Is the CPI a Suitable Measure for Defining Price Stability?

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Introduction

The central objective of the Bank of Canada's monetary policy is to ensure price stability in the Canadian economy. Although this is a broad objective, it is based on a quite specific definition of prices. The inflation control target ranges used by the Bank have been determined according to the year-over-year change in the consumer price index (CPI) and, by extension, in the CPI excluding food, energy, and the effect of indirect taxes (CPIXFET). A pertinent question, therefore, is whether the CPI is a suitable measure for defining price stability. We approach this issue from three different but complementary angles.[1]

First, we use various statistical tools to test whether the level of the CPI shares a common trend with two other price measures: the implicit deflator for gross domestic product (GDPD) and the general level of unit labour costs (ULC). We begin our analysis with the observation that there will always be some degree of uncertainty over what is the most appropriate definition of prices, or of the inflation rate, in the economy. But to the extent that there is a common trend among the various price measures, a monetary

1. Lebow, Roberts, and Stockton (1992); Edey (1994); Yates (1995); and Freedman (1996) examine questions similar to those dealt with in this paper.

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policy that targets growth in the CPI (or its level) should stand a good chance of stabilizing the other price measures around the same trend.

In the second part of the paper, we compare the rate of change in the CPIXFET against new measures of the trend or "core" inflation rate. These new measures eliminate or attenuate the effect of the CPI components that show the most pronounced fluctuations in each period, on the hypothesis that these extreme fluctuations represent temporary shocks rather than any basic price trend. If the CPIXFET inflation rate compares favourably with these new measures of inflation, it could indicate that the CPIXFET is a useful measure for the conduct of monetary policy, besides offering the advantage of simplicity.

As a third step, we describe and estimate the size of various types of bias in the measure of CPI inflation in Canada. This question is important, since the total measurement bias could be an operational measure of price stability defined in terms of the change in the CPI. As an additional step, building on Crawford (1993), we examine the hypothesis that there is a potentially large positive bias related to the introduction of new product brands, since the CPI does not account for the effects of broadening consumer choice.

1 The Relationship Between the CPI and Other Price Measures

In this section, we test for the presence of a common stochastic trend between the CPI, the implicit GDP deflator, and unit labour costs. We would expect these different price measures to share a common trend, for two reasons. First, the various inflation rates are all influenced by common exogenous variables (for example, aggregate demand shocks or commodity price shocks). In addition, there are causality relationships, cointegration relationships, or simply temporal relationships among the various price measures (or their growth rates) that, in principle, should link them fairly closely. There may, for example, be relationships between unit labour costs and producer prices, or between producer prices and consumer prices; or again, changing inflation expectations may have an impact on wages, and hence on unit labour costs.

In this section, we present first some summary statistics on the relationships between the three inflation rates, such as simple correlations and the principal components linking these rates, as well as price-level cointegration tests. Then we estimate the relationships between the inflation rates using a vector error-correction model (VECM), and we apply stochastic simulations to this model to assess the degree of divergence between the inflation rates and relative prices over different time horizons.

The VECM accounts for the influence of common exogenous factors, as well as the dynamic relationships among the inflation rates and the long-term relationships among price levels.

1.1 An overview of the data

In this section, we briefly examine the data on the CPI, the GDP deflator at factor cost (GDPD), and unit labour costs (ULC) over the past four decades. We use an estimate of the GDP at factor cost, obtained by subtracting government indirect tax revenues from the GDP at market prices and dividing the result by the GDP at factor cost in constant 1986 dollars. We obtain our estimate of ULC from the ratio between total employee remuneration (excluding the military) and the GDP at factor cost in constant 1986 dollars.

Figure 1 shows the year-over-year percentage change in the CPI ($\Delta cpi1$), in the GDP at factor cost ($\Delta gdpd1$), and in ULC ($\Delta ulc1$) since the mid-1950s. The similarity between these three inflation measures is readily apparent. In fact, the average rates of change of these price indexes over the 1956-95 period are almost identical: 4.6, 4.4, and 4.8 per cent, respectively. Their variability is also comparable, with standard deviations of 3.1, 3.5, and 3.8 percentage points, respectively. In addition, there is a fairly high correlation among the inflation rates: 0.88 between $\Delta cpi1$ and $\Delta gdpd1$, 0.78 between $\Delta cpi1$ and $\Delta ulc1$, and 0.84 between $\Delta gdpd1$ and $\Delta ulc1$.

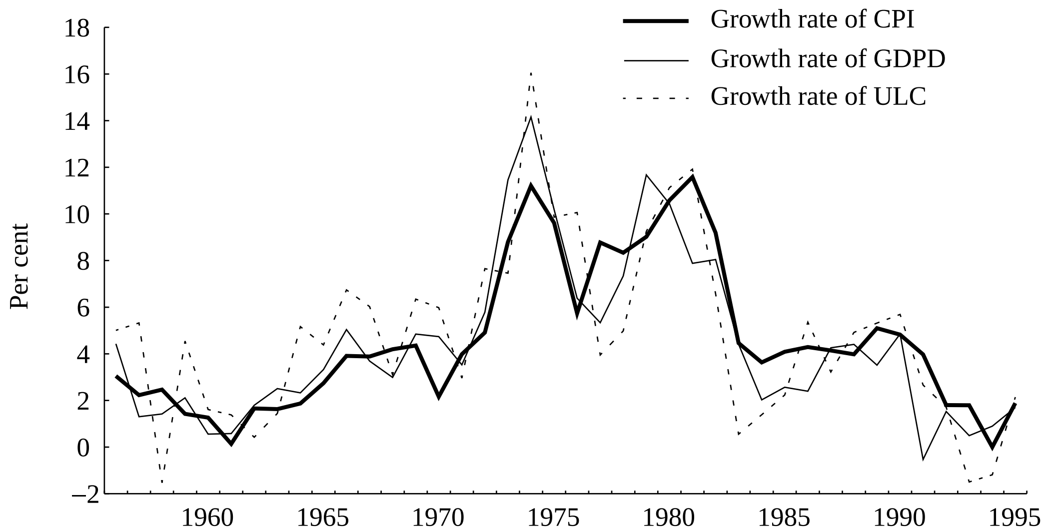
An analysis of the principal components reveals that the first of these components (the linear combination of the three inflation rates that maximizes the variance common to the three series) gives a very similar weighting to $\Delta cpi1$, $\Delta gdpd1$, and $\Delta ulc1$. This may indicate that each of these price measures plays a similarly important role in inflation dynamics in Canada. Moreover, the first component explains 90 per cent of the total variance of the three inflation rates. There is thus a dominant short-term common trend.

We now test the hypothesis of cointegration between the levels of the price indexes. The presence of cointegration is clear evidence of a common long-term trend among the price measures. We test this hypothesis using the VECM method developed by Johansen (1988) and by Johansen and Juselius (1990).[2] Table 1 presents L-max (maximum eigenvalue) and Trace statistics

2. The technical aspects of the procedure for VECM estimation and cointegration testing in this model are well described in the paper by Paquet (1994). For estimating and applying the tests, we used the CATS program, available in RATS (see Hansen and Juselius 1995).

Figure 1

Growth Rates of Various Price Indexes (Annual Data)



for testing cointegration between the logarithms of CPI, GDPD, and ULC (that is, between *cpi*, *gdpd*, and *ulc*, within two- or three-variable systems).[3]

In systems (1) and (2), we find cointegration relationships between *cpi* and *gdpd*, on the one hand, and between *cpi* and *ulc*, on the other. In fact, in these systems we cannot reject the hypothesis, at a confidence level of over 90 per cent, of a cointegration vector linking the CPI with each of the other two indexes. However, the one-to-one relationship between the price indexes is rejected in both systems, although the long-term coefficients are not far from a value of unity. In system (3), the absence of cointegration between *gdpd* and *ulc* cannot be rejected, which indicates that there is no significant long-term relationship between the GDPD and ULC, even though the CPI is individually linked to each of them. The results of the three-variable system (4) show that there is only one cointegration vector, while the presence of a second vector would be needed to identify full cointegration between the three variables. The first cointegration vector appears to represent the relationship between the CPI and GDPD, while the second relationship, though not significant at normal confidence levels, appears to be the one linking GDPD and ULC. It should be noted that

3. The principal characteristics of the VECMs are described at the bottom of Table 1. It should be noted, however, that the models include a series of exogenous stationary variables, which we discuss in detail in the next subsection. The presence of these variables changes the cointegration test distribution. Further research should allow recalculation of the critical values in the presence of exogenous variables.

Table 1

Tests for Cointegration Between Logarithms of Price Indexes

	Cointegration tests			Multivariate specification tests (p-value)			Hypothesis tests	
System	H_0	L-max	Trace	LM(1)	LM(4)	Normality	Long-term unconstrained/ constrained vector coefficients	p-value
1) *cpi*, *gdpd*	$r = 0$	21.14*	21.48*	0.34	0.07	0.45	[1, –1.049] / [1, –1]	0.00
	$r \leq 1$	0.34	0.34					
2) *cpi*, *ulc*	$r = 0$	14.04+	15.80#	0.16	0.51	0.77	[1, –1.033] / [1, –1]	0.10
	$r \leq 1$	1.76	1.76					
3) *gdpd*, *ulc*	$r = 0$	5.53	5.54	0.27	0.19	0.03	[1, –0.971] / [1, –1]	0.19
	$r \leq 1$	0.00	0.00					
4) *cpi*, *gdpd*, *ulc*	$r = 0$	26.81*	32.86#	0.15	0.56	0.67	[1, –1.043, –0.012]	na
	$r \leq 1$	6.04	6.05				[0.244, 1, –1.206] / na	
	$r \leq 2$	0.01	0.01					

Notes: The systems are estimated for the period 1962Q1-1995Q4. The order of the systems is equal to 5. The systems also include three exogenous variables and several binary variables.

All our estimations include a constant in each system equation, but its role is not predetermined. It may be a constant that is partly inside the cointegration vector, and partly outside, where it then serves to identify the stochastic trend of the data. In no case do we assume that the systems include a deterministic trend.

The L-max and Trace statistics, proposed by Johansen (1988), allow cointegration testing. When we test H_0: $r = 0$, we are testing the hypothesis that the number of cointegration vectors is zero. If the hypothesis cannot be rejected, it indicates no cointegration, and the analysis is finished. If the hypothesis is rejected, it means there is at least one cointegration vector, and we must then follow the procedure for verifying whether there is more than one vector. In the following step, we test the hypothesis H_0: $r \leq 1$. If this hypothesis cannot be rejected (and we have already rejected H_0: $r = 0$), it means that there is at most one cointegration vector; if the hypothesis is rejected, it means there is more than one vector. The + sign indicates a statistic that is significant at a confidence level above 90 per cent; # means a confidence level above 95 per cent; * means a confidence level above 99 per cent; na means not applicable. The critical values for the cointegration test are taken from Osterwald-Lenum (1992).

The LM(1) and LM(4) statistics test the hypothesis that there is no first- and no fourth-order serial correlation in the residuals.

transforming these two equations with three unknowns yields, by substitution, the following three relationships:

$$cpi = 1.06gdpd;\ cpi = 1.02ulc;\ gdpd = 0.96ulc.$$

These relationships are reasonably close to unit relationships.

An examination of the various statistics (simple correlations, principal components, and cointegration tests) shows a fairly high degree of concordance among the movements of the various price indexes in both the short and long terms. That leads us to believe that there is a common trend among the price levels. Despite this concordance, however, inflation rates and relative prices can diverge significantly over prolonged periods of time. In fact, as can be seen in Figure 1, $\Delta cpi1$ was generally lower than $\Delta gdpd1$ and $\Delta ulc1$ between the early 1960s and the mid-1970s, but has generally exceeded $\Delta gdpd1$ and $\Delta ulc1$ since the early 1980s. In fact, the annual growth in the CPI surpassed that of the GDPD and ULC by about 1 percentage point per year, on average, over the period 1981-95. The differences between these inflation rates are reflected in the persistent gaps between the levels of price indexes, as can be seen in Figure 2.

1.2 VECM estimation results

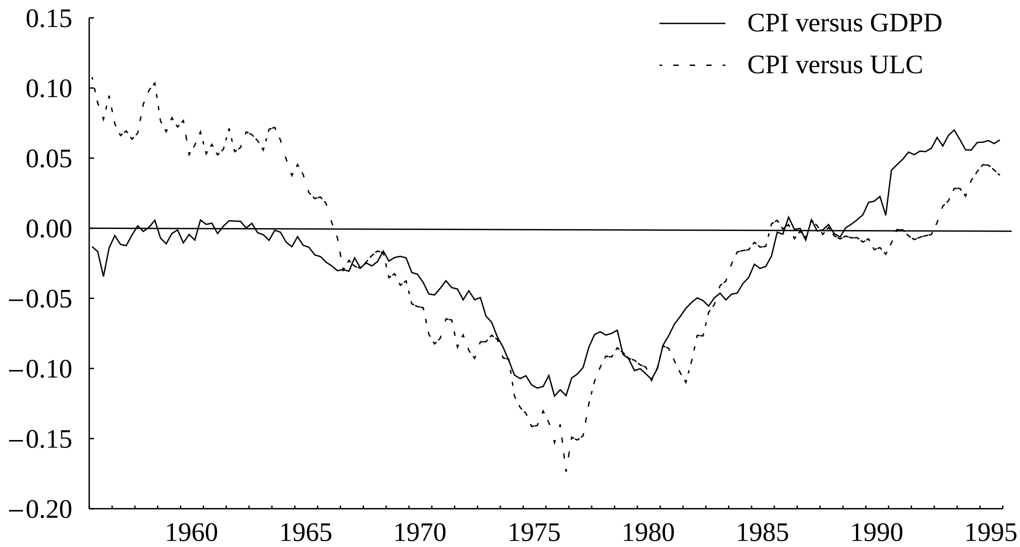
At this point, a discussion of the importance and persistence of the deviation between inflation rates and relative prices is useful.

First, we present our results from estimating a VECM linking CPI, GDPD, and ULC inflation rates, and we examine the relationships among the inflation rates in the model and the role of the common variables. Then, in the next subsection, we apply stochastic simulations to the model to test the degree of divergence between inflation rates and relative prices over different time horizons.

The VECM we estimate is a three-equation system, where the dependent variables are expressed in first differences (that is, the first difference of the logarithms for the three price measures); this system also includes a set of two linear relationships between the price levels. Each equation contains four lags for each inflation rate. We decided on four lags as a reasonable choice, because error autocorrelation and heteroscedasticity problems disappear in these circumstances. The VECM model also includes a fifth lag for long-term relationships. We set the number of long-term relationships linking the three price indexes at two, even though tests show only one cointegration vector, not two. We show later that the second vector may be important in at least one of the VECM equations. We used the Johansen and Juselius estimation procedure to determine values for the parameters: these are the two relationships shown in system (4) in Table 1. In

Figure 2

Differences Between the Logs of CPI and Other Indexes



addition, we imposed the constraint that these relationships appear only in equations where they are significant, to simplify the price-adjustment process.

The VECM includes three exogenous variables to measure the influence of shocks common to each inflation rate. The first is the cyclical measure of the output gap, *ygap*, as calculated by the Bank of Canada, lagged by one quarter. This estimate of the output gap is published regularly in the Bank's *Monetary Policy Report*. The second and third exogenous variables—*ddpcom* and *ddpoil*—measure the impact of commodity prices (other than energy) and oil prices. These two price measures, in U.S. dollars, are expressed as a ratio of the U.S. GDP deflator. They are then transformed to logarithms and expressed as second differences. The contemporaneous value as well as the first four lags for the *ddpcom* and *ddpoil* variables appear in the three VECM equations. We also tried to introduce the effect of imported inflation into these equations, but without success, since the variables used were not significant.[4]

4. Note as well that all the equations include some auxiliary variables to take account of certain sudden, temporary shifts in inflation rates. These auxiliary variables do not appear in the VECM's long-term relationships, but only in the short-term dynamics. The first binary variable is needed for the ULC equation; the growth rate of ULC declined from an average of about 11 per cent in 1975 and very early 1976 to −0.43 per cent in 1976Q3, and rose to 22.5 per cent in 1976Q4. Two binary variables are also needed to reflect the introduction of the goods and services tax in January 1991. In preliminary results without the binary variables, the equations showed estimation errors that were abnormally distributed as a result of these changes.

Table 2

VECM Estimation Results

	VECM model		
Coefficients	Δcpi	$\Delta gdpd$	Δulc
Constant	−0.007	0.012	0.013
	(3.37)	(3.15)	(2.96)
cpi–1.04**gdpd*–0.01**ulc* (*t*-5)	−0.047	0.039	0.045
	(4.13)	(2.27)	(1.98)
gdpd–1.21**ulc*+0.24*cpi* (*t*-5)	—	−0.027	—
		(2.06)	
$\Sigma\Delta cpi$ (*t*-4 to *t*-1)	0.274	0.581	0.673
	(1.99)	(2.79)	(2.43)
$\Sigma\Delta gdpd$ (*t*-4 to *t*-1)	0.252	0.502	0.355
	(2.68)	(3.33)	(1.87)
$\Sigma\Delta ulc$ (*t*-4 to *t*-1)	0.125	−0.042	−0.060
	(1.88)	(0.40)	(0.45)
ygap (*t*-1)	0.047	0.072	0.208
	(3.05)	(3.06)	(6.78)
ddpcom (*t*-4 to *t*)	0.021	0.096	−0.038
	(0.67)	(1.98)	(0.60)
ddpoil (*t*-4 to *t*)	0.016	0.050	0.015
	(1.44)	(3.05)	(0.69)
R^2	0.848	0.761	0.706
SEE (annual rate)	0.013	0.020	0.026
Durbin-Watson statistic	2.070	2.036	2.059
Proportion of quarterly variance explained by			
ygap	0.236	0.270	0.304
ddpcom	0.009	0.016	0.007
ddpoil	0.014	0.029	0.000

Note: The models are estimated with quarterly data from the first quarter of 1963 to the fourth quarter of 1995. In addition to the variables shown in the table, they include several binary variables (see Subsection 1.2 for further details). The absolute value of the t-statistics is shown in parentheses. SEE is standard error of estimation.

Table 2 shows the results of estimating the VECM model with quarterly data covering the period 1963-95. Note first of all that the long-term relationships between the price levels seem to be significant.[5] Since these relationships appear in the three equations, it is fair to say that all prices influence each other over the long run. However, since the adjustment coefficients are fairly small, the relationships between the price levels represent a phenomenon operating over the extreme long term, with little influence on the short-term profile of inflation rates. We return to this question in the next subsection.

5. The t-statistics associated with the long-term vectors should be interpreted with caution, since the cointegration tests indicate the presence of a single vector.

Variations in the CPI and in the GDPD are heavily influenced by their own past history, which may reflect either the effect of past inflationary expectations on current inflation, or the effect of price-adjustment costs. Moreover, there are some important cross-relationships between the fluctuations in the CPI and those of the GDP deflator. These cross-dynamics may reflect several influences. The effect of changes in the GDPD on changes in the CPI may reflect the influence on future consumer prices of fluctuations in the prices of various inputs, such as commodities, capital goods, or wage levels, the effects of which are felt directly or indirectly in the GDPD. The effect of changes in the CPI on changes in the GDPD may reflect the influence of the CPI on workers' inflation expectations, on wage demands, and consequently on producer prices. The cross-effects between the CPI and the GDPD may also explain why, in both models, ULC changes have no direct effect on price changes, except for their small (but significant) effect on CPI fluctuations. Changes in ULC, however, are largely determined by changes in consumer prices, a result that may reflect the influence of shifting inflation expectations on wage demands.

These three equations also show the influence of the output gap and commodity prices as common factors. Note first that changes in the GDPD react somewhat more than changes in the CPI do to the output gap (*ygap*), but it is the changes in ULC that are most influenced by current economic conditions. Cozier (1991) obtained a similar result. Moreover, a partial variance decomposition analysis, the results of which are presented in Table 2, shows that changes in *ygap* explain an important part (between 25 and 30 per cent) of the quarterly variance of each of the inflation rates. By contrast, commodity price shocks (*ddpcom* and *ddpoil*) have a significant influence on the GDP deflator, but they have no significant effects on the CPI or on ULC. Commodity prices may influence the CPI (and ULC) indirectly, through their effects on the GDP deflator, however. This might explain why changes in the deflator often precede those in the CPI (and those in ULC). According to the variance decomposition analysis, changes in *ddpcom* and in *ddpoil* explain just over 4 per cent of the quarterly variance in the GDPD and about 2 per cent of the variance in the CPI, but their effects on ULC are negligible.

1.3 Stochastic simulation results

Now that we have estimated the VECM model, we can attempt to assess the degree of deviation between inflation rates and relative prices by subjecting the model to a series of stochastic simulations.

We subjected the VECM to a series of 100 draws. Each draw includes 80 quarters of random disturbances applied directly to each of the three inflation rates, with a simulated profile of 80 quarters for each of the three exogenous variables. The standard deviations of the disturbances affecting the inflation rates, obtained from the VECM estimations, are set at 1.3, 2.0, and 2.6 per cent (annual rates), respectively, for the Δcpi, $\Delta gdpd$, and Δulc equations. It should be noted that the cross-correlations between the estimation errors of the three VECM equations are not very high, which suggests that including the variables *ygap, ddpcom*, and *ddpoil* probably suffices to capture the greater part of the short-term influence of the common shocks.[6] To obtain simulated values for the exogenous variables *ygap*, *ddpcom*, and *ddpoil*, we estimated AR(2) models for these variables, which we then subjected to random disturbances with standard deviations obtained from estimating these models. The standard deviations for *ygap, ddpcom*, and *ddpoil* resulting from these simulations are, respectively, 2.3, 25, and 65 per cent (annual rates).[7]

Using the simulated data from the 100 draws, we calculated several statistics to gauge the relationships between the inflation rates.[8] In the first part of Table 3, we show the standard deviations for the differences between the average inflation rates over periods of 1, 2, 3, 5, 10, and 20 years, obtained from the simulated data. First, the results show clearly that the differences between the inflation rates can be quite pronounced. The standard deviation for the difference between the average annual rate of change in the CPI and that in the GDPD is 2.0 percentage points, and it reaches 2.3 percentage points for the difference between the average annual rate of change in the CPI and that in ULC. In addition, the results show that the differences between the inflation rates may be quite persistent. For example, the standard deviations for the differences between the average inflation rates are, respectively, 1.8 and 1.7 percentage points over a two-year horizon, and they are well above 1 percentage point over a five-year horizon.

The second part of Table 3 shows the simulated measures of variability in relative prices over different horizons. The main observation emerging from these simulations is that the long-term relationships found in

6. The correlation coefficients between the estimation errors for the Δcpi and $\Delta gdpd$ equations, the Δcpi and Δulc equations, and the $\Delta gdpd$ and Δulc equations are 0.23, 0.07, and 0.36, respectively.

7. As shown in the previous section, the influence of the output gap on inflation is much greater than that of commodity prices. On the one hand, *ygap* shocks are more persistent than *ddpcom* and *ddpoil* shocks. On the other, *ygap* shows larger effects than the other two variables in the inflation equations.

8. Before examining these simulated relationships, we should point out that the VECM simulations allow a fairly good reproduction of the variability of the inflation rates, as well as the simple correlations between the inflation rates observed during our estimation period. That leads us to believe that this model can also provide a satisfactory explanation for the underlying relationships between the inflation rates.

Table 3

Measures of Variation in Differences in Inflation Rates and Relative Prices (from Stochastic Simulations with the VECM Model)

	Standard deviation of difference between average inflation rates over various horizons					
	1 year	**2 years**	**3 years**	**5 years**	**10 years**	**20 years**
	percentage points					
CPI versus GDPD	2.0	1.8	1.6	1.2	0.8	0.4
CPI versus ULC	2.3	1.7	1.6	1.5	1.0	0.5
	Standard deviation of relative prices over various horizons					
CPI versus GDPD	2.0	3.5	4.8	6.2	8.3	8.4
CPI versus ULC	2.3	3.4	4.8	7.3	10.4	10.4
	Standard deviation of difference between average inflation rates over various horizons (with values of *ygap, ddpcom,* and *ddpoil* set at zero)					
CPI versus GDPD	1.5	1.2	1.1	0.8	0.5	0.2
CPI versus ULC	1.7	1.0	0.9	0.8	0.6	0.3

the VECM serve to stabilize relative price variability within a standard deviation of about 10 percentage points. However, we also find that the process of convergence of relative prices is a very long-run phenomenon, requiring a period of at least 10 years.[9]

In the third part of Table 3, we present the measures of variability in the differences between the inflation rates obtained from simulations where the values of the exogenous variables *ygap*, *ddpcom*, and *ddpoil* are set at zero. What interests us here is whether the divergences between the inflation rates are attributable to systematic factors (that is, the effect of common exogenous variables). If so, it may be easier to explain these divergences, and they may therefore represent less uncertainty for the conduct of monetary policy. Comparing these results with those in the upper part of Table 3, we find that the common variables explain a significant part of the difference between the inflation rates—for example, between 0.5 and 0.6 percentage points of the difference between the average annual inflation rates. Yet, from a different perspective, these results show that a large part of the inflation rate divergences still derives from the random shocks affecting each of them and the fairly long delays in their interactions.

Given the size of the divergences among the inflation rates, another interesting question arises for the monetary authorities: How frequently does the difference between the rates of change in the CPI and in the

9. These results could have interesting implications for future research on policies aimed at stabilizing the level of a price index rather than its rate of change.

Table 4

Frequency of Cases Where Differences in Annual Average Inflation Rates Exceed +/– 1, 2, or 3 Per Cent

	+/– **1%**	+/– **2%**	+/– **3%**
CPI versus GDPD	50 times in 100	18 times in 100	2 times in 100
CPI versus ULC	59 times in 100	23 times in 100	9 times in 100

GDPD (or ULC) exceed a given margin? Among the 100 draws, we compiled the number of times that the difference between the average annual inflation rates exceeded +/– 1, 2, or 3 percentage points, using VECM simulations where the values of the exogenous variables *ygap*, *ddpcom*, and *ddpoil* were set at zero. We were interested in identifying the "non-predictable" portion of the difference between the inflation rates. The results of the simulations, presented in Table 4, show that the difference between the average annual rate of change in the CPI and in the GDPD and the difference between the average annual rate of change in the CPI and in ULC exceed +/– 1 percentage point frequently, more than 5 times in 10. These frequencies diminish to about 2 times in 10 when we examine cases where the difference between the inflation rates exceeds +/– 2 percentage points, and they are fewer than once in 10 when we look at situations where the difference exceeds +/– 3 percentage points.

1.4 General observations

Our statistical analysis shows a strong similarity between the short-term and the long-term variation in the CPI, the GDP deflator, and unit labour costs, and this leads us to believe that there is a common trend among these three measures. In addition, the VECM model estimation identifies significant temporal relationships between the changes in these three measures. For example, changes in the GDP deflator can often precede those in the CPI. However, despite this concordance, the inflation rates diverged significantly for extended periods over the last four decades. Our simulation results show, however, that there is a high probability that these divergences are contained within a band of +/– 2 percentage points.

2 Different Measures of Core Inflation in the CPI

The inflation-reduction targets announced in 1991 were stated in terms of the 12-month change in the CPI. A background paper published at the time indicated that, to reach the targets set for the CPI, the Bank of Canada would in the short term use the CPI excluding the highly volatile components of food and energy, given that the total CPI and the CPI excluding food and energy had historically behaved very similarly over long periods of time. The paper also stated that the targets might be temporarily readjusted in the event of major changes in indirect tax rates.

With the establishment of specific inflation objectives, not only in Canada but in other countries, the question of core inflation has assumed increasing importance, and various approaches have been developed to measure it. The approach used in this section involves calculating new inflation rates from statistical measures that are based exclusively on the CPI. This approach was first tried with U.S. data by Bryan and Pike (1991), who found that the median of movements in CPI components constituted a better representation of core inflation than the weighted average of those movements (which is, by definition, the inflation rate as calculated by the CPI). The idea was again studied by Bryan and Cecchetti (1993), with the calculation of weighted medians and weighted averages of trimmed distributions. Roger (1995) examined a wide variety of statistical measures of core inflation and compared them with official measures from the Reserve Bank of New Zealand. The present paper draws heavily on these previous research efforts, although our analysis is, of course, set in the context of the Canadian economy.

In the following subsections, we first discuss the theoretical framework underlying this approach and explain the methodology used. Then we present the new measures and a comparison with the core inflation measure published by the Bank of Canada. We examine as well a measure of core inflation that excludes the eight components of the CPI that were the most volatile over the observation period. Finally, we attempt to discriminate among the various measures of core inflation according to their capacity to predict the rate of change in CPIXFET in simple indicator models.

2.1 Defining core inflation and outlining the methodology

Core inflation should be a measure of the basic trend in prices. The measure should therefore take account of price changes caused by aggregate demand pressures, permanent supply shocks, and shifting expectations, but should ignore disturbances resulting from temporary shocks. If a shock occurs in a particular sector, only the firms in that sector will be affected, and if the shock is large enough, they will need to adjust their prices, thus introducing asymmetry in the distribution of relative prices. For the economy as a whole, we assume that extreme fluctuations in this distribution, which are usually asymmetric, reflect temporary supply shocks.

To assess the core inflation rate, therefore, we must eliminate extreme relative fluctuations from our measures.[10]

The food and energy components have been removed from the core inflation index because fluctuations in their prices reflect primarily temporary shocks. There are several other components of the CPI besides food and energy whose movements could also be associated with temporary shocks.[11] It is from this viewpoint that the new measures of core inflation are considered.

To describe how these new measures are constructed, we must first represent the inflation rate (as measured by changes in the CPI) as a weighted average of the changes in its individual components. To eliminate extreme fluctuations in relative prices, we calculated the weighted average of the distribution trimmed by a certain percentage at each side. Weighted averages for several trimmed distributions have been calculated by Laflèche (1997), but for the purposes of this analysis we present only the data for the weighted average of the distribution trimmed by 10 per cent at each side (WAT10), and trimmed of values higher and lower than the average +/– 1.5 times the standard deviation (WATSD). The latter measure has the advantage of not discarding extreme values if they are not too far off the average. Trimming 5 per cent from each side of a normal distribution is approximately equivalent to discarding values higher and lower than the average +/– 1.5 times the standard deviation. We also examine the weighted median (WMED), which does not eliminate extreme fluctuations but accords them less weight than does the weighted average.

In this study, we decompose the CPI into 54 components, for which continuous series can be constructed beginning in November 1978 (or earlier, for some components).[12] (The components and their weighting in the basket for 1992 are shown in Table 6, discussed in the next subsection.) In calculating the various measures of core inflation, we have updated the

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10. Of course, if the distribution is symmetric, then excluding the extreme variables will have no effect and the core inflation rate will be equal to the inflation rate as measured by the total CPI.

11. Other types of temporary supply shocks would include a change in indirect taxes (such as the sharp cut in tobacco taxes in February 1994), a change in regulated prices, or an increase in prices following a sudden jump in the price of an imported input (perhaps reflecting an exchange rate shift).

12. Official data for some components are available only as of December 1984. In these cases, consistent series were obtained back to 1978 using historical data from Statistics Canada. Between 1978 and 1986, the CPI is decomposed into 53 components. If we were to limit ourselves to core inflation series beginning in 1995, we could calculate the new measures using 182 components of the CPI, which is the highest level of disaggregation of the index.

weighting of the different components periodically (every two years) to reflect changes to the basket or changes in prices within the same basket.

The core inflation measures are calculated using 12-month changes in the components, since both the core inflation indicator used in the conduct of monetary policy (CPIXFET) and the inflation target (total CPI) are expressed in terms of 12-month changes. They could have been established using monthly or quarterly changes, but this would have posed several difficulties.[13] For one thing, the prices of some components are updated by Statistics Canada only once or twice a year. Over the reporting period for these prices, monthly changes may be high without necessarily representing supply shocks. In fact, the published monthly change usually represents, in these cases, an accumulation of moderate monthly price changes. In other cases, for example with property taxes and education costs, the actual prices change only once a year.

For another thing, extreme movements in monthly price changes are often the result of seasonal factors, and although seasonal factors are certainly temporary shocks, they are not the only ones that we are trying to eliminate from our measures. Extreme changes linked to seasonal factors may in fact mask important movements in other components that reflect other types of temporary supply shocks. In that case, the trimmed distribution might eliminate only seasonal effects and ignore other shocks.

Finally, it is important to note that all the new core inflation measures were calculated after the data for each of the 54 components were adjusted for the introduction of the GST in January 1991. This adjustment must be made because the various measures cannot eliminate a shock that affects the majority of index components. However, the effects of specific changes in indirect taxes (such as the sharp cut in tobacco taxes in February 1994), which result in extreme movements for some components, are naturally eliminated (or attenuated, in the case of the weighted median) by these measures.

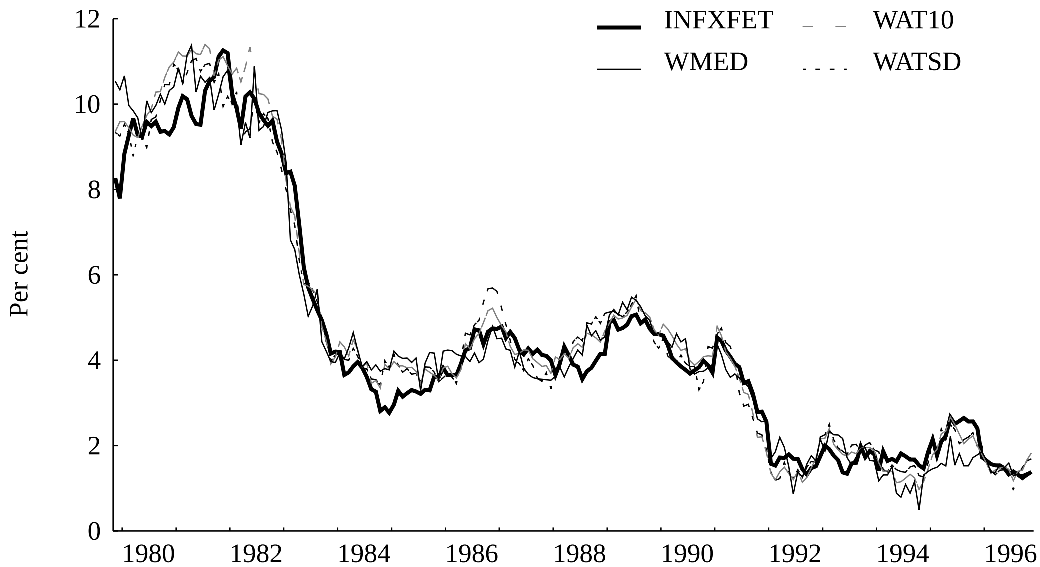
2.2 Comparing the new and the traditional measures

Figure 3 illustrates the weighted median (WMED), the weighted average of the distribution trimmed by 10 per cent on each side (WAT10), and the weighted average of the distribution from which values higher and lower than the average +/– 1.5 times the standard deviation have been trimmed (WATSD). These series are presented together with the 12-month

13. Calculating core inflation measures using 12-month changes in the total index components also has some drawbacks. One of these is that any components that undergo a major shock will generally be eliminated from the measures for a period of several months, perhaps even a full year.

Figure 3

Trend Inflation Measures and the 12-Month Growth Rate in CPIXFET



rate of change in the CPI excluding food, energy, and the effect of indirect taxes—a measure we refer to herein as INFXFET, the inflation rate that corresponds to CPIXFET.[14] We find that the profiles of the three new measures are very similar and that they correspond closely to that of INFXFET. This is important because if one of the new measures is close to the "true" measure of the core inflation rate, then the short-term measures used by the Bank of Canada in the conduct of monetary policy have tracked it closely over the observation period.

The averages for the three new measures are similar to that for INFXFET (see Table 5). However, they are somewhat lower than the average inflation rates for the total CPI (INF) and for the CPI excluding food and energy (INFXFE).[15] The main reason is that core inflation measures

14. The monthly series for the CPI excluding food, energy, and the effect of indirect taxes begin only in 1984. However, we have a quarterly series for implicit taxation rates on the CPI excluding food and energy, from which we have obtained, through interpolation, an approximation of the 12-month change in CPIXFET for the period 1978-85.

15. The rates of change in the CPI and in CPIXFE show similar averages simply because the average growth in food and energy prices was almost identical to that of the other components over the period of observation. However, there were prolonged periods when food and energy prices behaved quite differently from prices for other components as a whole.

Table 5

Averages and Standard Deviations of Inflation Rates over the Period November 1979 to November 1996

	INF	INFXFE	INFXFET	WAT10	WATSD	WMED	INFX8
1979-96							
Average	4.82	4.86	4.52	4.70	4.61	4.57	4.61
Standard deviation	3.38	3.07	2.82	3.07	2,89	2.98	2.69
1991-96							
Average	1.84	2.02	2.07	1.95	1.99	1.87	2.15
Standard deviation	1.19	1.33	0.82	0.84	0.81	0.81	0.46

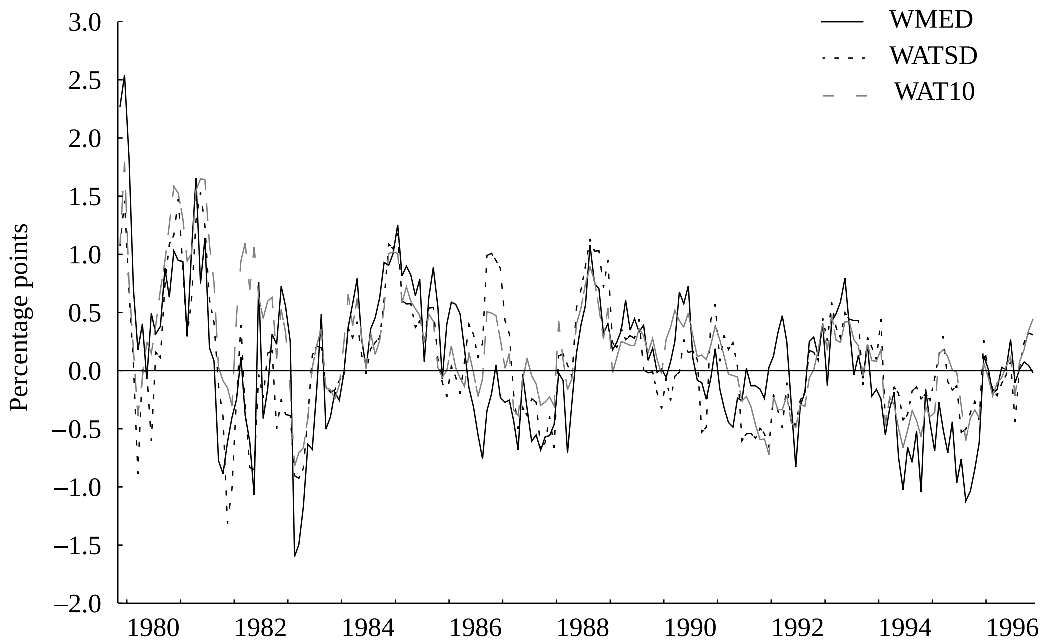
exclude—systematically in the case of INFXFET and frequently in the case of the new measures—the effect of changes in indirect taxes, which on average exerted a positive effect on measures of CPI and CPIXFE inflation during our observation period. For example, the implicit rate of taxation on CPIXFE components increased by 7 percentage points during the observation period (1979-96), which corresponds to an average effect on inflation of about 0.4 percentage points per year. As expected, given their construction the core inflation measures are less volatile than the rate of change in the overall index, as can be seen from their standard deviation (Table 5). They are, however, slightly more volatile than INFXFET.

Although the three new measures generally behave similarly, they do diverge on occasion. This is explained by differences in their construction. The weighted average of the distribution trimmed according to the standard deviation (WATSD) eliminates fewer components than does WAT10, but it has the advantage of eliminating only those components whose changes are far off the average, while the WAT10 chops 10 per cent from each side of the distribution, whether the changes in those components are “extreme” or not. Furthermore, the WATSD measure is the least variable of the three measures. Advantages of the weighted median over the other measures are that it does not eliminate any of the index components and it does not require the choice of a trimming percentage. That does not necessarily make it the best measure for the core inflation rate, however. For example, Figure 3 shows that the 1994 tobacco tax cut, which is clearly a temporary supply shock, has its greatest effect on the weighted median measure of core inflation.

As can be seen in Figure 4, the differences between the new measures and INFXFET are generally not very pronounced during our observation period, and the divergences last no longer than one or two years. In fact, the divergences between the three new measures and INFXFET show a standard deviation of about 0.5 percentage points from 1980 to 1996. Moreover, as Figure 4 suggests, there is evidence that the differences between the various

Figure 4

Deviation Between New Measures and the Rate of Change in CPIXFET



core inflation measures narrow as the general level of inflation falls. For example, the divergences between WATSD and INFXFET showed a standard deviation of about 0.7 percentage points from 1980 to 1983 but no higher than 0.3 percentage points since 1991.

Table 6 presents the frequency of elimination of the various components entering into the calculation of WAT10 and WATSD over the observation period. The table should be read as follows: the price of meat, for example, was eliminated 65 times from the calculation of the WAT10 measure during the 205 monthly observations that make up our sample from November 1979 to November 1996, or 32 per cent of the time; for the WATSD measure, meat was eliminated only 13 times, or 6 per cent of the time.[16] The components may be eliminated completely or partially—we do not make this distinction in the calculations shown in Table 6.

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16. If extreme fluctuations in relative prices reflect temporary supply shocks, the components showing such fluctuations should be eliminated just about as often when their fluctuations are to the right of the distribution as when they are to the left (for example, a sharp price rise, linked to a temporary supply shock, should be followed fairly shortly by a sharp drop). Our tests show that this is true for most of the components. Among the exceptions are the cost of intercity transportation and the price of tobacco products, which were eliminated most often from the overall index when their fluctuations were to the right of the distribution (that is, after a sharp rise).

The first conclusion we can draw from this table is that it is unnecessary to eliminate all food prices from the overall index. In fact, even though the prices of some food products are very volatile (fruits and vegetables, for instance), other subcomponents accounting for some 50 per cent of the food basket—restaurant meals, dairy products, and bakery products—are rarely excluded from the WAT10 and WATSD measures, because they generally show very moderate price variation. Systematically excluding them from the INFXFET may lose some pertinent information on the fundamental trend of inflation. By contrast, it is reasonable to exclude the cost of energy, since most of its subcomponents show frequent and extreme price fluctuations, which can be associated with temporary shocks. In fact, apart from electricity, the energy components (fuel oil, natural gas, and gasoline, or more than 75 per cent of the energy basket) are often eliminated from the new statistical measures we calculated.

Besides two food categories (fruits and vegetables) and three energy subcomponents (fuel oil, natural gas, and gasoline), three other components are often eliminated in the new measures: mortgage interest costs, intercity transportation (primarily air transportation), and tobacco products. The last two components are most often eliminated because of temporary supply shocks (intercity transportation prices are sensitive to changes in fuel prices, and tobacco products are often affected by changes in indirect taxes). Monetary policy no doubt plays a large role in fluctuations in mortgage interest costs. A tightening of monetary policy, for example, aimed at reducing the inflation rate, has a perverse short-term effect on inflation, since higher interest rates will cause a temporary rise in mortgage interest costs. This perverse effect explains why some countries, such as the United Kingdom and New Zealand, exclude this component from their core inflation measures.

We thus present another measure of core inflation: the 12-month growth rate of the CPI excluding these eight most volatile components—INFX8. These components, as listed in the preceding paragraph, are also identified in Table 6 as the shaded entries. Here we choose to exclude the components that were eliminated more than 50 per cent of the time from the WAT10 measure, and more than 25 per cent of the time from the WATSD measure.

The INFX8 measure, diagrammed in Figure 5, has the advantage over the other statistical measures of being simpler to understand and to calculate; it can be represented as an index, rather than as fluctuations; and it can be constructed for a longer period. Although it looks much like INFXFET, INFX8 stands out among the alternative measures of core inflation on the basis of its behaviour. It is the least variable of the new

Table 6

Frequency of Elimination of the CPI Components in the Calculation of WAT10 and WATSD

Components	Weight	WAT10 #	WAT10 %	WATSD #	WATSD %
Food					
Meat	2.94	65	32	13	6
Fish and other seafood	0.45	47	23	18	9
Dairy products and eggs	1.95	15	7	0	0
Bakery and other cereal products	1.91	23	11	3	1
Fruits, fruit preparations, and nuts	1.31	109	53	59	29
Vegetables and vegetable preparations	1.27	150	73	117	57
Other food products	2.74	58	28	14	7
Food purchased from restaurants	5.42	0	0	0	0
Energy					
Electricity	2.82	19	9	2	1
Gasoline	3.54	142	69	93	45
Natural gas	0.88	126	61	83	40
Fuel oil and other fuels	0.54	127	62	101	49
Shelter					
Rented accommodation	7.27	15	7	0	0
Mortgage interest cost	5.67	113	55	53	26
Replacement cost	3.50	90	44	39	19
Property taxes	3.32	47	23	15	7
Homeowner’s insurance premiums	0.87	68	33	27	13
Homeowner’s maintenance and repairs	1.30	36	18	7	3
Other owned-accommodation expenses	1.25	12	9	1	1
Water	0.47	57	28	14	17
Household operations and furnishings					
Communications	2.02	73	36	37	18
Child care and domestic services	1.14	14	7	2	1
Household chemical products	0.70	34	17	7	3
Paper, plastic, and foil supplies	0.76	36	18	16	8
Other household goods and services	1.28	7	3	0	0
Furniture	1.49	14	7	3	1
Household textiles	0.54	28	14	6	3
Household equipment	1.78	9	4	0	0
Services related to household furnishings	0.32	0	0	0	0
Clothing and footwear					
Clothing	4.34	9	4	0	0
Footwear	0.91	12	6	3	1
Clothing accessories and jewellery	0.73	86	42	27	13
Clothing material, notions, and services	0.64	0	0	0	0
Transportation					
Purchase of automotive vehicles	7.09	65	32	0	0
Rental and leasing of automotive vehicles	0.46	96	47	43	21
Automobile parts, maintenance, and repairs	2.03	23	11	11	5
Other automobile operating expenses	3.70	87	42	27	13
Local and commuter transportation	0.59	54	26	26	13
Intercity transportation	0.88	122	60	95	46

(continued)

Table 6 (cont'd)

Frequency of Elimination of the CPI Components in the Calculation of WAT10 and WATSD

		WAT10		WATSD	
Components	**Weight**	**#**	**%**	**#**	**%**
Health and personal care					
Health-care goods	0.68	33	16	15	7
Health-care services	1.11	0	0	0	0
Personal-care supplies and equipment	1.60	20	10	5	2
Personal-care services	0.96	3	1	0	0
Recreation, education, and reading					
Recreational equipment and services (excluding vehicles)	1.79	33	16	9	4
Purchase of recreational vehicles	0.79	22	11	2	1
Operation of recreational vehicles	0.37	35	17	3	1
Home-entertainment equipment and services	1.39	111	54	28	14
Travel services	1.66	51	25	19	9
Other recreational services	2.04	32	16	3	1
Education	1.56	83	40	25	12
Reading material and other printed matter	0.76	26	13	10	5
Alcoholic beverages and tobacco products					
Served alcoholic beverages	0.96	22	11	1	0.5
Alcoholic beverages purchased from stores	2.00	23	11	2	1
Tobacco products and smokers' supplies	1.55	115	56	74	36

Notes: Frequencies of elimination are calculated from November 1979 to November 1996, except for the component "Other owned-accommodation expenses," which runs from January 1986 to November 1996. The weights shown in the table are those for January 1995 (see Statistics Canada 1995). # means the number of times the component was eliminated from the calculation. Shaded items are those excluded in the INFX8 measure of core inflation.

measures we calculated (see Table 5).[17] This is particularly evident in the period 1991-96, when the standard deviation for INFX8 is barely half as great as that for the other measures. Furthermore, the sum of the weights for the eight excluded components (15.6 per cent of the CPI basket in 1996), although much higher than the sum of the excluded components in WAT10 (10 per cent) and WATSD (9.6 per cent), is much lower than the sum of the weights for the food and energy components (25.8 per cent).

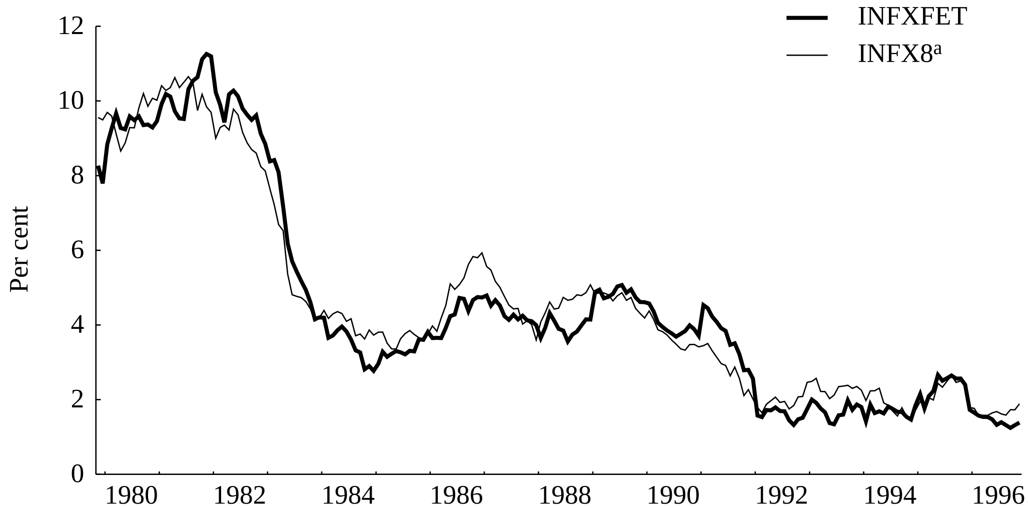
2.3 The results of our indicator models

In this section we examine the temporal relationships between five core inflation measures (INFXFET, WAT10, WATSD, WMED, and INFX8)

17. It is interesting to note that a measure of core inflation that systematically excludes the seven most volatile components (that is, the eight excluded from INFX8 with the exception of mortgage interest costs) does not stand out from the other measures the way INFX8 does. This suggests that the role of mortgage interest in the definition of core inflation may warrant special attention.

Figure 5

12-Month Change in CPIXFET and CPI Excluding the Eight Most Volatile Components



a. Adjusted for the effects of GST in January 1991.

using simple indicator models. We are especially interested in whether the lagged level of a given core inflation measure adds information to that already contained in the particular dynamics of the other measures. Of course, criteria other than an indicator might be used to compare the various measures. Someone interested in a particular inflation model (a Phillips curve model, for example) might wish to compare the core inflation measures using that model.

The reference indicator model has the following form:

$$P_{i,\,t} = A0 + A1{*}P_{i,\,t\text{-}12} + A2{*}P_{i,\,t\text{-}24} + A3{*}P_{j,\,t\text{-}12},$$

where $A0$ to $A3$ are the coefficients to be estimated, P_i corresponds to each of the measures i of the core inflation rate, and P_j corresponds to each of the other measures of core inflation (other than i). The indicator model is estimated for each of the measures of inflation with monthly data covering the period November 1981 to November 1996.[18] Each model is first estimated with 12- and 24-month lags in the dependent variable ($P_{i,\,t\text{-}12}$ and

18. The variance-covariance matrix correction procedure proposed by Newey and West (1987) is used in the regressions, since the overlap of observations creates an autocorrelation problem in the errors.

$P_{i,\,t\text{-}24}$) as the only explanatory variables.[19] We then add lags (of 12 months) for the other core inflation measures $(P_{i,\,t\text{-}12})$ to each model in turn.

The results of the indicator models are summarized in Table 7. Note that, on the basis of R^2 statistics, the new core inflation measures allow us to reduce the prediction error variance of INFXFET by 6 to 11 per cent, compared with the univariate model. Since the new inflation measures add some information for predicting INFXFET, they may well contain useful information for the conduct of monetary policy. Note also that it is the indicator models with the INFX8 variable that show the highest R^2, and that the t-statistics for the coefficients linked to this variable are greater than those of the other core inflation measures. Among the five core inflation measures, then, the INFX8 variable seems to be the one that contains the most independent information. The statistical measures WAT10, WATSD, and WMED are less useful than INFX8 in terms of explanatory power.

2.4 Overall observations

We may draw some interesting conclusions from this analysis. First, over the observation period, the inflation rate for the CPI excluding food, energy, and the effect of indirect taxes (CPIXFET) behaved similarly to the new measures. Assuming that these new measures actually represent core inflation, this means that the rate of change in the CPIXFET has been a suitable indicator for the monetary authorities. Second, our analysis indicates that it is unnecessary to exclude all food prices from the overall index, since many food products (50 per cent of the food basket) rarely show extreme price fluctuations. By contrast, the prices of gasoline, natural gas, and fuel oil (more than 70 per cent of the energy basket) are highly volatile; this seems to provide grounds for excluding them from the overall index. In addition to certain food prices (in particular, fruits and vegetables) and most energy prices, these new measures often eliminate mortgage interest, intercity transportation, and tobacco products. This prompted us to examine another measure of core inflation (INFX8), which excludes the eight most volatile components of the CPI basket. INFX8 is the least variable of the core inflation measures we calculated. It is also the one that adds the most information for predicting the traditional measure of core inflation.

3 Measurement Bias in the CPI

The CPI measures the change over time in the cost of purchasing a fixed basket of goods and services, whereas a true cost-of-living index would

19. We also estimated indicator models with 36- and 48-month lags in the dependent variable. Although these lags were significant, including them in the models does not alter our conclusions as to the indicator role of the core inflation variables $(P_{j,\,t\text{-}12})$.

Table 7

Summary Results of the Indicator Models for Trend Inflation Rates

Indicator models for the following variables	R^2 of indicator models					
	Univariate models	Bivariate models including the following independent variables				
		INFXFET	WAT10	WATSD	WMED	INFX8
INF	0.64	0.68	0.73	0.74	0.74	0.75
		(4.39)	(8.60)	(8.60)	(7.23)	(9.62)
INFXFE	0.57	0.65	0.72	0.72	0.74	0.73
		(7.29)	(12.56)	(13.12)	(12.15)	(14.44)
INFXFET	0.73	na	0.80	0.80	0.79	0.84
			(8.27)	(7.97)	(7.44)	(10.65)
WAT10	0.75	0.75	na	0.76	0.76	0.81
		(2.48)		(2.86)	(2.41)	(7.39)
WATSD	0.72	0.72	0.72	na	0.73	0.78
		(2.13)	(0.29)		(1.97)	(7.47)
WMED	0.75	0.75	0.75	0.76	na	0.78
		(1.33)	(0.59)	(2.05)		(4.61)
INFX8	0.75	0.79	0.77	0.76	0.75	na
		(5.99)	(4.83)	(3.43)	(0.70)	

Note: The reference indicator model takes the following form:

$$P_{i,t} = A0 + A1 * P_{i,t-12} + A2 * P_{i,t-24} + A3 * P_{j,t-12}$$

where $A0$ to $A3$ are the coefficients to be estimated, P_i corresponds to each measure of inflation or core inflation, and P_j corresponds to each measure of core inflation. The equations are estimated using monthly data from November 1981 to November 1996. The t-statistics are calculated after applying the Newey-West correction to the variance-covariance matrix. The absolute values of t-statistics are shown in parentheses. na means not applicable.

measure the change in the minimum cost of achieving a given standard of living. This conceptual difference means that the CPI may be a biased measure of the change in the true cost of living. Measurement biases can also occur because of the practical difficulties in measuring pure price changes. This section describes the potential sources of bias and presents estimates of their magnitudes in the Canadian CPI.[20] If the sum of the individual biases is positive, the CPI overstates the increase in the cost of living.

The discussion focusses primarily on the "upper bound" estimate of the bias, which may be interpreted as the upper end of a 95 per cent confidence interval. It also comments on the probable size of the mean bias.

3.1 Estimates of bias

3.1.1 Commodity-substitution bias

The CPI is constructed using the Laspeyres index formula, which holds the quantities of individual categories of goods and services unchanged at their base-period levels. Since quantities are fixed, the CPI does not reflect the ability of consumers to adjust the composition of their spending following changes in the relative prices of goods and services. As a result, the change in the CPI will overstate the increase in the true cost of living. The magnitude of this commodity-substitution bias increases with the length of time between basket weight revisions and with the amount of variation in the relative prices of different goods and services. Empirical evidence reported by Bérubé (1998) indicates that this bias is approximately 0.1 per cent a year in the Canadian CPI, given the current practice of updating the basket weights every four years. Future improvements in the CPI methodology, such as more frequent basket updates and shorter lags in implementing new weights, would reduce the bias.

3.1.2 Formula bias

Formula bias refers to a measurement error arising from the micro aggregation formula that is used to construct the price index for an individual good or service from price data collected at retail outlets. Statistics Canada's micro formula is a geometric mean of price relatives. One of the desirable properties of this formula is that it implicitly allows quantity substitutions towards those outlets where the relative price of the item has fallen. This means that the geometric mean formula should provide

20. An earlier study of measurement bias in the Canadian CPI is Crawford (1993). This section summarizes a forthcoming updated version of that study (Crawford 1998).

a good measure of the changes in the cost of purchasing the item, so formula bias is probably negligible in Canada.

The consumer price indexes for some other countries use the arithmetic mean of price relatives as their micro aggregation formula. Empirical evidence shows that a price index based on this formula can have a significant positive formula bias.[21]

3.1.3 Quality bias

Some changes in market prices reflect changes in product quality rather than changes in the price of an item of constant quality. Only the latter effect should be incorporated in the CPI, which is intended to measure pure price changes. Therefore, statistical agencies use various techniques to adjust the observed price movements in order to remove the estimated effect of changes in quality. A quality bias occurs if the magnitudes of these quality adjustments are inappropriate.

It is important to note that quality bias can be in either direction for different components in the CPI. The bias is positive if Statistics Canada underestimates the effect of quality improvements on market prices. Conversely, the quality bias is negative if the effect of quality improvements is overestimated. The magnitude and direction of the quality bias at the level of the all-items CPI depend on the net effect of all upward and downward biases for individual components. Statistics Canada believes that the net bias is not significant at the all-items level because upward biases for some components are likely to be offset by downward biases for other components.[22]

Available evidence does not permit a definitive statement about the magnitude and direction of quality bias in the all-items CPI for Canada. Nevertheless, possible upward biases for certain items, such as consumer durable goods and pharmaceuticals, are likely to be offset at least in part by downward biases for other items, including rent and possibly clothing. The bidirectional nature of quality bias, combined with the fact that bias will be

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21. One reason for this positive formula bias is that the arithmetic mean of price relatives implicitly uses fixed base-period quantities for the outlets in the price sample. Accordingly, it does not take into account the ability of consumers to switch their spending on the item towards those outlets where the price of the item has become relatively cheaper. Schultz (1987) shows that the upward bias in the arithmetic mean of the price relatives formula tends to be accentuated if the index level for each period is obtained by chain linking. Schultz (1994) provides Canadian empirical evidence on the quantitative effects of using a different micro aggregation formula.

22. Statistics Canada (1995, 22).

zero for some commodities that are not subject to changes in product quality, will constrain the upper bound for this bias.

One approach to estimating the quality bias in the all-items CPI would be to assume that the *net bias* from all components other than durable goods is zero. In this case, the quality bias in the all-items CPI would equal the basket weight for durable goods in the Canadian CPI (14.28 per cent) multiplied by the annual bias for consumer durables. Gordon's (1990) estimated bias—1.05 per cent per year for consumer durables in the U.S. CPI over the 1973-83 period—is used as an estimate of the bias for durable prices in Canada.[23] If the net bias for other components is zero, an annual bias of 1.05 per cent for consumer durables would amount to a quality bias of 0.15 per cent per year in the all-items CPI for Canada.

If, instead, an allowance is made for a net positive bias for components other than durable goods, a reasonable upper bound estimate of the annual quality bias in the CPI would be 0.2 per cent. One reason for regarding 0.2 per cent as an upper bound estimate is the treatment of the cost of government-mandated safety and antipollution equipment for automobiles. Official CPI methodologies assume that these mandated features are a quality improvement, and apply a quality adjustment equal to the manufacturers' estimated cost of these changes. Triplett (1988) takes the opposite view by arguing that these legislated costs should be treated as a pure price increase rather than a quality improvement; this implies that automobile price indexes would have a significant negative quality bias. An intermediate view is that there could be a negative quality bias for automobiles if consumers do not value the mandated safety and antipollution equipment by the full amount of their resource costs. If this is the case, Gordon's estimate of the quality bias for durable goods (and, therefore, the estimated bias for these goods in the Canadian CPI) is probably too high.

3.1.4 Outlet-substitution bias

Shifts in market shares from high- to low-price retailers have occurred recently in Canada with the entry of new discount retailers and warehouse stores. It is likely that the CPI has not captured the full effect of these shifts on the prices paid by consumers, resulting in a positive outlet-substitution bias. Even if the outlet price samples were updated to be

23. Of course, the quality bias for consumer durable goods in Canada need not coincide with Gordon's estimate for the same goods in the U.S. CPI, because different quality adjustment techniques may have been used in the two countries. In addition, Gordon's estimate for the 1973-83 period may overstate future biases if the methods of quality adjustment tend to improve over time.

consistent with the new market shares, the traditional sample rotation methodology would not record a measured price decline. When outlet samples are revised, it is assumed that the price differential between high- and low-price outlets is entirely offset by a difference in outlet quality—that is, *quality-adjusted* prices are equal at all types of outlets.[24] If, instead, the quality-adjusted price is lower at the low-price outlet, the shift in market shares produces a decrease in the average quality-adjusted price, which is not reflected in the CPI.

Estimates of outlet-substitution bias must take into account several factors. First, for the price index of a typical individual commodity subject to the bias, an estimate of the bias is obtained using information on the annual shift in market shares and the quality-adjusted price differential between different types of outlets. The bias in the all-items CPI is then determined by multiplying this estimate by the proportion of the CPI basket subject to the bias. These factors are now considered.

Data for the market shares of major and discount department stores show an acceleration in the pace of shifts in market shares in recent years. During the 1980s, the market share of discount department stores increased at an average annual rate of approximately 1 percentage point per year. From 1992 to 1996, the average annual shift in market shares rose to 2.7 percentage points, with particularly large movements occurring in 1994 and 1995 following the entry of a major retailer into the Canadian market.

This information suggests that the annual shift in market shares is currently about 2.5 percentage points. It may be unrealistic to expect such rapid growth rates to continue indefinitely. The recent entry of lower-price, lower-service retailers in some sectors represents an expansion in the price and quality combinations available to consumers. Given these new opportunities, we would expect consumers to adjust their spending patterns to achieve a desired balance between retailers offering different combinations of price and quality. Rapid changes in market shares may occur in the early stages of this process as the availability of the new formats becomes more widespread. However, the annual change in market shares should eventually diminish once most consumers have completed their reallocation of spending among the different types of outlets. With this forward-looking perspective, 2.5 percentage points appears to be a reasonable upper bound estimate for the average annual shift in market shares.

The second factor to be considered in estimating the outlet-substitution bias is the average quality-adjusted price differential between

24. Outlet quality may be lower at the low-price outlets if they provide less service (including after-sale service and product warranties) and have less-accessible locations.

high- and low-price outlets. These quality-adjusted differentials are not directly observed. Anecdotal evidence confirms that competitive forces tend to reduce any initial differences in quality-adjusted prices—for example, competitive pressures have induced cost- and price-cutting moves by established retailers in several sectors. If competitive pressures were eventually to cause quality-adjusted prices to be equalized at all types of outlets, there would be no outlet-substitution bias. Rather than adopt this extreme assumption, we take an average differential of 10 per cent as a working hypothesis. With this differential, and the estimated annual shift in market shares, the upper bound for the outlet bias in the price index for a typical commodity subject to this bias is 0.25 per cent.

Finally, the annual outlet bias in the all-items CPI is the product of the bias for a typical commodity (0.25 per cent) and the share of the CPI basket subject to this bias. A partial list of CPI components subject to shifts in market shares includes consumer durable goods, food, clothing, household operations, and air transportation. An upper bound estimate for the share of the CPI basket susceptible to this bias is 40 per cent. Therefore the upper bound for the annual outlet-substitution bias in the all-items CPI is 0.1 per cent.

3.1.5 New-goods bias

Biases may also occur if the CPI measure does not capture the effects of the introduction of new goods onto the market. Although the distinction can sometimes be quite arbitrary, it is convenient to decompose the total new-goods bias into a bias associated with the introduction of entirely new categories of goods (a new-products bias) and a bias caused by the introduction of new brands of existing products (a new-brands bias).

New-products bias

The traditional discussion of new-products bias focusses on certain categories of new products (typically new electronic items such as video cassette recorders and computers) that experience a period of rapidly falling prices in the early stages of their product cycles. The CPI will contain a positive bias if these goods are excluded from the CPI basket during the period of falling prices. In estimating the size of this bias, information is needed for the typical decline in the relative price of excluded new products and the share of these goods in current household spending. The most likely traditional sources of new-products bias are consumer durable goods, particularly household appliances and electronic equipment. Spending on new types of products is unlikely to be as large as the total basket weight for the categories of goods most susceptible to this bias. Since household appliances and electronic equipment account for approximately 2 per cent of the present CPI basket, excluded new products in these categories probably represent less than 0.5 per cent of current consumption expenditures. If the relative price of a typical new product declines by 50 per cent over a four-year period, and these items account for 0.5 per cent of current spending after four years, the new-products bias would be approximately 0.06 per cent per year.

Some goods or services (such as cable television) might be regarded as new products in the sense that their product attributes are quite different from those of previous goods or services, even though the prices for these items have not shown the rapid declines seen for some new electronic goods. Nevertheless, since the initial market prices are below their reservation levels, they will contribute to a new-products bias. Additional positive judgment for these types of commodities is used to place the upper limit for new-products bias at 0.15 per cent per year.

New-brands bias

The introduction of new brands of existing categories of goods (for example, a new brand of cereal) may be another source of upward bias. If the new brand is not a perfect substitute for the existing brands, an increase in the number of brands will lower the minimum cost of reaching a given standard of living, thereby reducing the cost of living. Since the CPI does not make allowance for these potential effects, the introduction of new brands may lead to an upward bias.

It is difficult to measure the value that consumers place on increases in the number of brands of existing products. Some have argued that this bias is considerable by noting that there have been significant increases in brand selection over long periods of time. When evaluating these arguments, it is important to recognize that relatively small annual biases can give large cumulative biases that are consistent with the anecdotal evidence. A judgmental estimate for the upper bound of this bias is 0.15 per cent.

In summary, the estimated upper bound for the combined annual bias from new types of products and new brands is 0.3 per cent.

3.1.6 Total measurement bias

The sum of the estimates for the individual biases suggests that the upper bound for the total annual bias in the all-items CPI is 0.7 per cent (Table 8). Since quality bias is the only bias that could be negative, the lower bound of the bias is likely to be positive, implying that the CPI does

Table 8

Estimated Annual Bias in the CPI

Bias	**Canada (upper bound)**	**Canada (mean)**	**U.S. Shapiro-Wilcox (mean)**	**U.S. Advisory Commission (mean)**
Commodity-substitution bias	0.1	0.1	0.2	0.15
Formula bias	—	—	0.25	0.25
New-goods bias				
New-products bias	0.15			
		0.2[a]	0.2[a]	0.6[b]
New-brands bias	0.15			
Quality bias	0.2	0.1	0.25	
Outlet-substitution bias	0.1	≅ 0.06	0.1	0.1
Total	0.7	≅ 0.5	1.0	1.1

a. New-products and new-brands bias together.

b. Separate estimates were not provided for new-goods and quality biases.

overstate the increase in the cost of living. Given the current CPI methodology, the most likely mean of the annual bias is approximately 0.5 per cent.

These estimates make no allowance for the possibility that fiscal pressures will cause governments to rely increasingly on higher user fees for government-supplied goods and services. Higher user fees would not be reflected in the CPI if they were imposed on items excluded from the CPI basket. The resulting downward bias in the CPI would offset some of the positive bias from the other sources.

Table 8 shows estimates of the bias in the U.S. CPI from the U.S. Senate Advisory Commission (1996) and Shapiro and Wilcox (1996). Their estimates of the mean bias in the U.S. CPI are in the 1 per cent range, compared with our estimate of 0.5 per cent for Canada. Methodological differences in constructing the price indexes account for much of the difference in the bias estimates for the two countries. Commodity-substitution bias will tend to be lower in Canada because basket weights are currently updated every 4 years, whereas updates occur approximately every 10 years in the U.S. CPI. There is a significant formula bias in the U.S. CPI because individual component indexes are constructed using an arithmetic mean of price relatives, whereas the geometric mean formula used by Statistics Canada has a negligible bias. Finally, quality bias estimates are higher in the U.S. CPI because of the much greater basket weight for medical services, which may have a significant upward bias.

3.2 Implications for monetary policy

One reason for selecting price stability as the goal of monetary policy is the belief that benefits accrue from a policy that promotes confidence in the value of money. Another rationale is that price stability clarifies the signals in individual price movements because agents can more readily distinguish between relative and absolute price movements when the general price level is stable. This section considers some implications of measurement biases for the definition of an inflation target.

If the inflation target were to allow the CPI to rise at a rate equal to the total measurement bias, the implicit policy objective would be to stabilize the true cost of living. This policy would also maintain the "value of money" if value were defined as the level of utility that can be obtained with one unit of money. Since all biases are estimated relative to the true cost-of-living index, a consistent application of the value-of-money approach would include all types of bias in the definition of the inflation target.

The implications of the new-goods bias may be somewhat different from other biases when the signal extraction problem is considered. The introduction of a new good results in an implicit decline in relative price as the price of the new product (or brand) falls below its reservation level. If the inflation target is equal to the total measurement bias, the policy seeks to stabilize the price level for all goods that exist in the current period, with the prices of goods that existed in the previous period rising at a rate sufficient to offset the implicit price decline for the new goods. If agents are able to distinguish more accurately between relative and absolute price movements when there is stability in a price index that includes new goods, the assumed inflation target will maintain the value of money and also alleviate the signal extraction problem. However, if the generalized price increases for goods that existed in the previous period make it more difficult for agents to identify relative price movements, there could be a case for excluding the new-goods bias from the definition of the inflation target. In that case the general price level would be stabilized for only those goods that existed in the previous period, and the true cost of living would decline.

In practice, any trade-off between the value-of-money and signal extraction criteria may be insignificant. If the new-goods bias is small, the inflation target that stabilizes the value of money will be very close to the target that stabilizes the price level of goods existing in the previous period.

Conclusions

Given that the Bank of Canada's inflation-control objectives are established on the basis of the consumer price index (CPI), it is useful to examine some of the characteristics of this measure of prices.

Our analysis shows, first, that there is a high degree of similarity between short-term and long-term variations in the CPI and changes in the other measures (the GDP deflator and unit labour costs). Our results suggest that this similarity is due to the relatively close relationship between the various price measures. For example, some of the evidence indicates that changes in the GDP deflator can often lead changes in the CPI, while the latter will frequently affect wage changes and, therefore, changes in unit labour costs. All things considered, the CPI is probably a representative measure that can be used in the definition of an inflation rate target. However, it must be recognized that inflation rates may diverge, sometimes considerably. For this reason, it is important that the monetary authorities continue paying close attention to the behaviour of the various price measures and the relationships between them, as they do now, for example, in the *Monetary Policy Report*.

On the assumption that the CPI is a representative index of prices in the economy, we focus on two specific questions concerning the measure of consumer price trends. The first is whether the inflation measure used by the Bank of Canada—the rate of change in the CPI excluding food, energy, and the effects of indirect taxes (CPIXFET)—is a good measure of core inflation. That does seem to be the case, since this measure generally tracks the new statistical measures that eliminate or attenuate the effects of CPI components showing the greatest fluctuation each month. However, we think it is important to monitor the behaviour of the new measures of core inflation against the Bank's official indicator, since we do not know what the "true" measure of core inflation is. Finally, since the tests show that some measures seem to contain specific information on the *future* behaviour of core inflation and overall inflation, it seems important to pursue research into their usefulness for the conduct of monetary policy.

The second question we examine regarding the trend of consumer prices deals with the positive measurement bias in the CPI inflation rate. If the goal of monetary policy is to preserve the value of money, then the inflation-control target should allow for an average annual increase in the CPI equal to the estimated total measurement bias. (The operational measure of price stability should also reflect the other factors discussed in various papers in this volume.) Setting the inflation target is a little less certain when we consider the difficulty that economic agents may have in distinguishing between relative and absolute price movements of new and existing goods. However, given the small size of the new-goods bias, there is probably little practical difference between an inflation target that satisfies the criterion of maintaining the value of money and one that takes account of the possible difficulties in signal extraction.

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