

Performance of Core Indicators of Japan's Consumer Price IndexMonetary Affairs Department
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The Bank of Japan (BOJ), in conducting monetary policy, employs the core indicators of the consumer price index (CPI) to identify the underlying trend of inflation by excluding various idiosyncratic disturbances from the overall CPI. Considering that sources of such idiosyncratic disturbances are not always constant over time, this article examines the performance of the core indicators by focusing on the stability over the estimation period. Empirical evidence reveals that the CPI excluding fresh food and trimmed mean generally show better performance than other indicators. It also shows that the performance of the CPI excluding fresh food is deteriorating currently, even though such deterioration, affected by large swings in crude oil prices, is likely to be temporary. In examining the underlying trend of inflation and explaining it to the public, it is thus important to consider various indicators, such as trimmed mean, and the CPI excluding fresh food and energy, even though the CPI excluding fresh food remains a main indicator, considering its high public awareness.

Introduction

The Bank of Japan (BOJ) defines “Price Stability Target” at 2 percent by using the overall index in the consumer price index (CPI). While the CPI is influenced by various idiosyncratic disturbances in the short term, such effects diminish in the medium to long term. It is thus appropriate to use the overall index with the broadest coverage when considering the price stability in the medium to long term.

However, in conducting monetary policy, the BOJ needs to identify the underlying trend of inflation from the monthly publication of the CPI data. To that end, it employs the core indicators of the CPI that exclude various idiosyncratic disturbances when identifying the underlying trend of inflation and explaining it to the public.¹

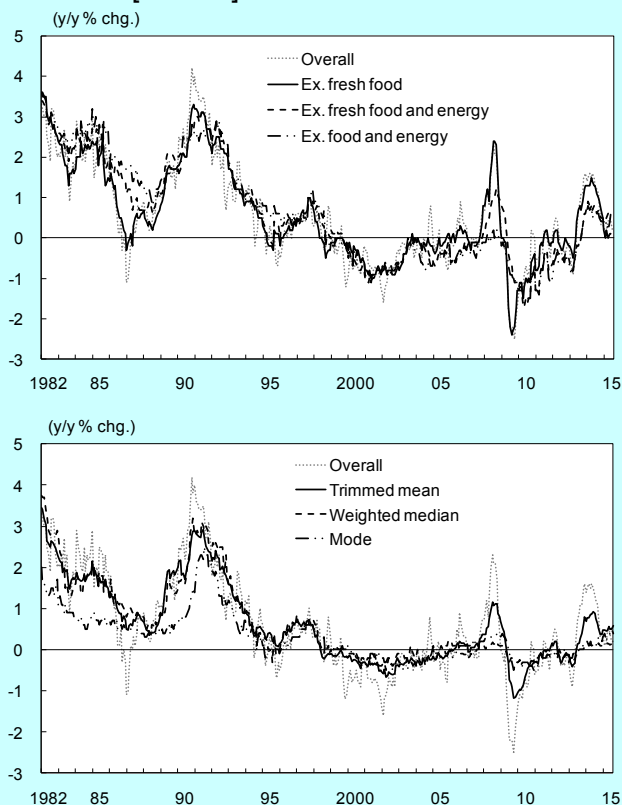
It should be noted that sources of such idiosyncratic disturbances are not always constant over time. It is rather the case that items that should be excluded from the overall index vary over time in accordance with economic and price developments. In addition to fresh food with volatile price fluctuations due to weather conditions, energy is producing significant disturbances currently, reflecting large swings in crude oil prices since the collapse of

Lehman Brothers. It is thus highly possible that the performance of the core indicators varies over time.

This article comprehensively examines the performance of the core indicators by focusing on the stability of their performance over the estimation period. Following the empirical framework of Shiratsuka (2006) and updating data for ten years, the performance of the core indicators is examined in two respects: one is the tractability of the current underlying trend of inflation, and the other is the predicting power of the underlying inflation trend in the future.² In doing so, the performance of the core indicators is examined by paying attention to the stability over time.

The six core indicators considered in this study are categorized into two groups (Chart 1). The first group includes the CPI excluding fresh food, the CPI excluding fresh food and energy, and the CPI excluding food and energy. These always exclude pre-specified items with high short-term volatility. The second group includes trimmed mean, weighted median, and mode.³ These adjust the distorted impacts from outlier items with extreme increases/decreases by mechanically excluding such outlier items. Thus, the items excluded are not specified in advance.

[Chart 1] CPI Core Indicators



Source: Ministry of Internal Affairs and Communications, "Consumer Price Index."

Note: CPI excluding fresh food and energy, trimmed mean, weighted median, and mode are calculated by the Research and Statistics Department, Bank of Japan. Figures are adjusted to exclude the estimated effect of changes in the consumption tax rate.

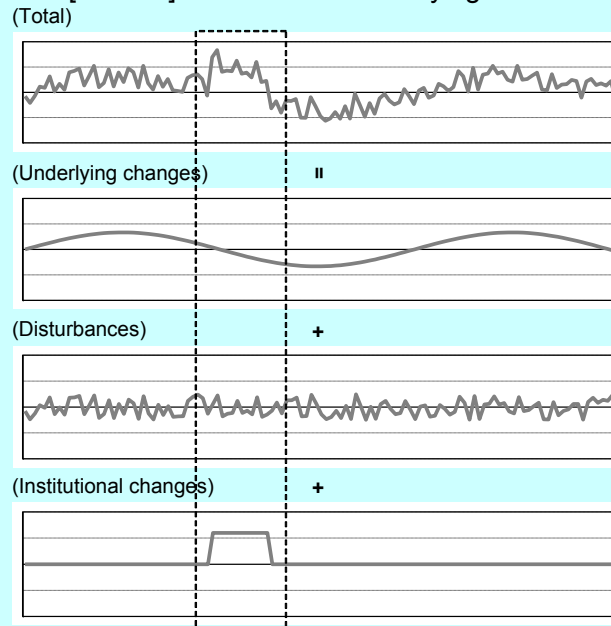
Effects of Idiosyncratic Disturbances

Basic concept

Chart 2 gives a hypothetical example of how to extract the underlying trend of inflation by excluding the effects of idiosyncratic disturbances.

Overall changes in inflation (top panel) correspond to the sum of: (i) the underlying component that moves on a cyclical trend (second panel), (ii) the idiosyncratic component that fluctuates from time to time (third panel), and (iii) the one-time component, including institutional changes, that rises/declines for a certain period of time and then vanishes (bottom panel). Therefore, overall changes in inflation tend to move up and down in the short term due to the effects of various disturbances, thereby making it difficult to identify its underlying trend. Focusing on the period surrounded by the dotted lines, overall changes first pick up, and then drop sharply. However, this movement is influenced by changes in the institutional component and the underlying trend starts to decline when overall inflation rises.

[Chart 2] Extraction of Underlying Trend



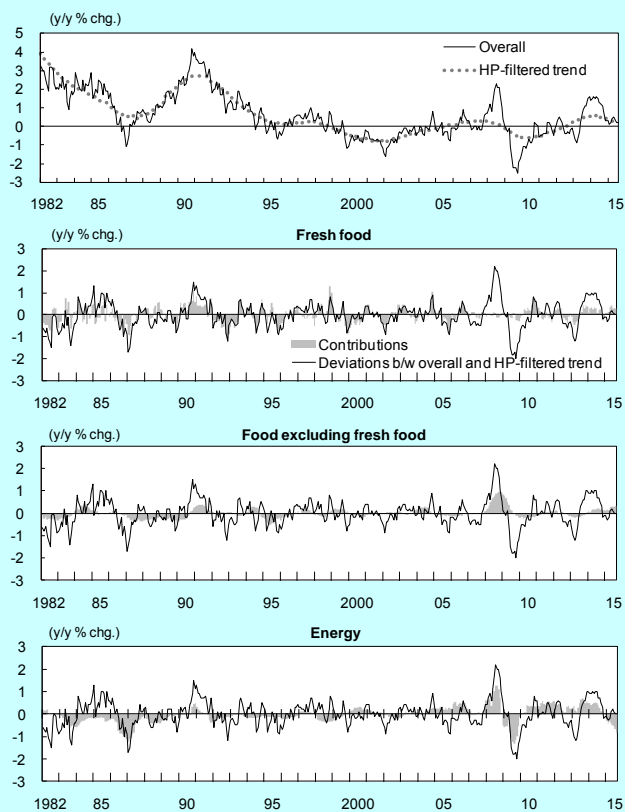
As shown in the hypothetical example above, it is crucially important to exclude the effects of idiosyncratic disturbances appropriately when identifying the underlying trend of inflation.

Effects of idiosyncratic disturbances

Which items produce idiosyncratic disturbances, thereby making it difficult to extract the underlying trend of inflation in Japan's CPI? Chart 3 plots the contributions of possible idiosyncratic factors on the deviations between the overall CPI and its Hodrick-Prescott (HP) filtered trend. HP-filtering is a statistical method to extract smooth components from time-series data as an underlying trend.

Looking at Chart 3, deviations between year-on-year changes in the overall CPI and those in the HP-filtered trend move up and down with short intervals. These fluctuations are mainly attributable to fresh food, confirming that fresh food, with high short-term volatility due to weather conditions, is the most significant source of idiosyncratic disturbances in the CPI. The chart also shows that the contributions of energy become larger during the periods from 1986 to 1987 as well as the period after 2000s. In the first period, energy related prices, including electricity, declined significantly, reflecting the yen appreciation after the Plaza Accord and the crude oil price plunge due to the reverse oil-shock. In the second period, crude oil prices showed large swings several times after the collapse of Lehman Brothers, making the contributions of energy larger as well as more persistent.

[Chart 3] Deviations between Overall Inflation and Its Trend



Source: Ministry of Internal Affairs and Communications, "Consumer Price Index."

Note: The trend is computed by applying the Hodrick- Prescott filter to the overall index with the smoothing parameter of 14,400, which is the default for monthly data.

It is thus confirmed that fresh food continues to be the most significant source of idiosyncratic disturbances in Japan's CPI. In addition, energy sometimes becomes an additional major source of disturbances. It should be noted that sources other than fresh food are not always significant, suggesting that the performance of the core indicators are likely to vary over time.

In the following, statistical methods are applied to examine the performance of the core indicators by focusing on the stability of the performance over time.⁴

Tractability of Current Underlying Trend

First, the tractability of the current underlying trend of inflation is tested by applying two approaches.

Deviations from overall CPI

The first approach examines whether year-on-year changes in the core indicators and those in the overall CPI are equalized over the medium to long term. This implies that both indexes are supposed to show similar

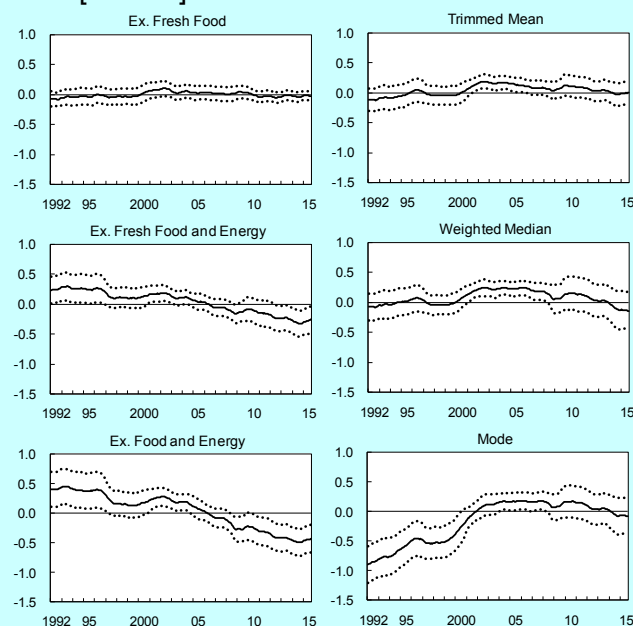
movements in the medium to long term, as the effects of idiosyncratic disturbances are smoothed out. This also corresponds to the idea that the numerical definition of price stability uses the overall CPI, whereas the current underlying trend of inflation is monitored mainly by the core indicators.

More precisely, differences in the year-on-year changes in the core indicators and those in the overall CPI are regressed on a constant term, thereby testing the hypothesis whether the estimates are different from zero at a certain significance level. In doing so, estimations are repeatedly carried out using subsamples of ten years while paying attention to changes in estimates and their statistical significance over time (rolling regression).

Looking at the estimation results in Chart 4, the CPI excluding fresh food shows the highest performance in a fairly stable manner: confidence intervals are extremely narrow and include zero over the whole period. Trimmed mean, the CPI excluding fresh food and energy, and weighted median come next: confidence intervals are generally narrow and mostly include zero. In contrast, the CPI excluding food and energy, and mode show relatively poor performance.

The empirical evidence confirms that the CPI excluding fresh food neither overestimates nor underestimates the level of the CPI inflation over ten years. This suggests that excluded items, even though

[Chart 4] Deviations from Overall Index



Note: Figures in the charts show estimates of the constant term that are estimated repeatedly using subsamples of 120 months ending at each month on the horizontal axis. The dotted lines show 95-percent confidence intervals, computed from autocorrelation robust standard errors based on Newey-West's method.

having the smallest weight among all the core indicators, have fairly symmetric effects on the CPI inflation. Trimmed mean, the CPI excluding fresh food and energy, and weighted median also deliver satisfactory performance. However, the CPI excluding food and energy, and mode show significant and persistent deviations, indicating the existence of biases in estimating the level of the CPI inflation.

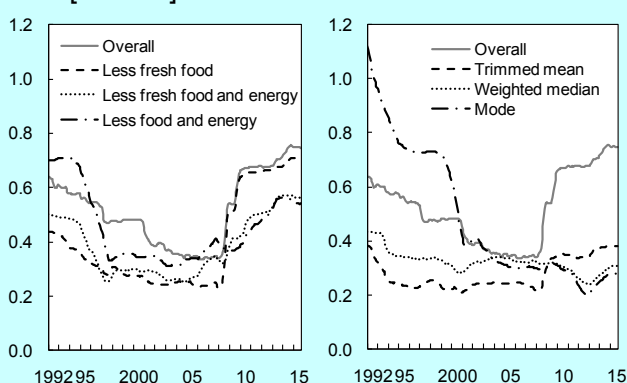
Deviations from trend inflation

The second approach examines to what extent the core indicators trace the HP-filtered trend, as a proxy for the underlying trend, on a real time basis. Root mean squared errors (RMSEs) are used as a yardstick to examine the deviations, and computed repeatedly from subsamples of ten years.

Looking at the estimation results in Chart 5, trimmed mean generally shows the smallest RMSEs, and weighted median and the CPI excluding food and energy follow. In contrast, the CPI excluding food and energy, and mode show significant deviations, especially until the second half of the 1990s. Meanwhile, the CPI excluding fresh food shows rather limited deviations until the mid 2000s, while it significantly increases the deviations thereafter.

To sum up, trimmed mean shows the highest and the most stable performance over the whole period. It exhibits high tractability of the underlying trend of inflation on a real time basis by properly excluding time-varying sources of idiosyncratic disturbances. The CPI excluding fresh food worsens its performance in tracing the underlying trend of inflation, as disturbing effects of energy become significant after the second half of the 2000s.

[Chart 5] Deviations from Trend Inflation



Note: Root mean squared errors, which are the square root of the mean squared deviations, are used for quantitative assessment of the degree of deviations from the trend inflation. Figures in the charts are computed repeatedly using subsamples of 120 months ending at each month on the horizontal axis.

Assessment on tractability of current underlying trend

Two types of statistical analysis show that trimmed mean and the CPI excluding fresh food have generally high and stable performance in tracking the current underlying trend of inflation. It should be noted that the performance of the CPI excluding fresh food is deteriorating currently, even though such deterioration, affected by large swings in crude oil prices, is likely to be temporary.

Predictive Power on Future Underlying Trend

Next, the predictive power of the core indicators regarding the future direction of the underlying trend of inflation is examined. Rolling estimations are again employed to examine the stability of the predictive power over time.

Statistical test on predictive power

The first estimation exercise employs the specification below:

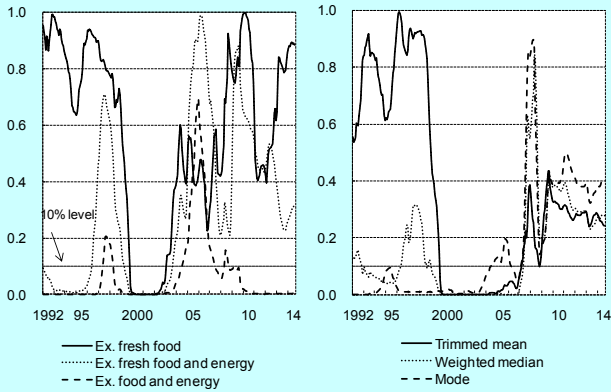
Estimation Equation 1

$$\pi_{t+h} - \pi_t = \alpha + \beta(\pi_t^{CORE} - \pi_t) + \varepsilon_t,$$

where π denotes the year-on-year changes of the overall CPI and π^{core} refers to the year-on-year changes in the core indicators. The parameter h takes the value of 12 (months). α and β are estimated coefficients. Estimation equation 1 examines whether the deviations between the overall CPI and the core indicators are just temporary, and the overall CPI tends to converge to the core indicators, as the idiosyncratic disturbances diminish.

If $\alpha=0$ and $\beta=1$ in estimation equation 1, the core indicator will be an unbiased predictor of the overall CPI until one-year ahead. Chart 6 summarizes the test results on the joint hypothesis of $\alpha=0$ and $\beta=1$. In terms of the duration for not rejecting the joint hypothesis even at the 10-percent confidence level, i.e. p-values exceed 0.1, the CPI excluding fresh food is the longest and trimmed mean comes next. The CPI excluding fresh food and energy, weighted median, and mode are slightly shorter, and the CPI excluding food and energy is the shortest.

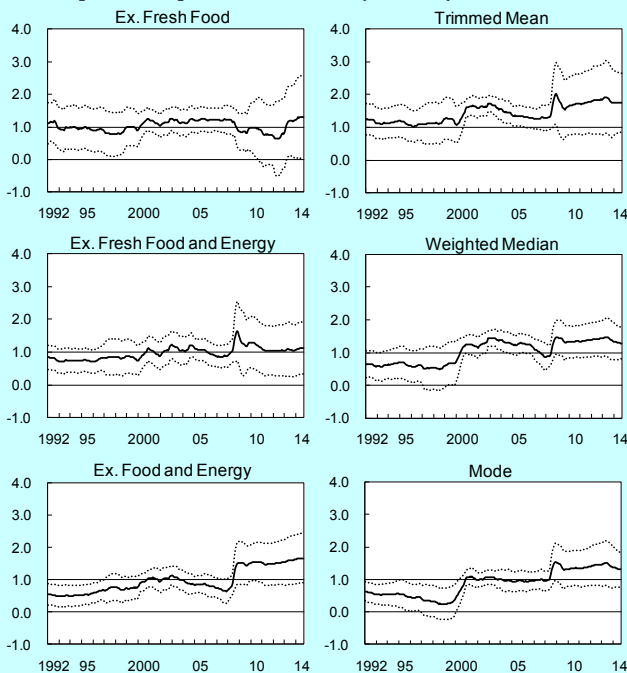
[Chart 6] Joint Hypotheses Test on Equation 1



Note: Figures in the charts show p-values for joint hypotheses testing on $\alpha=0$ and $\beta=1$ in estimation equation 1, based on the rolling estimation results using subsamples of 120 months ending at each month on the horizontal axis.

Focusing further on the estimates of the slope coefficient, β , which are expected to be positive and not to be different from one at a certain significance level, Chart 7 plots the estimates for all the six core indicators. The CPI excluding fresh food and energy is positive and not different from one over the whole period. Trimmed mean shows generally the same results except for the short period in the early 2000s. The CPI excluding fresh food becomes less credible after the mid-2000s, as the confidence intervals get wider and include zero, even though they are not statistically significantly different from one over the whole period. Weighted median is also not different

[Chart 7] Estimates for β in Equation 1



Note: Figures shown in the charts show estimates for β in estimation equation 1, based on the rolling regression results using subsamples of 120 months ending at each month on the horizontal axis. The dotted lines show 95-percent confidence intervals, computed from autocorrelation robust standard errors based on Newey-West's method.

from one throughout most of the period, but is not statistically significantly positive in the second half of the 1990s when confidence intervals become wider. The CPI excluding food and energy, and mode show relatively weak predictive power, especially in the 1990s.

Next, the second estimation exercise employs an alternative specification of estimation equation 2 below, replacing the explained variable from the overall CPI to the core indicators:

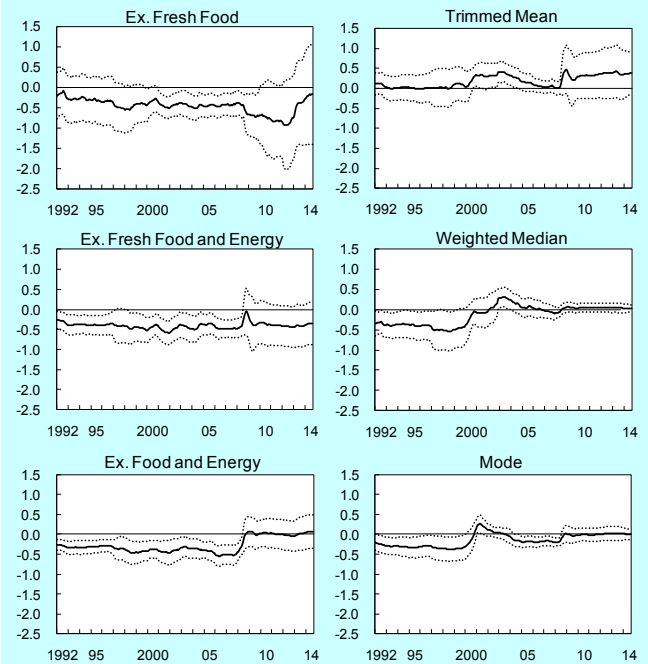
Estimation Equation 2

$$\pi_{t+h}^{CORE} - \pi_t^{CORE} = \gamma + \eta(\pi_t^{CORE} - \pi_t) + \varepsilon_t^{CORE},$$

where γ and η are estimated coefficients. Estimation equation 2 examines whether the deviations between the overall CPI and the core indicators are just temporary, but the core indicators do not tend to converge to the overall CPI, as the idiosyncratic disturbances diminish. In this case, the slope estimates of η are expected not to be different from zero at a certain significance level.

Looking at Chart 8 for the estimation results, the estimates of η for all the core indicators are generally close to zero. Among them, trimmed mean shows the most stable performance, as evidenced by the results that estimates are not significantly different from zero over almost the entire period. Focusing on the recent

[Chart 8] Estimates for η in Equation 2



Note: Figures shown in the charts show estimates for η in estimation equation 2, based on the rolling regression results using subsamples of 120 months ending at each month on the horizontal axis. The dotted lines show 95-percent confidence intervals, computed from autocorrelation robust standard errors based on Newey-West's method.

period, the estimates for weighted median and mode are close to zero with very narrow confidence intervals. In contrast, the performance of the CPI excluding fresh food is deteriorating currently, as clearly seen in the widening of the confidence intervals.

Summary of test results

To sum up the test results for predictive power, trimmed mean and the CPI excluding fresh food are judged as showing relatively high performance. However, it should be noted that, just the same as the tractability of the underlying trend of inflation, the performance of the CPI excluding fresh food is deteriorating currently, due to large swings in crude oil prices.

Concluding Remarks

This article examined the six core indicators used in Japan by applying statistical methods to compare their performance in two respects: (i) tractability of the current underlying trend of inflation, and (ii) predictive power on the future underlying trend of inflation. Given that idiosyncratic disturbances, which make it difficult to identify the underlying trend, possess a time-varying nature both in sources and magnitude of impacts, the performance of the core indicators was examined paying attention to the stability over time.

To sum up the overall test results, it is confirmed that the CPI excluding fresh food and trimmed mean show relatively high performance. At the same time, it should be noted that the performance of the CPI excluding fresh food is deteriorating currently, although such deterioration is likely to be temporary due to large swings in crude oil prices.

Thus, it is important to monitor a wide range of indicators in properly assessing the underlying trend of inflation and explaining it to the public. Although the CPI excluding fresh food, given its high public awareness, remains a main core indicator, other indicators, such as trimmed mean and the CPI excluding food and energy, also need to play an important role. It is also necessary to examine the performance of the core indicators continuously, considering their time-varying nature.

indicators. For details, see Yoshihiko Hogen, Takuji Kawamoto, and Moe Nakahama, “Core Inflation and the Business Cycle” (Bank of Japan Review, 15-E-6, 2015).

² See Shigenori Shiratsuka, “Core Indicators of Japan’s Consumer Price Index” (Bank of Japan Review 06-E-7, 2006).

³ The details of the core indicators in the second group, which are less familiar to the public, compared with those in the first group, are summarized below. Trimmed mean mechanically discards a certain percentage from each tail of the price fluctuation distribution (10-percent). Weighted median is the weighted average of price changes of the item at around the 50 percentile point of the distribution (5-percent in the center of the distribution). Mode corresponds to the highest frequency (density) in the distribution. As explained in the main text, those indicators are called limited influence indicators, which imply that the effects of outlier items are excluded.

⁴ The sample period starts in 1982, when the adverse effects of the oil-shock were generally subdued, and ends in August 2015, which is the end of data readily available when preparing this article.

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¹ The Bank of Japan started employing some new core