A New Measure of Core Inflation

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- *While the Bank of Canada's inflation-control target is specified in terms of the rate of increase in the total consumer price index, operationally, the Bank uses a measure of trend or "core" inflation as a short-term guide for its monetary policy actions.*
- *When the inflation targets were renewed in May 2001, the Bank of Canada announced that it was adopting a new measure of core inflation. This new measure—previously known as CPIX—excludes the eight most volatile components of the CPI and adjusts the remaining components for the effects of indirect taxes.*
- *The new measure of core inflation has a firmer statistical basis, a better correspondence with economic theory, and does a better job of predicting future changes in overall inflation.*
- *While the new measure of core inflation has some advantages over the old one, the Bank of Canada will continue to monitor the old measure of core inflation, as well as a broad range of indicators of price pressures, when assessing the underlying trend in inflation and the likely future path for inflation.*

Since Canada's adoption of an inflation-control target in February 1991, the target range has been specified in terms of the 12-month rate of change in the total consumer price index (CPI). The original announcement also indicated that the Bank would use a measure of trend or "core" inflation as a shorter-term operational guide in its formulation of monetary policy. Core inflation came to be defined as the 12-month rate of increase in the CPI excluding food, energy, and the effects of changes in indirect taxes (CPIXFET).

The conduct of monetary policy focuses on core inflation for several reasons. Some of the goods and services included in the total CPI have very volatile prices whose movements typically reverse themselves relatively quickly. Since it takes about a year before monetary policy actions even begin to significantly affect inflation (with most of the impact occurring in six to eight quarters), responding to these short-run fluctuations would be inappropriate, since the response is not necessary to keep future inflation on target and has the potential to be a source of volatility in both real economic activity and inflation itself.

The focus on core inflation as an operational guide is consistent with targeting the total CPI because, over longer periods of time, the rates of increase in the total CPI and core measures such as the CPIXFET have tended to move in a very similar fashion and are likely to continue to do so in the future. Hence, achieving the target rate of increase for the core CPI will tend to bring about a similar rate of increase in the total CPI over time. The Bank has also indicated that if the longer-run trends in core inflation and the rate of increase in the total CPI were expected to diverge, the desired path for core inflation would be adjusted so that the expected trend in total CPI inflation was centred on the midpoint of the inflation-control range. In

this sense, total CPI inflation remains the target, but core inflation guides policy actions to keep total CPI inflation on target.

Another reason for the focus on core inflation is to see through the first-round effects of changes in indirect taxes (such as sales and excise taxes). The first-round effect of a change in an indirect tax is an increase in the price level that is proportional to the tax increase. This raises inflation temporarily, but once the price level has reached its new level, the rate of increase in the price level (i.e., inflation) is unaffected. Given the discrete and temporary nature of the impact on inflation of these first-round effects, the Bank has indicated that it would accommodate these, but that it would not accommodate the second-round effects that could arise if the initial price change related to the change in indirect taxes began feeding into expectations of future inflation, wages, and the prices of other goods and services (Bank of Canada 1991). Because core inflation excludes the first-round effects of changes in indirect taxes, it provides a way to operationalize and to communicate the Bank's policy of seeing through or accommodating these first-round effects of changes in indirect taxes.

Core inflation also tends to be a better indicator of future inflation developments than total CPI inflation. Because it takes about a year before monetary actions have any significant effect on inflation, successfully targeting inflation requires the Bank of Canada to look ahead to what inflation is likely to be in one to two years. Core inflation is helpful for looking through short-run factors and focusing on the underlying trend that is likely to persist into the future.

In practice, there are various ways to measure the underlying trend in inflation, and academics and researchers at central banks in a number of countries have proposed a number of alternatives.[1] Hence, while the Bank has used CPIXFET as its measure of core inflation, it continued to explore other measures of trend inflation for Canada (see Laflèche 1997a, 1997b; Crawford, Fillion, and Laflèche 1998; Hogan, Johnson, and Laflèche 2001). Starting in November 1997, the Bank also began regularly publishing two of these alternative measures in its *Monetary Policy Report*. The decision to publish these two alternatives—known as CPIX and CPIW—reflected the fact that they both provided additional insight into inflation developments and trends, particularly when examined in relation to CPIXFET.

Both CPIX and CPIXFET are based on removing certain volatile components from the total CPI basket. CPIX differs from CPIXFET in that the components excluded from the CPI to form CPIX are not exactly the same as those excluded to form CPIXFET (although there is considerable overlap). CPIW includes all the components in the total CPI but adjusts the weight of each component in the CPI basket by a factor that is inversely proportional to the component's variability. Hence, the more volatile components get smaller weights in CPIW than in the total CPI.

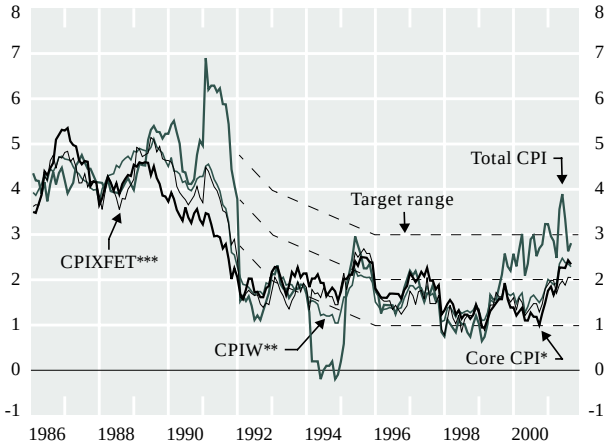
As Chart 1 illustrates, all three measures of trend inflation—CPIXFET, CPIX, and CPIW— have moved in a similar fashion through time. This is true both before a low rate of inflation was achieved (1981–91) and after (1992–2001). This conclusion is reinforced by the relatively high contemporary correlations between these three measures as reported in Table 1.

At the same time, Chart 1 also reveals that the behaviour of these three measures of trend inflation, while

Chart 1

Measures of the Inflation Rate

Year-over-year percentage change



* Core CPI excludes the eight most volatile components from the CPI as well as the effect of changes in indirect taxes on the remaining components.

** CPIW adjusts each CPI basket weight by a factor that is inversely proportional to the component's variability.

*** CPIXFET excludes food and energy and adjusts the remaining components to remove the effect of changes in indirect taxes.

1. See, for example, Bryan and Cecchetti (1993), Blix (1995), Roger (1995, 1998), Cutler (2001), and Clark (2001).

Table 1

Contemporaneous Correlation between Alternative Measures of Trend Inflation

Correlation	Jan. 1981 to Jan. 1991	Feb. 1992 to July 2001
(CPIXFET, CPIX)*	0.71	0.81
(CPIXFET, CPIW)	0.83	0.70
(CPIX, CPIW)	0.63	0.71

* Inflation in various indexes is defined as the 12-month rate of change of the index.

similar, is not identical. In particular, during certain periods, the three measures have taken different paths through time. Thus, as more experience was gained with low inflation, these (and other) measures of trend inflation continued to be monitored, assessed, and evaluated. The Bank concluded that while no single measure outperformed the others across all dimensions in all periods, overall, CPIX possessed some advantages over the alternatives. As a result, the Bank of Canada decided to adopt CPIX as its measure of core inflation, replacing CPIXFET. This was announced as part of a package of refinements to inflation targeting when the inflation targets were renewed in May 2001 (Bank of Canada 2001).

This new core measure has both statistical and theoretical advantages. In brief, its use puts the measurement of core inflation on a firmer statistical foundation, and the components it excludes correspond more closely to the types of components that should be excluded on the basis of economic theory. At the same time, CPIXFET and CPIW continue to contain useful information. Thus, the Bank will continue to monitor and publish CPIXFET and CPIW as alternative measures of underlying or trend inflation.

The remainder of this article examines the new measure of core inflation in more detail, first defining it more precisely, and then examining its advantages.

What Is the Bank's New Core CPI Measure?

There are 182 goods and services in the CPI. As discussed in more detail in Laflèche (1997a, 1997b) and Hogan, Johnson, and Laflèche (2001), these goods and services can be grouped into 54 components for which data are available on a comparable basis back to 1986 for all 54 components and back to 1979 for most components. These components are themselves subindexes for categories of goods and services such as "bakery and other cereal products," "food purchased from restaurants," "paper, plastic, and foil supplies," and "home entertainment equipment and services."

The new core CPI measure (hereafter simply "core CPI") excludes the eight most volatile of these 54 components from the total CPI and then adjusts the remaining components to remove the effect of changes in indirect taxes.[2] The eight components excluded are fruit, vegetables, gasoline, fuel oil, natural gas, intercity transportation, tobacco, and mortgage-interest costs.[3]

The new core CPI measure . . . excludes the eight most volatile of these 54 components from the total CPI and then adjusts the remaining components to remove the effect of changes in indirect taxes.

As shown in Table 2, five of the eight components excluded from core CPI are also excluded from CPIXFET. Specifically, both exclude fruit, vegetables, gasoline, natural gas, and fuel oil. The difference between core CPI and CPIXFET is that the former does not exclude all the food and energy components in the total CPI but does exclude three components outside the food and energy baskets. Whereas the only food items that core CPI excludes are fruit and vegetables, which make up 2.7 per cent of the total CPI, CPIXFET excludes six other food components, which make up a further 16.2 per cent of the total CPI basket. With respect to energy, the only difference between core CPI and CPIXFET is the treatment of electricity—it is included in the former but not in the latter. Excluding considerably less of the food basket in the total CPI

2. The indirect tax adjustment follows the method explained in the September 1991 issue of the *Bank of Canada Review*. This tax adjustment is applied to the CPI excluding the eight most volatile components as published by Statistics Canada. The Bank of Canada publishes this tax effect on its Web site (www.bankofcanada.ca) on the afternoon prior to Statistics Canada's release of the CPI. An hour after Statistics Canada publishes the CPI, the Bank provides its latest figures for core CPI inflation on its Web site.

3. The components "fruit," "vegetables," and "tobacco" are short forms for "fruit, fruit preparations, and nuts," "vegetables and vegetable preparations," and "tobacco products and smokers' supplies," respectively.

Table 2

Components Excluded from Core CPI and CPIXFET

Component	Weight in total CPI		Standard deviation*	Percentage of time more than 1.5 standard deviations from mean*
	Excluded from CPIX	Excluded from CPIXFET		
Fruit (fruit, fruit preparations, and nuts)	1.40	1.40	5.18	25
Vegetables (vegetables and vegetable preparations)	1.25	1.25	9.14	45
Gasoline	3.93	3.93	10.60	51
Natural gas	1.02	1.02	11.81	53
Fuel oil and other fuel	0.58	0.58	15.46	52
Mortgage-interest cost	4.91		5.56	28
Intercity transportation	1.00		8.60	47
Tobacco (tobacco products and smokers' supplies)	1.66		15.13	30
Meat		2.90	3.86	2
Fish and other seafood		0.41	3.40	13
Dairy products and eggs		2.08	1.50	0
Bakery and other cereal products		2.04	1.84	0
Other food products		2.82	2.63	5
Food purchased from restaurants		4.98	2.45	0
Electricity		2.65	3.72	2
Total	15.75	26.06	-	-

* January 1986 to July 2001

and a little less of the energy basket raises the proportion of the total CPI basket covered by core CPI relative to CPIXFET. This broader coverage is partly offset by the three components that are excluded from core CPI but not from CPIXFET—these are mortgage-interest costs, intercity transportation, and tobacco, which together make up 7.6 per cent of the total CPI basket. The net effect is that core CPI now includes 84 per cent of the total CPI basket compared with the 74 per cent covered by CPIXFET.

The broader coverage of core CPI is an advantage for two reasons. First, other things being equal, the larger the proportion of the total basket covered by the measure of core inflation, the more likely it is that core inflation and total CPI inflation will share the same underlying trend. Second, public acceptance of the use of a measure of core inflation as an operational guide for monetary policy is likely to be enhanced if the core measure covers a broader range of the expenditures made by households.

A Firmer Statistical Foundation

The construction of the new measure of core inflation is based on the statistical properties of the 54 components of the CPI. The price change for each component is defined as the 12-month percentage change in its price. From the 54 percentage price changes, it is possible to construct, at each point in time, the cross-sectional sample distribution of price changes. The mean of this distribution is simply the average price change across the 54 subindexes. The distribution of price changes provides a simple way to position the price change in each component relative to the mean price change. When this is repeated for each period through time, it becomes readily apparent that the changes in most of these subindexes are typically relatively close to the mean price change, or, to say the same thing, they are near the centre of the distribution of price changes. It is also apparent that a relatively small number of other subindexes are frequently a long way from the mean price change; that is, they are frequently in the tails of the distribution of price changes.

Core CPI measures underlying inflation by excluding components that are frequently in the tails of the cross-sectional distribution of price changes. To be more specific, the components excluded from the CPI were found to be in the 10 per cent tails of the cross-sectional distribution (that is, the 10 per cent of the distribution that is furthest from the mean) more than 50 per cent of the time. An alternative, and very similar, description is that the eight components excluded were more than 1.5 standard deviations from the mean of the cross-sectional distribution at least 25 per cent of the time.

Table 2 illustrates the statistical motivation for core CPI. The table lists 15 components of the total CPI, the weight of each component in the total CPI, the standard deviation of the 12-month rate of change of the price subindex, and the percentage of time this rate of change is more than 1.5 standard deviations from the mean of the cross-sectional distribution of price changes at each point in time. The first eight components listed are the eight excluded from the total CPI to form the core CPI. The percentage of the time that these components are more than 1.5 standard deviations from the mean of the cross-sectional distribution ranges from 25 per cent for fruit to 53 per cent for natural gas. These components are also the most volatile through time, as indicated by the standard deviations (shown here in Table 2) or the standard deviations of their price movements relative to core inflation (not shown).

The next seven components in the table are components that are excluded from CPIXFET but not from core CPI. The standard deviations of these components are considerably lower, as is the percentage of time that these components are more than 1.5 standard deviations from the mean of the cross-sectional distribution. Indeed, three of the components are never more than 1.5 standard deviations from the mean of the distribution over this sample period—dairy products and eggs, bakery and other cereal products, and food purchased from restaurants. This indicates that, from a statistical perspective, there is no good reason to exclude these components from the measure of core inflation.

Note also that the three components excluded from core CPI but not from CPIXFET—mortgage-interest costs, intercity transportation, and tobacco—are all considerably more volatile than the seven components excluded only from CPIXFET. This points out another advantage of the core CPI. By using clear statistical criteria, core CPI excludes only genuinely volatile components, while at the same time ensuring that all volatile components are, indeed, excluded. In this respect, core CPI is more complete in what it excludes, while at the same time pursuing a minimalist approach to exclusions.

There is always a risk that the components that have had the most volatile prices over the historical sample will not be the same in the future. In updating earlier work by Laflèche (1997a), Hogan, Johnson, and Laflèche (2001) provide some assurance that the volatility observed in the eight components excluded from core CPI is not particularly sensitive to the time period. In particular, they find that when the historical sample is restricted to include only data over the inflation-targeting period (post-1991), the means and the standard deviations of most of the components fall dramatically relative to the earlier data, but the same eight components remain among the most volatile group.

Nonetheless, we cannot rule out the possibility that changes in market structure or regulation will affect the behaviour of some of the price subindexes and could potentially change the membership of the high-volatility group. Hence, continuing research and analysis is required to periodically reassess the volatility of the components of the CPI and to understand the implications for the measurement of underlying inflation. Of course, the possibility that relationships will change over time poses a challenge for almost any measure of core inflation. The statistical basis for the new measure of core CPI at least makes the identification of such change more straightforward. It is not the Bank's intention, however, to make changes in the definition of core inflation without clear evidence of a significant change in the behaviour of the component prices as well as compelling arguments based on economic theory. In particular, the Bank does not intend to change the definition of core inflation over the five-year period covered by the new agreement between the Bank and the government on the inflation-control target.

Better Correspondence with Theory

The expectations-augmented Phillips curve of Friedman (1968) and Phelps (1969) provides a useful theoretical framework within which to explain movements in inflation. The framework suggests that underlying inflation depends on expectations of inflation and on a measure of the level of economic activity relative to a sustainable level of output that can be maintained with all resources being fully utilized but without the emergence of shortages and production bottlenecks. This sustainable level of output is called potential output. In the short run, inflation is also affected by relative price changes and by temporary supply shocks. If the relationship linking these various influences is assumed to be linear, this gives rise to an equation of the following general form:

$$\pi = \pi^e + \lambda y + \delta q + \varepsilon ,$$

where π is inflation, π^e is expected inflation, y is the output gap (which is the percentage difference between actual output and the economy's potential output), q captures changes in key relative prices such as the relative price of oil, ε is an unexplained disturbance term that is typically interpreted as reflecting temporary supply shocks, and λ and δ are positive coefficients.

Because not all prices are perfectly flexible in the short run, an increase in the price of one very important good, such as oil, will typically not be immediately offset by small declines in all other prices and, hence, the overall price level will rise. This will show up as an increase in the rate of change of the price level—measured inflation. Provided the relative price change does not affect expected inflation or the output gap, this effect on inflation will be temporary, since once the price level has adjusted, its rate of change (i.e.,

inflation) is no longer affected. In the event that the relative price change is ongoing for a long time, other prices will eventually adjust to offset it, so the effect on inflation will not be ongoing. Similarly, provided temporary supply shocks (as captured by ε) do not affect expected inflation or the output gap, their effect on inflation will be very short-lived. Once the temporary supply disturbance goes away, so does the effect on inflation.

[A] direct approach to measuring core inflation is to exclude components of the aggregate price index that are likely to be the source of important relative-price movements and supply disturbances.

Since temporary supply disturbances and relative price shocks affect inflation only in the short run, underlying or core inflation can be described by the first part of the Phillips curve equation: $\pi^e + \lambda y$. This raises the possibility that core inflation could be measured by estimating a Phillips curve and using the estimated value of the parameter λ, together with observations on expected inflation and the output gap, to separate inflation into its core and non-core parts. In practice, however, this is complicated by the fact that both expected inflation and the output gap are not directly observable and must themselves be estimated. An alternative and more direct approach to measuring core inflation is to exclude components of the aggregate price index that are likely to be the source of important relative-price movements and supply disturbances. Indeed, this was part of the reasoning behind the Bank's original measure of core inflation—the CPI excluding food, energy, and the effect of changes in indirect taxes.[4]

Certain types of food and energy are both subject to significant temporary supply shocks. In the former case, they result from the vagaries of the weather, and in the latter, from the supply decisions of the OPEC cartel. Changes in indirect taxes are a type of supply shock—they affect the price level permanently but inflation only temporarily.

At the same time, it is also clear that not all food components are likely to be affected by weather-related supply disturbances to the same degree. For fruit and vegetables, the effect is clearly important, but the impact on the cost of restaurant meals is likely to be very small, since other costs, such as labour and rent, are important inputs into restaurant meals. An attractive feature of core CPI is that the components that are excluded on the basis of their volatility are exactly those that are most likely to be significantly affected by temporary supply shocks. In particular, in the food category, core CPI excludes only fruit and vegetables. The link between the theoretical case for excluding fruit and vegetables and the statistical case is that fruit and vegetable prices are statistically very volatile precisely because they are heavily influenced by weather-driven supply shocks that are typically quickly reversed.

Similarly, gasoline, fuel oil, and natural gas are all removed from core CPI because supply shocks result in considerable volatility in the prices for these goods.[5] The world price of oil, which is significantly influenced in the short run by the supply decisions of the OPEC cartel, has an important influence on total CPI inflation, since the price of oil directly affects consumer prices for gasoline and heating oil and indirectly affects the prices of other energy sources, such as natural gas. Supply shocks that affect oil prices also typically have a significant influence on airfares and, hence, on the price index for intercity transportation. When combined with frequent seat sales, the result is that the price index for intercity transportation is very volatile, and it is therefore removed from core CPI. Removing intercity transportation from the measure of core inflation also has the advantage of reducing the first-round effects of energy-price shocks on core inflation. This is useful since the Bank is prepared to accommodate the first-round effects but not the second-round effects.

It should also be noted that electricity prices are not excluded from core CPI. This reflects the fact that, unlike the prices of gasoline, fuel oil, and natural gas, the price of electricity has not been particularly affected by temporary supply shocks, and as a result,

4. Another consideration was that the CPI excluding food and energy was already well-known, having been in common use since the mid-1970s.

5. Note that the weights given to fuel oil and natural gas in the CPI reflect direct purchases. Hence, removing these components from core inflation excludes only such direct purchases. It does not exclude energy costs that are part of the rent or shelter components of the CPI.

its price has been considerably less volatile than the prices of these other forms of energy (Table 2). As the market for electricity is privatized or becomes less regulated in some provinces, the price of electricity could become more closely related to the prices of other forms of energy, in which case its price may become more volatile. The extent to which this happens, however, will depend on the how supply shocks to other types of energy affect the demand for electricity and how electricity is priced in a market where there may be contracts of various types. These issues will require ongoing scrutiny as the market structure for electricity evolves.

Tobacco prices are significantly influenced by changes in excise taxes, which constitute the clearest example of a supply shock. It is, therefore, appropriate to remove tobacco from the measure of core inflation. An alternative would be to include tobacco but to adjust tobacco prices for the effects of indirect taxes (as was done with the old measure of core—CPIXFET). If the tax adjustment was very precise, this approach would be preferable. In practice, however, the tax adjustment involves some approximations, and changes in the excise taxes on tobacco products are both relatively frequent and large. Thus, the approximations are both larger and more frequent for this component. Removing tobacco from core CPI avoids the need to frequently adjust tobacco prices for the effect of changes in indirect taxes and, hence, avoids the associated approximations.[6] Excluding those tobacco products from core inflation also removes the effects of supply shocks on the pre-tax tobacco price that result from changes in the government policies that affect tobacco companies.

Finally, core CPI also removes mortgage-interest costs. This is attractive from a theoretical perspective, since the Bank's policy instrument—the target overnight rate of interest—has a very direct effect on mortgage rates at shorter maturities, and this gives a misleading signal of the future trend in inflation. For example, a rise in the target for the overnight rate will tend to boost mortgage-interest costs, resulting in a rise in inflation in the very short run. But looking beyond this horizon, the higher interest rates will dampen spending and thus reduce inflationary pressures. Excluding mortgage-interest costs removes this perverse and transitory effect of monetary policy on inflation, making it easier to identify the trend in inflation. For this reason, most major inflation-targeting central banks exclude mortgage-interest costs from either their targeted measure of inflation or their measure of underlying inflation. These include the Bank of England, the Reserve Bank of New Zealand, the Swedish Riksbank, and the Reserve Bank of Australia.

A Better Predictor of Future Inflation

The discussion of the economic theory underlying the concept of core inflation has been based on the presumption that a clear distinction can be made between a relative price change that is not related to a change in the output gap or inflation expectations, and one that is. Given that the output gap and inflation expectations are not directly observable, this distinction, while logically correct, can be difficult to make in practice. As Laidler and Aba (2000) have recently stressed, while changes in relative prices do not cause inflation, such changes may be indicative of changes in the economy's ability to produce goods and services relative to their demand (the output gap) or may be a catalyst for changes in inflation expectations, and both these factors can affect inflation. Hence, while an increase in a key relative price does not itself cause higher inflation, it may indicate inflationary pressures that, if ignored, will result in higher inflation (see also Parkin 1984).

This argument cannot be dismissed. There is uncertainty associated with measures of the output gap and inflation expectations, and, in practice, relative-price movements may themselves be symptoms of changes in the output gap or in inflation expectations that are not easy to detect. In this setting, using a measure of inflation that excludes volatile components as an operational guide to monetary policy actions could be counterproductive. Suppose, for example, that some prices are simply more flexible than others and, hence, tend to move more quickly in response to changes in aggregate demand relative to supply. Excluding the most volatile prices could remove precisely those prices that provide the best signal of the future path for inflation.

These arguments highlight two critical points. First, core inflation cannot be used as an indicator of future inflation to the exclusion of other indicators. To be effective, monetary policy must consider a variety of measures of the degree of slack in several markets,

6. The tax adjustment assumes that the full impact of the tax on the final consumer price of tobacco products is immediate. In practice, however, the full impact is sometimes spread over more than one month, so the tax adjustment is only approximate in the short run. Moreover, even in the long run, the pre-tax price may be affected to a small degree by the price change.

such as labour markets, goods markets, and real estate markets, as well as alternative measures of inflation expectations. Moreover, information relevant to these fundamental factors, including financial indicators and the information in the movements of prices themselves, must also be taken into account.

Core inflation cannot be used as an indicator of future inflation to the exclusion of other indicators.

Second, whether measured core inflation does in fact capture the underlying trend in inflation is ultimately an empirical question. The fact that the core CPI is now on a firmer statistical foundation and the fact that the most volatile prices are precisely those for which temporary supply shocks are likely to be particularly important both provide reassurance that measured core inflation does exclude transitory factors while retaining trend elements. Nevertheless, in the end, the usefulness of core inflation as an operational guide for monetary policy will depend on how well it isolates the underlying trend in inflation.

If measured core inflation does capture inflation's underlying trend, it should be helpful in predicting future inflation. In particular, if the measure of underlying inflation does capture the underlying trend, then deviations between underlying and total inflation should be reversed in the future, with total inflation coming back to underlying inflation. There are a number of ways to evaluate the predictive content of measures of underlying inflation. A particularly simple approach is to estimate the following regression suggested by Cogley (1998):

$$\pi^T_{t+j} - \pi^T_t = a + b\left(\pi^U_t - \pi^T_t\right) + \mu_t, \qquad (1)$$

where π^T_t is the rate of inflation in the total index, π^U_t is the rate of underlying inflation, a and b are coefficients to be estimated, and μ_t captures the unexplained or residual variation. The left-hand side, or dependent variable, is the change in the rate of inflation in the total index. If measured underlying inflation captures the trend in inflation, then when underlying inflation is currently above total inflation (i.e., $\pi^U_t - \pi^T_t > 0$), the rate of inflation in the total index should tend to rise in the future ($\pi^T_{t+j} - \pi^T_t$ should go up), in which case, parameter b will be positive. More specifically, if the difference between measured underlying inflation and total inflation ($\pi^U_t - \pi^T_t$) captures the transitory component of inflation, then b should be close to unity.

Table 3 reports estimation results for equation (1) for two measures of underlying inflation—core CPI and CPIXFET. The total index is the total CPI adjusted for the effects of indirect taxes. The adjustment for indirect taxes puts both the explanatory and dependent variables on the same tax-adjusted basis. This makes the test more demanding, since the temporary effect of changes in indirect taxes on the 12-month rate of change in the total CPI is largely a matter of arithmetic.[7] The index j is set to 18 months, so the dependent variable is the change in inflation over the next 18 months. The assumption is that transitory fluctuations in inflation are those that last less than 18 months.[8] Results are reported for two estimation periods. The first estimation period is from 1986 to January 2000,

Table 3

Underlying Inflation as a Predictor of Future Total Inflation

$\pi^T_{t+18} - \pi^T_t = a + b\left(\pi^U_t - \pi^T_t\right) + \mu_t$

Coefficient	Measure of underlying inflation			
	π^{core}	$\pi^{CPIXFET}$	π^{core}	$\pi^{CPIXFET}$
a	-0.33 (-3.79)*	-0.31 (-3.18)	-0.11 (-1.13)	-0.01 (-0.09)
b	1.06 (8.67)	1.04 (5.81)	1.06 (5.76)	0.80 (3.14)
$\bar{R}^2$	0.31	0.16	0.23	0.08
Estimation period	January 1986 to January 2000	January 1986 to January 2000	February 1991 to January 2000	February 1991 to January 2000

* Bracketed terms are *t*-statistics.

7. Results are similar using the change in the total CPI as the dependent variable, but, as expected, the explanatory power of the regressions is higher and the difference in the results between using the new core or CPIXFET as the measure of underlying inflation is smaller. This arises because an important part of the variation in the dependent variable is due to changes in indirect taxes that drop out of the 12-month rate of change of the total index almost automatically after one year.

8. As a practical matter, the results are affected very little if j is set to 12, so transitory fluctuations are those that last less than one year.

which corresponds to the period over which a detailed tax adjustment is available for the relevant price indexes.[9] The second estimation period starts several years later in 1991 to correspond to the inflation-targeting period.[10]

Three results in Table 3 stand out. First, the parameter b is positive and statistically different from zero for both measures of underlying inflation over both sample periods. Thus, when underlying inflation is above total inflation, total inflation tends to rise in the future. Second, for both measures of underlying inflation, the parameter b is estimated to be close to unity, suggesting that both measures of underlying inflation are removing transitory components of inflation. Third, while both measures of underlying inflation are useful in predicting future total inflation, the new measure of core inflation outperforms CPIXFET. The $\bar{R}^2$ statistic reported in Table 3 measures the proportion of the variation of the dependent variable that is explained by the explanatory variable. As reported, the $\bar{R}^2$ for regressions using the core CPI is about 30 per cent, compared with about half that for CPIXFET. So both measures of underlying inflation have explanatory power for the future path of total inflation, but the new measure offers some improvement.

Finally, as a check on these results, equation (1) can also be run in "reverse" to see if the difference between underlying and total inflation can predict the future course of underlying inflation. As suggested above, if some prices are simply more flexible than others and, hence, tend to move more quickly in response to changes in aggregate demand, excluding the most volatile prices could eliminate the prices that are the best predictors of future inflation. If this is the case, then the trend in inflation will be better measured by total inflation itself, and deviations between measured underlying inflation and total CPI inflation will be resolved with measured underlying inflation adjusting back towards total CPI inflation. This can be tested with the regression

$$\pi^U_{t+18} - \pi^U_t = \alpha + \beta\left(\pi^T_t - \pi^U_t\right) + \vartheta_t . \qquad (2)$$

If measured underlying inflation tends to adjust back to total inflation, then β will be positive and statistically different from zero. As shown in Table 4, over both estimation samples and for both the new core and CPIXFET, β is negative and statistically indistinguishable from zero, and the explanatory power of the regressions is very low (as measured by the very low $\bar{R}^2$s). Hence, it does not appear that underlying inflation, as measured by either the new core or CPIXFET, adjusts back towards the total index.

Table 4

Total Inflation as a Predictor of Future Underlying Inflation

$\pi^U_{t+18} - \pi^U_t = \alpha + \beta\left(\pi^T_t - \pi^U_t\right) + \vartheta_t$

Coefficient	Measure of underlying inflation			
	π^{core}	$\pi^{CPIXFET}$	π^{core}	$\pi^{CPIXFET}$
α	-0.37 (-6.99)*	-0.32 (-4.27)	-0.19 (-3.65)	-0.19 (-2.43)
β	-0.18 (-2.49)	-0.13 (-0.94)	-0.29 (-3.19)	-0.02 (-0.12)
$\bar{R}^2$	0.03	0.00	0.08	-0.01
Estimation period	January 1986 to January 2000	January 1986 to January 2000	February 1991 to January 2000	February 1991 to January 2000

* Bracketed terms are *t*-statistics.

Conclusion

In summary, while the objective of monetary policy is to control the rate of total CPI inflation, there are good theoretical reasons to use a concept of core inflation as an operational guide for monetary policy as well as a good empirical basis to do so. The Bank's new measure of core inflation has a firmer statistical basis, a better correspondence with economic theory, and an improved empirical performance. As such, it provides a better guide for monetary policy. Nevertheless, core inflation is not a substitute for careful analysis of the information in a wide range of indicators, including

9. With j set to 18, the last observation of the dependent variable is the change in inflation between January 2000 and July 2001.

10. The effect of relative-price shocks on overall inflation depends to an important degree on the monetary regime in place. In the 1970s, the misinterpretation of shocks to productivity growth and the supply of labour resulted in monetary policy inadvertently validating the temporary increases in total CPI inflation associated with the large positive oil-price shock. As a result, total CPI inflation led an increase in narrower measures of inflation that exclude the food and energy components. With the advent of inflation targets, the Bank has been very clear that it will not accommodate the second-round effects of relative-price shocks on other prices. In this setting, core inflation can be expected to provide a leading indicator of overall inflation.

prices themselves. Because it takes at least a year for monetary actions to significantly affect inflation, to be effective, monetary policy must look ahead to what inflation is likely to be a year to two years into the future. Core CPI inflation is an important indicator, but other factors, such as the state of demand relative to supply in a range of markets, inflation expectations, and financial conditions all affect the future course of inflation. Successfully targeting the rate of increase in the total CPI requires a thorough consideration of all these factors.

Literature Cited

Bank of Canada. 1991. "Targets For Reducing Inflation: Further Operational and Measurement Considerations." *Bank of Canada Review* (September): 3–23

———. 2001. "Bank Releases Background Information on Renewal of the Inflation-Control Target." *Bank of Canada Review* (Summer): 58.

Blix, M. 1995. "Underlying Inflation—A Common Trends Approach." Sveriges Riksbank Working Paper No. 23.

Bryan, M.F. and S.G. Cecchetti. 1993. "Measuring Core Inflation." NBER Working Paper No. 4303. National Bureau of Economic Research, Cambridge, Mass.

Clark, T. 2001. "Comparing Measures of Core Inflation." *Federal Reserve Bank of Kansas City Economic Review* 86 (2): 5–31.

Cogley, T. 1998. "A Simple Adaptive Measure of Core Inflation." Federal Reserve Bank of San Francisco Working Paper No. 98-06.

Crawford, A., J.-F. Fillion, and T. Laflèche. 1998. "Is the CPI a Suitable Measure for Defining Price Stability?" In *Price Stability, Inflation Targets, and Monetary Policy*, 39–73. Proceedings of a conference held by the Bank of Canada, May 1997.

Cutler, J. 2001. "Core Inflation in the U.K." External MPC Unit Discussion Paper No. 3, March. London: Bank of England.

Friedman. M. 1968. "The Role of Monetary Policy." *The American Economic Review* 58 (March): 1–17.

Hogan, S., M. Johnson, and T. Laflèche. 2001. "*Core Inflation*," Bank of Canada Technical Report No. 89 (January).

Laflèche, T. 1997a. "Mesures du taux d'inflation tendanciel." Bank of Canada Working Paper No. 97–9.

———. 1997b. "Statistical Measures of the Trend Rate of Inflation." *Bank of Canada Review* (Autumn): 29–47.

Laidler D. and S. Aba. 2000. "It's Time to Ignore Core Inflation." *Backgrounder.* C.D. Howe Institute (November 1).

Parkin, M. 1984. "On *Core Inflation* by Otto Eckstein." *Journal of Monetary Economics* 14: 251–64.

Phelps, E.S. 1969. "The New Microeconomics in Inflation and Employment Theory." *The American Economic Review* 59 (May): 147–60.

Roger, S. 1995. "Measures of Underlying Inflation in New Zealand, 1981–95." Reserve Bank of New Zealand Discussion Paper No. G95/5.

———. 1998. "Core Inflation: Concepts, Uses and Measurement." Reserve Bank of New Zealand Discussion Paper No. G98/10.