Evaluating Measures of Core Inflation

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- *The Bank of Canada's inflation-control target is expressed in terms of total consumer price index (CPI) inflation, but because movements in the CPI are frequently caused by transitory fluctuations in prices, the Bank uses a measure of core inflation as an operational guide to the underlying trend of inflation.*
- *When the inflation targets were renewed in 2001, the Bank adopted a new measure of core inflation, CPIX, to replace CPI excluding food and energy. This measure excludes eight of the most volatile components of the CPI and adjusts the remaining components for the effect of changes in indirect taxes.*
- *Recent research conducted at the Bank shows that CPIX still has advantages over the alternatives. However, it remains an imperfect measure of underlying inflation. Other measures of core inflation, in particular CPIW, which down-weights (rather than excluding) volatile components, provide valuable additional information about trend inflation.*
- *The Bank will therefore retain CPIX as its official measure of core inflation, but will continue to closely monitor the other measures.*

At the centre of the Bank of Canada's monetary policy is the inflation-control target, currently the 2 per cent midpoint of a 1 to 3 per cent range. The target is set in terms of the 12-month rate of increase in the total consumer price index (CPI), the most commonly used indicator of inflation in the Canadian economy. Since the CPI measures the prices of consumer goods and services, it is the most relevant estimate of the cost of living of Canadians. As well, the CPI is the price index that is most familiar to the general public, is available monthly, is published in a timely fashion, and is never revised.

Since inflation targeting was adopted in 1991, the Bank has chosen, for reasons discussed below, to focus on a measure of core inflation as a shorter-term operational guide for monetary policy. When the inflation-control targets were renewed in 2001, the Bank moved to a new measure of core inflation, CPIX, which it had been monitoring for some time. As Macklem (2001, 5) notes, "While no single measure outperformed the others across all dimensions in all periods, CPIX possessed some advantages over the alternatives."

In this article, we review the experience with the Bank's current measure of core inflation, specifically, whether the criteria used to select it in 2001 still favour the measure today. We begin by discussing the relevance of measures of core inflation to the conduct of monetary policy and then describe the measures the Bank is currently monitoring. This is followed by a re-evaluation of the various measures, using an updated sample period. Their performances are compared on the basis of empirical criteria, including volatility, absence of bias vis-à-vis total inflation, and the ability to predict future inflation. Practical criteria, such as timeliness and credibility, are also reported on. The article concludes that CPIX still satisfies all criteria. No other

measures significantly outperform it, and it has the advantage of being familiar to the public.

Some Background on the Use of a Core Inflation Measure

Core inflation has proved useful in the conduct of monetary policy in a number of ways. First, core inflation is a better indicator of current underlying inflationary pressures than total CPI. Total CPI can be misleading, since certain components of the index can be volatile as a result of temporary shocks. Short-run movements in inflation caused by these temporary shocks or the initial effect of changes in indirect taxes tend to reverse themselves fairly quickly. Given that the effect of monetary policy builds up gradually, it would be neither feasible nor desirable for monetary policy to counter such temporary movements. In fact, attempting to do so would increase economic volatility. The core inflation measure is useful because it excludes the components that are most subject to temporary supply shocks or relative price changes.

Second, to the extent that core inflation isolates the underlying trend to which total inflation will return, it provides a useful short-term operational guide for the conduct of monetary policy. Given the lags in the effects of interest rate changes on output and inflation, monetary policy must be forward looking. Thus, policy decisions today are based on what inflation is expected to be 18 to 24 months in the future. Projections of future total CPI inflation are based on a range of information, but core inflation is one relatively simple indicator that is straightforward to measure on a timely basis.

Over longer periods, the total CPI and core measures of the CPI that exclude components with short-run volatility have tended to move in a very similar fashion. As long as core and total inflation share a common long-term trend over a roughly two-year horizon, focusing on core inflation is consistent with targeting total inflation. The Bank targets total inflation in order to meet its objective of providing an environment with low, stable, and predictable inflation, one that helps households make the best consumption decisions. It therefore sets the inflation target in terms of the year-over-year rate of change in total CPI (i.e., total inflation), which is the best available estimate of the cost of living for Canadian households. Focusing on core inflation does not mean that the Bank is not concerned about inflation in the components excluded from this measure (e.g. fruit, vegetables, or gasoline), which represent a significant proportion of the consumer basket. Core inflation is simply a convenient guide to help the Bank achieve its objective of controlling total inflation.

Finally, core inflation has also proven useful for communicating monetary policy to the public. Analyzing and comparing the evolution of both core and total inflation in the *Monetary Policy Report* help the general public to better understand and assess the monetary policy decisions of the Bank.

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The first measure of core inflation, which the Bank adopted in 1991, was the 12-month rate of change in CPIXFET, defined as the CPI excluding food, energy, and the effect of changes in indirect taxes. When the inflation targets were renewed for the third time, in May 2001, the Bank chose CPIX as its operational guide for policy because it demonstrated both theoretical and statistical advantages over CPIXFET (see Box 1). Specifically, CPIX excludes eight of the most volatile components of the CPI and the effect of changes in indirect taxes on the remaining components.[1] It is worth noting that these eight components represent a smaller proportion of the consumer basket than the 12 food and energy components excluded from CPIXFET.

There is no unique definition of core inflation and no way to measure it directly. Although CPIX was chosen over other possible measures, it remains an imperfect estimate of underlying trend inflation. For this reason, the Bank regularly conducts research on core inflation measures and closely monitors several measures that have proven useful.

Alternative Measures of Core Inflation Monitored by the Bank

In addition to its official measure of core inflation, the Bank carefully follows the development of other measures of underlying inflation, including CPIW, a "double-weighted" measure. Instead of excluding the

1. The eight components are fruit, vegetables, gasoline, fuel oil, natural gas, intercity transportation, tobacco, and mortgage-interest costs.

Box 1:
Theoretical Foundations for Excluding the Eight Components from CPIX

The Bank's measure of core inflation, CPIX, excludes only two food components,[1] fruit and vegetables, which are frequently affected by weather-related disturbances to crops. CPIXFET excludes all the food components, including meat, fish, dairy products, bakery products, other food products, and food purchased from restaurants, which are not as often exposed to temporary shocks and, hence, are not very volatile.

Among the energy components, which are all excluded from CPIXFET, three are excluded from CPIX: gasoline, natural gas, and fuel oil. Prices of these components are clearly influenced by the world price of oil, which is very volatile and is determined on foreign markets. Electricity prices were not excluded from CPIX, because they were not particularly affected by supply shocks and, hence, were not very volatile over the sample period (January 1986 to July 2001).

1. This discussion is taken from Macklem (2001, 8-9).

Three volatile components included in CPIXFET were excluded from CPIX: intercity transportation, tobacco products, and mortgage-interest costs. Intercity transportation includes airfares, which are significantly influenced by oil prices. Prices of tobacco products vary substantially with changes in excise taxes, which are clearly temporary shocks.[2]

Mortgage-interest costs are a unique case. They are excluded from core inflation because a rise in interest rates from monetary policy actions aimed at reducing inflation would raise mortgage-interest costs, adding temporarily to inflation. This would send the wrong signal about the underlying short-run trend of inflation. Many other central banks exclude this component from their core measure for the same reason.

2. The core measure is adjusted to take into account the effect of changes in indirect taxes. However, the tax adjustment is only an approximation. Excluding tobacco products avoids the need to frequently adjust tobacco prices for the effect of changes in indirect taxes and, hence, avoids the approximation.

most volatile components from the total price index, as CPIX does, CPIW reduces their influence by assigning to each of the 54 components a weight inversely proportional to its variability.[2] This weight is defined as the reciprocal of the standard deviation of the change in relative prices.[3] In other words, the more volatile the relative price of a component, the lower its weight. The second weight, by which the first is multiplied, is the original weight in the CPI basket, which represents the importance of the component in consumer spending. Some empirical tests have shown that CPIW is among the most informative measures of core inflation (Laflèche 1997; Hogan, Johnson, and Laflèche 2001). This is the principal reason why the Bank monitors CPIW closely and mentions it regularly in its *Monetary Policy Report*.

2. At the most detailed level, the CPI consists of 264 components. We combined some components, however, in order to obtain historical series that all start on the same date and do not change over time. The statistical core inflation measures are therefore constructed using historical series for 54 components of the CPI, which all begin in 1986. For more detail, see Hogan, Johnson, and Laflèche (2001).

3. The change in relative prices is measured by the difference between the change in the price of a component and the inflation rate as measured by the total CPI.

Two other measures are also regularly monitored by the Bank: MEANSTD and WMEDIAN. These measures are "order statistics," calculated using the cross-sectional distribution of the year-over-year changes in the prices of the 54 components of the CPI.[4] To understand these measures, the annual inflation rate—the year-over-year change in total CPI—must be seen as the weighted average of the year-over-year change in each of its components.

WMEDIAN is the weighted median of the monthly distribution of the year-over-year changes in the prices of the 54 components of the CPI. This weighted median is the value that separates the ordered distribution into two parts, with the sum of the weights of each part being equal to 50 per cent. No component is excluded from this measure. WMEDIAN may vary considerably with the change in the shape of the distribution: If the distribution is very asymmetrical, WMEDIAN will diverge considerably from the mean, that is, from total inflation.

4. The measures are called order statistics because they are calculated using an ordered distribution. For simple numerical examples of these statistical measures, see Laflèche (1997, 34).

MEANSTD excludes price components whose rate of increase or decrease exceeds 1.5 standard deviations from the average. Once these components are eliminated, the weighted average of the year-over-year changes in the prices of the remaining components is calculated to obtain the core measure. Components whose year-over-year change is among the lowest or the highest, and hence, at the extremities of the distribution, are thereby eliminated. An important characteristic of this measure is that the components excluded differ from one month to the next.

The main difference between CPIX and the other measures of core inflation described above is that no component is systematically excluded from the other measures. This difference has both advantages and disadvantages. In systematically excluding specific components, there is a risk of either losing pertinent information about inflationary pressures and the underlying trend of inflation or inappropriately continuing to include a price following a change in its behaviour. There is no such problem with order-statistics measures, which have the additional advantage of being able to capture the effect of unusual one-time changes in components that are typically not volatile. It is harder, however, to explain changes over time in order statistics than in exclusion-based measures such as CPIX. Doing so requires keeping track of the components that are excluded every month (with MEANSTD) and determining which components are responsible for the variation of the weighted median (with WMEDIAN).

When all the measures convey the same message, it is reasonable to assume that the Bank has a relatively good estimation of underlying inflationary pressures.

As noted above, although CPIX was chosen as the official core inflation measure because it had some advantages over the other measures, it remains an imperfect estimate of the underlying trend of inflation. To evaluate this trend, the Bank therefore relies on several measures of underlying inflation in the conduct of monetary policy. When all the measures convey the same message, it is reasonable to assume that the Bank has a relatively good estimation of underlying inflationary pressures. When the measures diverge, however, there is more uncertainty about the trend, requiring a close examination of the reasons for the disparity.

The following example is a good illustration. From May 2001 to October 2002, CPIX remained well inside the target bands, close to the 2 per cent inflation-control target. Between November 2002 and March 2003, however, it fluctuated around the upper band of the target. While CPIX and CPIW both increased substantially during this period, MEANSTD and WMEDIAN did not. The volatility evident in CPIX and CPIW, and the rise in both measures, was driven mainly by the behaviour of electricity prices and auto insurance premiums. Because these two components had suddenly become more volatile, they were excluded from MEANSTD during that period (remember that the components excluded from this order statistic change from one month to the next, depending on their volatility). The other order statistic, WMEDIAN, also remained well inside the target band during this period. After this upward trend between November 2002 and March 2003, core inflation dropped rapidly, to 2.1 per cent, in April 2003. It is clear that CPIX and CPIW overestimated the underlying trend of inflation during this period, since the rise in inflation was not reflecting demand pressures, but large relative price movements in electricity and auto insurance premiums. The order statistics, however, because of their ability to remove the effects of temporary movements in components that are not usually volatile, were better indicators of the underlying trend of inflation over this period.

Following this period of volatility in the prices of electricity and auto insurance premiums, two new exclusion-based measures, CPIX9 and CPIX10, were added on an experimental basis to the set of measures of underlying inflation monitored by the Bank. CPIX9 excludes the same components as CPIX, as well as electricity prices, while CPIX10 further excludes auto insurance premiums.

Evaluating the Measures of Core Inflation

Despite the widespread use of core inflation by central banks, there is no unique concept or measure of core inflation. However, all the measures described above are based on the concept that total inflation can be separated into two components: the core part, representing the underlying trend of inflation as shaped by the pressure of aggregate demand against capacity,

and the non-core part, which reflects price movements caused by temporary shocks or relative price changes. The empirical criteria used to evaluate our core measures are derived from this concept.

The first criterion is the volatility of a component, reflecting the underlying notion that a component subject to temporary shocks is more volatile than one that is not. To meet this criterion, it is necessary to determine which CPI components are the most volatile and whether the source of their volatility reflects temporary shocks or relative price changes.

The second criterion for evaluating potential core measures is the volatility of the measures themselves. If core inflation actually represents the underlying trend in inflation, one would expect it to be more stable than total inflation. By definition, the measures that exclude or reduce the influence of the most volatile CPI components will be less volatile than total inflation. Comparing the volatility of the various core measures, however, helps to determine which ones exclude the right components (i.e., those most often influenced by temporary shocks or large relative price changes) and, hence, which measure is the best estimate of the underlying trend of inflation.

The third empirical criterion is the absence of bias between the core measures and total inflation. This criterion is backward looking: We verify whether, over time, the measures and total inflation followed the same trend or diverged. A significant divergence between the two measures indicates that they do not share the same long-term trend and contradicts the basic notion that core inflation represents the underlying trend of inflation.

The fourth criterion—the ability of a core measure to predict total inflation—is also derived from the fact that core inflation represents the underlying trend of inflation. In the short run, total inflation can diverge temporarily from its trend, but it should, by definition, return to it in the long term. The empirical tests assess the hypothesis that divergences between total inflation and the core measures are temporary. It is expected that core measures contain more information about the future trend of inflation than the latest 12-month increase in total CPI. If this was not the case, core measures would not be useful guides in the conduct of monetary policy.

These empirical criteria are time sensitive. The volatility of the CPI components and of the core measures is calculated over a specific time period and may therefore change over time. A component that was excluded because it was highly volatile over a specific time period may have recently become less volatile, while a component that was not very volatile over the same period may have since become more volatile and be excluded. As well, assessments of the bias and the predictive power of the core measures may yield different results over different time periods. When the inflation-control target was renewed in 2001, these criteria favoured CPIX. Recent research conducted at the Bank shows that CPIX continues to have some advantages over the other measures of core inflation. Empirical results drawn from Armour (2006) and supporting these conclusions are described below.

The central bank must take into account some practical criteria related to the timeliness of the core measures and their understanding and acceptance by the general public.

In addition to the empirical criteria, the central bank must take into account some practical criteria related to the timeliness of the core measures and their understanding and acceptance by the general public. These criteria are discussed at the end of this section.

Component volatility

Component volatility figured prominently in the 2001 move from CPIXFET to CPIX as the Bank's measure of core inflation. CPIX not only had stronger statistical support than CPIXFET (the eight components excluded from it were all very volatile, which was not the case for all of the 12 components excluded from CPIXFET), but also had better theoretical foundations, as explained in detail in Box 1.

Because volatility is time sensitive, it is necessary to periodically re-evaluate whether the eight components excluded from core inflation remain among the most volatile and whether the volatility of other components has increased enough to justify their exclusion. The statistical criteria used to determine the components to be excluded from CPIX are the standard deviation and the frequency of exclusion from MEANSTD (i.e., components whose rate of change, in absolute value, exceeded 1.5 standard deviations from the mean). For this study, we revisited the 2001 computa-

Table 1

Standard Deviation of the 12-Month Change in Selected Components of the CPI

Sample: February 1991 to December 2005

Rank	Component	Standard deviation
1	Fuel oil and other fuel	16.9
2	Natural gas	16.0
3	Tobacco products and supplies	12.0
4	Gasoline	11.1
5	Vegetables and vegetable preparations	8.1
6	**Other auto operating expenses**[1]	5.6
7	Intercity transportation	5.3
8	Fruit, fruit preparations, and nuts	4.9
12	**Electricity**	4.2
13	Homeowners' insurance premiums	4.0
14	Mortgage-interest costs	3.9
15	Meat	3.2
22	Fish and other seafood	2.5
23	Other food products	2.5
36	Bakery and other cereal products	1.7
39	Dairy products and eggs	1.6
53	Food purchased from restaurants	0.8

Note: The components Electricity, Meat, Fish and other seafood, Other food products, Bakery and other cereal products, Dairy products and eggs, and Food purchased from restaurants are excluded from CPIXFET, but not from CPIX.

1. Includes automobile insurance premiums

Table 2

Frequency of Exclusion from MEANSTD of Selected Components of the CPI

Sample: February 1991 to December 2005

Rank	Component	Exclusion from MEANSTD (%)
1	Fuel oil and other fuel	56
2	Natural gas	55
3	Gasoline	49
4	Vegetables and vegetable preparations	40
5	Education	40
6	Tobacco products and supplies	37
7	Intercity transportation	34
8	Recreational equipment and services	33
9	Mortgage-interest costs	26
10	**Other auto operating expenses**[1]	22
11	Lease and rental of autos	20
12	Fruit, fruit preparations, and nuts	19
18	Fish and other seafood	7
19	**Electricity**	7
23	Other food products	5
33	Meat	2
40	Dairy products and eggs	0
41	Bakery and other cereal products	0
42	Food purchased from restaurants	0

Note: The components Electricity, Meat, Fish and other seafood, Other food products, Bakery and other cereal products, Dairy products and eggs, and Food purchased from restaurants are excluded from CPIXFET, but not from CPIX.

1. Includes auto insurance premiums

tions, including data only from the inflation-targeting period ending in December 2005, and found few changes in the results.[5] The eight components excluded from CPIX remain among the most volatile, based on their standard deviations and their frequency of exclusion from MEANSTD (see Tables 1 and 2).

The volatility of some components has nonetheless changed. Of the seven components excluded from CPIXFET but not from CPIX, only electricity has become more volatile. Of the three components excluded from CPIX but not from CPIXFET, mortgage-interest costs have become less volatile, likely owing to the conduct of monetary policy under a credible, constant inflation target. In fact, longer-term interest rates have been quite stable over the past several years. In addition to components excluded from either core inflation or CPIXFET, auto insurance premiums (the largest part of the "Other auto operating expenses" component) have exhibited more volatility.[6]

Based on their volatility, electricity prices and auto insurance premiums have become potential candidates for exclusion.

Based on their volatility, electricity prices and auto insurance premiums have become potential candidates

5. In Macklem (2001), the volatility was calculated over the period January 1986 to July 2001. An important shift is observable, however, in the mean of the inflation rate between the pre-inflation-targeting period (January 1986 to January 1991) and the inflation-targeting period (February 1991 to December 2005). To avoid the bias that this shift could create, the statistics cited in this article are calculated over the inflation-targeting period only.

6. It is worth noting that some components, such as Education and Recreational equipment and services, are among the most volatile in terms of their frequency of exclusion from MEANSTD. These components are not, however, considered very volatile on the basis of their standard deviation over the sample period.

for exclusion. It is important, however, to carefully examine the source of their volatility before deciding to remove them from the measure of core inflation. Box 2, below, reviews the advantages and disadvantages of excluding electricity prices and auto insurance premiums.

Volatility in core measures

In addition to the volatility of the components of the CPI, we considered the volatility of the overall measures. If core inflation measures properly capture trend

Box 2: Electricity Prices and Auto Insurance Premiums

When constructing exclusion-based measures of core inflation, volatility alone is insufficient to justify the exclusion of a component; there must also be some support from economic theory. The two recent shocks to electricity prices and auto insurance premiums illustrate this point.

When CPIX was created, the price of electricity had been quite stable for many years. Since then, however, changes in the Alberta and Ontario electricity markets have made the price of electricity more volatile. In Ontario, temporary deregulation followed by an electricity shortage and an exceptionally warm summer pushed the price up in 2002, and the provincial government's refund pushed it down in 2003. Electricity prices have since returned to a more stable path. Tables 1 and 2 provide evidence of this volatility: Electricity ranks relatively high both in terms of its standard deviation and its frequency of exclusion from MEANSTD. As well, Table 3 shows that CPIX9 has lower volatility than CPIX.

For now, electricity prices are still regulated in Ontario and Alberta, and we do not know what will happen in the other provinces. Deregulating electricity prices may well result in increased volatility, so that excluding electricity prices would be justified. The timing of the exclusion is problematic, however, given the difficulty in differentiating between volatility and trend movements that could occur during the transition to a deregulated market. CPIX9 could become biased relative to total CPI over the transition period.

Between January 2002 and January 2003, automotive vehicle insurance premiums rose by 30 per cent. The most plausible explanation for this trend is a combination of rising claim costs and the bursting of the technological bubble in 2001, which meant that rising claims were no longer offset by solid investment returns for insurance companies. Subsequently, many provinces imposed price reductions on insurance companies, and auto insurance premiums reverted to a more stable path. Again, Tables 1 and 2 show the effects of these unusual price movements. The category "Other auto operating expenses" (of which auto insurance premiums are the main component) ranks high in terms of both its standard deviation and its exclusion from MEANSTD. Furthermore, as shown in Table 3, CPIX10 has lower volatility than CPIX or CPIX9 and is biased relative to total CPI over this period. This suggests that instead of characterizing auto insurance price movements, which are seldom reversed, as volatile they could be characterized as subject to infrequent persistent shifts in their trend.

While the specific combination of events that caused the dramatic premium increases may be a one-time or rare event, this component may nevertheless be subject to similar price movements because of the way insurers adjust their premiums.[1] Given that the regulatory process is not expected to change, the kind of surges in auto insurance premiums sometimes observed in the past may recur. Since trend movements in these prices would not be related to current demand pressures, excluding auto insurance premiums has some theoretical justification.[2] However, the issue of bias relative to total CPI would likely remain.

Overall, it does not seem appropriate at this time to exclude the price of electricity and auto insurance premiums from the official core measure. However, since a recurrence of the types of events that led to large changes in these prices is likely, it is important for the Bank to continue to monitor CPIX9 and CPIX10 closely.

1. Insurers must convince the government that their costs have increased significantly. The process is long, and a substantial cumulative cost increase is required before the government will allow insurers to raise their premiums.

2. A similar argument can be made for regulated prices more generally.

Table 3

Summary Statistics for Core Inflation Measures

Sample: February 1991 to December 2005

	Mean	Standard deviation	Coefficient of variation	Mean absolute change
CPIXT	1.90	0.86	0.45	0.29
CPIX	1.87	0.48	0.26	0.16
CPIXFET	1.77	0.66	0.37	0.17
CPIW	1.86	0.59	0.32	0.14
WMEDIAN	1.71	0.59	0.34	0.22
MEANSTD	1.76	0.60	0.34	0.23
CPIX9	1.84	0.46	0.25	0.15
CPIX10	1.71	0.39	0.22	0.14

inflation, they should be less volatile than total CPI inflation.

One way to examine the volatility of a series is the dispersion around its sample mean. Table 3 reports the standard deviation and coefficient of variation for each measure.[7] For the inflation-targeting period, all traditional measures have coefficients of variation substantially lower than that of total inflation excluding the effects of changes in indirect taxes (CPIXT), with CPIX having the lowest value.[8] Both CPIX9 and CPIX10 have even lower volatility than CPIX, pointing to the importance of the recent movements in electricity prices and auto insurance premiums.

To examine the robustness of the above results, Table 3 also reports the mean of the absolute monthly change in year-over-year inflation. This alternative measure of volatility depends less directly on the persistence of inflation. Based on this measure, CPIX, CPIXFET, and CPIW are much less volatile than total inflation, with variability about half that of CPIXT. CPIW has the lowest value of these three core measures. CPIX9 and CPIX10 are also less volatile than CPIX, with CPIX10 matching CPIW. WMEDIAN and MEANSTD are the most volatile measures. Actually, the order-statistics measures exhibit the largest volatility, no matter how it is measured.

7. The coefficient of variation is the standard deviation divided by the mean. If the means of these series are similar, the ranking of the coefficient of variation should not be much different from that of the standard deviation. However, given some evidence in the literature that the variance of inflation increases with the mean, the coefficient of variation may be a more appropriate measure than the standard deviation.

8. All of the inflation rates of the components used to build up the cross-sectional measures have been adjusted only for the effects of the 1991 Goods and Services Tax and the 1994 tobacco tax, the two largest indirect tax effects. However, other changes in indirect taxes that generate large swings in relative prices are eliminated or down-weighted, depending on the construction of each measure. Therefore, CPIXT is a better benchmark than CPI.

Absence of bias

Core inflation and total inflation must share the same long-term trend to ensure consistency between the short-term operational measure and the inflation target. Core inflation should be unbiased relative to total inflation. An absence of bias supports the claim that only short-term shocks are excluded from the core inflation measure.

A simple way to identify bias is to compare the unconditional means of the various core measures with that of CPIXT. Table 3 shows that the means of CPIXT, CPIX, CPIW, and CPIX9 all fall within the same range. The means of CPIXFET and MEANSTD are slightly lower than the others, but the differences are not statistically significant. CPIX10 and WMEDIAN have the lowest means, and they are statistically significantly different from the mean of CPIXT, indicating a bias relative to total CPI inflation. This is not surprising for CPIX10, given the surge in auto insurance premiums in 2002–03. In the case of WMEDIAN, this result indicates that the distribution of the year-over-year changes in the 54 CPI components is often asymmetrical. All the other measures, including CPIX, have followed the same trend as total inflation over the past 14 years.

Predictive power

If core inflation represents the underlying trend of inflation, it should contain more information about the future trend of inflation than total inflation itself. Moreover, it is expected that divergences between total inflation and core inflation will be temporary, i.e. total inflation may diverge from core inflation in the short run, but comes back to it in the long run.

A common way to test the hypothesis that divergences between total inflation and core inflation are only temporary is to estimate the following equations:

$$(\pi_{t+h} - \pi_t) = \alpha + \beta(\pi_t^{Core} - \pi_t) + u_t, \qquad (1)$$

$$(\pi_{t+h}^{Core} - \pi_t^{Core}) = a + B(\pi_t - \pi_t^{Core}) + v_t, \qquad (2)$$

where $\pi_{t+h} - \pi_t$ is the change in total inflation, $\pi_{t+h}^{Core} - \pi_t^{Core}$ is the change in core inflation, u_t and v_t are random error terms, and h is the time horizon.[9] The idea behind these equations is that if core inflation is above total inflation, total CPI must have been hit by a specific shock that will be reversed.

9. These are Cogley's (2002) equations, which were estimated in Macklem (2001).

Table 4

Regressions: $(\pi_{t+12} - \pi_t) = \alpha + \beta(\pi_t^{Core} - \pi_t) + u_t$

Estimation period: January 1992 to December 2005

CPIXT	$\bar{R}^2$	α (s.e.)	β (s.e.)	p-value H_0: (β = 1, α = 0)
CPIX	0.30	0.05	0.96*	0.97
		(0.22)	*(0.39)*	
CPIXFET	0.31	0.21	1.09*	0.48
		(0.19)	*(0.34)*	
CPIW	0.44	0.14	1.32*	0.46
		(0.20)	*(0.39)*	
WMEDIAN	0.37	0.31	1.03*	0.22
		(0.18)	*(0.32)*	
MEANSTD	0.32	0.23	1.03*	0.45
		(0.19)	*(0.31)*	
CPIX9	0.27	0.06	0.95*	0.96
		(0.22)	*(0.41)*	
CPIX10	0.38	0.22	1.08*	0.56
		(0.21)	*(0.31)*	

Note: Standard errors (s.e.) are corrected for serial correlation.
* Indicates significance at 95 per cent level

Table 5

Regressions: $(\pi_{t+12}^{Core} - \pi_t^{Core}) = a + B(\pi_t - \pi_t^{Core}) + v_t$

Estimation period: January 1992 to December 2005

CPIXT	$\bar{R}^2$	a (s.e.)	B (s.e.)
CPIX	–0.01	–0.01	0.00
		(0.10)	*(0.22)*
CPIXFET	0.01	–0.01	0.13
		(0.12)	*(0.18)*
CPIW	0.04	0.00	0.19
		(0.08)	*(0.21)*
WMEDIAN	0.02	0.00	–0.13
		(0.07)	*(0.19)*
MEANSTD	0.00	0.02	–0.07
		(0.06)	*(0.17)*
CPIX9	0.00	–0.01	0.05
		(0.10)	*(0.25)*
CPIX10	0.00	0.01	0.01
		(0.05)	*(0.17)*

Note: Standard errors (s.e.) are corrected for serial correlation.

Total CPI inflation should therefore be expected to increase in the future ($\beta > 0$), but core inflation should be unaffected ($B = 0$). If the restriction $\alpha = 0$ and $\beta = 1$ holds, equation (1) collapses to: $\pi_{t+h} = \pi_t^{Core} + u_t$. In that case, core inflation is an unbiased predictor of total inflation.

Tables 4 and 5 show the results for the 12-month horizon. It is not possible to reject the joint hypothesis $\beta = 1$ and $\alpha = 0$ with 95 per cent confidence for any of the core measures considered; nor is it possible to reject the hypothesis that ($B = 0$), suggesting that all the core measures are unbiased predictors of total inflation. This also means that deviations between core and total inflation are not persistent and that total inflation moves towards core rather than vice versa. This confirms the hypothesis that the core inflation measures are better than total inflation itself in forecasting future total inflation.

Desirable measures of core inflation should be relatively smooth and down-weight or exclude components with transitory, highly volatile fluctuations. Moreover, if the measure is a good estimate of core inflation, the coefficient β should be positive and close to one. Both of these features tend to raise the $\bar{R}^2$.[10] According to this criterion, CPIW, the regression that obtains the highest $\bar{R}^2$, has the best overall performance among the alternative measures of core inflation (see Table 4).

In summary, these results show that all of the measures of core inflation are unbiased predictors of total inflation and contain more information about the future trend of inflation than total inflation itself. Moreover, CPIW has the best overall performance of all the core measures.

Practical criteria

Central banks must consider certain practical criteria when choosing their core measures. First, core measures must be timely: It is important for policy-makers to have data readily available. The core inflation measures monitored by the Bank can all be calculated the day inflation data are released by Statistics Canada.

Second, core measures should ideally not be revised. Most economic variables are periodically revised, causing some problems for monetary policy decisions or communication, but these variables are not closely tied to an explicit policy target. Revisions of the core measures would reduce their usefulness both as decision-making and communication tools. Among the set of core measures monitored by the Bank, only CPIW is subject to revision. One of the weights of this double-weighted measure is defined as the reciprocal of the standard deviation of the change in relative prices. Since the standard deviation being calculated over a specific time period would change with the time period selected, so would the weight. However, as reported

10. In equation (1), the $\bar{R}^2$ provides a measure of the predictive ability of the *difference* between core and total inflation to predict the *change* in total inflation. The $\bar{R}^2$ is positively related to β and to the ratio of the variance of the component of total inflation *not explained by the core measure* to the variance of the change in total inflation.

in Armour (2006), the extension of the period on which the CPIW weights are calculated did not lead to significant historical revisions of the CPIW time series. Moreover, this problem is not insurmountable: the weights could be updated every few years (e.g., every four years) and the new series linked to the old one in order not to change the history.

Credibility is the third practical criterion. To be credible, a core measure must be understood and accepted by the public. A very sophisticated measure would be more difficult to explain and, hence, probably less acceptable. Exclusion-based measures such as CPIX and CPIXFET are the most easy to understand. The order-statistics measures, WMEDIAN and MEANSTD, require some statistical knowledge to be understood, since they are more technically sophisticated than the exclusion-based measures. Moreover, because their movements are not as easy to explain as those of CPIX and CPIXFET, they are only used internally. The double-weighted measure, CPIW, is also more difficult to understand than CPIX. However, although it seems at first to be very complicated, its concept is actually quite simple. The difficulty lies in the calculation of the special weight, which is based on the volatility of the component. Despite its sophistication, the double-weighted measure has been published on a regular basis in the *Monetary Policy Report*.

Summary of Results and Conclusion

Although there has been some reshuffling among components in the volatility rankings, the eight components excluded from CPIX remain among the most volatile over the inflation-targeting period. Two other components, electricity prices and auto insurance premiums, had periods of increased volatility over the past five years. These prices have recently returned to a more stable path, but the events that caused their volatility could recur. For now, their exclusion would be premature, but the Bank will continue to monitor the core measures that exclude them, CPIX9 and CPIX10.

All our measures of core inflation continue to satisfy the empirical criteria. They are unbiased, have lower volatility than total CPI inflation, and contain information about the future trend of total inflation.

Because of their simplicity, exclusion-based measures are well understood and accepted by the public. Their evolution compared with that of total CPI is easy to explain, which helps the Bank to communicate its monetary policy decisions. Order-statistics measures and their movements are less accessible to the general public. The double-weighted measure, CPIW, is also more sophisticated than CPIX and, in addition, is subject to revisions.

The general conclusion is that CPIX still satisfies all of the empirical and practical criteria. No core measure significantly outperforms it. Moreover, CPIX is familiar to the public and well accepted.

Although there has been some reshuffling among components in the volatility rankings, the eight components excluded from CPIX remain among the most volatile over the inflation-targeting period.

Although the double-weighted measure, CPIW, is more sophisticated than the official core measure, it does slightly better than the other core inflation measures on purely statistical grounds. Therefore, it seems to us that among the alternative measures, CPIW merits closer study.

All the core measures contain information on the underlying trend in inflation and are particularly useful for identifying the source and nature of persistent but temporary shocks that affect inflation and push it away from the target. Although the Bank will retain CPIX as its official measure of core inflation, it will continue to monitor the other measures closely. It will also continue to report CPIW in the *Monetary Policy Report*. Research will also be conducted regularly to ensure that the Bank has the most reliable estimate of the underlying trend in inflation.

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