errors based on consumers' outlook of interest rates to identify monetary policy surprises for each consumer. Second, the survey allows us to examine how consumers update their information sets. The FIRE hypothesis assumes that every economic entity makes decisions using the updated information set. However, the past studies support the *sticky information* hypothesis, which stipulates that economic agents do not always revise their information sets (Carroll, 2003). In contrast to the FIRE hypothesis, it theorize that economic agents are inattentive; even professional forecasters submit their forecasts based on old information sets (Andrade and Le Bihan, 2013). (Andrade and Le Bihan, 2013).[7] In the following empirical

[5]See Kikuchi and Nakazono (forthcoming) for more details about the survey.

[6]Table 1 lists the basic statistics of forecasts for interest rates by consumers.

[7]For example, Carroll (2003) provides micro foundations for the sticky information theory and derives a simple equation suitable for empirical analysis. Dupor et al. (2010) develop a model that integrates sticky prices and information and find

sections, we use the estimates of the frequency of updating information sets as a proxy for how consumers are attentive to interest rates. Heterogenous attention contributes to solving issues under the limits of unconventional monetary policies, such as "forward guidance puzzle" (Del Negro et al., 2015; Carlstrom et al., 2015; Campbell et al., 2019). Third, the survey allows us to examine whether a monetary policy shock influences consumption expenditure. If an unexpected monetary easing policy is associated with greater current consumption, it may suggest that monetary policies succeed in influencing the intertemporal allocation of consumption.

Table 2 shows the proportion of consumers that update their information sets on interest rates. First, the table shows that more than half of consumers hardly collect information on interest rates. While less than 50% of consumers update their information sets, the remainder never collect any information.[8] In the context of attention to economic variables, the basic statistics show that the effects of a monetary policy shock may vary among consumers. Attentive consumers are likely to respond to a monetary policy shock in accordance with economic theories while inattentive consumers might never do. Thus, the existence of consumers who are inattentive to the development of fundamental values of economic variables may cast doubt on the transmission of monetary policies. Section 6 examines whether attention matters for the transmission mechanism of monetary policies.

3.2 Survey on consumption expenditure

3.2.1 Home-scanner data

We also use panel data (SCI) on the consumption expenditure, collected by a marketing company, Intage. The SCI records day-to-day shopping information collected on an ongoing basis from more than 50,000 consumers aged 15–79 all over Japan. The scanner da22ta includes a panel data set of consumers' buying histories. Respondents scan the barcode of every item they purchase using a portable scanner. They record the quantity purchased, purchase price, and purchase channel (i.e., supermarket or convenience store) of purchased items. Thus, the data set allows us to see who bought what, when, where, how many, and at what price. The data set covers items which households purchase frequently, such as food (except for fresh food, prepared food, and lunch boxes), beverages, daily miscellaneous goods, cosmetics, pharmaceutical products, and cigarettes.[9]

that both rigidity types are present in the U.S. data. Using Japanese data, Hori and Kawagoe (2013) and Kikuchi and Nakazono (forthcoming) test the sticky information hypothesis for consumer inflation forecasts.

[8] From the theoretical perspective, the fact that not all consumers regularly update their information sets does not support the FIRE hypothesis while verifying information rigidities.

[9] Since our scanner data cover daily necessities, they do not include housing, utilities, durables, clothing, and services. O'Connell et al. (2021) also use household scanner data similar to the data we use.

The sample period covers January 2015 through December 2019.[10] The data also contain the profile of the same respondents about demographic, educational, and financial information. Thus, the data set allows us to identify each respondent's age, gender, educational attainments, and income level.

There are two caveats concerning the SCI data on consumption expenditures. First, Table 3 shows that women outnumber men. As in Kaplan and Schulhofer-Wohl (2017) and D'Acunto et al. (2021b), our data also show that the expenditure by women is larger than that of men. Second, the coverage of the data relative to Japanese households' consumption is not large. Using the SCI data, Diamond et al. (2020) report that the items included in the data cover approximately 30% of the weight of the Japanese Consumer Price Index (CPI).[11]

However, there are advantages in the use of scanner data. First, the panel data on consumption expenditure contain information of subjects about age, occupation, education, income, wealth and where they lives. Rich covariates contribute to controlling for socio-economic factors in empirical sections. Second, the panel data can be matched with other surveys that suit the researchers' interests and purpose. The literature combines scanner data with inflation expectations from the same respondents. Diamond et al. (2020), Kikuchi and Nakazono (forthcoming), and D'Acunto et al. (2021b) show how consumers form inflation expectations, while Kikuchi and Nakazono (2020a) find a relationship between consumption and inflation expectations.[12] This study matches the data with survey on interest-rate forecasts. It allows us to identify *perceived monetary policy shocks* and examine the causal effects of a shock on consumption expenditures.

4 Identifying a subjective monetary policy shock

This section explains how we identify a monetary policy shock at the micro level. We present the two types of shocks: one is obtained from the forecast errors of interest rates, while the other is identified by estimating the Taylor rule.

4.1 Forecast error of the interest rates

To identify an unexpected monetary policy shock, decomposing exogenous and endogenous changes is crucial. The extant literature uses forecast errors for the decomposition. As the first option for identifying a monetary policy shock, we simply follow this straightforward strategy by relying on

[10] Table 3 shows the descriptive statistics of the monthly data from 2015Q4 to 2019Q4.

[11] D'Acunto et al. (2021b) use similar scanner data from U.S. consumers, and report that the scanner data cover around 25% of the US households' consumption.

[12] Kikuchi et al. (2023) match the panel data we use with a survey on the effects of the COVID-19 pandemic on daily life and examine how fear of the COVID-19 contagion influences consumption expenditures.

forecast errors from households' survey about interest rates. The decomposing approach closely follows Paiella and Pistaferri (2017). Paiella and Pistaferri (2017), who decompose wealth effect on consumption, distinguish exogenous and endogenous wealth changes using (partly imputed) household forecast errors about asset prices.[13] Similar to Paiella and Pistaferri (2017), we use subjective expectation data and compute forecast errors about interest rate forecasts for 10-year ($\mathbb{F}_t^j[i_{j,t+k}]$) at time $t+k$ by household j when the same respondent j borrows money.[14] Forecast errors of household j are defined as $i_t - \mathbb{F}_{t-1}^j[i_{j,t}]$. Development $\mathbb{F}_{t-1}^j[i_{j,t}]$ corresponds to *endogenous* changes in interest rates, while forecast errors are regarded as exogenous changes.

However, there is a mismatch between the forecasting and forecasted variables. The forecasting variable i_t^{10year} is a risk-free bond yield, while the survey asks respondents to answer interest rates when they borrow money for 10 years. Furthermore, identified changes in interest rates contains heterogeneous risk premiums on each respondent. Risk premiums should be purged from original forecasts to obtain the households' outlook about "risk-free" rates. To remove risk premiums from raw forecasts, we regress forecast errors on individual fixed effects:

$$FE_t^j \equiv i_{f,t}^{10year} - \mathbb{F}_{t-1}^j[i_{j,t}^{10year}] = c_j + \varepsilon_t^j. \tag{2}$$

We assume that fixed effects c_j capture each respondent's risk premium, which is constant over the survey periods. We define residuals ($\hat{\varepsilon}_t^j$) obtained from Equation (2) as a subjective monetary policy shock (mps_t^j) at time t for household j.

Table 4 lists basic statistics of subjective monetary policy shocks ($\hat{\varepsilon}_t^j$) at the micro level. It provides evidence that the identified shocks are reasonable. First, Table 4 shows that shocks seem to be random and that the average of identified shocks is almost zero. By definition, shocks should have no systematic bias and be unpredictable.

To check whether there are systematic biases, we regress shocks on covariates of respondents. Table 5 lists the estimation results. It indicates that shocks are unpredictable, as the socio-economic factors of respondents, such as gender, age, educational attainments, and income levels, fail to explain shocks. Thus, we verify that identified shocks guarantee the principles to be satisfied.

Second, identified shocks are interpretable as long-term interest rate shocks. Figure 2 presents development of the 10-year yield on Japanese government bond and the average of identified monetary policy shocks, indicating a close correlation between them. It comes with no surprise, as

[13]By regressing consumption on unexpected changes in housing wealth, Paiella and Pistaferri (2017) show significantly positive effects of wealth on consumption.

[14]As Section 3 shows, our survey asks households to forecast the levels of 10-year interest rates after three and six months.

shocks are measured as the deviation from the actual interest rates. Rather, evidence that forecast errors track actual values warrants verification. The Bank of Japan introduced yield curve control (YCC) in September 2016. After that, both short- long-term interest rates were almost completely controlled around 0.0%. In fact, the 10-year bond yields have fluctuated within a very narrow margin: from -0.3% to 0.2%. Consequently, the long-term interest rate was used as one of the policy instruments under the new policy of YCC, becoming a *de facto* exogenous variable. Figure 2 reflects the context of the changes in monetary policies. Since identified shocks correspond to subjective deviation from the policy instrument, they mirror unexpected changes in monetary policies. Thus, the subjective forecast errors with respect to interest rates identified by Equation (4) can be used as a reasonable measurement for monetary policy shocks.

In the current study, we benefit from identifying subjective monetary policy shocks, as identified shocks are heterogeneous among households, thus enabling us to examine the responses to *micro-level* policy shocks.

4.2 Estimating the Taylor rule

While we can obtain monetary policy shocks from the forecast errors of interest rates, we can employ a more formal strategy. As the second strategy for identifying a monetary policy shock, it is based on the Taylor rule. We construct unexpected changes in interest rates that are orthogonal to unexpected changes in growth and inflation. We use the following equation to identify monetary policy shocks:[15]

$$i_t^{Policy} = \bar{i} + \phi \left(\mathbb{F}_{t-1}^{j} \left[\pi_t \right] - \bar{\pi} \right) + \kappa \left(\mathbb{F}_{t-1}^{j} \left[y_t \right] - \bar{y} \right) + \varepsilon_t^j, \tag{3}$$

where i_t^{Policy} and $\bar{i}$ are defied as policy rates and equilibrium (nominal) interest rates, respectively. π_t ($\bar{\pi}$) and y_t ($\bar{y}$) are inflation (target rate of inflation) and (equilibrium) growth rates, respectively. $\mathbb{F}_{t-1}^{j} \left[\pi_t \right]$ and $\mathbb{F}_{t-1}^{j} \left[y_t \right]$ denote household j's forecasts of inflation and growth rates over the next horizon at $t-1$, respectively. By estimating Equation (3), we can obtain residuals $\hat{\varepsilon}_t^j$. The residuals are the measures of the subjective monetary policy shock.

However, estimating Equation (3) is not straightforward. As the Japanese economy has been

[15]To show the validity of the identification strategy, we estimate monetary policy shocks at the macro level using Equation (3). We regress policy rates on forecasts of inflation and growth rates using Consensus Forecasts from 1994 to 2014. We use the 3-month yen certificate of deposit rates to 2000Q2. Then, we use 10-year bond yields as i_t^{Policy} after 2000Q3. Figure B.1 in Appendix shows the impulse responses to identified monetary policy shocks by Local Projection (Jordà, 2005). The figure shows that contractionary monetary policy shocks decrease GDP, consumption, investment, and (core) CPI. The results suggests that our identification strategy of monetary policy shocks is appropriate reasonable.

under the liquidity trap, short-term nominal interest rates are almost zero. Thus, instead, we use long-term interest rates as policy rates. Our strategy to identify monetary policy shocks does not exploit information about short-term interest rates or employ information about the size of the central bank's balance sheet. Further, we cannot rely on overnight call rates because the policy rates have been almost zero since 1999 in Japan. We do not use changes in the excess reserve, which were employed by the Bank of Japan as a main policy indicator before March 2006. While the Bank of Japan adjusted the level of excess reserve and purchased the government bonds from 2003 to 2006, the bank's intention seems to have been to enhance the interest rate channel. For example, the bank provided forward guidance, which it called a commitment policy, to lower the longer-term interest rates.[16] Asset purchases in government bonds also aim to lower longer-term interest rates. As for increases in excess reserve in a timely manner, the bank attempts to avoid excess volatility in key policy rates to ensure a well-functioning interest rate channel. As the bank consistently attempts to lower longer-term interest rates and maintain the interest rate channel under the ELB of short-term nominal interest rates, our strategy for identifying monetary policy shocks relies on information about long-term interest rates.

Instead of estimating Equation (3), we consider the following equation:

$$i_t^{10year} = \rho \times i_{t-1}^{10year} + \beta_1 \times \mathbb{F}_{t-1}^j \left[\pi_{t-1,t+3}\right] + \beta_2 \times \mathbb{F}_{t-1}^j \left[q_t^{Nikkei225}\right] + \mathbf{X}\delta + \varepsilon_t^j, \qquad (4)$$

where i_t^{10year} denotes yields on 10-year (risk-free) bond at time t. We use the long-term interest rates as policy rates. $\mathbb{F}_{t-1}^j \left[\pi_{t-1,t+3}\right]$ denotes household j's inflation expectations over the next 4-quarter horizon.[17] While a survey on inflation expectations is contained in our dataset, a survey on growth rate forecasts is not. Thus, we replace growth rate forecasts ($\mathbb{F}_{t-1}^j \left[y_t\right]$) with stock price forecasts ($\mathbb{F}_{t-1}^j \left[q_t^{Nikkei225}\right]$), which are included in the survey. $\mathbb{F}_{t-1}^j \left[q_t^{Nikkei225}\right]$ denotes household j's stock index forecasts (%) on Nikkei 225 over the next one-quarter horizon at time t.[18]

[16]In October 2003, the bank enhanced monetary policy transparency to clarify its intentions regarding the future path of monetary policy.

[17]Our survey contains both inflation expectations and stock index forecasts. As for inflation expectations, we ask households to answer the questions regarding their outlook for price changes in the next one, three, and ten years. Respondents are asked to answer the following questions: "What will the CPI levels be over the next one, three, and ten years, given that the current CPI level is 10,000? Provide price level figures over each period, excluding the impact of consumption tax hikes, on the price levels." The questionnaire directly measures households' inflation expectations in the short, medium, and long term. While some surveys ask respondents to choose from options such as "prices will probably rise" or "prices will probably fall," our survey can obtain the numeric measures that captures the households' inflation forecasts. For example, when a respondent answers 10,080, 10,600, and 11,000 as her forecasts for the price levels over the following one, three, and ten years, respectively, her forecasts for annualized inflation rates over the next one, three, and 10 years (or the next 4, 12, and 40 quarters) are calculated as 0.80%, 1.96%, and 0.96%, respectively. See Kikuchi and Nakazono (forthcoming) for more details about the survey of inflation expectations.

[18]Every quarter, we ask each respondent to provide an outlook of the levels of Nikkei 225. We ask respondents to answer

$\mathbf{X}$ includes control variables, such as (quarterly) time dummies, individual fixed effects, and the respondents' socio-economic factors (age, income levels, and educational attainment as a dummy variable). The equation includes the lag value of the dependent variable to gauge the persistence of the monetary policy. Estimating Equation (4) allows us to obtain residuals ($\hat{\varepsilon}_t^j$), which are proposed by this study as a subjective monetary policy shock.

5 Impulse responses to a micro-monetary-policy shock

This section presents the micro-level responses to a subjective monetary policy shock. The estimation strategy depends on (simple) local projections following Jordà (2005):

$$\log c_{t+h}^j - \log c_{t-1}^j = \beta^h \hat{\varepsilon}_t^j + \sum_{k=1}^{K} \gamma_k^h X_{t-k} + c_j + \delta_t + \eta_{t+h}^j, \tag{5}$$

where $h = 0, 1, \ldots, 4$ for the quarterly data on a subjective monetary policy shock ($\hat{\varepsilon}_t^j$) and (logarithm of) consumption expenditures of household j at h ($\log c_{t+h}^j$). The estimated coefficients β^h convey the change at horizon h in response to a micro-level monetary policy shock at the respective frequency. X_t denotes a vector of control variables, including fixed effects, age, income level, educational attainment, and lagged values (lag 1) of monetary policy shocks and dependent variables.

We first estimate the impulse responses to a monetary policy shock from forecast errors using the entire data. Figure 3 illustrates the impulse responses. It shows that consumption slightly increases approximately by 0.5% just after a subjective monetary policy shock (a surprising 100bps interest rate increase). An unexpected hike in interest rates induces both the substitution and the income effects. Thus, the sign of the consumption response depends on which effect is dominant. When the income effect is dominant, the response can be positive on average.

To decompose the two effects, we use subsamples from households with loans and those with financial assets. The top (bottom) panel in Figure 4 show the impulse responses using the subsample from households with loans (those with financial assets of ten million yen or above). The top panel in the figure show the expected signs of β^h: the consumption of borrowers significantly declines

the following questions: "What do you think will be the levels of Nikkei 225 after three and six months. Provide figures (in yen) for each month." Then, we compute growth rates (%) of stock index forecasts from the survey date t, which is calculated by $\log\left(F_t^j\left[q_{t+1}\right]\right) - \log\left(q_t\right)$. For example, suppose that household j's forecast on Nikkei 225 over the next three-month horizon is 20,200, $F_t^j\left[q_{t+1}\right]$, and the stock index is 20,000 at the survey date t, (q_t). In this case, her forecast (%) on the change in the stock index change is 1.0%.

in response to a subjective monetary policy shock, whereas that of asset holders increases. The top panel in the figure shows a significant decline of approximately 1.5% in consumption at the third quarter after a 1% unanticipated interest rate increase. This finding is line with that by Cloyne et al. (2020), which presents the impulse responses of consumption by mortgagor or borrowers. Conversely, the bottom panel in the figure shows a significant increase of approximately 1.5% in consumption at the second quarter after a 1% unanticipated interest rate increase. This implies that the income effect dominates the substitution effect for asset holders.

Second, we estimate the impulse responses to a monetary policy shock based on the Taylor rule. Figure 5 shows the impulse responses using subsamples from households with loans (top panel) and with financial assets of ten million yen or above (bottom panel). The top panel in the figure shows the expected signs of β^h: the consumption of borrowers significantly declines in response to a subjective monetary policy shock, whereas that of asset holders increases. The top panel in the figure shows a significant decline of approximately 1.5% in consumption at the third quarter after a 1% unanticipated interest rate increase. This result is consistent with the findings by Cloyne et al. (2020), which presents the impulse responses of consumption by mortgagor or borrowers. In contrast, the bottom panel in the figure shows a significant increase of 1.5% in consumption at the second quarter after a 1% unanticipated interest rate increase. This indicates that the income effect dominates the substitution effect for asset holders.

6 Attentive households

While the previous section suggests that debt holders decrease their consumption significantly in response to a monetary surprise, what induces them to react to a shock? Why do households with loans respond to an unexpected tightening with a sizable decrease in consumption expenditures? A new class of behavioral macroeconomic models with imperfect information has recently emerged that provides valuable insights into these questions (Sims, 2003; Gabaix, 2019, 2020). In line with the literature on rational inattention *a la* Sims (2003), the results in the previous section confirm that a high attention of households in debt to a change in interest rates is what drives the responses of consumption expenditure.

Further, the existing literature suggests that limited cognitive resources limit attention to a full set of news. Thus, the attention of economic agents depends on the situation. For example, Coibion and Gorodnichenko (2015), Kikuchi and Nakazono (forthcoming), and D'Acunto et al. (2021b) argue that households pay more attention to price changes in products, such as gasoline and food which they frequently purchase, as compared to overall price changes. These studies support the view that households in debt are likely to pay careful attention to changes in interest rates. Suppose that households with loans face an unexpected rise in interest rates. When the debt-servicing costs for households with large loans account for a considerable portion of consumption expenditure, frequent and meticulous attention to interest rates may be paid, which may entail significant responses to monetary policy shocks. This may be the case when we think about asset holders. When a surprising hike in interest rates yields additional cash flow from assets, frequent attention to interest rates may be paid, evoking considerable and quick responses from asset holders to monetary policy shocks.

Based on the survey about the methods of households' information collection, we examine whether the frequency of updating information sets about interest rates predicts the responses of consumption to a subjective monetary policy shock. Using a subsample of attentive households that update their information sets about interest rates at least once a quarter, we estimate Equation (5). Figure 6 shows the results. Figure 6 shows the impulse responses using the subsamples from attentive households with loans to a shock using forecast errors (top panel) and the Taylor rule (bottom panel), respectively. Both of the top and bottom panel in Figure 6 show an immediate decline in consumption just after a shock occurs. Furthermore, the impact is large. Specifically, the maximum impact is -3.0% in the top panel, while it is -7.5% at the third quarter in the bottom panel; it is larger than those shown in the top panels in Figures 4 and 5. The large and quick effects of a monetary policy shock on consumption imply that the meticulous attention to interest rates matters for the responses of consumption to a monetary policy shock.

The large impact also holds for the case of households with financial assets. Figure 7 shows a significant increase in consumption. Figure 7 shows the impulse responses using subsamples of attentive households with financial assets of ten million yen or more to a shock by forecast errors (top panel) and the Taylor rule (bottom panel), respectively. Both of the top and bottom panels in Figure 7 show a significant increase in consumption at the first quarter after a one percentage point subjective monetary policy shock. The panels show an immediate response just after a shock occurs; however, the bottom panel shows that it is not significant. Furthermore, the maximum impacts are 2.0% in the figure, which is larger than those shown in the bottom panels in Figures 4 and 5. Thus, the empirical evidence supports the view that meticulous attention entails significant and quick responses to a monetary policy shock.

7 Robustness check

This section checks the robustness of our benchmark results. To this end, we estimate the Taylor rule by each respondent. Specifically, we estimate the following equation:

$$i_t^{10year} = \rho^j \times i_{t-1}^{10year} + \beta_1^j \times \mathbb{F}_{t-1}^j \left[\pi_{t-1,t+3}\right] + \beta_2^j \times \mathbb{F}_{t-1}^j \left[q_t^{Nikkei225}\right] + \mathbf{X}\delta^j + \varepsilon_t^j. \quad (6)$$

The difference between Equation (4) and Equation (6) is the variation in the determinants in the Taylor rule. Equation (6) allows for variation in ρ^j, β_1^j, and β_2^j for each respondent j.

Figures 8 and 9 shows the results. Figure 8 shows the impulse responses using subsample of households with loans (top panel) and those with financial assets of ten million yen or above (bottom panel). The top panel in the figure show the expected signs of β^h: the consumption of borrowers significantly declines in response to a subjective monetary policy shock, whereas that of asset holders increases. The top panel in the figure shows a significant decline of approximately 1.3% in consumption at the first quarter after a 1% unanticipated interest rate increase. In contrast, the bottom panel in the figure shows a significant increase of approximately 1.8% in consumption at the second quarter after a 1% unanticipated interest rate increase. This result implies that the income effect dominates the substitution effect for asset holders.

8 Conclusion

Despite the extensive literature on heterogeneous-agent models examining the heterogeneous effects of monetary policy shocks, direct empirical evidence on the effects of heterogeneous shocks is scarce. This study proposes and identifies a micro monetary policy shock at the household level. Using a novel household survey on interest rates, we first distinguish between exogenous and endogenous interest rate changes and define the exogenous component as a subjective monetary policy shock that is cross-sectionally heterogeneous for each household. Our empirical results show the stark contrasts in the dynamics of consumption between borrowers and lenders. Specifically, we show that consumption by borrowers *decreases*, in response to an unexpected subjective hike in interest rates, whereas that of asset holders *increases*. We also find large and quick responses of consumption when households are attentive to interest rates. Our empirical findings support the theoretical prediction of not only HANK models, but also behavioral macroeconomics under imperfect information.

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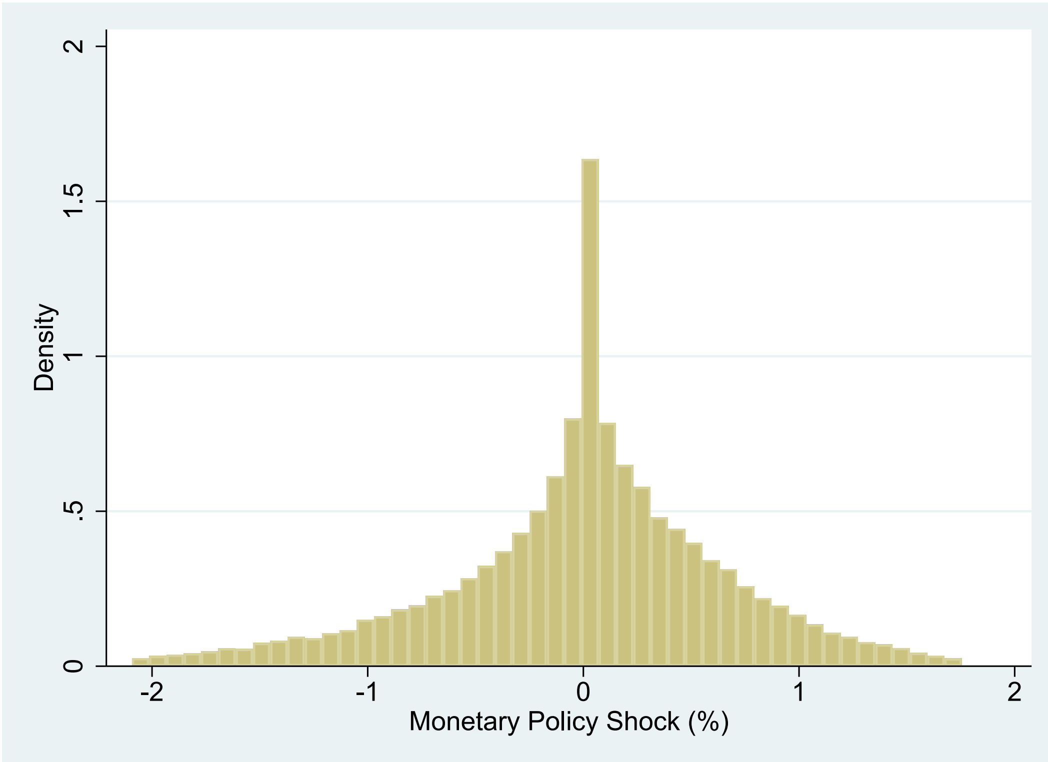


Figure 1: Histogram of a subjective monetary policy shock for each household j ($\hat{\varepsilon}_t^j$)

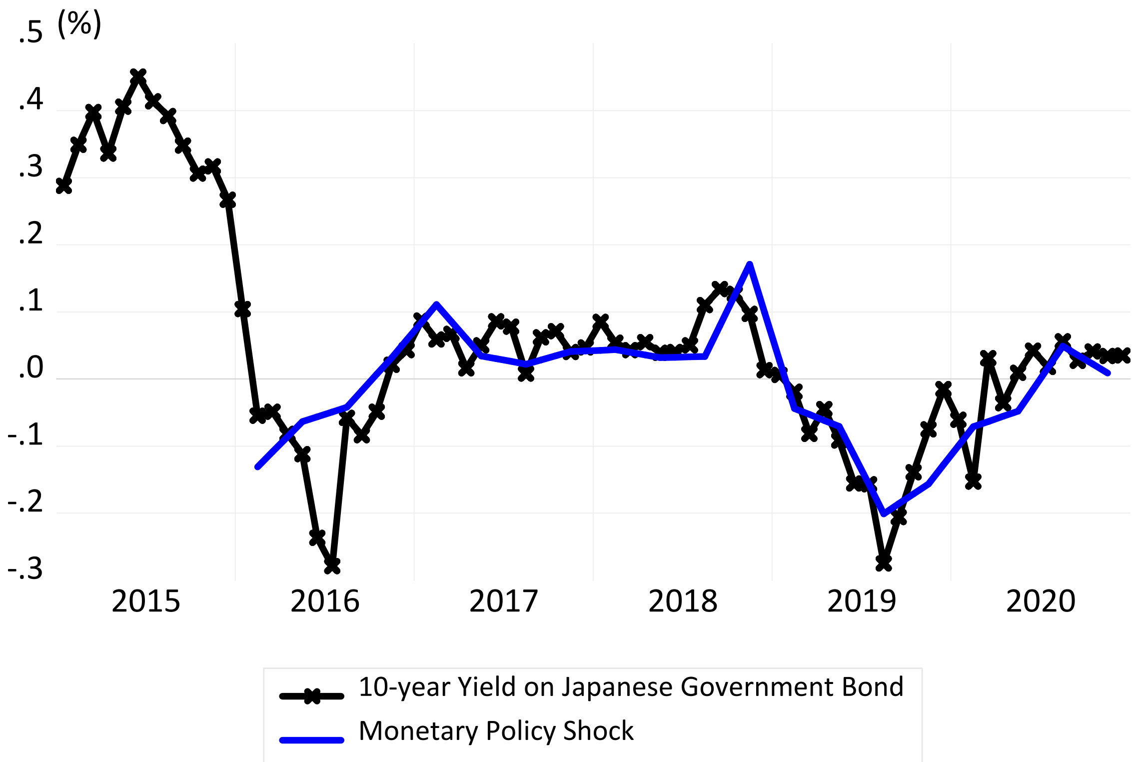


Figure 2: Development of 10-year yield on Japanese government bond and the average of the identified subjective monetary policy shocks ($\hat{\varepsilon}_t^j$)

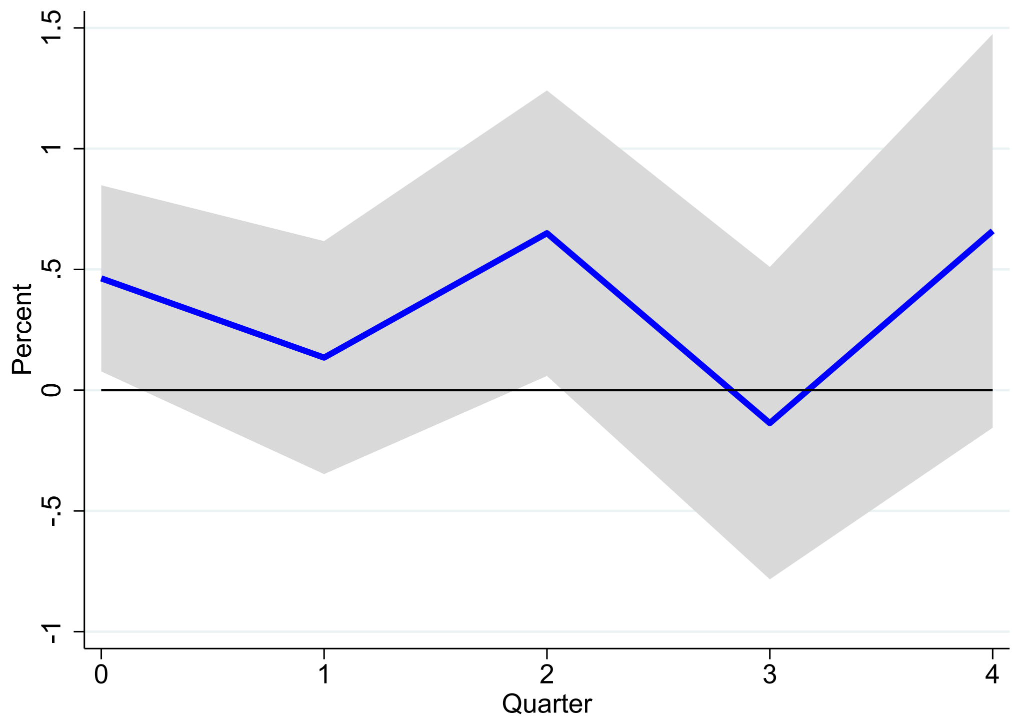
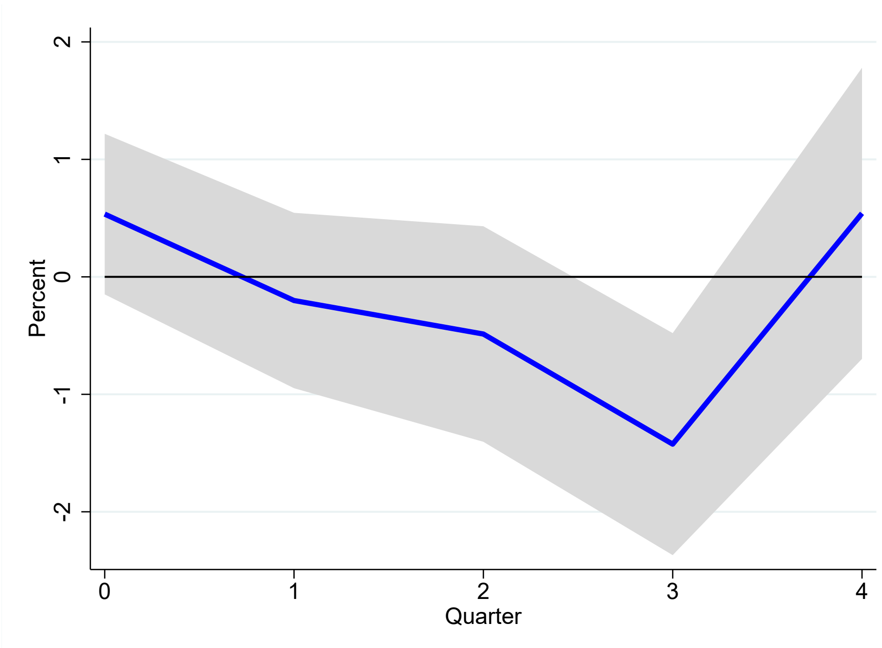


Figure 3: Impulse responses of imputed consumption to a one percentage point subjective monetary policy shock (from forecast errors) at the micro level ($\hat{\varepsilon}_t^j$), using the entire sample. The shaded area denotes the 68% confidence interval.

(a) Households with loans



(b) Households with financial assets of ten million yen or more

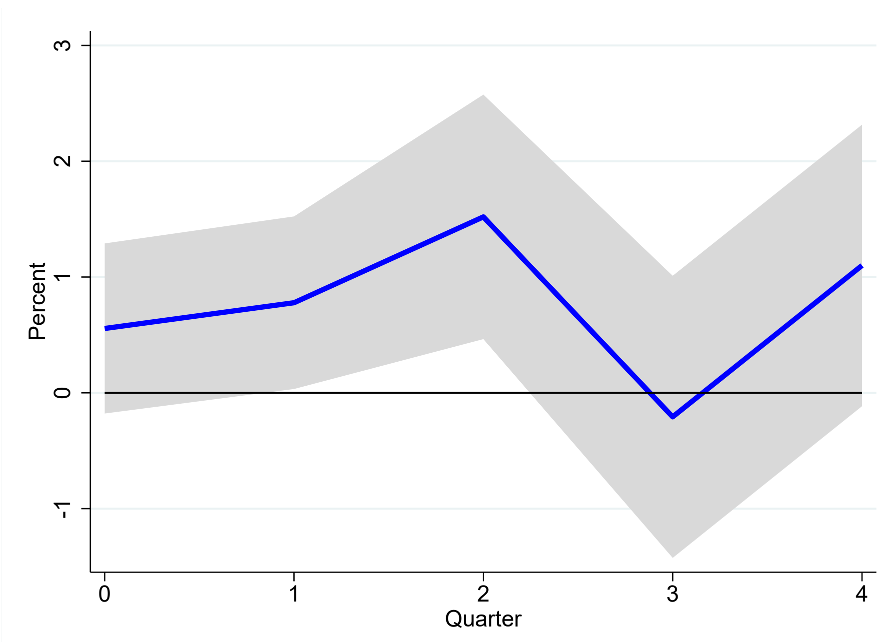
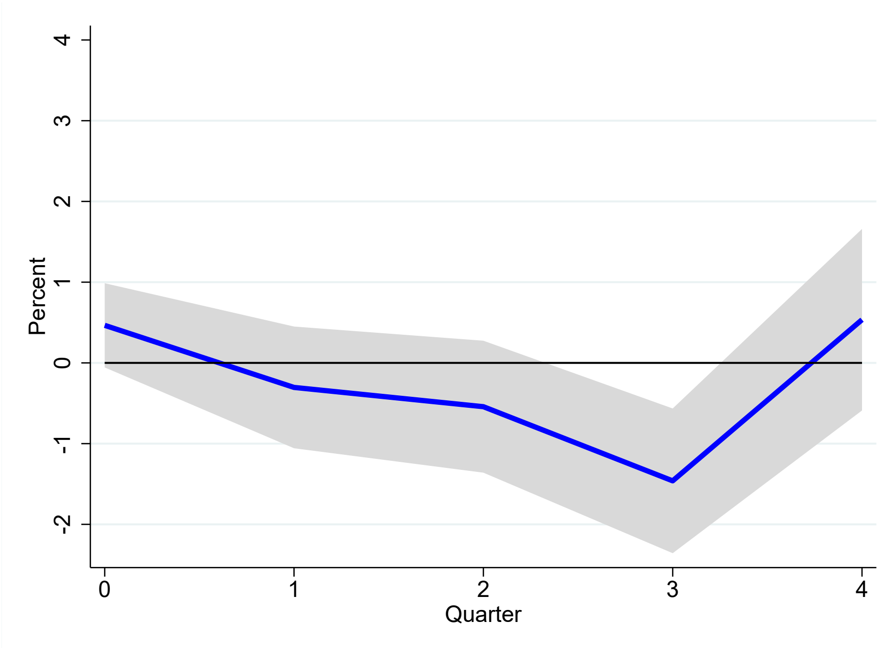


Figure 4: Households with loans: Impulse responses of imputed consumption to a one percentage point subjective monetary policy shock (from forecast errors) at the micro level ($\hat{\varepsilon}_t^j$), using the subsample from households with loans (top panel) and with financial assets of ten million yen or more (bottom panel). The shaded area denotes the 68% confidence interval.

(a) Households with loans



(b) Households with financial assets

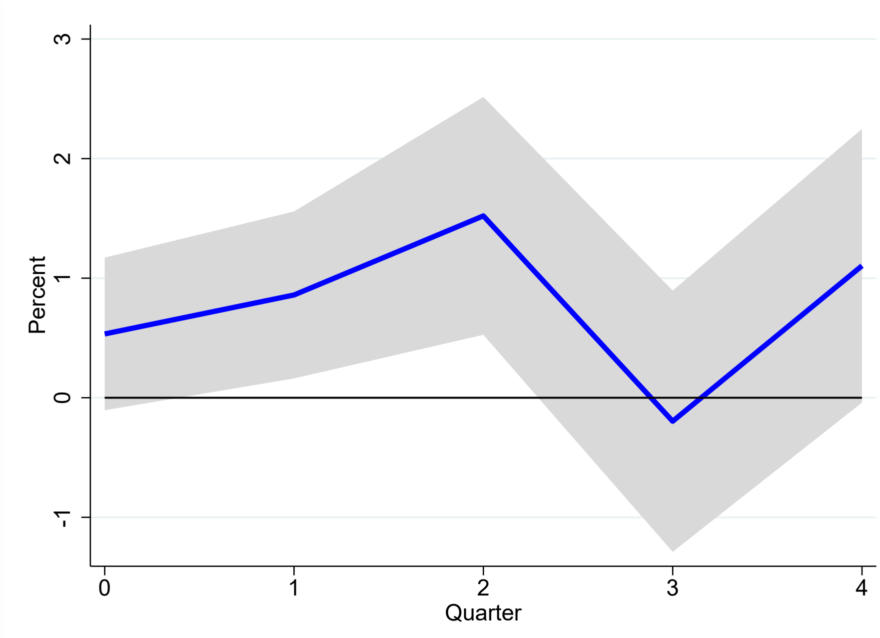
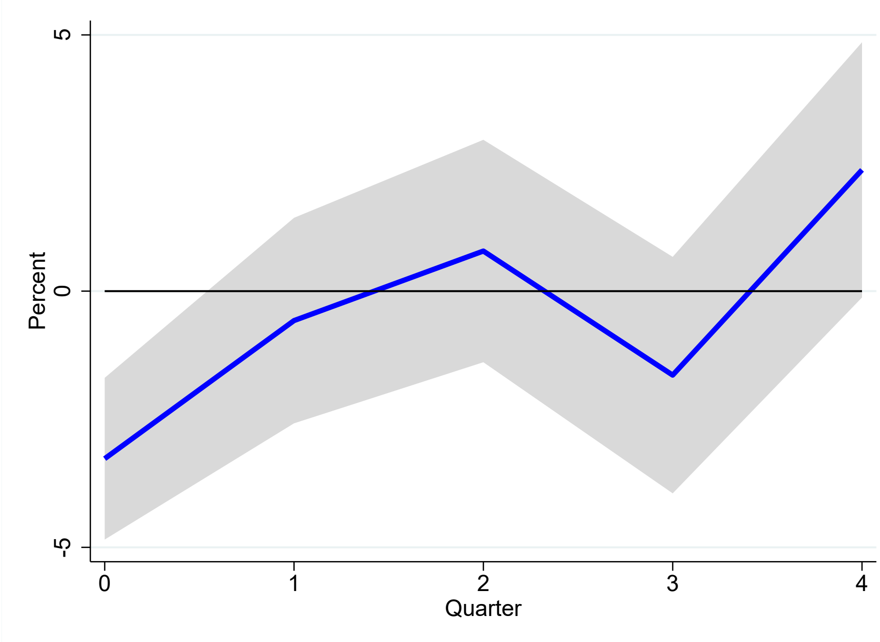


Figure 5: Households with loans (top panel) and with financial assets (bottom panel): Impulse responses of imputed consumption to a one percentage point subjective monetary policy shock (from the Taylor rule) at the micro level ($\hat{\varepsilon}_t^j$), using the subsample from households with loans (top panel) and with financial assets of 10 million yen or more (bottom panel). The shaded area denotes the 68% confidence interval.

(a) Attentive households with loans: a shock from forecast errors



(b) Attentive households with loans: a shock from the Taylor rule

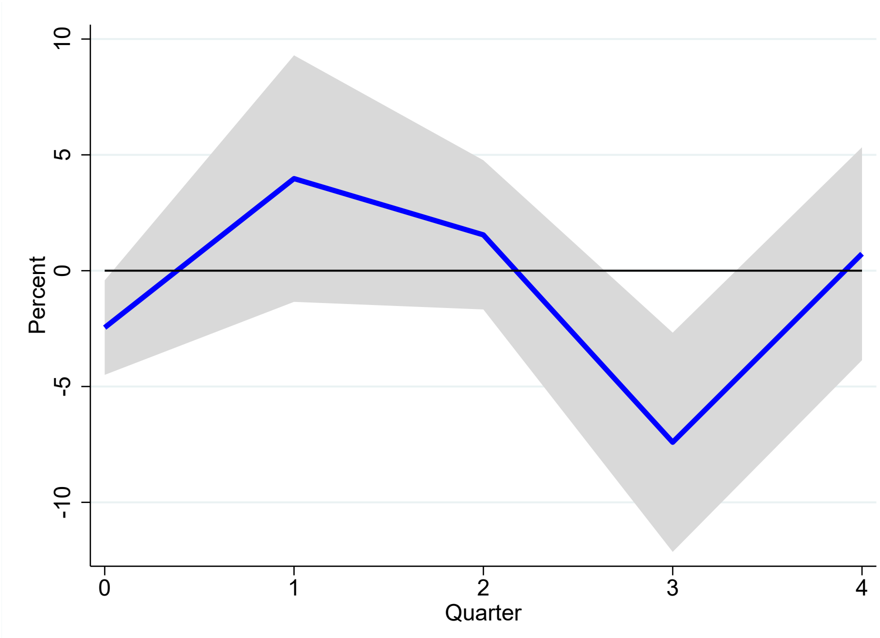
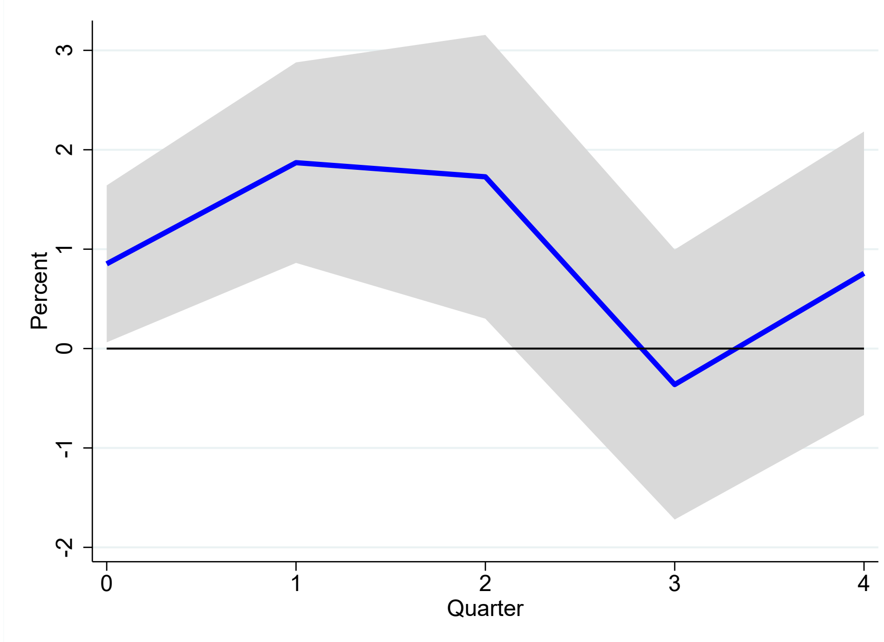


Figure 6: Households that update information sets about prices: Impulse responses of imputed consumption to a one percentage point subjective monetary policy shock from forecast errors (top panel) and the Taylor rule (bottom panel) at the micro level ($\hat{\varepsilon}^j_t$), using the subsample from households with loans. The shocks are identified based on the Taylor rule at the individual level from Equation (4) The shaded area denotes the 68% confidence interval.

(a) Attentive households with financial assets: A shock from forecast errors



(b) Attentive households with financial assets: A shock from the Taylor rule

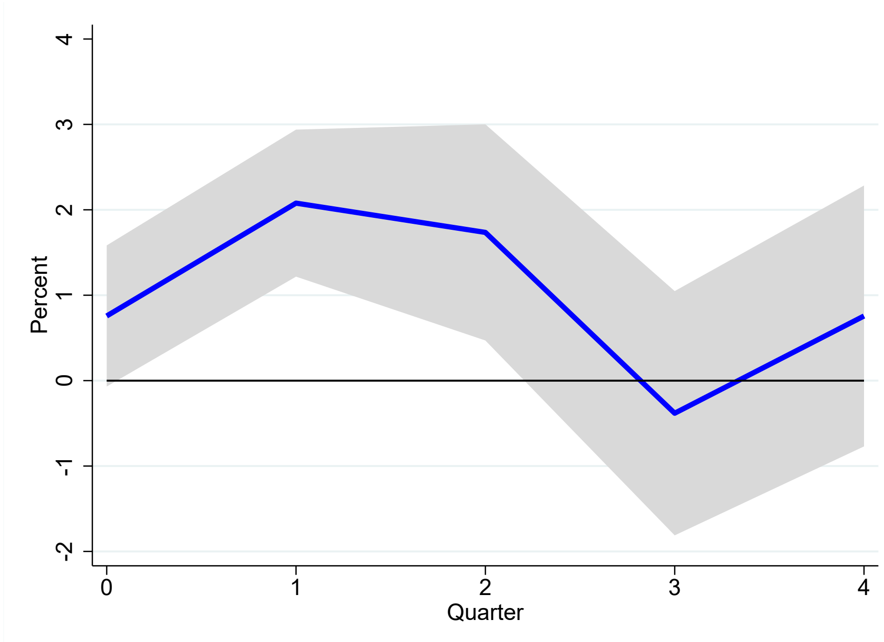
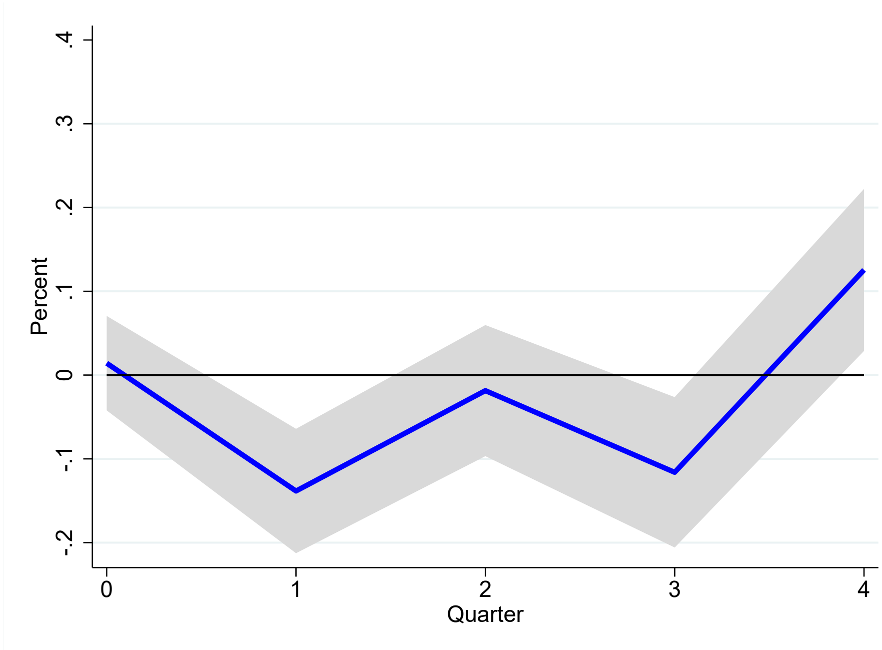


Figure 7: Households that update information sets about prices: Impulse responses of imputed consumption to a one percentage point subjective monetary policy shock from forecast errors (top panel) and the Taylor rule (bottom panel) at the micro level ($\hat{\varepsilon}_t^j$), using the subsample from households with financial assets of 10 million yen or more. The shocks are identified based on the Taylor rule at the individual level from Equation (4) The shaded area denotes the 68% confidence interval.

(a) Households with loans



(b) Households with financial assets

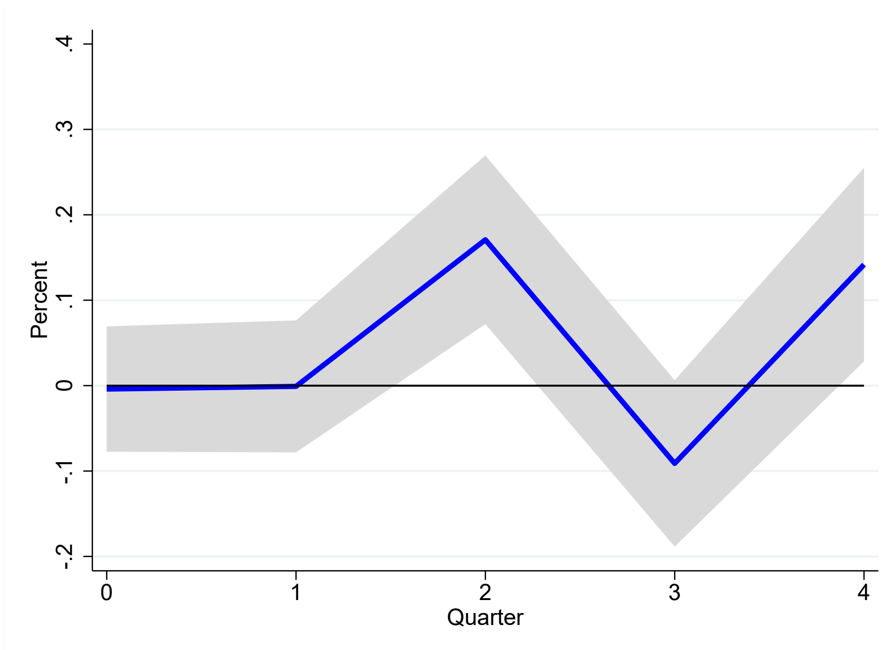
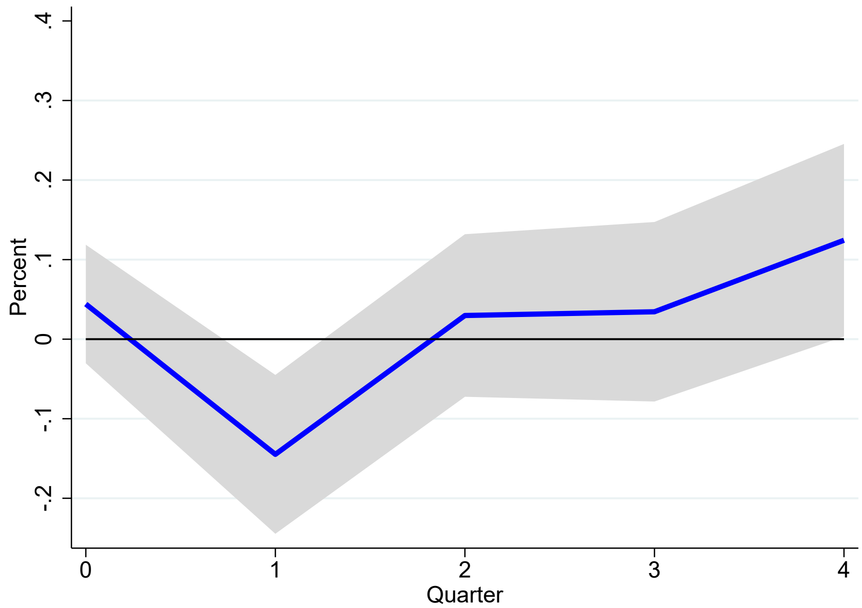


Figure 8: Robustness check: Households with loans (top panel) and with financial assets (bottom panel): Impulse responses of imputed consumption to a one percentage point subjective monetary policy shock at the micro level ($\hat{\varepsilon}_t^j$), using the subsample from households with loans (top panel) and with financial assets of 10 million yen or more (bottom panel). The shocks are identified based on the Taylor rule at the individual level from Equation (6). The shaded area denotes the 68% confidence interval.

(a) Attentive households with loans



(b) Attentive households with financial assets

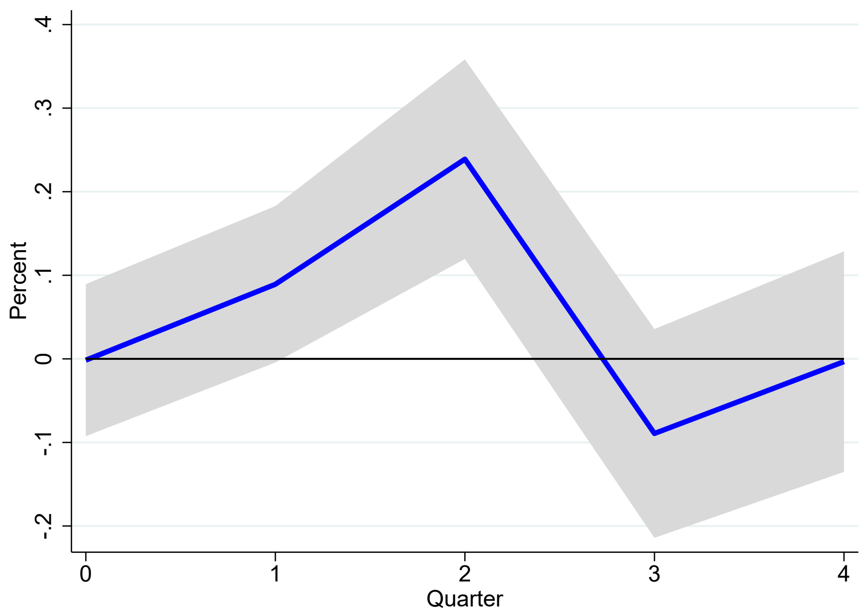


Figure 9: Households that update information sets about prices: Impulse responses of imputed consumption to a one percentage point subjective monetary policy shock at the micro level ($\hat{\varepsilon}_t^j$), using the subsample from households with loans (top panel) and with financial assets of 10 million yen or more (bottom panel). The shocks are identified based on the Taylor rule at the individual level from Equation (6). The shaded area denotes the 68% confidence interval.

Table 1: Basic statistics of households' interest rate forecasts

	After 3 months			After 6 months		
	Mean	Median	Obs.	Mean	Median	Obs.
All	1.8%	1.0%	51,176	1.9%	1.1%	51,176
Female	1.8%	1.0%	14,774	2.0%	1.1%	14,774
Male	1.7%	1.0%	36,402	1.9%	1.1%	36,402
Age below 40	1.7%	1.0%	8,948	1.8%	1.0%	8,948
Age 40-59	1.8%	1.0%	28,025	1.9%	1.0%	28,025
Age 60-79	1.8%	1.2%	14,203	2.0%	1.4%	14,203
Non-college grad	2.0%	1.0%	17,407	2.2%	1.2%	17,407
College grad	1.6%	1.0%	33,484	1.8%	1.0%	33,484
Low income	1.8%	1.0%	35,530	2.0%	1.1%	35,530
High income	1.6%	1.0%	15,611	1.7%	1.0%	15,611
Without loans	1.7%	1.0%	28,512	1.9%	1.0%	28,512
With loans ($\geq$ 30million yen)	1.7%	1.0%	2,325	1.8%	1.1%	2,325
Information set updated	1.7%	1.0%	33,661	1.8%	1.0%	33,661
Information set NOT updated	2.1%	1.0%	6,765	2.3%	1.1%	6,765

Note: The forecasts of interest rates above 10 percent are trimmed. The data are from 2015Q4 to 2020Q4.

Table 2: The fraction of households that update information sets about interest rates

	Information set updated			
	YES		NO	Total
	Once a week or more	less than once a week		
All	32%	55%	13%	100%
Female	20%	63%	17%	100%
Male	36%	52%	12%	100%
Age below 40	30%	53%	17%	100%
Age 40-59	31%	56%	13%	100%
Age 60-79	34%	54%	12%	100%
Non-college grad	26%	57%	17%	100%
College grad	35%	54%	11%	100%
Low income	30%	55%	15%	100%
High income	36%	54%	10%	100%
Without loans	32%	54%	14%	100%
With loans ($\geq$ 30million yen)	33%	59%	8%	100%

Note: “Low Income” and “High Income” are denoted as households’ annual income below 4 million yen and 7 million yen and above, respectively.

Table 3: Descriptive statistics of monthly household expenditure (yen)

	Purchase amount		Obs.
	Mean	Median	
All	21,183	17,585	51,176
Female	29,863	27,215	14,774
Male	17,660	14,261	36,402
Age below 40	16,526	12,988	8,948
Age 40-59	21,510	17,799	28,025
Age 60-79	23,471	20,085	14,203
Non-college grad	24,089	21,174	17,407
College grad	19,734	16,027	33,484
Low income	20,609	17,195	35,530
High income	22,483	18,546	15,611
Without loans	21,581	17,985	28,512
With loans ($\geq$ 30million yen)	19,030	15,606	2,325
Information set updated	20,706	16,999	33,661
Information set NOT updated	21,650	18,556	6,765

Note: The data are from 2015Q4 to 2020Q4.

Table 4: Basic statistics of monetary policy shocks at the household level

	MP shocks $\hat{\varepsilon}_{j,t}$			
	Mean	Median	Standard deviation	Observations
All	-0.003%	0.015%	0.705	51,176
Female	-0.004%	0.005%	0.727	14,774
Male	-0.003%	0.019%	0.696	36,402
Age below 40	-0.003%	0.014%	0.638	8,948
Age 40-59	-0.000%	0.017%	0.704	28,025
Age 60-79	-0.008%	0.013%	0.746	14,203
Non-college grad	-0.003%	0.004%	0.726	17,407
College grad	-0.002%	0.021%	0.694	33,484
Low income	-0.001%	0.013%	0.716	35,530
High income	-0.006%	0.019%	0.680	15,611
Without loans	-0.003%	0.018%	0.719	28,512
With loans ($\geq$ 30million yen)	0.005%	0.013%	0.619	2,325
Information set updated	-0.004%	0.016%	0.695	33,661
Information set NOT updated	0.005%	0.011%	0.701	6,765

Note: The data are from 2015Q4 to 2019Q4.

Table 5: Do covariates predict a subjective monetary policy shock?

Dependent variable: A subjective monetary policy shock $\hat{\varepsilon}_t^j$		
Independent variables: Covariates	(1)	(2)
β_1: D^{Female}	-0.00104	0.000454
	(0.00615)	(0.00611)
β_2: Age	-0.000782	-0.00312
	(0.00622)	(0.00619)
β_3: Age $\times$ Age	0.0000	0.000209
	(0.000440)	(0.000438)
β_4: Income level	-0.000642	-0.000544
	(0.000977)	(0.000971)
β_5: Educational attainment	0.000259	0.000253
	(0.00171)	(0.00170)
Time dummy	NO	YES
Observations	67,183	67,183

The standard errors between parentheses are clustered at the individual level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

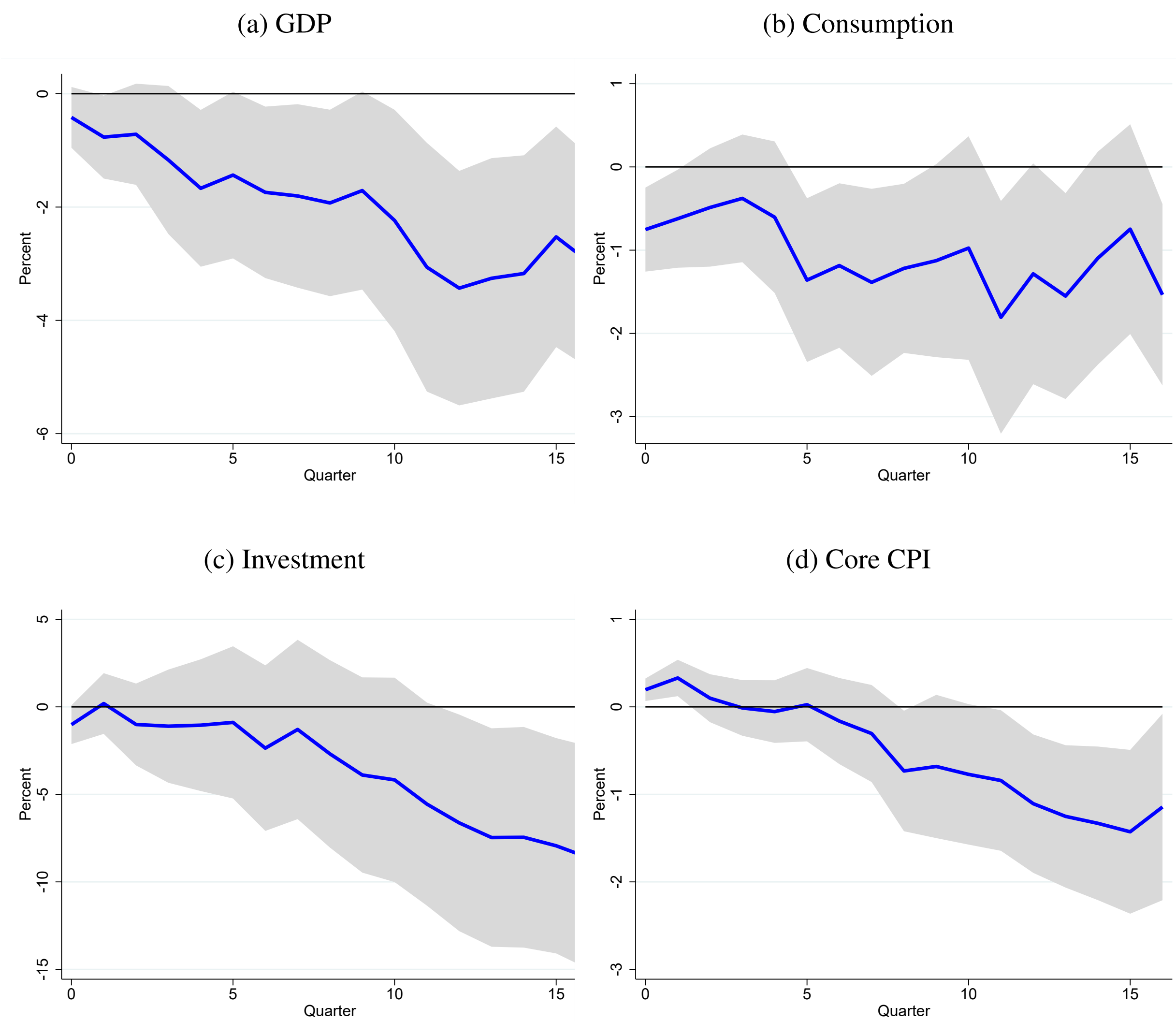


Figure B.1: Macro-macro responses to a monetary policy at a quarterly frequency from 1994 to 2019. The figure shows impulse responses to a one percentage point contractionary monetary policy shock. The confidence bands are calculated using the 68% interval.