Underlying Inflation and the Distribution of Price Change: Evidence from the Japanese Trimmed-Mean CPI

Hitoshi Mio and Masahiro Higo

In this paper, we analyze the use of the trimmed-mean Consumer Price Index (trimmed CPI) as a measure of underlying inflation. We focus on empirical evidence that the cross-sectional price change distribution often but temporarily skews extremely to each side and that large but temporary variations in inflation correspond to the occurrence of the skewness. We find that the skewness of the distribution is mainly caused by idiosyncratic, temporary relative price shocks and that the components which contribute to the skewness of the distribution shift from time to time.

Trimming 15 percent from each tail of the cross-sectional price change distribution systematically mitigates the fluctuation of the price index related to broad-based temporary relative price shocks. Thus, the trimmed CPI can be regarded as more appropriate for identifying underlying inflation compared with the CPI excluding fresh foods (CPI ex. fresh foods), which is generally regarded as the "core inflation index" in Japan.

Distinguishing temporary price variations and underlying inflation using a measure of the skewness of the price change distribution provides central banks with increased information for evaluations of prior policies and present price developments, and for predictions of future inflation.

Key words: Underlying inflation; Trimmed CPI; Price change distribution; Temporary relative price shock

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I. Introduction

This paper examines the characteristics of the trimmed-mean Consumer Price Index (trimmed CPI) as a means to identify underlying inflation. We calculate trimmed CPIs based on the percentage price changes over a 12-month horizon for the 88 components that comprise the Japanese CPI, conduct some empirical analyses on the characteristics of the trimmed CPI, and discuss the use of the trimmed CPI as an indicator of underlying inflation.

Calculation of the trimmed CPI follows prior research and is explained in the subsequent chapter. Simply stated, we exclude a fixed percentage of the components that comprise the CPI at each tail of the cross-sectional price change distribution and aggregate the remaining components with some fixed weights. In other words, components that experience extreme relative price variation are ignored in the calculation of the index.

Because the CPI and other price indices are simple weighted averages of the observed prices of various goods and services in market transactions, when the prices of some components temporarily show large variations due to idiosyncratic relative price shocks, the aggregate price indices also tend to temporarily show large variations. Thus, in practice, it is extremely difficult to identify underlying inflation from the growth rate of a specific price index. Consequently, in evaluating underlying inflation using the CPI, a "core inflation index," which excludes, *a priori*, specific components that are regarded as subject to extreme price variations due to temporary factors, has been widely adopted in many nations. The definition of the "core inflation index" varies among countries. For instance, in Japan, the percentage changes of the CPI excluding fresh foods (CPI ex. fresh foods), which ignores three components of perishables, has been generally regarded as a candidate for identifying underlying inflation.

In contrast, trimmed CPIs do not exclude any components *a priori*, but rather systematically determine which components to exclude at each point in time based on the percentage price change of individual components, i.e., information on the relative price variability, to identify underlying inflation. This field of research is being pursued in the United States and many other countries including England, Canada, and New Zealand. In this paper, we examine the characteristics of the Japanese trimmed CPI in detail.

Following this introduction, Chapter II briefly presents the concept of trimmed-mean indices and introduces the prior research. In Chapter III, we calculate several trimmed CPIs based on the percentage changes over a 12-month horizon with various trimming ratios, compare the values of these indices over time, and apply a VAR estimation to check the statistical causality from money growth to the trimmed CPI as well as the causality from other macroeconomic variables. In Chapter IV, we analyze the contribution to the relative price shock component from individual components, discuss the causes of relative price shocks, and consider the appropriateness of eliminating these components from what we call underlying inflation. In Chapter V, we predict future inflation using the relative price shock component to examine the use of the measure of asymmetry in the price change distribution to identify underlying inflation. Finally in Chapter VI, we offer conclusions and discuss some future tasks.

II. Outline and Objectives of Trimmed-Mean Indices

In this chapter, we briefly present the concept of trimmed-mean indices and introduce prior research in this field including Shiratsuka (1997) and the series of works by Bryan and Cecchetti.

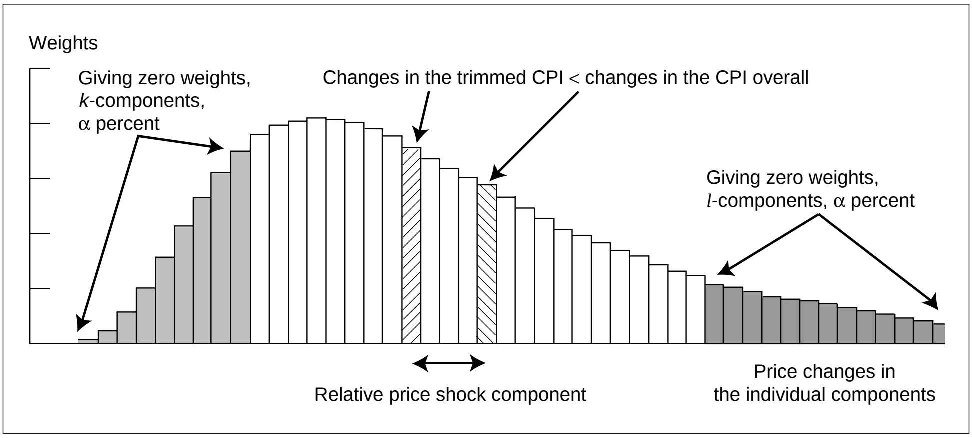
A. Outline of Trimmed-Mean Indices

A trimmed mean is a class of population parameters whereby the sample points in a sample space are rearranged from lowest to highest values (the order statistic), a fixed percentage of the lowest and highest sample points are ignored, and the mean value is calculated for the remaining sample points.

Bryan and Cecchetti (1994) and Shiratsuka (1997) applied this scale to CPIs and calculated trimmed CPIs based on the inflation in individual components over some time horizon for each period, and trimmed (assigned a zero weight to) a fixed percentage of the components on each tail of the price change distribution[1] (Figure 1).

Trimmed-mean indices are designed to identify underlying inflation by ignoring components that experience extreme relative price variation. While the CPI ex. fresh foods[2] excludes perishables in a somewhat *ad hoc* manner and has traditionally been used in Japan to evaluate underlying inflation, the trimmed CPI does not exclude any components *a priori*, but rather determines which components to

Figure 1 Price Change Distribution for Individual Components and the Trimmed CPI



1. Incidentally, the dispersion of this distribution indicates the relative price variability. Thus, hereafter, the terms "price change distribution" and "distribution of relative price variability" are used interchangeably. When there is no relative price variability, the variance of the price change distribution is equal to zero. Large skewness in the price change distribution indicates that there exist some components which experienced idiosyncratic relative price shocks. See Appendix 1 for prior research regarding the relationship between inflation rates and relative price variability.
2. The CPI ex. fresh foods is calculated by removing fresh fish and shellfish, fresh vegetables, and fresh fruits from the overall CPI. The weighted sum of these three components to the overall CPI on a 1995 basis is 5.0 percent. See Appendix 2 for a description of the 88 individual components.

exclude at each point in time based on the information of the cross-sectional price change distribution.[3]

As shown in Figure 1, when the price change distribution skews to the right—that is, when the skewness is positive—there is a relationship in which the weighted mean (in this case, the CPI overall) is greater than the trimmed mean (the trimmed CPI). The divergence between these two indices reflects the degree of skewness in the price change distribution, i.e., the distribution of relative price variability. Thus, when the skewness is large, the evaluation of the inflation at each point in time differs substantially depending on which index is used. In this paper, this divergence is referred to as the "relative price shock component," and its characteristics are analyzed in detail.

B. Prior Research on Trimmed-Mean Indices

The major prior research on the use of the trimmed CPI is the series of works by Bryan and Cecchetti (see, for instance, Bryan and Cecchetti [1994]). They assume long-run monetary neutrality, and hypothesize that the price change of individual components comprises the sum of the money growth rate and exogenous relative price shocks peculiar to individual components:[4]

3. The trimmed CPI is expressed by the following formula.

$$TM(2\alpha) = \frac{1}{1-\frac{2\alpha}{100}} \sum_{i=k+1}^{n-l} w_{(i)} x_{(i)} \qquad \sum_{i=k+1}^{n-l} w_{(i)} = 1 - \frac{2\alpha}{100}, \tag{F.1}$$

where

$TM(2\alpha)$ is the trimmed CPI, trimming the component on each tail of the distribution by α percent,
$x_{(i)}$ is the inflation rate for components with the i-th smallest inflation rate,
$w_{(i)}$ is the weight for components with the i-th smallest inflation rate,
k is the number of components to be trimmed from the left tail of the price change distribution,
l is the number of components to be trimmed from the right tail of the price change distribution.

The weighted mean equals the case where α=0 and the weighted median equals the case where lim $\alpha \to 50$. Also, the series where α=0 is approximately the same as the percentage changes of the weighted geometric mean index. If p_i^t is the price of the i-th component at time t and w_i is the weight, the percentage change for the aggregate price index over the s-th horizon is approximately equal to

$$\sum_{i=1}^{n} w_i \left(p_i^t \big/ p_i^{t-s} - 1 \right) \cong \sum_{i=1}^{n} w_i \ln \left(p_i^t \big/ p_i^{t-s} \right). \tag{F.2}$$

The right-hand side of equation (F.2) can be rewritten as

$$\left(\sum_{i=1}^{n} w_i \ln p_i^t \right) - \left(\sum_{i=1}^{n} w_i \ln p_i^{t-s} \right) = \ln \left\{ \prod_{i=1}^{n} \left(p_i^t \right)^{w_i} \right\} - \ln \left\{ \prod_{i=1}^{n} \left(p_i^{t-s} \right)^{w_i} \right\}. \tag{F.3}$$

This approximates

$$\prod_{i=1}^{n} \left(p_i^t \right)^{w_i} \Big/ \prod_{i=1} \left(p_i^{t-s} \right)^{w_i} - 1, \tag{F.4}$$

which is approximately the same as the percentage change of the weighted geometric mean price index. As we change the weight w_i for each five-year period, our index approximately indicates the percentage changes of the five-year interval chain weighted geometric mean index. Comparing the 12-month percentage changes of this index with the 12-month percentage changes of the CPI algebraic weighted mean, there is virtually no difference, so we treat the 0 percent trimmed CPI as the "CPI overall" for all of the following analyses.

4. Bryan and Cecchetti state that "Sources of such noise include changing seasonal patterns, broad-based resource shocks, exchange-rate changes, changes in indirect taxes, and asynchronous price adjustment" (Cecchetti [1997]). However, it should be noted that it is not necessarily self-evident that the effect of these shocks should be ignored in terms of "price stability." Our basic understanding is that price movements which are caused by temporary supply shocks should be ignored in terms of "price stability." See chapters IV and V for a detailed discussion.

$$p_{i,t} = p^{money}_{t} + x_{i,t}, \tag{1}$$

where

$p_{i,t}$ is the inflation rate of the i-th component at time t,
p^{money}_{t} is the inflation rate due to the money growth rate at time t,
$x_{i,t}$ is the relative price shock to the i-th component at time t.

In this model, in the long run, the aggregate value of $x_{i,t}$ for all the components i is defined as zero and the aggregate value of the percentage price changes for all the individual components $p_t = \sum p_{i,t}$ is equal to p^{money}_{t}, which is parallel to the money growth rate. They argue that in practice, however, because relative price adjustments are not completed in the short run, the price change distribution temporarily skews and a divergence appears between $p_t = \sum p_{i,t}$ and p^{money}_{t}.[5] Bryan and Cecchetti conducted Granger's causality tests between the money growth and the percentage changes of CPI overall, the trimmed CPI including the median, and the CPI excluding food and energy as candidates for p^{money}_{t}. They also examined the ability of these different measures to predict the future inflation measured by the CPI overall. Their conclusion is that the weighted median, which is a 100 percent trimmed CPI,[6] is the best candidate for p^{money}_{t} among these indices (Bryan and Cecchetti [1994]). Bryan and Cecchetti note that although long-term centered moving averages of monthly inflation rates can be regarded as strong candidates for identifying underlying inflation, the long-term centered moving averages for the most recent periods cannot be obtained and thus lose timeliness (Bryan and Cecchetti [1994], Cecchetti [1997]).[7] They argue that the trimmed CPI can be used as a substitute for this purpose.

In Japan, prior research on the use of the trimmed CPI includes that by Shiratsuka (1997). He breaks down the Japanese CPI into the 88 components, calculates the trimmed CPI over a 12-month horizon, and compares its path to those of the CPI overall and the CPI ex. fresh foods. He shows a substantial divergence between the path of the trimmed CPI and those of the other two indices in 1980–81 and again in 1986–87. As these periods coincide with the second oil shock and with the shock generated by drastic changes in foreign exchange rates, Shiratsuka argues that temporary shocks to particular components brought about temporary price variation. Moreover, he concludes that the trimmed CPI successfully filtered out the effects from these temporary shocks, and is therefore an effective means of identifying underlying inflation.

5. See Appendix 1 for a discussion of this issue.
6. See Footnote 3.
7. Moving averages of economic variables are broadly adopted as a means to reflect underlying movements. See Higo and Nakada (1998), for instance, for the application of various methods of time-series analysis including moving averages to the Japanese CPI to identify the underlying inflation. They claim that the addition of new data can change the estimation results and that, in particular, identified underlying trends around the end of the sample period are likely to be revised by the addition of new data.

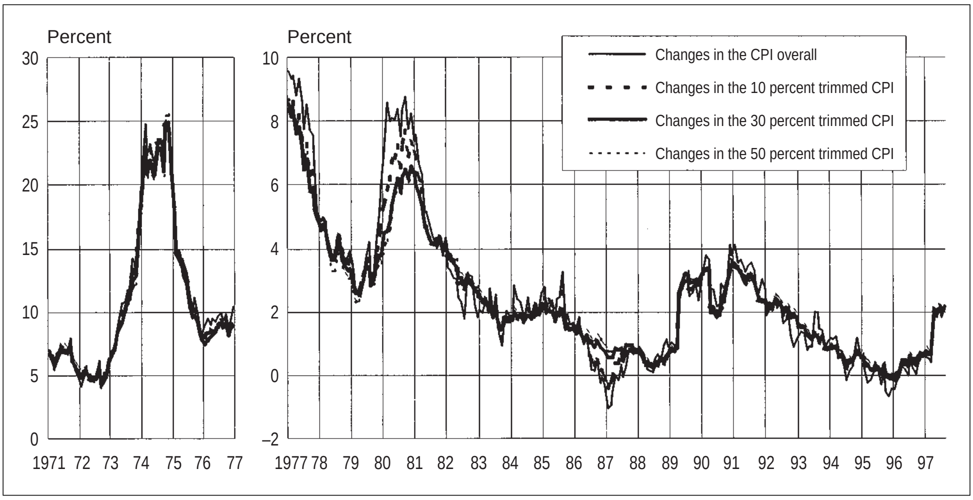
III. Characteristics of the Japanese Trimmed CPI: Comparison with Prior Research

In this chapter, we first calculate trimmed CPIs with various trimming ratios, compare them to the CPI ex. fresh foods, and provide an outline of their characteristics. Then, by employing spectral analysis of the percentage changes of the various indices including trimmed CPIs, and by estimating a VAR model to test the existence of Granger's causality, we try to verify empirically whether the characteristics of trimmed CPIs are consistent with the prior research in the United States—that is, whether the trimmed CPIs successfully screen out only high-frequency price variation components and whether Granger's causality exists from money growth to the trimmed CPI. In contrast to the recent analysis conducted by Bryan and Cecchetti (1999), we focus on the percentage changes over a 12-month horizon in the following analysis.[8]

A. Outlook of the Japanese Trimmed CPI

Figure 2 presents historical data on Japanese trimmed CPIs with various trimming ratios. The figure shows periods where there is a divergence between the 10 percent

Figure 2 Historical Data on the Japanese Trimmed CPIs



8. The various inflation measures for the following analyses are all based on the percentage changes over a 12-month horizon. The advantage of focusing on these is that they are generally used for evaluating underlying inflation in many nations, including Japan (Higo [1999]). Also, this conveniently averts the issue of seasonal adjustment. While we applied seasonal adjustments for the 88 components using X-12-ARIMA, we found that the estimated ARIMA models are easily affected by changes in the estimation period, and thus have a problem in terms of stability. On the other hand, the disadvantage is that the raw data are processed by time-series methods to some extent, that is, averaging the data over some length of time. This causes some difficulties in interpretation of the following analyses. First, discovery of the turning point of the time series tends to be delayed (Kimura [1996]). Second, the effect of relative price shocks that cause once-for-all price level shifts seems to continue for one year (see, for instance, the case for public utilities in Figure 10). Because our goal is to show the relative effectiveness of the trimmed CPI compared to indicators that have traditionally been regarded as candidates for identifying underlying inflation, we focus on 12-month percentage changes. Thus, the results of this paper and prior research in the United States, which is based on a monthly inflation rate, cannot be directly compared. For analysis based on the inflation rate over a much shorter time horizon applying X-11 seasonal adjustment for the Japanese CPI, see Bryan and Cecchetti (1999).

trimmed CPI (which trims 5 percent from each tail of the price change distribution) and the 30 percent trimmed CPI, especially during 1980–81 and 1986–87. However, there is little divergence between the 0 percent trimmed CPI (the CPI overall),[9] or between the 30 percent trimmed CPI and the 50 percent trimmed CPI.

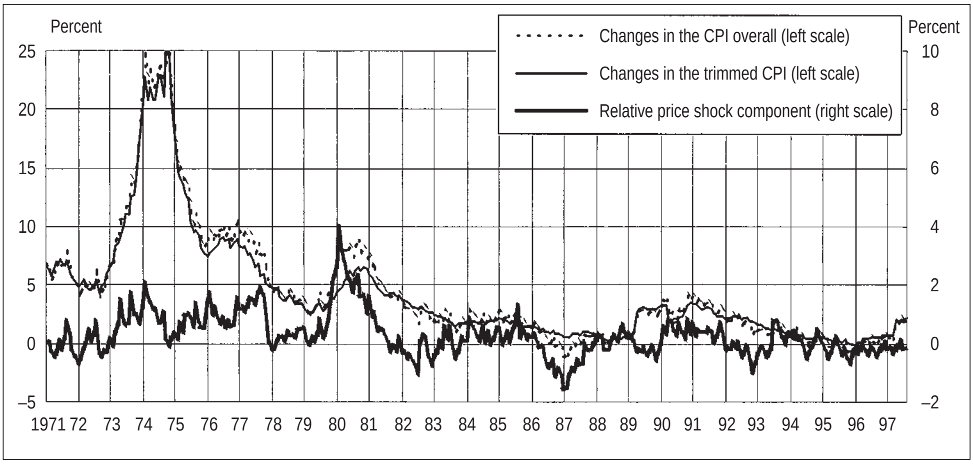
Using the method applied by Bryan, Cecchetti, and Wiggins (1997) to identify the optimal trimming ratio for the Japanese CPI, we determined that the optimal trimming ratio is 30 percent. Accordingly, the 30 percent trimmed CPI is regarded as the trimmed CPI for the following analyses.[10]

Figure 3 presents changes in the CPI overall and the trimmed CPI, as well as the divergences between these two indices (the relative price shock component). It shows that large-scale divergences occurred in three periods: 1973–77, 1980–81, and 1986–87. (In particular, during 1980–81, when the second oil shock occurred the divergence peaked at 4.0 percent.) Also, all three of these divergences narrowed after a set period of time. On the other hand, during the price declines in 1995, when the changes in the CPI overall were negative, there was virtually no divergence. Consistent with the research conducted by Shiratsuka (1997), these observations indicate the price change distribution, i.e., the distribution of relative price variability, highly skewed several times since 1970, and during these periods the changes in the CPI overall and the trimmed CPI may offer us differing information regarding underlying inflation.

B. Spectral Analysis of the Japanese Trimmed CPI

Next, we conduct spectral analysis of the changes of the CPI overall, the trimmed CPI, and the CPI ex. fresh foods to identify which frequency components are included in the variation of these indices.

Figure 3 Historical Divergences between the Changes in the CPI Overall and Changes in the 30 Percent Trimmed CPI

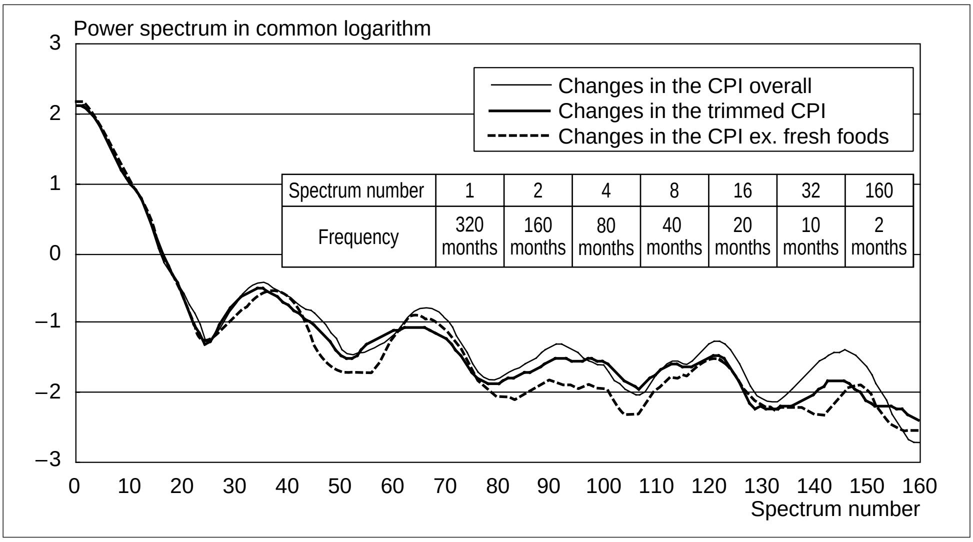


9. See Footnote 2.
10. See Appendix 3 for the details of the calculation of the optimal trimming ratio.

Figure 4 shows the power spectrum distributions for the changes of the CPI overall, the trimmed CPI, and the CPI ex. fresh foods. Applying a Fourier transformation, the data can be described as a linear combination of constant and periodic functions. A power spectrum means a contribution to the variability at every frequency.[11] In Figure 4, the horizontal axis indicates the spectrum number—that is, the reciprocal of the frequency—and the vertical axis indicates the common logarithm of the power spectrum. Because the spectrum number is the reciprocal of the frequency, components with a small spectrum number are those with a low frequency. Dividing the frequency range in Figure 4 into the following three sub-ranges, the variability of the trimmed CPI shows distinctive characteristics compared with the CPI overall and the CPI ex. fresh foods.

First, for the low-frequency (long-cycle) sub-range with a cycle of more than three years—that is, a power spectrum with spectrum numbers of 0 to 9—the power spectrums for all three indices are essentially the same. Second, for the middle-frequency sub-range with a cycle of approximately four months to three years and with spectrum numbers of 10–80, the power spectrums for both the trimmed CPI and the CPI ex. fresh foods are smaller than that of the CPI overall, but the relationship between the trimmed CPI and the CPI ex. fresh foods is not clear. Finally, for the high-frequency sub-range with a cycle of two to four months and spectrum numbers of 80 to 160, the power spectrum of the trimmed CPI is smaller than that of the CPI overall, but larger than that of the CPI ex. fresh foods.

Figure 4 Spectral Distribution of the Changes in the CPI Overall, Changes in the Trimmed CPI, and Changes in the CPI Ex. Fresh Foods



Spectrum number	1	2	4	8	16	32	160
Frequency	320 months	160 months	80 months	40 months	20 months	10 months	2 months

11. See Harvey (1981) for details regarding the frequency domain analyses and Fourier representation.

These results demonstrate that the trimmed CPI excludes the variation in three frequency ranges evenly, whereas the CPI ex. fresh foods particularly excludes high-frequency (short-cycle) price variation, and thus confirms that the trimmed CPI does not have the characteristic of removing only the short-cycle price variation.[12]

C. Granger's Causality Test Using a VAR Model

Next, we statistically test the hypothesis presented in prior research that variability in trimmed CPI primarily reflects the money growth rate, by checking if the money growth rate "causes" the trimmed CPI in Granger's sense.[13] To test this hypothesis, we estimated a VAR model with five variables. We also check whether there is a statistical causal relationship between the relative price shock component and the various macroeconomic variables in the model. The variables used appear in Table 1.

Table 1 Variables for Estimate of the VAR Model

Interest rate	R	Overnight call rate with collateral (annual rate)
Production	q	Changes in the index for industrial production
Money	m	Changes in M2+CDs
Prices	pT	Changes in the trimmed CPI
Relative price shock component	rps	Changes in the CPI overall minus changes in the trimmed CPI
Estimation period	January 1977–March 1997	
Length of the lags	Four (chosen by AIC)	

Note: Adjustments are made for the effects of the consumption tax on prices (calculations by the Bank of Japan Research and Statistics Department).

The results of the causality test are presented in Table 2.

The results show that money growth does not statistically cause the trimmed CPI in Granger's sense. On the contrary, the trimmed CPI causes money growth. Moreover, the trimmed CPI is caused by nominal interest rates and production. These results indicate that fluctuation of the trimmed CPI is closely related to fluctuation of various macroeconomic variables, and that it is difficult to explain the variability of the trimmed CPI as a pure monetary phenomenon. In other words, contrary to the results of prior research in the United States, the results do not strongly support the hypothesis that the trimmed CPI primarily reflects the money growth rate.[14]

12. Caution should be taken in interpreting the results of the spectral analysis because the trimmed CPI adopted in this paper is based on the percentage changes over a 12-month horizon. Specifically, the effect of relative price shocks that cause once-for-all price level shifts seems to continue for one year (see, for instance, the case for public utilities in Figure 10) and thus may be viewed as a mid- to long-cycle variation component. However, as stated above, the trimmed CPI screens out the effect of shocks with cycles of up to three years, and considering this point, our conclusion that "the trimmed CPI does not have the characteristic of removing only the short-cycle variation" still stands. This point is confirmed in the analysis of autocorrelation in Chapter IV.
13. See Yamamoto (1988) for more detail on Granger's causality test. Also, see Okina (1985) for the limitation to applying statistical causality tests in economic analysis.
14. As stated above, our analysis simply applies prior research conducted in the United States to Japan. This presumes that underlying inflation is determined by money growth. However, when using Japanese M2+CDs data, it should be noted that the variability of consumer prices is extremely small compared to the variability of M2+CDs, which is influenced by asset price movements and other factors, and the variability of M2+CDs is influenced by financial liberalization and technological innovations, and encompasses factors that do not necessarily influence underlying inflation; and thus, it tends to be difficult to detect a statistical causality from M2+CDs to price indices.

Table 2 Results of the Causality Test

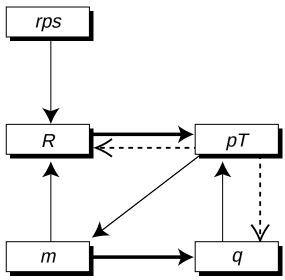
F-value

Dependent variables	Independent variables: *pT*	*rps*	*m*	*R*	*q*
pT	1,310.1	1.4	0.2	4.9	2.4
rps	1.4	77.0	1.0	1.1	1.5
m	2.7	0.4	2,346.9	1.0	0.4
R	1.6	2.8	2.8	2,067.6	1.5
q	1.4	0.3	5.0	0.6	137.5

P-value

Dependent variables	*pT*	*rps*	*m*	*R*	*q*
pT	***			***	**
rps		***			
m	**		***		
R	+	**	**	***	
q			***		***

Granger's causality:
*** = significant at 1 percent level Lead → lag
** = significant at 5 percent level Lead → lag
+ = significant at 20 percent level Lead - - → lag



Sources:
q: *Index for Industrial Production Monthly* (Ministry of International Trade and Industry, Minister's Secretariat, Research and Statistics Department)
R, m: *Economic Statistics Monthly* (Bank of Japan, Research and Statistics Department)
pT, rps: *Consumer Price Index Monthly* (Management and Coordination Agency, Statistics Bureau)

Next, looking at statistical causality among the relative price shock component, i.e., divergence between the changes in the CPI overall and the changes in the trimmed CPI (*rps* in Table 2) and the other macroeconomic variables shows that the relative price shock component is block exogenous. This suggests that the relative price shock component does not fluctuate due to other macroeconomic variables, but rather fluctuates due to other exogenous factors. Conversely, it also implies that the relative price shock component does not have precedence over these macroeconomic variables aside from interest rates.

IV. Detailed Analysis of the Relative Price Shock Component

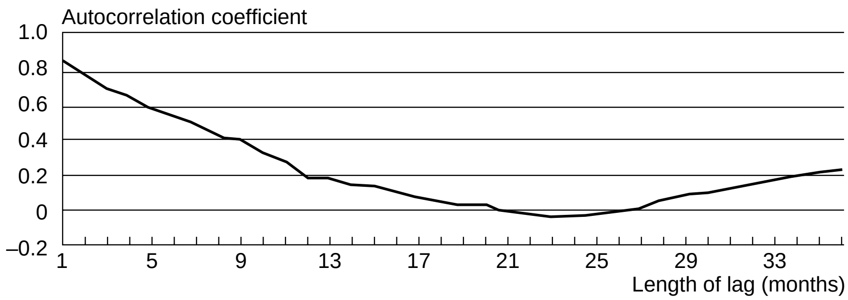
As demonstrated above, the trimmed CPI in Japan does not necessarily have the same characteristics found in prior research in the United States. Here, to analyze the reasons for this discrepancy in detail, we investigate precisely which types of components account for the divergence between the changes in the CPI overall and the changes in the trimmed CPI, that is, the relative price shock component. As stated in the previous chapter, it is important to note that the relative price shock component is block exogenous and thus it is likely that the price change distribution skews due to exogenous factors. In this chapter, we first present an autocorrelation coefficient of the relative price shock component—breaking down the contribution to the relative price shock component by individual component—discuss the nature of relative price shocks, and consider whether fluctuations in the trimmed CPI reflect underlying inflation.

A. Autocorrelation Coefficient of the Relative Price Shock Component

The spectral analysis in Chapter II suggested that the fluctuations in the relative price shock component contain more long-cycle variation than that of perishables.

From the perspective of the autocorrelation coefficient (Figure 5), there is a strong serial correlation in the relative price shock component, and the continuation period is 1.5 to 2.0 years. Serial correlation with a long lag would not be observed if the relative price shock component mainly contains short-cycle variation. Thus, this result also indicates that the trimmed CPI excludes not only short-cycle fluctuations but also mid- to long-cycle price variation from the CPI overall.

Figure 5 Autocorrelation Coefficient of the Relative Price Shock Component

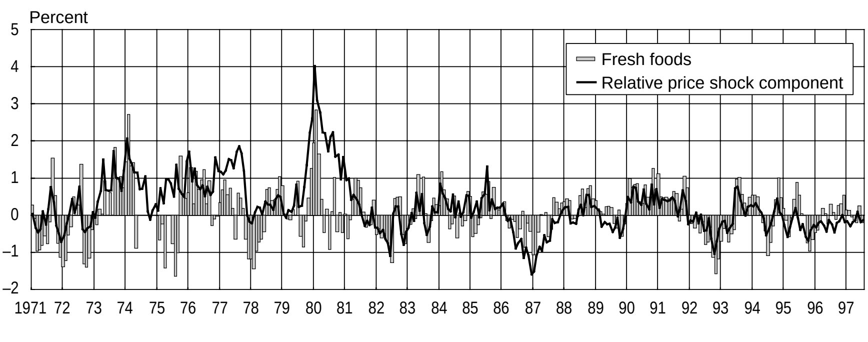


B. Breaking Down the Relative Price Shock Component

Following the results in Section IV.A, we analyze the contribution of the individual components to the relative price shock component.

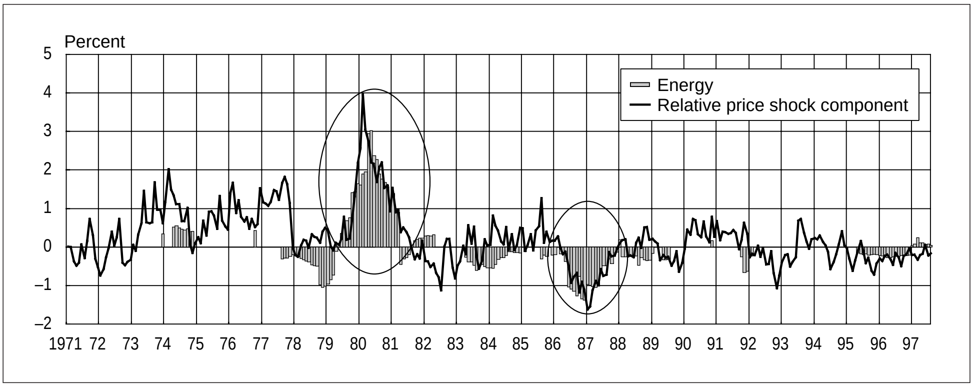
First, Figure 6 presents the contribution of fresh foods to the relative price shock component. The figure shows that the fluctuations in the relative price of fresh foods provide a very good explanation for the short-cycle fluctuations of the relative price shock component. This indicates that fresh foods shift to each tail of the price change distribution in short cycles. However, the relative price fluctuations of fresh foods cannot explain consecutive occurrences of the relative price shock component, such as those during 1980–81 and 1986–87.

Figure 6 Contribution of Fresh Foods



Next, Figure 7 shows the contribution of energy-related components.[15] While energy-related components are trimmed less frequently than fresh foods, they are trimmed for consecutive periods of one to two years, and their contribution is extremely large. In particular, when the relative price shock component occurred continuously during the second oil crisis in 1980–81 (when oil prices were hiked), and again in 1986–87 (when the yen appreciated sharply versus the U.S. dollar and oil prices dropped), this can be explained well by the contribution from energy-related components. The skewness in the price change distribution during these periods was obviously created by the large-scale relative price variation of energy-related components.

Figure 7 Contribution of Energy-Related Components



From the 1990s, the frequency of appearance of energy-related components and their contribution have both declined. This may be attributed to the decline in the weight of energy-related components and the decrease in exogenous shocks, such as the oil shocks.

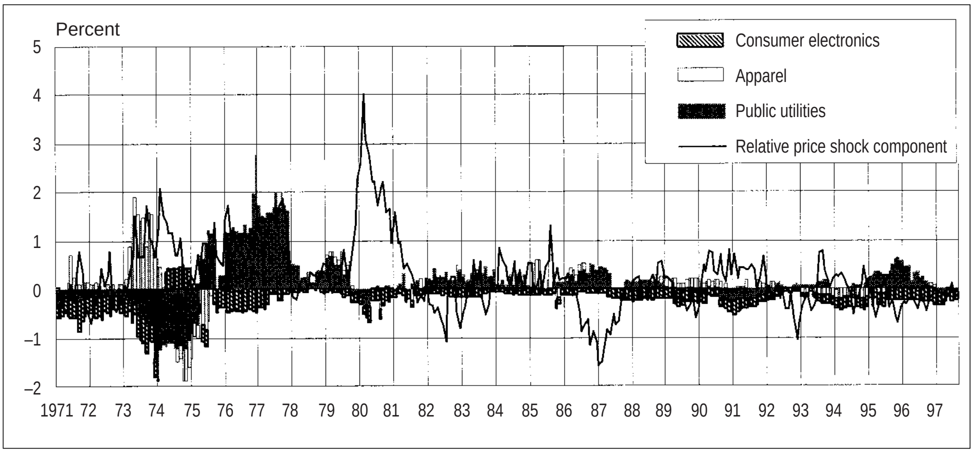
Figure 8 presents components that caused the relative price shock component other than fresh foods and energy. The figure shows that the consecutive occurrence of the relative price shock component during 1973–78 can be explained by fluctuations in the relative price of apparel in the first half of this period and public utilities in the latter half.[16]

Among these, the relative price of public utilities empirically fluctuates with a time lag versus the overall price movements. Looking at each period in some detail, first, during the first oil shock of 1973–74, even though the prices of most other components increased sharply, the relative price of public utilities *declined* continuously for over one year because of government policy to limit rises in public utility charges, and thus public utilities were excluded from the trimmed CPI during this

15. Energy-related components comprise fuel, light and water charges, and automotive maintenance. On a 1995 basis, the weight of energy-related component expenses is 10.6 percent of the CPI overall. See Appendix 2 for a description of the weights of the 88 components.

16. Here, consumer electronics include domestic durables, heating and cooling appliances, air-conditioning equipment, TV sets and audio devices, and other recreational durables (with a weight on a 1995 basis of 2.0 percent). Apparel includes Japanese clothing, clothing, footwear, cloth, and thread (3.9 percent), and public utilities include public transportation, communication, education, and cigarettes (10.8 percent). For details, see Appendix 2.

Figure 8 Contribution of Public Utilities, Apparel, and Consumer Electronics



period. Then in 1975–77, when inflationary pressures had decreased, various public utility charges were raised[17] and public utilities shifted to the right tail of the price change distribution and were trimmed once again. Thus, during this period public utilities were the main cause of the consecutive large relative price shock component. In 1995–96, when the trend toward zero inflation became clear, public utility fees remained on the right tail of the price change distribution, and checked the decline in the CPI.

Finally, while the contribution of consumer electronics to the relative price shock component is extremely small, averaging less than 0.2 percent, it is located on the left side of the price change distribution throughout the observation period, consistently pushing down the CPI.

C. Relative Price Shock Components and Appropriateness of Exclusion from Underlying Inflation

Next, in light of the concept of underlying inflation, we consider whether it is really appropriate to exclude the individual components that comprise the relative price shock component.

The first condition for the trimmed CPI to reflect underlying inflation is that the relative price fluctuations of the components that are excluded by trimming must be caused by temporary factors. If the relative price fluctuation of a given component is persistent (that is, in cases where a relative price shock hits a certain component continuously), it is not clear whether the influence of the shock should be neglected from underlying inflation.[18]

17. Telephone charges and fares for Japan National Railways and other railroads contributed to these fluctuations. For details, see Economic Planning Agency (1973–77).
18. First, if a relative price shock hits a certain component for a long period, persistent skewness in the price change distribution leads to persistent divergences between the changes in the CPI overall and the changes in the trimmed CPI. In this case, the changes in the trimmed CPI do not represent an “efficient” estimator for future inflation measured by the CPI overall. Second, this may depend, in part, on whether the desirable policy regime accommodates the level shift in the overall inflation rate caused by this type of shock.

The second condition for the trimmed CPI to reflect underlying inflation is that the trimmed components do not contain forecasting power for future inflation. Unlike the first condition, this second condition is applied when the estimated underlying inflation is to be used not only for an evaluation at the present point in time but also to determine the future inflation pressures. For central banks, which attempt to take preemptive policy actions, this is an important point in terms of the conduct of monetary policy.[19]

As shown in Figure 9 [1] and [2], to determine if the relative price shock components contain information for future inflation, it is necessary to check the level shifts in inflation, i.e., changes in the inflation trend, as a consequence of the relative price shock. In case [1], there is no level shift in inflation. Thus, there is no information loss from the trimming and the trimmed CPI provides an efficient prediction of future inflation. In contrast, in case [2], because the relative price shock accompanies a level shift in inflation, there may be some information loss regarding future inflationary pressures from the trimming.

Figure 9 Information for Future Inflation in the Relative Price Shock Component

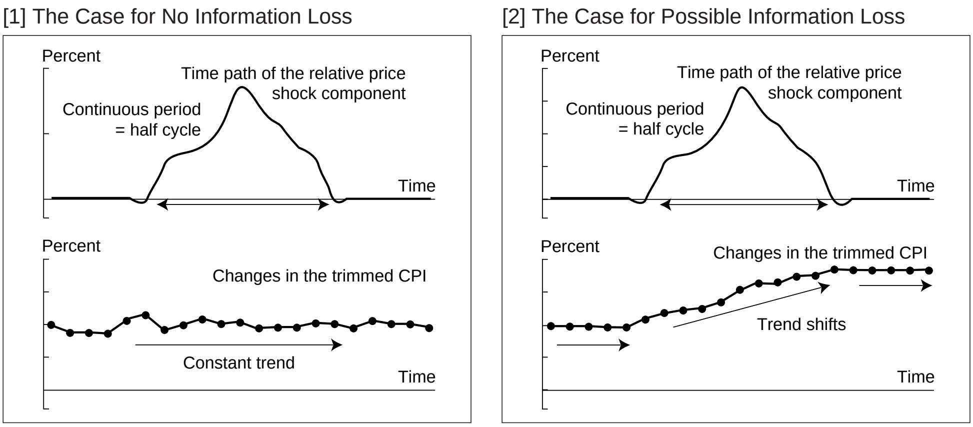


Figure 10 presents the causes of relative price shock by individual components that have mainly contributed to the relative price shock component over the past 30 years. Subsequently, we discuss whether it is acceptable to trim these relative price shocks from underlying inflation.

19. For instance, the following types of cases are considered as instances where the relative price shock component contains information for future inflation rates.

First, where a sector-specific supply shock has a large spillover effect to the other sector's price-setting behavior (via the input-output structure), and consequently becomes a large aggregate supply shock (Bruno and Sachs [1985]). Even if the entire effect of the shock lasts temporarily, it may affect the fluctuation in inflation expectations and consequently cause a shift in aggregate demand. Traditionally, energy components were considered as one example of this case.

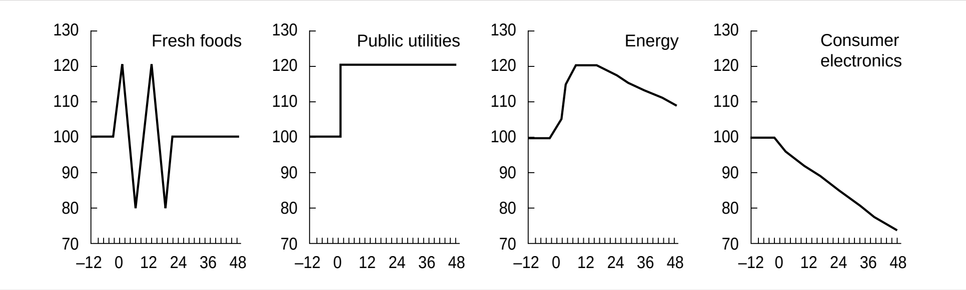
Second, cases where price rises are initially observed for only a limited number of components due to the differentials of the price rigidity among components. Typically, market commodities are regarded as "leading indicators" for future inflation in this sense.

Figure 10 Summary of Relative Price Shock by Individual Component

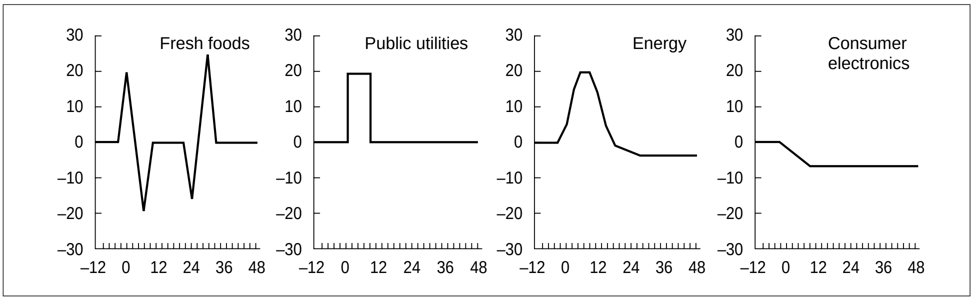
[1] Summary of Relative Price Shock by Individual Component

Component	Continuation period of the shock	Characteristics of the shock	Appropriate to trim?	Note
Fresh foods	Less than one year	Irregular weather, etc.	Yes	Continuous rise in 1990–91
Public utilities	One year	Discretionary price revisions	Yes	Lagged rise
Energy	One to two years	Changes in the oil price	Yes	—
Consumer electronics	Throughout the observation period	Technological innovations	?	Continuous factors

[2] Typical Price Level Movement by Individual Component



[3] Typical 12-Month Percentage Price Change by Individual Component



Fresh foods

The relative price fluctuations of fresh foods are very volatile and trimmed very frequently. The extreme relative price variations for fresh foods are mostly due to temporary factors such as irregular weather, and excluding the relative price fluctuations of these components on underlying inflation is deemed appropriate.

However, there are certain exceptions. During 1990–91, unlike the regular situation, fresh foods were located on the right tail of the price change distribution for two consecutive years. The persistent relative price increase in fresh foods during this period might indicate tight labor market conditions, and fresh food prices may have functioned as a leading indicator providing a warning of future inflation.[20] From this aspect, excluding fresh foods may entail a possible information loss regarding

20. See Economic Planning Agency (1990, 1991).

future inflation and it might be inappropriate to trim fresh foods. This case suggests that when the emphasis is on using the trimmed CPI to predict future inflation pressures, analysis is required to determine whether or not the relative price shock component contains information regarding future inflation pressures.

Public utilities

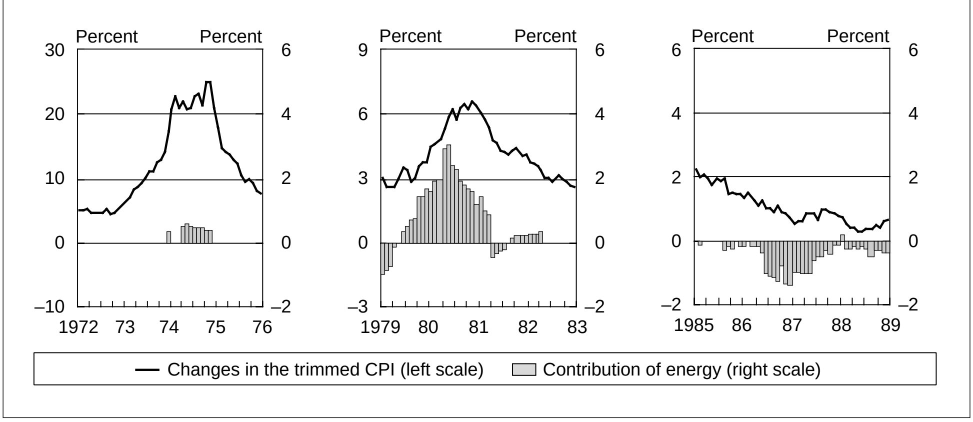
The large relative price fluctuations in public utilities last for a period of about one year. As shown in Figure 10, the price revisions of these components are permanent, so the relative price change tends to continue for one year. The relative price changes of these components are always temporary, so they do not represent factors that comprise underlying inflation. Therefore, it is deemed appropriate to exclude the large relative price variation in public utilities.

Energy

The relative price variations of energy last for a period of about one to two years. As these relative price fluctuations are temporary and result from exogenous oil price variation, it is considered appropriate to exclude the large relative price variation of these components from underlying inflation. Nevertheless, as discussed above, relative price variation of energy may lead to a shift in the inflation trend through the changes in inflation expectations and thus cause information loss about future inflation. Using the concept shown in Figure 9, we examine this in more detail for three periods when there were large relative price variations in energy.

First, during the first oil shock of 1973–74 (shown in the leftmost chart of Figure 11), the contribution of energy to the relative price shock component was extremely small. This indicates that there was very little divergence between the pace of price increases of energy and other components. While this paper does not analyze the reasons for this,[21] it can be said that during this period the movements of the trimmed CPI reflected underlying inflation.

Figure 11 Periods with Large Relative Price Variations in Energy



21. Recently, identification of the shocks using a structural VAR model, which puts constraints on the stochastic nature of the shocks, has become popular. For interesting research related to our paper, see Bernanke, Gertler, and Watson (1997). They examine whether the decline of output during the oil shock was due to a negative aggregate supply shock or to the tight monetary policy (i.e., negative aggregate demand shock) adopted at that time, and they conclude that tight monetary policy was the dominant factor.

Next, during the second oil shock of 1979–81 (shown in the middle chart of Figure 11), the contribution of energy to the relative price shock component peaked at over 3 percent in 1980. Incidentally, the inflation rate was approximately 6 percent as evaluated by the trimmed CPI and about 9 percent according to the overall CPI. This indicates that energy prices rose unilaterally. During this period, the trimmed CPI rose from 3 percent to a peak of over 6 percent. However, the inflation rate reverted to its prior level after the relative price shock component disappeared, so the relative price shock component did not contain information regarding future inflation. Thus, we can conclude that during this period the movements of the trimmed CPI reflected underlying inflation.

Finally, during the period from 1985 when the yen appreciated sharply versus the U.S. dollar and oil prices declined (shown in the rightmost chart of Figure 11), there was a large negative contribution of energy to the relative price shock component, but the movements of the trimmed CPI were stable. Thus, one can conclude that the changes in the trimmed CPI reflected underlying inflation and the effect of the relative price fluctuations of energy on underlying inflation was limited throughout this period.

Even during all three periods when there were large fluctuations in the price of crude oil, the relative price variability in energy was not linked to subsequent inflation. Therefore, even in light of the forward-looking perspective of the second condition stated above, it is appropriate to exclude the effect of the relative price variation in these components.[22]

Consumer electronics

Consumer electronics consistently lowered its relative prices throughout the observation period. This apparently reflects continuous technological innovations in the production of these components. As stated above, when relative prices continuously move down due to these types of long-term, structural factors, the issue of whether or not it is appropriate to exclude their influence on underlying inflation depends, in part, on the understanding of desirable policy regimes and cannot be determined *a priori*.

Regardless of this, as for practical considerations of whether the trimming may have a serious effect on the reliability of the trimmed CPI, as shown in Figure 8, the contribution to the relative price shock component from consumer electronics is extremely small, averaging under 0.2 percent.[23] Thus, empirically this is clearly not a major issue affecting the usefulness of the trimmed CPI.

Summarizing the above discussion, the relative price shock component, which is the divergence between the changes in the CPI overall and those of the trimmed CPI, mostly represents sector-specific and exogenous supply shocks. The relative price shock component includes components that continue for about one to two years, but no cases are observed whereby the relative price shock prompted a level shift in

22. Note that based on this analysis alone, one cannot conclude that monetary policy responses were *not* required during these periods. This is because the changes in the trimmed CPI themselves reflect the macroeconomic environment. For example, it is not clear that the movements of the trimmed CPI would have remained stable during 1979–81 if the Bank of Japan had ignored the relative price shock and had not implemented monetary tightening, or similarly during the period from 1985 if the Bank had not implemented monetary expansion.
23. This is partly because the weight of consumer electronics in the CPI is sufficiently small (less than 3 percent). Moreover, this weight has consistently declined over the past 20 or so years. See Appendix 2.

inflation. Consequently, even though it is not empirically verified that the money growth causes the changes in the trimmed CPI as in the results of prior research in the United States, compared with the CPI ex. fresh foods, the trimmed CPI is apparently preferable as a candidate for identifying underlying inflation.

Nevertheless, the appropriateness of continuously excluding the influence of the long-run relative price variation of consumer electronics is not certain, although this is not a problem at present because of the low contribution from these components to the relative price shock component.

Moreover, defining underlying inflation as inflationary pressures, the relative price variation for energy during the second oil shock in 1979–81 and the period from 1985 and for fresh foods during 1990–91 may have contained information about future inflation. Thus, particularly, when emphasizing a forward-looking perspective, it may not be appropriate to rely solely on the changes in the trimmed CPI. Rather, the usefulness of the trimmed CPI increases through combination with additional analyses of the content of the relative price shock component and of the causes of the relative price shock component.

V. Underlying Inflation, Relative Price Variability, and Prediction of Future Inflation

A. Relationship between Underlying Inflation and Relative Price Variability: An Intuitive Understanding

In this chapter, based on the analyses in chapters III and IV and using information on the price change distribution, we propose an intuitive understanding of how to distinguish between underlying inflation and temporary price variation due to relative price shock.

There are two opposite cases when exogenous relative price shocks occur to specific components and the price changes of those components surpass those of other components. The first is the case in which the effect of the shock on inflation is temporary (Figure 12), and the second is the case in which the shock is translated into the underlying inflationary process (Figure 13).

Figure 12 Dynamics of the Price Change Distribution Case in Which the Relative Price Shock Component Does Not Contain Information Regarding Future Inflation

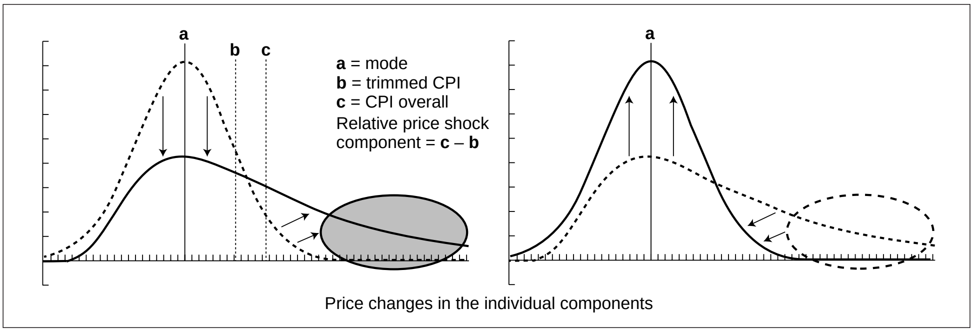
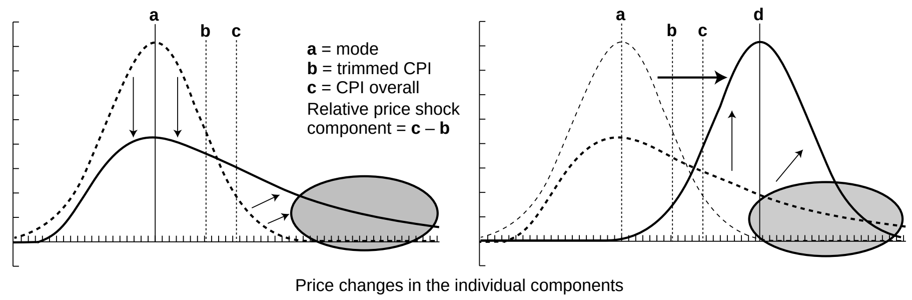


Figure 13 Dynamics of the Price Change Distribution Case in Which the Relative Price Shock Component Contains Information Regarding Future Inflation



In both cases involving exogenous positive relative price shocks, the price change distribution is skewed to the right, and the inflation rate measured by the CPI overall rises (indicated by **c**). At this point, the inflation rate measured by the trimmed CPI (indicated by **b**) mitigates the influence of the relative price shocks, and does not change as much as that of the CPI overall. Thus, a divergence occurs between the two indices (the relative price shock component, **c** – **b**). In the case where the influence of the shock on inflation is temporary (Figure 12), the relative price shock component disappears after a certain period of time, and the CPI overall and the trimmed CPI both *revert* to their original level, **a**. In this case, one may conclude that the relative price shock component does not contain information regarding future inflation, and that the trimmed CPI is a better indicator—that is, a statistically more efficient estimator—of future inflation than the overall CPI.

On the other hand, the latter case shows that the relative price shock component contains information regarding future inflation (Figure 13). In this case, along with a shift in the price change distribution itself, the CPI overall and the trimmed CPI both *rise* from **a** to **d**. Thus, excluding the relative price shock component from the CPI overall may induce a loss of information regarding future inflation.

Accordingly, when the relative price shock is accompanied by rises (or falls) in the CPI overall, by evaluating whether the trimmed CPI rises (falls) or remains stable, it is possible to examine whether the price movements accompanying relative price shocks have become endogenous—that is, that the shocks are translated into the underlying inflationary process. Also, by analyzing whether the causes of the relative price shock are temporary or contain information regarding future inflation, one may deduce which of the two patterns of the dynamics will likely follow in the future, and predict future inflation assuming that the present macroeconomic environment will remain constant and no additional relative price shocks will occur.

B. Prediction of Future Inflation Rates Using the Relative Price Shock Component

Based on the intuitive understanding explained in Section V.A, we propose a more quantitative method to extract information regarding underlying inflation by using the relative price shock component. The analysis in chapters III and IV suggests that in most cases price fluctuations related to relative price shocks are temporary phenomena (the case of Figure 12). Thus, it should be possible to improve prediction of future inflation by *controlling* temporary price variation due to relative price shocks in the forecasting equation.

Here, we adopt the following inflation forecasting equation.

$$CPIDOT_t - CPIDOT_{t-i} = \sum_{j=0}^{n} \beta_j RPS_{t-i-j} + u_t, \tag{2}$$

where

$CPIDOT_t$ is the changes in the CPI overall at time t,
$TM(30)_t$ is the changes in the trimmed CPI at time t,
RPS_t is the relative price shock component defined by $CPIDOT_t - TM(30)_t$ at time t.

Moving the second term on the left-hand side of equation (2) to the right-hand side yields

$$CPIDOT_t = CPIDOT_{t-i} + \sum_{j=0}^{n} \beta_j RPS_{t-i-j} + u_t. \tag{3}$$

This shows that future inflation measured by the CPI overall is predicted by two components: the lag in the CPI overall and the lags in the relative price shock components. The model attempts to *control* temporary price variation due to relative price shocks by incorporating the relative price shock component in the equation.

The first term on the right-hand side of equation (3) represents present inflation that comprises both present underlying inflation and the present relative price shock. The second and subsequent terms on the right-hand side represent the present and past relative price shocks. Parameter β indicates the extent to which future inflation is influenced by the present and past relative price shock components. A negative β indicates that after a given period of time, the inflation will revert toward the level represented by **a** or **b** in Figure 12. It also means that the price variation due to the relative price shock is temporary.[24]

Controlling the effect of past and present relative price shocks, there are two remaining factors that may cause systematic prediction error during the forecast span. The first is changes in macroeconomic conditions and the second is the occurrence of additional relative price shocks. Assuming that these two factors do not occur, the estimate provides an efficient prediction for future inflation at a given time t.

24. In particular, for cases where $\beta_0 = -1, \beta_1, \ldots, \beta_n = 0$, and u_t~NID $(0, \sigma_t^2)$, equation (2) can be rewritten as

$$CPIDOT_t = TM(30)_{t-1} + u_t. \tag{F.5}$$

This means that the trimmed CPI gives efficient predictions for future inflation. In other words, the future inflation rate reverts to the trimmed CPI on average and the relative price shock component does not contain *any* information about future inflation. Also, $\beta_1, \ldots, \beta_n \neq 0$ indicates that information regarding the acceleration of the skewness is added as an explanatory factor. These lag terms are intended to quantitatively express the conclusion of Chapter IV that the continuation period of the relative price shock component varies depending upon the content of the relative price shocks.

We have adopted a forecast span of $i = 18$. In other words, we forecast inflation 1.5 years ahead.[25] We first run a regression that contains full lags of 18 to 24 months for the relative price shock components. Then we exclude lags of 19–23 months whereby the coefficient is not significant and run a regression again.[26] The results of the estimation are as follows.

C. Estimation Results

$$CPIDOT_t - CPIDOT_{t-18} = \underset{(-6.576)^{***}}{-1.194\, GAP_{t-18}} - \underset{(-5.493)^{***}}{0.989\, GAP_{t-24}}.$$

Adjusted R^2 = 0.378, standard error = 1.846, Durbin-Watson = 0.12.

(Figures in parentheses are t-values. *** indicates that the coefficient is statistically significant at the 1 percent level.[27])

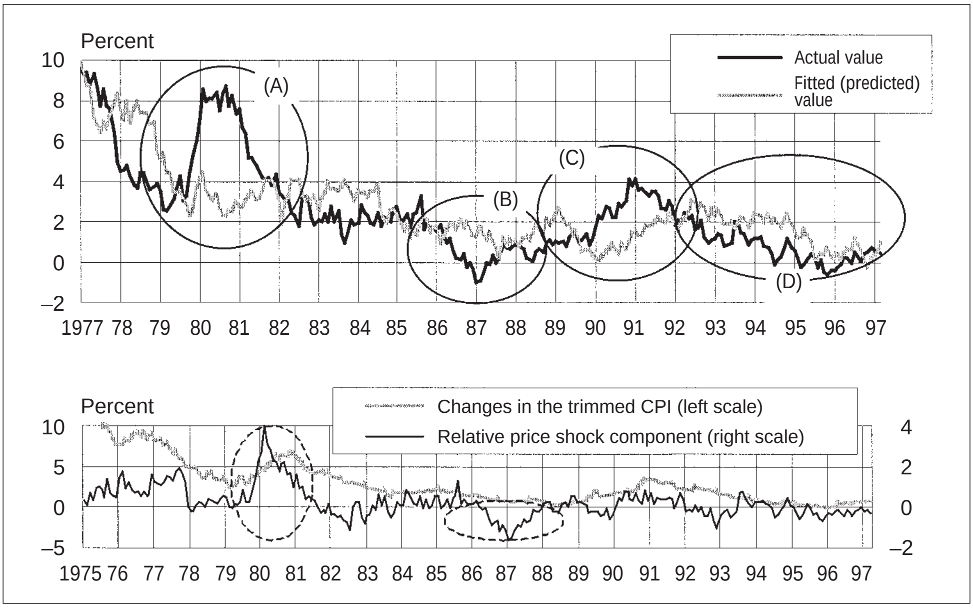
The parameter estimates for β_0 and β_6 are –1.194 and –0.989, respectively. Because β_0 is close to –1, in the past, on average, inflation accompanying the relative price shock reverted to the level of the trimmed CPI after a span of 1.5 years. This corresponds to level **b** in figures 12 and 13. Additionally, the fact that β_6 is also significant indicates that information on the acceleration of the skewness of the price change distribution is useful for measuring the speed at which the price change distribution reverts to the prior level.[28]

The upper chart of Figure 14 shows the path of the actual and fitted values of the prediction, and the lower chart shows the past inflation measured by the trimmed CPI as well as the relative price shock component.

Looking at these points in detail, during periods (A) and (B), serial prediction error appeared in 1979 and again in 1985. Because the occurrence of relative price shocks 1.5 years ahead cannot be incorporated into the present prediction, initial prediction error cannot be avoided. But the more important issue is whether or not accurate prediction is possible when the relative price shock occurs, assuming that no additional shocks will take place. Figure 14 demonstrates that in cases (A) and (B), this was possible. By *controlling* the effect of the relative price shock, the prediction at the second half of 1979 and at the first half of 1986, when the relative price shock occurred, successfully forecasts actual inflation 1.5 years ahead. Note again that the actual inflation converged to the predicted level in the second half of 1981 and in the second half of 1987.

25. Due to the lag of monetary policy, meaningful prediction of the conduct of monetary policy requires a certain period of time. However, prolonging the forecast span increases the probability that new shocks will occur during the span, making it more difficult to identify the factors that cause prediction error. The selection of the forecast span involves a trade-off between these two factors. We chose an 18-month prediction span to avoid this trade-off as much as possible.
26. Changing the forecast span between one and two years and changing the lag length of the relative price shock component does not have any large influence on the result, i.e., on the path of the predicted values shown in Figure 14.
27. It should be noted that because the Durbin-Watson (DW) statistic is small at 0.12, suggesting an AR(1) process in the error term, the t-value may have been overestimated. Because predicted values do not account for changes in systematic factors over the forecast span, the low value of the DW statistic is, in a certain respect, unavoidable.
28. Fixing the starting point for the estimation period at 1977 and varying the ending point consecutively from 1982 forward, the estimates of β_0 and β_6 remain stable between 1.11 to 1.25 and 0.97 to 1.21, respectively. This means that even when the estimation period is changed, the paths for the fitted values are stable.

Figure 14 Historical Paths of the Actual Values and the Fitted Values



More fundamentally, macroeconomic factors determine the location of the price change distribution. For instance, when the growth rate of aggregate demand increased, the price change distribution shifted to the right, that is, moved from **a** to **d** as shown in Figure 13. When inflation rates fluctuate due to changes in macroeconomic factors during the forecast span, there should be a serial prediction error. Periods (C) and (D) correspond to these cases.

First, during period (C), the acceleration of inflation from the beginning of 1987 can be explained by the reversion of temporary price declines caused by the negative skew of the price change distribution from the appreciation of the yen and decline in crude oil prices from the second half of 1985. This temporary acceleration of inflation should have ceased at the end of 1988, and because no additional relative price shocks took place, the prediction from the beginning of 1989 followed a declining path converging toward the inflation rate 1.5 years prior. But in fact, inflation continued to accelerate until it peaked at 4 percent in 1990, and there was a large serial prediction error. Checking whether this prediction error was caused by additional relative price shocks, we find that there was no such major relative price shock at that time. Therefore, the increase in the inflation rate during this period is probably explained by macroeconomic factors.

Similarly, during the price declines from 1991 through 1995 (period [D]), there is a serial prediction error, but aside from the slight fluctuations in the prices of fresh food components, there were virtually no large relative price shocks. Accordingly, it is also likely that the decline in inflation rates during this period is explained by macroeconomic factors.

Based on these results, while the deflation at the beginning of 1987 and that in the second half of 1995 were evaluated as being of a similar degree using the changes in the CPI overall as a measure of the inflation rate, there were substantial differences in content during these two periods as suggested by Shiratsuka (1997), and the developments in the second half of 1995 should be recognized as being *more deflationary* phenomena. These conclusions also imply that macroeconomic factors accelerated the inflation recorded from early 1989 through the end of 1990.

The use of information about the skewness of the price change distribution in terms of the conduct of monetary policy is summarized in the following three points.

First, the prediction of midterm inflation can be improved by incorporating the reversion effect of the skewed price change distribution.

Second, checking the shift of the price change distribution provides useful information about the appropriateness of the policy reaction against the relative price shock. For instance, if an over-expansionary policy is implemented against a positive relative price shock to maintain an output level which is not sustainable, then a shift in the price change distribution to the right can be observed. In this case, inflation initially caused by the relative price shock is translated into the underlying inflationary process. Based on the analysis from 1970, in most cases the skewness in the price change distributions from relative price shocks generally follows the pattern shown in Figure 12, and thus the policy reactions were generally appropriate. However, sufficient preemptive policy action may not have been taken during the price rises from 1989, which were apparently caused by macroeconomic factors, and during the price declines from 1991.

Finally, when present inflation rates cannot be explained by past underlying inflation rates and information on the relative price shock component, logically there must be additional relative price shocks or changes in macroeconomic factors. Thus, it is possible to analyze the cause of fluctuations in inflation at an early stage by using the information on the price change distribution. By conducting analyses combining the micro-level shock information contained in relative price movements together with macroeconomic information on money supply trends, the output gap, and so on, it becomes possible to make an appropriate evaluation of inflation.

VI. Conclusions

The conclusions of this paper are summarized as follows.

In this paper, we examined the characteristics of the Japanese trimmed CPI, which is designed to identify underlying inflation, from various perspectives. We find that contrary to the results of prior research in the United States, there is no statistically significant causality from the growth rate of the money supply (M2+CDs) to inflation as measured by the trimmed CPI, and that the trimmed CPI mitigates not only short-cycle price variation but a wide-frequency range of price variation.

Through a detailed analysis of the characteristics of the trimmed components, we find that, compared with the CPI ex. fresh foods, the trimmed CPI successfully excludes the effect of temporary relative price shocks. Because the components that experience relative price shocks vary from time to time, the trimmed CPI, which does not require a prior *ad hoc* specification of the components to be ignored, has an advantage in that it does not require any changes in the general concept of core inflation.

However, relative price shocks are not necessarily short-cycle phenomena. Sometimes, as in the case of energy-related components, the shocks may continue for a period of about one to two years. Moreover, there is a possibility, albeit small, that these shocks may have a spillover effect on other components and generate underlying price movements. Thus, when the trimmed CPI is used from a forward-looking perspective to gauge future inflationary pressures, it is always necessary to judge whether the components with large relative price fluctuations located at the tails of the price change distribution have only a temporary limited influence on inflation, or whether they contain information for future underlying inflation.

To support these conclusions quantitatively, we estimated the inflation forecasting equation for 18 months in the future incorporating the relative price shock component, which is a measure of the skewness of the price change distribution, as an explanatory variable. We confirmed that by checking both the developments of the skewness of the price change distribution and the developments of the trimmed CPI, it is possible to derive important information for the conduct of policy, including future inflation predictions, evaluations of the appropriateness of past policy implementation, and analyses of the causes of current inflation.

APPENDIX 1: LITERATURE ON THE CORRELATION BETWEEN INFLATION RATES AND RELATIVE PRICE VARIABILITY

In microeconomics, relative prices are determined by preferences and technological constraints, which are real factors, and the price levels of individual components simply express the monetary value. Meanwhile, it is generally accepted that the macroeconomic inflation rate is determined, at least in the long run, by the growth rate of money via the Cambridge transaction equation $M = kPY$ (where M is the money supply, P the price level, Y the real output, and k the reciprocal of the velocity of money). In this manner, conventional economics dictates that inflation rates are caused by monetary factors and relative price fluctuations by real factors, and that there is no correlation between the two. Nevertheless, empirical studies in many nations have shown that there is a positive correlation between inflation rates and relative price variability.

Appendix Figure 1 plots Japanese inflation rates as measured by the CPI overall and the weighted standard deviation calculated from percentage price changes in the 88 components that comprise the CPI. Here, the weighted standard deviation at time t, $STDEV_t$, is calculated in equation (A.1), and indicates the extent of the relative price variability.

$$STDEV_t = \sqrt{\sum_{i=1}^{88} w_{i,t} \left(p_{i,t} - p_t^* \right)^2}, \tag{A.1}$$

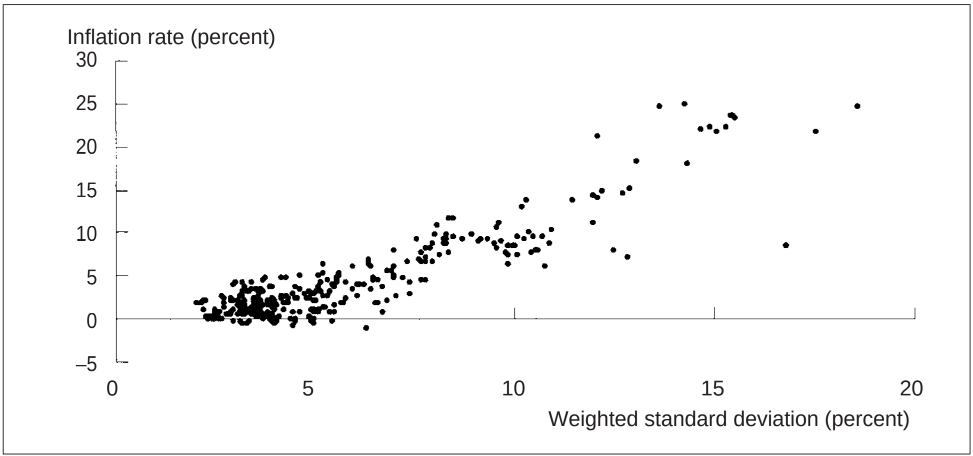
where

$w_{i,t}$ is the weight of the i-th component at time t,

p_t^* is the inflation rate measured by the CPI overall at time t,

$p_{i,t}$ is the inflation rate of the i-th component at time t.

Appendix Figure 1 Japanese CPI Inflation Rates and the Weighted Standard Deviation



Appendix Figure 1 shows that the inflation rate and the relative price variability, which are theoretically determined independently and should have no correlation, actually have a strong positive correlation. To date, various research has been conducted on how this relationship should be interpreted, and what implications this has for actual macroeconomic performance and for the conduct of monetary policy.

Among these research efforts, Barro (1976) emphasizes the importance of monetary shocks. He postulates that changes in the unexpected money supply (monetary shocks) generate unexpected price movements, leading to "illusions" in each market, and because transactions are actually conducted based on these "illusions," there are variations in the relative prices. In this model, the monetary shock is the cause and the relative price variability is the result. Barro claims that monetary shocks impede the efficient allocation of resources, and he concludes that to avoid this, policy makers should follow a rule whereby the growth in the money supply is maintained at a constant rate.

In contrast, Fischer (1981) conducted one of the most outstanding surveys in this field of research, concluding that while there are various causes of relative price variability, including monetary factors, at least in the United States from 1970, real shocks to specific sectors were the primary cause of relative price variability.

Moving into the 1990s, Ball and Mankiw (1995) focused not on the relation between *the mean* (the inflation rate) and *the variance* (the second moment) of the price change distribution, which was the object of prior research, but rather on the relation between *the mean* and *the skewness* (the third moment) of the price change distribution. They argued that the high correlation between *the mean* and *the skewness* observed indicates the existence of price rigidity from a New Keynesian perspective.

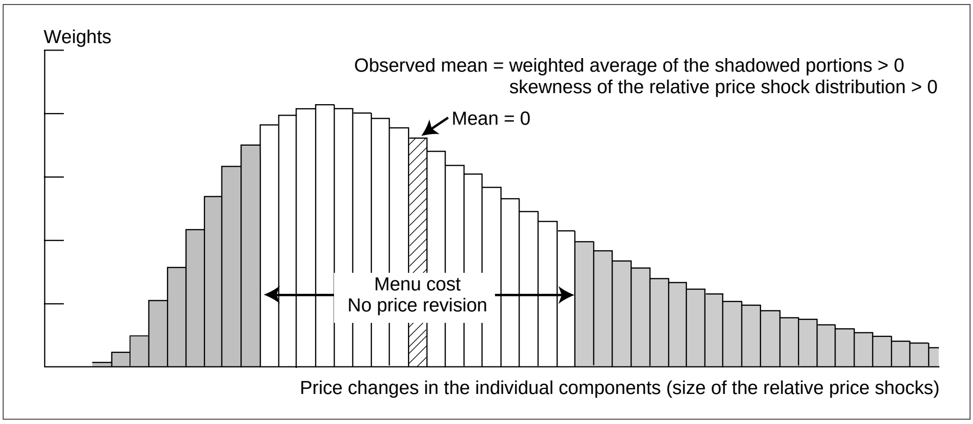
Ball and Mankiw assume, as noted above, that relative price shocks to a given component should be offset by the relative price variability of other components, and thus not cause macroeconomic inflation in the long run. However, because of the skewness in the shape of the relative price shock distribution and due to the existence of menu costs,[29] in some sectors, actual price changes are not implemented when minimal relative price shocks occur in the short run. As shown in Appendix Figure 2, they demonstrate that there is a positive correlation between *the observed mean* and *the skewness*, and they claim that the existence of a positive correlation between *the mean* and *the skewness* provides proof of the existence of menu costs.

Balke and Wynne (1996) use the real business cycle model developed by Long and Plosser (1983), and conduct simulations on the price movements of individual components when productivity shocks with different time-series characteristics and spillover effects on other sectors hit six sectors. Their results show that when the productivity shocks have serial correlation and when they have a spillover effect on other sectors through the input-output structure, there is a positive correlation between the mean of the price changes of the individual components (the inflation rate) and the skewness, casting doubt on the conclusions reached by Ball and Mankiw.

Debelle and Lamont (1997) used cross-sectional data on inflation rates and relative price variability for different cities. They observed a positive correlation between the two,

29. Menu costs are the costs incurred when enterprises implement price changes. When these costs exceed the loss incurred by not implementing price changes, enterprises choose not to revise their prices, and thus increase the producer's surplus in comparison with the case when the prices are revised. The concept of menu costs provides a microeconomic foundation for the existence of downward price rigidity. See, for example, Mussa (1977), Mankiw (1985), and Blanchard and Kiyotaki (1987). Also see Fukuda (1995) for the status of menu costs in macroeconomics.

Appendix Figure 2 Relationship between Skewness in the Relative Price Shock Distribution and the Mean



casting doubt on the conclusion reached by Barro (1976) that the correlation between inflation rates and relative prices may be attributed to monetary factors.

While the above outline is only a brief summary of the prior research in this field, theories stressing the importance of monetary shocks as factors causing variability in relative prices appear to be declining, while theories stressing the importance of real shocks are becoming dominant. In fact, the analysis in this paper (the cross-sectional breakdown in Chapter IV) confirms that most of the components showing large dispersion and skewness in relative prices are components that have been subjected to real shocks at that time.

Nevertheless, no firm conclusion has yet been reached as to why inflation rates and relative price variability or skewness of the price change distribution have a positive correlation. Is price rigidity the root cause of this correlation, or do shocks themselves have serial correlation, and does this just reflect a dynamic converging process toward equilibrium? The policy implications vary depending on the answer to this question. If, as Ball and Mankiw assert, this correlation proves the existence of price rigidity, discretionary monetary policy for macroeconomic stability would be justified. However, if, as Balke and Wynne assert, this correlation simply reflects the existence of real shocks that have a serial correlation, the observed facts by themselves cannot justify discretionary policy actions. Moreover, the desirable policy action will differ depending on whether the real shock is a demand shock or a supply (productivity) shock as Balke and Wynne contend.

The analytical results of this paper appear to support the position that the main cause of relative price variability lies in real sectoral supply shocks, but our analysis is not intended to supply a clear answer to this theoretical debate. In the future, we believe it will be necessary to devise a theoretical backbone by finding common points between the theoretical research cited above and the empirical analysis of the dynamism of the price change distribution presented in this paper. This should result in a deeper understanding of the relationship between inflation rates and relative price variability, and the possible establishment of a general concept of underlying inflation for use by policy makers.

APPENDIX 2: WEIGHTS IN THE JAPANESE CPI

[1] Fresh Foods

Components/base year	Weight (total = 10,000)					
	1970	75	80	85	90	95
Fresh fish & shellfish	281	288	266	231	209	188
Fresh vegetables	302	260	250	217	215	191
Fresh fruits	250	227	170	154	137	117
Total	833	775	686	602	562	496

[2] Energy

Components/base year	Weight (total = 10,000)					
	1970	75	80	85	90	95
Fuel, light & water charges	437	450	582	649	553	590
Electricity	183	177	229	269	240	266
Gas	127	169	202	205	165	167
Kerosene	42	49	78	72	40	38
Other fuel & light	36	9	3	2	—	—
Water & sewerage charges	48	46	70	101	108	119
Automotive maintenance	157	252	358	433	420	469
Gasoline	100	156	213	216	176	173
Others	57	96	145	217	244	296
Total	594	701	940	1,082	974	1,058

[3] Consumer Electronics

Components/base year	Weight (total = 10,000)					
	1970	75	80	85	90	95
Domestic durables	129	118	78	75	67	60
Heating & cooling appliances	44	63	39	49	50	45
TV sets & audio devices	176	86	73	78	61	52
Other recreational durables	17	36	31	24	44	44
Total	367	303	221	226	223	201

[4] Apparel

Components/base year	Weight (total = 10,000)					
	1970	75	80	85	90	95
Japanese clothing	116	100	78	59	54	39
Clothing	309	347	336	318	353	273
Footwear	90	99	93	82	82	66
Cloth	107	77	42	27	18	11
Thread	17	11	6	10	4	3
Total	641	633	556	497	511	391

[5] Public Utilities

Components/base year	Weight (total = 10,000)					
	1970	75	80	85	90	95
Public transportation	312	220	324	334	354	341
Communication	155	184	206	214	221	216
Education	334	326	382	413	466	455
Cigarettes	211	139	137	115	92	72
Total	1,012	870	1,050	1,076	1,133	1,084

Note: Sums of the individual items do not necessarily equal the subtotals or totals.

APPENDIX 3: CALCULATION OF THE OPTIMAL TRIMMING RATIO

Here, we apply the method used by Bryan, Cecchetti, and Wiggins (1997) to find the optimal trimming ratio (α percent) for the trimmed CPI that best reflects underlying inflation from a trimmed CPI series. First, we assume that the historical centered moving average series of a CPI for some period reflects the underlying inflation. Then, we search for the trimmed CPI with a trimming ratio that minimizes the root mean square error (RMSE) from the centered moving average series.

The root mean square error is expressed by the following formula.

$$RMSE(2\alpha) = \sum_{t=1}^{n} \sqrt{\frac{\left(p_t^{\alpha} - \pi_t^{(\tau)}\right)^2}{n}}, \tag{A.2}$$

where

$RMSE\,(2\alpha)$ is the root mean square error of a trimmed CPI with a trimming ratio of 2α percent,

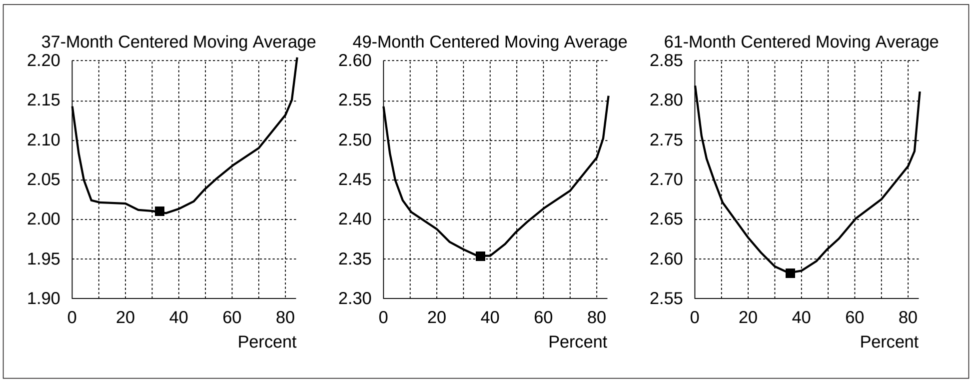
$\pi_t^{(\tau)}$ is the centered moving average for τ periods of the changes in the CPI overall at time t,

p_t^{α} is the trimmed CPI with a trimming ratio of 2α percent at time t,

n is the number of samples.

It is also necessary to check whether the results are robust to the length of τ. We tried τ = 37, 49, and 61. The results of these calculations are presented in Appendix Figure 3.

Appendix Figure 3 RMSE of Each Trimmed CPI from Centered Moving Averages of Over Three Years



The figure clearly shows that the optimal trimming ratio that minimizes the RMSE is around 30 percent, and this is not dependent on the length of the benchmark centered moving average. This result indicates that trimming 15 percent from each tail of the price change distribution provides the series which is closest to the centered moving averages. The analysis in this paper adopts 30 percent as the optimal trimming ratio for the trimmed CPI.

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