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Developments in Inflation Expectations over the Three Years since the Introduction of Quantitative and Qualitative Monetary Easing (QQE)

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More than three years have passed since the Bank of Japan introduced QQE. This article provides analysis on developments in inflation expectations and on factors that have affected those developments during that period. Developments in inflation expectations can be divided into three phases in which inflation expectations rose, were flat, and weakened. While QQE pushed up inflation expectations, exogenous developments, such as the decline in crude oil prices and the volatility in global financial markets stemming from emerging economies, seem to have exerted downward pressure. Inflation expectations in Japan are inclined to develop in tandem with observed inflation; that is, expectations formation is largely adaptive. Thus, since summer 2014, with a fall in observed inflation rates due to exogenous factors, such as the decline in crude oil prices, inflation expectations followed suit, strongly reflecting the fall.

Introduction[1]

In January 2013, the Bank introduced the price stability target of 2 percent in terms of the year-on-year rate of change in the consumer price index (CPI), and in April that year, it introduced QQE with the aim of achieving the target at the earliest possible time. As a result, economic activity and price developments improved significantly, and Japan's economy is no longer in deflation, which is commonly defined as a sustained decline in prices. Nevertheless, despite the Bank's unprecedentedly large-scale monetary easing, the price stability target of 2 percent has not been achieved. On this point, developments in inflation expectations are important. This article provides analysis on these developments and on factors that have affected them during the period of more than three years since the introduction of QQE. The following three points are an overview of the results.

The first point is that developments in inflation expectations during the more than three years can be divided into three phases -- a rising phase (from April 2013 through summer 2014), a flat phase (from summer 2014 through summer 2015), and a weakening phase (since summer 2015 up until recently) -- and that the timing of changes in phases almost coincides with when adverse exogenous factors emerged, such as the decline in crude oil prices (since summer 2014) and volatile global financial markets stemming from emerging economies (since summer 2015).

The second point that the results of the analysis suggested is that the introduction of QQE (April 2013) and expansion of QQE (October 2014) had positive effects on the rise in inflation expectations. In contrast, the results also suggested that the effects of "QQE with a Negative Interest Rate" (January 2016) did not outweigh the adverse effects of, for example, the volatility in global financial markets stemming from emerging economies since summer 2015 and the low crude oil prices.

The last point is well known -- namely, inflation expectations in Japan are inclined to develop in tandem with observed inflation compared to other major economies; that is, expectations formation is largely adaptive. This is an important factor in understanding the reason for inflation expectations -- which had been rising steadily following the introduction of QQE -- becoming largely flat and consequently weakening as a result of exogenous factors, such as the decline in crude oil prices since summer 2014 and the volatility in global financial markets since summer 2015.

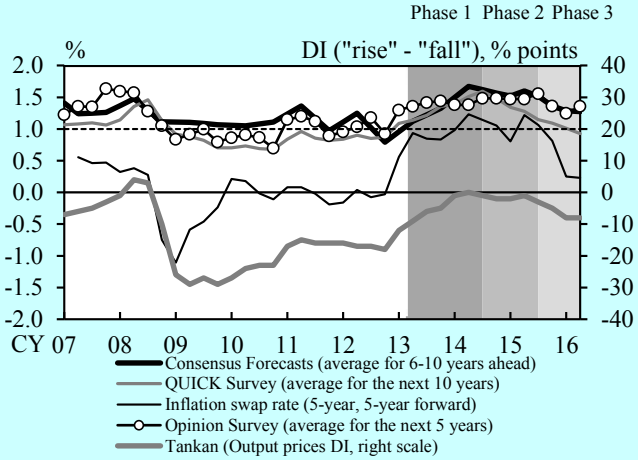
Three Phases of Developments in Inflation Expectations (Rising, Being Flat, and Weakening) and the Effects of Exogenous Factors

Phases divided by developments in inflation expectations

There are several ways to gauge inflation expectations, including market indicators estimated, for example, using inflation swaps, as well as indicators based on the results of surveys of households, firms, or experts (such as economists or market participants). While short-term fluctuations vary across these indicators, reflecting their different characteristics, overall developments in inflation expectations since the introduction of QQE can be broadly divided into three phases: Phases 1 to 3 (Chart 1).

Phase 1 is the period after the introduction of QQE -- which was in April 2013 -- through summer 2014. In this period, indicators of inflation expectations rose clearly. Phase 2 is from summer 2014 through summer 2015. During this period, indicators of inflation expectations were largely unchanged. Phase 3 is the period since summer 2015 up until now. Many indicators of inflation expectations have weakened during this phase. However, different indicators of inflation expectations all move in slightly different ways, so that the exact timing of the three phases differs somewhat depending on which of the indicators one focuses on.

[Chart 1] Medium- to Long-Term Inflation Expectations of Households, Firms, and Experts



Note: Semiannual data from the "Consensus Forecasts" up through 2014/Q2 are linearly interpolated. Opinion Survey figures exclude inflation expectations by respondents whose annual inflation expectations were ±5% or greater. The output prices DI in the *Tankan* represents the difference between the share of firms that raised prices in the preceding three months and the share of firms that lowered prices.

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

Dividing inflation expectations into phases using a statistical method

Thus, the exact timing of the three phases is examined using principal component analysis. This analysis is a technique that makes use of common factors that are extracted from multiple indicators, thus creating a new composite indicator. In this particular case, "synthesized inflation expectations indicators" were built based on the first principal component extracted from three separate indicators of inflation expectations of households (*Opinion Survey on the General Public's Views and Behavior*[2]), firms (diffusion index for change in output prices in the *Short-Term Economic Survey of Enterprises in Japan* [*Tankan*][3]), and experts. With regard to experts' inflation expectations, three indicators were used: the *Consensus Forecasts* (economists' inflation expectations), the *QUICK Monthly Market Survey* (inflation expectations of fixed income market participants), and the inflation swap rate (market participants' inflation expectations computed from inflation swaps. Each of these three indicators was synthesized with households' and firms' inflation expectations indicators to build a synthesized inflation expectations indicator.

The results of the principal component analysis indicated that the contribution ratio of the first principal component -- the share of the variance of the first principal component to total variance -- was more than 85 percent for all three synthesized inflation expectations indicators. This means that the first principal component accounted for more than eight tenths of total variations in inflation expectations of households, firms, and experts. Moreover, the eigenvectors of the first principal component -- which are weight coefficients for calculating the first principal component -- were more or less the same among inflation expectations of households, firms, and experts. This suggests that the first principal component extracts information from inflation expectations of households, firms, and experts in a balanced manner (Chart 2). Considering these, the "synthesized inflation expectations indicators" can be regarded as capturing the common trend in inflation expectations of the three different groups of economic agents (i.e., households, firms, and experts). Therefore, these new indicators make it possible to determine the timing of changes in phases after smoothing out idiosyncratic variations.

Looking at developments in the "synthesized inflation expectations indicators," these increased in

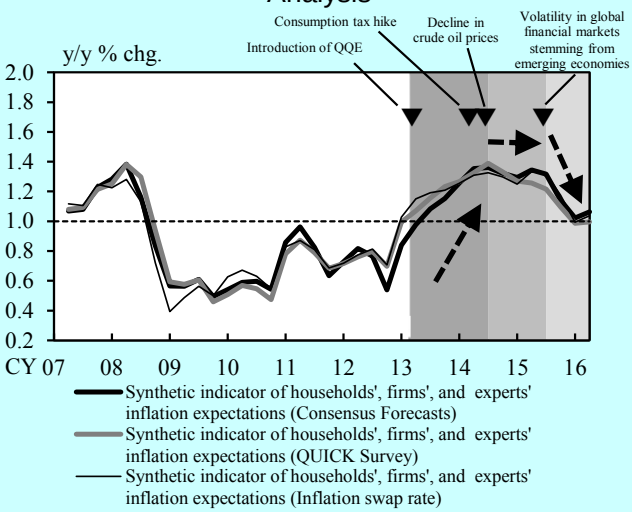
Phase 1 (from April 2013 through summer 2014), remained largely flat in Phase 2 (from summer 2014 through summer 2015), and weakened in Phase 3 (since summer 2015) (Chart 3). Thus, developments in synthetic indicators for inflation expectations obtained from the statistical method provide support for the timing of the division into these three phases.

[Chart 2] Contribution and Eigenvector of the First Principal Component

	Contribution of the first principal component (%)	Eigenvector of the first principal component		
		Households	Firms	Experts
Households, firms, and experts (Consensus Forecasts)	85.9	0.59	0.59	0.55
Households, firms, and experts (QUICK Survey)	90.2	0.57	0.59	0.57
Households, firms, and experts (Inflation swap rate)	86.9	0.59	0.59	0.55

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

[Chart 3] Synthesized Inflation Expectations Indicators Obtained through Principal Component Analysis



Notes: 1. Semiannual data from the "Consensus Forecasts" up through 2014/Q2 are linearly interpolated. Opinion Survey figures exclude inflation expectations by respondents whose annual inflation expectations were ±5% or greater. The output prices DI in the *Tankan* represents the difference between the share of firms that raised prices in the preceding three months and the share of firms that lowered prices.
2. Inflation expectations of households are represented by the "Opinion Survey" and those of firms are represented by the *Tankan*. The different lines show synthesized inflation expectations when using data from the "Consensus Forecasts," the "QUICK Survey," and the inflation swap rate for experts' inflation expectations, respectively.
3. A correlation matrix is used for principal component analysis.

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

The timing of changes in phases and exogenous shocks

The aforementioned timing of changes in phases coincided with that of the occurrence of adverse exogenous shocks. Specifically, inflation expectations changed from a "rising phase" (Phase 1) to a "flat phase" (Phase 2) in summer 2014, when crude oil prices declined and demand weakened following the consumption tax hike in April 2014. Then, at the time when adverse exogenous shocks occurred -- such as the slowdown in emerging economies since summer 2015 and the resultant volatility in global financial markets -- inflation expectations changed from a "flat phase" (Phase 2) to a "weakening phase" (Phase 3). All of this suggests that developments in inflation expectations -- which had been rising steadily since the introduction of QQE, became largely flat between summer 2014 and summer 2015, and weakened after summer 2015 -- were significantly affected by exogenous factors such as the decline in crude oil prices.

Examination of Inflation Expectations Dynamics

The underlying trend in Japan's inflation has improved steadily since the introduction of QQE. However, the price stability target of 2 percent has not been achieved. To examine why, this section presents a decomposition of the deviation of the observed inflation rate from the price stability target into several factors based on a model that consists of the Phillips curve and the mechanism of inflation expectations formation.

Formularization of the model and a method of decomposition

The model consists of a system of three equations, in which (1) the observed inflation rate depends on the output gap and short-term inflation expectations (Phillips curve), (2) short-term inflation expectations depend on the observed inflation rate in the previous period and medium- to long-term inflation expectations (the mechanism of inflation expectations formation), and (3) medium- to long-term inflation expectations depend on the price stability target set by the central bank and medium- to long-term inflation expectations in the previous period (the same formation mechanism). Both short-term (1 year ahead) and medium- to long-term (6-10 years ahead) inflation expectations are taken from the *Consensus Forecasts* for which long-term time-series data are available.[4] The observed inflation rate is measured in terms of the CPI for all items less fresh food and energy.

(1) Phillips curve
Observed inflation rate (%)
= Short-term inflation expectations (%)
+ α × 1-quarter lagged output gap (%)
+ Residuals

(2) Mechanism of inflation expectations formation (short-term)
Short-term inflation expectations (%)
= β × Medium- to long-term inflation expectations (%)
+ (1 - β) × 1-quarter lagged observed inflation rate
+ Residuals

(3) Mechanism of inflation expectations formation (long-term)
Medium- to long-term inflation expectations (%)
= ρ × 1-quarter lagged medium- to long-term inflation expectations (%)
+ (1 - ρ) × Price stability target (2%)
+ Residuals

Note that the residuals in equations (1) to (3) above represent shocks to (a) the observed inflation rate, (b) inflation expectations, and (c) the credibility of the price stability target, respectively. Specifically, when equations (2) and (3) are substituted for equation (1), the deviation of the observed inflation rate from the price stability target of 2 percent can be decomposed into these three shocks and the output gap. (For more details on the decomposition, see BOX "Decomposition of the Deviation into Three Types of Shocks.")

Three types of shocks

The aforementioned three types of shocks can be explained as follows.

(a) Observed inflation rate shocks: These are calculated as the deviations of the observed inflation rates from the Phillips curve. These deviations include short-term fluctuations in the observed inflation rate as well as the impact of developments in the real economy on the observed inflation rate not fully captured by the output gap.

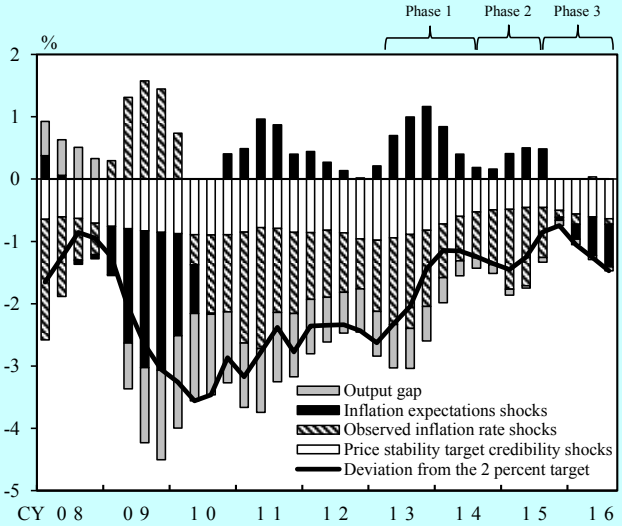
(b) Inflation expectations shocks: These are calculated as deviations of short-term inflation expectations from the relationship determining short-term inflation expectations. Such deviations include discontinuous changes in inflation expectations caused by a switch in the monetary policy regime, the effects of exchange rate movements that potentially have a persistent effect on prices, and second-round effects caused by energy price fluctuations.

(c) Price stability target credibility shocks: These are shocks that cause medium- to long-term inflation expectations to deviate from the price stability target. In contrast to the United States, where medium- to long-term inflation expectations are anchored, in Japan anchoring of inflation expectations to the price stability target of 2 percent is still in progress. Consequently, credibility shocks are negative throughout the observation period.

Decomposition results

The chart below shows the decomposition results. The results for each of the three phases can be summarized as follows (Chart 4).[5]

[Chart 4] Decomposition of Deviation of the Observed Inflation Rate from the 2 Percent Target



Notes: 1. Figures for the CPI (all items less fresh food and energy) are calculated by the Research and Statistics Department, Bank of Japan. They are adjusted to exclude the estimated effects of changes in the consumption tax rate. The figure for 2016/Q3 is that of July.
2. The figure for the output gap for 2016/Q2 is that for 2016/Q1.
3. Semiannual data from the "Consensus Forecasts" up through 2014/Q2 are linearly interpolated, and those from 2014/Q3 onward are quarterly data. They are adjusted to exclude the estimated effects of changes in the consumption tax rate.
Sources: Consensus Economics Inc., "Consensus Forecasts"; Ministry of Internal Affairs and Communications; Bank of Japan.

Phase 1: From April 2013 onward, Japan experienced a clear positive shock to inflation expectations, which suggests that the introduction of QQE provided a positive shock pushing up inflation expectations. Furthermore, the negative output gap, which previously had been putting downward pressure on prices, shrank to around 0 percent. A possible interpretation is that the decline in real interest rates brought about by the introduction of QQE led to an

improvement in the output gap. Reflecting these developments, the deviation of the observed inflation rate from the price stability target narrowed steadily.

Phase 2: The positive effect of the shock to inflation expectations witnessed in Phase 1 diminished over time. The additional positive effect of improvements in the output gap on the observed inflation rate disappeared. These developments can be regarded as reflecting the effects of the slowdown of Japan's economy, which was partly due to the consumption tax hike in April 2014. Moreover, the size of the negative observed inflation rate shocks increased, which suggests that, as a result of weaker private consumption, downward pressure on prices was greater than can be explained by changes in the output gap. However, due to the expansion of QQE in October 2014, inflation expectations shocks became clearly positive again, which helped to offset the negative shocks. Consequently, the deviation from the price stability target of 2 percent remained almost flat in Phase 2.

Phase 3: Since summer 2015, with global stock prices declining, partly as a result of the slowdown in emerging economies, the yen has appreciated against major currencies, while crude oil prices declined further toward the beginning of 2016. Against this backdrop, inflation expectations shocks have become negative. This suggests that inflation expectations have been pushed down partly by the second-round effects of the fall in crude oil prices, and that these negative effects have not yet been offset by the introduction of "QQE with a Negative Interest Rate" in January 2016. In this situation, the deviation of the observed inflation rate from the price stability target of 2 percent has been gradually widening.

Adaptive Component Playing a Large Role in the Formation of Inflation Expectations in Japan

Inflation expectations can be regarded as consisting of two components: a forward-looking component shaped by an expectation that the inflation rate will rise to the central bank's price stability target of 2 percent, and a backward-looking, or adaptive, component reflecting the observed inflation rate. As is the case with the United States, where the forward-looking component is sufficiently strong, even if the observed inflation rate deviates temporarily from the price stability target, due for example to fluctuations in crude oil prices, people expect the inflation rate to revert to close to 2 percent in due

BOX: Decomposition of the Deviation into Three Types of Shocks

This BOX explains how the deviation of the observed inflation rate from the price stability target of 2 percent can be decomposed into (a) observed inflation rate shocks, (b) inflation expectations shocks, and (c) price stability target credibility shocks.

The model in the text can be expressed as follows.[6]

(1) $\pi_t = \pi_t^e + \alpha y_{t-1} + \varepsilon_t^d$ (Phillips curve)

(2) $\pi_t^e = \beta \pi_t^{*e} + (1-\beta)\pi_{t-1} + \varepsilon_t^e$ ([Short-term] inflation expectations formation)

(3) $\pi_t^{*e} = \rho \pi_{t-1}^{*e} + (1-\rho)\pi^* + \varepsilon_t^c$ ([Long-term] inflation expectations formation)

π_t is the observed inflation rate, π_t^e is short-term inflation expectations, π_t^{*e} is medium- to long-term inflation expectations, π^* is the price stability target (2 percent), and y_t is the output gap.

Solving equations (1) - (3) with respect to $\pi_t - \pi^*$, we have

$$\pi_t - \pi^* = \sum_{j=0}^{\infty}(1-\beta)^j(\alpha y_{t-j-1} + \varepsilon_{t-j}^d + \varepsilon_{t-j}^e + \beta\rho\sum_{i=0}^{\infty}\rho^i\varepsilon_{t-j-i-1}^c + \beta\varepsilon_{t-j}^c)$$

Then, we get three shocks as follows.[7]

Observed inflation rate shocks $= \sum_{j=0}^{\infty}((1-\beta)^j \times \varepsilon_{t-j}^d)$

Inflation expectations shocks $= \sum_{j=0}^{\infty}((1-\beta)^j \times \varepsilon_{t-j}^e)$

Price stability target credibility shocks $= \sum_{j=0}^{\infty}(1-\beta)^j(\beta\rho\sum_{i=0}^{\infty}(\rho^i\varepsilon_{t-j-i-1}^c) + \beta\varepsilon_{t-j}^c)$

Meanwhile, in Chart 4 in the main text, the "output gap" factor is calculated as $\sum_{j=0}^{\infty}((1-\beta)^j \times \alpha y_{t-j-1})$

course. Therefore, the observed inflation rate will gravitate toward the target -- the expression used in this situation is that inflation expectations are "anchored."

However, in Japan, as inflation expectations have not been anchored to the price stability target of 2 percent due to the prolonged deflation, the adaptive component dominates in the formation of inflation expectations. On this point, compared with the United States, the euro area, and the United Kingdom, inflation expectations are affected by the 1-quarter lagged observed inflation rate to a greater degree in Japan, and the adaptive component plays a considerably larger role in the formation of inflation expectations (Chart 5).[8]

[Chart 5] Mechanism of Inflation Expectations Formation in Advanced Economies

(1) Estimation Equations

Equation (a): Contribution of observed inflation to inflation expectations 1 year ahead

Inflation expectations 1 year ahead (%)
$= \theta \times$ Observed inflation rate (lagged 1 quarter, %)
$+ (1 - \theta) \times$ Inflation expectations 6-10 years ahead (%)

Equation (b): Contribution of observed inflation to inflation expectations 6-10 years ahead

Inflation expectations 6-10 years ahead (%)
$= \theta \times$ Observed inflation rate (lagged 1 quarter, %)
$+ (1 - \theta) \times$ Central bank price stability target (2%)

(2) Estimation Results for θ

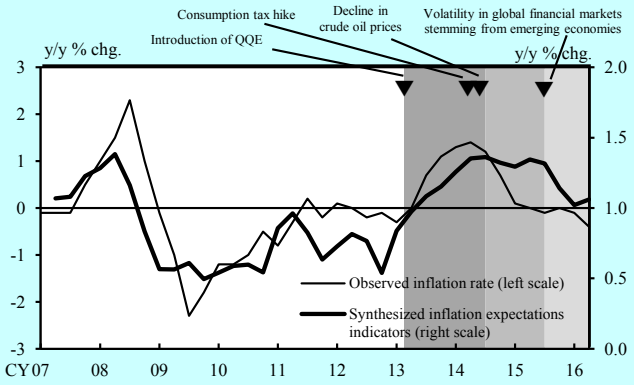
	Estimation using headline inflation rates as observed inflation rates		Estimation using core inflation rates as observed inflation rates	
	Equation (a)	Equation (b)	Equation (a)	Equation (b)
Japan	0.69 ***	0.38 ***	0.70 ***	0.38 ***
	(0.39)	(0.34)	(0.37)	(0.33)
U.S.	0.13 ***	0.05	0.45 ***	0.08
	(0.28)	(0.37)	(0.21)	(0.38)
Euro area	0.31 ***	0.03 ***	0.55 ***	0.05 ***
	(0.29)	(0.08)	(0.24)	(0.08)
U.K.	0.09 *	0.18 ***	0.26 ***	0.24 ***
	(0.37)	(0.36)	(0.35)	(0.40)

Notes: 1. The estimation periods are as follows: 2000/Q1-2016/Q3 for Japan and the United States; 2003/Q2-2016/Q3 for the euro area; and 2005/Q1-2016/Q3 for the United Kingdom.
2. The result of the statistical significance test for the coefficient of each explanatory variable indicates that asterisks denote statistical significance; namely, *** at 1 percent, ** at 5 percent, and * at 10 percent.
3. Standard errors of regression are given in parentheses.
4. Core inflation rates are the rate of change in the consumer price index (CPI) or the Harmonized Index of Consumer Prices (HICP) for all items excluding the following: fresh food in the case of Japan; food and energy in the case of the United States; unprocessed food and energy in the case of the euro area; and food, energy, alcohol, and tobacco in the case of the United Kingdom.
5. Figures for the observed inflation rate and inflation expectations in Japan are adjusted to exclude the estimated effects of changes in the consumption tax rate.

Sources: Consensus Economics Inc., "Consensus Forecasts"; Ministry of Internal Affairs and Communications; BLS; Eurostat; ONS.

Since summer 2014, inflation expectations, which had increased steadily until then, have become flat and subsequently weakened due to exogenous factors such as the substantial decline in crude oil prices. This could be attributable to the fact that the observed inflation rate declined due to exogenous factors and that this exerted downward pressure on inflation expectations through the "adaptive formation mechanism" (Chart 6).

[Chart 6] Synthesized Inflation Expectations Indicators and the Observed Inflation Rate



Notes: 1. Figures for the observed inflation rate are the CPI (all items less fresh food). They are adjusted to exclude the estimated effects of changes in the consumption tax rate.
2. Synthesized inflation expectations indicators are calculated by using the "Opinion Survey," *Tankan*, and "Consensus Forecasts."

Sources: Consensus Economics Inc., "Consensus Forecasts"; Ministry of Internal Affairs and Communications; Bank of Japan.

Concluding Remarks

During the more than three years after the introduction of QQE, inflation expectations rose during the first year, were largely flat during the second year, and weakened in the latest year. These changes were driven by two conflicting forces comprised of monetary easing, which has exerted upward pressure, and adverse exogenous factors -- such as the decline in crude oil prices and the volatility in global financial markets stemming from emerging economies -- which applied downward pressure.

On the monetary policy front, the introduction of QQE and its expansion seemed to have pushed up inflation expectations. This is attributable to the policy effects on people's forward-looking expectations formation exerted by the Bank's monetary policy framework, which consists of (1) the Bank's strong commitment to the price stability target of 2 percent and (2) aggressive monetary easing that underpins the commitment. On the other hand, the effects of the Bank's "QQE with a Negative Interest Rate" did not outweigh the strong adverse exogenous shocks caused

by developments such as volatile global financial markets stemming from emerging economies since summer 2015. The large impact of exogenous factors on inflation expectations was due to the fact that the adaptive component plays a large role in Japan's inflation expectations formation.

[1] This article is a supplement to *Comprehensive Assessment: Developments in Economic Activity and Prices as well as Policy Effects since the Introduction of Quantitative and Qualitative Monetary Easing (QQE)* released by the Bank of Japan in September 2016.

[2] Looking at responses of the *Opinion Survey on the General Public's Views and Behavior*, many responses regarding changes in price levels per year on average over the next five years include somewhat extreme answers -- such as more than 10 percent for an annual rate of change in price levels -- that far exceed observed inflation rates. Hence, the analysis was conducted using the aggregate data compiled from individual responses excluding extreme answers that are more than 5 percent and less than minus 5 percent.

[3] With regard to firms' medium- to long-term inflation expectations, the *Tankan* includes "Inflation Outlook of Enterprises." However, the Summary of "Inflation Outlook of Enterprises" has been compiled since March 2014 and thus accumulation of time-series data from this survey was not sufficient yet. These data were not used for this analysis because they did not provide developments since the introduction of QQE in April 2013.

[4] 1-year ahead expectations are adjusted to exclude the estimated effects of the change in the consumption tax rate.

[5] It should be noted that, as a result of the revision of the base year for the CPI from 2005 to 2010 (which resulted in a downward revision of the year-on-year rate of change in the CPI for all items less fresh food and energy for 2011 by 0.7 percentage point), the decomposition results for 2011 overestimate the negative observed inflation rate shock and the positive inflation expectations shock.

[6] The parameters of the model are set based on the estimated results using Japan's data. In order to avoid simultaneous equation bias, the first two equations are estimated by Generalized Method of Moments (GMM). Estimation results are as follows.

1. $\pi_t = \pi_t^e + \underset{(0.02)}{0.11^{***}} y_{t-1} + \varepsilon_t^d$

2. $\pi_t^e = \underset{(0.02)}{0.29^{***}} \pi_t^{*e} + \underset{(0.02)}{0.71^{***}} \pi_{t-1} + \varepsilon_t^e$

Sample period is 2000/Q1-2016/Q2. Standard errors are in parentheses. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. Standard errors of the above two regressions are 0.55 and 0.37, respectively.

We conducted some robustness checks by estimating the above equations using different sample periods. Consequently, α was estimated almost stably at around 0.1. β was estimated generally within the range of 0.2-0.4. In detail, when we extended the sample period including the data before 2000/Q1, β was estimated as being somewhat smaller (more adaptive), and when we used the data of the more recent sample period, β became slightly larger (less adaptive). Therefore, we set $\alpha = 0.1$ and $\beta = 0.3$. With respect to ρ, as the price stability target of 2 percent has not been achieved yet, it is not appropriate to set ρ based on an estimation result. On the other hand, as the price stability target of 2 percent has not been achieved for a long time, if we set ρ as a smaller value, ε_t^c becomes more largely negative. Hence, $\beta\rho\sum_{i=0}^{\infty}(\rho^i\varepsilon_{t-j-i-1}^c)$ and $\beta\varepsilon_{t-j}^c$ offset each other to some extent and the outcome of the decomposition is not largely affected. We conducted the decomposition at $\rho = 0.4$.

[7] In Chart 4 in the text, we calculate $\sum_{j=0}^{\infty}$ and $\sum_{i=0}^{\infty}$ as $\sum_{j=0}^{10}$ and $\sum_{i=0}^{10}$.

[8] Fuhrer (2012) argues that around 40 percent of the changes in short-term inflation expectations in the United States can be explained by developments in the observed inflation rate (the CPI for all items less food and energy) based on inflation expectations obtained from the *Survey of Professional Forecasters*. His argument is consistent with the estimation results shown in this article. (For details, see Jeff Fuhrer, "The Role of Expectations in Inflation Dynamics," *International Journal of Central Banking*, Vol. 8 No. S1, 2012.)

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