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Assessing Measures of Inflation Expectations: A Term Structure and Forecasting Power Perspective

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This article presents approaches to assessing various measures of inflation expectations in terms of their term structure and forecasting power. First, looking at inflation expectations by forecast horizon, movements in measures of short-term inflation expectations are relatively similar across different economic agents, while there is considerable heterogeneity in long-term inflation expectations. Second, in terms of the forecasting power for future inflation, while measures of longer-term inflation expectations have a larger bias, once this bias is removed, many measures have forecasting power. Moreover, composite indicators based on the term structure and forecasting power of individual measures suggest that medium- to long-term inflation expectations have risen moderately in recent years.

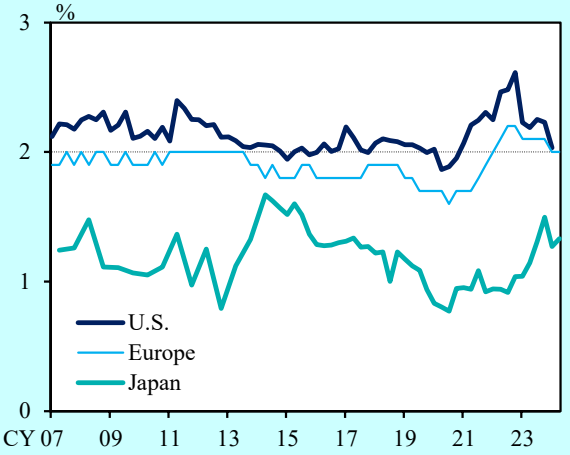
Introduction

Inflation has risen sharply around the world as a result of the increase in demand and the supply constraints associated with the resumption of economic activity in the wake of the COVID-19 pandemic as well as the subsequent rise in commodity prices as a result of heightened geopolitical tensions.

Recent medium- to long-term inflation expectations of economists in Japan and abroad (Chart 1) indicate that – despite some upward movement as economies recovered from the pandemic – expectations in the United States and Europe have generally remained anchored at the inflation target of around 2 percent. A closer look shows that although there was a period when inflation expectations shifted somewhat upward as inflation rates were elevated, inflation expectations have recently returned to around 2 percent, partly due to the effects of monetary tightening.

On the other hand, although inflation expectations in Japan have been rising recently, they remain lower than those in the United States and Europe, and below the Bank of Japan's price stability target of 2 percent. This is mainly due to the fact that in Japan, people's behavior and mindset based on the assumption that wages and prices will not increase easily became entrenched in society as a result of the past experience of prolonged low growth and deflation. That said, the Bank of Japan's baseline outlook is that as firms become more proactive in their wage- and price-setting behavior – that is, as the virtuous cycle between wages and prices intensifies – inflation expectations will rise further toward 2 percent, and the Bank expects that the inflation rate will gradually become anchored at that level.

[Chart 1] International Comparison of Medium- to Long-term Inflation Expectations



Note: Based on economists' forecasts. Figures for Japan are from the Consensus Forecasts (6 to 10 years ahead), those for the U.S. from the Survey of Professional Forecasters (10 years ahead), and those for Europe from the Survey of Professional Forecasters (Long-run).
Sources: Consensus Economics Inc., "Consensus Forecasts"; Federal Reserve Bank Philadelphia; ECB.

Thus, understanding inflation expectations, which reflect people's perceptions of price developments, is extremely important for assessing whether price stability is being achieved in a sustainable manner.[1] However, there are various measures of inflation expectations, with some based on surveys of different types of economic agents and others based on market prices. Even the expectations of the same type of agents have different meanings and statistical characteristics

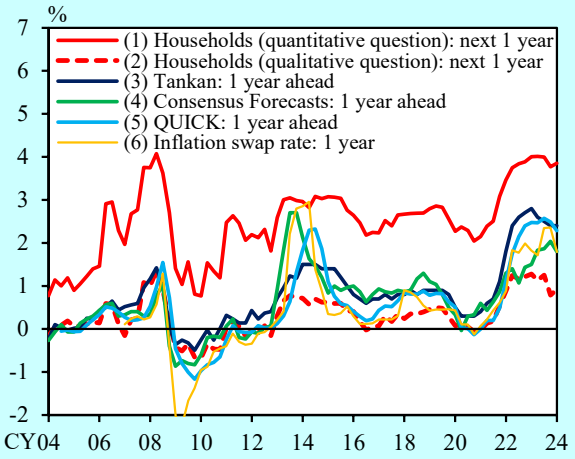
depending on their forecast horizon, so that they need to be interpreted with caution. Against this background, this article examines the characteristics of various measures of inflation expectations in Japan from two perspectives: the term structure of inflation expectations from the near to the distant future, and the forecasting power of measures of inflation expectations with respect to future inflation. In addition, this article proposes new composite indicators that aggregate a range of information on inflation expectations based on the term structure and forecasting power of these measures, and examines recent developments in inflation expectations using such indicators.

Term Structure of Measures of Inflation Expectations

Measures of Inflation Expectations by Forecast Horizon and Type of Economic Agents

Chart 2 shows the short-term (about 1 year ahead) inflation expectations of various economic agents.

[Chart 2] Measures of Inflation Expectations: Short-term



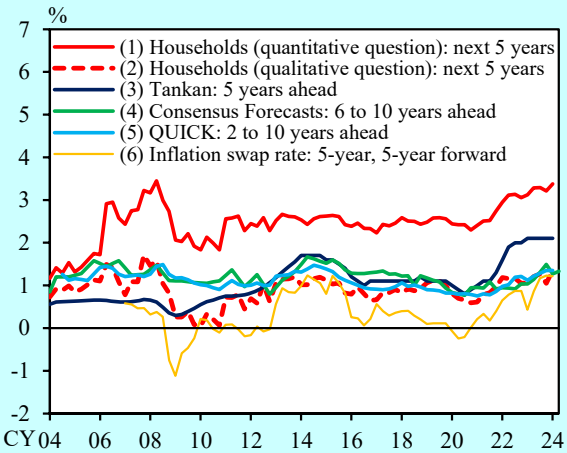
Note: Figures for Measure (4) (based on the Consensus Forecasts) are the average of forecasts for 3 to 5 quarters ahead.
Sources: Bank of Japan; QUICK, "QUICK Monthly Market Survey <Bonds>"; Consensus Economics Inc., "Consensus Forecasts"; Bloomberg.

As measures for households' inflation expectations, we use the results of the Bank of Japan's "Opinion Survey on the General Public's Views and Behavior." The survey asks two types of questions to capture inflation expectations. The first asks respondents to provide a numerical value for their expected inflation rate. To construct the measure of households' inflation expectations based on this question (Measure (1)), extreme responses exceeding plus or minus 5 percent are replaced by plus or minus 5 percent, respectively.[2] The second is a qualitative question that asks respondents whether they expect prices to go up or down with five response categories. To construct a measure based on this question (Measure (2)), the results are quantified using the modified Carlson-Parkin method.[3] Next, with regard to firms' inflation expectations, we use their outlook for general prices taken from the *Tankan* survey (Measure (3)).[4] As measures of the inflation expectations of experts, we use the inflation outlook in the Consensus Forecasts, which represents the expectations of economists, and in the QUICK Survey, which represents the expectations of market participants (Measures (4) and (5), respectively). As a market-based measure of inflation expectations, we use inflation swap rates (inflation swaps are financial derivatives with the consumer price index as the underlying asset) estimated and published by Bloomberg (Measure (6)).[5]

Developments in these six measures all show similar trends, albeit with differences in their levels. After rising from 2004 to 2008, they fell sharply after the global financial crisis and remained low for a while. After the Bank of Japan started with quantitative and qualitative monetary easing in 2013, the measures rose sharply until 2015 but then began to decline gradually.[6] More recently, they have risen substantially again in the wake of the COVID-19 pandemic. Looking at the levels of individual measures, Measure (1), which is obtained by aggregating the numerical responses of households (based on the quantitative question in the "Opinion Survey"), is consistently higher than the other measures, suggesting that the responses may be biased upward.

Chart 3 shows the medium- to long-term inflation expectations of the different economic agents.

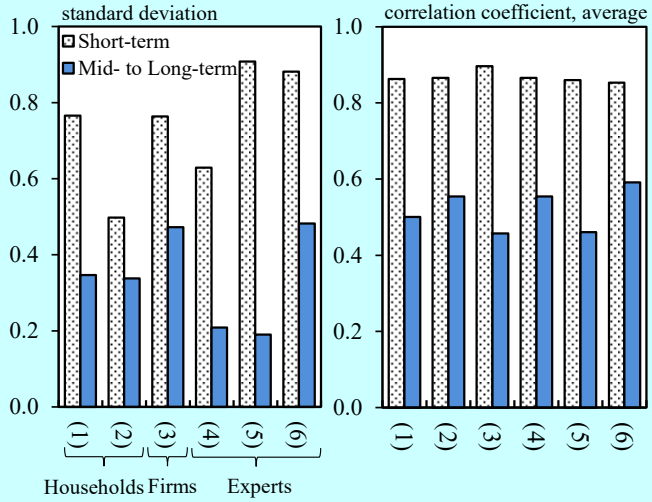
[Chart 3] Measures of Inflation Expectation: Medium- to Long-term



Sources: Bank of Japan; QUICK, "QUICK Monthly Market Survey <Bonds>"; Consensus Economics Inc., "Consensus Forecasts"; Bloomberg.

While developments are broadly similar to those in short-term inflation expectations, there are some notable differences: all measures show a smaller range of fluctuation; the difference in levels between measures is more pronounced; and the correlation between developments is smaller (Chart 4). This is likely due to the fact that developments in short-term inflation expectations are more in line with current economic activity and prices and therefore tend to contain similar information, so that they tend to be more closely correlated. On the other hand, medium- to long-term inflation expectations depend to a large extent on different economic agents' perceptions of the price-formation mechanism and past experience, which are likely to be subject to greater heterogeneity across economic agents.

[Chart 4] Volatility and Co-movement of Measures of Inflation Expectations



Note: The numbers on the horizontal axis refer to Measures (1) to (6). The estimation period is from 2007Q1 to 2023Q4. Figures in the right chart are simple averages of the coefficient of correlation with the other five indicators.

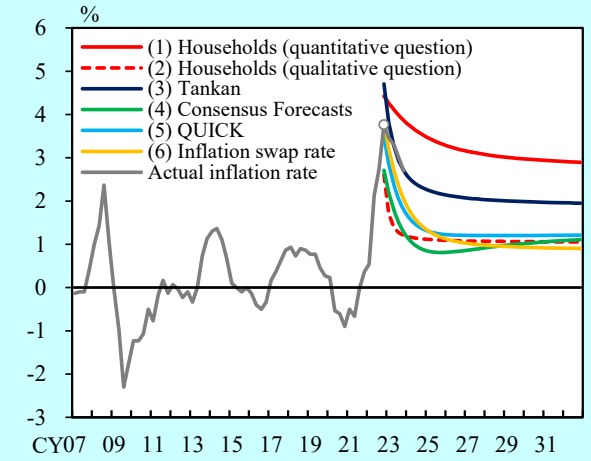
Sources: Bank of Japan; QUICK, "QUICK Monthly Market Survey <Bonds>"; Consensus Economics Inc., "Consensus Forecasts"; Bloomberg.

Term Structure of Inflation Expectations

Chart 5 shows the term structure of inflation expectations from the short term to the long term.

It should be noted that, for all measures, values are only available for a specific forecast horizon, and those horizons are not identical across measures. For example, the "Opinion Survey" only asks about the perceived rate of change in prices (compared to one year ago), the expected rate of change in prices over the next 1 year, and the expected rate of change in prices over the next 5 years. Therefore, for this article, we construct a time-series model that allows the term structure of inflation expectations to change over time and interpolate values for forecast horizons that are not available.[7]

[Chart 5] Term Structure of Inflation Expectations



Note: The chart shows the estimates of economic agents' inflation expectations by forecast horizon as of 2022Q4. The estimates are obtained using the dynamic Nelson-Siegel model. The actual inflation rate is based on the CPI excluding fresh food (and the effects of consumption tax hikes).

Sources: Bank of Japan; Ministry of Internal Affairs and Communications, QUICK, "QUICK Monthly Market Survey <Bonds>"; Consensus Economics Inc., "Consensus Forecasts"; Bloomberg.

Looking at the term structure as of 2022Q4, when inflation peaked most recently, the inflation expectations of all types of economic agents generally start from the actual inflation rate and decline toward the future. Although there is heterogeneity in the levels across measures, the direction of change in inflation expectations follows a similar pattern for many measures, indicating that households, firms, and experts share a similar view of future developments in price inflation.

Forecasting Power of Measures of Inflation Expectations

As indicated by the above characteristics, inflation expectations can be regarded as containing information about different types of agents' views on the future rate of inflation. Previous studies have made conflicting arguments with regard to whose inflation expectations should have higher forecasting power. Some have argued that the inflation expectations of economic agents with more information about the future, such as experts, should have higher forecasting power. Others, in contrast, have argued that the inflation expectations of economic agents such as households and firms should have higher forecasting power, since they refer to their own inflation expectations when making consumption and investment decisions and engaging in wage and price negotiations, and their inflation

expectations therefore are likely to have a direct impact on actual price developments. Given these conflicting arguments, there is no consensus on which measure is the most useful. This article therefore provides a comparison and examination of the forecasting power of the different measures of inflation expectations using a simple approach following previous studies.[8]

Methodology for Examining Forecasting Power

To examine the forecasting power of measures of inflation expectations, we focus on forecasts of the annualized rate of change in the consumer price index (CPI) from (1) the present to 1 year ahead and (2) from the present to 3 years ahead, using the inflation expectations for the corresponding forecast horizon. Since there is little point in forecasting short-term fluctuations in the inflation rate, we use the CPI excluding fresh food and energy and the effects of consumption tax hikes. To evaluate the forecasting power, the root mean squared forecast error (RMSFE) is used as an indicator. The benchmark used is the inflation rate itself, that is, the forecast error that is obtained by assuming that the inflation rate remains unchanged from its current level. The forecast power of each measure of inflation expectations is then examined by testing whether its forecast error is statistically significantly smaller than (i.e., the measure is superior to) the benchmark.[9]

When testing for forecasting power, the bias in the measures of inflation expectations is also taken into account. As mentioned earlier, the measures differ in their average levels, suggesting that there may be a persistent gap between some of the measures and the inflation rate. As shown in Chart 6, with regard to 1-year-ahead inflation expectations, statistical tests reveal a notable upward bias in the measure based on households' expectations using the quantitative question, as well as a small upward bias in firms' expectations.[10] With regard to 3-year-ahead inflation expectations, there is an upward bias in all measures except for the measure based on inflation swaps; that said, similar calculations using data from 2013 onward only yield a similar pattern as for 1 year ahead expectations, suggesting that the biases may have diminished in recent years.[11] The following section also examines whether removing these biases can improve forecasting power.

[Chart 6] Upward Bias in Measures of Inflation Expectations

%

	All period		From 2013Q2	
	1 year ahead	3 years ahead	1 year ahead	3 years ahead
Households (quantitative)	2.3 ***	2.3 ***	2.2 ***	2.0 ***
Households (qualitative)	0.0	0.4 **	-0.2	0.1
Tankan	0.5 ***	0.7 ***	0.5 **	0.6 **
Consensus Forecasts	0.2	0.5 **	0.0	0.2
QUICK	0.1	0.4 *	-0.0	0.1
Inflation swap rate	-0.1	-0.1	-0.1	-0.3

Note: Figures are based on the regression results for the following model: $\pi_t^e - \pi_t = \alpha + \varepsilon_t$, where π_t denotes the actual inflation rate, π_t^e represents each measure of inflation expectations, and α can be interpreted as the upward bias of a measure. The regressions use data from 2007Q1 to 2023Q4. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. The actual inflation rate is based on the CPI excluding fresh food and energy (and the effects of consumption tax hikes).

Forecasting Power of Measures of Inflation Expectations by Forecast Horizon

Chart 7 provides an overview of the forecast error of each measure (relative to the benchmark) for (1) inflation up to 1 year ahead and (2) inflation up to 3 years ahead.[12]

[Chart 7] Forecasting Power of Measures of Inflation Expectations

(1) For inflation over the next 1 year

	Unadjusted	Bias adjusted
Households (quantitative)	1.19	-0.33 **
Households (qualitative)	-0.25 **	-0.31 **
Tankan	-0.36 **	-0.47 ***
Consensus Forecasts	-0.17 *	-0.19 **
QUICK	-0.24 **	-0.27 **
Inflation swap rate	-0.38 ***	-0.40 ***

(2) For inflation over the next 3 years

	Unadjusted	Bias adjusted
Households (quantitative)	1.57	-0.22 ***
Households (qualitative)	-0.02	-0.24 ***
Tankan	0.05	-0.35 ***
Consensus Forecasts	0.10	-0.18 **
QUICK	0.02	-0.18 **
Inflation swap rate	-0.18 ***	-0.19 ***

Note: The chart shows the forecast error (RMSFE) of each measure of inflation expectations, relative to the benchmark (i.e., rate of change in the CPI excluding fresh food and energy). A Diebold-Mariano test was conducted with the null hypothesis that the forecast error of each measure is equal to or greater than that of the benchmark. ***, **, and * denote that the null hypothesis is rejected at a significance level of 1%, 5%, or 10%, respectively. The results in (1) are for 2007Q1 to 2022Q4, while those in (2) are for 2007Q1 to 2020Q4.

First, looking at the forecasting power for inflation over the next 1 year, many measures of inflation expectations have a statistically significantly smaller forecast error than the benchmark (i.e., they outperform the benchmark). Although the measure for households based on the quantitative question has no forecasting power when unadjusted for bias, its forecasting power improves substantially when adjusted for bias and is in fact greater than (i.e., the forecast error is smaller than) that of the measure for economists based on the Consensus Forecasts. In contrast, the forecasting power of the other measures is about the same with and without adjustment for bias. Next, looking at the forecasting power for inflation over the next 3 years, while all measures except the one based on inflation swaps show no forecasting power before the adjustment for bias, their forecasting power improves substantially once they are adjusted for bias.

Thus, it is useful to take biases into account in order to improve the forecasting power of measures; that said, it should also be noted that biases may change over time. For example, if economic agents increasingly believe that medium- to long-term inflation will remain at around 2 percent, measures of medium- to long-term inflation expectations may converge to around 2 percent, in which case the bias is likely to diminish. Moreover, the forecast performance of the measures may also change from phase to phase. Given that the mechanisms underlying inflation expectations and price formation are complex and unclear in many respects, excessive reliance on specific measures solely from the standpoint of their forecasting power should be avoided.[13]

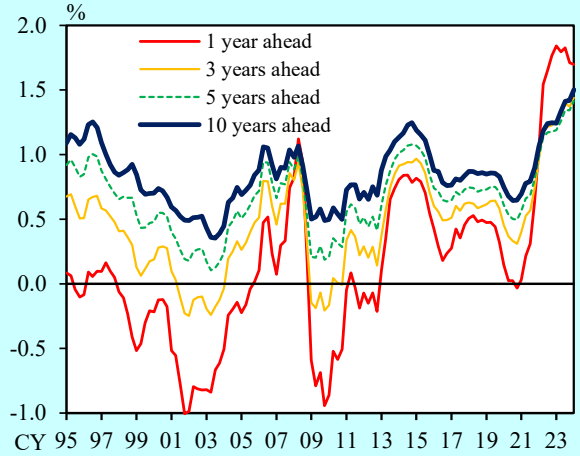
Composite Indicators of Inflation Expectations

While, as seen above, the measures of the inflation expectations of different economic agents and for different forecast horizons each have their own idiosyncrasies, they all have a certain explanatory power, and it is useful to look at a variety of measures in order to grasp the perceptions of future inflation developments of each type of economic agents. On the other hand, when examining the role of inflation expectations using an economic model, it is useful to aggregate this information into one single indicator. The following therefore presents the construction of composite indicators of inflation expectations using two approaches that take the characteristics of the different measures in terms of their term structure and forecasting power into account.

Construction of Composite Indicators

The first method is to use principal component analysis to extract a common trend in the inflation expectations of different economic agents. Specifically, we use the estimates obtained above for different forecast horizons to construct composite indicators for these forecast horizons by estimating the first principal component (common trend) of the measures for households, firms, and experts for each forecast horizon. Since there are a total of six measures – one for firms based on the *Tankan*, two for households, based on the quantitative and the qualitative question, and three for experts, based on the Consensus Forecasts, the QUICK Survey, and inflation swaps – there are six possible combinations when using one measure for each of the three types of economic agents. Thus, for each combination, we extract the common trend of the three measures and then calculate the average of the six values thus obtained. While this approach is based on the same idea as the "synthesized inflation expectations indicator" proposed by Nishino et al. [2016], it differs in that we interpolate values for forecast horizons for which no observations are available and then calculate composite indexes by aligning the forecast horizons. This allows us to assess the term structure of composite inflation expectations.[14]

[Chart 8] Principal Component-Based Composite Index of Inflation Expectations, by Forecast Horizon



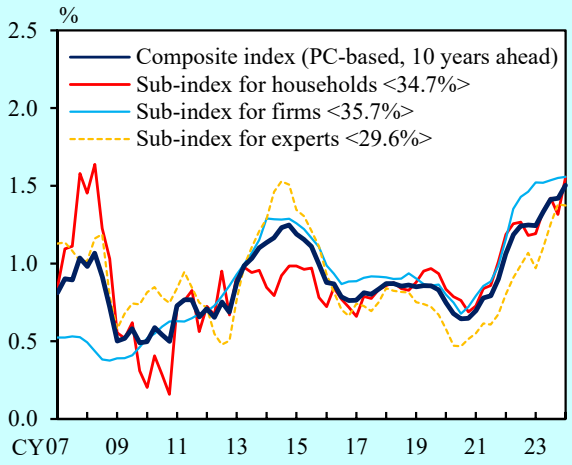
Note: The chart shows the principal component-based composite index of inflation expectations for different forecast horizons. The common trend was extracted from the six measures of inflation expectations, namely, the two measures for households (qualitative and quantitative questions, "Opinion Survey on the General Public's Views and Behavior"), the one measure for firms (*Tankan*), and the three measures for experts (Consensus Forecasts, QUICK, and inflation swap rates), using principal component analysis. Figures up to 2006 are rough estimates due to data constraints and are shown for reference.

Sources: Bank of Japan; QUICK, "QUICK Monthly Market Survey <Bonds>"; Consensus Economics Inc., "Consensus Forecasts"; Bloomberg.

Looking at the developments in the principal component-based composite index of inflation expectations (PC-based CIE) for each forecast horizon, inflation expectations for all forecast horizons have increased substantially since 2020 and have recently reached their highest levels since the mid-2000s (Chart 8). The indexes for the different forecast horizons all follow a similar pattern in terms of their upward and downward movements over the observation period, but while 1-year-ahead inflation expectations have recently started to decline, longer-term inflation expectations have continued to rise moderately. Moreover, looking at the convergence to long-term inflation expectations, while inflation expectations 3 years or more ahead have recently all converged to very similar levels, in the past, and especially before 2013, even 5-year-ahead expectations did not show any convergence to long-term expectations and the pace of increase in inflation was expected to be very moderate.

Next, Chart 9 presents the composite index for 10-year-ahead inflation expectations, as well as the sub-indexes for households, firms, and experts. As can be seen in the chart, during the phases of rising inflation expectations in 2007 and 2013, the different indicators showed divergent developments, while in the current phase all indicators are rising, with firms' inflation expectations' somewhat ahead and experts' inflation expectations lagging somewhat behind.

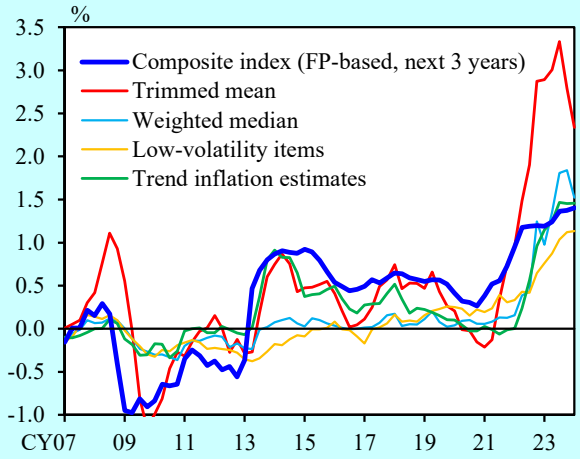
[Chart 9] Principal Component-Based Composite Index of Inflation Expectations, by Type of Economic Agents



Note: For the estimation methods and sources, see Chart 8. Numbers in angular brackets indicate the share of each sub-index in the overall composite index.

The second method employs the forecast combination approach, which is based on the idea of combining various forecasting models to increase forecasting power. Specifically, using the inverse of the RMSFE of each measure of inflation expectations as weights, the weighted average of the six measures is calculated, so that the measures with the highest forecasting power are given a larger weight.[15] To enhance the forecasting power of our composite index, (1) we use the bias-adjusted value of each measure (taking into account changes in bias over time), and (2) construct time-varying weights using the exponential moving average, in which past information decays at a constant rate, to account for the possibility that the forecasting power of each measure may change depending on the particular phase or situation.[16]

[Chart 10] Forecasting Power-Based Composite Index of Inflation Expectations



Note: The forecasting power-based composite index is calculated as the weighted average of the six measures of inflation expectations, namely, the two measures for households (qualitative and quantitative questions, "Opinion Survey on the General Public's Views and Behavior"), the one measure for firms (*Tankan*), and the three measures for experts (Consensus Forecasts, QUICK, and inflation swap rates), with time-varying weights based on the inverse of the RMSFE for 3-year inflation forecasts. The other indicators are also based on Band of Japan staff calculations.

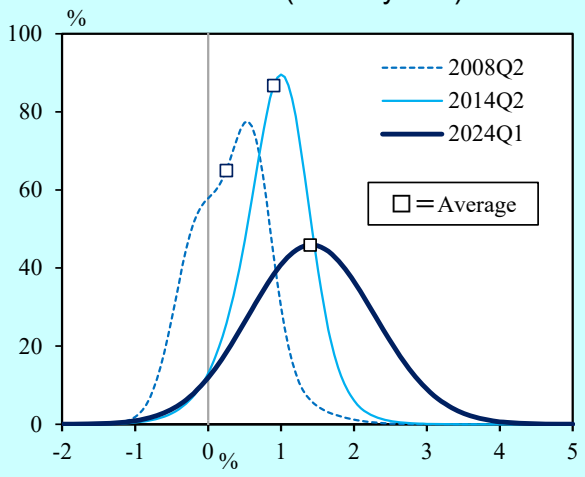
Sources: Bank of Japan; QUICK, "QUICK Monthly Market Survey <Bonds>"; Consensus Economics Inc., "Consensus Forecasts"; Bloomberg.

Looking at developments in the forecasting power-based composite index of inflation expectations (FP-based CIE) for next 3 years inflation (Chart 10), like the PC-based CIE, it has risen substantially since 2020 and has recently reached its highest level since the mid-2000s. Moreover, when this index is compared with various indicators of the underlying trend in the CPI (the trimmed mean and weighted median of item-level price changes, and price changes in low-volatility items[17]) and with estimates of trend inflation obtained using econometric methods based on a Phillips curve model,[18] these indicators show similar movements and a strong correlation. This suggests that the FP-based composite index of inflation expectations is related to developments in underlying inflation.[19]

Composite Distribution of Forecasts

For the FP-based composite index, it is also possible to construct the composite distribution by calculating the weighted average of the forecast distributions based on the six measures used in the composite index. For example, the dispersion of the computed composite distribution will be larger if the forecasts implied by the measures are widely dispersed than when all the forecasts are relatively close to each other. Moreover, since the forecast error of each measure is allowed to vary over time, the shape of the composite distribution will also be wider as the forecasting power of the measures declines.

[Chart 11] Composite Distribution of Inflation Forecasts (next 3 years)



Note: The composite distribution at each point in time is calculated as the weighted average of the forecast distributions based on the six measures of inflation expectations making up the forecasting power-based composite index (see Chart 10), with time-varying weights. The forecast distributions are calculated assuming that the measures follow a normal distribution and using the forecast value of each measure as the mean and the forecast error as the variance.

Chart 11 shows the composite distribution of expectations for inflation over the next 3 years. The latest data for 2024Q1 suggests that the distribution has widened and the likelihood that inflation over the next 3 years will reach about 2 percent has steadily increased.

Since the shape of the composite distribution can vary considerably depending on technical assumptions such as the smoothing method and the time-varying weights, it should be viewed as just one of various estimates and be interpreted with some caution. That said, it should be noted that the shape of the current distribution suggests that the degree of uncertainty in forecasts is increasing.[20]

Conclusion

This article provided an overview of the characteristics of the measures of inflation expectations of different economic agents in terms of their term structure and forecasting power. The analysis showed that although there are large upward biases in the level of inflation expectations measures, especially for longer forecast horizons, many measures have significant forecasting power with regard to future inflation once these biases are adjusted for. Since the mechanisms underlying the formation of inflation expectations and their impact on price developments are complex, it is important to look at a variety of measures together when monitoring inflation expectations. In addition, the composite indicators aggregating the information contained in the individual inflation expectations measures using statistical methods suggest that there recently has been a moderate rise in inflation expectations, implying that the likelihood that underlying inflation is rising toward 2 percent has increased.

To accurately capture the underlying inflation trend, it is necessary to examine not only various measures of inflation expectations but also other information from a variety of perspectives.[21] Keeping these points in mind, it is important to continue to further deepen our understanding of inflation expectations going forward.

[1] For details on the heightened role of inflation expectations in the current phase and the importance of looking at both short- and long-term inflation expectations of various economic agents in order to understand developments in inflation expectations, see:

Adrian, T. [2023]: "The Role of Inflation Expectations in Monetary Policy," Remarks at the IBF/Deutsche Bundesbank Symposium, May 2023.

Binder, C., and R. Kamdar [2022]: "Expected and Realized Inflation in Historical Perspective," *Journal of Economic Perspectives*, vol. 36, number 3, 131-156.

Williams, J. C. [2023]: "Effective Dialogue and Well Anchored Inflation Expectations: Essential Tools for Navigating Challenging Times," in: Bank for International Settlements (eds.), *Central Banking in the Americas: Lessons from Two Decades*, 149-162.

[2] The reason for treating household responses exceeding ±5 percent as outliers is that, as discussed by Sekine et al. [2008], while they are unlikely to all be accurate forecasts, they have a significant impact on the calculated mean. In our analysis, instead of removing extreme responses as in the trimmed mean, we used the Winsorized mean, where outliers are replaced by values at the end of an acceptable range.

Sekine, T., K. Yoshimura, and C. Wada [2008]: "On Inflation Expectations," Bank of Japan Review Series, 2008-J-15 (available in Japanese only).

[3] For details on the modified Carlson-Parkin method using information on the percentage of responses in five response categories, see:

Ito, Y., and S. Kaihatsu [2016]: "Effects of Inflation and Wage Expectations on Consumer Spending: Evidence from Micro Data," Bank of Japan Working Paper Series, 16-E-7.

[4] Since the *Tankan* started to survey firms' inflation outlook for general prices in 2014, data for the period before that do not exist. This article uses estimates from Nakajima [2023a] for the period before 2014, estimated retroactively using other information from firms' survey responses, including from the Cabinet Office's "Annual Survey of Corporate Behavior."

Nakajima, J. [2023a]: "Estimation of Firms' Inflation Expectations Using the Survey DI," IER Discussion Paper Series A.749, Hitotsubashi University.

[5] As a measure of inflation expectations based on market transaction prices, the break-even inflation rate (BEI), which is defined as the difference between the yield on inflation-indexed government bonds and the yield on non-indexed government bonds, would also be useful. However, since the Japanese government did not issue inflation-indexed bonds between 2008 and 2013, and the characteristics of the inflation-indexed bonds before and after the 2008–2013 hiatus differ substantially in terms of whether the principal is guaranteed or not, it is difficult to generate long-term time series data by maturity, so that the BEI rate is not used in the analysis here. For more details, see:

Hiraki, K., and W. Hirata [2020]: "Market-based Long-term Inflation Expectations in Japan: A Refinement on Breakeven Inflation Rates," Bank of Japan Working Paper Series, 20-E-5.

[6] The large increase in experts' 1-year-ahead expectations around 2013 likely reflects the fact that they factored in the impact of the consumption tax rate hike in 2014.

[7] Following Aruoba [2016], who estimates the term structure of inflation expectations for the United States, this article constructs a dynamic Nelson-Siegel model. The observed data used to estimate the model are as follows: for Measures (1) and (2) on households' inflation expectations, the perceived rate of change in prices (compared to a year earlier), the expected rate over the next 1 year, and the expected rate over the next 5 years from the "Opinion Survey;" for Measure (3) on firms' inflation expectations, firms' inflation outlook for general prices 1, 3, and 5 years ahead in the *Tankan*; for Measure (4) on economists' inflation expectations, quarterly forecasts up to 2 years ahead, and yearly forecasts up to 5 years ahead and the average of forecasts for 6 to 10 years ahead from the Consensus Forecasts; for Measure (5) on market participants' expectations, forecasts for 1 year, 1 to 2 years, and 2 to 10 years ahead from the QUICK Survey; and for market-based Measure (6), 1 year swap rates, 1-year, 4-year forward swap rates, and 5-year, 5-year forward swap rates. Meanwhile, since the effect of the consumption tax hikes seen in the short-term forecasts of experts can be regarded as a temporary special factor, we construct and use a series in which this effect is removed in the estimation of the term structure to avoid any impact on the estimation results.

Aruoba, S. B. [2016]: "Term Structures of Inflation Expectations and Real Interest Rates," Federal Reserve Bank of Philadelphia Working Paper 16-09/R.

For a study on the term structure of inflation expectations in Japan, see:

Maruyama, T., and K. Suganuma [2020]: "Inflation Expectations Curve in Japan," *Japanese Journal of Monetary and Financial Economics*, vol. 8, 1-28.

[8] There is a considerable empirical literature, especially abroad, on the forecasting power of measures of inflation expectation. Examples include the studies by Ang et al. [2007] and Adeney et al. [2017], who, similar to the analysis in this article, examine the forecasting performance of various measures of inflation expectations after adjusting for bias.

Adeney, R., I. Arsov, and R. Evans [2017]: "Inflation Expectations in Advanced Economies," RBA Bulletin March 2017, 31-44.

Ang, A., G. Bekaert, and M. Wei [2007]: "Do Macro Variables, Asset Markets, or Surveys Forecast Inflation Better?" *Journal of Monetary Economics*, vol. 54, 1163-1212.

In addition, there have also been various recent empirical analyses of the usefulness of measures of inflation expectations in forecasting inflation. See, for example:

Bae, E., A. Hodge, and A. Weber [2024]: "U.S. Inflation Expectations during the Pandemic," IMF Working Paper, 24/25.

Diercks, A. M., C. Campbell, S. Sharpe, and D. Soques [2023]: "The Swaps Strike Back: Evaluating Expectations of One-Year Inflation," FRB Finance and Economics Discussion Series, 2023-061.

Eva, K., and F. Winkler [2023]: "A Comprehensive Empirical Evaluation of Biases in Expectation Formation," FRB Finance and Economics Discussion Series, 2023-042.

[9] Specifically, as in previous studies such as Faust and Wright [2013], we conduct a Diebold-Mariano test with the null hypothesis that the forecast error of a measure of inflation expectations is equal to or greater than the forecast error of the benchmark (the actual inflation rate).

Faust, J., and J. H. Wright [2013]: "Forecasting Inflation," in: *Handbook of Economic Forecasting*, vol. 2, 2-56.

In terms of forecasting models using measures of inflation expectations, there are alternative approaches, such as examining whether including inflation expectations measures in a Phillips curve model provides additional information (see, e.g., Coibion et al. [2018] and Nakajima [2023a]). However, since the objective of this article is to examine whether measures of inflation expectations are useful when used in the least processed form possible, the approach adopted was to directly compare measures of inflation expectations with the future inflation rate. Moreover, this means that the approach is equivalent to tests in previous studies of whether economic agents' expectations are rational (i.e., rationality tests with regard to $\mathrm{E}[\pi_t] = \pi_t^e$).

Coibion, O., Y. Gorodnichenko, and R. Kamdar [2018]: "The Formation of Expectations, Inflation, and the Phillips Curve," *Journal of Economic Literature*, vol. 56, number 4, 1447-1491.

[10] Specifically, following previous studies such as Mankiw et al. [2003], a *t*-test (mean bias test) was conducted against the null hypothesis that the historical mean of the measure of inflation expectations and that of the actual inflation rate are equal.

Mankiw, N. G., R. Reis, and J. Wolfers [2003]: "Disagreement about Inflation Expectations," *NBER Macroeconomics Annual*, vol. 18, 209-248.

For Japan, previous studies have pointed out that there is an upward bias in the responses of households (Kamada [2008]) and small business owners (Uno et al. [2018]).

Kamada, K. [2008]: "Downward Stickiness of Households' Inflation Expectations: An Analysis Using the 'Opinion Survey of the General Public's Views and Behavior'," Bank of Japan Working Paper Series, 08-J-8 (available in Japanese only).

Uno, Y., S. Naganuma, and N. Hara [2018]: "New Facts about Firms' Inflation Expectations: Simple Tests for a Sticky Information Model," Bank of Japan Working Paper Series, 18-E-14.

[11] Regarding changes in the bias in measures of inflation expectations, Ang et al. [2007], for example, based on a survey of household inflation expectations conducted by the University of Michigan in the United States, reported that an upward bias tends to emerge when inflation declines. For Japan, Kamada [2008] pointed out that the lower the inflation rate, the larger the upward bias may be, given the existence of downward rigidity in the distribution of households' inflation expectations. Moreover, the link between inflation expectations and wage- and price-setting behavior appears to be strengthening, as seen in the

resurgence of base pay increases in labor-management wage negotiations since 2014, which may be reducing the bias.

[12] Here, the forecast error is calculated using a specification that allows the bias to change (decrease) from the second quarter of 2013 (when quantitative and qualitative monetary easing was introduced). That said, the results remain essentially unchanged when the bias is assumed to be constant, although the forecasting power is somewhat lower.

[13] In this context, Reis [2023] argues that instead of trying to find one best measure of inflation expectations from a particular perspective, such as predictive power, it is useful to capture as many signals as possible from different measures, since the inflation expectations of different economic agents play different roles in macroeconomic activity and are interrelated.

Reis, R. [2023]: "Four Mistakes in the Use of Measures of Expected Inflation," *AEA Papers and Proceedings,* vol. 113, 47-51.

[14] To construct their composite indicator (i.e., the "synthesized inflation expectations indicator"), Nishino et al. [2016] used (1) the quantitative question on households' inflation expectations 5 years ahead in the "Opinion Survey on the General Public's Views and Behavior," (2) the diffusion index for changes in output prices in the *Tankan*, (3) the Consensus Forecasts (6 to 10 years ahead), (4) the QUICK Survey (average for the next 10 years), and (5) the inflation swap rate (5-year, 5-year forward). This means that their indicator is composed of both short- and long-term information, so that it is not possible to capture features such as the nature of the currently observed differential movements in short- and long-term expectations.

Nishino, K., H. Yamamoto, J. Kitahara, and T. Nagahata [2016]: "Developments in Inflation Expectations over the Three Years since the Introduction of Quantitative and Qualitative Monetary Easing (QQE)," Bank of Japan Review Series, 2016-E-13.

The principal component analysis was conducted using data from 2007 onward, the first year from which all source data are available. Figures before 2007 are reference values calculated retrospectively using the weights obtained in the principal component analysis and available data (note that for the period before 2005, only the Consensus Forecasts and the retrospective estimates by Nakajima [2023a] based on the *Tankan* are available). Moreover, as in Nishino et al. [2016], the period mean and variance of the first principal component are standardized to be identical to the period mean and variance of the measures of inflation expectations of experts (average of the three measures), which have relatively small biases.

[15] The advantages of forecast combination include that (1) the use of multiple forecasts makes it possible to produce estimates that are robust to structural changes and (2) it reduces the noise in forecasts (see, e.g., Diebold and Pauly [1987] and Timmermann [2006]). Meanwhile, the usefulness of employing the inverse of forecast errors as weights, as in this article, was shown by Hubrich and Skudelny [2016], among others.

Diebold, F. X., and P. Pauly [1987]: "Structural Change and the Combination of Forecasts," *Journal of Forecasting*, vol. 6, number 1, 21–40.

Timmermann, A. [2006]: "Forecast Combinations," in: *Handbook of Economic Forecasting*, vol. 1, 135–196.

Hubrich, K., and F. Skudelny [2016]: "Forecast Combination for Euro Area Inflation: A Cure in Times of Crisis?" ECB Working Paper Series, no. 1972.

[16] Specifically, the time-varying MSFE (exponential moving average) of measure i at time t is obtained using the following specification, where $\pi^{e}_{i,t-h}$ represents inflation expectations measure i from h quarters earlier and π^{h}_{t} is the actual inflation rate from h quarters earlier to time t:

$$MSFE_{i,t} = \lambda MSFE_{i,t-1} + (1-\lambda)\left(\pi^{e}_{i,t-h} - \pi^{h}_{t}\right)^2$$

where the decay parameter λ is set to 0.93 (i.e., half of the weight is given to information from the previous two and a half years). In addition, for the calculations, we use the long-run time series described in footnote 14, and for $MSFE_{i,0}$ at the start of the data (1991Q3) we use the simple average for the estimation period (the effect of which gradually fades away). The weight of each measure i at time t is calculated as the share of the inverse of the square root of the $MSFE_{i,t}$ in the total of all measures.

[17] For details on the trimmed mean and weighted median, see Hogen et al. [2015]. Ozaki et al. [2024] conducted a quantitative analysis using several methods, including focusing on low-volatility items that are less susceptible to temporary factors than conventional indicators, in order to identify upward price pressures stemming from the linkage between wages and prices during the current phase.

Hogen, Y., T. Kawamoto, and M. Nakahama [2015]: "Core Inflation and the Business Cycle," Bank of Japan Review Series, 2015-E-6.

Ozaki, T., M. Jimbo, T. Yagi, and A. Yoshii [2024]: "Recent Developments in the Linkage between Wages and Prices," Bank of Japan Review Series, 2024-E-2.

[18] Specifically, the trend inflation estimates in the figure are the estimated intercepts of the Phillips curve obtained using a regime-switching model following Nakajima [2023b].

Nakajima, J. [2023b]: "Estimating Trend Inflation in a Regime-Switching Phillips Curve," IER Discussion Paper Series A.750, Hitotsubashi University.

[19] Conceptually, inflation expectations correspond to the intercept of the Phillips curve and are an important factor in determining underlying inflation.

[20] The current widening of the distribution is mainly due to the fact that, over the past several years, actual inflation has exceeded the ex-ante expectations of economic agents, leading to an increase in the forecast error of the various measures.

[21] See Box 4 of the April 2024 issue of the Bank of Japan's *Outlook Report* (*Outlook for Economic Activity and Prices*) for a discussion of approaches to examining underlying inflation during the current phase. In addition to the approaches presented in this article, which focus on people's inflation expectations, it is beneficial to comprehensively assess underlying inflation by exploiting a variety of approaches, such as various indicators of underlying CPI inflation calculated using price statistics and trend inflation estimates based on various models.

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