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Koichiro Kamada*
kouichirou.kamada@boj.or.jp

Jouchi Nakajima**
jouchi.nakajima@boj.or.jp

Shusaku Nishiguchi***
shusaku.nishiguchi@economics.ox.ac.uk

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Bank of Japan
2-1-1 Nihonbashi-Hongokucho, Chuo-ku, Tokyo 103-0021, Japan

* Monetary Affairs Department
** Monetary Affairs Department (currently International Department)
** Monetary Affairs Department (currently University of Oxford)

ARE HOUSEHOLD INFLATION EXPECTATIONS ANCHORED IN JAPAN? *

Koichiro Kamada†, Jouchi Nakajima‡, and Shusaku Nishiguchi§

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Abstract

This paper investigates household inflation expectations and discusses the central bank's ability to anchor them. We use micro-data from a household survey on inflation expectations and fit a normal inverse Gaussian distribution to the data to remove the distortions included in them. The underlying distribution thus obtained is examined to characterize household inflation expectations, particularly from the term-structure point of view. The analysis indicates that long-term expectations are immune to actual price developments, while short-term expectations are easily affected by actual inflation. The paper also investigates to what extent household inflation expectations have been influenced by the Bank of Japan's policy stance. The analysis shows that the price stability target and the quantitative and qualitative monetary easing, introduced by the Bank in 2013, contributed to strengthening the anchor of inflation expectations. Nonetheless, the anchor still needs to be improved so that household expectations are invulnerable to any disturbances in actual inflation rates.

JEL classification: E31, E52, E58

Key words: inflation expectations, term structure, expectations dispersion, inflation target, inflation anchor, quantitative and qualitative monetary easing

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† Monetary Affairs Department, Bank of Japan (kouichirou.kamada@boj.or.jp)

‡ Monetary Affairs Department, Bank of Japan (currently International Department, jouchi.nakajima@boj.or.jp)

§ Monetary Affairs Department, Bank of Japan (currently University of Oxford, shusaku.nishiguchi@economics.ox.ac.uk)

1. INTRODUCTION

Inflation expectations are one of the important indicators to monitor how effectively monetary policy keeps general prices stable. They are also important since the management of inflation expectations is one policy measure to achieve price stability. Numerous theoretical researches have been conducted to examine how inflation expectations influence actual price developments (e.g., Mishkin, 2007). In contrast, there has been little empirical research regarding what factors influence inflation expectations, whether central banks can manage inflation expectations in the private sector and, if they can, to what extent. To close this gap, much effort has recently been devoted to empirically characterizing the behavior of inflation expectations and to looking for critical factors that influence the formation of actual expectations. This paper is one such effort.

In the literature, central banks' ability to manage inflation expectations has been discussed in the context of the effectiveness of inflation targeting (e.g., Svensson, 2011). Inflation targeting is a policy in which a central bank commits to achieving an explicitly specified target rate of inflation. If the policy succeeds, inflation expectations are anchored, which in turn stabilizes actual inflation rates. Since it was first introduced by New Zealand in 1990, inflation targeting has been adopted by many countries, both advanced and emerging. The policy entered its golden age as the world economy enjoyed the *Great Moderation*. However, inflation expectations were seriously disrupted by soaring international commodity prices and the global financial crisis toward the end of the 2000s. Skepticism on inflation targeting has spread quickly worldwide (Frankel, 2012). Amid this situation, the Board of Governors of the Federal Reserve System (FRB) introduced a long-run goal for inflation in 2012, and the Bank of Japan (BOJ) set a price stability target in 2013. The ability of inflation targeting to anchor inflation expectations is once again being given an opportunity to be tested.

Two tests are used in the literature to qualify or disqualify an inflation target as an anchor of inflation expectations. The first test focuses on a central tendency of inflation expectations and requires inflation targeting to keep it close to the target against actual price disturbances (Bernanke, 2007). We call this the *central tendency test* below. The

second test focuses on the dispersion of expectations and requires inflation targeting to reduce it so that inflation expectations cluster around the target. We name this the *dispersion test*. It is noteworthy here that in the assessment of inflation targeting, more weight is put on long-term expectations than on short-term expectations. There is a good reason for this practice. Suppose that an actual inflation rate deviates from the target. Households revise their short-term expectations, taking into consideration the sticky adjustment process of actual inflation. In this process, short-term expectations are dispersed, reflecting the diversity of households' life styles, information-handling abilities, and so on. In contrast, long-term expectations are relatively immune to the influence of actual price developments. Thus, if inflation targeting works properly, at least long-term inflation expectations must be stable and clustered around the target.

There are a limited number of rigorous empirical studies discussing the effects of inflation targeting on household inflation expectations at the present. Among them, Bryan and Palmqvist (2005) report that in Sweden, household inflation expectations tended to concentrate on a focal point when inflation targeting was adopted in 1993. Rosenblatt-Wisch and Scheufele (2014) discuss that in Switzerland, household inflation expectations became more stable and less dispersed after an explicit definition of price stability was publicized in 1999 (Swiss National Bank, 1999). Nishiguchi et al. (2014) argue that in Japan, the disagreement of household inflation expectations has diminished since the introduction of a price stability target in 2013. On the contrary, Trehan and Zorrilla (2012) report that in the U.K., one of the frontrunners of inflation targeting (Bank of England, 1993), household inflation expectations have diverged from the target and become widely scattered since the end of the 2000s. Meanwhile, household inflation expectations remained stable in the U.S., where inflation targeting had not yet been officially adopted at that time. No broad consensus has been formed so far on the ability of inflation targeting to anchor inflation expectations. More efforts should be devoted to research on the formation process of households' expectations from various perspectives.

The paper explores the micro-data from the *Opinion Survey on the General Public's Views and Behavior* (Opinion Survey) to characterize the behavior of household inflation

expectations. We have a particular interest in how inflation expectations reacted to the BOJ's policy change. Three features are remarkable here.[1]

First, the paper uses a normal inverse Gaussian (NIG) distribution to remove various distortions from the survey data. Kamada (2013) points out that the distortions in survey data, such as downward rigidity of price expectations, could have a serious impact on the results of statistical tests. To circumvent this problem, in the literature the "median" is used as the central tendency of expectations and the "inter-quartile range" is employed as a measure of dispersion (e.g., Capistrán and Ramos-Francia, 2010; Carroll, 2001; Dovern et al., 2012). This paper takes a different approach and uses a NIG distribution to remove those distortions. This allows us to characterize inflation expectations in a language used by a broader audience, such as "mean", "variance", and so on.

Second, the paper emphasizes the importance of the term-structure point of view in characterizing inflation expectations. The information used in the formation of short-term inflation expectations differs, both in size and in quality, from that used in the formation of long-term expectations. Consequently, short-term inflation expectations behave differently from long-term expectations. We analyze the micro-data to identify the differences and similarities between long-term and short-term inflation expectations and are interested in the determinants of inflation expectations, particularly in the influence of actual inflation on expected inflation.

Third, the paper shows that households' knowledge on central bank objectives determines the size of the impact of inflation targeting on inflation expectations. Not all households are familiar with a central bank's policy objectives. The BOJ's price stability target and quantitative and qualitative monetary easing are no exceptions: Some households understand them well, while others do not. An important implication is that the impact of inflation targeting on inflation expectations depends on how many

[1] The purpose of this paper is to describe the behavior of inflation expectations; the effects of changes in inflation expectations on the real economy are beyond the scope of the paper. Interested readers should consult the related literature, including Ichiue and Nishiguchi (2015) and Bachmann et al. (2015).

households understand the policy and to what extent. The paper divides households into two groups—well-informed and poorly-informed—and shows that the impact of inflation targeting on expectation formation differs between the two groups qualitatively and quantitatively.

The remainder of the paper is organized as follows. Section 2 points out various distortions included in the survey of household inflation expectations. Section 3 introduces a parametric method to analyze micro-data, the main engine in this paper, and applies it to characterize household inflation expectations. Section 4 discusses further the role of monetary policy for anchoring inflation expectations. Section 5 concludes.

2. DISTORTIONS IN INFLATION EXPECTATION SURVEY

2.1. Outline of the Opinion Survey

This paper uses the micro-data from the Opinion Survey. The survey has been conducted by the BOJ since 1993 to monitor households' various economic perceptions, such as income developments, employment conditions, and monetary policy. In each survey, 4,000 individuals aged 20 or over are chosen throughout Japan.[2] In recent surveys, about 50 percent of responses were valid for inclusion in the data set. The survey does not provide panel data, since respondents are replaced every survey round. This paper uses the 34 rounds of survey conducted from September 2006 to December 2014.

The Opinion Survey asks households three questions about inflation: (i) current inflation perceptions or a *realized* inflation rate from a year ago, (ii) 1-year inflation expectations or *short-term* inflation expectations a year from now, and (iii) 5-year inflation expectations or *long-term* inflation expectations over the next five years per

[2] Stratified two-stage random sampling is employed in this process to mitigate geographical sampling bias.

annum.[3] For each of these questions, households are asked a quantitative as well as a qualitative question. In the case of long-term inflation expectations, the qualitative question asks "What is your outlook for prices over the next five years?" Households pick one from five choices.[4] On the other hand, the quantitative question asks "By what percent do you think prices will change per year on average over the next five years?" Households choose "up" or "down" and fill in a blank box with a numerical number. We focus on answers to quantitative questions in this paper.

2.2. Distortions in households' responses

Various distortions are included in households' survey responses on inflation expectations. We need to remove these distortions from the data to observe the true dynamics of inflation expectations by which households' economic activity is driven. Kamada (2013) scrutinized the micro-data from the 15 rounds of the Opinion Survey conducted from March 2004 to September 2007 and pointed out the following four distortions: there are (i) too many integers, (ii) zeros, and (iii) multiples of 5, but (iv) too few negative values.[5] As shown in Table 1, these distortions are still observed in the 34 rounds of survey conducted from September 2006 to December 2014: As for long-term expectations, 91 percent are integers; 39 percent are multiples of 5; 14 percent are zero; only 6 percent are negative. Distortions (ii) to (iv) are visualized in Figure 1, where the histogram is constructed from the micro-data on long-term inflation expectations collected in the December 2012 survey. Similar results are obtained for short-term expectations and for current inflation perceptions.

Kamada (2013) argues that distortions (ii) and (iv) mentioned above are both consequences of the downward rigidity of price expectations, which in turn are

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[3] The survey asks households about the change in tax-exclusive prices, not in tax-inclusive prices.

[4] The five choices are "Will go up significantly", "Will go up slightly", "Will remain almost unchanged", "Will go down slightly", and "Will go down significantly."

[5] The distortions discussed here are not specific to the Opinion Survey. For instance, Bryan and Palmqvist (2005) found similar distortions in the Michigan Survey of Consumer Attitudes in the U.S. and in the Households Purchasing Plans Survey in Sweden.

generated from households' strategic behavior aiming at influencing the central bank's policymaking process.[6] The Opinion Survey asks households whether inflation is favorable or unfavorable. In the December 2014 survey, for instance, about 80 percent of respondents answered that inflation is unfavorable. In the same survey, households were also asked about their future income. More than 90 percent of respondents answered that their income would decrease or not change over the next year. If their income expectations are correct, inflation would reduce their income measured in real terms. Thus, households who expect inflation have an incentive to report their prediction honestly aiming at pushing the central bank to mitigate future inflation. On the contrary, those who expect deflation have no incentive to report their predictions as they are and to urge the central bank to stop deflation, since they think of deflation as favorable. According to Kamada's strategic response hypothesis, the latter households will write down "0" instead of reporting a negative number they have in mind.

Additional distortion is generated from the methodology of the survey. To collect data, the Opinion Survey used the in-home method through June 2006 and the mail method thereafter. Two data sets were compiled in the June 2006 survey: one collected by the in-home method and the other by the mail method. Table 2 shows the means and medians of inflation expectations collected by the two methods. The inflation expectations collected by the mail method are higher than those collected by the in-home method on average. Again, Kamada's (2013) strategic response hypothesis comes into play here. When the in-home method is used, respondents are under high pressure to give responses when survey investigators visit them. In contrast, when the mail method is employed, the respondents are free from such pressures. According to Kamada's strategic response hypothesis, only those who have an incentive to make a response will return the answer sheets to the investigators. That is, households who expect inflation respond to the survey, while those who expect deflation ignore it. Consequently, inflation expectations tend to be higher when the mail method is used than when the in-home method is used. We call this the mail-method bias.

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[6] Bryan and Palmqvist (2005) explained these distortions from the viewpoint of near-rational behavior of households (see Akerlof et al., 2000).

The existence of downward rigidity in expected prices and the mail-method bias should be taken seriously when reading survey responses. Figure 2 shows the dynamics of the mean responses of inflation expectations and compares them with the developments of actual inflation rates. The actual inflation rate was negative from 2009 to 2010, and stayed around 0 percent through 2012. In comparison, the mean response of current inflation perceptions became negative only temporarily in early 2010; the mean responses of long-term and short-term inflation expectations were both positive throughout the sample period. Clearly, household inflation expectations reported in the survey suffer upward biases. Quantifying these biases is an indispensable step to understand the behavior of household inflation expectations correctly.

2.3. Quantifying distortions non-parametrically

Kamada (2013) introduced a non-parametric method to adjust survey micro-data for some of the distortions mentioned above.[7] The Kamada method enables us to quantify the size of distortions in households' responses and to estimate the *potential distribution*, i.e., the distribution that would be obtained if there were no distortions in households' responses. An advantage of using this method is that there is no need to assume a specific distribution *a priori*. This is a particularly useful assumption in the current context, where we have no idea about the true distribution of inflation expectations. Readers who are interested in the details of the Kamada method should consult Appendix A.

Here we apply the Kamada method to the 34 rounds of the survey conducted from September 2006 to December 2014 and quantify the size of distortions in households' responses on inflation expectations. Table 3 presents the results. Note first that the degree of downward rigidity is quite large. The estimated share of respondents who have negative expectations or perceptions in mind but report 0 percent is around 70 to 80 percent. Second, the probability of multiples of 5 is overestimated by about 12

[7] Kamada (2013) employed Kahn's (1997) test, which was originally designed to verify the existence of downward rigidity in nominal wages, to quantify downward rigidity of inflation expectations.

percent points in positive territory and by around 1 to 2 percent points in negative territory.

The potential distribution is estimated simultaneously with distortions. Figure 3 shows the potential distribution of long-term expectations constructed from the data collected in the December 2012 survey. Note that the share of negative expectations is restored and that of 0 percent expectations decreases instead. Table 4 presents descriptive statistics of the potential distribution averaged over the sample period.[8] Note that long-term expectations are less dispersed than short-term expectations, which are less dispersed than current inflation perceptions. This is one of the interesting characters of household inflation expectations. We will return to this issue in the next section.

Another important question is whether the potential distribution can be approximated by a normal distribution. Let us focus on long-term expectations. As shown in Table 4, the skewness of the potential distribution is 0.3 on average, reflecting households' cautious attitudes toward inflation. The kurtosis is 3.2 on average. This value is very close to 3, i.e., the kurtosis of a normal distribution. However, as reported by Nishiguchi et al. (2014), the kurtosis of the true distribution has been increasing since the BOJ changed its policy stance in 2013. These findings suggest that the true distribution of long-term expectations is hardly approximated by a normal distribution. We introduce a NIG distribution, which transforms more flexibly than a normal distribution, in the next section where we estimate the distribution of inflation expectations parametrically.

The mail-method bias is estimated as follows. First, the Kamada method is applied to the survey conducted through June 2006 by the in-home method; then, the mean of the potential distribution is calculated for the June 2006 survey. Next, the Kamada method is applied to the survey conducted from June 2006 onwards by the mail

[8] We estimate the potential distribution for each of long-term expectations, short-term expectations, and current inflation perceptions for each of the 34 rounds of the survey. Table 4 shows the averaged descriptive statistics of mean, standard deviation, skewness, and kurtosis of the estimated true distributions.

method; then, the mean of the potential distribution is calculated for the June 2006 survey. Now we have two means for the June 2006 survey, one by the in-home method and the other by the mail method. The difference between the two gives us an estimate of the mail-method bias. As shown in Table 5, the mail-method bias is estimated to be near 1 percent point for any forecast horizon. However, it should be noted that this result is obtained by only one round of survey.

As shown in Figure 4, inflation expectations and perceptions are both revised down significantly after correcting for downward rigidity and mail-method bias. Current inflation perceptions fell into negative territory toward the end of the 2000s, following the actual movement of inflation rates. Interestingly, short-term inflation expectations plunged into negative territory earlier than current inflation perceptions. In contrast, long-term expectations were relatively stable and stayed at around 2 to 3 percent throughout the sample period.

3. BEHAVIORAL FEATURES OF INFLATION EXPECTATIONS

3.1. Parametric estimation of the underlying distribution of inflation expectations

An advantage of using the Kamada method is that there is no need to assume a specific distribution in estimation. This method, however, has the drawback that the shape of the potential distribution changes over time only marginally. This will be a disadvantage when the distribution of inflation expectations changes its shape drastically. The Kamada method may underestimate the effects of inflation targeting on inflation expectations, missing changes in the values characterizing the shape of the distribution, such as variance, skewness, and kurtosis.

Given these considerations, we replace the Kamada method with a parametric method so as to capture the *underlying distribution* of inflation expectations. The underlying distribution is a distribution that would be obtained if there were no

distortions and noises in households' responses.[9] We use a NIG distribution to estimate the underlying distribution. A NIG distribution is used frequently in the finance literature due to its flexibility in modeling an asymmetric and fat-tailed distribution of stock returns. The density function of a NIG distribution is defined by four parameters, i.e., m, v, a, and b, as follows.

$$f(x|m,v,a,b) = \frac{va \cdot \exp\left(v\sqrt{a^2-b^2}\right)K\left(a\sqrt{v^2+(x-m)^2}\right)\exp\left(b(x-m)\right)}{\pi\sqrt{v^2+(x-m)^2}}, \quad (1)$$

where $K(\cdot)$ is a Bessel function.[10] The descriptive statistics are also functions of the four parameters as follows.

$$\text{mean} = m + vb/c, \ (c = \sqrt{a^2-b^2}), \quad (2a)$$

$$\text{variance} = va^2/c^3, \quad (2b)$$

$$\text{skewness} = 3b/a\sqrt{vc}, \quad (2c)$$

$$\text{kurtosis} = 3(1+4b^2/a^2)/vc. \quad (2d)$$

Denote household i's inflation expectations at survey round t by x_{it} and the underlying distribution of inflation expectations by $f(x|m_t, v_t, a_t, b_t)$. Then the distorted distribution of household inflation expectations is given by $g(x \mid m_t, v_t, a_t, b_t, \rho_t, \phi_t, \theta_t)$ as follows.

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[9] Following Kamada (2013), we distinguish the *potential* and *underlying distributions*. As defined in the previous section, the potential distribution is a distribution that would be obtained if there were no distortions. In other words, the potential distribution excludes distortions, but includes noises. On the other hand, neither distortions nor noises are included in the underlying distribution.

[10] Here we use a modified Bessel function of the third kind, which is defined as follows.

$$K(x) = \frac{1}{2}\int_0^\infty \exp\left\{-\frac{x}{2}\left(y+\frac{1}{y}\right)\right\}dy.$$

$$g(x \mid m_t, v_t, a_t, b_t, \rho_t, \phi_t, \theta_t) =$$

$$\begin{cases} f(x) + \rho_t \int_{\underline{x}}^{0} f(s)ds & \text{for } x = 0 \quad (3a) \\ (1-\rho_t) f(x) & \text{for } -4 \le x < 0 \quad (3b) \\ (1-\rho_t)(1-\theta_t) f(x) & \text{for } \underline{x} \le x < -4,\ x \ne -5, -10 \quad (3c) \\ (1-\rho_t) f(x) + \frac{1}{2}\theta_t \int_{\underline{x}}^{-4} (1-\rho_t) f(s)ds & \text{for } x = -5, -10 \quad (3d) \\ f(x) & \text{for } 0 < x < 4 \quad (3e) \\ (1-\phi_t) f(x) & \text{for } 4 \le x < 14,\ x \ne 5, 10 \quad (3f) \\ f(x) + \frac{1}{2}\phi_t \int_{4}^{14} f(s)ds & \text{for } x = 5, 10 \quad (3g) \\ (1-\theta_t) f(x) & \text{for } 14 \le x < 19,\ x \ne 15 \quad (3h) \\ f(x) + \theta_t \int_{14}^{19} f(s)ds & \text{for } x = 15, \quad (3i) \end{cases}$$

where $\underline{x}$ is a sample floor. A sample below this value is discarded as an outlier. The floor is set equal to median minus 13 here, as is assumed in Kamada (2013). Note that equation (3) is a natural extension of the Kamada method (see Appendix A for detail). Equations (3a) to (3d) deal with downward rigidity in price expectations. Parameter ρ is used to measure the degree of downward rigidity. Equations (3c) to (3i) treat answers in multiples of 5. Parameter ϕ is used to treat answers around 5 and 10, while parameter θ is used to deal with answers around multiples of 5 except for 5 and 10.[11]

The parameters are estimated by the maximum likelihood method. We can define a likelihood function for each survey round. The time-t likelihood function is given by $L_t = \prod_i g(x_{it} \mid m_t, v_t, a_t, b_t, \rho_t, \phi_t, \theta_t)$. There are two advantages of using the current method. First, it allows us to estimate the parameters for each round of the survey. This contrasts to the Kamada method, for which a number of survey rounds are necessary before the estimation is conducted. Second, as a result, the current method captures the shape of the underlying distribution in a flexible way. The underlying distribution may

[11] Here the specification is slightly different from that in the Kamada method. In the latter, parameter ϕ is used to treat answers in multiples of 5 in negative territory and parameter θ is for positive territory. See Appendix A for details of the Kamada method.

change its shape over time. This is particularly the case if the economy is hit by a large shock, for instance, by a drastic change in monetary policy stance. The method proposed here assumes that the underlying distribution changes its shape every survey round, and thus allows us to capture the evolution of expectations correctly.

3.2. Empirical results

Figure 5 shows the evolution of distortion parameter estimates. Two points are noteworthy here. First, downward rigidity distorts more than half of households' responses and thus must be eliminated before any implications are extracted from the data. For long-term expectations, the estimate of ρ varies between 0.5 and 0.8 with an average of 0.6; for short-term expectations, the estimate varies between 0.6 and 1.0 with an average of 0.8. These figures are close to what is obtained in the Kamada method. Figure 6 shows the underlying distribution of long-term expectations constructed from the data collected in the December 2012 survey. The distribution is less fat-tailed than that obtained in the Kamada method (Figure 3), but not very different from the latter. Second, downward rigidity is more serious for short-term expectations than it is for long-term expectations. This result is explained by Kamada's (2013) strategic response hypothesis. Generally speaking, households tend to be more serious about inflation in the near future than that in the far future. Thus, those expecting deflation are more likely to answer "0" to the question on short-term expectations than on long-term expectations.

Table 6 provides the test result for the existence of the mail-method bias. As mentioned before, this bias is calculated as the difference between the two mean values estimated from the two sets of data collected in the June 2006 survey: one by the in-home method and the other by the mail method. The top panel indicates that a significant gap exists, whether long-term or short-term expectations, between the two mean values. Meanwhile, no significant gaps are observed for the other statistics. Thus, we can safely ignore the gaps in other statistics when estimating the mean gap, or the mail-method bias. As shown in the bottom panel, the estimated bias is 1.0 percent point for long-term expectations, 1.0 percent point for short-term expectations, and 1.5 percent point for current inflation perceptions.

Figure 7 displays the evolution of the underlying distribution. First we focus on the development of the mean. Those who are reluctant to use the Opinion Survey often emphasize the following fact: In spite of the pervasive deflation in Japan from 2009 to 2010 in terms of the core CPI, households' reports on inflation, whether expected or realized, were positive almost all the time. On the other hand, the figure shows that once distortions and noises are removed, the mean of current inflation perceptions took negative values from 2009 to 2013, and that of short-term expectations did from 2009 to 2010. Note that the mean of long-term expectations, even if adjusted for distortions and noises, has remained in positive territory and never taken negative values.

Next, we examine household inflation expectations from the term-structure point of view. To crystallize the dynamic relationship between long-term and short-term expectations, we divide the sample into four subsamples according to the developments of current inflation perceptions: (i) the phase from March 2007 to September 2008, in which prices rose steadily together with the economic recovery; (ii) the phase from September 2008 to March 2010, in which prices fell sharply amid the economic turmoil triggered by the Lehman shock; (iii) the phase from March 2010 to December 2012, in which prices experienced only negligible ups and downs in the stagnant global economy in the aftermath of the financial crisis; (iv) the phase from December 2012 to December 2014, after the BOJ introduced the price stability target.

In each panel of Figure 8, the underlying distributions of long-term inflation expectations are placed at the top; those of short-term expectations in the middle; those of current inflation perceptions at the bottom. The underlying distribution drawn by the broken line is obtained from the first round of the survey conducted in each phase, while that drawn by the thick line is constructed from the final round of the survey in the same phase. White and black circles indicate the mean values of the underlying distributions. The lines connecting those circles swing to the right in inflation phases and to the left in deflation phases like a pendulum. That is, the longer the expectation horizon is, the smaller the swing of expectations is. Furthermore, the longer the expectation horizon is, the smaller the dispersion of expectations is. From the long term point of view, these findings suggest that Japanese household inflation expectations

have been anchored to a certain focal point.

Keynes discussed a similar contrast between long-term and short-term expectations in his *General Theory* in the context of entrepreneurs' decision-making in production and investment. As for short-term expectations, he mentioned, "[T]he most recent results usually play a predominant part in determining what these expectations are" (Keynes, 1936, p. 51). On the other hand, as for long-term expectations, he argued, "[I]t is of the nature of long-term expectations that they cannot be checked at short intervals in the light of realized results" (*ibid*). Our findings on the term structure of household inflation expectations are consistent with his arguments or can be interpreted as supporting his discussion empirically in the context of household inflation expectations.

We do not necessarily claim that household inflation expectations are independent of monetary policy and evolve autonomously. The behavior of inflation expectations may partly be governed by human instincts or social customs. At the same time, however, it seems to reflect households' understanding of monetary policy aiming at price stability (Bernanke, 2007). Keynes argued, "[Long-term expectations] are liable to sudden revision. Thus the factor of current long-term expectations cannot be even approximately eliminated or replaced by realized results" (Keynes, 1936, p. 51). Monetary policy may be one of those factors that move long-term expectations significantly. Below, we look at two episodes suggesting that the BOJ's monetary policy influenced the formation process of households' expectations.

The first episode is comprehensive monetary easing (CME), which was introduced by the BOJ in October 2010. As seen in Figure 7, CME succeeded in raising the level of inflation expectations. The mean of long-term inflation expectations shifted up discretely by about one percent point, up to the ceiling rate of 2 percent in the framework of the *understanding of medium- to long-term price stability*. The rise in short-term expectations was much larger: the mean jumped up by about 3 percent points from a negative value to the ceiling rate of 2 percent. As shown in Table 7, these moves in mean values are both statistically significant. However, no significant changes are observed in other statistics, particularly in the variance. CME passed the central

tendency test for an inflation expectations anchor, but failed the dispersion test mentioned in Section 1.

The second episode is the BOJ's introduction of a price stability target in January 2013 and QQE in April 2013. Below, "QQE" stands for the sequence of these two policy decisions unless mentioned otherwise. As seen in Figure 7, the mean of short-term expectations jumped up drastically by about 2 percent points up to the current target level of 2 percent.[12] The mean of long-term expectations also rose significantly in a statistical sense as shown in Table 7, though it appears almost flat in Figure 7. One of the most interesting facts about QQE is that it has changed the shape of the distribution of inflation expectations. First, the variance of inflation expectations, both long-term and short-term, was reduced significantly. Second, the kurtosis of inflation expectations, especially of long-term expectations, jumped up immediately after the introduction of the new policy, as pointed out by Nishiguchi et al. (2014). To sum up, QQE not only reduced the dispersion of inflation expectations, but also enhanced the concentration of them. Clearly, QQE passed the two tests for an inflation expectations anchor.

Another striking impact of QQE is on the skewness of inflation expectations. One of the purposes of the policy is to get rid of the deflation mindset prevailing in Japan. As seen in Figure 7, the skewness of inflation expectations, particularly of long-term expectations, jumped up when the policy was introduced. On the other hand, CME was not successful in getting rid of the deflation mindset. Under the latter policy from 2010 to 2012, the skewness of long-term expectations increased temporarily, but fell back shortly, and that of short-term expectations stayed around zero.

Lastly, it is fair to mention that not all the monetary policies implemented in the past had an impact on inflation expectations. Since its introduction of the understanding of medium- to long-term price stability in March 2006, the BOJ has strengthened the definition of price stability in steps. For instance, the meaning of the understanding of medium- to long-term price stability was clarified in December 2009.

[12] The mean of short-term expectations declined gradually toward 0 percent after it jumped up in line with the introduction of CME.

The price stability goal in the medium to long term was introduced in February 2012. In these cases, however, no significant impact on inflation expectations was observed, as shown in Table 7.

4. How To Strengthen the Anchor of Inflation Expectations

The purpose of this section is two-fold. First, we construct a formal framework to test the significance of various factors that are supposed to affect inflation expectations simultaneously. In the previous section, it was suggested that household expectations have been influenced by current inflation perceptions; and it is also indicated that they have been affected by the central bank's monetary policy stance.[13] To take both these factors into consideration at once, we propose a regression model and search for significant factors that affect the location and shape of the underlying distribution of inflation expectations. Second, we discuss whether households' recognition of the objectives of the central bank affects the size of an impact of monetary policy. For this purpose, we divide the sample into two groups, one for those who well recognize central bank objectives and the other for those who recognize them only poorly, and compare the effects of individual policy measures on inflation expectations between the two groups.

4.1. Inflation expectations in a regression model

Let parameters m_{it}, v_{it}, a_{it}, and b_{it} be dependent variables to be explained. Denote a vector of explanatory variables by w_{it}. Then, the general form of multiple regression models employed in this section is given by

[13] As shown by Badarinza and Buchmann (2009), realized inflation rates or inflation perceptions have a significant impact on inflation expectations. Mankiw et al. (2004) statistically tested the possibility that inflation forecasts of professional forecasters and households are influenced by news related to the actual development of inflation.

$$m_{it} = \alpha^m + \beta_w^m w_{it}, \tag{4a}$$

$$v_{it} = \alpha^v + \beta_w^v w_{it}, \tag{4b}$$

$$a_{it} = \alpha^a + \beta_w^a w_{it}, \tag{4c}$$

$$b_{it} = \alpha^b + \beta_w^b w_{it}. \tag{4d}$$

Note that two suffixes are attached to m, v, a, and b: suffix i denotes an agent and suffix t a survey round. The former suffix is necessary if agent-specific information is included in explanatory variables. In this case, density $g(x_{it} | m_{it}, v_{it}, a_{it}, b_{it}, \rho_t, \phi_t, \theta_t)$, which inflation expectations x_{it} follow, is also agent-specific. We assume that the distortion parameters are common to all the households. Then, the maximum likelihood function is given by $L = \prod_t \prod_i g(x_{it} \mid m_{it}, v_{it}, a_{it}, b_{it}, \rho_t, \phi_t, \theta_t)$ for relevant survey rounds and households.[14]

In this section, we focus on two types of explanatory variable: a variable measuring actual inflation and a dummy indicating a change in the central bank's policy stance. First, we use households' inflation perceptions, denoted by π_{it}, as a measure of actual inflation rates. Alternatively, we can use realized inflation rates. Appendix B presents the results obtained using alternative definitions of consumer price index, such as headline CPI, core CPI, and so forth. In doing so, however, the sensitivity of inflation expectations to actual inflation is likely to be estimated wrongly. Consumption baskets vary across households and thus inflation perceptions differ among them. Ignoring this heterogeneity could result in a biased estimation of the effects of actual inflation on expected inflation. For this reason, we prefer using households' inflation perceptions as a measure of actual inflation.

Note that there is a caveat about the use of household inflation perceptions as a measure of actual inflation. As discussed in the previous sections, the data on household inflation perceptions include various distortions. Thus, they need to be adjusted for those distortions before being put in the regression model. Consider, for

[14] In the estimation below, to reduce the computational load, we use the estimates of ρ_t, θ_t, and ϕ_t obtained in the previous section.

instance, a household who reports that its perceived inflation rate is 0 percent. We have two possibilities in this case: Its underlying inflation perception may be 0 percent or may be a certain negative value, though the household reports "0" strategically. We have no way to identify its perceptions, but can specify a probability distribution of its inflation perceptions. We use equation (3) to estimate the underlying distribution of inflation perceptions every survey round. Denote the estimated underlying distribution by $\hat{f}(x)$ and the estimated degree of downward rigidity by $\hat{\rho}$. Then, the conditional density of inflation perceptions is given by

$$P(y|x=0) \propto \hat{\rho}\hat{f}(y) \cdot I\left[\underline{x} < y < 0\right] + \hat{f}(0) \cdot I[y=0],$$

where I is an index function, which takes 1 if the condition specified in [ ] is satisfied and 0 otherwise. A sample of underlying inflation perceptions is generated from this conditional density function. Similarly, we estimate a conditional density function for an answer given in a multiple of 5 and generate a sample stochastically from it. We repeat random sampling several times and estimate the model by maximizing the averaged likelihood functions.

Second, we use two policy dummies: one for CME denoted by d_t^c, which takes 0 before October 2010 and 1 thereafter, and the other for QQE denoted by d_t^q, which takes 0 before January 2013 and 1 thereafter. Monetary policy may not only have a direct impact on inflation expectations, but also have an indirect impact by influencing the sensitivity of those expectations to actual inflation. Taking this possibility into account, we specify the regression model as follows.

$$m_{it} = (\alpha^m + \beta_\pi^m \pi_{it}) + (\alpha_c^m + \beta_c^m \pi_{it}) d_t^c + \left(\alpha_q^m + \beta_q^m \pi_{it}\right) d_t^q, \tag{5a}$$

$$v_{it} = \alpha^v + \alpha_c^v d_t^c + \alpha_q^v d_t^q, \tag{5b}$$

$$a_{it} = \alpha^a + \alpha_c^a d_t^c + \alpha_q^a d_t^q, \tag{5c}$$

$$b_{it} = \alpha^b + \alpha_c^b d_t^c + \alpha_q^b d_t^q. \tag{5d}$$

We include actual inflation rates only in m_{it}, as in equation (5a), though it is easy to re-specify the model so that v_{it}, a_{it}, and b_{it} are also influenced by actual inflation rates.

This specification provides useful information on whether a certain policy contributes to strengthening an inflation expectations anchor. Coefficient β^m is positive in a normal situation. Coefficient α^m is positive in an inflationary economy and negative in a deflationary economy. Let us start with the situation where α^m is below the target rate of inflation and π_{it} is positive. The inside of the second parentheses in the right-hand side of equation (5a) indicates the marginal effects of CME on m_{it}, which depend on the three factors of α_c^m, β_c^m, and π_{it}. Note that m_{it} increases (i) if α_c^m is positive or (ii) if β_c^m is positive. Case (i) is a favorable case for a central bank aiming at raising inflation expectations; case (ii) is unfavorable since expectations are more easily disturbed by actual inflation. The most favorable situation emerges when α_c^m is positive and β_c^m is negative. The same argument can be made for QQE, based on α_q^m and β_q^m.

Table 8 presents the estimation results. The entries under the header of "Baseline" show how the mean of inflation expectations would be determined if CME and QQE were not implemented. Those under the headers of "CME" and "QQE" indicate the marginal effects of introducing each of these policies on the mean of inflation expectations. Following the introduction of each policy, inflation expectations, whether short-term or long-term, shifted upward (α_c^m, $\alpha_q^m > 0$), and their sensitivity to actual inflation declined (β_c^m, $\beta_q^m < 0$). Note, however, that α_q^m is not statistically significant for long-term expectations. As shown in Table 7, the mean of inflation expectations had already been raised almost up to 2 percent by CME. Thus, in a sense, it is natural for QQE to have no more impact on the mean of long-term inflation expectations. Nonetheless, we would say that an inflation expectations anchor can be strengthened more. As shown under the header of "Total", the total sensitivity to actual inflation is significantly positive ($\beta_\pi^m + \beta_c^m + \beta_q^m > 0$). Therefore, an inflation expectations anchor will be strengthened further by reducing the value of β_q^m and raising the value of α_q^m.

4.2. Effects of recognition of central bank objectives on inflation expectations

Reactions to a policy change vary across households. Nishiguchi et al. (2014) divided the micro-data from the Opinion Survey into two groups, i.e., one whose members know the price stability target and the other whose members do not know it, and

argued that the price stability target had different impacts on the distributions of inflation expectations between the two groups. Particularly, it was pointed out that the kurtosis of long-term inflation expectations of those who know the target is larger than that of those who do not know it. This implies the following hypothesis: Households who well recognize monetary policy are more sensitive to the central bank's policy announcements than those who do not. If this hypothesis is statistically true, it provides important information for planning monetary policy.

Households are divided into two groups, named A and B, according to their response to the question, "Do you know that one of the Bank's objectives is to achieve price stability?"[15] Group A is the group of those who answer "Know about it" or "Have read or heard of it, but do not know much about it" and group B is the group of those who answer "Have never heard of it." About 80 percent of households belong to group A, as shown in Figure 9. The specification of the regression model is basically the same as equation (5) except for the inclusion of a dummy which identifies which group a certain household belongs to. A_{it} is a dummy variable that takes 1 if a household belongs to group A and 0 otherwise; B_{it} takes 1 if it belongs to group B and 0 otherwise. Then the regression model is given as follows.

$$\begin{aligned} m_{it} = {} & A_{it}\{(\alpha_A^m + \beta_A^m \pi_{it}) + (\alpha_{Ac}^m + \beta_{Ac}^m \pi_{it}) d_t^c + (\alpha_{Aq}^m + \beta_{Aq}^m \pi_{it}) d_t^q\} \\ & + B_{it}\{(\alpha_B^m + \beta_B^m \pi_{it}) + (\alpha_{Bc}^m + \beta_{Bc}^m \pi_{it}) d_t^c + (\alpha_{Bq}^m + \beta_{Bq}^m \pi_{it}) d_t^q\}, \end{aligned} \tag{6a}$$

$$v_{it} = A_{it}\{\alpha_A^v + \alpha_{Ac}^v d_t^c + \alpha_{Aq}^v d_t^q\} + B_{it}\{\alpha_B^v + \alpha_{Bc}^v d_t^c + \alpha_{Bq}^v d_t^q\}, \tag{6b}$$

$$a_{it} = A_{it}\{\alpha_A^a + \alpha_{Ac}^a d_t^c + \alpha_{Aq}^a d_t^q\} + B_{it}\{\alpha_B^a + \alpha_{Bc}^a d_t^c + \alpha_{Bq}^a d_t^q\}, \tag{6c}$$

$$b_{it} = A_{it}\{\alpha_A^b + \alpha_{Ac}^b d_t^c + \alpha_{Aq}^b d_t^q\} + B_{it}\{\alpha_B^b + \alpha_{Bc}^b d_t^c + \alpha_{Bq}^b d_t^q\}. \tag{6d}$$

The estimation results are presented in Table 9. We have two sub-tables: one for

[15] Nishiguchi et al. (2014) used the answers to the question "Do you know that the Bank has set the 'price stability target' at 2 percent in terms of the year-on-year rate of change in the consumer price index (CPI)?" But this question has been incorporated into the Opinion Survey only recently since the introduction of the price stability target in January 2013. Thus, we do not use the answers to this question since we have to analyze the effectiveness of monetary policy from the long-term perspective.

group A and the other for group B. We compare these sub-tables with Table 8 and discuss the effects of a difference in policy recognition on the degree of policy impacts. Two points are remarkable here. First, the results for group A are almost the same as those for entire households. This is not surprising, since about 80 percent of households belong to group A. In particular, the decline in the sensitivity of inflation expectations to inflation perceptions is attributed to a change in the action of group-A households. The sensitivity of group-B households also declined, but the change was not statistically significant.

Second, the table shows why QQE did not raise the mean of long-term inflation expectations significantly: Group-A households raised their inflation expectations and lowered their sensitivity to actual inflation at the same time. In contrast, group-B households lowered their expectations in response to the introduction of the policy, cutting back on the policy effects which occurred among group-A households. This finding has important implications for the timing for the policy effects to appear. That is, the policy effects of inflation targeting appear in two steps. As the first step, the policy immediately invokes reactions among those who recognize central bank objectives well, leading their inflation expectations toward the target. As the second step, as the actual inflation rate rises gradually after some quarters of lags, inflation expectations start moving among those who do not recognize the central bank's objectives.

Lastly, we discuss the relationship between the results obtained above and the discussion made by Mankiw et al. (2004), who examined the evolution of the distribution of inflation expectations after the Fed introduced a new monetary policy in August 1979 to fight the stubbornly high inflation. According to their analysis, the distribution of inflation expectations did not make a simple parallel shift in response to the policy change. First, the distribution flattens out; then, it shifts leftwards gradually; finally, it becomes bell-shaped again. Mankiw et al. argue that this evolution can be explained by the sticky-information model, where households consist of two groups: one whose members catch the policy information quickly and the other whose members receive the information with a delay. Our model similarly assumes two

groups of households, but explains the evolution of inflation expectations in a different manner. That is, one group responds immediately to the policy announcement, but the other moves with a delay, reacting to a change in actual inflation which comes only gradually after the policy announcement. The difference in reaction between the two groups may come from a difference in the way each household uses its limited information-processing capacity.

Our model is closer to Sims's (2003, 2006) theory of rational inattention. To simplify the story, suppose that a household has limited information-processing capacity so that it takes into account only one type of information at a time. A type-I household uses only the central bank's announcements in the formation of inflation expectations, and a type-II household relies solely on the actual inflation rate. In the empirical model employed above, a type-I household belongs to group A, and a type-II household to group B. This is too simplified a story to describe the complex reality, but it suggests a way to strengthen an inflation expectations anchor. First, the anchor is strengthened by purifying a member in group A to a type-I household. Our empirical study indicates that members in group A have strengthened their type-I character since the introduction of QQE. Second, the anchor is strengthened as well by increasing the share of group A. As shown in Figure 9, however, the share has been increasing only gradually since the introduction of the policy. This implies that announcing an inflation target is not enough to anchor inflation expectations completely. Further knowledge needs to be accumulated about policy measures that allow central banks to increase the number of households that use central bank announcements in the formation of inflation expectations.

5. CONCLUDING REMARKS

This paper investigated the features of household inflation expectations and discussed the central bank's ability to anchor them. A NIG distribution was used to estimate the underlying distributions of long-term and short-term inflation expectations. Then, the mean, variance, skewness, and kurtosis were calculated to be analyzed mainly from the term-structure point of view. The analysis showed that the variability of inflation

expectations depends on households' forecast horizons. That is, the longer the forecast horizon is, the smaller the variability of expectations tends to be. Inflation expectations also vary across households, reflecting the diversity of households' income, life style, and so forth. The longer the forecast horizon is, the smaller the dispersion tends to be.

This paper employed rigid statistical methods to evaluate the impact of the BOJ's monetary policy on household inflation expectations. Two results are worth noting here. First, inflation expectations of Japanese households were affected differently by CME in 2010 and by QQE in 2013. CME succeeded in pushing up inflation expectations toward 2 percent, i.e., the upper bound of *understanding of medium- to long-term price stability*, but failed to reduce the dispersion of expectations. In contrast, QQE succeeded in reducing the dispersion of inflation expectations. Second, Japanese households have become more sensitive to the central bank's announcements and less susceptible to actual price movements. The policy had an impact mainly on the households who well recognize the central bank's objectives, but not much on those who do not. The anchor of inflation expectations will be strengthened further if households better recognize the central bank's objectives.

As shown in this paper, inflation targeting works even if the central bank has only limited room for the conventional policy of short-term interest rate control and thus implements a variety of unconventional policy measures. The paper raises new questions, however. Since its introduction of the understanding of medium- to long-term price stability in March 2006, the BOJ has strengthened the definition of price stability in steps. A question arises: Why did the clarification of the understanding of medium- to long-term price stability in December 2009 and the introduction of the price stability goal in the medium to long term in February 2012 have no significant impact on inflation expectations? Some advocates of inflation targeting might insist that only a "target" has a policy impact. But this argument holds under the assumption that households strictly distinguish a "target" from an "understanding" or a "goal". This assumption does not seem persuasive. Indeed, the inflation expectations anchor has weakened in the U.K., where the inflation target has been publicized in a formal way. Under what monetary and fiscal conditions does inflation targeting work

effectively? What policy package, including large-scale asset purchases, forward guidance, etc., should be implemented together with inflation targeting? To enhance the performance of inflation targeting, we should accumulate further detailed empirical studies.

APPENDIX A. NON-PARAMETRIC ESTIMATION OF DISTORTIONS

Kamada (2013) defines the *underlying distribution* as a distribution that would be obtained if there were no distortions and noises in households' survey responses. In the Kamada method, it is assumed that the underlying distribution changes its location, but its shape is fixed throughout the sample period. Denote the median of households' answers on inflation expectations by m.[16] Define α_q as the share of underlying expectations falling between $m+q$ and $m+q+1$ unless influenced by any distortions or noises. Let $P_{q,t}$ be the share of reported expectations lying between $m+q$ and $m+q+1$. Then the model to be estimated is given by

$$P_{q,t} = \alpha_q - \alpha_q \cdot \rho \cdot D0_{q,t} + (\sum_{j<q} \alpha_j)\rho \cdot Z_{q,t} - \theta \cdot D1_{q,t} + 4\theta \cdot D2_{q,t} - \phi \cdot U1_{q,t} + 4\phi \cdot U2_{q,t} + \varepsilon_{q,t}, \quad \forall q = -13, \dots, 13. \tag{A1}$$

In the above, $D0_{q,t}$ is a dummy that takes 1 if the interval from $m+q$ to $m+q+1$ falls into negative territory and takes 0 otherwise; $Z_{q,t}$ is a dummy that takes 1 if the interval from $m+q$ to $m+q+1$ includes 0 and takes 0 otherwise; ρ is the share of expectations passed on to 0 from negative territory and indicates the degree of downward rigidity of price expectations. $D2_{q,t}$ is a dummy that takes 1 if the interval from $m+q$ to $m+q+1$ includes −5 or −10 and takes 0 otherwise; $D1_{q,t}$ is a dummy that takes 1 if the interval from $m+q$ to $m+q+1$ includes −4 or a smaller number, excluding −5 and −10, and takes 0 otherwise; θ is the share of expectations rounded to

[16] As mentioned in Section 2, most of the answers are in integers. Thus, the median is also given by an integer in most cases. But only rarely, the median is not an integer. In that case, we use the largest integer no greater than the median instead. To eliminate outliers, we impose a restriction on the survey answers: $-13 \leq q \leq 13$.

multiples of 5. $U1_{q,t}$, $U2_{q,t}$, and ϕ are defined similarly for positive territory. An error term $\varepsilon_{q,t}$ contains the contribution of all remaining factors specific to round t of the survey, and thus is not necessarily discarded as distortion or noise. The *potential distribution* is obtained as the sum of the error term and the underlying distribution. Equation (A1) is a system of equations and can be estimated simultaneously in the standard econometric method.

APPENDIX B. REALIZED INFLATION IN EXPECTATION FORMATION

Here we are interested in which price index, headline or some partial index, is the most influential in the formation process of households' expectations. We focus on the headline CPI and three partial CPI as a measure of the actual inflation rate, i.e., prices for all items, prices for all items less fresh food, prices for all items less food and energy, and items related to food and energy. We put these price indices in equation (5) alternatively and define the index that maximizes the maximum likelihood as the most influential index in the formation process of households' expectations.

Table B presents the estimation results. The most influential consumption items vary depending on the length of the forecast horizon. To form long-term expectations, households look at the "core CPI", i.e., prices for all items less fresh food. In comparison, to form short-term expectations, they look at the "headline CPI", i.e., prices for all items. Interestingly, households' perceptions of inflation are consistent with the prices of food and energy, i.e., consumption items encountered by households every day.[17] To sum up, households take a broad range of goods and services into account for expectation formation, but tend to focus on the prices for necessities to understand the present price conditions.

The last point has an important implication for the stability of household inflation expectations. As discussed in Section 4, household inflation expectations are affected

[17] Our results are consistent with the empirical study by Cavallo et al. (2014), who examined a large set of micro-data and showed that household inflation expectations are affected by the developments of commodity prices sold in supermarkets.

by current inflation perceptions, which in turn are strongly affected by food and energy prices, as shown above. The psychological role that prices of food and energy play in the formation of inflation expectations is heavier than the pecuniary share in households' consumption expenditures.

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Table 1. Characteristics of households' answers on inflation rates

	Total	Integer	Multiples of 5 (excluding 0)	Zero	Negative
Long-term inflation expectations	2,000	91	39	14	6
Short-term inflation expectations	2,034	95	45	27	7
Current inflaion perceptions	2,027	95	47	29	11

Notes: 1. "Total" indicates the number of households; the other figures are in %.

2. Averaged from September 2006 to December 2014.

Table 2. Difference between in-home and mail methods

	Mean (%)			Median (%)		
	In-home	Mail	Difference	In-home	Mail	Difference
Long-term inflation expectations	3.1	5.2	+2.1	2.0	3.0	+1.0
Short-term inflation expectations	3.7	4.8	+1.1	2.0	3.0	+1.0
Current inflaion perceptions	2.4	3.6	+1.2	0.0	1.5	+1.5

Note: The June 2006 survey.

Table 3. Results of Kamada method: Estimated distortion parameters

	Share of expectations passed on to 0 percent from deflationary expectations (percent)	Share of expectations rounded to -5 or -10 (percent point)	Share of expectations rounded to 5 or 10 (percent point)
	ρ	4θ	4ϕ
Long-term inflation expectations	70.9 (1.9)	0.67 (0.05)	12.73 (0.13)
Short-term inflation expectations	82.9 (1.3)	1.00 (0.06)	13.23 (0.17)
Current inflaion perceptions	75.6 (1.5)	1.86 (0.12)	12.03 (0.19)

Note: Standard errors in parentheses.

Table 4. Descriptive statistics of potential distribution obtained by Kamada method

	Mean (%)	Standard deviation (%)	Skewness	Kurtosis
Long-term inflation expectations	3.1	5.0	0.3	3.2
Short-term inflation expectations	2.7	5.7	0.1	2.6
Current inflation perceptions	2.0	6.2	0.2	2.4

Notes: 1. Averaged from September 2006 to December 2014.

2. The mail-method bias is not corrected.

Table 5. Mail-method bias in potential distribution obtained by Kamada method

	Mean (%)		
	In-home	Mail	Difference
Long-term inflation expectations	2.5	3.7	+1.2
Short-term inflation expectations	2.5	3.4	+0.9
Current inflation perceptions	-0.1	1.1	+1.3

Note: The June 2006 survey.

Table 6. Mail-method bias in underlying distribution obtained by parametric method

(a) Descriptive statistics

	Mean (%)			Standard deviation (%)		
	In-home	Mail	Difference	In-home	Mail	Difference
Long-term inflation expectations	2.6	3.6	+1.0***	3.1	3.9	+0.8
Short-term inflation expectations	2.5	3.4	+1.0***	4.7	4.1	-0.7
Current inflation perceptions	0.0	1.4	+1.4***	4.9	4.5	-0.4

	Skewness			Kurtosis		
	In-home	Mail	Difference	In-home	Mail	Difference
Long-term inflation expectations	1.3	1.7	+0.4	4.1	5.9	+1.8
Short-term inflation expectations	0.3	0.4	+0.1	1.0	0.7	-0.3
Current inflation perceptions	0.0	0.1	+0.0	0.3	0.2	-0.1

Notes: 1. The June 2006 survey.

2. *** indicates significance at the 1% level.

(b) Estimated mail-method bias

	Mean (%)		
	In-home	Mail	Difference
Long-term inflation expectations	2.8	3.8	+1.0***
Short-term inflation expectations	2.6	3.7	+1.0***
Current inflation perceptions	0.3	1.8	+1.5***

Notes: 1. The June 2006 survey.

2. *** indicates significance at the 1% level.

Table 7. Statistical test for difference in descriptive statistics of underlying distribution

Long-term inflation expectations	Mean (%)		Variance		Skewness		Kurtosis	
	Before	After	Before	After	Before	After	Before	After
December 2009	1.24	1.15	17.6	18.3	0.55	0.58	2.55	2.97
October 2010	1.15	1.76 ***	18.3	17.1	0.58	0.75	2.97	2.67
February 2012	1.76	1.89	17.1	15.9	0.75	0.71	2.67	2.11
January 2013	1.89	2.08 *	15.9	13.3 *	0.71	2.24 ***	2.11	10.82 ***

Short-term inflation expectations	Mean (%)		Variance		Skewness		Kurtosis	
	Before	After	Before	After	Before	After	Before	After
December 2009	-1.05	-1.19	28.9	27.3	0.00	0.00	0.15	0.18
October 2010	-1.19	0.93 ***	27.3	28.1	0.00	0.02	0.18	0.09
February 2012	0.93	0.85	28.1	25.3	0.02	0.05	0.09	0.16
January 2013	0.85	2.59 ***	25.3	16.1 ***	0.05	0.62 ***	0.16	1.36 *

Notes: 1. We divide the period from March 2009 to December 2014 into five subsamples with four specified months in the table as separations, and conduct statistical tests to compare the descriptive statistics of adjacent subsamples separated by each month. The null hypothesis of the statistical test is "the mean / variance / skewness / kurtosis is equal between two subsamples."

2. In December 2009, the meaning of the understanding of medium- to long-term price stability was clarified. In December 2010, comprehensive monetary easing (CME) was introduced. In February 2012, the price stability goal in the medium to long term was introduced. In January 2013, the price stability target was introduced.

3. ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

4. The mail-method bias, 1.0% for both long- and short-term inflation expectations, is corrected in the means.

Table 8. Estimation result of multiple regression model

Long-term inflation expectations		Baseline	CME	QQE	Total
Mean	Constant	0.752 ***	0.220 **	0.084	1.056 ***
	Inflation perceptions	0.427 ***	-0.038 ***	-0.053 ***	0.336 ***
Variance	Constant	20.106	-0.869	-3.277 ***	15.960
Skewness	Constant	1.448 ***	0.030	1.410 ***	2.888 ***
Kurtosis	Constant	3.129	0.688 ***	7.680 **	11.497

Short-term inflation expectations		Baseline	CME	QQE	Total
Mean	Constant	0.378 ***	0.681 ***	0.596 ***	1.655 ***
	Inflation perceptions	0.735 ***	-0.110 ***	-0.067 ***	0.558 ***
Variance	Constant	32.092	0.272	-8.198 ***	24.167
Skewness	Constant	0.161	-0.015	0.489 ***	0.635 ***
Kurtosis	Constant	0.052	-0.002	1.118 **	1.168

Notes: 1. "QQE" stands for the introduction of a price stability target and quantitative and qualitative monetary easing.

2. ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

3. The mail-method bias, 1.0% for both long- and short-term inflation expectations, is corrected in the mean for "Constant" of "Baseline."

Table 8. Estimation result of multiple regression model for recognition of central bank objectives

(a) Long-term inflation expectations

Recognizing monetary policy well		Baseline	CME	QQE	Total
Mean	Constant	0.973 ***	0.202 **	0.167 ***	1.342 ***
	Inflation perceptions	0.414 ***	-0.037 ***	-0.098 ***	0.279 ***
Variance	Constant	20.026	0.859	-4.124 **	16.761
Skewness	Constant	1.508 ***	-0.018	1.408 ***	2.898 ***
Kurtosis	Constant	3.120	1.307 ***	7.545 **	11.972

Not recognizing monetary policy		Baseline	CME	QQE	Total
Mean	Constant	0.448 ***	0.204 *	-0.154 **	0.498 ***
	Inflation perceptions	0.573 ***	-0.019 ***	-0.014	0.540 ***
Variance	Constant	44.329	1.382 ***	11.897 **	57.608
Skewness	Constant	0.828 ***	0.032	-0.227 **	0.633 ***
Kurtosis	Constant	1.057	2.140 *	4.437 **	7.634

(b) Short-term inflation expectations

Recognizing monetary policy well		Baseline	CME	QQE	Total
Mean	Constant	0.496 ***	0.655 ***	0.361 ***	1.512 ***
	Inflation perceptions	0.516 ***	-0.113 ***	-0.070 ***	0.333 ***
Variance	Constant	14.448	-0.579 ***	-1.813 ***	12.055
Skewness	Constant	0.157	0.018 ***	0.756 ***	0.931 ***
Kurtosis	Constant	0.525	0.011 *	2.772 **	3.308

Not recognizing monetary policy		Baseline	CME	QQE	Total
Mean	Constant	0.297 ***	0.419 ***	0.054	0.770 ***
	Inflation perceptions	0.818 ***	-0.099	-0.056	0.663 ***
Variance	Constant	30.769	-0.387	-3.259 ***	27.123
Skewness	Constant	0.172	0.012 *	0.642 ***	0.826 ***
Kurtosis	Constant	0.105	0.009	1.240 **	1.354

Notes: 1. "QQE" stands for the introduction of a price stability target and quantitative and qualitative monetary easing.
2. ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.
3. The mail-method bias, 1.0% for both long- and short-term inflation expectations, is corrected in the mean for "Constant" of "Baseline."

Table B. Estimation result of multiple regression model: Effects of realized inflation on inflation expectations

Log-likelihood	Long-term inflation expectations	Short-term inflation expectations	Current inflation perceptions
All items less energy and food	-140,246.5	-131,981.5	-132,093.1
All items less fresh food (Core)	-140,130.5	-131,720.5	-130,639.2
All items (Headline)	-140,143.0	-131,464.5	-131,050.0
Items related to energy and food	-140,178.9	-131,622.1	-130,443.5

Long-term inflation expectations		Baseline	CME	QQE	Total
Mean	Constant	1.759 ***	0.358 ***	0.081 *	2.198 ***
	Realized inflation	0.302 ***	-0.057	-0.069 ***	0.176 ***
Variance	Constant	18.585	-0.283	-0.954 ***	17.347
Skewness	Constant	1.233 ***	0.049	1.462 **	2.744 ***
Kurtosis	Constant	5.526	0.661 ***	7.092 **	13.279

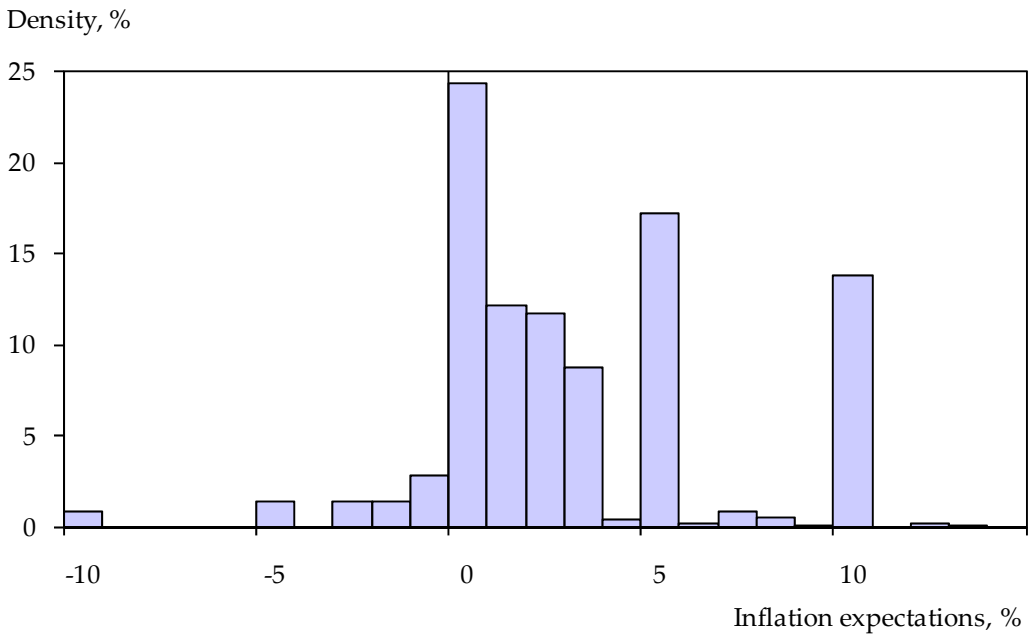
Short-term inflation expectations		Baseline	CME	QQE	Total
Mean	Constant	0.945 ***	0.512 ***	1.085 ***	2.542 ***
	Realized inflation	0.655 ***	-0.023	-0.006	0.626 ***
Variance	Constant	35.474	0.911	-14.003 ***	22.382
Skewness	Constant	0.009	-0.047	0.587 ***	0.549 ***
Kurtosis	Constant	0.148	0.138	0.893 **	1.179

Current inflation perceptions		Baseline	CME	QQE	Total
Mean	Constant	0.152 ***	1.076	1.383	2.611 ***
	Realized inflation	0.877 ***	-0.037	0.086	0.926 ***
Variance	Constant	38.415	0.835	-12.697 ***	26.553
Skewness	Constant	0.165 ***	-0.171	0.079	0.073 ***
Kurtosis	Constant	0.527	0.034	0.061	0.622

Notes: 1. Parameter estimates are obtained from the model using the realized inflation whose log likelihood is the highest, indicated by the shadow in the top panel.

2. "QQE" stands for the introduction of a price stability target and quantitative and qualitative monetary easing.
3. ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.
4. The mail-method bias, 1.0% and 1.5% for long- and short-term inflation expectations, and current inflation perceptions, respectively, is corrected in the mean for "Constant" of "Baseline."

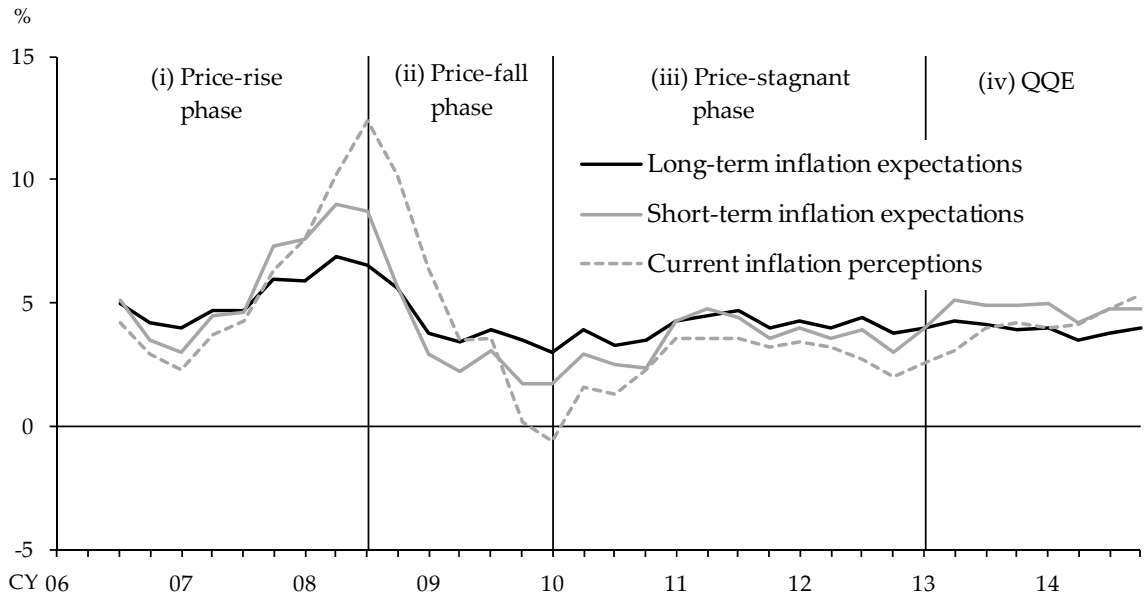
Figure 1. Distribution of survey answers on long-term inflation expectations



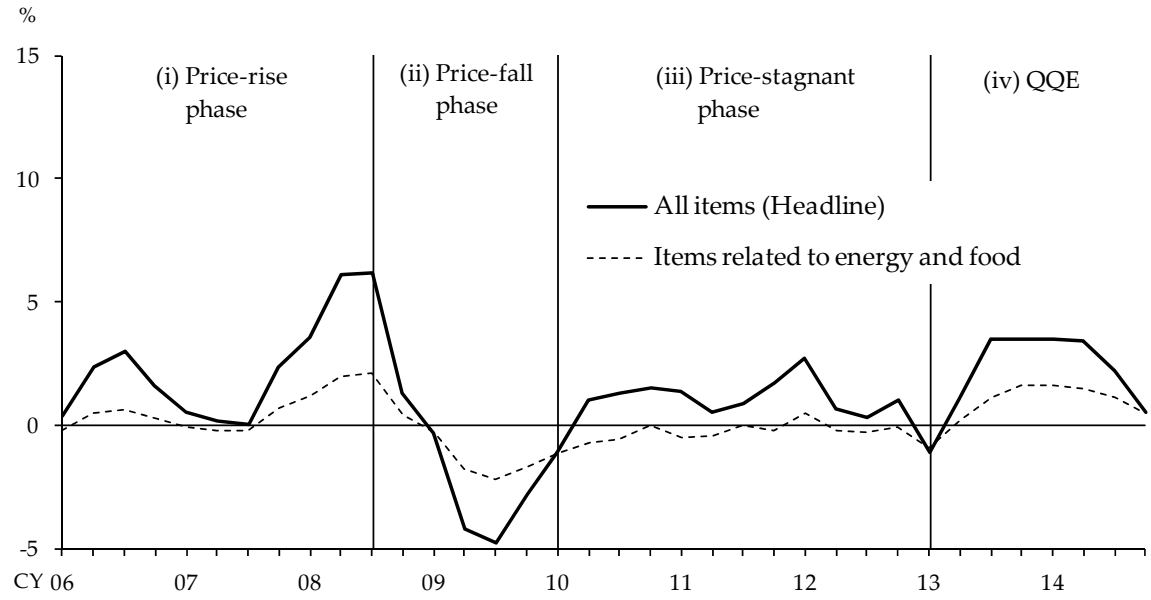
Note: The December 2012 survey.

Figure 2. Mean responses of inflation expectations and perceptions, and developments of actual inflation rates

(a) Inflation expectations and perceptions

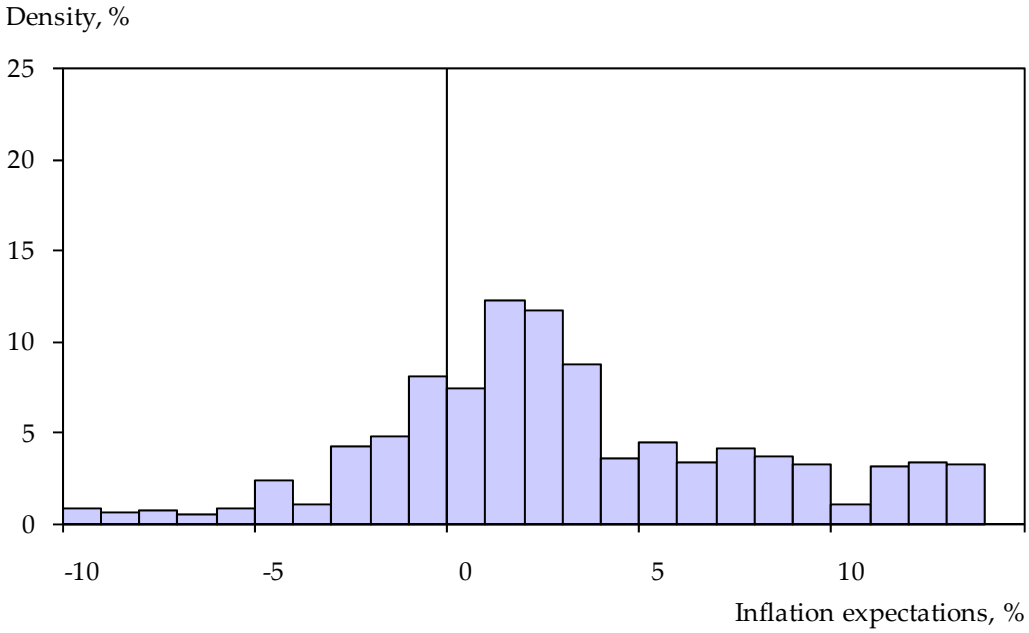


(b) Actual inflation rates



Notes: 1. Outliers above and below 0.5% are cut off for inflation expectations and perceptions.
2. The direct effects of the consumption tax hikes are excluded for actual inflation rates.

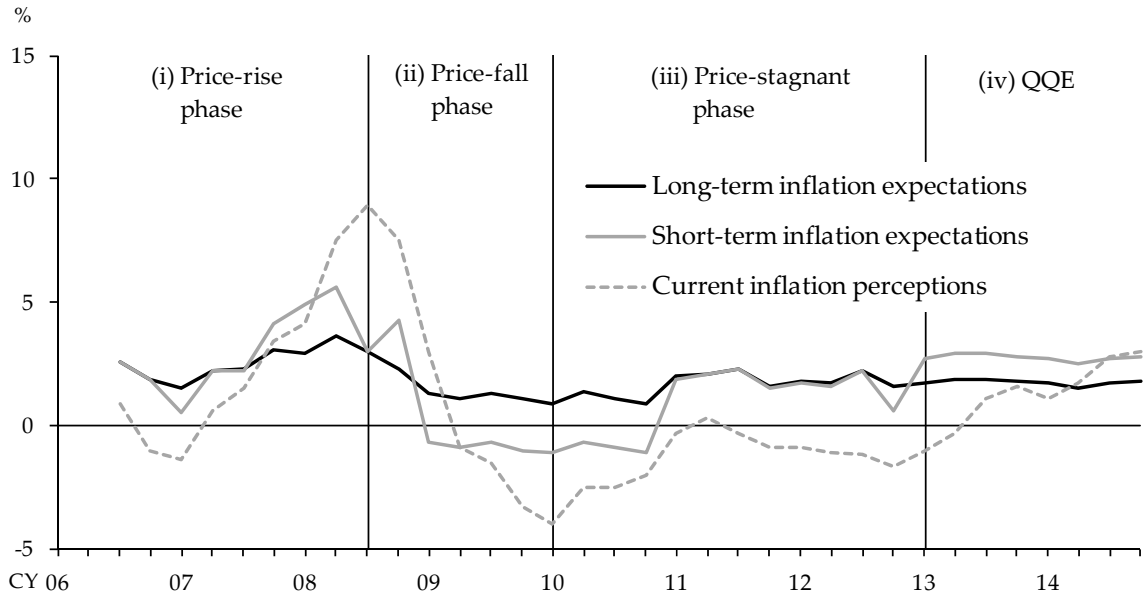
Figure 3. Potential distribution of long-term inflation expectations obtained by Kamada method



Notes: 1. The December 2012 survey.

2. The mail-method bias is not corrected.

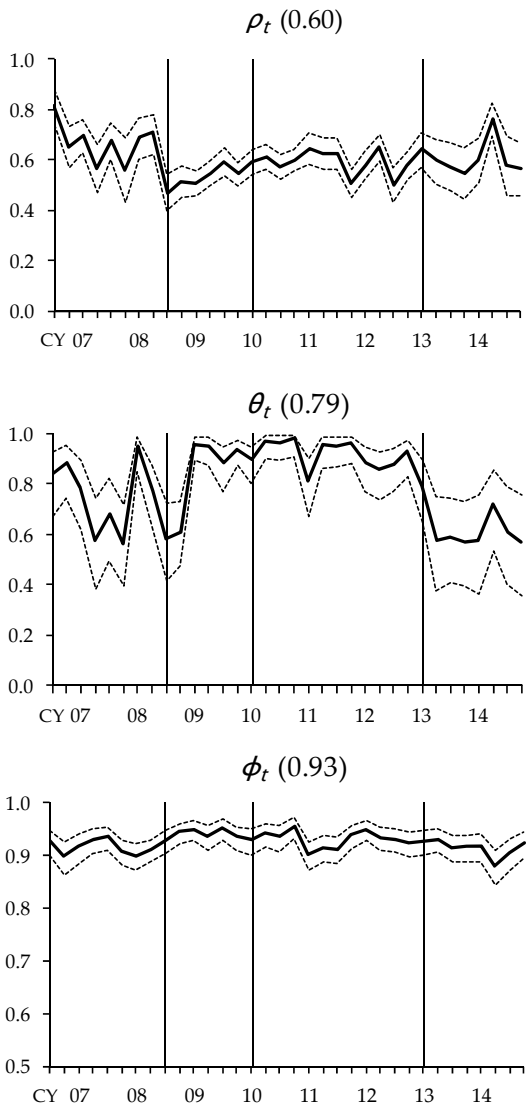
Figure 4. Means of potential distribution of inflation expectations and perceptions obtained by Kamada method



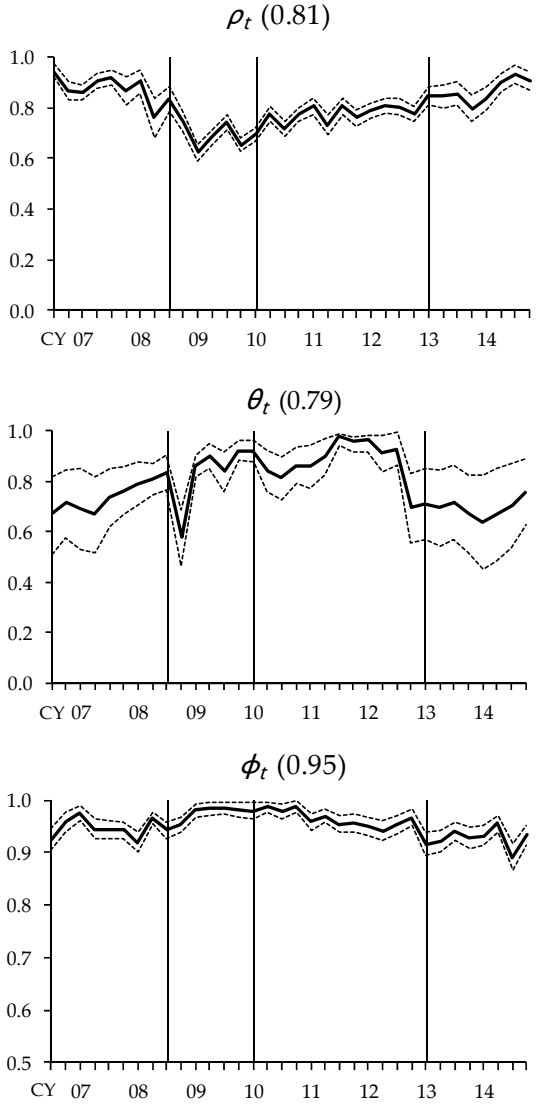
Note: The mail-method bias, 1.2%, 0.9%, and 1.3% for long- and short-term inflation expectations, and current inflation perceptions, respectively, is corrected.

Figure 5. Results of parametric method: estimated distortion parameters

(a) Long-term inflation expectations

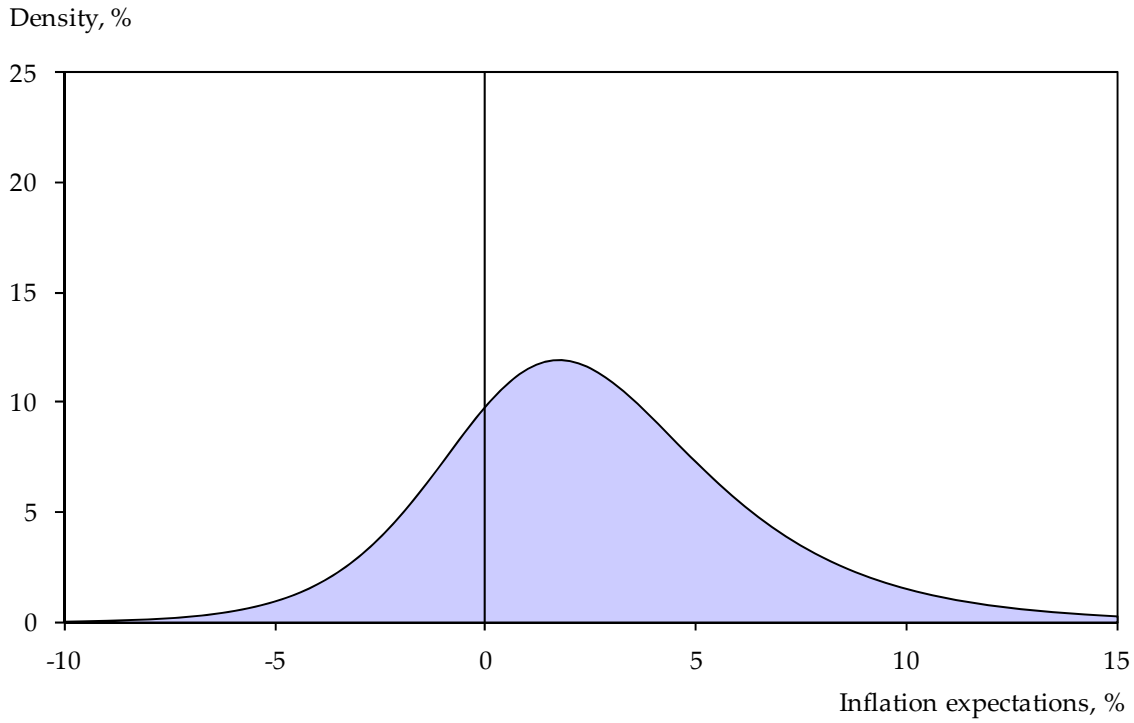


(b) Short-term inflation expectations



Note: Dotted lines indicate 95 percent confidence intervals. Averaged values over the sample period are in parentheses.

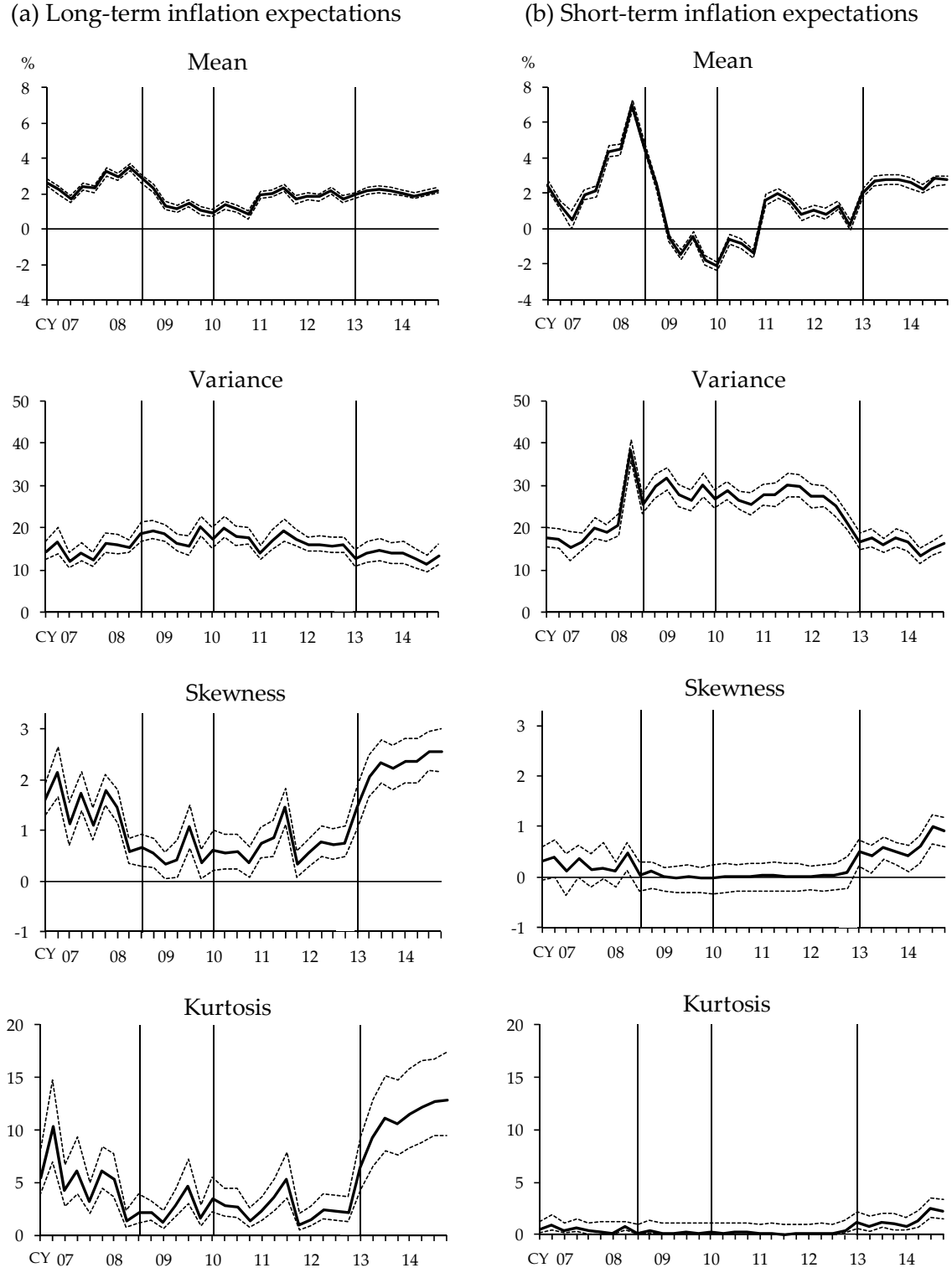
Figure 6. Underlying distribution of long-term inflation expectations



Notes: 1. The December 2012 survey.

2. The mail-method bias is not corrected.

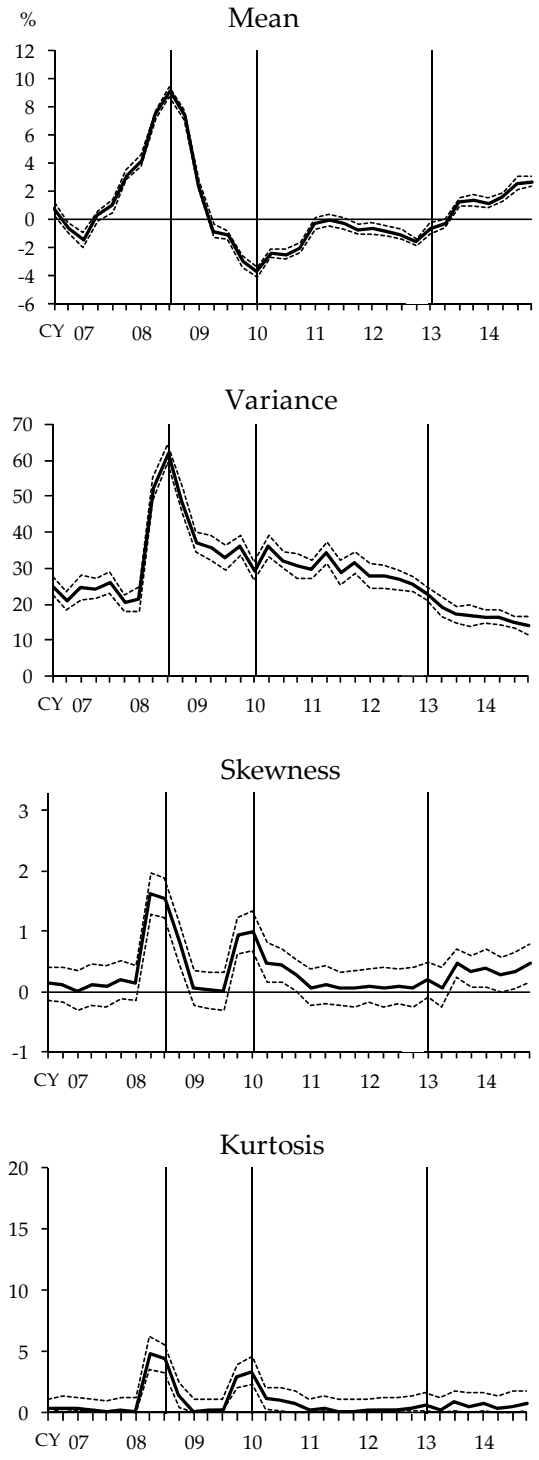
Figure 7. Descriptive statistics of underlying distribution of inflation expectations and perceptions



Note: The mail-method bias, 1.0% for both long- and short-term inflation expectations, is corrected in the means. Dotted lines indicate 95 percent confidence intervals.

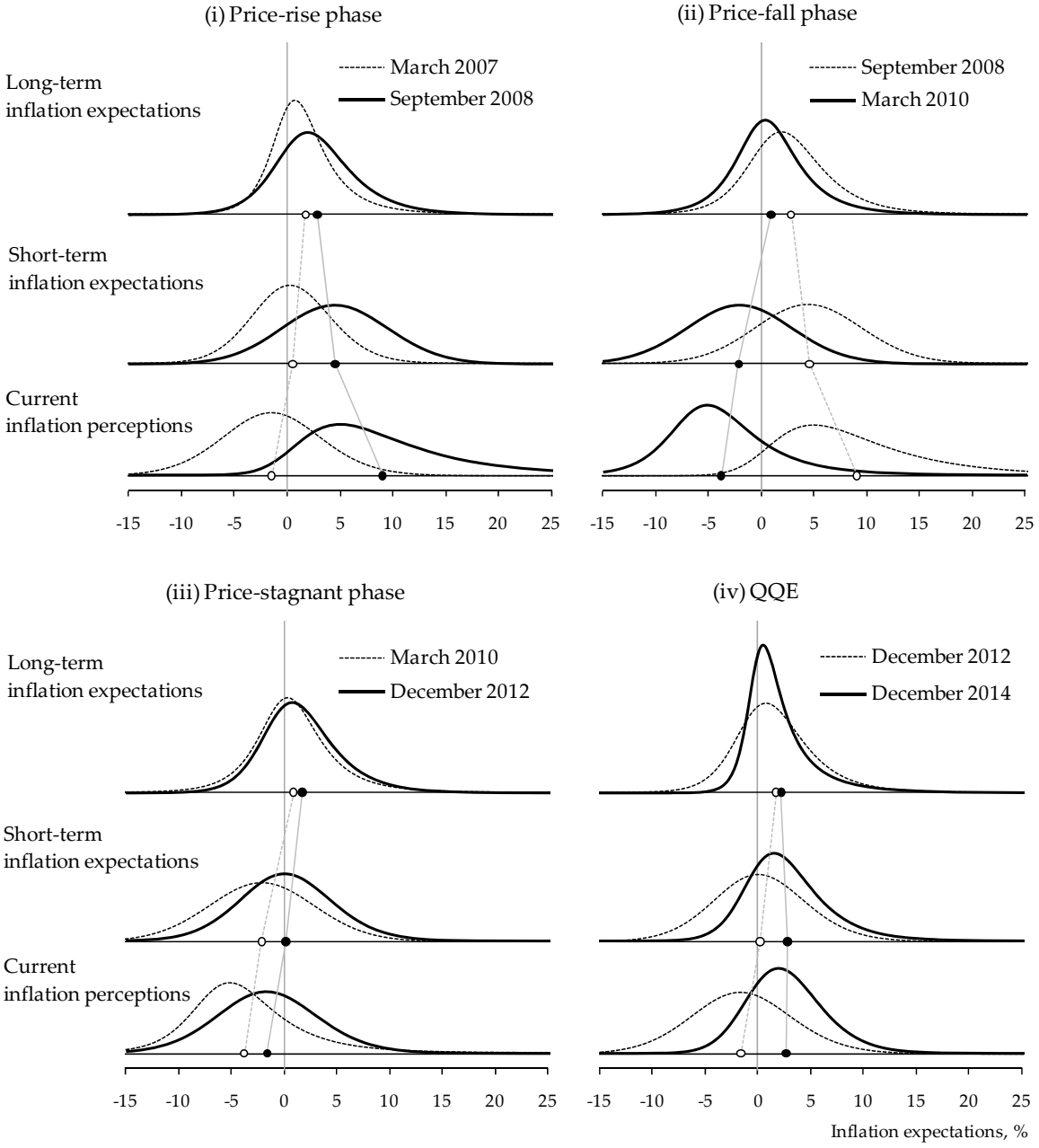
Figure 7. (cont.)

(c) Current inflation perceptions



Note: The mail-method bias, 1.5% for current inflation perceptions, is corrected in the means. Dotted lines indicate 95 percent confidence intervals.

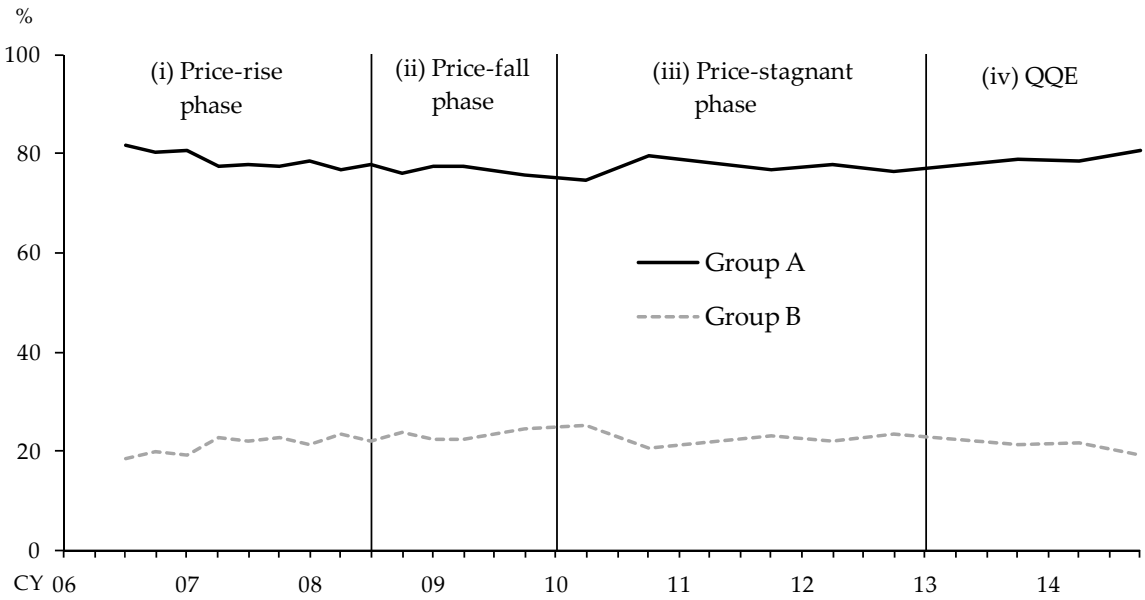
Figure 9. Term structures of inflation expectations and perceptions



Notes: 1. White and black circles indicate the means of the distribution depicted by the dotted and solid curves, respectively.

2. The mail-method bias, 1.0% and 1.5% for long- and short-term inflation expectations, and current inflation perceptions, respectively, is corrected.

Figure 9. Recognition of Bank's objectives of price stability



Note: To the question "Do you know that one of the Bank's objectives is to achieve price stability?" Group A is the household whose members answer "Know about it" or "Have read or heard of it, but do not know much about it." Group B is the one whose members answer "Have never heard of it."