Households' Attention to the Central Bank, Inflation Expectations, and Spending *

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June 2024

Abstract

Using household-level data from a Japanese survey that includes questions about knowledge, interest, and views on the Bank of Japan, we find that lower-income households pay less attention to the Bank, and their inflation expectations are more closely associated with inflation perceptions. To explain these findings, we construct a rational inattention model in which households face idiosyncratic income risk and borrowing constraints. The model suggests that lower-income households pay less attention to information about future inflation, including information from the central bank, since they are less able to adjust spending and thus benefit less from such information. The model also suggests that this information helps mitigate the bias in inflation expectations arising from overextrapolation. Our results imply that central bank communication about future inflation should focus more on those who pay more attention to the central bank since their spending tends to be more sensitive to inflation expectations.

JEL Classification: E21, E50, E61
Keywords: Central bank communication; Rational inattention; Inflation expectations; Euler equation; Survey data

*An earlier version of this paper, Ichiue et al. (2019), was circulated under the title"Households' Liquidity Constraint, Optimal Attention Allocation, and Inflation Expectations."The authors thank Kosuke Aoki, Marianne Baxter, Martin Ellison, Christopher Gibbs, Naohisa Hirakata, Yoshihiko Hogen, Masahiro Hori, Ryo Jinnai, Bruce Preston, Toshitaka Sekine, Tomohiro Sugo, Yosuke Uno, Mirko Wiederholt, Donghoon Yoo, Tack Yun, participants at 2019 JEA Spring Meeting, CEF 25th International Conference, SWET 2019, Deutsche Bundesbank-Banque de France Joint Conference on Household Expectations, and 6th Annual CIGS End of Year Macroeconomic Conference, and seminars at Australian National University, University of Sydney, Reserve Bank of Australia, University of Queensland, Bank of England, and Osaka University, and staff members of the Bank of Japan for invaluable comments. Any remaining errors are the sole responsibility of the authors. The views expressed in this paper are those of the authors and do not necessarily reflect the official views of the Bank of Japan and the views or policies of the International Monetary Fund, its Executive Board, or its Management.

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1 Introduction

Central bank communication to the general public is regarded as a potential tool to guide people's inflation expectations and, in turn, influence their spending. When nominal interest rates are stuck at the effective lower bound, policymakers may be able to stimulate spending by making people believe in higher future inflation (Krugman (1998), Eggertsson and Woodford (2003)). Central bank communication also matters when interest rates are away from the effective lower bound. For instance, when high inflation creates high inflation expectations among people, they may attempt to spend before prices rise, leading to self-fulfilling, persistently high inflation. This tragedy could be avoided if the central bank credibly communicated its ability and willingness to lower inflation.

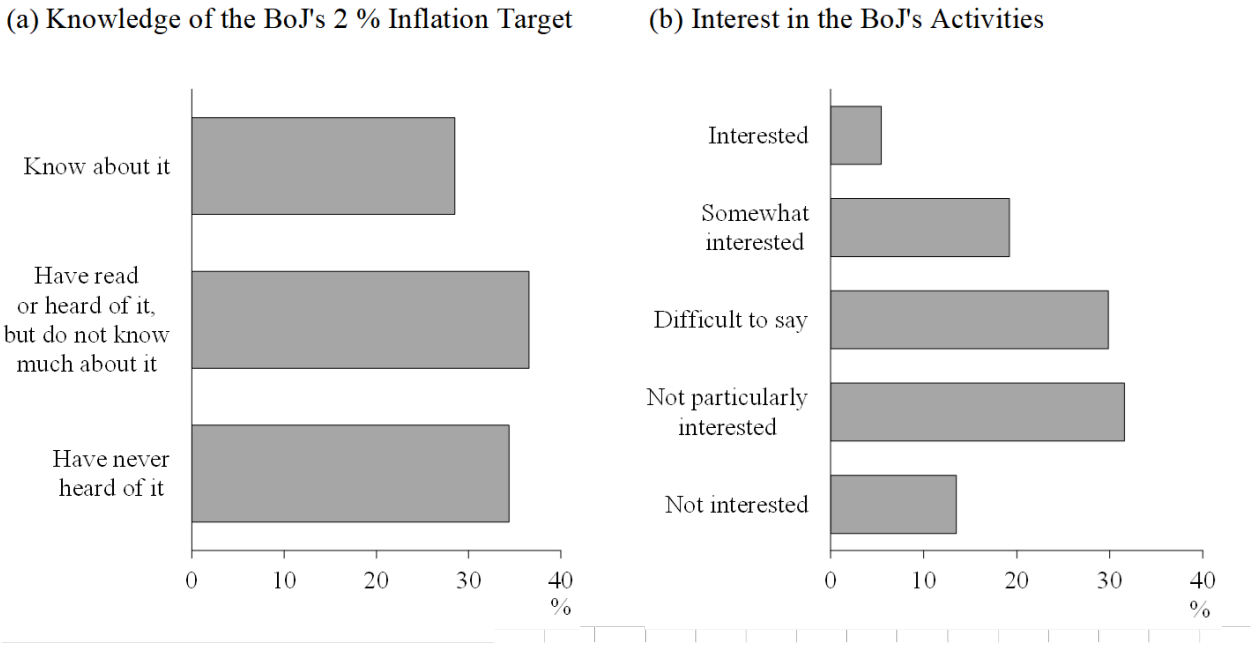
To examine the effectiveness of central bank communication, the literature often conducts randomized controlled trials (RCTs) in which the treatment groups are informed of the central bank's inflation target, its outlook for inflation, and so forth (e.g., Armantier et al. (2016); Binder and Rodrigue (2018); Coibion et al. (2022)). The results of such RCTs suggest that information from central banks can alter inflation expectations, but these results also imply that many people do not pay serious attention to such information until informed through RCTs. These results are consistent with much survey-based evidence that knowledge about monetary policy and inflation is limited, particularly among households with certain sociodemographic factors, such as low-income households. [1]

This study examines heterogeneity among households at different income levels in the degree of attention paid to the central bank and inflation information. We also investigate how households' attention to inflation information is related to their spending decisions and inflation expectations.

The empirical part of this study uses two datasets from Japanese household surveys: the "Opinion Survey on the General Public's Views and Behavior"and the"Preference Parameters Study."In particular, the Opinion Survey, which has been quarterly conducted by the Bank of Japan (BoJ), provides straightforward evidence that a majority of households do not pay attention to the central bank. For instance, Figure 1 shows that only 20-30% of Japanese

[1]For the literature reviews on central bank communication to the general public and knowledge of inflation and monetary policy, see Blinder et al. (2022) and Dräger (2023). Hayo and Neuenkirch (2014) and van der Cruijsen et al. (2015) find that the majority of households express a weak desire to be informed about monetary policy. See also Souleles (2004), Burke and Manz (2014), Carvalho and Nechio (2014), Dräger et al. (2016), Binder (2017), Mellina and Schmidt (2018), Rumler and Valderrama (2020), Bottone et al. (2021), Coleman and Nautz (2023), and Coibion et al. (2023b), among others.

Figure 1: Percentage of Responses to Questions about the Bank of Japan



Note Panel (a) represents the percentage of each choice to the question"Do you know that the Bank has set the price stability target at 2% in terms of the year-on-year rate of change in the CPI?"in the Opinion Survey on the General Public's Views and Behavior. Panel (b) represents the percentage of each choice to the question"How would you describe your level of interest in the Bank's activities?"Both panels show simple averages of the percentages of choices in the surveys from September 2006 to September 2016. See Section 2.1 for the details of the Opinion Survey.

households know the BoJ's inflation target and are interested or somewhat interested in the BoJ's activities. Our empirical analysis uses individual households' answers to these questions as indicators of the degree of attention to the BoJ. Our main empirical findings based on the two datasets are summarized as follows. First, lower-income households' spending decisions are less sensitive to their inflation expectations. Second, lower-income households pay less attention to the BoJ. Third, lower-income households' inflation expectations correlate more closely with their perceptions of year-on-year inflation.

In the theoretical part of this study, we explain the empirical findings using a rational inattention model. In the model, households face idiosyncratic income risk and borrowing constraints, as in McKay et al. (2016). In addition, households determine the degree of attention to information on future inflation, taking losses from imprecise information into account. Furthermore, we assume that households overextrapolate the past when forming inflation expectations, drawing on previous findings that households' inflation expectations and

perceptions are strongly positively correlated (e.g., Jonung (1981) and Dräger and Nghiem (2021)). This model explains the empirical findings as follows. First, lower-income households' spending is less sensitive to their inflation expectations since they are more likely to face borrowing constraints. Second, lower-income households pay less attention to the central bank since they have less ability to adjust consumption and thus benefit less from information that helps forecast future inflation, including the central bank's policy stance, outlook, and so forth. Third, lower-income households' inflation expectations are more closely associated with their inflation perceptions since households that pay less attention to information on future inflation are less able to correct the bias in their expectations arising from overextrapolation.

After discussing other potential factors behind the empirical findings, such as cognitive abilities, we conclude that central bank communication about future inflation is likely to be transmitted more to households whose spending is more responsive to inflation expectations. This is because those households are better able to exploit information obtained through communication to adjust their spending and thus have more incentive to pay attention to the central bank. Our results provide various policy implications. For instance, the central bank's efforts to improve communication with households that pay more attention to the central bank may be rewarded to a larger extent since these households' spending tends to be more sensitive to inflation expectations. Moreover, as central bank communication can mitigate the bias in inflation expectations arising from overextrapolation to a greater extent, it may be more effective in reducing the risk of persistent deviation of inflation from the target. Note that these policy implications are only in terms of influencing aggregate spending through guiding inflation expectations. For instance, communication with a broad audience may be essential to maintain political support for central bank independence.

This study contributes to the growing literature on central bank communication to the general public. Several studies examine the impact of changing the way of delivering information. For instance, Haldane and McMahon (2018) investigate the effect of a new version of the Bank of England's Inflation Report, augmented with new content aimed at speaking to a less-sophisticated audience. They find that website activity substantially increased after this change. [2] Our study complements these studies by examining the types of people on whom the central bank should focus when seeking to influence aggregate spending.

[2]See also Bholat et al. (2019), Kryvtsov and Petersen (2021), Rholes and Petersen (2021), and Coibion et al. (2023a) among others.

The empirical validity of the effects of central bank communication on spending depends on the validity of two effects: the effect of central bank communication on inflation expectations and the effect of inflation expectations on spending. As mentioned above, previous studies suggest that central bank information alters inflation expectations if it reaches people, but many people do not pay attention to it. On the other hand, a large body of studies examines the effect of inflation expectations on spending (e.g., Bachmann et al. (2015); Ichiue and Nishiguchi (2015); Duca-Radu et al. (2021); Dräger and Nghiem (2021); Jinnai et al. (2021); Crump et al. (2022)). While many studies find evidence that higher inflation expectations lead to larger current spending on average, this is not necessarily the case for certain types of households, such as low-income households. If both effects are valid only for a subset of households, central bank communication seems to have limited effects on aggregate spending. However, our results suggest that the overlap of the subsets may matter. That is, if households that pay more attention to central bank communication can change their spending more strongly in response to their inflation expectations, then communication might have a non-negligible impact on aggregate spending.

To the best of our knowledge, only recent studies examine the relationship between attention to information on inflation and decisions on intertemporal consumption allocation. For example, Macaulay (2022) constructs a theoretical model in which households with greater sensitivity of consumption to inflation expectations pay more attention to information about current inflation. Meanwhile, based on microdata, D'Acunto et al. (2023) find that inflation expectations of higher-IQ individuals are more sensitive to news, and their spending decisions are more in line with the Euler equation. In contrast to these studies, this paper is particularly interested in attention to the central bank and how it is related to inflation expectations and spending.

This study also relates to the literature on rational inattention (Sims (2003); Mackowiak and Wiederholt (2015); among others). Our rational inattention framework closely follows the model proposed by Dräger and Lamla (2017). Further, while Cavallo et al. (2017) and Dräger and Lamla (2017) suggest that households pay attention to inflation information when inflation is volatile, our study is unique in that it focuses on attention motives associated with income levels. In other words, in contrast with these previous studies, which analyze the effect of a macroeconomic condition (i.e., inflation volatility) on the degree of attention to inflation, we analyze the effect of an idiosyncratic condition (i.e., individual households'

income levels).

The remainder of this paper is organized as follows. Section 2 explains the data and presents empirical results. Section 3 develops the theoretical model. Finally, Section 4 concludes this paper and discusses policy implications. The Appendices include additional evidence and the derivation of the theoretical model.

2 Empirical Analysis

This section investigates household-level data from two surveys in Japan and shows empirical results, which motivate our theoretical analysis in the next section. In what follows, we first overview the datasets and then present and discuss the empirical results.

2.1 Overview of Datasets

We utilize data from two surveys, the "Preference Parameters Study" and the "Opinion Survey on the General Public's Views and Behavior." Both surveys ask about household income and inflation expectations, but each has different advantages.

Preference Parameters Study. The Preference Parameters Study (PPS) is an annual survey conducted from January to March by the Institute of Social and Economic Research, Osaka University. The Institute provides panel data of the responses from 2003. We use data from 2004 to 2013 since the survey started asking about inflation expectations in 2004 and was not conducted in 2014 and 2015. Surveyed households are randomly drawn from men and women aged 20 to 69 by a self-administered placement method. The response rate to each survey is more than 70%, and the data cover about 4,000 households on average each year. While this study focuses on Japan, the PPS asked the same questions to households in the U.S. from 2005 to 2013 and China and India from 2009 to 2013.

An advantage of the PPS is the availability of quantitative data. In this survey, households are asked to choose items representing numerical ranges for many variables, including the expected inflation rate and the expected change in expenditure. For instance, the inflation expectation question asks households to choose one among 11 options with 1 percentage point intervals. Specifically, the question on inflation expectations in the 2013 survey is as follows:

- *By what percentage do you expect consumer prices will change in 2013, compared with the previous year?*

  00. Decrease by at least 4.5%; 01. Decrease by at least 3.5% but less than 4.5%; 02. Decrease by at least 2.5% but less than 3.5%; 03. Decrease by at least 1.5% but less than 2.5%; 04. Decease by at least 0.5% but less than 1.5%; 05. Change by less than 0.5% in either direction; 06. Increase by at least 0.5% but less than 1.5%; 07. Increase by at least 1.5% but less than 2.5%; 08. Increase by at least 2.5% but less than 3.5%; 09. Increase by at least 3.5% but less than 4.5%; 10. Increase by at least 4.5%.

Furthermore, the question regarding the expected change in expenditures is as follows:

- *In 2013 what will be the approximate percentage change in your family's total annual expenditures compared with 2012?*

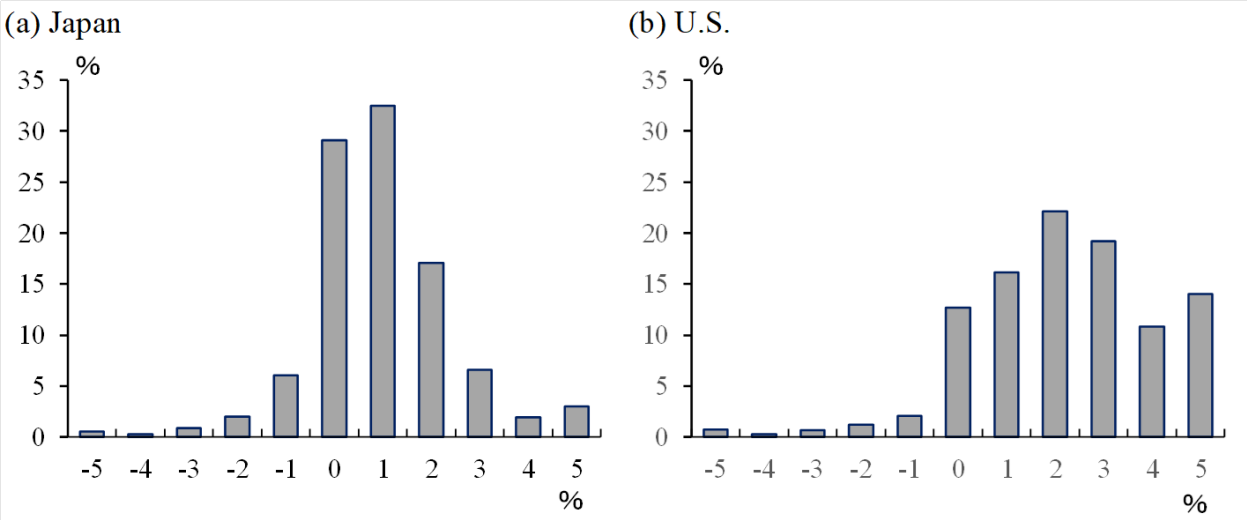
  00. Decrease by at least 9%; 01. Decrease by at least 7% but less than 9%; 02. Decrease by at least 5% but less than 7%; 03. Decrease by at least 3% but less than 5%; 04. Decease by at least 1% but less than 3%; 05. Change by less than 1% in either direction; 06. Increase by at least 1% but less than 3%; 07. Increase by at least 3% but less than 5%; 08. Increase by at least 5% but less than 7%; 09. Increase by at least 7% but less than 9%; 10. Increase by at least 9%.

As the PPS provides information in the form of responses in numerical ranges, we use the mid-point of the numerical range of each response category in the regression analysis. For the lowest and highest categories, which have an open-ended range, we subtract or add half of the interval from the cut-off value following conventional practice (see, Boero et al. (2015)). For instance, for the above question of inflation, we assign 5% to"Increase by at least 4.5%."Figure 2 compares distributions of 1-year inflation expectations of households in Japan and the U.S. This figure shows that inflation expectations were highly concentrated around 0 to 1% in Japan, while they were more evenly distributed with a peak of 2% in the U.S.

Finally, since the PPS asks various other questions, this study uses answers to some of these questions as control variables, as will be discussed later.

Opinion Survey on the General Public's Views and Behavior. The Opinion Survey is conducted by the BoJ. This survey collects repeated cross-sectional data of responses to

Figure 2: Distributions of Inflation Expectations over 1 Year



Note: This figure compares distributions of inflation expectations over 1 year of households in Japan and the U.S. using data from the Preference Parameters Study. "5%" represents "at least 4.5%," "4%" represents "at least 3.5% but less than 4.5%," and so forth. All individual responses to the surveys conducted between 2005 and 2013 are equally used to calculate the distributions.

various questions. For each wave, 4,000 individuals aged 20 or over are chosen using the two-stage stratified random sampling. The response rate is approximately 50%. The survey was conducted annually from 1993 to 1998, semi-annually from 1999 to 2003, and has been conducted quarterly since 2004. The completed questionnaires were collected by researchers visiting respondents' homes before September 2006, but the responses have been received by post since then. Kamada et al. (2015) point out that survey responses differ depending on the method used. Furthermore, associated with the change in survey methodology, the wording of the questionnaire also slightly changed. To avoid estimation bias arising from the changes in methodology and wording, we do not use the survey data before September 2006. As a result, our observation period is generally from September 2006 to September 2018.

One advantage of the Opinion Survey is that it asks questions about the BoJ, as illustrated in Figure 1. This study focuses on four questions as follows:

- *Do you know that the Bank has set the price stability target at 2% in terms of the year-on-year rate of change in the CPI?*

  1. Have never heard of it; 2. Have read or heard of it, but do not know much about it; 3. Know about it.

- *Do you know that one of the Bank's objectives is to achieve price stability?*

  1. Have never heard of it; 2. Have read or heard of it, but do not know much about it; 3. Know about it.

- *How would you describe your level of interest in the Bank's activities?*

  1. Not interested; 2. Not particularly interested; 3. Difficult to say; 4. Somewhat interested; 5. Interested.

- *How would you describe the Bank's relationships to our lives?*

  1. Not Related; 2. Not particularly related; 3. Difficult to say; 4. Somewhat Related; 5. Related.

The regression analysis in the next subsection uses answers to these questions as indicators of the degree of attention to the BoJ.

Another advantage of the Opinion Survey is that it asks about both inflation expectations and perceptions. Thus, the data are suitable to examine the relationship between them. In more detail, it asks households questions about (1) their perceptions of actual year-on-year inflation, (2) their expectations of inflation over the coming 1-year period, and (3) their expectations of inflation per year over the next 5 years. For instance, the questions on inflation perceptions and 1-year inflation expectations are as follows:

- *How do you think prices have changed compared with 1 year ago?*

  (Note: Prices are defined as overall prices of goods and services you purchase.)

  1. Have gone up significantly; 2. Have gone up slightly; 3. Have remained almost unchanged; 4. Have gone down slightly; 5. Have gone down significantly.

- *What is your outlook for prices 1 year from now?*

  1. Will go up significantly; 2. Will go up slightly; 3. Will remain almost unchanged; 4. Will go down slightly; 5. Will go down significantly.

While the Opinion Survey generally asks respondents to choose from three or five options, it also asks for numerical responses only regarding inflation perceptions and expectations. Qualitative and quantitative questions each have their disadvantages. Since the number of possible answers is limited for qualitative questions, the information contained therein is

likely less than for quantitative questions. In addition, answers to qualitative questions may be seriously affected by the wording of choices. On the other hand, qualitative questions may be more appropriate than quantitative questions if households have difficulty translating their sense of price changes into a reasonable number, as discussed by D'Acunto et al. (2022). In fact, survey respondents often answer extreme numbers. Thus, we must deal with outliers properly. Furthermore, as pointed out by Kamada (2013), various biases are observed in the quantitative answers in the Opinion Survey: for example, responses are likely to be multiples of 5. [3] Finally, the response rate for the quantitative questions in our sample is slightly lower than for the qualitative questions. This fact does not necessarily support using qualitative responses. This is because less confident respondents may tend to answer only the qualitative questions, resulting in relatively low-quality data. Overall, given that both qualitative and quantitative questions have their issues, this paper uses answers to both to check the robustness of the results.

2.2 Regression analysis

This subsection performs regression analysis to examine heterogeneity among households at different income levels in the sensitivity of spending to inflation expectations, the degree of attention paid to the BoJ, and the relationship between inflation expectations and perceptions.

2.2.1 Sensitivity of spending to inflation expectations

We here estimate the Euler equation and investigate whether the elasticity of intertemporal substitution (i.e., the absolute value of the sensitivity of expected spending growth to expected inflation) differs across income groups using the data from the PPS. Specifically, we run the following ordinary least squares (OLS) regression:

$$y^e_{i,t} = \beta_1 \pi^e_{i,t} + \beta_2 \pi^e_{i,t} d_{i,t} + \beta_3 d_{i,t} + \gamma x_{i,t} + \psi_i + \tau_t + \epsilon_{i,t} \tag{1}$$

where $y^e_{i,t}$ is household i's expected growth rate of real spending over 1 year, $\pi^e_{i,t}$ is the expected inflation rate, $d_{i,t}$ is a vector of two dummy variables for income per household member, $x_{i,t}$ represents control variables, and ψ_i and τ_t are household and time-fixed effects, respectively.

[3] Interestingly, as shown in Figure 2, these biases are not clearly observed in the PPS, in which respondents are asked to pick from 11 choices. This may be because these choices give respondents information on a plausible range of the inflation rate.

The question about expenditures does not explicitly state that answers should be given in real or nominal terms. However, we assume that responses are given in nominal terms because individuals appear to respond in nominal terms unless requested to respond in real terms. Thus, we calculate the expected growth rate of real spending by subtracting the expected inflation rate from the expected nominal expenditure percent change.

The income per household member is calculated by dividing household income in the previous year by the current number of household members. [4] Then, households are classified into the following three groups based on the income per household member: (i) less than 1.5 million yen, (ii) from 1.5 to 3.0 million yen, and (iii) more than 3.0 million yen. We refer to households in these three groups as high-income, middle-income, and low-income households. We use the high-income group as the reference group. Therefore, while the coefficient of the non-interaction term of inflation expectations, β_1, is expected to be negative, the coefficients of the interaction terms between inflation expectations and income-group dummies, β_2, are expected to be positive if spending is less sensitive to inflation expectations for lower-income households. [5]

This regression controls for expected real income changes over the next 1 year and past nominal income changes compared to 1 year ago. [6] We also add a dummy variable for households planning large expenses in the future to control for a temporary spike in household spending, although excluding this dummy generally does not change our results. [7] Relatedly,

[4]While the current number of household members is asked as an exact number in the PPS, household income is not. For instance, the survey in 2018 asks"Approximately how much was the annual earned income before taxes and with bonuses included of your entire household for 2017? (If you are a student, please indicate the income of your parents' entire household.)"The possible responses to this question are range categories essentially with the 2-million yen interval as: 1. Less than ¥1,000,000, 2. ¥1,000,000 to less than ¥2,000,000, 3. ¥2,000,000 to less than ¥4,000,000,..., 11. ¥18,000,000 to less than ¥20,000,000, and 12. ¥20,000,000 or more. We convert this information into numerical data using each range's mid-point. For the highest category with an open-ended range of more than 20 million yen, we assign 21 million yen by adding half of the interval to the cut-off value.

[5]Coefficient estimates are usually biased toward zero due to attenuation bias. However, since the dependent variable in regression (1) is calculated by subtracting inflation expectations, the coefficient estimate of the non-interaction term of inflation expectations can be biased toward the opposite direction. This is not a serious problem in this paper since we are mainly interested in the coefficients on the interaction terms or the differences in sensitivity of spending to inflation expectations across households with different income levels.

[6]Although past real income changes may be ideal for controlling for, they cannot be calculated since households do not report price changes compared to 1 year ago in the PPS. Our main results remain almost unchanged when we exclude the past nominal income changes.

[7]Regarding the statement"I plan to spend a lot of money or plan to purchase expensive items in the future,"respondents pick the answer from five ordered choices, where "1"means it is particularly true for the respondent and "5"means it does not hold at all. The dummy variable takes one if "1"or "2"is chosen and zero otherwise.

Table 1: Summary Statistics for Main Variables from the PPS

	Possible values	Obs.	Mean	Std. dev.
Expected real expenditure change	-15, -14,…, 15 (%)	29,055	-0.06	4.41
Expected inflation	-5, -4,..., 5 (%)	29,197	0.95	1.48
Low income	0: No, 1: Yes	37,637	0.34	0.48
Middle income	0: No, 1: Yes	37,637	0.44	0.50
Few financial assets	0: No, 1: Yes	35,048	0.27	0.44

Note: This table reports the possible values, number of observations, mean, and standard deviation of the main variables obtained from the Preference Parameters Study.

we exclude households that purchased a house or condo in the previous year and households in the top 1% of the sample in each survey wave in terms of spending on durable goods as a percentage of income.

Table 1 reports the summary statistics of the main variables used in this regression. Although the number of observations differs across the variables, at least 25,000 observations are available for all regressions. This table shows that 34% and 44% of our sample are classified as low-income and middle-income households, respectively.

Table 2 shows the estimation results. Robust standard errors are reported in the parentheses as in the other tables reporting regression results in this paper. Column (1) represents the result of the regression without income dummies and their interactions with inflation expectations. The coefficient on inflation expectations is negative and statistically significant. This result suggests that higher inflation expectations are associated with lower expected consumption growth, which is consistent with the Euler equation. The point estimate of the elasticity of intertemporal substitution is 0.159. Note that Havranek (2015) surveys the literature and concludes that when the reporting bias is corrected, the average estimate of the elasticity of intertemporal substitution based on macro data is zero, while that based on microdata is around 0.3-0.4. Our estimate is around half of the average of micro estimates.

Column (2) reports the result of the regression with income dummies and their interaction terms with inflation expectations. The interaction term is positive and significant for the low-income group at the 5% level and the middle-income group at the 10% level. In addition,

Table 2: Estimation Results of the Euler Equation

	(1)	(2)	(3)
Expected inflation	-0.159***	-0.241***	-0.204***
	(0.030)	(0.045)	(0.036)
× Middle income		0.096*	
		(0.052)	
× Low income		0.112**	
		(0.057)	
× Few financial assets			0.129**
			(0.056)
Expected real income change	0.172***	0.171***	0.172***
	(0.012)	(0.008)	(0.012)
Percieved nominal income change	0.093***	0.093***	0.097***
	(0.010)	(0.008)	(0.010)
Middle income		-0.123	
		(0.118)	
Low income		-0.077	
		(0.146)	
Few financial assets			-0.141
			(0.116)
Planning large expenditures	0.631***	0.628***	0.596***
	(0.075)	(0.072)	(0.078)
Observations	27,910	27,860	25,917
Number of households	7,471	7,466	7,076
Adjusted R-squared	0.176	0.177	0.183

Note: This table represents the results of the regressions of the Euler equation. Robust standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10% levels, respectively. The observation period is from 2004 to 2013. The estimate of the constant term is not reported.

the coefficient is larger for the low-income group than for the middle-income group, although the difference is not large. These results suggest that lower-income households adjust their spending in response to inflation expectations to a lesser extent, possibly because these households are more likely to face liquidity constraints, as will be discussed in the next section. On the other hand, the coefficient on the non-interaction term shows that the point estimate of the elasticity of intertemporal substitution is 0.241 for high-income households.

The PPS also asks about households' holdings of financial assets, such as savings, stocks, and insurance policies. Since asset holdings are another important determinant of liquidity constraints, we check the robustness of results to using data on asset holdings instead of income. Specifically, we define households with few assets as those that hold financial assets worth less than 2.5 million yen. As shown in Table 1, 27% of our sample are classified as households with few assets. Column (3) of Table 2 shows the result when using a dummy variable that takes one for households with few financial assets and zero for those without. The coefficient on the interaction term between the inflation expectation and the"few financial assets"dummy is positive and significant, suggesting that spending of households with fewer assets is less responsive to inflation expectations, possibly because they are more likely to face liquidity constraints.

2.2.2 Attention to the BoJ

We here examine the level of attention paid to the BoJ. To this end, we utilize unique data from households' responses to questions about the BoJ in the Opinion Survey.

We employ an ordered probit model in which an unobserved continuous variable of households' attention to the BoJ, $a^*_{i,t}$, explains the observed discrete survey response, $a_{i,t}$. In the baseline case, we use respondents' knowledge of the BoJ's 2% inflation target as the proxy for their attention to the BoJ. Hence, the observed discrete response is defined as follows:

$$a_{i,t} = \begin{cases} \text{Know about the inflation target} & \text{if } \alpha_2 < a^*_i \\ \text{Do not know much about the inflation target} & \text{if } \alpha_1 < a^*_{i,t} \leq \alpha_2 \\ \text{Have never heard of the inflation target} & \text{if } a^*_{i,t} \leq \alpha_1 \end{cases} \tag{2}$$

with cut-off parameters α_1 and α_2. The unobserved variable is represented as

$$a^*_{i,t} = \beta d_{i,t} + \gamma x_{i,t} + \tau_t + \epsilon_{i,t}, \tag{3}$$

where $d_{i,t}$ represents a vector of dummy variables of income categories, $x_{i,t}$ represents a vector of control variables, and τ_t represents time-fixed effects.

As in the exercise with the PPS data above, households are classified into the following three categories based on income per household member: (i) less than 1.5 million yen, (ii) from 1.5 to 3.0 million yen, and (iii) more than 3.0 million yen. [8] Again, we use the high-income group as the reference group. Thus, the coefficients on the dummy variables are negative if lower-income households tend to pay less attention to the BoJ.

The control variables include dummy variables of respondents' gender, age categories, and work status. The reference groups for the dummy variables are male, under 29, and regular employee. We also use a dummy variable of financial literacy since it is likely an important determinant of attention to the central bank. Following Ichiue and Nishiguchi (2015), respondents with high financial literacy are defined as those who, in the question about the reasons behind their assessment of economic conditions, answered "Economic indicators and statistics."[9] Finally, adding time-fixed effects may be important since macroeconomic variables, such as inflation volatility, can play essential roles in determining the degree of attention to information on inflation, including information from the central bank.

Table 3 reports the summary statistics of the main variables obtained from the Opinion Survey. The number of observations is relatively small for the questions about the BoJ, mainly because these questions are often asked once every two waves. Furthermore, since the question about the 2% inflation target was newly added to the survey in September 2013, the observation period for this question is from September 2013 to September 2018. Nonetheless, more than 40,000 observations are available for the regression analysis. This table shows that 53% and 32% of our sample are classified as low-income and middle-income households, respectively. [10]

Column (1) in Table 4 presents the baseline result. The coefficients on the low-income and middle-income households are negative and significant. Moreover, the absolute value of the coefficient is larger for the low-income households than for the middle-income households. These results suggest that lower-income households pay less attention to the BoJ's 2% inflation target. In the table, the marginal effect represents the change in the probability (in %)

[8] See Appendix A for the calculation of income per household member.

[9] The other choices are "Media reports," "Business performance of the company I work for or of my own company," "Income level for myself or other family members," "Bustle of shopping streets and amusement quarters," and "Other." The results are robust to changing the definition of households with high financial literacy so that it also includes households that answered "Media reports." See Appendix A for the details.

[10] Although we define income classifications similar to those for the PPS, the share of low-income households is higher here possibly due to the data limitation. However, our results are robust to focusing on households with relatively high-quality data, as discussed in Appendix A.

Table 3: Summary Statistics for Main Variables from the Opinion Survey

	Possible values	Obs.	Mean	Std. dev.
Knowledge of 2% target	1: Have never heard of it, 2: Have read or heard of it, but do not know much about it, 3: Know about it	43,203	1.93	0.80
Knowledge of BoJ's objectives	1: Have never heard of it, 2: Have read or heard of it, but do not know much about it, 3: Know about it	64,515	2.07	0.75
Interest in BoJ's activities	1: Not interested, 2: Not particularly interested, 3: Difficult to say, 4: Somewhat interested, 5: Interested	64,477	2.76	1.10
BoJ's relationship to our lives	1: Not related, 2: Not particularly related, 3: Difficult to say, 4: Somewhat related, 5: Related	64,477	3.95	1.03
Expected inflation (1 year, quantitative)	numerical answer	91,590	3.89	4.22
Expected inflation (5 year, quantitative)	numerical answer	91,590	3.68	3.76
Perceived inflation (1 year, quantitative)	numerical answer	91,560	3.97	5.04
Expected inflation (1 year, qualitative)	-2: Will go down significantly, -1: Will go down slightly, 0: Will remain almost unchanged, 1: Will go up slightly, 2: Will go up significantly	107,518	0.73	0.73
Expected inflation (5 year, qualtative)	-2: Will go down significantly, -1: Will go down slightly, 0: Will remain almost unchanged, 1: Will go up slightly, 2: Will go up significantly	106,231	0.98	0.81
Perceived inflation (1 year, qualitative)	-2: Have gone down significantly, -1: Have gone down slightly, 0: Have remained almost unchanged, 1: Have gone up slightly, 2: Have gone up significantly	107,721	0.65	0.83
Low income	0: No, 1: Yes	106,896	0.53	0.50
Middle income	0: No, 1: Yes	106,896	0.32	0.46
High financial literacy	0: No, 1: Yes	108,535	0.11	0.31

Note: This table reports the possible values, number of observations, mean, and standard deviation for the main variables obtained from the Opinion Survey.

that a household answers that it knows about the inflation target for a one-unit increase in the independent variable while holding the other independent variables at their mean values. The marginal effects in column (1) show that the low-income and middle-income households display 14 and 9 percentage points lower probabilities of answering that they know about the inflation target than the high-income households.

Columns (2)-(4) show the results when one of three alternative variables is used as a proxy for households' attention to the BoJ. The three variables relate to the knowledge that one of the BoJ's objectives is to achieve price stability, interest in the BoJ's activities, and the BoJ's relationship to our lives. The marginal effect represents the change in the probability (in %) that a household chooses the option representing the highest attention to the BoJ (i.e.,"Know about it," "Interested,"or"Related") for a one-unit increase in the independent variable while holding the other independent variables at their mean values. We obtain similar results to the baseline result. These results suggest that income is an important determinant of attention to the central bank.

Finally, we briefly touch on the coefficients of control variables. In all four regressions, the coefficient on the high financial literacy dummy is positive and significant, suggesting that households with higher financial literacy pay more attention to the BoJ. This result makes sense, implying that our measure of financial literacy is relevant. We also find that females pay less attention to all aspects of the BoJ than males, older people tend to pay more attention, except for the question about the BoJ's relationship to our lives, and non-regular employees pay less attention than regular employees.

2.2.3 Inflation Expectations and Perceptions

To examine the heterogeneity in the relationship between inflation expectations and perceptions across households with different income levels, we here use answers to quantitative questions in the Opinion Survey. Appendix B shows that the main results are robust to using answers to qualitative questions.

We run an OLS regression as follows:

$$\pi^e_{i,t} = \beta_1 \pi^p_{i,t} + \beta_2 \pi^p_{i,t} d_{i,t} + \beta_3 d_{i,t} + \gamma x_{i,t} + \tau_t + \epsilon_{i,t}. \tag{4}$$

where $\pi^e_{i,t}$ is expected inflation for 1 or 5 years, and $\pi^p_{i,t}$ is perceived changes in the price level compared to 1 year ago. To deal with outliers, the expected and perceived inflation rates are

Table 4: Estimation Results for Attention to the Bank of Japan

	(1) Knowledge of 2% target		(2) Knowledge of BoJ's objectives		(3) Interest in BOJ's activities		(4) BOJ's relationship to our lives	
		Marginal effect		Marginal effect		Marginal effect		Marginal effect
Middle income	-0.268***	-8.65	-0.232***	-8.18	-0.152***	-1.73	-0.144***	-5.53
	(0.018)		(0.015)		(0.013)		(0.013)	
Low income	-0.435***	-13.53	-0.451***	-15.28	-0.268***	-2.82	-0.279***	-10.47
	(0.017)		(0.014)		(0.013)		(0.013)	
High financial literacy	0.536***	17.57	0.383***	13.19	0.497***	6.29	0.263***	10.01
	(0.021)		(0.015)		(0.014)		(0.014)	
Female	-0.593***	-18.15	-0.334***	-11.04	-0.212***	-2.06	-0.033***	-1.23
	(0.012)		(0.010)		(0.009)		(0.010)	
Age 30-39	0.152***	3.22	0.095***	2.59	0.116***	0.67	-0.069***	-2.56
	(0.026)		(0.020)		(0.017)		(0.018)	
Age 40-49	0.378***	8.89	0.326***	9.57	0.251***	1.63	-0.077***	-2.85
	(0.024)		(0.020)		(0.017)		(0.017)	
Age 50-59	0.593***	15.18	0.488***	15.00	0.365***	2.61	-0.060***	-2.23
	(0.025)		(0.019)		(0.017)		(0.017)	
Age 60-69	0.875***	24.51	0.604***	19.06	0.569***	4.86	-0.006	-0.24
	(0.024)		(0.019)		(0.017)		(0.017)	
Age 70 or older	0.954***	27.30	0.547***	17.04	0.675***	6.30	-0.066***	-2.43
	(0.025)		(0.020)		(0.019)		(0.019)	
Agriculture, forestry, or fisheries	-0.041	-1.22	-0.165***	-5.31	0.015	0.15	-0.010	-0.35
	(0.040)		(0.029)		(0.029)		(0.029)	
Self-employed, working for a family business, or professional	0.075***	2.26	-0.035**	-1.17	0.090***	0.94	0.059***	2.20
	(0.022)		(0.017)		(0.016)		(0.017)	
Non-regular employee	-0.128***	-3.67	-0.189***	-6.06	-0.105***	-0.95	-0.067***	-2.42
	(0.018)		(0.015)		(0.014)		(0.014)	
Other (e.g., full-time homemaker, student, pensioner, unemployed)	0.069***	2.10	-0.034**	-1.14	-0.002	-0.02	0.044***	1.62
	(0.017)		(0.014)		(0.013)		(0.013)	
Pseudo R-squared	0.0959		0.0918		0.0521		0.0074	
Number of observations	42,568		62,700		62,648		62,658	

Note: This table shows the estimation results of the ordered probit models that examine determinants of attention to the Bank of Japan (BoJ). Columns (1)-(4) show the results when using answers to questions about knowledge of the BoJ's 2% inflation target, knowledge of the BoJ's objectives, interest in the BoJ's activities, and the BoJ's relationship to our lives, respectively, as a proxy for attention. Robust standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10% levels, respectively. The marginal effect represents the change in the probability (in %) that a household responds, for example, that it knows about the inflation target for a one-unit increase in the independent variable while holding the other independent variables at their mean values. The reference groups for the dummy variables are high-income, low-financial literacy, male, under 29, and regular employee. The observation period is from September 2013 to September 2018 for column (1) and from September 2006 to September 2018 for the others.

winsorized at the 10th and 90th percentiles. [11] The other variables (i.e., the income dummy variables, controls, and time-fixed effects) are the same as in regression (3). [12]

The estimation results are presented in Table 5. The coefficient estimates for most control variables are not reported to save space. Column (1) shows the result for the regression of 1-year inflation expectations. The coefficient on the non-interaction term of perceived inflation is positive and significant at the 1% level, implying that expected and perceived inflation are positively correlated for high-income households. As for the interaction terms, although the coefficient for middle-income households is insignificant, that for low-income households is positive and significant at the 1% level. This result suggests that lower-income households put more weight on perceived inflation when forming their inflation expectations.

Column (2) presents the result when inflation expectations over the next 5 years are used as the dependent variable. Again, both the non-interaction term of perceived inflation and the interaction term between perceived inflation and the low-income dummy are positive and significant at the 1% level. In addition, now, the coefficient of the interaction term between perceived inflation and the middle-income dummy is also positive and significant at the 5% level. The coefficient of the interaction term for middle-income households is smaller than that for low-income households. These results also suggest that lower-income households' inflation expectations are more closely associated with inflation perceptions.

Columns (3) and (4) show the results for 1-year and 5-year inflation expectations, respectively, when including an interaction term between perceived inflation and the high financial literacy dummy. The results for the coefficients on perceived inflation and its interaction with income dummies remain essentially unchanged, suggesting that our main results are robust. Meanwhile, the coefficient on the interaction term between the high financial literacy dummy and perceived inflation is negative but insignificant in both columns. [13]

[11] Our main results are robust to winsoring inflation variables at the 5th and 95th percentiles. Since the inflation variables take extreme values for many households in this case, however, we generally winsorize inflation variables at the 10th and 90th percentiles.

[12] The results are again robust to focusing on households with relatively high quality data and using alternative measures of financial literacy. See Appendices A.

[13] As shown in Appendices A and B, the coefficient of the interaction term between perceived inflation and the high financial literacy dummy is often negative and significant when using slightly different regression models. This result suggests that those with greater financial literacy rely less on perceived inflation when forming inflation expectations. This result makes sense if perceived inflation is useful to some extent to forecast inflation because of the persistence of inflation but less useful for those with higher financial literacy since they have more information on future inflation.

Table 5: Inflation Perceptions and Expectations with Quantitative Data

	(1) 1 year	(2) 5 year	(3) 1 year	(4) 5 year
Perceived inflation	0.445***	0.271***	0.446***	0.273***
	(0.008)	(0.008)	(0.008)	(0.008)
× Middle income	0.014	0.021**	0.014	0.021**
	(0.010)	(0.009)	(0.010)	(0.009)
× Low income	0.048***	0.046***	0.048***	0.046***
	(0.009)	(0.009)	(0.009)	(0.009)
× High financial literacy			-0.008	-0.014
			(0.010)	(0.010)
Middle income	0.134***	0.077*	0.135***	0.079*
	(0.040)	(0.041)	(0.040)	(0.041)
Low income	0.242***	0.167***	0.243***	0.169***
	(0.039)	(0.040)	(0.039)	(0.040)
High financial literacy	-0.032	-0.113***	-0.001	-0.060
	(0.035)	(0.036)	(0.044)	(0.044)
Adjusted R-squared	0.372	0.175	0.372	0.175
Number of observations	89,974	89,974	89,974	89,974

Note: This table shows the estimation results of the ordinary least squares regressions that examine the relationship between inflation expectations and perceptions. Columns (1) and (2) show the results for the regressions without the interaction term between perceived inflation and the high financial literacy dummy, while columns (3) and (4) show the results for the regressions with the interaction term. Columns (1) and (3) use inflation expectations over 1 year as the dependent variable, while columns (2) and (4) use inflation expectations over 5 years. Robust standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10% levels, respectively. While the regressions control for gender, age, and working status, the coefficient estimates are not reported to save space. The observation period is from September 2006 to September 2018 for all regressions.

3 Theory

The empirical analysis in the previous section finds that lower-income households' spending is less sensitive to their inflation expectations, they pay less attention to the central bank, and their inflation expectations are more closely associated with their inflation perceptions. This section develops a theoretical model to explain these empirical findings. Subsection 3.1 discusses households' decisions regarding consumption conditional on inflation expectations when households face idiosyncratic income risk and borrowing constraints. Subsection 3.2 considers a rational inattention framework in which households decide the degree of attention to information on future inflation. Subsection 3.3 extends the model by further assuming that households overextrapolate the past when forming inflation expectations. Finally, subsection 3.4 discusses other potential explanations for the empirical findings.

3.1 Consumption Decisions

This subsection considers households' consumption decisions conditional on inflation expectations when they face idiosyncratic income risk and borrowing constraints. We use a model similar to the one in McKay et al. (2017), a simplified version of the model presented by McKay et al. (2016). However, while they assume rational expectations, our model endogenizes households' information structure by applying the rational inattention framework, as will be discussed in the next subsection. The relatively simple model setup of households' consumption decisions is essential to our analysis since the endogenous information structure complicates the model.

In the model, the economy has an infinite number of periods, indexed by t, and is populated by a unit continuum of *ex-ante* identical households. The utility of household h is given by

$$\mathbb{E}_{h,t} \sum_{s=0}^{\infty} \beta^s U_{h,t+s}, \tag{5}$$

where $U_{h,t} = \ln c_{h,t} - l_{h,t}$, $c_{h,t}$ is consumption, $l_{h,t}$ represents labor supply, and $\beta \in (0,1)$ is the subjective discount factor. $\mathbb{E}_{h,t}$ represents the expectations operator conditional on the household's information set in period t after it decides the degree of attention to information on future inflation (which is specified in the next subsection).

Households' income depends on stochastic idiosyncratic income status $z_{h,t} \in \{0,1\}$, where $z_{h,t} = 0$ and $z_{h,t} = 1$ represent high-income and low-income states, respectively. The income

status follows a first-order Markov chain where the transition probability from the high-income state to the low-income state is denoted as ω_H and that from the low-income state to the low-income state is denoted as ω_L. We assume $0 < \omega_H < \omega_L < 1$, meaning that current low-income households are more likely to have been low-income than high-income households in the previous period. High-income households earn labor income, $w_{h,t}l_{h,t}$, and receive dividends but pay a tax of $\omega m/(1-\omega)$ to finance a transfer to low-income households. Here, $w_{h,t}$ is the real wage and is set by the household as in Mackowiak and Wiederholt (2015), and $\omega \equiv \omega_H/(1-\omega_L+\omega_H)$ represents the unconditional probability of the low-income state. On the other hand, low-income households receive m units of consumption goods, which are their only source of income, as a transfer. We assume that m is low enough that $c_{h,t} > m$ always holds for high-income households.

The budget constraint is given by

$$P_t c_{h,t} + b_{h,t+1} = P_t I_{h,t} + R_t b_{h,t}, \tag{6}$$

where P_t is the price of goods in period t, R_t is the gross nominal interest rate between periods $t-1$ and t, and $b_{h,t}$ is bond holdings by household h between periods $t-1$ and t. $I_{h,t}$ is real income after the transfer and is expressed as

$$I_{h,t} = \begin{cases} w_{h,t}l_{h,t} + \frac{D_t}{1-\omega} - \frac{\omega m}{1-\omega} & \text{if } z_{h,t} = 0 \\ m & \text{if } z_{h,t} = 1 \end{cases} \tag{7}$$

where D_t is the real dividend, which is equally distributed only among high-income households.

For analytical tractability, this model imposes strict borrowing constraints that prevent households from taking negative bond positions as

$$b_{h,t+1} \geq 0. \tag{8}$$

The bonds are assumed to be in zero net supply. Consequently, in equilibrium, there is no possibility of saving, so wealth remains zero for all households. Therefore, low-income households always consume m. On the other hand, even without assets, high-income households can change their consumption by changing their labor supply. Therefore, while low-income households are liquidity-constrained, high-income households are not. For the sake of notation simplicity, $c_{h,t}$ represents high-income households' consumption thereafter.

A representative firm demands labor forces based on the following linear production technology:

$$Y_t = AL_t, \tag{9}$$

where Y_t is output, A is the invariant labor productivity, and

$$L_t \equiv \left[\frac{1}{1-\omega} \int_0^{1-\omega} l_{h,t}^{\frac{\eta-1}{\eta}} dh \right]^{\frac{\eta}{\eta-1}} \tag{10}$$

is aggregate labor input where $\eta > 1$. The firm's cost minimization leads to a labor demand function that is given by

$$l_{h,t} = \left(\frac{w_{h,t}}{W_t} \right)^{-\eta} L_t, \tag{11}$$

where

$$W_t \equiv \left[\frac{1}{1-\omega} \int_0^{1-\omega} w_{h,t}^{-(\eta-1)} dh \right]^{-\frac{1}{\eta-1}} \tag{12}$$

represents the aggregate real wage. On the other hand, the real dividend is expressed as

$$D_t = Y_t - \int_0^{1-\omega} w_{h,t} l_{h,t} dh. \tag{13}$$

The goods market clearing condition is given by

$$Y_t = C_t, \tag{14}$$

where

$$C_t \equiv \int_0^{1-\omega} c_{h,t} dh + \omega m. \tag{15}$$

Under this setup, each household maximizes its utility (5) subject to the budget constraint (6), the borrowing constraint (8), and the labor demand function (11). As in McKay et al. (2017), high-income households change consumption in accordance with the following Euler equation,

$$c_{h,t}^{-1} = \beta \mathbb{E}_{h,t} \left[R_{t+1} \frac{P_t}{P_{t+1}} \{ (1-\omega_H) c_{h,t+1}^{-1} + \omega_H m^{-1} \} \right]. \tag{16}$$

In what follows, the model is analyzed in a linear-quadratic framework. The first-order approximation of the Euler equation around the steady state is derived as

$$\hat{c}_{h,t} = -\mathbb{E}_{h,t}[\hat{r}_{t+1}] + \zeta \mathbb{E}_{h,t}[\hat{c}_{h,t+1}] \tag{17}$$

where $\hat{r}_{t+1}$ represents the deviation of the real interest rate between periods t and $t+1$ from its steady state, $\hat{c}_{h,t}$ represents the log deviation of $c_{h,t}$ from the steady-state value of high-income households' consumption, which is denoted as $\bar{c}_H$, and $\zeta \equiv \frac{(1-\omega_H)\bar{c}_H^{-1}}{(1-\omega_H)\bar{c}_H^{-1} + \omega_H m^{-1}}$. Note that, since $0 < \omega_H < 1$, $0 < \zeta < 1$ holds.

We assume that the nominal interest rate is zero to explain our empirical findings based on data from Japan, where the policy rate has remained near zero since the late 1990s.

Appendix D shows that our analysis is applicable even to economies far from the effective lower bound of interest rates. Based on the assumption of zero nominal interest rate, equation (17) is rewritten as

$$\hat{c}_{h,t} = \mathbb{E}_{h,t}[\pi_{t+1}] + \zeta \mathbb{E}_{h,t}\left[\hat{c}_{h,t+1}\right] \tag{18}$$

where π_{t+1} is the inflation rate in period $t+1$. The steady-state inflation rate is assumed to be zero for simplicity. From equation (18), $\hat{c}_{h,t}$ can be expressed as

$$\hat{c}_{h,t} = \sum_{s=1}^{\infty} \zeta^{s-1} \mathbb{E}_{h,t}\left[\pi_{t+s}\right]. \tag{19}$$

Equations (18) and (19) indicate that high-income households' consumption reacts to changes in their inflation expectations. On the other hand, low-income households' consumption is fixed at m and does not react to changes in their inflation expectations. While the model is simple with only two income classes, it is consistent with our empirical finding that lower-income households' spending is less sensitive to their inflation expectations.

3.2 Rational Inattention

This subsection examines how households' attention to information about future inflation depends on their ability to change consumption. To this end, we use a rational inattention framework that builds on Dräger and Lamla (2017). Specifically, in the framework, households choose the precision of their posterior beliefs about future inflation, taking the costs and benefits of information acquisition into account. The information on future inflation in this model can be interpreted as including information about the central bank since households may improve their inflation forecasts by using information about the central bank's policy stance, outlook, and so forth.

Information structure. Households' perceived law of motion for inflation is as follows:

$$\pi_{t+1} = \rho \pi_t + \epsilon_{t+1}, \tag{20}$$

where ρ is the autocorrelation coefficient and ϵ_{t+1} is the innovation in inflation, which follows

$$\epsilon_{t+1} \sim i.i.d.\, \mathcal{N}\left(0, \sigma^2\right). \tag{21}$$

This type of specification is also used by Wiederholt and Vellekoop (2017) and Cavallo et al. (2017).

We assume that in period t, households observe $\{\pi_{t-s}\}_{s=0}^{\infty}$ and $\{\epsilon_{t-s}\}_{s=0}^{\infty}$. The precision of posterior beliefs about ϵ_{t+1} is a choice variable for them. Let σ^{-2} and $\sigma_{h,t}^{-2}$ denote the precision of the prior and posterior beliefs of ϵ_{t+1}, respectively. When households decide to acquire information on future inflation, $\sigma_{h,t}^{-2} > \sigma^{-2}$ holds, and they observe the following signal:

$$s_{h,t} = \epsilon_{t+1} + \nu_{h,t} \tag{22}$$

where

$$\nu_{h,t} \sim i.i.d.\, \mathcal{N}(0, \left[\sigma_{h,t}^{-2} - \sigma^{-2}\right]^{-1}). \tag{23}$$

Here, $\left[\sigma_{h,t}^{-2} - \sigma^{-2}\right]^{-1}$ means the variance of the noise in the signal, while $\sigma_{h,t}^{-2} - \sigma^{-2}$ represents the precision of the signal. In the following, we assume that $\sigma_{h,t}^{-2} > \sigma^{-2}$ always holds for high-income households.

Inflation expectations and optimal consumption. From (20) to (23), the inflation expectation is expressed by

$$\begin{aligned} \mathbb{E}_{h,t}[\pi_{t+1}] &= \rho\pi_t + \frac{\sigma_{h,t}^{-2} - \sigma^{-2}}{\sigma_{h,t}^{-2}} s_{h,t} \\ &= \rho\pi_t + \frac{\sigma_{h,t}^{-2} - \sigma^{-2}}{\sigma_{h,t}^{-2}} \epsilon_{t+1} + \frac{\sigma_{h,t}^{-2} - \sigma^{-2}}{\sigma_{h,t}^{-2}} \nu_{h,t}, \end{aligned} \tag{24}$$

where $\frac{\sigma_{h,t}^{-2} - \sigma^{-2}}{\sigma_{h,t}^{-2}}$ represents the standard Kalman gain. The Kalman gain is higher as the precision of the signal, $\sigma_{h,t}^{-2} - \sigma^{-2}$, is higher, implying that inflation expectations depend more on the signal when the signal is more precise.

Since information on future innovation of inflation can be obtained only one period in advance, from equation (20), we obtain

$$\mathbb{E}_{h,t}[\pi_{t+s}] = \rho^{s-1} \mathbb{E}_{h,t}[\pi_{t+1}], \tag{25}$$

for $s = 1, 2, ...$ From equations (19) and (25),

$$\hat{c}_{h,t} = \frac{1}{1 - \zeta\rho} \mathbb{E}_{h,t} \left[\pi_{t+1}\right]. \tag{26}$$

By substituting (24) to this equation, the optimal consumption for high-income households is represented by

$$\hat{c}_{h,t} = \frac{1}{1 - \zeta\rho} \left(\rho\pi_t + \frac{\sigma_{h,t}^{-2} - \sigma^{-2}}{\sigma_{h,t}^{-2}} \epsilon_{t+1} + \frac{\sigma_{h,t}^{-2} - \sigma^{-2}}{\sigma_{h,t}^{-2}} \nu_{h,t} \right). \tag{27}$$

Loss function. We next derive the loss for households from imperfect information using a similar method as in Mackowiak and Wiederholt (2015). Since households are going to have perfect information on the innovation in the inflation rate, ϵ_{t+1}, in the next period, and there is no possibility of saving in equilibrium, the imprecision of current posterior beliefs does not affect future utilities. Therefore, the loss can be defined as the expected current utility under perfect information on ϵ_{t+1} minus that under imperfect information.

We first consider the loss function for high-income households. Specifically, we focus on the second-order approximated utility around the steady state and take the expected difference in the utility under perfect and imperfect information. As shown in Appendix C, this is represented by

$$\mathbb{E}_{h,t'}\left[U_{h,t}^{**} - U_{h,t}\right] \approx \theta \sigma_{h,t}^2, \tag{28}$$

where $U_{h,t}^{**}$ and $U_{h,t}$ are the utilities under perfect and imperfect information, respectively, and $\mathbb{E}_{h,t'}$ represents the expectations operator conditional on the household's information set before it decides the degree of attention in period t. Furthermore,

$$\theta \equiv \frac{\eta \overline{L}(1+\eta \overline{L})}{2(1-\zeta\rho)^2}, \tag{29}$$

where $\overline{L}$ is the steady state level of aggregate labor input. Since $\theta > 0$, (28) means that the expected loss is proportional to the imprecision of posterior beliefs about the inflation innovation, $\sigma_{h,t}^2$.

By contrast, low-income households' expected loss is always zero. This is because their consumption is fixed at m, irrespective of their inflation expectations, and thus, the expected utility is independent of information on future inflation.

Optimal degree of attention. We assume that households choose the degree of attention paid to information on future inflation, ϵ_{t+1}, to minimize the sum of the expected loss (28) and a cost of attention in terms of utility. Formally, this problem is given by

$$\min_{\sigma_{h,t}^{-2}} \left[\theta \sigma_{h,t}^2 + \mu \frac{1}{2} \log_2 \frac{\sigma_{h,t}^{-2}}{\sigma^{-2}}\right], \tag{30}$$

where μ represents the marginal cost of an additional unit of attention devoted to future inflation. The second term corresponds to the cost of attention, which is proportional to the change in entropy due to the signal, as in Dräger and Lamla (2017). Intuitively, the cost is higher as the precision of signal, $\sigma_{h,t}^{-2} - \sigma^{-2}$, is greater.

Taking the first-order condition of (30) with respect to $\sigma_{h,t}^{-2}$ yields the following solution of optimal precision of information:

$$\sigma_{h,t}^{*-2} = 2\ln(2)\frac{\theta}{\mu}. \tag{31}$$

This equation indicates that the optimal precision of posterior beliefs is higher as the sensitivity of the expected loss to the imprecision of posterior beliefs (θ) is higher, or the marginal cost for an additional unit of attention (μ) is lower. We assume that the ratio of θ to μ is large enough so that $\sigma_{h,t}^{*-2} > \sigma^{-2}$ holds for high-income households. By contrast, low-income households are not at all concerned about future inflation because they do not incur any expected loss from imperfect information, while more attention requires more cost. Hence, $\sigma_{h,t}^{*-2} = \sigma^{-2}$ holds for them.

These results suggest that lower-income households pay less attention to information on future inflation, including information from the central bank because the information is less useful for their consumption decisions. On the other hand, higher-income households have a stronger interest in the same information because they can exploit it to make consumption decisions more efficiently. [14]

Discussion. This model provides insight into the optimal communication strategy for the central bank. In the model, an improvement in central bank communication about future inflation is represented by a decline in the marginal cost of attention, μ. Since (31) holds for high-income households, a lower μ is associated with more precise information or closer attention to the central bank. On the other hand, since $\sigma_{h,t}^{*-2} = \sigma^{-2}$ for low-income households, they do not pay attention to central bank communication even if it improves.

Although the marginal cost, μ, is the same for high-income and low-income households in this model, we can easily extend the model so that this can differ between different income levels. This extended model suggests that the central bank should aim to lower the marginal cost for high-income households but not for low-income ones. More generally, improved communication about future inflation with households whose spending is more responsive to inflation expectations is more likely to pay off. In practice, however, the central bank

[14] Recall that our theory assumes, for simplicity, that low-income households receive a real transfer. It appears more realistic to assume that low-income households receive a nominal transfer that is not adjusted promptly in response to price changes. In this case, low-income households are likely to pay attention to current prices because higher prices lead to lower real income, which may trigger bargain hunting. Even if so, low-income households still do not necessarily pay attention to future inflation since such information is useless when they cannot intentionally change their intertemporal consumption allocation.

may not be able to clearly detect households with high sensitivity of spending to inflation expectations. In this case, just facilitating access to central bank information by those interested could be a solution. This is because households' ability to change spending may be revealed by their actions to obtain central bank information. In other words, central bank communication should focus more on those who pay more attention to the central bank since their spending is more likely to be responsive to information from the central bank.

While this model assumes, for simplicity, that there are only two types of households and that low-income households cannot change consumption at all, the reality is clearly more complicated. For instance, if low-income households can change their consumption to some extent and if improving communication with them is easier than with high-income households, the central bank may have to prioritize improving communication with low-income households. Our results do not rule out this possibility and suggest that the ease of improving communication is not the only determinant of optimal strategy and that the central bank needs to consider its communication strategy, taking households' ability to alter their consumption and their incentives to pay attention to central bank information into account.

3.3 Overextrapolation

This subsection extends the model by adding overextrapolation of inflation expectations. The literature finds that households' inflation expectations and perceptions are strongly positively correlated (e.g., Jonung (1981) and Dräger and Nghiem (2021)), which may be because of overextrapolation. Although empirical evidence for overextrapolation is somewhat mixed, the analysis here examines whether our empirical finding that lower-income households' inflation expectations are more closely associated with inflation perceptions can be explained once overextrapolation is accepted. [15]

Recall the assumption that the innovation in inflation, ϵ_{t+1}, is perceived to follow an unbiased normal distribution (21). Here, we further assume that the actual innovation

[15] For instance, Angeletos et al. (2021) find initial underreaction of inflation expectations in response to shocks followed by delayed overreaction, using professional forecast data. On the other hand, Kuchler et al. (2023) survey the literature on housing market expectations, suggesting that individuals naively extrapolate from recent local housing price changes when forming expectations about future price changes. Greenwood and Shleifer (2014) find that survey measures of investor expectations of stock market returns are positively correlated with past stock market returns.

follows

$$\epsilon_{t+1} \sim i.i.d.\, \mathcal{N}\left(-\delta\pi_t, \sigma^2\right), \tag{32}$$

where δ represents the degree of overextralolation. We assume $0 < \delta < \rho$, indicating that the actual autocorrelation coefficient of inflation is $\rho - \delta$, which is higher than zero but lower than the perceived autocorrelation coefficient of ρ. Therefore, households tend to overextrapolate past inflation when forming inflation expectations.

Now, we consider the case in which households optimize the precision of information on future inflation. When the expected inflation rate is regressed on the perceived inflation rate and a constant, the slope coefficient is

$$\frac{\mathbb{E}[\mathbb{E}_{h,t}[\pi_{t+1}]\pi_t]}{\mathrm{Var}(\pi_t)} = \rho - \frac{\sigma_{h,t}^{*-2} - \sigma^{-2}}{\sigma_{h,t}^{*-2}}\delta, \tag{33}$$

which is obtained from (24) and (32). For low-income households, since $\sigma_{h,t}^{*-2} = \sigma^{-2}$, the slope coefficient is ρ. On the other hand, for high-income households, since $\sigma_{h,t}^{*-2} > \sigma^{-2}$, the slope coefficient is smaller than ρ. Generalizing this result, lower-income households' inflation expectations are more dependent on inflation perceptions. This is because higher-income households' information about future inflation mitigates the bias in expectations arising from overextrapolation.

3.4 Other potential explanations

This subsection briefly discusses two other potential explanations of our empirical findings. We first consider the difference in consumption baskets. It is well known that the share of food and energy tends to be higher for lower-income households. The difference in the share of food and energy may explain the first finding. This is because a large portion of food and energy are necessities, and thus, households that consume more food and energy may have more difficulty changing their consumption. However, the difference in the share of food and energy may not explain the third finding. This is because food and energy prices are less persistent than many other prices, and thus, prices of lower-income households' consumption baskets must be less persistent. In fact, annual consumer price index data for five income-level groups from 1991 to 2022 show a clear tendency that the autocorrelation of the inflation rate is lower for lower-income households. [16] Thus, if lower-income households are rational,

[16]The Statistics Bureau of the Ministry of Internal Affairs and Communications has published annual consumer price indexes by income quintile for working households since 1990. The autocorrelations are 0.25,

their inflation expectations should depend less on past inflation. This prediction is in stark contrast with our empirical finding, suggesting the need for a different explanation. [17]

The second potential explanation is the difference in cognitive abilities. While our empirical analysis based on the Opinion Survey controls for financial literacy and checks the robustness to using an alternative definition of literacy, this may not fully control for unobservable differences in cognitive abilities. For instance, D'Acunto et al. (2023) find that inflation expectations of higher-IQ individuals are more sensitive to news, and their spending decisions are more in line with the Euler equation. Thus, IQ differences may explain our empirical findings if lower-IQ individuals tend to belong to lower-income households and pay less attention to news about the central bank. Even if so, we can still conclude that those who can change their spending more easily are more likely to pay attention to central bank communication about future inflation.

4 Concluding Remarks

Central bank communication is regarded as a potential tool to guide households' inflation expectations and, in turn, influence their spending. This study finds evidence that lower-income households' spending is less sensitive to inflation expectations, they pay less attention to the BoJ, and their inflation expectations are more closely associated with inflation perceptions. To explain these findings, we develop a rational inattention model. The model suggests, for example, that lower-income households pay less attention to information about future inflation, including information from the central bank, since they are less able to adjust spending and thus benefit less from such information. After discussing other potential mechanisms that might explain our empirical findings, we conclude that those who can change their spending more easily are more likely to pay attention to central bank communication about future inflation.

Our results provide at least six policy implications. First, even if attention to central bank communication about future inflation is weak on average, this does not necessarily

0.29, 0.32, 0.37, and 0.40 for the lowest to highest-income households, respectively. The results are robust to using a different observation period (i.e., 2006 to 2018, as our observation period for the Opinion Survey) and a different definition of the consumer price index (i.e., excluding imputed rent).

[17] D'Acunto et al. (2021) find that consumers rely on the price changes of goods in their grocery consumption bundles when forming expectations about aggregate inflation and that the weights they assign to price changes depend on the frequency of purchases rather than the expenditure share. This result suggests that households are actually behavioral, but it also implies that the difference in the expenditure share of food and energy cannot explain the difference in inflation expectations.

imply its weak effectiveness. The effectiveness should be evaluated by considering how well the communication reaches out to those who can change their spending relatively strongly in response to information from the communication. Second, the central bank should not aim to enhance communication equally with the general public. Instead, it may focus more on those who pay more attention to central bank information since they are more likely to be able to change their spending based on information obtained through communication. Third, it may not be very rewarding for the central bank to spend much effort communicating with those who complain about inflation. Those people may be seriously damaged by inflation because of their inability to adjust intertemporal consumption allocation. Fourth, facilitating access to central bank information by those interested may be more productive than proactive access from the central bank. While households' ability to change spending may not be easily detected by the central bank, it may be revealed by their behavior in seeking information about the central bank. Fifth, enhancing consumers' ability to change their intertemporal consumption allocation by, for example, reducing the probability that they face liquidity constraints may improve the efficiency of communication. Sixth, as information from the central bank helps mitigate the bias in inflation expectations arising from overextrapolation to a larger extent, central bank communication is more effective in reducing the risk of persistent deviation of inflation from the target.

Note that we are not opposed to efforts to educate those who pay little attention to central bank information. If it is relatively easy to improve communication with those people, such efforts are likely to be rewarded. Our results suggest that easiness to improve communication is not the sole determinant of optimal communication strategy, and that the central bank needs to take households' ability to alter their spending into account. Note also that the policy implications above are only in terms of influencing aggregate spending through guiding inflation expectations. Communication with a broad audience may be crucial, for instance, to maintain political support for central bank independence.

This study also highlights opportunities for future research in this field. One avenue is to study firms' behavior, while the focus of this paper is on households. For instance, the more sticky the price of its product, the more incentive a firm may have to pay attention to information about future inflation when setting it. This is because the firm cannot change the price over a longer period of time and thus has to take greater account of future inflation. If this is the case, the central bank should focus more on firms that pay more attention to

its communication since the prices of their products are more likely to be set based on information obtained through communication.

Another avenue is to add the rational inattention framework used in this paper to the Heterogeneous Agent New Keynesian (HANK) model. The HANK model suggests that even if the direct effect of monetary policy is weak since only a limited share of households can alter consumption strongly in response to changes in real interest rates, the general equilibrium effect is large, particularly through an increase in labor demand (see, for example, Kaplan et al. (2018)). As such, even if the direct effect of communication on spending is small, the general equilibrium effect could be large.

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A Income per Household Member and Financial Literacy

This appendix first describes how we calculate income per household member using data from the Opinion Survey. It then discusses whether the results in the main text are robust to focusing on households with relatively high data quality and using an alternative measure of financial literacy.

We calculate income per household member by dividing household income in the previous year by the current number of household members. Then, households are classified into the following three groups based on income per household member: (i) less than 1.5 million yen, (ii) from 1.5 to 3.0 million yen, and (iii) more than 3.0 million yen.

Household income is obtained from answers to the question"How much income did you and your spouse earn last year? (Annual income before deducting taxes; excludes temporary income such as retirement allowance and income from land sales, but includes pensions.)" The possible responses to this question are (a) Less than 3 million yen, (b) 3 million or more but less than 5 million yen, (c) 5 million or more but less than 10 million yen, (d) 10 million yen or greater, and (e) No income. We convert the responses into numerical data by generally using the mid-point of each range. For the largest income category,"10 million yen or greater," we use a value of 12.5 million yen, although this choice of value does not influence the three income categories since the number of household members who depend on the income of the respondent and its spouse is assumed to be three or less as will be discussed as follows.

In the Opinion Survey, respondents are not asked the exact number of household members. Instead, they are requested to choose from the following five categories: (a) Single-person household, (b) Married-couple household, (c) Two-generation household, (d) Three-generation household, and (e) Other. The number of household members is one in the case of (a) and two in the case of (b). In the other three cases, the number of household members is not apparent and is assumed to be three. According to the Population Census in 2015, the average number of two-generation household members is 3.3. Since household members other than the respondent and his/her spouse, such as grown children, may also earn income, which is not detected in the Opinion Survey, we judge that using a number slightly smaller than 3.3 is appropriate. Similarly, since old household members are likely to earn income from pensions or other sources, we assume that the number of household members

in a three-generation household who depend on the income of the respondent and his/her spouse is the same as in a two-generation household. For the other households, the same number of household members as for two- and three-generation households is assumed due to a lack of information.

Now, this appendix discusses the results of two types of robustness checks. The first type of robustness check uses data from only single-person households and married-couple households since the number of household members is precise for these households.

Table A1 shows that the results for attention to the BoJ are robust. All four columns show that most coefficients, including those on two income dummies, are essentially unchanged from those reported in Table 4 in the main text. If there is any change, the absolute values of the coefficients on the two income dummies are slightly higher than in Table 4.

Table A2 shows that the results for the heterogeneous relationship between inflation expectations and perceptions are also robust. Note that, in Table 5, the coefficient for the interaction term of middle-income households is insignificant for 1-year inflation expectations and significant only at the 5% level. On the other hand, in all columns of Table A2, the coefficient is highly significant. This result suggests that, in the analysis in the main text, measurement errors in income per household member, to some extent, prevent us from detecting the heterogeneous relationship between inflation expectations and perceptions.

Next, we show the results of robustness checks when using an alternative definition of financial literacy. In the main text, respondents with high financial literacy are defined as those who choose"Economic indicators and statistics"in the question about the reasons behind their assessment of economic conditions. We here define respondents with high financial literacy as those who choose"Economic indicators and statistics"or"Media reports".

Table A3 shows that the results for attention to the BoJ are again robust. All four columns show that most coefficients essentially do not change. However, the coefficient estimate of the high financial literacy dummy is clearly smaller than the corresponding estimate in Table 4. This result suggests that respondents who answer the question of economic conditions based on media reports pay less attention to the BoJ than those who follow economic indicators and statistics.

Table A4 shows that the results for the relationship between inflation expectations and perceptions are robust to using the alternative measure of financial literacy. All columns show that the coefficients on perceived inflation and its interactions with two income dummies

Table A1: Robustness Checks for Attention to the Bank of Japan

	(1) Knowledge of 2% target		(2) Knowledge of BoJ's objectives		(3) Interest in BOJ's activities		(4) BOJ's relationship to our lives	
		Marginal effect		Marginal effect		Marginal effect		Marginal effect
Middle income	-0.305***	-0.10	-0.306***	-0.11	-0.172***	-0.02	-0.184***	-0.07
	(0.024)		(0.020)		(0.018)		(0.019)	
Low income	-0.426***	-0.14	-0.480***	-0.17	-0.287***	-0.04	-0.314***	-0.12
	(0.028)		(0.023)		(0.021)		(0.021)	
High financial literacy	0.533***	0.19	0.385***	0.14	0.527***	0.08	0.267***	0.10
	(0.031)		(0.024)		(0.021)		(0.022)	
Female	-0.579***	-0.19	-0.330***	-0,11	-0.209***	-0.03	-0.027*	-0.01
	(0.019)		(0.016)		(0.015)		(0.015)	
Age 30-39	0.201***	0.04	0.058	0.02	0.141***	0.01	-0.050	-0.02
	(0.048)		(0.039)		(0.033)		(0.034)	
Age 40-49	0.441***	0.11	0.256***	0.08	0.225***	0.02	-0.110***	-0.04
	(0.047)		(0.040)		(0.035)		(0.035)	
Age 50-59	0.676***	0.18	0.424***	0.13	0.394***	0.03	-0.109***	-0.04
	(0.045)		(0.036)		(0.031)		(0.032)	
Age 60-69	0.972***	0.28	0.609***	0.20	0.610***	0.06	0.007	0.00
	(0.042)		(0.035)		(0.030)		(0.031)	
Age 70 or older	1.073***	0.32	0.560***	0.18	0.742***	0.08	-0.039	-0.02
	(0.044)		(0.037)		(0.033)		(0.033)	
Agriculture, forestry, or fisheries	-0.012	-0.00	-0.007	-0.00	0.133***	0.02	0.088	0.03
	(0.075)		(0.055)		(0.056)		(0.057)	
Self-employed, working for a family business, or professional worker	0.078**	0.03	0.012	0.00	0.134***	0.02	0.086***	0.03
	(0.037)		(0.030)		(0.027)		(0.029)	
Non-regular employee	-0.113***	-0.04	-0.146***	-0.05	-0.042*	-0.01	-0.059**	-0.02
	(0.034)		(0.028)		(0.025)		(0.027)	
Other (e.g., full-time homemaker, student, pensioner, unemployed)	0.123***	0.04	0.059***	0.02	0.064***	0.01	0.091***	0.03
	(0.030)		(0.025)		(0.022)		(0.023)	
Pseudo R-squared	0.0875		0.0909		0.0504		0.0089	
Number of observations	16,332		23,080		23,066		23,070	

Note: This table shows the estimation results of the ordered probit models that examine determinants of attention to the Bank of Japan (BoJ) using data for single-person households and married-couple households only. Columns (1)-(4) show the results when using answers to questions about knowledge of the BoJ's 2% inflation target, knowledge of the BoJ's objectives, interest in the BoJ's activities, and the BoJ's relationship to our lives, respectively, as a proxy for attention. Robust standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10% levels, respectively. The marginal effect represents the change in the probability (in %) that a household responds, for example, that it knows about the inflation target for a one-unit increase in the independent variable while holding the other independent variables at their mean values. The reference groups for the dummy variables are high-income, low-financial literacy, male, under 29, and regular employee. The observation period is from September 2013 to September 2018 for column (1) and from September 2006 to September 2018 for the others.

Table A2: Robustness Checks for Inflation Expectations and Perceptions

	(1) 1 year	(2) 5 year	(3) 1 year	(4) 5 year
Perceived inflation	0.455***	0.276***	0.454***	0.279***
	(0.009)	(0.009)	(0.010)	(0.009)
× Middle income	0.032***	0.042***	0.033***	0.042***
	(0.013)	(0.012)	(0.013)	(0.012)
× Low income	0.068***	0.067***	0.064***	0.066***
	(0.014)	(0.013)	(0.014)	(0.013)
× High financial literacy			0.004	-0.020
			(0.016)	(0.015)
Middle income	0.187***	0.152***	0.187***	0.154***
	(0.059)	(0.059)	(0.059)	(0.059)
Low income	0.166**	0.166**	0.165**	0.168**
	(0.069)	(0.069)	(0.069)	(0.069)
High financial literacy	-0.033	-0.141***	-0.048	-0.070
	(0.054)	(0.054)	(0.068)	(0.067)
Adjusted R-squared	0.376	0.181	0.376	0.181
Number of observations	32,857	32,857	32,857	32,857

Note: This table shows the estimation results of the ordinary least squares regressions that examine the relationship between inflation expectations and perceptions using data for single-person and married-couple households only. Columns (1) and (2) show the results for the regressions without the interaction term between perceived inflation and the high financial literacy dummy, while columns (3) and (4) show the results for the regressions with the interaction term. Columns (1) and (3) use inflation expectations over 1 year as the dependent variable, while columns (2) and (4) use inflation expectations over 5 years. Robust standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10% levels, respectively. While the regressions control for gender, age, and working status, the coefficient estimates are not reported to save space. The observation period is from September 2006 to September 2018 for all regressions.

Table A3: Robustness Checks for Attention to the Bank of Japan

	(1) Knowledge of 2% target		(2) Knowledge of BoJ's objectives		(3) Interest in BOJ's activities		(4) BOJ's relationship to our lives	
		Marginal effect		Marginal effect		Marginal effect		Marginal effect
Middle income	-0.275***	-8.96	-0.240***	-8.52	-0.163***	-1.90	-0.149***	-5.75
	(0.018)		(0.015)		(0.013)		(0.013)	
Low income	-0.445***	-13.97	-0.461***	-15.73	-0.281***	-3.03	-0.285***	-10.73
	(0.017)		(0.014)		(0.013)		(0.013)	
High financial literacy	0.193***	5.97	0.136***	4.49	0.210***	2.17	0.125***	4.64
	(0.013)		(0.010)		(0.009)		(0.009)	
Female	-0.606***	-18.76	-0.349***	-11.60	-0.232***	-2.29	-0.044***	-1.61
	(0.012)		(0.010)		(0.009)		(0.010)	
Age 30-39	0.156***	3.32	0.099***	2.70	0.124***	0.71	-0.064***	-2.36
	(0.026)		(0.020)		(0.017)		(0.018)	
Age 40-49	0.384***	9.10	0.331***	9.74	0.261***	1.70	-0.070***	-2.57
	(0.024)		(0.020)		(0.017)		(0.017)	
Age 50-59	0.598***	15.43	0.495***	15.27	0.377***	2.71	-0.051***	-1.90
	(0.025)		(0.019)		(0.017)		(0.017)	
Age 60-69	0.878***	24.81	0.615***	19.49	0.585***	5.04	0.005	0.17
	(0.024)		(0.019)		(0.017)		(0.017)	
Age 70 or older	0.960***	27.70	0.555***	17.38	0.686***	6.45	-0.057***	-2.10
	(0.025)		(0.020)		(0.019)		(0.019)	
Agriculture, forestry, or fisheries	-0.046	-1.36	-0.164***	-5.32	0.014	0.14	-0.010	-0.37
	(0.040)		(0.029)		(0.029)		(0.029)	
Self-employed, working for a family business, or professional worker	0.078***	2.40	-0.032*	-1.06	0.096***	1.03	0.064***	2.38
	(0.022)		(0.017)		(0.016)		(0.017)	
Non-regular employee	-0.131***	-3.81	-0.191***	-6.15	-0.107***	-0.99	-0.069***	-2.51
	(0.018)		(0.015)		(0.014)		(0.014)	
Other (e.g., full-time homemaker, student, pensioner, unemployed)	0.061***	1.88	-0.037***	-1.24	-0.010	-0.10	0.037***	1.37
	(0.017)		(0.014)		(0.013)		(0.013)	
Pseudo R-squared	0.0904		0.0881		0.0475		0.0063	
Number of observations	42,568		62,700		62,648		62,658	

Note: This table shows the estimation results of the ordered probit models that examine determinants of attention to the Bank of Japan (BoJ) when respondents with high financial literacy are defined as those who, to the question about the reasons behind their assessment of economic conditions, answered "Economic indicators and statistics" or "Media report." Columns (1)-(4) show the results when using answers to questions about knowledge of the BoJ's 2% inflation target, knowledge of the BoJ's objectives, interest in the BoJ's activities, and the BoJ's relationship to our lives, respectively, as a proxy for attention. Robust standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10% levels, respectively. The marginal effect represents the change in the probability (in %) that a household responds, for example, that it knows about the inflation target for a one-unit increase in the independent variable while holding the other independent variables at their mean values. The reference groups for the dummy variables are high-income, low-financial literacy, male, under 29, and regular employee. The observation period is from September 2013 to September 2018 for column (1) and from September 2006 to September 2018 for the others.

Table A4: Robustness Checks for Inflation Expectations and Perceptions

	(1) 1 year	(2) 5 year	(3) 1 year	(4) 5 year
Perceived inflation	0.444***	0.270***	0.453***	0.278***
	(0.008)	(0.008)	(0.008)	(0.008)
× Middle income	0.014	0.021**	0.014	0.021**
	(0.010)	(0.009)	(0.010)	(0.009)
× Low income	0.048***	0.046***	0.048***	0.046***
	(0.009)	(0.009)	(0.009)	(0.009)
× High financial literacy			-0.023***	-0.022***
			(0.007)	(0.006)
Middle income	0.130***	0.075*	0.131***	0.076*
	(0.040)	(0.041)	(0.040)	(0.041)
Low income	0.235***	0.163***	0.237***	0.164***
	(0.039)	(0.040)	(0.039)	(0.040)
High financial literacy	-0.115***	-0.154***	-0.025	-0.067**
	(0.025)	(0.025)	(0.031)	(0.031)
Adjusted R-squared	0.372	0.176	0.372	0.176
Number of observations	89,974	89,974	89,974	89,974

Note: This table shows the estimation results of the ordinary least squares regressions that examine the relationship between inflation expectations and perceptions when respondents with high financial literacy are defined as those who, to the question about the reasons behind their assessment of economic conditions, answered "Economic indicators and statistics" or "Media report." Columns (1) and (2) show the results for the regressions without the interaction term between perceived inflation and the high financial literacy dummy, while columns (3) and (4) show the results for the regressions with the interaction term. Columns (1) and (3) use inflation expectations over 1 year as the dependent variable, while columns (2) and (4) use inflation expectations over 5 years. Robust standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10% levels, respectively. While the regressions control for gender, age, and working status, the coefficient estimates are not reported to save space. The observation period is from September 2006 to September 2018 for all regressions.

essentially do not change from Table 5. Note that, looking at columns (3) and (4), the coefficient of the interaction term between perceived inflation and the high financial literacy dummy is significantly negative at the 1% level. This result suggests that those with higher financial literacy rely less on perceived inflation when forming inflation expectations.

B Analysis with Answers to Qualitative Questions of Inflation

The main text uses answers to the quantitative questions of inflation in the Opinion Survey to examine the relationship between inflation expectations and perceptions. This appendix

checks the robustness of the results to using answers to the qualitative questions.

We here estimate ordered probit models. We assume that an unobserved continuous indicator of inflation expectations of household i in period t, $\pi^{e*}_{i,t}$, is related to the observed discrete survey response, $\pi^{e}_{i,t}$, in the following way:

$$\pi^{e}_{i,t} = \begin{cases} \text{Price level will go up significantly} & \text{if } \alpha_4 < \pi^{e*}_{i,t} \\ \text{Price level will go up slightly} & \text{if } \alpha_3 < \pi^{e*}_{i,t} \leq \alpha_4 \\ \text{Price level will remain almost unchanged} & \text{if } \alpha_2 < \pi^{e*}_{i,t} \leq \alpha_3 \\ \text{Price level will go down slightly} & \text{if } \alpha_1 < \pi^{e*}_{i,t} \leq \alpha_2 \\ \text{Price level will go down significantly} & \text{if } \pi^{e*}_{i,t} \leq \alpha_1 \end{cases} \tag{34}$$

with cut-off parameters α_1, α_2, α_3, and α_4. Similar to the OLS regressions for the quantitative answers, the unobserved indicator of inflation expectations is determined as

$$\pi^{e*}_{i,t} = \beta_1 \pi^{p}_{i,t} + \beta_2 \pi^{p}_{i,t} d_{i,t} + \beta_3 d_{i,t} + \gamma x_{i,t} + \tau_t + \epsilon_{i,t}. \tag{35}$$

Here, $\pi^{p}_{i,t}$ is an indicator of perceived changes in the price level compared to 1 year ago. This takes -2, -1, 0, 1, or 2, each of which corresponds to each choice of answers to the question about inflation perceptions. For instance, 2 corresponds to"Have gone up significantly."[18] The other independent variables (i.e., income dummies and controls) are the same as in the OLS regressions for the quantitative answers.

The estimation results are presented in Table A5. We report the results for inflation expectations over 1 and 5 years in columns (1) and (2), respectively. While Table 5 shows the results with and without the interaction term between perceived inflation and the high financial literacy dummy, this table shows only the results for the models with it since the results do not essentially change even without it.

Consistent with the results for the quantitative answers in the main text, the coefficients of perceived inflation and its interaction term with the low-income dummy are positive and significant in both regressions. The table also shows the marginal effects of a one-unit change in the indicator of perceived inflation on the probability that the household chooses the answer"Will go up significantly" in the question about expected inflation when holding the other independent variables at their sample means. For example, in column

[18]Remember that the question regarding inflation perceptions is as follows:"How do you think prices have changed compared with 1 year ago? (Note: Prices are defined as overall prices of goods and services you purchase.)"The possible responses are: (a) Have gone up significantly; (b) Have gone up slightly; (c) Have remained almost unchanged; (d) Have gone down slightly; and (e) Have gone down significantly. The indicator used here takes -2, -1, 0, 1, or 2, each of which corresponds to (a) to (e), respectively.

Table A5: Inflation Perceptions and Expectations with Qualitative Data

	(1) 1 year	Marginal effect	(2) 5 year	Marginal effect
Perceived inflation	0.588***	9.43	0.342***	10.94
	(0.011)		(0.012)	
× Middle income	-0.003	0.34	0.020	0.62
	(0.013)		(0.014)	
× Low income	0.033***	1.54	0.049***	1.62
	(0.012)		(0.013)	
× High financial literacy	-0.005	0.17	-0.048***	-1.24
	(0.013)		(0.014)	
Middle income	0.041***	0.57	-0.008	0.27
	(0.013)		(0.013)	
Low income	0.073***	1.68	-0.000	1.19
	(0.013)		(0.012)	
High financial literacy	0.030**	0.38	0.055***	0.46
	(0.014)		(0.014)	
Pseudo R-squared	0.1305		0.0464	
Number of observations	104,342		103,144	

Note: This table shows the estimation results of the ordered probit model that examines the relationship between inflation expectations and perceptions. Columns (1) and (2) use inflation expectations over 1 year and 5 years, respectively, as the dependent variable. Robust standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10% levels, respectively. The marginal effect represents the change in probability (in %) that a household chooses "Price levels will go up significantly" for a one-unit increase in the independent variable, while holding the other independent variables at the mean values. While the regressions control for gender, age, and working status, the coefficient estimates are not reported to save space. The observation period is from September 2006 to September 2018 for all regressions.

(1), the marginal effect is 9.43 percentage points for high-income households, while that for low-income households is 10.98 (=9.43+1.54) percentage points.

Meanwhile, the coefficient on the interaction term between the high financial literacy dummy and perceived inflation is insignificant in column (1) but negative and significant in column (2). This result suggests that those with higher financial literacy rely less on perceived inflation when forming long-term inflation expectations.

C Expected Loss for High-income Households

This appendix derives the loss function for high-income households. Plugging the budget constraint (6) and the labor demand function (11) into period utility yields

$$U_{h,t} = \ln\left(w_{h,t}\left(\frac{w_{h,t}}{W_t}\right)^{-\eta} L_t + \frac{D_t}{1-\omega} - \frac{\omega m}{1-\omega} + \frac{R_t}{P_t} b_{h,t} - \frac{1}{P_t} b_{h,t+1}\right) - \left(\frac{w_{h,t}}{W_t}\right)^{-\eta} L_t. \quad (36)$$

The second-order approximation of this utility around the steady state is given by

$$\begin{aligned} U_{h,t} - \overline{U} \;\approx\; & \frac{1}{2}\overline{U}_{ww}\overline{W}^2\left(\frac{w_{h,t}-\overline{W}}{\overline{W}}\right)^2 + \overline{U}_{wW}\overline{W}^2\left(\frac{w_{h,t}-\overline{W}}{\overline{W}}\right)\left(\frac{W_t-\overline{W}}{\overline{W}}\right) \\ & + \overline{U}_{wL}\overline{W}\,\overline{L}\left(\frac{w_{h,t}-\overline{W}}{\overline{W}}\right)\left(\frac{L_t-\overline{L}}{\overline{L}}\right) \\ & + \overline{U}_{wD}\overline{W}\,\overline{D}\left(\frac{w_{h,t}-\overline{W}}{\overline{W}}\right)\left(\frac{D_t-\overline{D}}{\overline{D}}\right) + O_t. \end{aligned} \quad (37)$$

Here, $\overline{U}$ is the steady-state value of $U_{h,t}$, $\overline{U}_{ww}$ is the steady-state value of the second derivative of $U_{h,t}$ with respect to $w_{h,t}$, and so forth. $\overline{W}$ is the steady state level of the wage, which is equal to that of the aggregate wage. $\overline{D}$ is the steady state level of dividend. O_t represents the terms that are irrelevant to households' choice and is ignored in what follows for simplicity. To derive this approximation, we utilized $b_{h,t+1} = b_{h,t} = 0$, which holds in the equilibrium.

Next, from equation (36), $\overline{U}_{ww}$, $\overline{U}_{wW}$, $\overline{U}_{wL}$, and $\overline{U}_{wD}$ are expressed as

$$\overline{U}_{ww} = -\eta\overline{W}^{-2}\overline{L}(1+\eta\overline{L}), \quad (38)$$

$$\overline{U}_{wW} = \frac{\eta^3}{\eta-1}\overline{W}^{-2}\overline{L}^2, \quad (39)$$

$$\overline{U}_{wL} = \frac{\eta^2}{\eta-1}\overline{W}^{-1}\overline{L}, \quad (40)$$

and

$$\overline{U}_{wD} = \frac{1}{1-\omega}\frac{\eta^2}{\eta-1}\overline{W}^{-2}\overline{L}. \quad (41)$$

To derive these equations, we used

$$\overline{c}_H = \frac{\eta - 1}{\eta}\overline{W}. \tag{42}$$

This equation holds since

$$c_{h,t} = \frac{\eta - 1}{\eta} w_{h,t}, \tag{43}$$

which is derived from the first-order condition with respect to $w_{h,t}$. Now, (37) is rewritten as

$$\begin{aligned} U_{h,t} - \overline{U} &\approx -\frac{1}{2}\eta\overline{L}(1+\eta\overline{L})(\hat{w}_{h,t})^2 + \frac{\eta^3}{\eta-1}\overline{L}^2\hat{w}_{h,t}\hat{W}_t \\ &\quad + \frac{\eta^2}{\eta-1}\overline{L}^2\hat{w}_{h,t}\hat{L}_t + \frac{1}{1-\omega}\frac{\eta^2}{\eta-1}\overline{W}^{-1}\overline{L}\,\overline{D}\hat{w}_{h,t}\hat{D}_t \\ &= -\frac{1}{2}\eta\overline{L}(1+\eta\overline{L})(\hat{c}_{h,t})^2 + \eta^2\overline{L}^2\left(\hat{W}_t + \frac{1}{\eta-1}\frac{A\overline{W}^{-1}}{1-\omega}\hat{L}_t\right)\hat{c}_{h,t} \end{aligned} \tag{44}$$

where $\hat{w}_{h,t}$, $\hat{W}_t$, $\hat{L}_t$, and $\hat{D}_t$ represent log deviations from the steady state. To derive this, we utilized $\hat{w}_{h,t} = \hat{c}_{h,t}$, which is obtained from (43). We also used

$$\overline{D}\hat{D}_t = A\overline{L}\hat{L}_t - (1-\omega)\overline{W}\,\overline{L}(\hat{W}_t + \hat{L}_t), \tag{45}$$

which is obtained from equations (9), (10), (12), and (13).

From (44), we obtain the difference between second-order approximated utilities around the steady state under perfect and imperfect information as

$$\begin{aligned} U^{**}_{h,t} - U_{h,t} &\approx -\frac{1}{2}\eta\overline{L}(1+\eta\overline{L})[(\hat{c}^{**}_{H,t})^2 - (\hat{c}_{h,t})^2] \\ &\quad + \eta^2\overline{L}^2\left(\hat{W}_t + \frac{1}{\eta-1}\frac{A\overline{W}^{-1}}{1-\omega}\hat{L}_t\right)(\hat{c}^{**}_{H,t} - \hat{c}_{h,t}). \end{aligned} \tag{46}$$

Note that not only consumption but also wages are homogeneous across high-income households under perfect information. Thus,

$$\hat{W}_t = \hat{w}^{**}_{H,t} = \hat{c}^{**}_{H,t} \tag{47}$$

where $\hat{w}^{**}_{H,t}$ represents the log deviation of the optimal wage from the steady state under perfect information. On the other hand, using equations (9), (14), and (15)

$$AL_t = C_t = (1-\omega)c^{**}_{H,t} + \omega m. \tag{48}$$

Thus, from equations (42) and (48),

$$\hat{L}_t = \frac{(1-\omega)\bar{c}_H}{A\overline{L}}\hat{c}^{**}_{H,t} = \frac{1-\omega}{A\overline{L}}\frac{\eta-1}{\eta}\overline{W}\hat{c}^{**}_{H,t} \tag{49}$$

By substituting (47) and (49) to (46), we obtain

$$\begin{aligned} U^{**}_{h,t} - U_{h,t} &\approx -\frac{1}{2}\eta\overline{L}(1+\eta\overline{L})[(\hat{c}^{**}_{H,t})^2 - (\hat{c}_{h,t})^2] + \eta\overline{L}(1+\eta\overline{L})\hat{c}^{**}_{H,t}(\hat{c}^{**}_{H,t} - \hat{c}_{h,t}) \\ &= \frac{1}{2}\eta\overline{L}(1+\eta\overline{L})(\hat{c}^{**}_{H,t} - \hat{c}_{h,t})^2 \end{aligned} \tag{50}$$

From (23) and (27), the optimal level of $\hat{c}_{h,t}$ under perfect information is expressed as

$$\hat{c}^{**}_{H,t} = \frac{1}{1-\zeta\rho}\left(\rho\pi_t + \epsilon_{t+1}\right). \tag{51}$$

From equations (27) and (51),

$$\hat{c}^{**}_{H,t} - \hat{c}_{h,t} = \frac{1}{1-\zeta\rho}\left(\frac{\sigma^{-2}}{\sigma^{-2}_{h,t}}\epsilon_{t+1} - \frac{\sigma^{-2}_{h,t} - \sigma^{-2}}{\sigma^{-2}_{h,t}}\nu_{h,t}\right). \tag{52}$$

Therefore, since $\mathbb{E}_{h,t'}[\epsilon_{t+1}\nu_{h,t}] = 0$, $\mathbb{E}_{h,t'}[\epsilon^2_{t+1}] = \sigma^2$, and $\mathbb{E}_{h,t'}[\nu^2_{t+1}] = (\sigma^{-2}_{h,t} - \sigma^{-2})^{-1}$, from (50) and (52), the expected loss function is expressed as

$$\mathbb{E}_{h,t'}[U^{**}_{h,t} - U_{h,t}] \approx \frac{\eta\overline{L}(1+\eta\overline{L})}{2(1-\zeta\rho)^2}\sigma^2_{h,t}. \tag{53}$$

D Analysis without the Zero Lower Bound

The theory in the main text assumes that the nominal interest rate is zero to explain the empirical findings based on Japanese data. This appendix shows that the analysis is essentially applicable even to economies that are far from the effective lower bound of interest rates.

The model setup in this appendix is essentially the same as in the main text, but a few modifications are made. Specifically, since the nominal interest rate is not assumed to be zero, the Euler equation is represented by (17), not (18). Moreover, instead of assuming that households' perceived law of motion for the inflation rate is the AR(1) process in equation (20), we here assume that households' perceived law of motion for the real interest rate follows an AR(1) process as

$$r_{t+1} = \rho r_t + \epsilon_{t+1}. \tag{54}$$

We also assume that the steady-state level of the real interest rate is zero just for simplicity. This equation indicates that the real interest rate is perceived to follow an AR(1) process, possibly because households perceive that the central bank follows the Taylor principle (Taylor (1993)) or changes the real interest rate linearly and positively in response to a change in the inflation rate that follows an AR(1) process.

With these modifications, the inflation rate no longer exists in the model. Thus, as the expected inflation rate is represented by equation (24) in the main text, the expected real interest rate is represented by

$$\mathbb{E}_{h,t}[r_{t+1}] = \rho r_t + \frac{\sigma_{h,t}^{-2} - \sigma^{-2}}{\sigma_{h,t}^{-2}}\epsilon_{t+1} + \frac{\sigma_{h,t}^{-2} - \sigma^{-2}}{\sigma_{h,t}^{-2}}\nu_{h,t}. \tag{55}$$

Furthermore, just as the optimal consumption of high-income households depends on the inflation rate in the main text as shown in equation (27), it here depends on the real interest rate as shown in

$$\hat{c}_{h,t} = -\frac{1}{1-\zeta\rho}\left(\rho r_t + \frac{\sigma_{h,t}^{-2} - \sigma^{-2}}{\sigma_{h,t}^{-2}}\epsilon_{t+1} + \frac{\sigma_{h,t}^{-2} - \sigma^{-2}}{\sigma_{h,t}^{-2}}\nu_{h,t}\right). \tag{56}$$

This equation suggests that when the real interest rate increases, possibly in response to a rising inflation rate, current consumption decreases.

Even with these modifications, the loss function is identical to (28). Thus, the optimal precision of information for high-income households is also identical to (31). Therefore, we can conclude that lower-income households pay less attention to information on future real rates, including that from the central bank.