Inflation Measures for Monetary Policy: Measuring the Underlying Inflation Trend and Its Implication for Monetary Policy Implementation

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Few will argue against the view that price stability plays an important role in promoting medium- to long-term economic growth. However, a consensus has yet to be gained as to how we should define price stability in the context of monetary policy operations and a desirable rate of inflation. In addition, measured inflation rates are affected by various temporary shocks, and it is indeed quite a difficult issue to assess whether the underlying inflation trend is stable or not.

This paper reexamines the definition of price stability from the practical viewpoint of monetary policy implementation, and discusses the usefulness of a limited influence estimator (LIE) as an indicator to trace the underlying inflation trend. The LIE is deemed useful in adjusting for the effects of various temporary shocks, and in gauging the underlying trend in price changes. In particular, the strength and direction of the underlying inflation trend become more evident when year-to-year and seasonally adjusted month-to-month changes of the LIE are used in combination with other indexes such as changes in the overall CPI (or the overall CPI excluding fresh food).

Key words: Monetary policy; Price stability; Underlying inflation; Limited influence estimator; Skewed and fat-tailed distribution of individual price changes

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I. Introduction

This paper reexamines the definition of price stability from the practical viewpoint of monetary policy implementation, and discusses how to extract the underlying inflation trend from measured inflation rates. In addition, it constructs experimental measures to gauge the underlying inflation trend, and applies such measures to assess development of inflation since the late 1980s.

It is generally assumed that the ultimate goal for monetary policy is "price stability." Since monetary policy involves a long lag between policy action and its influence on inflation, the policy must be implemented in a preemptive way. In order to do this, it becomes crucial for monetary policy to gauge and respond appropriately to the underlying rate of inflation by separating the measured inflation rate into a temporary component and a permanent component. However, changes in actual price indexes—the consumer price index (CPI), the wholesale price index (WPI), and the GDP deflator—are affected by various types of temporary shocks. Therefore, it is indeed quite difficult to assess whether the underlying rate of inflation is stable or not.

In Japan, when we want to see the "underlying inflation rate," we usually focus on the development of the "overall CPI excluding fresh food," which excludes the impact of changes in the prices of fresh food that are subject to temporary shocks, such as bad weather.[1] However, given that prices of fresh food are likely to be affected by temporary shocks, it does not necessarily mean that such shocks are always the sole source of temporary disturbance. In addition, if the distribution of shocks that induce temporary disturbances to the overall price index is distorted, then the overall index, which is calculated as a weighted average of individual items, will overstate the importance of external temporary disturbances.[2]

Given the problems inherent in current price indexes, this paper examines the usefulness of a limited influence estimator (LIE) as an index to gauge the development of underlying inflation. This estimator is calculated by excluding the effects of items located at both ends of the cross-sectional distribution of individual price changes, and can be regarded as an attempt to extract a permanent component that reflects the underlying movement of inflation.

Bryan and Cecchetti (1994) and Cecchetti (1996) argue that the performance of the LIE is satisfactory from various viewpoints, such as its ability to predict future price changes, its relation to monetary aggregates, and its capacity to gauge the underlying inflation trend. In addition, the Reserve Bank of New Zealand, which adopts inflation targeting as its policy strategy, has adopted the LIE for policy judgments, and Roger (1994) has pointed out that this index has the merit of eliminating discretionary judgments in deciding which items are to be removed in order to see the underlying inflation trend.

1. It is often the case in other countries that food and energy are excluded. For example, in the United States, the index that excludes food and energy is called the "core price index."
2. In addition, price indexes inherit measurement error problems, including quality adjustment, which generally bring upward bias, thus leading to an overvaluation of inflation. The magnitude of such measurement errors is likely to vary according to the current economic conditions and the pace of technological innovation. For more about problems of measurement errors in the Japanese CPI, see Shiratsuka (1995).

This paper is composed as follows. Chapter II. examines how we should define and gauge price stability from the practical viewpoint of monetary policy implementation. Chapters III. and IV. take up temporary factors and seasonal factors in price changes, and discuss the problems and adjustment methods associated with these factors in order to gauge the underlying inflation trend. In Chapter V., the LIE is calculated and employed to assess the development of Japan's inflation since the 1980s. In conclusion, Chapter VI. summarizes the empirical results obtained in this paper and discusses the implications for monetary policy strategy.

The main conclusion of this paper can be summarized as follows:

[1] Few will argue against the view that price stability plays an important role in promoting medium- to long-term economic growth. However, a consensus has yet to be gained as to how we should define price stability in the context of monetary policy operations and a desirable rate of inflation. In addition, measured inflation rates in price indexes, such as the CPI, the WPI, and the GDP deflator, are affected by various temporary shocks, and it is indeed quite difficult to assess whether the underlying inflation trend is stable or not.

[2] The LIE is deemed useful in adjusting for the effects of various temporary shocks, and in gauging the underlying trend in price changes. In particular, the level and direction of the underlying inflation trend become more evident when year-to-year and seasonally adjusted month-to-month changes of the LIE are used in combination with other indexes such as changes in the overall CPI (or the overall CPI excluding fresh food).

[3] In the late 1980s and early 1990s, often referred to as the "bubble" era, Japan experienced a large fluctuation in asset prices as well as in real economic activity. In those days, most people judged that the underlying trend in price changes was stable. However, based on the findings of this paper, it can be pointed out that (1) underlying inflation increased from a magnitude of around 0 in mid-1988 to 4 percent at the end of 1990, casting doubt on the judgment that prices were stable even during the "bubble" era; and (2) it is highly possible that the deflationary impact of the yen appreciation during 1986–87 has been overstated.

[4] Since there is a long lag between policy action and its influence on inflation, it seems crucial to conduct monetary policy in a preemptive way. In this context, it is deemed important to check the underlying inflation measures based on both year-to-year changes and on seasonally adjusted month-to-month changes.

II. Price Stability as an Ultimate Goal of Monetary Policy

This chapter discusses the definition of price stability and how to adjust price indexes as a measure of price stability or the underlying inflation trend. It will be shown that, in conducting monetary policy, to ensure meaningful price stability does not necessarily mean to realize a certain and constant target inflation rate.

A. Views on Price Stability

There are three ways of defining price stability: (1) to focus on a tolerable target range; (2) to focus on "sustainable economic growth under price stability"; and (3) to focus on the stability of inflation expectations.

1. Focus on a tolerable target range

The first definition enables one to set a tolerable target range for the inflation rate and let monetary authorities take policy actions based on economic conditions at the time as long as the inflation rate lies within the target range. This approach assumes lexicographic order among monetary policy objectives, among which price stability has the primary importance, and considers other objectives only when the inflation rate remains within the target range. Monetary policy is regarded as a failure when the first-priority objective (price stability) is off target, even though at the same time other objectives (e.g., economic growth, employment) show good performance.

A typical example of a tolerable target range is inflation targeting, a monetary policy strategy increasingly adopted by some countries, such as New Zealand, Canada, the United Kingdom, and Sweden, in recent years.[3] Under this framework, a target range for the inflation rate, which is the ultimate goal of monetary policy, will be announced in advance. Other than this framework, the opportunistic approach advocated by some Federal Reserve Board (FRB) economists is based on a similar way of thinking.[4]

On the one hand, such a definition has a major advantage in objectively assessing the effects of monetary policy by the inflation rate figures. On the other hand, based on consideration of the "bubble" era, if one wishes to argue the hypothetical case of setting a target range during the "bubble" era, one should be ready to answer questions such as what kind of price index should have been adopted and what specific target range should have been set in order to conduct an appropriate monetary policy.

2. Focus on "sustainable economic growth under price stability"

The second definition considers price stability as an inflation rate consistent with sustainable economic growth. This is similar to setting a goal of avoiding large fluctuations in the real economy and in the general price level.[5] Price stability in itself is, however, a necessary but not a sufficient condition for sustainable economic

3. For details of inflation targeting, see Bank of Japan (1995) and Shiratsuka (1996). Charles Freedman (1996), Deputy Governor of the Bank of Canada, and Haldene (1996), an economist at the Bank of England, have pointed out that inflation targeting has been employed by setting inflation expectations as an intermediate objective. Based on such a view, the framework of inflation targeting can be regarded as quite similar to that of inflation expectation targeting, which is explained below.

From the viewpoint of "rules versus discretion," a monetary policy based on inflation targeting is reiterated as a policy responding to supply shocks with discretion while keeping in mind the targeted range for inflation rate. This does not mean that inflation targeting is a strict policy rule like the "K percent rule." Rather, as Bernanke and Mishkin (1997) have pointed out, inflation targeting is better understood as a policy framework that allows the central bank "constrained discretion" and increases the transparency and coherence of monetary policy.

4. The opportunistic approach is the notion that, while maintaining price stability as the ultimate goal of monetary policy, monetary authorities should refrain from taking rough-and-ready policy responses considering the possibility of favorable external shocks on inflation if and when the inflation rate is at a level not so divergent from the long-term objective level, or is not likely to diverge from the current level. For details, see Orphanides and Wilcox (1996).

5. Mieno (1994), former Governor of the Bank of Japan, stated during his speech at the Kisaragi-kai meeting in May 1994 that "Price stability does not mean the stability of price indexes. Real price stability can be achieved when such stability is backed by medium- to long-term, well-balanced, and sustainable economic growth."

growth.[6] Furthermore, coupled with the fact that an operational definition of the inflation rate necessary for sustainable economic growth is quite difficult to come up with, "the price index that should be stabilized" still remains a relevant question even as the central bank focuses on sustainable economic growth.

3. Focus on the stability of inflation expectations

The third definition focuses on the stabilization of economic agents' inflation expectations. As a necessary condition for maximizing economic stability and efficiency, price stability—in particular lowering public inflation expectations—is emphasized.[7]

Such a definition conceptually combines two earlier definitions of price stability, since it takes into account sustainable economic growth while setting a goal for the stability of measured inflation: in sum, a view that aims at "sustainable price stability." This third definition of price stability is conceptually clearer than the second one, since it embodies the containment of inflation expectations as a criterion. According to this definition, if keeping interest rates low is judged to strengthen substantially future public expectations of inflation, a central bank will—even when the statistically measured inflation rate has been stable—raise interest rates ahead of time in order to prevent future inflation. However, a quantitative assessment of expected inflation is still difficult at this stage in Japan, because Japan lacks tools—such as inflation-indexed bonds—to measure inflation expectations directly.[8]

B. Price Stability as an Ultimate Goal of Monetary Policy

Three definitions pertaining to price stability have been examined so far, although a consensus has yet to be gained as to which one should be adopted.

In the draft of the new Bank of Japan Law, it is explicitly stipulated that the primary goal for monetary policy is to pursue price stability. At the same time, the Bank's ultimate goal is thought to be the improvement of public economic welfare. Along this line of thinking, under the new Law, the Bank of Japan is required to pursue "stability of price in itself" based on certain criteria and, through its accomplishment, is required to ensure stability of the economy as well as to provide the basis for medium- to long-term economic growth. This will be similar to setting a goal for "sustainable price stability" derived from the third definition of price stability—that is, to focus on inflation expectations.

Of course, insofar as the price stability mentioned above keeps future price developments in mind, it is not necessarily equivalent to a low measured inflation rate, and thus cannot in itself be defined as a desirable level of inflation rate itself.

One direction along this line of thinking is to measure the actual and expected inflation rates simultaneously: the introduction of inflation-indexed bonds or

6. Among the recent empirical studies of new growth theory, Fischer (1993) and Barro (1995) have shown that price stability has positive effects on economic growth. For discussions pertaining to new growth theory, see, for example, Barro and Sala-i-Martin (1995) and Fujiki (1996).
7. For example, in an introductory speech at the August 1996 Federal Reserve Bank of Kansas City Symposium entitled "Achieving Price Stability," Alan Greenspan, Chairman of the Federal Reserve Board, referred to an operational definition of price stability from a central banker's point of reference: "Price stability obtains when economic agents no longer take account of the prospective change in the general price level in their economic decision making." (See Greenspan [1996].)
8. For details of the methodology for deriving inflation expectations from market prices of inflation-indexed bonds, see Kitamura (1997).

the utilization of information extracted from existing financial market data are possible approaches.

Another direction is to extract the underlying trend inherent in the price index itself. In this case, we in Japan are accustomed to focus on the development of the "overall CPI excluding fresh food," which excludes the impact of changes in the prices of fresh food that are subject to temporary shocks, such as bad weather. However, since measured inflation is affected by various types of temporary shock, it is not an easy task to extract information pertaining to the underlying inflation trend.[9] Such an attempt can be interpreted as a modification of the conventional price indexes, such as the CPI, the WPI, and the GDP deflator, which are used as proxies for measuring price stability. This paper attempts to examine the latter of the two directions mentioned above.

C. Measuring Price Stability

When we define price stability as "sustainable price stability" and consider its changes to be the underlying inflation trend, price indexes for monetary policy makers are trend components that are obtained by excluding seasonal and temporary components from observed price movements. That is, if we denote price changes as

$$\text{(price changes)} = \text{(trend)} + \text{(seasonal fluctuations)} + \text{(temporary fluctuations)}$$

then the trend element is what monetary policy should focus on.[10] In other words, seasonal and temporary fluctuations can be thought of as temporary components in a broad sense, and the trend as a permanent component.

There have been attempts to decompose data fluctuations into temporary factors and permanent factors, especially within the framework of time-series analysis. For example, Beveridge and Nelson (1981) applied a univariate time-series model, while Blanchard and Quah (1989) employed a bivariate time-series model. With respect to the former attempt, however, there is a need to place certain assumptions for the relationship between temporary and permanent factors and thus, as Watson (1986) pointed out, estimated results will differ according to assumption. Problems will also arise in the latter case when there are three or more kinds of external shocks.

This paper takes note of the fact that the cross-sectional distribution of individual price changes is asymmetric and fat-tailed, and tries to extract permanent factors that reflect the underlying inflation trend by taking advantage of cross-sectional information at each period. Specifically, we construct the LIE that uses only the core portion of information by ignoring price information lying in both tails of the cross-sectional

9. In addition, it has been pointed out that measurement errors of price indexes bring upward bias, thus leading to an overvaluation of inflation. In considering the implications for monetary policy, it is important to recognize that the magnitude of such measurement errors is not constant—that is, it is likely to vary according to current economic conditions and the pace of technological innovation.
10. It should be noted that the "trend" described here includes both the deterministic and the stochastic trend. The stochastic trend regards trend shifts in each period as a probability variable, and cyclical changes are defined as changes of the stochastic trend. In other words, it is assumed that each period's shock, which is a probability variable, is accumulated to define the current price level; that is, a shock, once it has occurred, has a permanent effect.

distribution of individual price changes at each period. This is a statistic generally called the median or trimmed mean.

This approach has the following two advantages. First, the estimators are robust or outlier resistant.[11] When the cross-sectional distribution of price changes diverges from normal distribution, the weighted average will not be a robust estimator, although such a point can be supplemented by using a median or trimmed mean.[12]

The second advantage is its operational simplicity. Ease of calculation is quite an important feature for a policy judgment indicator, and the statistic mentioned above can be easily obtained by simply calculating the weighted average of individual price changes. In addition, this estimator is compiled by using currently available information, thus a data update will never change past estimators, while estimators of time-series analysis are usually recalculated retroactively.

In the following chapters, temporary disturbances and seasonality—both of which should be excluded in extracting underlying inflation or the permanent component of price fluctuations—are examined in turn.

III. Impact of Temporary Disturbances

This chapter first deals with the effects of temporary disturbances and then, as a method of adjusting such disturbances, examines the concept of the LIE.

A. Problems Inherent in the CPI

1. Excluding specific items from the overall index

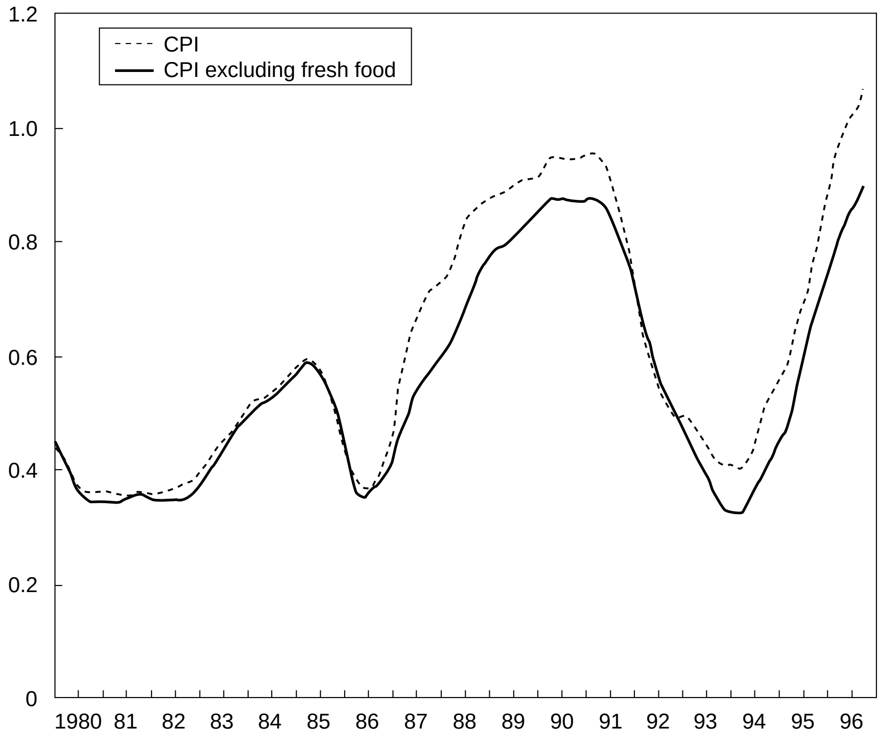
In Japan, when we want to see the "underlying inflation rate," we usually focus on the development of the "overall CPI excluding fresh food." This series ignores price changes of fresh food, which are strongly subject to temporary shocks, such as bad weather. However, it is open to question whether excluding only fresh food is enough for correcting temporary disturbances.[13]

Figure 1 shows the movement of the coefficient of variation for year-to-year changes in the overall CPI and the overall CPI excluding fresh food. As you can see, except for a certain period, the variability of the overall CPI excluding fresh food has been smaller than that of the overall CPI, although the difference between the two differs according to the period, and its magnitude is not large.

This result implies that it might be difficult to assess underlying inflation by using the overall CPI excluding fresh food. An approach that excludes only specific items from the overall index is not satisfactory for solving problems such as (1) items which bring temporary disturbances are not limited to specific items, such as fresh food; and (2) the overall index, which is calculated by a weighted average of individual items, overstates the importance of outlier items.

11. In this paper, we are using the term "robust" to refer to the property of statistics that is insensitive to small deviations from the assumptions. For the details of discussion on robust statistics, see Huber (1981).
12. See Bryan, Cecchetti, and Wiggins (1997), for the details of the methodology used to assess the efficiency of the LIEs.
13. There is a case to be made for excluding oil-related products and public utility charges besides fresh food, although such an approach still carries over the problem of instability of disturbing factors because only specific items are excluded from the overall index.

Figure 1 Coefficient of Variance



Note: Coefficients are calculated from the preceding five-year period.

2. Instability of disturbing factors

In order to see which items in the CPI are likely to become temporary disturbing factors, Table 1 sorts out item groups that lie within a 15 percent range from both ends of the cross-sectional distribution for year-to-year changes in individual prices. For the period between base-year revisions of the CPI statistics, the weight of each item group in the total (upper row), the weights for outlier items (items lying within a 15 percent range from both ends of the price change distribution, middle row), and the coefficient of variation (CV in the table) of the weights for outlier items (lower row) are shown.[14]

When we look at fresh food, although its weight in the total has been declining, some 4–6 percent of it has been counted as outliers and the coefficient of variation has been small, thus implying that fresh food has been constantly included in outliers.

Among the categories other than fresh food, items that belong to food (excluding fresh food), transportation and communications, reading and recreation, education, and clothes and footwear have often been outliers. The coefficients of variation of these categories are generally low, which implies that they have rather constantly been outliers.

14. Items included within a 15 percent range from both ends of the price change distribution and thus counted as outliers correspond to the shadowed portion of Figure 3.

Table 1 Distribution of Outliers among Categories

	Food excluding fresh food	Fresh food	Housing	Fuel, light, and water charges	Furniture and household utensils	Clothes and footwear	Medical care	Transpor-tation and communi-cations	Education	Reading and recreation	Miscel-laneous
Period: January 1971–December 1975											
Weight	0.297	0.083	0.120	0.044	0.054	0.098	0.032	0.076	0.033	0.107	0.055
Mean	0.069	0.038	0.020	0.000	0.017	0.025	0.018	0.018	0.006	0.052	0.037
CV	0.345	0.673	1.148	5.481	0.461	0.810	0.695	0.982	2.145	0.386	0.195
Period: January 1976–December 1980											
Weight	0.302	0.078	0.121	0.045	0.051	0.099	0.027	0.083	0.033	0.115	0.047
Mean	0.071	0.055	0.007	0.020	0.018	0.004	0.005	0.037	0.023	0.042	0.019
CV	0.233	0.336	1.709	1.084	0.781	1.914	1.506	0.482	0.646	0.334	0.549
Period: January 1981–December 1985											
Weight	0.288	0.069	0.121	0.058	0.048	0.089	0.029	0.103	0.038	0.107	0.049
Mean	0.053	0.051	0.004	0.017	0.013	0.011	0.009	0.062	0.029	0.036	0.015
CV	0.229	0.294	1.822	1.367	0.515	1.250	0.976	0.414	0.476	0.358	0.446
Period: January 1986–December 1990											
Weight	0.269	0.060	0.138	0.065	0.047	0.080	0.028	0.116	0.041	0.110	0.046
Mean	0.031	0.041	0.024	0.049	0.014	0.025	0.004	0.032	0.028	0.038	0.011
CV	0.545	0.343	1.375	0.482	0.589	0.819	1.520	0.617	0.647	0.416	0.963
Period: January 1991–December 1995											
Weight	0.258	0.056	0.148	0.055	0.044	0.086	0.031	0.118	0.047	0.112	0.045
Mean	0.046	0.042	0.020	0.004	0.020	0.030	0.009	0.038	0.036	0.042	0.012
CV	0.358	0.311	0.477	3.245	0.184	0.661	0.903	0.631	0.515	0.362	0.806

Notes: 1. The inflation rate figure is the change from a year earlier. The outliers contain 15 percent of both ends of the cross-sectional distribution of individual price changes.
2. Weight is the latest base-year basis (for example, the weights for the period from January 1971 to December 1975 are 1970 base-year basis).

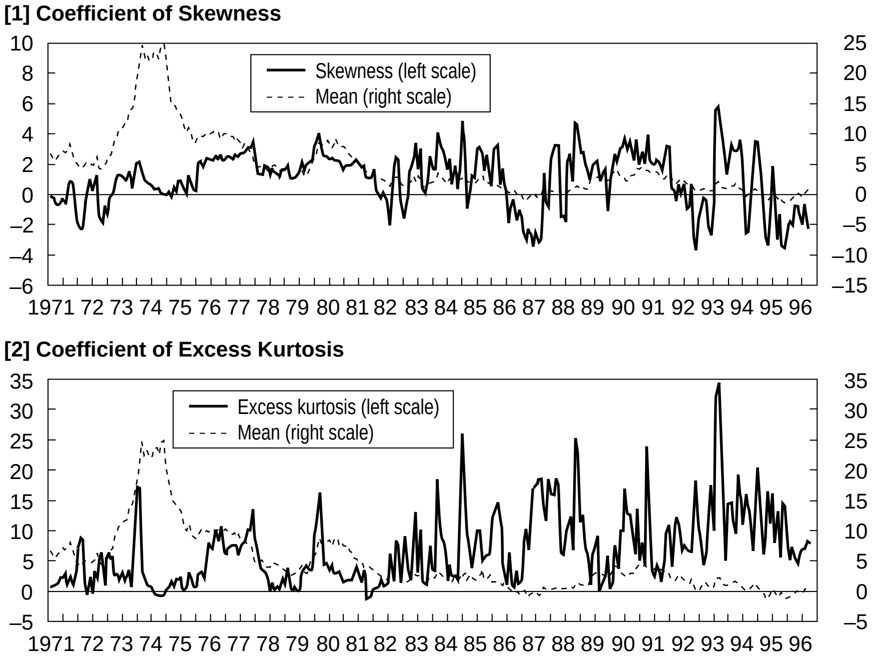
However, if you look at the weights of outlier items in their groups, only a limited portion is counted as an outlier, which in turn implies that it will be difficult to avoid the effects of temporary disturbing factors on these groups by excluding specific items.

3. Skewed and fat-tailed distribution of individual price changes

When the distribution of sectoral price shocks is skewed and fat-tailed, the overall index, which is calculated by a weighted average of individual items, will overstate the importance of temporary external disturbances, therefore it cannot offset all the effects of sectoral shocks. Consequently, the index calculated by weighted average does not necessarily provide appropriate information regarding underlying inflation. Rather, the LIE, which uses only a core portion of information by excluding items lying in both ends of the cross-sectional distribution of individual price changes in each period, will serve as the desirable index to be considered.

In order to look at the shape of the cross-sectional distribution for individual price changes in the CPI, its third and fourth moments (coefficients of skewness and excess kurtosis) are calculated for disaggregated CPI data in 88 categories, which are continuously available retroactively to 1970. The results are shown in Figure 2.[15]

Figure 2 Skewness and Excess Kurtosis of the Cross-Sectional Distribution of Individual Price Changes



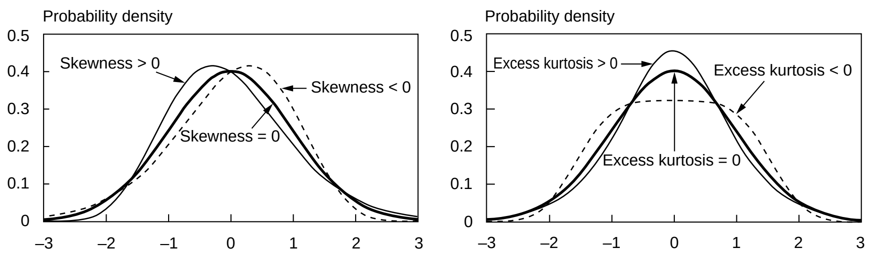
Notes: 1. CPI data are disaggregated into 88 categories, which are continuously available retroactively to 1970.
2. Coefficients of skewness and excess kurtosis are calculated by the formulas as follows:

$$\text{Coefficient of skewness} = \sum_{i=1}^{n} \frac{(x_i - \mu)^3 \cdot w_i}{\sigma^3},$$

$$\text{Coefficient of excess kurtosis} = \sum_{i=1}^{n} \frac{(x - \mu)^4 \cdot w_i}{\sigma^4} - 3,$$

where μ is weighted mean, σ weighted standard deviation, and w_i weight.

15. The third and fourth moments of a distribution are often used in studying the shape of a probability distribution, in particular, its skewness (i.e., lack of symmetry) and excess kurtosis (i.e., tallness or flatness). The third and fourth moments of the normal distribution are both equal to zero. The third moment is positive for a right-skewed distribution and negative for a left-skewed distribution, while the fourth moment is positive for leptokurtic (fat-tailed) and negative for platykurtic (slim-tailed) distributions, as shown in the figure below.



Source: Yoshiba (1996).

When we look at the coefficient of skewness, which shows the degree of asymmetry in distribution, the shape of the distribution is skewed to the right and to the left as the inflation rate fluctuates. That is, under high inflation, the third moment of individual price changes increases in positive value and the shape of the distribution skews to the right. In contrast, under low inflation, the third moment becomes negative and the shape of the distribution skews to the left.[16]

The coefficient of excess kurtosis that shows the degree of sharpness of density near its center is generally large in positive value, suggesting that the shape of distribution is fat-tailed. In addition, if we test whether the cross-sectional distribution of individual price changes follows a normal distribution, the hypothesis is rejected at a 5 percent significance level for about 90 percent of the entire sample period.[17] From this result, we can safely say that the cross-sectional distribution of individual price changes is generally asymmetric and fat-tailed because of the concentration of temporary shocks to outlier items. Therefore, it seems desirable to look at the LIE, which extracts only core information by excluding both ends of the individual item's price change distribution in each period.

B. Limited Influence Estimator

1. The basic concept of a limited influence estimator

The LIE is a price index that excludes outliers in a cross-sectional distribution of individual price changes in a certain period, and has two types: weighted median and trimmed weighted mean. The weighted median is obtained by historically connecting the median rate of price changes in each period, taking account of the weight of individual items. Similarly, the trimmed weighted mean is obtained by first excluding only certain weights of items that lie in both ends of the cross-sectional price change distribution, and then historically connecting the weighted average value of rates of price changes for the remaining items. In general, the weighted median and the trimmed weighted mean are believed to show moderate fluctuations, since they exclude the effects of outlier items.[18]

As shown in Figure 3, the construction method of various price indexes can be illustrated as follows. For the "mean," a weighted average of the rates of increase of the prices of 10 items gives us a result of 2 percent. The "median," which does not take account of weights, will be the simple average of the fifth and sixth items, and is 2 percent. On the other hand, for the "weighted median," the median is calculated as the rate of increase of the price of the item whose accumulated weight reaches 50 (the

16. In the United States, Ball and Mankiw (1995) examined the shape of distribution of price changes for the producer price index (36 classes) and showed that the shape is right-skewed in an inflation phase and left-skewed in a deflation phase.

17. The estimator used to test the normality of distribution, shown below, follows the χ^2 distribution with two degrees of freedom.

$$\text{(Test statistics)} = \text{(number of sample)} \times \left[\frac{(\text{skewness})^2}{6} + \frac{(\text{excess kurtosis})^2}{24}\right] \sim \chi^2\,(2)$$

18. To calculate the weighted average of rates of change is almost equivalent to calculating the geometric mean at the index level. Therefore, the LIE seems to be already adjusted to take account of the index formula problem, which is one of the causes of measurement error inherent in the CPI and can be systematically corrected. For details concerning measurement errors in the Japanese CPI, see Shiratsuka (1995).

total is assumed to be 100); thus, 1.5 percent of the sixth item will be the value. Similarly, the "trimmed mean" is calculated as the weighted average after excluding a certain portion (in this example, 10 percent from the top and bottom) of items, the largest increase rate (15 percent) and the smallest (–7 percent) are excluded from the calculation, giving the result as 1.5 percent.

Figure 3 Calculation Method of Inflation Indicators

	Mean = 2 percent		Median = 2 percent		Weighted median = 1.5 percent		10 percent trimmed mean = 1.5 percent	
	Weight	Percent changes						
1	10	15.0	10	15.0	10	15.0	~~10~~	~~15.0~~
2	5	6.0	5	6.0	5	6.0	5	6.0
3	10	4.0	10	4.0	10	4.0	10	4.0
4	10	3.5	10	3.5	10	3.5	10	3.5
5	10	2.5	10	2.5	10	2.5	10	2.5
6	10	1.5	10	1.5	10	1.5	10	1.5
7	15	1.0	15	1.0	15	1.0	15	1.0
8	5	–0.5	5	–0.5	5	–0.5	5	–0.5
9	15	–2.5	15	–2.5	15	–2.5	15	–2.5
10	10	–7.0	10	–7.0	10	–7.0	~~10~~	~~–7.0~~

2. Theoretical foundation of the LIE

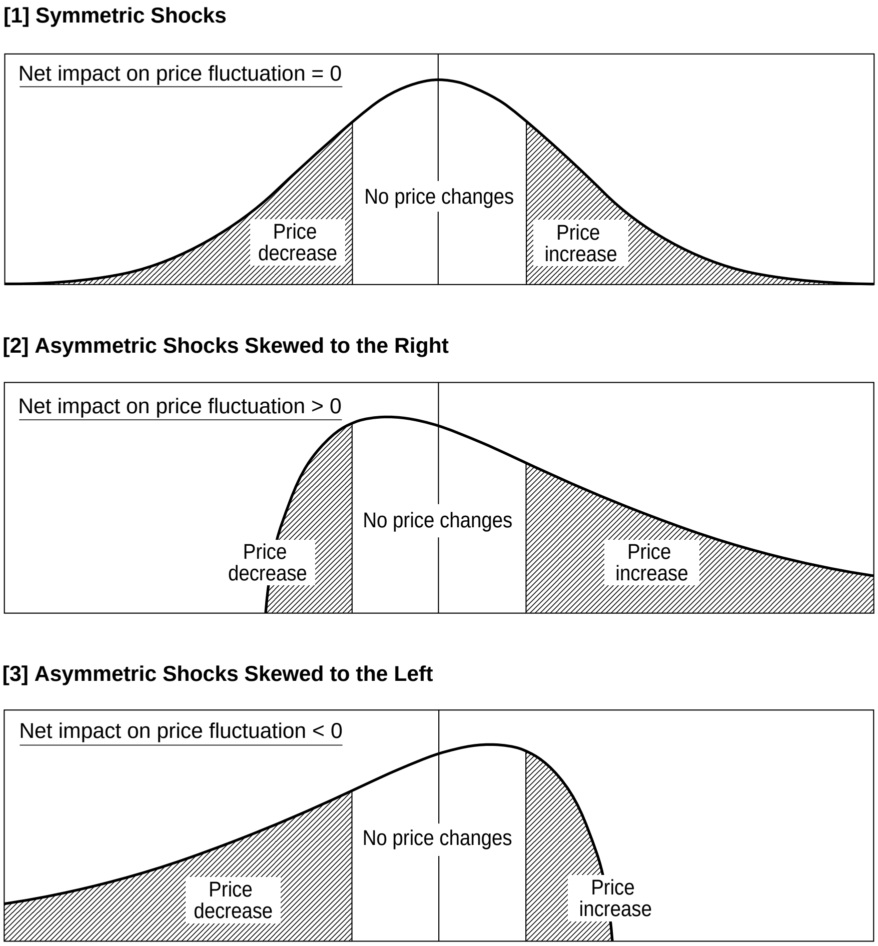
There are two models to explain why the shape of the cross-sectional distribution of individual price changes is asymmetric: (1) a model that assumes the existence of a menu cost and asymmetric price shocks (Ball and Mankiw [1995]); and (2) a model that assumes the accumulative influence of sectoral shocks (Balke and Wynne [1996]).

Ball and Mankiw (1995) assumed the existence of a menu cost (changing prices is costly), and showed a model in which the general price level shifts toward the direction of the skewness in distribution, if sectoral shocks are asymmetric.

Figure 4 illustrates these points. Given the existence of a menu cost, firms, in general, will try not to revise prices if the effects of the shocks they are confronting are lower than the menu cost.

In this case, as in Figure 4 [1], if the distribution of shocks has an average of zero and is symmetric in shape, the impacts of upward and downward pressures on the general price level will offset each other (so that the shadowed area becomes symmetric, and equivalent in area) and the average will not change. If the distribution is skewed to the right, as in Figure 4 [2], even when the average is equal to zero, the impact of upward pressure on the general price level will more than offset that of downward pressure (so that the shadowed area of the right side is larger than that of the left side), which leads to an increase in the general price level. In contrast, if the distribution is skewed to the left, as in Figure 4 [3], the result will be a decrease in the general price level.

Figure 4 Distribution of Price Shocks



Note: Average is equal to zero in all cases.

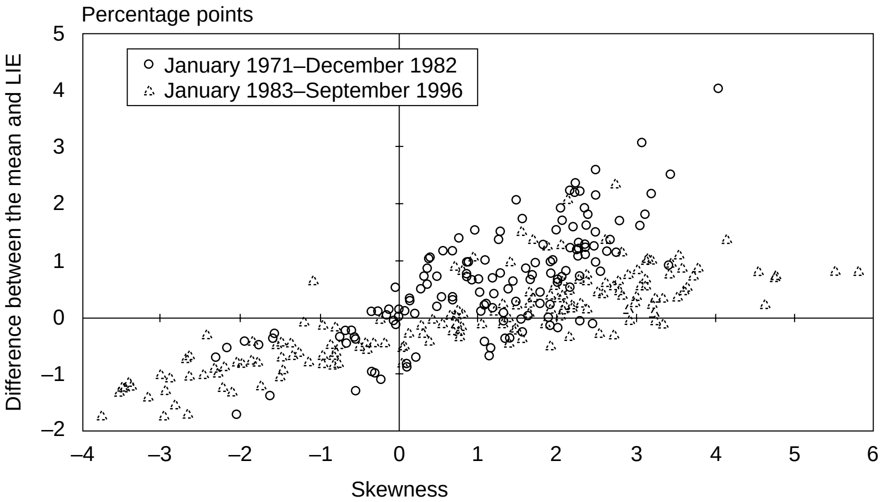
Balke and Wynne (1996) used a dynamic equilibrium model with flexible prices, and showed that, if there is an asymmetric structure in the input-output relationship among sectors, the distribution of price changes will be skewed even under symmetric shocks and will have a positive correlation with inflation. That is, as the magnitude of the shocks to the economy increases, inflation becomes higher. Moreover, since the output-input structure is constant, the larger the shocks are, the larger the degree of skewness in the cross-sectional distribution of individual price changes becomes.

Both models claim the existence of a positive correlation between the skewness of price change distribution and inflation. In the Ball-Mankiw model, however, it is assumed that correlation between the skewness of price change distribution and inflation will disappear in the long run when prices become flexible. The Balke-Wynne model, in contrast, assumes that this correlation continues over time.

3. Correction of the impact of skewness on distribution using the LIE

To what extent does the LIE correct the impact of skewness on the cross-sectional distribution of the individual price changes? If we plot the difference between the weighted average value and the LIE as well as the coefficient of skewness, as shown in Figure 5, you can see the positive correlation between the two. This illustrates the fact that the LIE is correcting the effect that makes the average move toward the direction of the skewness in distribution.[19]

Figure 5 Skewness Cross-Sectional Inflation Distribution and Difference between the Mean and LIE



Notes: 1. The mean, LIE, and coefficient of skewness are calculated from the year-to-year changes in inflation.
2. The LIE corresponds to 15 percent trimmed weighted mean.

IV. Effects of Seasonal Fluctuation

The seasonality of price changes can also be included among the temporary components of inflation, and serves as an additional factor making the measurement of underlying inflation difficult.

A. Importance of Seasonal Adjustment

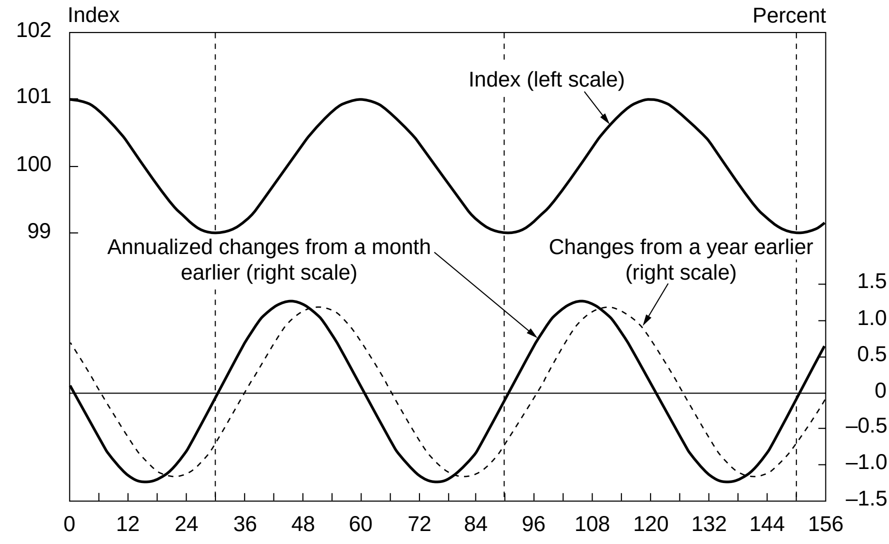
In order to look at the direction of underlying inflation, seasonal factors should be excluded from original (non-seasonally adjusted) data series. The most simple and often-used way to do this is to look at the year-to-year changes. However, this

19. With respect to the statistical robustness of the positive correlation between inflation and skewness of the distribution, Bryan and Cecchetti (1996) pointed out that effects of small sample bias are substantial, and thus need further research. However, this should not alter our conclusion that the LIE will exclude price-disturbing effects and will serve as an appropriate measure to gauge underlying inflation.

method, as Kimura (1995) pointed out, induces the following problems: (1) year-to-year changes can be largely affected by the previous year's development; and (2) year-to-year changes provide incorrect information regarding turning points in underlying inflation.

For the assessment of the underlying inflation trend, it is important to ascertain the turning point of the cyclical pattern of price movements. From this point of view, the lagged nature of year-to-year changes is problematic. Figure 6 compares year-to-year changes with month-to-month changes in a hypothetical cycle derived from a sine function. Month-to-month changes are positive when the cyclical component moves from the bottom trough to the peak, and are negative from the peak to the trough, thus providing information that helps one to recognize the turning point. In contrast, there are lags in year-to-year changes, and their magnitude depends on the length and amplitude of the cycle.

Figure 6 Leads and Lags in Annualized Changes from a Month Earlier and Changes from a Year Earlier



Note: Index is calculated by the following sine function: $I_t = \sin[\pi(t+15)/30] + 100$.
Source: Kimura (1995).

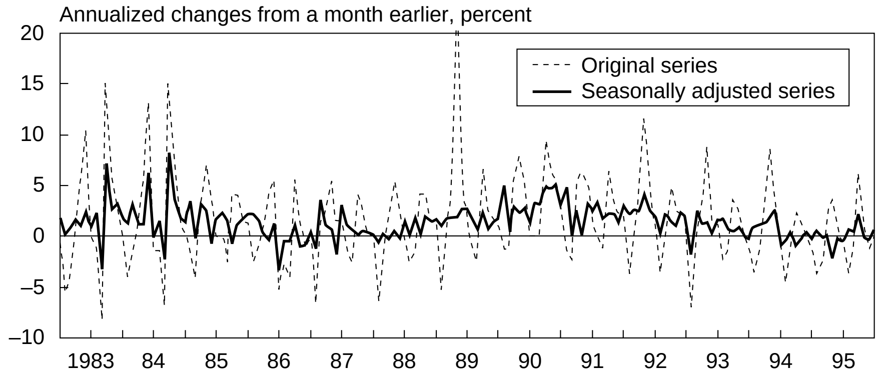
Given the problems inherent in year-to-year changes, it seems desirable to also look at month-to-month changes in order to examine the direction of underlying inflation.

Recently, the application of the X-12-ARIMA procedure has been advocated. This method enables us to cope more flexibly with some existing problems such as the instability of seasonal adjustment factors in data updates, and unnatural movements in seasonally adjusted series.[20] In fact, if we compare a seasonally adjusted time series with the raw data series for the overall CPI excluding fresh food, as shown

20. For details of X-12-ARIMA, see Kimura (1995, 1996).

in Figure 7, the seasonally adjusted series shows a much smoother development, thus better illustrating the underlying trend of price changes. However, problems pertaining to the weighted average index, such as its likeliness to overstate the effects of outlier items, cannot be corrected just by conducting seasonal adjustments on the overall index.

Figure 7 Seasonally Adjusted Inflation Rate



Note: Seasonal adjustment was conducted by the X-12-ARIMA procedure with the following options:
Sample period: January 1980–December 1995
ARIMA model: (0 1 1)(0 1 1)$_{12}$
Level shift adjustment: April 1989
Trading day adjustment: none

B. Adjustment of Seasonal Fluctuation

In the following, we will construct the LIEs, on both a seasonally adjusted month-to-month change basis and a year-to-year change basis: in the former case, we will first make seasonal adjustment for data in 88 categories, and then will move on to calculate the LIE.[21]

Application of the X-12-ARIMA procedure to seasonal adjustment for the disaggregated CPI series is conducted in the following way. Among the CPI components, there are items such as public utility charges that have a low frequency and change irregularly, and are thus not necessarily suitable for seasonal adjustment methods like X-12-ARIMA. Therefore, in seasonally adjusting individual items, (1) public utility charge related items[22] and (2) items that do not show statistically significant seasonal changes are excluded from the seasonal adjustment. Then, by using the auto selection command for the ARIMA model, which is one of the functions of the X-12-ARIMA

21. As to the seasonal adjustment of individual items, only the seasonally variable components have been excluded from the raw data series, leaving temporary variable components estimated by X-12-ARIMA as they are. In order to separate temporary variable components from cyclical components, it is necessary to run an X-12-ARIMA estimation each and every time. Since we follow the conventional methodology of conducting seasonal adjustment by using pre-estimated seasonal adjustment factors, we correct only for seasonally variable components.
22. With respect to items such as public utility charges that show ladder-type price changes, a three-month moving average has been used to smooth the fluctuations in month-to-month changes.

program, seasonal adjustment is conducted. As for level shift factors, those which were affected significantly by the April 1989 tax reform have been adjusted *ex post* and *ex ante;* and for outlier factors, only those that were automatically searched and that are statistically significant have been adjusted *ex ante*. With respect to items for which we cannot specify the optimal ARIMA model by auto selection command, the model has been specified based on Akaike's information criterion (AIC) out of the ARIMA model candidates identified by auto-correlation and partial auto-correlation patterns.

V. Measures to Gauge the Underlying Inflation Trend

Based on the previous discussion, this chapter will construct an index to measure underlying inflation and carry out a case study using an LIE based on price changes since the late 1980s.

A. Assessment of Price Changes Using the LIE

We will estimate two types of LIEs, one on a year-to-year change basis and one on a month-to-month change basis, and examine price changes since the late 1980s. In making policy judgments, an LIE on a year-to-year change basis is deemed useful in assessing the level of inflation, while an LIE on a month-to-month change basis is useful for assessing the momentum of inflation.

As to data, 88 categories, which form the minimum classification available continuously from 1970 up to now, are used. In addition, out of the weighted median and the 5 percent, 10 percent, 15 percent, 20 percent, and 25 percent trimmed means, the relatively stable 15 percent trimmed mean is used as the LIE.[23]

1. The LIE on a year-to-year change basis

Figure 8 shows the trend of the LIE on a year-to-year basis. Among the LIE, overall CPI, and overall CPI excluding fresh food, the LIE generally shows the most stable transition, indicating that temporary shocks are largely eliminated in the LIE.

Let's focus on the encircled four points of time: they correspond to the first oil crisis, second oil crisis, yen appreciation phase after the Plaza Accord, and the yen appreciation of 1995.

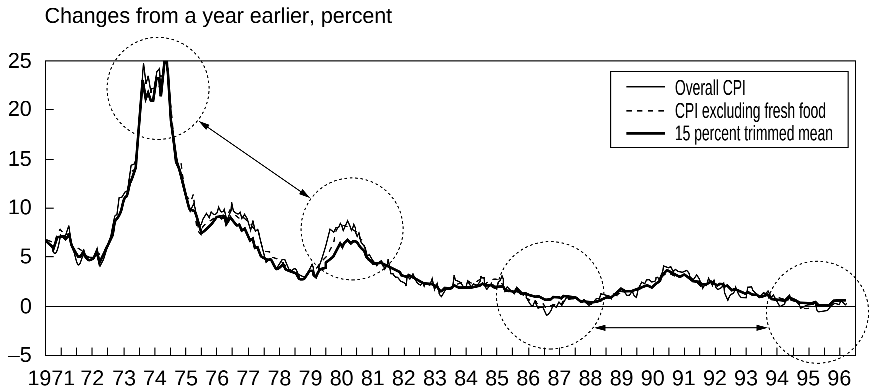
When we compare the first and second oil crises, inflation during the first oil crisis reached a peak of 24 percent on an annual basis for the overall CPI excluding fresh food and the LIE, with both rising almost at the same rate. In contrast, during the second oil crisis, the overall CPI excluding fresh food reached 8.7 percent, much higher than the 6.6 percent measured by the LIE. The different movement of two indicators during these two phases is quite in line with our experience: during the first oil crisis, referred to as "skyrocketing inflation," hyperinflation spread over almost all

23. If you compare the coefficients of variation of the six estimators, none shows an absolutely stable performance. Since correcting outliers more than 15 percent will not help improve overall stability, we have adopted a 15 percent trimmed mean as the LIE. The problem of which estimator is appropriate as an LIE awaits future research, including research into its statistical efficiency and its relation to other financial and real economic indicators. For details of discussion on the criteria for choosing the most appropriate or efficient LIE from the candidates, see Bryan, Cecchetti, and Wiggins (1997).

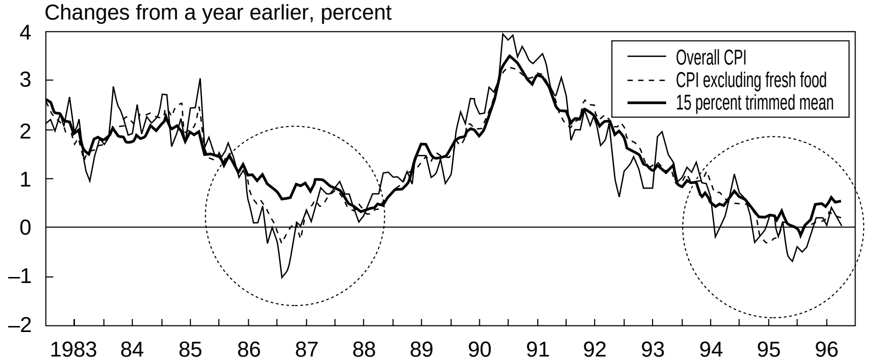
goods and services; while during the second crisis, Japan was successful in avoiding "home-made inflation" and inflation was limited to a small group of products.[24]

Similar phenomena can be observed in the movement of price indicators during the two yen appreciation phases, after the Plaza Accord and in 1995 (Figure 8). During the yen appreciation phase after the Plaza Accord, the year-to-year change of the overall CPI excluding fresh food recorded a negative value in early 1987, while the LIE was in a range between 0.5 percent and 1 percent, thus showing a large divergence between the two indicators. In contrast, in the yen appreciation phase in 1995, when the yen rose rapidly to an exchange rate of ¥80 per U.S. dollar, inflation measured by the overall CPI excluding fresh food and the LIE both recorded negative values and there was no divergence between the two as was observed in the phase after the Plaza Accord. This difference might be attributable to the fact that the effect of the fall in prices caused by the yen appreciation after the Plaza Accord was felt strongly and

Figure 8 LIE (Year-to-Year Change Basis)



■ **Enlarged Figure of Recent Period**



Note: Adjusted for the impact of tax reform in April 1989.

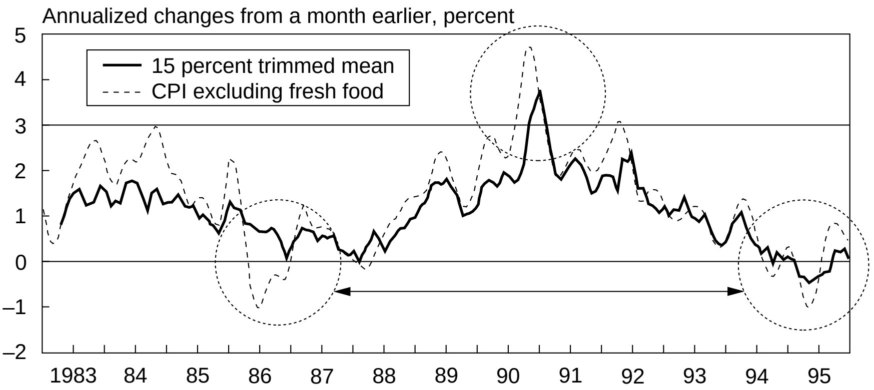
24. Blinder (1982) applied the approach that excludes the impact of certain items, and pointed out that the impact of upward pressure on certain items, such as food and energy, was significant in both the first and second oil crises in the United States.

exclusively by a very limited range of items, while in 1995 deflationary pressure affected a fairly wide range of goods and services, implying that the risk of a deflationary spiral has perhaps increased. In addition, from the fact that the inflation rate recorded its trough at around the end of 1995, it might be the case that the deflationary impact on the economy other than yen appreciation has been substantial.

2. The LIE on a month-to-month change basis

As a next step, in order to assess the momentum of inflation, we have estimated the seasonally adjusted LIE on month-to-month basis. Figure 9 plots a 15 percent trimmed weighted mean and cyclical and trend components of a seasonally adjusted series by X-12-ARIMA.[25] As you can see, the 15 percent trimmed weighted mean has been moving almost in parallel with the seasonally adjusted overall CPI excluding fresh food.

Figure 9 LIE (Seasonally Adjusted Month-to-Month Change Basis)



Notes: 1. Figures for the 15 percent trimmed mean are three-month moving averages.
2. Adjusted for the impact of tax reform in April 1989.

However, if we look at both movements more closely, the following two features can be pointed out. First, during the periods of rapid yen appreciation, the seasonally adjusted overall CPI excluding fresh food was substantially lower than the LIE in 1986, although there was not much divergence between the two in 1995. This contrast might have stemmed from the difference, as in the explanation of Figure 8, between those situations in which deflationary pressure was limited to a small group of items and those in which it was spread over a wide range of goods and services.

Second, during the Gulf Crisis in 1990, the seasonally adjusted overall CPI excluding fresh food rose more rapidly than the LIE. This seems to imply that the rise in inflationary pressure in this period strongly affected some specific items that reflected the rise in crude oil price caused by the Gulf Crisis. Of course, it is true that the inflation rate, which reached almost 4 percent measured by the LIE, was indeed large.

25. Seasonally adjusted series are calculated by using data from January 1982 to September 1996.

These observations seem to suggest that the basic direction of inflationary and deflationary pressures can be clearly traced if we examine the movement of both the seasonally adjusted LIE and the overall CPI excluding fresh food on a month-to-month basis.

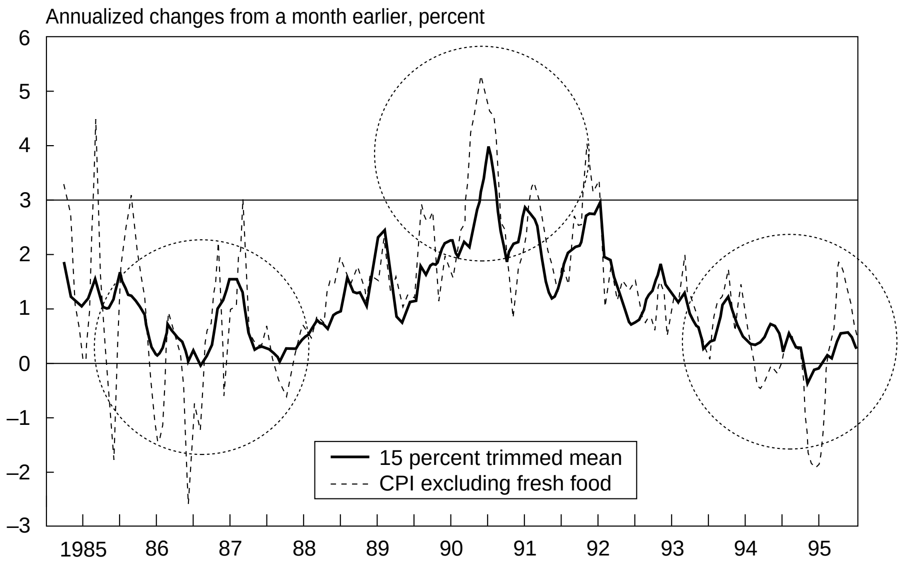
3. Simulation based on available data up to each period

In estimating the LIE on a month-to-month basis, a seasonally adjusted time series calculated *ex post* from data recorded between January 1982 and September 1996 is used. However, if one wishes to argue the effectiveness of the LIE, it is not fair to conduct an analysis based on information that becomes available *ex post*.

Therefore, in the following sections, we will check how the earlier results might be affected if we use only information available at each point of time. Specifically, necessary seasonal adjustments are conducted for both the LIE and the overall CPI excluding fresh food based on data for the past 5 years retroactive from the preceding year.

Based on the estimated results shown in Figure 10, our earlier observations are confirmed: the 15 percent trimmed weighted mean and the seasonally adjusted overall CPI excluding fresh food show large divergence during the periods of post-Plaza Accord (1986–97) and Gulf Crisis (late 1990), indicating that price shocks are concentrated on specific items. However, it should be noted that divergence of both indicators also increased during the yen appreciation period of 1994 to 1995, suggesting that it might be difficult to distinguish which impact was substantial—the yen's appreciation or deflationary pressure on the overall economy.[26]

Figure 10 Simulation with Data Available in Each Time Period



Notes: 1. Figures are three-month moving averages.
2. Adjusted for the impact of tax reform in April 1989.

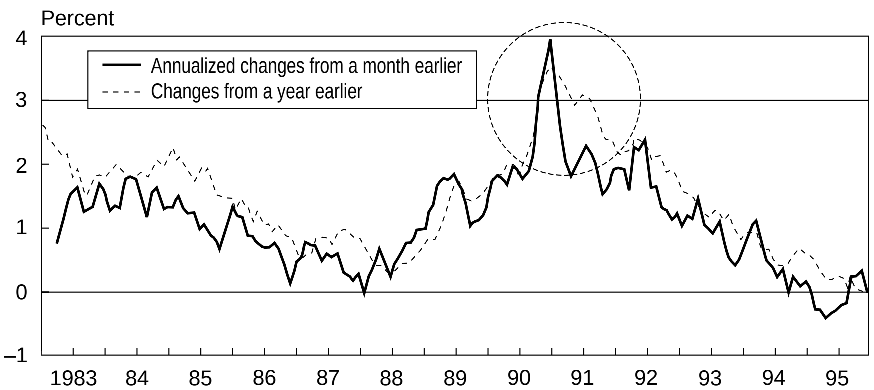
26. However, since the estimates shown in Figure 8 are not all based on *ex post* information, it is highly possible that we can correct information obtained from relatively volatile month-to-month changes by looking at the LIE on month-to-month and year-to-year bases in parallel.

4. Comparison of the LIE on year-to-year change and month-to-month change bases

Finally, we compare movements in the LIE on a month-to-month change basis with those on a year-to-year change basis.

Figure 11 plots series on a month-to-month change basis and on a year-to-year change basis for the 15 percent trimmed weighted mean. From this figure, you can see that inflation intensified rapidly from 1988 to 1990. After having reached its peak at the end of 1990, inflation was around 3 percent on a year-to-year change basis until late 1991, while the month-to-month change basis increase, despite its high rate, suddenly slowed after entering 1991, suggesting that inflation had peaked.

Figure 11 Comparison of LIEs, Year-to-Year Change and Month-to-Month Change Bases



Notes: 1. Figures are three-month moving averages.
2. Adjusted for the impact of tax reform in April 1989.

These results seem to suggest that we can better assess the level and direction of the underlying inflation trend by combining several indicators such as the LIE on seasonally adjusted month-to-month change and year-to-year change bases, and the overall CPI (or the overall CPI excluding fresh food) on a year-to-year change basis and a seasonally adjusted month-to-month change basis.

B. Assessment of Price Developments since the Late 1980s

During the late 1980s and the early 1990s, often referred to as the "bubble" era, Japan experienced large fluctuations in asset prices as well as in real economic activity. Most people held that underlying price stability was maintained during this period. That is, it was generally believed that the general price level was relatively stable, while large fluctuations in asset prices led to high volatility of the business cycle. However, were we right in saying that price stability was maintained during this period?

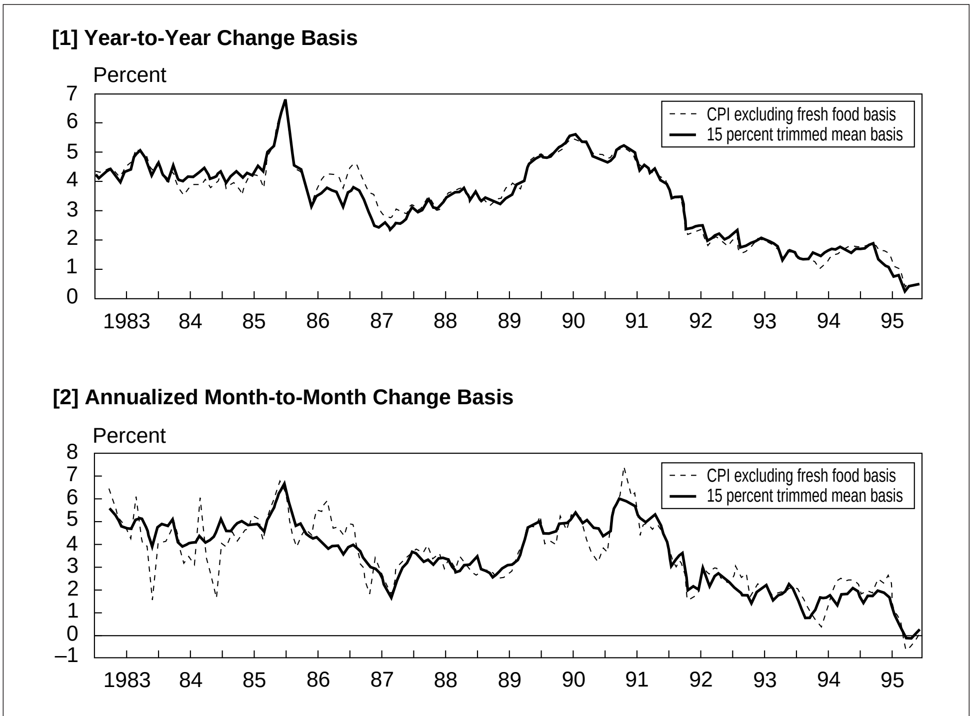
First, it should be pointed out that the underlying rate of inflation, after hitting a trough in mid-1988 and peaking at the end of 1990, has increased substantially from around 0 percent to over 4 percent in two and a half years.

Second, the deflationary impact stemming from the appreciation during 1986 and 1987 might well be overstated. It can also be stated that the tolerable inflation rate during the economic recovery phase from its trough in November 1986 was not as high as expected.

Third, inflation on a year-to-year change basis was over 3 percent until after mid-1991, while that on a month-to-month change basis suddenly slowed at the beginning of 1991, indicating more clearly the peaking of the inflation trend. Since there is a long lag between policy action and its influence on inflation, it seems crucial to conduct monetary policy in a preemptive way. In this context, it is deemed important to check the inflation measures based on year-to-year changes as well as those based on seasonally adjusted month-to-month changes.

In addition, during phases in which the overall CPI excluding fresh food diverges from the LIE, the real interest rate obtained by using these two indexes will show different movements. Figure 12 plots real short-term interest rates calculated by deflating the call money market rate with the overall CPI excluding fresh food and with the 15 percent trimmed weighted mean. Between mid-1986 and mid-1987, when the discount rate was cut five times, from 5 percent to 2.5 percent, the divergence between the overall CPI excluding fresh food and the 15 percent trimmed weighted mean widened substantially and thus induced different movements of real short-term interest rates. In particular, during the latter half of 1986, since the real interest rate on a CPI basis rose while the real interest rate on an LIE basis remained almost unchanged, different assessments could be made with respect to the extent of monetary relaxation during this period.

Figure 12 Real Short-Term Interest Rates



VI. Conclusion

After discussing the definition of price stability in the context of monetary policy operations, this paper examined, by excluding the effects of temporary shocks on price changes, the price index that reflects the underlying inflation trend. In addition, by using this price index, the development of inflation since the late 1980s was assessed.

Based on our results, the LIE is deemed useful in adjusting for the effects of various temporary shocks, and in gauging the underlying inflation rate. In particular, the level and direction of the upward trend in the inflation rate become more evident when year-to-year and month-to-month changes of the LIE are used in combination with other indexes such as year-to-year and seasonally adjusted month-to-month changes in the overall CPI (or the overall CPI excluding fresh food).

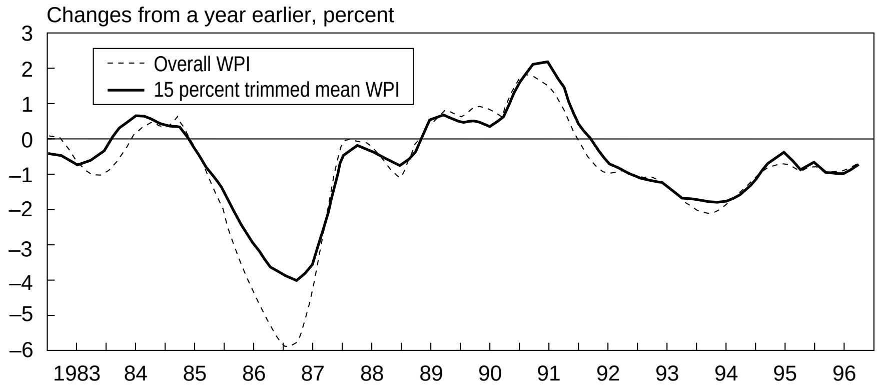
In order to utilize the LIE as an indicator for the judgment of inflation development, the following three points await future examination. First, in order to ensure simplicity in calculation, the LIE used in this paper is constructed for 88 categories of the CPI whose time series are available continuously since 1970. Since the LIE is calculated from rates of change, the series of each base period can be directly connected. Therefore, by using individual item indexes in each period, we can construct an index based on a more detailed classification of every five years, and make available a more accurate time series if we connect such indexes.[27]

Second, in this paper, assessment of price development using the LIE is mainly conducted on actual time-series figures and thus may be deemed naive. Of course, as shown in this paper, a substantial amount of information necessary to gauge the underlying inflation trend could be obtained just by looking at the figures. However, in order to evaluate the effectiveness of the LIE as an indicator in operating preemptive monetary policy, we need to investigate further the statistical relationship between these price indexes and other financial and real economic indicators.

Third, we believe that it is useful to apply this LIE framework to the WPI as well. Figure 13 compares the WPI 15 percent trimmed weighted mean on a year-to-year basis, based on the series disaggregated in 21 categories that are retroactively available, with the WPI for all commodities on a year-to-year basis. Even from this figure, we can obtain the same information as we gathered by using the CPI with respect to the three periods: post-Plaza Accord, the Gulf Crisis, and yen appreciation during 1994 and 1995. In particular, since the weights of items in the WPI are based on the nominal value of shipments in the Census of Manufacturers, and thus the fluctuation in raw material prices is likely to be amplified, the LIE might well be substantially useful.[28]

27. The LIE on a month-to-month basis, however, requires seasonal adjustment for CPI components, and thus the continuity of the time series across all base revisions is not guaranteed at the item level. In this case, we need to make use of categories at a more aggregated level than items.
28. As to this point, it might be worthwhile to consider shifting the WPI weights to a net shipment basis.

Figure 13 Limited Influence Estimator for WPI



Note: The 15 percent trimmed mean is calculated with the disaggregated data into 21 subgroups. Linked indexes are readily available.

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