(Box 4) Approaches to Examining Underlying Inflation

In forecasting consumer price inflation, it is important to capture the underlying inflation trend by examining the factors that fundamentally drive price changes and excluding the effects of temporary fluctuations, such as in input prices.

Capturing an underlying inflation trend is not an easy task, even under normal circumstances, and it is especially difficult in the current phase. The reason is that price inflation in the current phase is characterized by two notable components: (1) cost-push inflation triggered by the sharp rise in import prices and (2) the intensification of the virtuous cycle between wages and prices, where price increases have been accompanied by wage increases resulting from changes in firms' wage- and price-setting behavior following the first component (Chart B4-1). The direct impact of the first component is likely to fade once the rise in import prices comes to a halt, and in this sense it can be regarded as a temporary change (Chart B4-2). On the other hand, the effect of the second component is expected to push up prices in the long run by making price developments better reflect domestic supply and demand conditions and by raising inflation expectations. Therefore, in the current phase, it is important to extract the second component in order to capture the underlying inflation trend. Given the specific nature of the current phase, this box presents three approaches to examining underlying inflation.

Chart B4-1: Price Developments in the Current Phase (Conceptual Diagram)
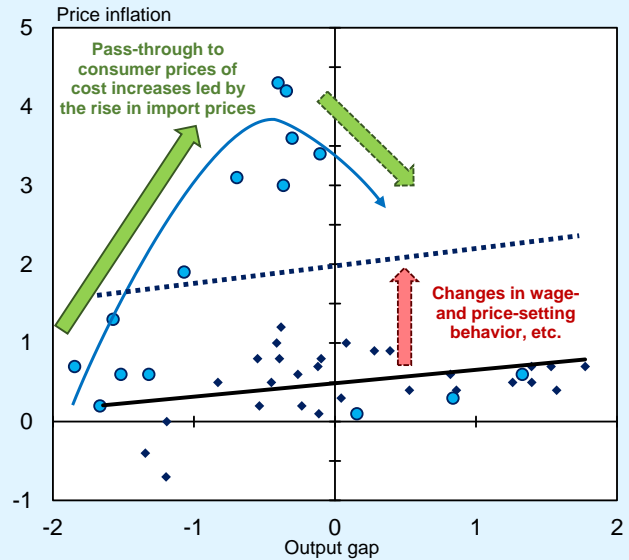
Chart B4-2: Import Prices and the CPI
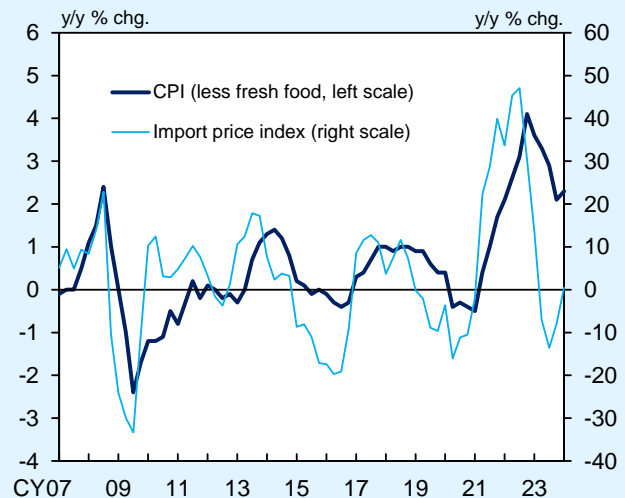
Sources: Bank of Japan; Ministry of Internal Affairs and Communications.
Note: Figures of the import price index are on a yen basis. The CPI figures are staff estimates and exclude mobile phone charges and the effects of the consumption tax hikes, policies concerning the provision of free education, and travel subsidy programs.

The first approach is to construct indicators from price statistics that (1) are less susceptible to temporary fluctuations, such as in import prices, and (2) reflect underlying developments such as changes in labor costs. As for the former, the Bank has conventionally used consumer price indicators that exclude highly volatile items (such as fresh food and energy) and indicators that use information on the distribution of price changes (such as the trimmed mean, the weighted median, and the mode); however, in the current phase, these indicators, like the CPI itself, have risen sharply since prices of an extremely wide range of items have shown large increases in the wake of the rise in import prices.[31] Therefore, the Bank has recently developed a new indicator that extracts *low-volatility items*, which are less susceptible to temporary factors, by classifying items based on their rate of price change (Chart B4-3[1]).[32] While this indicator remained close to zero percent for the past 25 years or so, it has been rising gradually recently.

Meanwhile, with regard to the latter, i.e., indicators reflecting developments in labor costs, one method is to use a model to extract the part of changes in consumer prices that can be regarded as due to *wage factors*, while another method would be to extract the trend component of the CPI for services, where labor costs account for a

[31] The Bank has been compiling various measures of underlying inflation for many years and regularly releases some of them on its website. For details, see "Measures of Underlying Inflation" under Research Data on the Bank's website.

[32] For details, see "Recent Developments in the Linkage between Wages and Prices," *Bank of Japan Review Series*, forthcoming. The Review article also focuses on cost information for items that make up the CPI and presents developments in items with a low share of import costs to total costs and items with a high share of labor costs to total costs.

Chart B4-3: Measures of Underlying Inflation Based on Price Statistics

1. Indicators Excluding Items Susceptible to Temporary Fluctuations
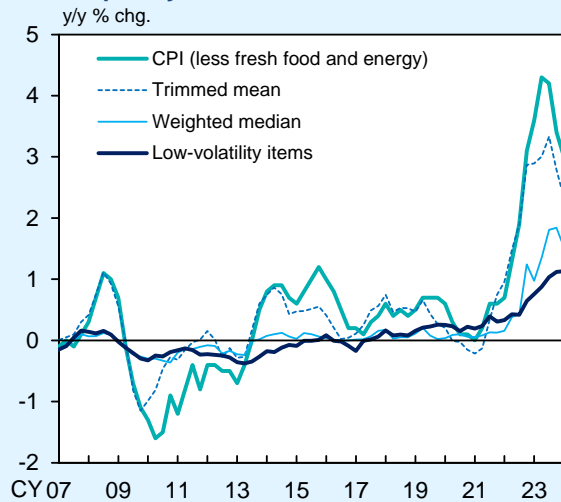
Sources: Bank of Japan; Ministry of Internal Affairs and Communications.
Notes: 1. The CPI figures are staff estimates and exclude mobile phone charges and the effects of the consumption tax hikes, policies concerning the provision of free education, and travel subsidy programs.
2. Low-volatility items are items that fall into the bottom third in terms of their volatility using long-term time series data for the CPI (less fresh food).

2. Indicators Likely Reflecting Wage Developments
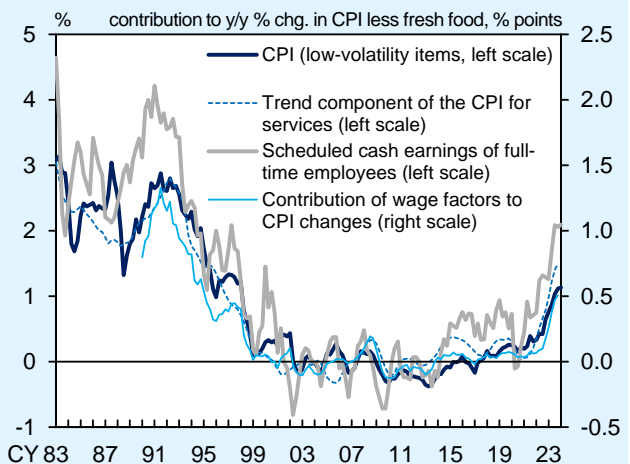
Sources: Ministry of Internal Affairs and Communications; Ministry of Health, Labour and Welfare; Bank of Japan.
Notes: 1. Figures for low-volatility CPI items and scheduled cash earnings of full-time employees are year-on-year percentage changes, while those for the trend component of the CPI for services are the 6-quarter backward moving averages of annualized quarter-on-quarter percentage changes. Figures for scheduled cash earnings of full-time employees before 1994 are those for regular employees. Moreover, figures from 2016 onward are based on continuing observations following the sample revisions.
2. Figures for the contribution of wage factors to CPI changes are based on the relationship between the CPI and wages, estimated using a 4-variable VAR model comprising import prices (yen basis), the output gap, wages (scheduled cash earnings of full-time employees), and price indices for low-, medium-, and high-volatility items in the CPI. The estimates are obtained using 20-year rolling regressions for low-, medium-, and high-volatility CPI items.
3. Figures for the trend component of the CPI for services are the composite of the sector-specific price trend for services and the common trend in services prices and wages. The figures are estimated using category-level services prices and industry-level scheduled cash earnings.

large share in overall costs (Chart B4-3[2]). These indicators have been rising moderately in recent years, and their developments are similar to those in wages (scheduled cash earnings of full-time employees), which means they may be useful for examining the linkage between wages and prices.

The second approach is to focus on indicators related to inflation expectations, which represent people's perceptions of price developments. [33] However, such indicators of inflation expectations vary across economic agents and forecast horizons, and have different meanings, statistical characteristics, and biases. In addition to carefully examining each of the individual indicators (Chart 39), the Bank has constructed a composite index that aggregates the information contained in each of the indicators using statistical methods.[34] This composite index of inflation expectations has recently been hovering around the past 20-year peaks for all horizons (Chart B4-4[1]). A more detailed look shows that 1-year-ahead inflation expectations have declined somewhat in an adaptive manner that reflects the decline in actual inflation, while longer-term inflation expectations have continued to rise moderately. Moreover, the sub-indexes of 10-year inflation expectations for households, firms, and economists and market participants all have been increasing recently (Chart B4-4[2]).

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[33] Conceptually, medium- to long-term inflation expectations correspond to the intercept of the Phillips curve (i.e., the intersection with the vertical axis) shown in Chart B4-1.

[34] Specifically, using principal component analysis, the common components of each indicator are extracted. Moreover, the mean and variance of the aggregate indicators are based on the inflation expectations of economists and market participants, which have relatively small biases. For details, see "Assessing Measures of Inflation Expectations: A View from Term Structure and Forecasting Power," *Bank of Japan Review Series*, forthcoming.

Chart B4-4: Measures of Underlying Inflation Based on Indicators of Inflation Expectations

1. Composite Index of Inflation Expectations, by Forecast Horizon
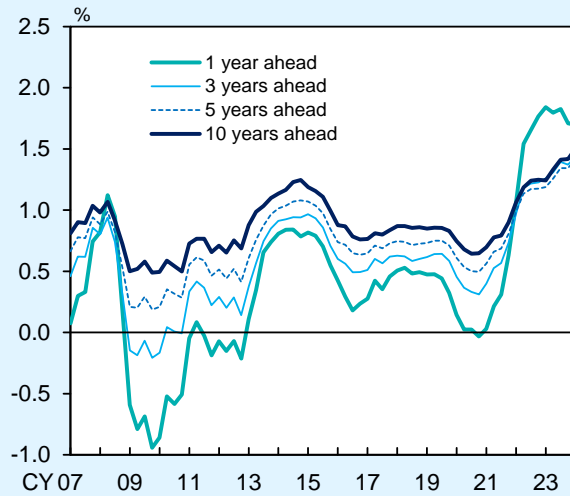
2. Composite Index of 10-Year-Ahead Inflation Expectations, by Type of Economic Agents
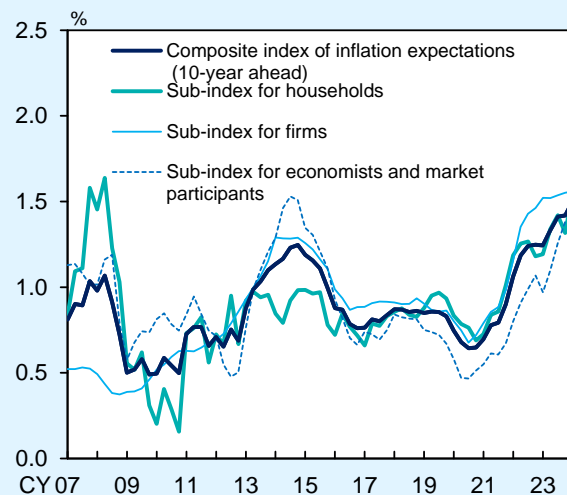
Sources: Bank of Japan; QUICK, "QUICK Monthly Market Survey <Bonds>"; Consensus Economics Inc., "Consensus Forecasts"; Bloomberg.
Note: Based on the first principal component for each forecast horizon extracted from the following six indicators: two indicators for households from the *Opinion Survey on the General Public's Views and Behavior* (for qualitative and quantitative questions), one indicator for firms from the *Tankan*, and three indicators for economists and market participants from the QUICK Survey, the Consensus Forecasts, and data based on inflation swap rates. Estimated using data as of April 12. Data for firms before 2014 are obtained from the following paper: Nakajima, J. (2023), "Estimation of Firms' Inflation Expectations Using the Survey DI," IER Discussion Paper Series A.749, Hitotsubashi University.

The third approach is to construct economic models and then estimate indicators of trend inflation using statistical methods. Trend inflation here is defined as the long-run value that actual inflation could converge to in the absence of additional shocks to the economy. While the literature provides a variety of models to estimate trend inflation, this box focuses on three. The first is a Phillips curve model with a time-varying intercept (Model 1). The second and third models focus not only on the relationship between prices and economic activity, but also on that between prices and wages; namely, a vector autoregressive (VAR) model that captures the changing relationships between price inflation, wage growth, and economic activity over time (Model 2), and a semi-structural model that assumes short- and long-run relationships between price inflation, wage growth, and inflation expectations (Model 3).

The estimation results in Chart B4-5 show that trend inflation estimates have gradually increased in all models. It should be noted, however, that the results need to be interpreted with some caution since they largely depend on the assumptions made in the models and as the results may be revised when new data become available.

All three approaches support, to varying degrees, the view that underlying inflation in Japan has been rising. It should be noted that all of the approaches presented in this box have limitations, such as the fact that they are based on specific assumptions. In particular, individual estimates and short-term changes in them should be interpreted with considerable latitude. To

Chart B4-5: Measures of Underlying Inflation Based on Macroeconomic Models (Estimates of Trend Inflation)
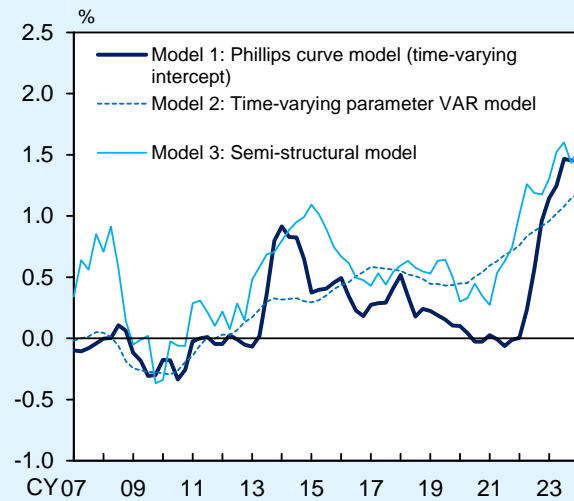
Sources: Bank of Japan; Ministry of Health, Labour and Welfare; Ministry of Internal Affairs and Communications; Cabinet Office; Google Trends; QUICK, "QUICK Monthly Market Survey <Bonds>"; Consensus Economics Inc., "Consensus Forecasts"; Bloomberg.

Notes: 1. Model 1 is based on a Phillips curve model with regime-switching intercept and slope. Its time-varying intercept is regarded as trend inflation. For details, see Nakajima, J. (2023), "Estimating Trend Inflation in a Regime-Switching Phillips Curve," IER Discussion Paper Series A.750, Hitotsubashi University.
2. Model 2 is based on a time-varying parameter VAR model with four variables: the CPI inflation rate, the output gap, import price growth, and wage growth. Trend inflation is defined as the long-run value that actual inflation could converge to for each date. For details, see Rudd, J. B. (2020), "Underlying Inflation: Its Measurement and Significance," FEDS Notes, September 18.
3. Model 3 is based on a semi-structural model with four endogenous variables: the CPI inflation rate, short- and long-term inflation expectations, and wage growth. Trend inflation is defined as the long-run value that actual inflation could converge to (400-quarter ahead value in the simulation) for each date. For details, see Nakamura, K. et al. (2024), "What Caused the Pandemic-Era Inflation?: Application of the Bernanke-Blanchard Model to Japan," Bank of Japan Working Paper Series, 24-E-1.

comprehensively assess the underlying inflation, it is necessary to take a variety of perspectives into account, including anecdotal information from firms, in addition to the analyses presented here.