Core Inflation: A measure of inflation for policy purposes

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1. Introduction

Monetary authorities generally seek to preserve the value of money and therefore to maintain a low rate of inflation. This is most evident in the communications of countries which have inflation targets, such as Australia, Canada, New Zealand, Sweden, and the United Kingdom. This focus on inflation raises several practical concerns including issues related to the accurate measurement of inflation.

In the context of particular economic models, inflation is a straightforward concept representing the rate of change in prices. Models are usually limited to a few markets at most and, correspondingly, to a few prices. In addition, shocks of any type are controlled events with effects readily distinguishable from the base-case dynamics of the model. In the context of implementing monetary policy, however, the conceptual definition of the inflation about which the monetary authority should be concerned is an open question, while the question of how to measure it, which can be thought of as putting the concept into practice, is just as difficult.

To implement policy, practitioners must take a stand on which inflation rate matters for policy. Many inflation-targeting countries, including Canada, have announced the inflation targets in terms of the growth in the consumer price index (CPI). CPI inflation approximates increases in the cost of living, and it is the final cost of consumer goods and services that matters for many contracts. This is important since the success of inflation targeting works largely through anchoring the inflation expectations which will be incorporated into decisions and contracts. The CPI directly affects both businesses and consumers. However, the CPI may not be the best measure of inflation on which to focus for policy purposes. Generally, policy makers focus on the more persistent movements in prices. Measures of the general underlying trend in inflation have been coined *core inflation*.

To better understand the motivation for research on core inflation, we introduce the notion of core inflation and its potential policy purposes. This provides some insight into the attributes of a useful measure of core inflation and what basis might be used to evaluate its success. To put the various measures of core inflation in some context, we discuss two broad approaches that have been used to measure core inflation: the statistical approach which focuses on exploiting the properties of the data, and the modelling approach, which draws on a conceptual notion of core inflation. We then introduce Canadian inflation measures in this context. To date, Canadian measures of core inflation are based on research using the first approach. This paper offers a preliminary evaluation of the measures of core inflation at the Bank of Canada. Most of the measures do seem to track the persistent movements in inflation. However, it is difficult to discriminate among them as they are quite similar in many respects. As a whole they provide useful information on the evolution of inflation.

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The paper proceeds as follows. Section 2 introduces the notion of core inflation while Section 3 outlines its policy purposes. Section 4 reviews the two main approaches to the measurement of core inflation in the literature. This is followed in Section 5 by a discussion of research on core inflation at the Bank of Canada. Several measures of underlying inflation are currently in use at the Bank of Canada and Section 6 contains some evaluation of these core measures. Section 7 concludes.

2. The notion of core inflation

Monetary authorities are not concerned with every fluctuation in prices. Rather, they focus on the underlying trend. Core inflation corresponds notionally to that general trend in inflation.

One way of defining core inflation is in the context of the quantity theory of money where the general trend in inflation corresponds to the inflation that arises as a result of a monetary disturbance. As quoted in Bryan and Pike (1991), Friedman (1969) noted that there are usually two different explanations of price movements.

> "One, common to all disturbances, is that the price movements reflect changes in the quantity of money... The other explanation has been in terms of some special circumstances of the particular occasion: good or bad harvests; disruptions in international trade; and so on in great variety."

To the extent that these special circumstances are the source of shifts in relative prices, the corresponding price movements will represent transitory fluctuations in the inflation rate. Their temporary nature suggests that they would not be of primary interest to policy makers. Moreover, these price changes will not become permanently incorporated into the underlying inflation process unless there is a change in the stance of monetary policy that accommodates any change in inflation expectations resulting from the shock.[1] For policy purposes, therefore, monetary authorities focus on the persistent trends in inflation. Measures of core inflation are used to capture these trends. As such, core inflation may be considered a measure of the inflation which is the outcome of policy.

Focusing on a measure of inflation which excludes short- to medium-run fluctuations is based on the idea that they represent changes in prices that are not of direct concern to policy makers and to which policy should not react. There are two main types of these fluctuations.

First, there will be fluctuations in prices to which the monetary authority will not wish to react simply because they are likely, by their volatile nature, to be quickly reversed on their own. Seasonality, the infrequent survey of particular prices, the timing of particular price changes, and other events may introduce noise into published price indexes.[2] Core inflation measures attempt to abstract from this noise.

Second, there will be other short-term fluctuations which represent price shocks arising from sources beyond the control of the monetary authority. These price shocks will be idiosyncratic to the markets

1. This is the spirit of the Bank of Canada's original inflation target announcements. It was stressed that "only the first-round effects on the CPI of short-run movements in food and energy prices and substantial changes in indirect tax changes would be accommodated, not any second-round or ongoing effects on the rate of inflation." *Bank of Canada Review*, September 1991, page 1.
2. There may be bias or noise in published inflation rates. Research on bias, where the methodology used to generate the price index creates persistent measurement problems, is critical though distinct from the research on core inflation and is not dealt with in this paper. (See Crawford et al. (1998) for a detailed discussion of bias in the CPI.)

where they originated and can be thought of as shifts in relative prices. Examples include: changes in supply, such as a crop failure, which might generate large changes in the relative price of a particular good or service, changes in taste which might also lead to a change in demand for a particular product and hence a sharp change in its relative price, or specific events such as changes in indirect taxes. One-time shifts in the level of the real exchange rate due to non-monetary sources could also lead to shifts in relative prices.

Since policy instruments have only a generalized and indirect effect on inflation, affecting it through a complex transmission mechanism, policy instruments are not well suited to reversing specific price changes originating in particular markets. Hence, policy makers focus on measures of inflation which abstract from these shifts in prices.

Until the 1990s, core inflation remained essentially a term for CPI inflation excluding food and energy in many countries. Recent experience with inflation targeting has motivated further research on core inflation. Policy is now tightly linked to published inflation rates. Measures of core inflation attempt to extract from published inflation rates the inflation that is of direct interest to policy makers. As a practical matter, this is done by decomposing published inflation into its persistent and transitory components. This may be achieved by specifying a theoretical model of core inflation and attempting to directly measure this inflation. Alternatively, a core measure can be derived by eliminating, to the extent possible, the price shocks that can be identified as being either noise, or as arising from a source that is somehow exogenous to the process influenced by monetary policy. In effect, the ongoing interest in core inflation reflects its usefulness as a tool for policy. A measure of core inflation would be both a better guide for current and future policy than published inflation rates and also represents the inflation that is most controllable.

3. Policy purposes of a core measure

To further understand why core inflation might be a useful tool for policy makers, we begin with a discussion of its policy purposes. Ideally, core inflation would be:

- *a good indicator of current and future trends in inflation;*
- *a good measure of inflation for empirical work; or*
- *a viable target for monetary policy.*

It may be that a core measure would suit one or all of these needs.

• *A good indicator of current and future trends in inflation*

Monetary authorities closely monitor all available data on the current state of the economy and the current inflation rate. This ensures that the most up-to-date information is incorporated into policy decisions. However, policy decisions are based on the more persistent movements in inflation. Core measures assist in the analysis of new developments by providing a means by which the monetary authority can separate the noise and short-run fluctuations in the data from its more persistent trend.

Considering that monetary policy affects inflation with long and variable lags, central banks are more concerned with the future evolution of inflation than with its current level. Recent data on inflation may represent one of the best sources of information about its future movements. When new data are available, core inflation measures extract the signal in the new data. The most useful measures of core inflation will minimize misleading signals about the future trend in inflation.

As an indicator, core inflation is a guide to policy makers as to whether current policy settings are likely to achieve the target. Policy makers may respond to the indicator at their discretion or they may take a less discretionary approach and incorporate the indicator into a policy rule. For example, Taylor rules use the current deviation of inflation from its target as a guide for policy.

By allowing policy makers to see through temporary or misleading fluctuations, core inflation can be a useful tool to assess the effectiveness of policy. It may even be a public measure. In this case, core measures would aid in the communication or transparency of policy since they may help to clarify why policy makers are or are not reacting to recent fluctuations in published inflation rates. Its use in communication of policy could also improve public understanding of the notion that policy is linked to the more persistent movements in inflation.

- ***A good measure of inflation for empirical work***

Policy makers are also concerned with developing their understanding of the evolving interactions between monetary policy, economic activity, and inflation. This suggests the need for empirical research as well as further investigations into policy rules. This research agenda requires the accurate measurement of inflation. It also raises the possibility that some of the changes in prices, although technically contributing to inflation, ought not to be included in the measure of inflation used in empirical work. Transitory shocks might obscure important relationships between monetary policy and prices as captured, for example, in an expectations-augmented Phillips curve. In this case, a core inflation measure might better illuminate the relationships of interest.

- ***A viable target for monetary policy***

If price fluctuations from non-monetary sources can be excluded, the resulting core inflation could be regarded as a measure of the inflation that is the *outcome* of policy. Therefore, some measures of core inflation could be considered to be more controllable by the monetary authorities than published inflation rates. This closer relationship suggests that core inflation might be a better target for monetary policy than published inflation rates.

Since the use of a target implies that the monetary authority will accept responsibility for inflation *ex post,* it makes sense to define the target in terms of the measure of inflation for which it has the most *ex ante* control. This would further establish accountability for policy.

Use of a core measure as a target would focus public attention on the persistent trend in inflation, bringing it into line with the focus of the monetary authority. This is important since the success of inflation targeting works largely through anchoring the inflation expectations which will be incorporated into decisions and contracts. To the extent that this focus reduces the passthrough of temporary shocks to public inflation expectations, the variability of inflation would be further reduced.

A target core measure would have to be viewed by the public as objective if it were also to be used for accountability for policy. This suggests that the methodology used to extract core inflation from public inflation rates ought not change frequently or be viewed by the public as either obscure or under the control of the monetary authority itself. In particular, the arrival of new information should not result in a change in the historical core inflation series.

CPI inflation is designed to approximate changes in the cost of living, an aspect of primary concern to the public. To the extent that core inflation differs from the concept of a cost of living measure, it might not be readily understood or accepted by the public. In particular, it might be difficult to explain an ongoing focus on core inflation by the monetary authority if core inflation deviated from published inflation rates for an extended period.

4. Alternative approaches to the measurement of core inflation

Research in the 1990s can be thought of as following two broad approaches that roughly correspond to focuses on the two main problems in the core inflation literature. These are:

- ***the modelling approach***

This research focuses on the conceptual problem: How do we define core inflation?

- ***the statistical approach***

This research focuses instead on the practical problem: How can we measure it?

Ideally, a measure of core inflation would *both* define core inflation and directly exploit the data in its measurement. To date, this ideal measure of inflation remains elusive.

4.1 The modelling approach

The **modelling approach** takes as its starting point a behavioural definition of core inflation. This approach has been dominated by the research of Quah and Vahey (1995). These authors acknowledge the importance of a theoretical definition for core inflation and use the notion to determine the long-run restrictions in their model. Other researchers that have come up with alternative Structural Vector Autoregressions (SVARs) based upon the original Quah and Vahey approach include Blix (1995), Bjornland (1997), Claus (1997), Dewachter and Lustig (1997), Fase and Folkertsma (1998) and Gartner and Wehinger (1998). Each of these papers tries to address some criticism of the SVAR literature or of its application to core inflation. Other models of inflation have also been proposed and may be notionally linked to the core inflation literature. For example, p-star, or the long-run equilibrium level of prices in standard p-star models could be interpreted as the price level that corresponds to core inflation. (Attah-Mensah (1996), Armour et al. (1996), and Hallman, Porter, and Small (1989) have developed versions of the p-star model.)

The modelling approach involves an attempt to define core inflation and to use a model to operationalize it. This approach provides the advantage that it draws a direct link between policy and core inflation as the inflation which is controllable through policy. This link makes it clear why the monetary authorities would care about this measure of inflation. The main obstacle to obtaining a model-based definition of core inflation is that any model will be subject to scrutiny of its assumptions. Assumptions about the flexibility of prices, the formation of inflation expectations, and about the nature and distribution of price shocks will drive the results in the model. Further, it is unlikely that the distribution of these shocks is time or policy invariant. One feature of the structural model approach is that the arrival of new data could change the historical core inflation series produced by the model. Another is that it is generated directly by the policy maker. These features ensure that all available information and the most up-to-date techniques are used to estimate the trend. The estimates will evolve over time. This is an important advantage on occasions where new data reveals problems with past estimates of the trend. On the other hand, these features complicate public discussion since revisions would continuously require explanation. Too many revisions would undermine the credibility of the core measure.

Finally, it is useful to note that the farther a core measure deviates from published inflation rates or the more obscure the link becomes, the less useful the measure becomes as a formal target or as a public gauge of current underlying inflation that can be used for accountability to the public.

Furthermore, if the model itself has everything needed to forecast inflation then there is no independent role for core. The empirical implementation of any model-based core measure including VARs will be subject to degrees of freedom problems once various relative price shocks have been taken into account. This suggests that if there are many types of shocks one wants to deal with - admittedly with priors - there may be advantages to the statistical approach.

These features limit the use of these measures of inflation to roles as indicators of inflation. Still, it should be noted that this is a very important use for a measure of underlying inflation.

4.2 The Statistical Approach

Researchers using the **statistical approach** focus directly on the problem of how to measure core inflation using existing data. They typically take published price indexes and inflation rates as a starting point and ask how the available data can be exploited to provide a core measure. In general, this research can be divided into two branches which effectively correspond to the aggregated and disaggregated approach. Within the disaggregated approach, there are two types of inflation measures: i) those that use the distribution of inflation at a point in time and ii) those that use the time series properties of the data.

The main weakness in this approach is its atheoretical nature. Some researchers using this approach have focused on techniques for decomposing inflation into its core and non-core components without formally providing a framework of why a particular choice of decomposition is appropriate or desirable. Ideally, a definition or at least some notion of core inflation would be used to justify the exclusion of particular sub-indices or events. This makes it clear exactly why policy makers would care about a particular subset of published inflation rates.

The main advantage to this approach is that it uses the available data to the fullest extent possible. Also, when the measure of core inflation is derived using a straightforward, non-subjective technique it can be used for public discussions of policy.

4.2.1 Aggregate approach

The first branch of the statistical approach is one that uses the full sample of aggregate data and statistical techniques to identify directly the core measure itself. This approach focuses exclusively on the information contained in the dynamics of the aggregate index.

In effect, $\pi_t = \pi_t + \varepsilon_t$ where π_t is the core inflation movement and ε_t is the error term which may be interpreted as noise or may be further decomposed into two terms which represent noise and short-run fluctuations which are not of concern due to their volatility or source.

Research along these lines includes simple averaging as is done with year-over-year calculations or averages over other horizons and seasonal adjustment, as well as more sophisticated filters such as those of Cogley (1998).

4.2.2 Disaggregated approach

The second branch of the statistical approach uses disaggregated price data to create a measure of the general increase in prices, or core inflation.

Research using the disaggregated approach includes the various papers on the weighted median and other limited information estimators by Bryan and Pike (1991); Bryan and Cecchetti (1993b, 1996); Bryan, Cecchetti and Wiggins II (1997); Cecchetti (1996); Roger (1995, 1997) and Shiratsuka (1997). Measures of core inflation used at the Bank of Canada are based on this approach. These measures are proposed in Crawford et al. (1998) and Laflèche (1997a, 1997b).

- ***Disaggregated approach using the distribution of inflation at a point in time***

An aggregate price index, such as the CPI, is the weighted average of many individual sub-indices at any particular time period, *t*. The disaggregated approach focuses exclusively on the cross-sectional distribution of the individual sub-indices. In these measures, large or volatile movements in particular sub-indices are compared to some threshold (such as the mean of the distribution). These fluctuations are interpreted as non-representative or idiosyncratic movements in individual prices which are excluded from the measure of the aggregate tendency in prices. Once a high variance subset of the distribution is excluded, the remainder of the distributed is reweighted so that the weights sum to one. The weighted mean of the remaining sub-indices is calculated and interpreted as core inflation. In some cases, the high variance subset is down weighted rather than excluded.

Let π_t^i be the growth in the ith subindex of an aggregate price index, and *c* and *nc* designate core and non-core parts of inflation, respectively, such that: $\pi_t = w_t \sum c\pi^i{}_t + x_t \sum nc\pi^i{}_t$ where $w_t + x_t = 1$. By implication, movement in the ith non-core component, $\sum nc\pi^i{}_t$, represents either noise or is interpreted as non-core price shocks. It is important to note that the sub-indices that are included in the core inflation part will differ from period to period.

Canadian measures based on this approach include: a measure which eliminates movements in the tails of the distribution (*meantsd*) and the weighted median (*wmedian*).

- ***Disaggregated approach using the time series properties of the data***

Other statistical measures use the full sample to derive a measure of underlying inflation from all existing data. Transitory movements are identified as either noise or one-time-only relative price shocks, where the latter are usually assumed to correspond to supply shocks. Unfortunately, transitory movements can only be perfectly identified with the benefit of hindsight. To get around this problem, this research uses the broad historical time-series properties of the sub-indices to determine the candidates for exclusion. These properties may not persist into the future so these measures ought to be re-evaluated occasionally.

The most widely known Canadian measure based on this approach is the consumer price index excluding food, energy and indirect taxes (*CPIxFET*). The consumer price index excluding its eight most volatile components as well as indirect taxes (*CPIX*) also uses the historical volatility of individual sub-indices to identify the candidates for exclusion. There is also a measure which reweights the components according to their historical variability (*CPIW*).

5. Measures of underlying inflation at the Bank of Canada

For any purpose, it would seem that core would necessarily be a smooth measure of inflation. This suggests that averages might be a simple approach that could resolve many of the problems associated with the use of published inflation series. However, for the purpose of inflation as an indicator, there is a trade-off between longer-run averages, which tend to be reliable measures of underlying trends, and the up-to-date information in recent data. Though quite noisy, the timeliness of monthly data makes it an invaluable source of information on new developments that may hint at future trends in inflation.

The early-warning indicator use of a core measure has led some researchers to focus on short-term fluctuations in inflation in defining a core measure which takes full advantage of the timeliness of the data. For example, various U.S. researchers derive core measures based on monthly fluctuations (Bryan and Pike (1991), Bryan and Cecchetti (1993b)), while Roger (1995, 1997) emphasizes measures based on quarterly changes in inflation for New Zealand. However, the volatility in monthly and quarterly data suggests that sole reliance on higher frequency data could lead to policy errors or unnecessary volatility in the instruments of monetary policy. Cecchetti (1996) reports that changing the growth calculation from a month-to-month to a quarter-over-quarter growth rate halves the noise in inflation. (This is evident in Figure 1 which compares monthly, quarterly, and year-over-year movements in the CPI.)

Some of the noise in monthly inflation rates is inherent to the process of surveying prices and constructing a price index. Some prices are infrequently sampled and other prices are only adjusted occasionally. For example, tuition fees change once a year in Canada. These infrequent price changes are part of the overall inflation process and ought to be included in the inflation rate. However, at a monthly frequency, the magnitude of such price changes might be misleading if they are not well understood. Year-over-year growth rates allow a reasonably longer-term perspective. Further, they avoid by construction the problem of regular seasonality, though certainly not stochastic seasonal problems.

In Canada, monthly growth rates are scrutinized and compared to anticipated monthly growth rates but are not used in an official core measure. Since policy making is an imprecise art at best, changes in the trend in inflation require some confirmation before policy makers act. Thus, it seems prudent to limit the importance of a single month's data in a measure of underlying inflation.

Annual growth has important advantages if the core measure is to be used as a target. The smoothness of annual inflation rates enhances communication with the public. The inflation rate is not changing rapidly each month since it is an annual average and this helps to pin down the longer range inflation expectations of individuals and businesses. Finally, it is likely that an annual horizon or longer corresponds to the planning horizon of consumers and businesses negotiating and establishing changes in wages, pensions, loans, or other contracts that may take inflation into account.

For all of these reasons, core inflation measures in Canada are based on annual price changes. These core measures are introduced below.

- ***CPIxFET as a measure of core inflation***

The term core CPI inflation at the Bank of Canada officially corresponds to the 12-month change in the CPI excluding food and energy and the effects of indirect taxes (CPIxFET), which is shown in Figure 2.

Although CPI inflation is the official target in Canada, the Bank of Canada has officially adopted the CPIxFET inflation as the *operational target* for policy. This choice reflects several considerations.

First, its construction is easily understood by the public. Second, it is perceived as an objective measure of inflation because the CPI excluding food and energy is published independently by *Statistics Canada* and the methodology for adjusting for the effects of indirect taxes is clearly documented in the *Bank of Canada Review* (1991). Third, CPIxFET is a measure of core inflation. As such, CPIxFET shares the same general trend as the CPI but is much less volatile. Food and energy prices are notoriously more volatile than other prices. They have frequently been the source of large, unanticipated changes in CPI inflation. However, these large price changes have also typically been temporary. Since monetary policy acts only indirectly and over a long horizon to influence inflation, it is not well-suited to offsetting these temporary shifts in the inflation rate. Moreover, even if it were possible to offset these temporary shocks it might not be desirable to do so since it would involve increasing the volatility of monetary instruments. In addition, the nature of food and energy markets suggests an economic rationale for excluding these particular items. These prices are determined in markets where supply shocks (unrelated to monetary policy) are very important so that excluding these prices should produce a measure of inflation which is more controllable. As there has been no tendency for food and energy prices to rise at a different rate than total CPI inflation, focusing on the CPIxFET is effectively the same as focusing on the trend in the CPI itself with the advantage that uncertainty around the trend is reduced. Fifth, this common trend relationship to the official target is generally understood by the public. This understanding is necessary for transparency of policy. It creates a common ground for the communication of policy, particularly when CPIxFET deviates from the CPI and policy decisions require some explanation. It also aids in accountability since being outside the CPI target bands is placed in the context that the Bank is concerned with the more persistent movements in inflation. In summary, the use of CPIxFET as the operational target enhances communications and improves accountability since policy is based on a measure of inflation which is understood to be more controllable than the CPI.

One disadvantage to this measure is that, in excluding a portion of the expenditure-weighted CPI basket, it deviates even further from a cost-of-living index. This could lead to criticism from the public since they will be concerned with changes in the cost of living. Secondly, it is unlikely that every price movement in food and energy represents a relative price shock. Work by Crawford et al. (1998) shows that food consumed away from home, for example, is not a volatile price series and therefore belongs in the calculation of the underlying dynamics in inflation.

The effects of indirect taxes are also excluded from CPIxFET. In practice, this involves an adjustment to the inflation rate as a whole rather than the exclusion of specific portions of the basket as is the case when excluding food and energy. Price changes resulting from changes in indirect taxes represent one-time-only shifts in the price level. Moreover, indirect taxes are not related to the price of the good or service which is purchased, instead, they are charges to finance other government activity. In Canada, large changes in indirect taxes included the introduction of the value-added tax in 1991 and a large decline in tobacco taxes in 1994. The size of these shocks suggests the prudence of an approach that directly takes these changes into account, no matter that it is ad hoc in that it assumes tax changes are passed through one-for-one to consumer prices.

Since policy makers focus on the more persistent changes in inflation, they do not attempt to reverse these one-time shifts in the price level. Once these one-time shifts from changes in indirect taxes are excluded, the resulting inflation measure should be even more representative of price changes driven by the state of excess demand pressures in the economy and monetary phenomena. This further enhances its suitability as an operational target.

For these reasons, the CPIxFET is a useful guide for policy and tool for public communication and accountability. Its use as an operational guide will continue to work well as long as the two inflation series do not deviate for extended periods. It is also worth noting that, to the extent that the core measure more directly captures the underlying trend in inflation that is the outcome of policy, uncertainty about longer-run trends in inflation could be reduced even further by directly naming the core measure as the target. This would further disseminate to the public the notion that policy decisions are based on the more persistent movements in inflation.

5.1 Alternative measures of underlying inflation in use at the Bank of Canada

Other Canadian measures have been derived based on the disaggregated approach. Crawford et al. (1998) and Laflèche (1997a, 1997b) use the monthly distribution of 12-month changes in prices for 54 different subindexes of the CPI to generate the measures of core inflation discussed in the following sections. The longest consistent series of disaggregated prices that is available for all 54 subindices begins in 1985, therefore, these 12-month inflation measures begin in 1986.

The disaggregated approach was adopted because it makes the most of the available data. Aggregate time series approaches to measuring core inflation have been hampered by changes in the Canadian inflation process. There is evidence of regime changes in the Canadian data. (Ricketts and Rose 1995). The most recent of these shifts occurred in the early 1990s. Year-over-year growth in the CPI fell from 4.7% for the 1986 to 1991 period to 1.4% for the 1992 to 1998 period. Evidence on the time-series properties of the data suggest that this regime switch may be more than a shift in the mean. Research also suggests that the inflation process was non-stationary in earlier periods, but is now stationary in the recent inflation-targeting environment (St-Amant and Tessier 1998). These results must be interpreted cautiously due to the low power of the test and the short period used for the analysis, but there does seem to be evidence of a regime change emerging in the literature. (In a sense this is not surprising for a successful regime with a constant target would imply stationarity.) Close review of the individual prices that make up the aggregate inflation index suggests that this regime change may have occurred in a wide variety of prices. Almost all of the disaggregated prices in the CPI have lower means and standard deviations in the period after 1992 than in the earlier period (see Table A1).

Use of the empirical modelling approach is made difficult by this recent historical experience. Once a researcher has adjusted for regime changes and other important temporary shocks (such as the introduction of the GST) in the Canadian data, there remains very few degrees of freedom to estimate model-based measures of core inflation. A model which ignores these changes in the inflation process could lead to misleading inference. On the other hand, the existence of these changes in the inflation process cannot be firmly established unless the recent regime persists for a long enough period to generate a long time series. It may be that there is no regime change. In this case, a model which allows for these changes in the inflation process could lead to misleading inference. Explicit use of the disaggregated price data allows the researcher to access a wider range of information for the analysis. While the model-based approach is theoretically appealing, it has these practical problems; in contrast, the statistical approach is likely to yield a stable measure of core inflation even through periods of rapid change.

- ***MEANTSD***

MEANTSD is the weighted average of the cross-sectional distribution of price changes that has been trimmed to exclude values farther than 1.5 standard deviations from the average (see Figure 4). As such, it excludes the most volatile components at each *point in time*. This provides a measure which is roughly equivalent to one which trims 5% of the largest and smallest changes in the distribution, however, it has the advantage that it allows the amount trimmed to be dependent on the tightness of the distribution itself. The determination that any price change larger than 1.5 standard deviations represents an outlier is somewhat arbitrary. Interestingly, the same subcomponents are often excluded on both extremes of the distribution. In other words, extreme fluctuations tend to be reversed. This supports the interpretation that they represent temporary supply shocks.

One feature of this measure is that it may be more volatile *over time* than most measures of underlying inflation (See Tables 1 and 2). If annual price movements for a particular component vary such that the price is always close to 1.5 standard deviations, then it may be included one month when it is just below 1.5 standard deviations and then excluded the next when it is just above. This makes it difficult to compare monthly reports of the 12-month changes in inflation since the coverage of the measures tend to vary from month to month.

MEANTSD is not published by the Bank of Canada but is used in internal current analysis of evolving inflationary pressures. Every month, it is used in conjunction with information on which subcomponents are actually excluded (see Table 3 for an example). Thus, it is used as much as a way of highlighting the specifics of extreme price movements as it is of providing an underlying inflation rate.

- ***CPIX***

This measure of inflation is defined as the CPI excluding the eight subindices which have been most volatile, as well as indirect taxes (see Figure 5). These eight are fruit, vegetables, gasoline, fuel oil, natural gas, mortgage interest costs, inter-city transportation (mainly air fare), and tobacco products. In practice, this involves placing a weight of zero on the eight excluded price subindices and recomputing the aggregate price index. Year-over-year growth of the price index is then defined as CPIX inflation. CPIX is similar in spirit to the notion behind the CPIxFET. The subcomponents which are eliminated, however, are chosen based on a more objective evaluation of their volatility. The exclusion of this particular set of prices is also appealling due to the source of their dynamics. Most of the prices are volatile due to their particular market, for example, fruit, vegetables, gasoline, fuel oil, natural gas and inter-city transportation. All of these are items which are affected by world prices and are sensitive to the exchange rate. Others such as tobacco products and mortgage costs are affected by government policy.

The idea for CPIX originated with the observation that some elements of the aggregate food and energy subcomponents were not at all volatile. For example, food purchased in restaurants, dairy products, and bakery products were rarely excluded from MEANTSD. Eliminating these elements from the basket, as is done in CPIXFET, might in fact be excluding useful information on the trend in inflation. This suggested that it might be possible to have a measure of core inflation which was less volatile but which included more of the basket.

CPIX makes the most of what we do know about the historical variability of disaggregated prices to determine which price changes ought to be not to be included in core inflation. The following calculation is used to identify the most volatile subindices. First, a limited information estimator - trimmed of the 10% highest and lowest values of the ordered distribution in each period - is computed. Second, MEANTSD is computed. Recall that MEANTSD is trimmed of price changes over 1.5 standard deviations from the weighted average in each period. Any subcomponents which are trimmed from the limited information estimator over 50% of the time and from MEANTSD over 25% of the time are identified as volatile. In other words, the components that are most often among *the most volatile subcomponents at a point in time* are identified as candidates for exclusion. This calculation is made over the longest sample possible: November 1979 to November 1996 for most components and January 1986 to November 1996 for the exception.

The resulting core measure actually contains more of the basket than the Bank's official core inflation measure. Based on the 1996 basket weights, the CPIxFET excludes 26% of the total CPI basket, whereas the CPIX excludes only 16%. CPIX is also less volatile that CPIxFET. It is published regularly in the *Bank of Canada Review.*

- ***CPIW***

The choice to zero-weight particular components and recompute the aggregate index (as is done for CPIxFET, CPIX and MEANTSD) is based on the view that these extreme movements are uninteresting for the purposes of monetary policy. Yet, it is unlikely that all large movements correspond to either noise or one-time-only relative price shocks. At least on occasion, these movements may reflect changes in the inflation process. This will be an important exception from the perspective of the monetary authority. It may be useful to compute a measure that includes some effect from these large changes in prices rather than ignore these movements entirely. This is the notion behind CPIW (see Figure 6), which attenuates the influence of highly variable components. This measure has the advantage that it includes all elements of the initial basket. CPIW is published regularly in the *Bank of Canada Review.*

CPIW calculates the inflation rate by taking the initial basket weights and multiplying them by a second weight which corresponds to the reciprocal of the *historical* standard deviation of the relative price change. This standard deviation of the relative price change is computed as the difference between the variation in the component and the variation in the total CPI. It is calculated over the period 1986m1 to 1997m4. The new weight is obtained by multiplying the initial weight by the second weight. The product is then normalized so that the weights sum to one.

- ***Wmedian***

The weighted median is an order statistic which is defined as the 50th percentile of the weighted cross-sectional distribution of price changes. It is shown in Figure 3. As an order statistic, the weighted median will be a more robust measure of the tendency of the individual price changes that make up the distribution than the weighted mean if the distribution of price changes is non-normal. This measure is not used regularly at the Bank of Canada but we include it in this analysis since there is some evidence that the distribution of price changes in Canada may be non-normal.[3] Conclusions are tentative because the skewness and kurtosis of the distributions vary with the horizon used to calculate the price changes. Furthermore, the moments of the distribution are changing over time.

The cross-sectional distribution of price changes seems to be leptokurtic. Calculations based on the distribution of year-over-year changes indicate weighted kurtosis of 9.72 for the 1986-1991 high inflation subperiod. Weighted kurtosis does decline to 6.11 for the 1992-1998 sample, but this is far more than the kurtosis of 3 for a normal distribution. This suggests that eliminating extreme movements may be worthwhile. Note, however, if the distribution is symmetric, trimming the tails and recalculating the weighted mean will not result in any change in the weighted mean. Hence, we look at the skewness in the distribution.

There is evidence of skewness in the distribution when price changes are calculated at some frequencies, though not for those calculated over an annual horizon which is the one used in Canada to calculate measures of underlying inflation. Weighted skewness in year-over-year price changes averages about 0.15 for the full sample. However, weighted skewness seems to have fallen along with the mean of inflation in recent years. Average weighted skewness fell from 0.32 in the 1986-1991 period to zero in the 1992-1998 period. Therefore, it does not appear that on average skewness is a particular problem in the Canadian data. However, the standard deviation surrounding the skewness for the full sample is 1.44, indicating that skewness presents a problem during particular periods. The possibility of skewness during particular episodes could support the use of the weighted median as a measure of core inflation.

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3. Appendix 2 includes a detailed discussion of the moments of the distributions of price changes in Canadian data.

6. An evaluation of various measures of underlying inflation

All of the measures in section 5 yield useful information about core inflation. Nonetheless, policy makers require a means of discriminating among them. Any evaluation is complicated by the fact that there are no formal criteria by which the accuracy of a core inflation measure can be assessed. Since core measures are to be tools for policy it is reasonable to assess them based on their suitability to various policy purposes. Hence, we begin with a discussion of the attributes that would make different measures suitable as an indicator of current and future trends in inflation; for empirical work; or as a target for monetary policy.

As an indicator of current and future trends in inflation, the ideal core inflation would be a smooth measure that closely approximates the general trend in inflation. Furthermore, it would have some forecasting ability for the trend. In other words, the excluded portion would reflect short-run movements in inflation. As such, it would be independent of the future trend in inflation. Timeliness is also an important attribute if core inflation were to be used as a guide for policy. However, all of the core inflation measures are available at the same time so we do not evaluate these particular measures based on this last criteria.

As a better measure for empirical work, the core measure would tighten the estimates of the relationship between policy and other variables, for example, in expectations-augmented Phillips curves. Unfortunately, the absence of long time series makes this difficult to evaluate.

Generally, the same attributes that would make a core measure useful as an indicator of the trend in inflation or as a better measure for empirical work would also make it suitable as a guide to policy and more precisely, as an operational or intermediate target for policy. As a direct target, however, the core measure would be a public measure; therefore, it would also require a few additional attributes.

Targets are an important element in a strategy for communication with the public. Therefore, to be a viable target, a core measure would have to be understood by the public and acceptable to it. This suggests that measures which exclude too much of the consumer basket might be challenged by the public since they deviate too much from a cost of living index. This might recommend the CPIX rather than the CPIxFET, since the proportion of the basket which is excluded is smaller and can be defended on variability criteria. In addition, the relationship of the core measure as target to other published inflation rates (such as the CPI) would have to be transparent and its construction easily understood, since deviations of the core measure from published inflation rates would have to be addressed.

As a target, a core measure would have to make sense based on economic theory. This implies that it would be a good measure of the persistent trend in inflation. Furthermore, it should be clear to the public that the core measure is closer to the trend in inflation than other published measures and that it is the persistent movements in inflation that matter to the monetary authority. Only in this event would use of a core measure improve the transparency of policy decisions. This requirement would exclude very obscure measures of underlying inflation as candidates for the target, even if they were fairly accurate. For example, this would seem to suggest that MEANTSD is not a candidate for a public measure of core inflation and this is one reason why the Bank of Canada has chosen not to publish this measure.

A principle reason for naming a target for policy is to provide a benchmark on which to evaluate the success of policy. As a tool for accountability, it would have to be fairly clear that the monetary authority had some capacity to realize the target given the monetary policy instrument. This provides a strong argument for the use of a core measure as a target if that measure is shown to be a tighter measure of the inflation that is controllable. If such a core measure is named as the target, it might be possible to be more precise about the target since the core measure would be closer to the trend in inflation than CPI inflation; this could imply a smaller range for the target.

Note finally that, for a core measure to be useful, it would have to be clear why the particular decomposition chosen isolates core inflation and not something else.

- ***Does the core measure capture the persistent movements or is it still volatile?***

Table 1 lists the mean and standard deviation of each of the various core measures as well as the CPI. In terms of variability, defined as the standard deviation divided by the mean, each of the core measures improves on the variability in the CPI. However, there is very little to differentiate among the various core measures. The mean over the full sample ranges from 2.76 for the weighted median to 2.90 for both CPIW and MEANTSD . Measures of variability range from a low of 0.42 for CPIX, the least variable measure, to 0.51 for the weighted median.

Table 2 also reports the same statistics but over the period 1992m1 to 1998m8 to evaluate whether the core measures continue to perform well in the recent low and stable inflation period. The mean has declined for each of these measures and the CPI. The mean of the core inflation measures now ranges from 1.52 for the weighted median to a high of 1.87 for CPIX inflation. The higher mean for the CPIX reflects the exclusion of mortgage costs which have been declining due to low interest rates. The standard deviation has also fallen sharply, ranging from 0.43 for the MEANTSD to a low of 0.30 for CPIW. For most of the core measures, variability is about half of the 0.50 calculated for the CPI, with the lowest variability of 0.18 reported for both CPIW and CPIX.

As suggested by Cecchetti (1996), a longer-run two-sided moving average of inflation will provide us with a fairly good benchmark of the trend in inflation. We use this benchmark to assess the various core measures. Figure 7 graphs the weighted mean of the CPI changes and the two-sided 36-month moving average of the monthly weighted mean. The weighted mean is equivalent to CPI inflation except that the basket weights have changed approximately every four years and also, we have adjusted the components used to calculate the weighted mean for the effects of the GST in 1991 and the tobacco tax shock of 1994 to remove misleading shifts before calculating the more persistent trend. Table 4 reports the root mean square error and mean absolute deviations to compare how close each core measure captures the benchmark trend. It appears that the CPIW more closely approximates the persistent movements in the weighted mean better than the alternative measures.

- ***Does the core measure help predict future trends in inflation?***

In order to assess whether the core measure has any indicator properties for the future trend in inflation, we review the simple correlations between each core measure and the CPIxT (CPI excluding indirect taxes) at various future intervals: 6 months, 12 months, 18 months, and 24 months (see Tables 5 and 6)[4]. We report correlations between the core measures and the CPIxT rather than the CPI itself in order to abstract from the large indirect tax shocks in the data. The importance of indirect tax shocks is evident when comparing the CPI and the CPIxT at all samples. At 6 months ahead the correlation between the CPI and the CPIxT is only 0.65 despite a 6 month overlap in the data.

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4. Note that contemporaneous correlations and those 6 months ahead will include some overlap between the core measure and CPIxT since these are 12-month averages.

Table 5 shows the correlations over the full 1986 to 1998 sample period. These correlations are quite high. They suggest that core measures do contain information about future movements in inflation. At 24 months ahead, the correlation between CPIX and CPIxT is 0.75.

It may be that correlations are high simply because all of these measures capture the large downward shift in inflation in 1991. In addition, it is interesting to see how they perform in the recent inflation environment. Therefore, the same correlations are reported for the recent sample as well (see Table 6). At 6 and 12 months ahead, CPIxT is negatively correlated with most of the core inflation measures. The exception is the CPIxFET, which is slightly positively correlated 6 months ahead (during the period of overlap) and generally uncorrelated 12 months ahead. At 18 months ahead, correlations change sign and are now all positive. At this point, CPIxFET is the most highly correlated at 0.44 and CPIX the next highest at 0.40. This pattern of correlations through time suggests that many of the shocks which are excluded from the core measures but are included in the CPIxT have been eliminated between 12 and 18 months ahead. The core measures are still notably correlated with the CPIxT at 18 and 24 months ahead, suggesting that they do have useful information on the future trend in inflation. The highest correlation at 24 months is between CPIxT and CPIW; it is reported at 0.42.

These statistics represent correlations at particular periods in time. Other research at the Bank suggests that these conclusions hold up in a more dynamic analysis. Regressions on the CPI or core measures which use long lags (18 to 29 months) of either the CPI or core as explanatory variables indicate that the use of core measures significantly reduces the standard errors in simple forecasting equations. In effect, more closely identifying the trend improves forecasts of inflation. Not surprisingly, the core measures perform even better if the sample is limited to the recent period of low and stable inflation.

- ***Is it reasonable to exclude these particular subsets of the CPI?***

One can check to see whether the portion of the CPI excluded from a core measure has similar attributes to noise or reversible prices shocks. For example, we look for persistence in the excluded-from-core series. For the CPIX we evaluated each of the eight subcomponents which have been eliminated from this measure to see if they contain information on the trend in inflation. Augmented Dickey-Fuller (ADF) tests suggest that over the 1986m1-1998m8 sample, year-over-year changes in the price of each of the following subcomponents are stationary series: fruit, vegetables, inter-city transport, fuel oil, natural gas, and gasoline. This is encouraging since it suggests that these price changes are temporary. Tobacco and mortgage interest costs are I(1). These are the subindices most directly influenced by government policy so their exclusion is motivated differently. ADF tests run over the longest possible sample suggest all of the series are stationary. This longest available sample for most of these particular series is 1950m1 to 1998m8 for each of the subcomponents except fruits and vegetables, for which a consistent series is only available from 1979m1 to 1998m8.

Figure 8 graphs the difference between the CPI and each of the different measures of underlying inflation. These gaps are the excluded portions of each of the core measures and therefore, should represent temporary movements in inflation around its trend. These gaps could be interpreted as measures of relative price shocks. We test whether core inflation and the excluded portion are independent. To do so, we do a variation of Cogley (1998)[5] and test whether the excluded portion over or underpredicts the transient component of the CPI.

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5. These regressions are quite similar to those included in Crawford et. al (1998) $\pi_{t+h} = f(\pi_t, \pi_t^{core})$ and their finding that the sum of the coefficients was close to one.

We do the following OLS regression where π_t is CPI inflation at time *t*, π_{t+h} is CPI inflation at time *t+h*. In each regression, *h* equals 6, 12, and 18, respectively. π_t^{core} is the core measure and u_t is the random error term.

$$(\pi_{t+h} - \pi_t) = \alpha_t + \beta_t(\pi_t^{core} - \pi_t) + u_t \quad [6]$$

We test the joint restriction that $\alpha_t = 0$ and $\beta_t = 1$.[7] The restriction on β_t indicates whether the excluded portion of the core measure over- or under-predicts the transitory movements in inflation. If β_t is less than one then it overstates the transitory movements, if greater than one then it understates. This experiment captures the extent to which transient movements are subsequently reversed.

The regressions over the full 1986m1 to 1998m8 sample provide some interesting results (see Tables 7-9).[8] Six months ahead, CPIW provides the most encouraging result since the estimated coefficients are $\alpha_t = 0$ and $\beta_t = 1$ even without a restriction (see Table 7). We cannot reject the restriction that $\alpha_t = 0$ and $\beta_t = 1$ for any of the core measures (except CPIX) suggesting that what has been excluded from these measures reflects transitory movements. At this horizon, CPIX seems to underpredict the transient movements in the CPI.

However, at 12 and 18 months ahead, the test results are reversed (see Tables 8 and 9). The CPIX clearly performs much better at capturing transitory movements that are reversed over these longer horizons, since the freely estimated coefficient β_t is very close to one. The joint restriction that $\alpha_t = 0$ and $\beta_t = 1$ cannot be rejected for CPIX and MEANTSD at either the 12 or 18 month horizon, nor can it be rejected for CPIxFET at the eighteen month horizon. Overall, these results support a few measures of inflation, in particular, CPIW and CPIX seem to be useful measures of core inflation though over different horizons.

Next, we re-estimate the regressions to investigate whether these conclusions hold up for the low and stable inflation period of 1992m1 to 1998m8 (see Tables 10-12). Six months ahead, all measures do well. CPIW still fares best at this horizon since it is still the case $\beta_t = 1$ even without a restriction. We cannot reject the joint restriction that $\alpha_t = 0$ and $\beta_t = 1$ for any of the core measures except CPIX. These results suggests that what has been excluded by these measure accurately captures the transitory movements in the CPI at this horizon. As in the regressions over the full sample, CPIX seems to underpredict the transient movements in the CPI.

At the longer horizons of twelve and eighteen months, all of the measures overestimate the variable portion of the CPI (see Tables 11 and 12). The joint restriction is easily rejected by the data in each of the regressions and the estimated coefficients are well above one. This may reflect the fact that there is much less variability in the CPI over this period (except for the temporary decline in inflation due to the tobacco tax cut in 1994).

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6. Standard errors have been corrected using the Hansen and Hodrick (1980) adjustment where appropriate.
7. The simpler restriction that $\beta_t = 1$ leads to identical conclusions in each of the regressions.
8. Samples identified in Tables 7-12 are shorter than the full sample since the sample is adjusted as required to allow for *t+h* period ahead observations.

- ***Does a closer look at the components suggest that the logic behind their construction holds up?***

Both CPIX and CPIW use data on the historical volatility of the components to derive measures of underlying inflation. This approach is based on the assumption that the past will be representative of the future. To evaluate how this holds up, we investigate the recent period.

In deriving the CPIX, the standard deviation of the individual components of the CPI could have been used to determine which components are volatile instead of the components that were most frequently eliminated by MEANTSD or a 10% limited information estimator. Table A1 lists the mean and standard deviations of 54 individual components of the CPI. Over the full sample period, these eight are among those with the highest standard deviations. It is not surprising that they are frequently be in the tails of any monthly distribution of price changes.

Interestingly, though the means and standard deviations of all of the subcomponents have fallen dramatically, the same subset of eight still represent some of the most volatile components. Table A1 also reports the mean and standard deviations of two major subperiods, 1986 to 1991 and the low inflation period of 1992 to 1998. The Spearman rank correlation coefficient between the two periods is 0.63, suggesting that the relative volatility of the various components in the first period is indicative of that in the recent low and stable inflation period. This supports the choice of CPIX in the sense that it will likely perform out of sample. It also indicates that using constant weights based on an earlier period to reweight the components, as in CPIW, is a not a bad approximation.

Notice that if the premise upon which the CPIX measure is based is true, the eight subcomponents excluded historically ought to correspond to those most frequently excluded by MEANTSD in the current period. An investigation of the subcomponents eliminated indicates this is the case. Five of the components excluded from MEANTSD in August 1998 were among the eight excluded from the CPIX measure due to their historical volatility, namely fuel oil, gasoline, natural gas, inter-city transportation, and tobacco products (recall Table 3). This is not an unusual month.

Tables A2-A5 report the frequency that these components were eliminated from MEANTSD over the full sample and over two different subperiods: 1986m1 to 1998m8; 1992m1 to 1998m8; and 1996m12 to 1998m8. The columns in this table report the type of price included in the subindex, the number of times it was excluded from MEANTSD and the percentage of time it was excluded. In Table A2, for example, the first row indicates that education prices were eliminated by the MEANTSD procedure 44 times or 55% of the time. In each of these periods, the eight removed from CPIX were among the nine subindices thrown out due to their location over 1.5 standard deviations from the weighted mean. The ninth most frequently discarded subindex is education, which is also the one with the largest mean of any component (7.5%). This is not surprising given the large hikes in tuition fees in recent years due to cut-backs in government funding of universities. Note, however, that the education price subindex does not have a particularly high standard deviation. This would suggest although education prices is discarded by the criteria for MEANTSD , it may not belong among those components excluded from CPIX on the basis of their volatility, since it is not really volatile, merely persistently high.

6.1 Summary and related work

This assessment has focused on the properties that are required if these measures are to be a good indicator of current and future trends in inflation. This leaves further work to evaluate their usefulness as a measure for empirical work or as a viable target for monetary policy.

Other work at the Bank of Canada does lend some insight into the suitability of these measures to these last two uses. Hogan (1998) compares the performance of various core inflation measures in Taylor rules. He finds that the CPIxFE outperforms the CPI and the other measures of core in historical estimates of Taylor rules. However, his conclusions, like our own, are tentative due to the short sample available for the recent low inflation period. Kichian (1998) shows that the tighter the measure of core inflation used in the analysis, the more suitable is the model to estimate the output gap. She finds that the CPIxFE performs better than the CPI in a state-space model to measure potential output. Note that her model allows for dynamic effects of indirect taxes changes on inflation.

Finally, evaluation of the usefulness of core measures as a target is based on their performance in the other two roles as an indicator of current and future trends in inflation and as a measure of inflation for empirical work, as well as their suitability for public scrutiny and discussion. This suggests that the traditional core measure, CPIxFET could be considered as a possible direct target since the attributes which make it a useful operational target also make it suitable as a direct target. Moreover, it is the most straightforward and easily understood measure of core inflation. CPIX inflation might also make a suitable target since it is less variable than CPIxFET and at the same time, includes more of the original CPI basket than CPIxFET.

7. Conclusion

As a measure of the general trend in inflation, core inflation is a useful tool for policy makers in three possible ways: as an indicator of current and future trends in inflation, as a better measure of inflation for empirical work, or as a target for monetary policy.

The Bank of Canada currently monitors several measures of core or underlying inflation on a regular basis. All of these measures are based on the disaggregated approach to measuring core inflation. Furthermore, they are all based on 12-month price changes. Several items support the choice of year-over-year growth in monthly data for the inflation as either a guide to policy or as a target for policy. First, it provides an important smoothing aspect to the data. Month-over-month changes are simply too volatile for policy makers to respond to every movement. Second, for movements in year-over-year growth in the CPI, excess skewness and kurtosis do not seem to present any particular difficulties. Third, there are some price changes which are infrequently sampled and other prices which really only change occasionally or annually (such as tuition fees). These infrequent price changes can be gradually included in the inflation rate. Fourth, by construction, year-over-year growth rates avoid the problem of regular seasonality, though not stochastic seasonality. Finally, it is reasonable to think that contracts, pensions, and other economic planning that takes inflation into account would largely be done based on a somewhat longer horizon, such as an annual horizon. This final point supports the use of an annual inflation rate for public inflation targets.

The range of measures considered in this paper includes one which excludes the most volatile components historically (CPIX); one which includes all elements of the basket but down weights their influence on the aggregate inflation rate based on their volatility (CPIW); one which reflects the 50th percentile (wmedian); one which excludes the most volatile components at a point in time (MEANTSD) and identifies those shocks; and one which excludes prices traditionally considered to be affected by temporary supply shocks (CPIxFET). Each of these measures fares quite well in a comparison to aggregate CPI. However, the environment of low and stable inflation in Canada makes it difficult to differentiate among them, since the variability of all the measures is now quite low. Some tests seem to suggest the CPIW does best at capturing the trend in inflation, while others suggest the CPIX as a useful measure. Other research at the Bank of Canada, reviewed briefly above, shows that the Bank’s official core measure, CPIxFET, performs best on some other criteria. Overall, no one measure of core seems to stand out as ideal in the analysis.

Interestingly, the sharp drop in the means and standard deviations of the various core measures and the aggregate CPI are mirrored in the disaggregated data. The low inflation environment is evident in almost all disaggregated prices, at least to some extent. A review of their relative means and standard deviations suggests that if we recalculated the eight most volatile components to determine which to exclude based solely on recent data, we would choose the same eight which were excluded historically, namely, fruit, vegetables, gasoline, fuel oil, natural gas, inter-city transportation, mortgage interest costs, and tobacco products. Furthermore, it is reasonable to exclude these particular items for economic reasons. The first six of these subindices contain prices which are sensitive to the situation in world markets and to the exchange rate while the last two are heavily influenced by central bank or government policy.

Along with the decline in the mean and standard deviations of inflation, we report a decline in the skewness and kurtosis of the cross-sectional distribution of inflation. Although it appears that weighted skewness is not a problem on average, the level of kurtosis and the standard deviation of skewness suggests that the distribution of price changes is non-normal during specific episodes. This suggests that the weighted median is worth considering as a robust measure of underlying inflation.

Comparisons of the various measures of underlying inflation suggests that different measures do well along different dimensions. Each measure of core provides some particular insight into how inflation is evolving. Therefore, rather than selecting one measure as the best to perform the role of core inflation as an indicator of the trend in inflation, it might be more useful to have a limited number of measures of underlying inflation and to use the varied information in each of them to put together a more accurate picture of the dynamics in inflation. This is the approach currently in place at the Bank of Canada. In particular, the use of MEANTSD , the measure which specifically identifies the subcomponents which have extreme fluctuations, and others that exclude or down weight traditionally variable elements - CPIxFET, CPIX and CPIW - assist in identifying the source of the shock if there are differences in inflation as indicated by the different core measures. For example, CPIX has a higher mean over recent years because it excludes mortgage interest costs which have been declining due to low interest rates. It seems reasonable to adopt an approach which uses what is known about the data to its fullest extent. This ensures that the policy maker understands what is captured (or not) by the core inflation measures. For example, the list of what is eliminated from MEANTSD each month highlights the components which are most volatile at the moment. This approach will be most useful in periods of change when the core inflation measures diverge, since it would raise a warning signal to investigate further.

It may be interesting to pursue alternative avenues of research in the future. To date, work on the model-based approach has been hampered by the recent regime change. However, once low and stable inflation period persists for some time, the model-based approach could yield some interesting insights. The evidence on the usefulness of various core measures described in this paper would be strengthened by comparison with the very different alternative measures that are produced by the model-based approach.

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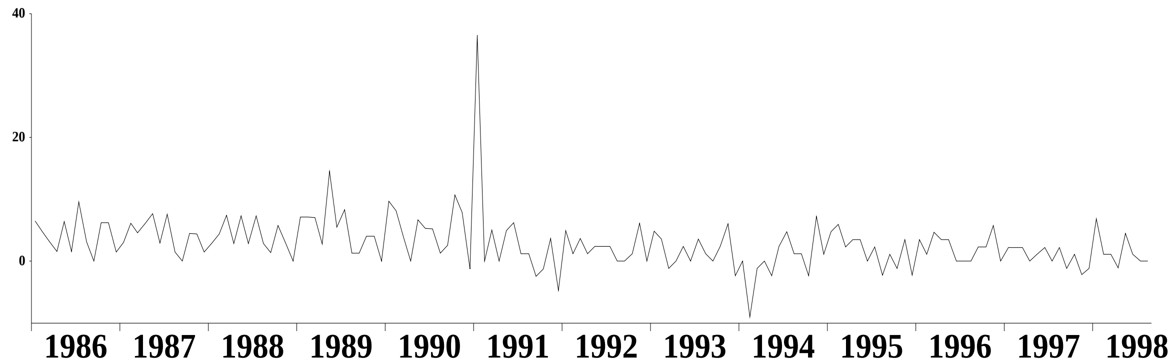
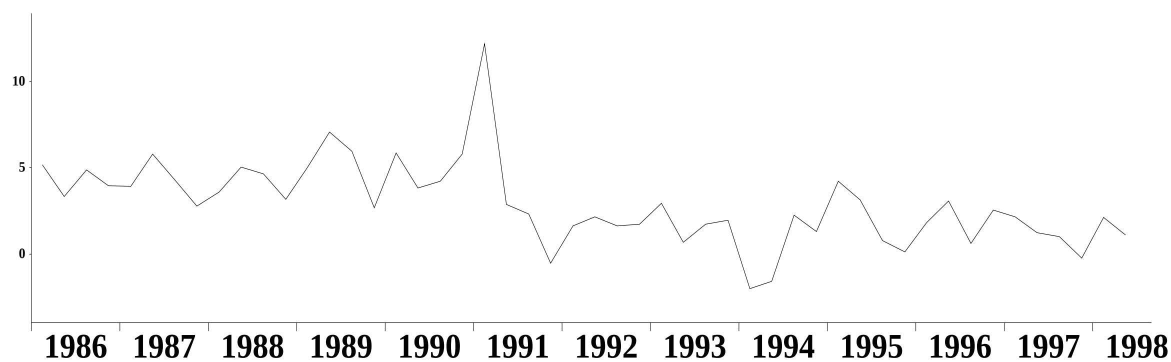
Figure 1: A comparison of different frequencies for price changes

Month over month growth of CPI, annualized
sample 86m1 to 98m8



Quarter over quarter growth of CPI, annualized
sample 86q1 to 98q2



Year over year growth of CPI
sample 86m1 to 98m8

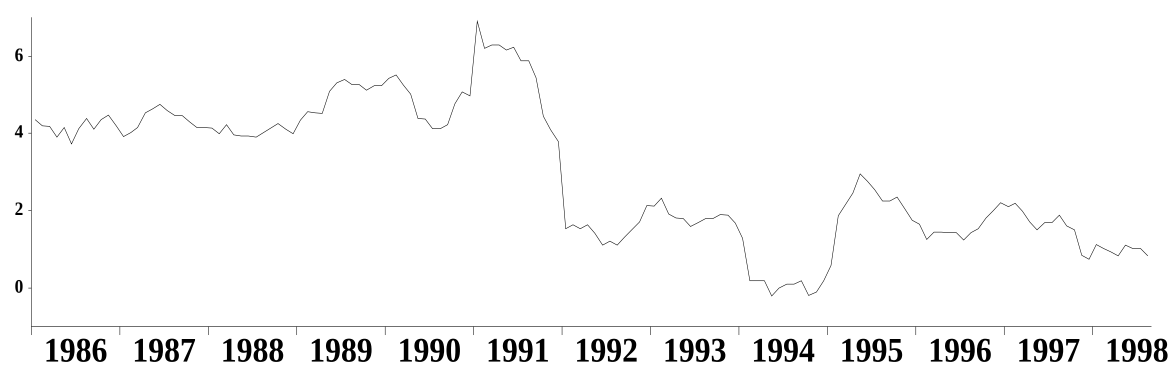


Figure 2: Year-over-year growth of CPIXFET and CPI (Sample 86m1 to 98m8)

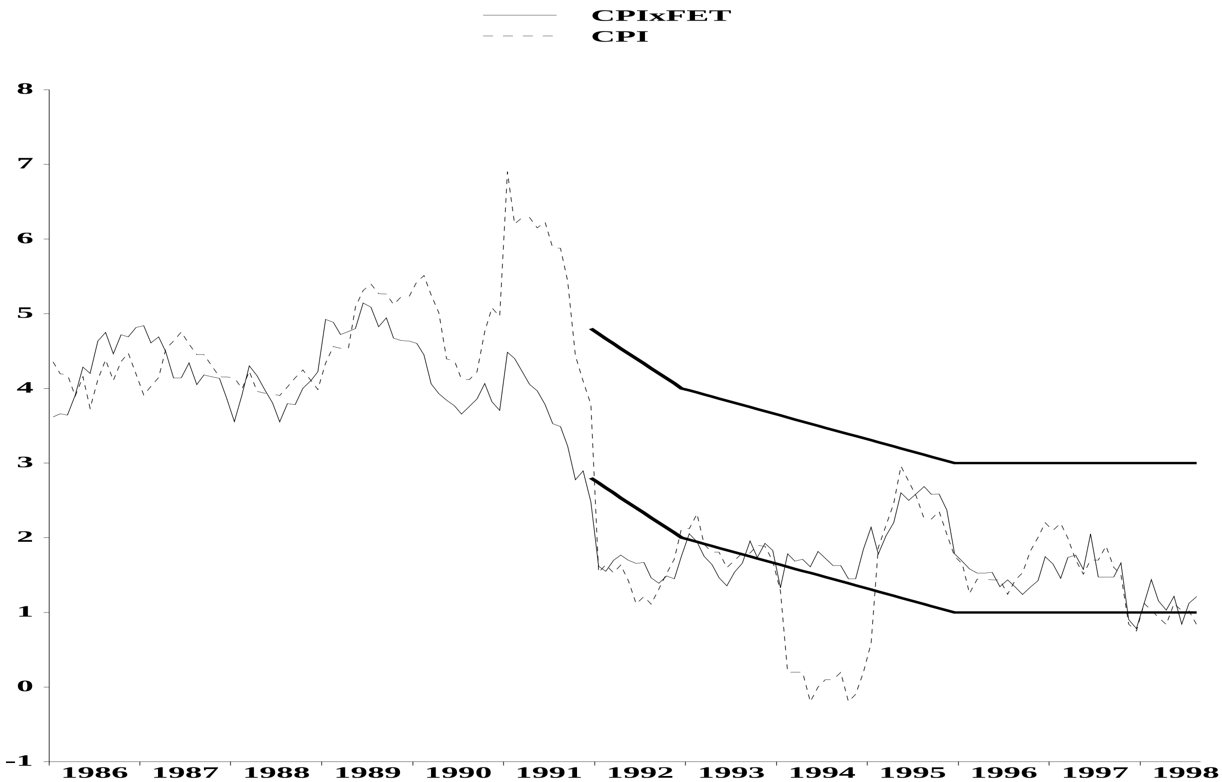


Figure 3: Year-over-year growth of WMEDIAN and CPI (Sample 86m1 to 98m8)

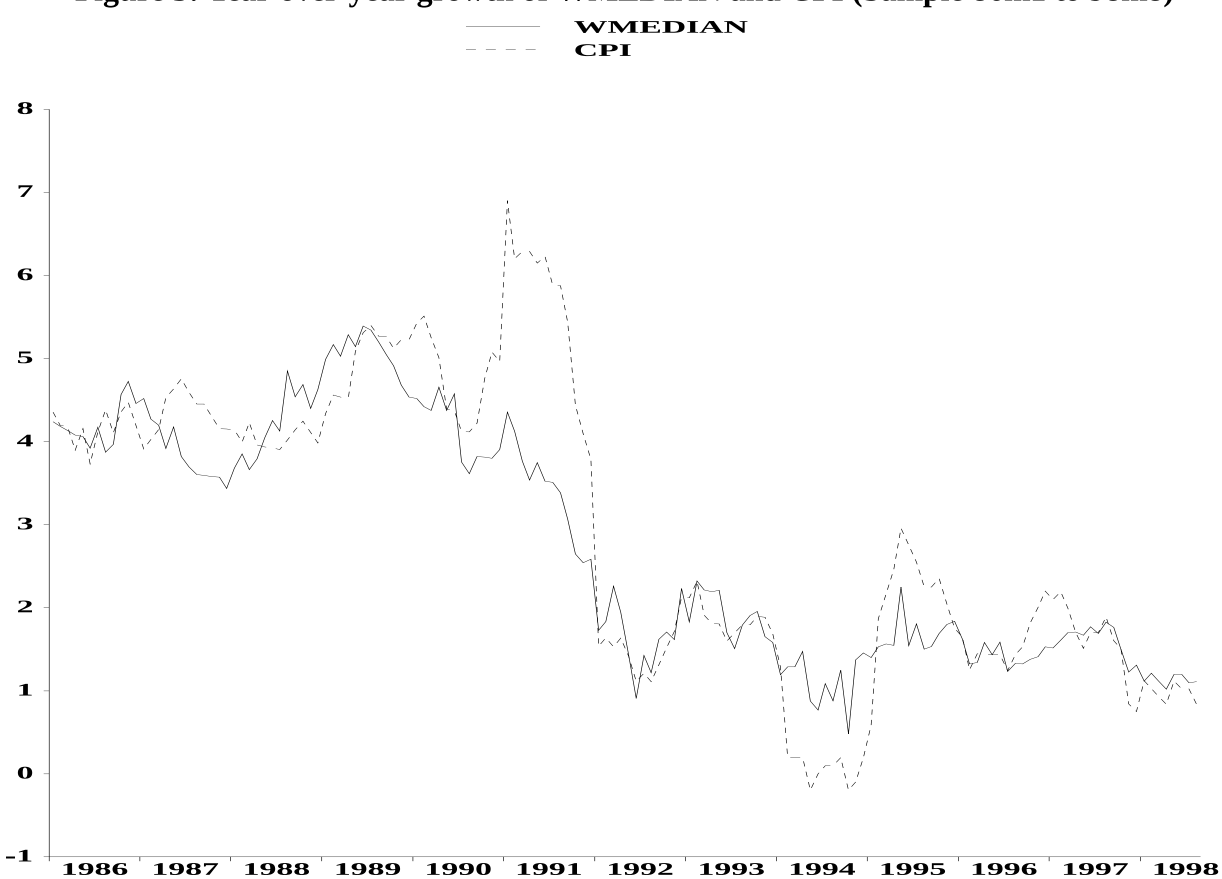


Figure 4: Year-over-year growth of MEANTSD and CPI (Sample 86m1 to 98m8)

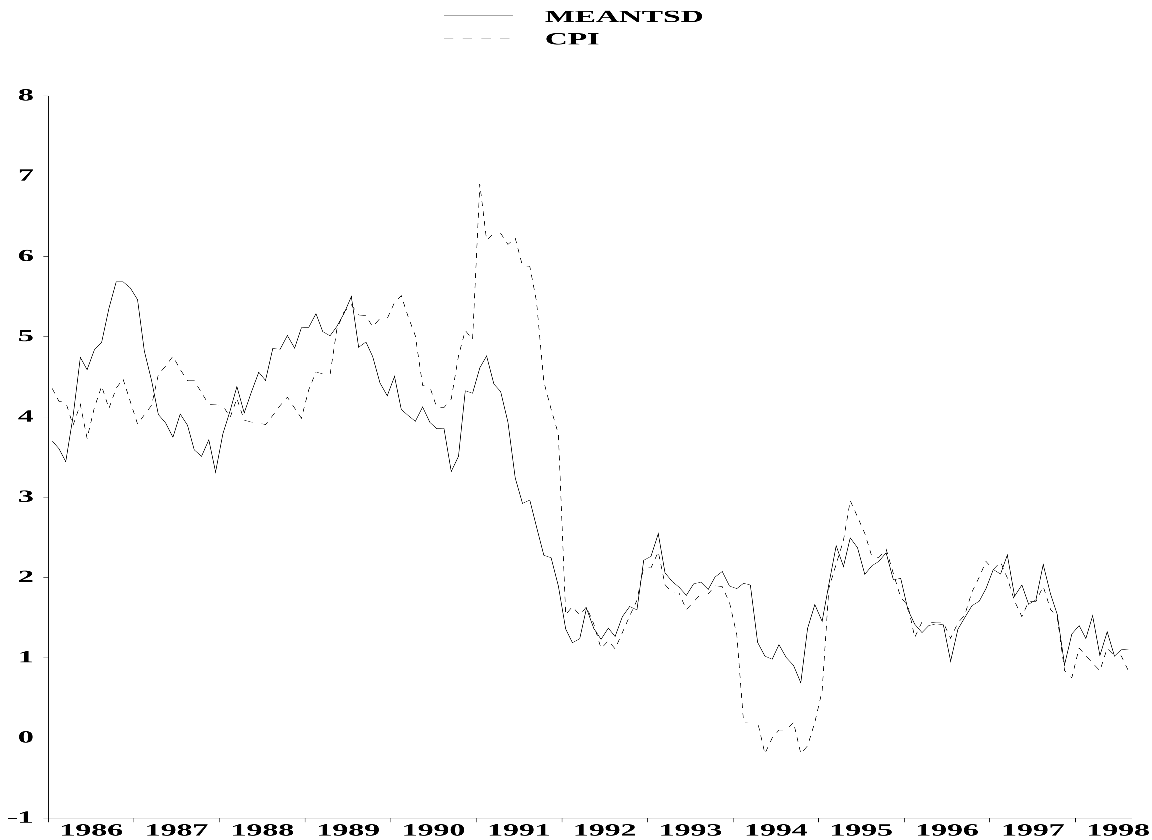


Figure 5: Year-over-year growth of CPIX and CPI (Sample 86m1 to 98m8)

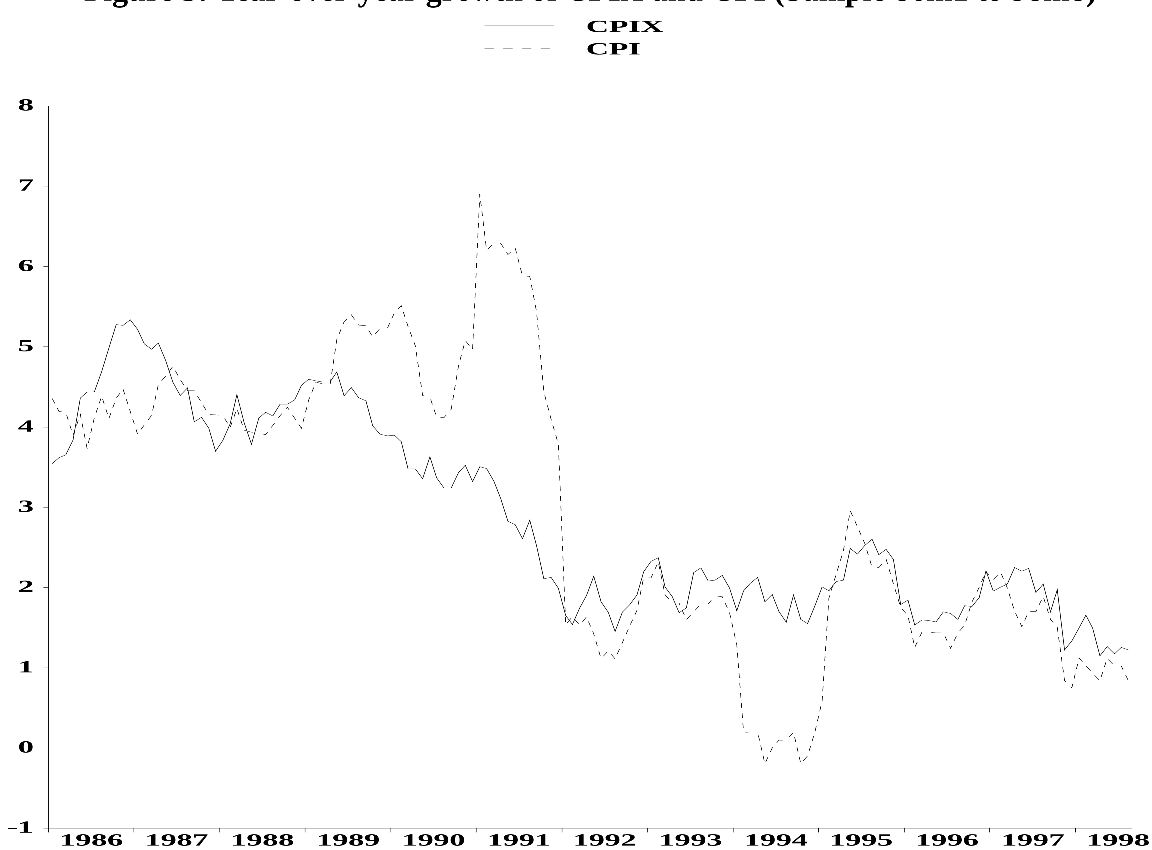


Figure 6: Year-over-year growth of CPIW and CPI (Sample 86m1 to 98m8)

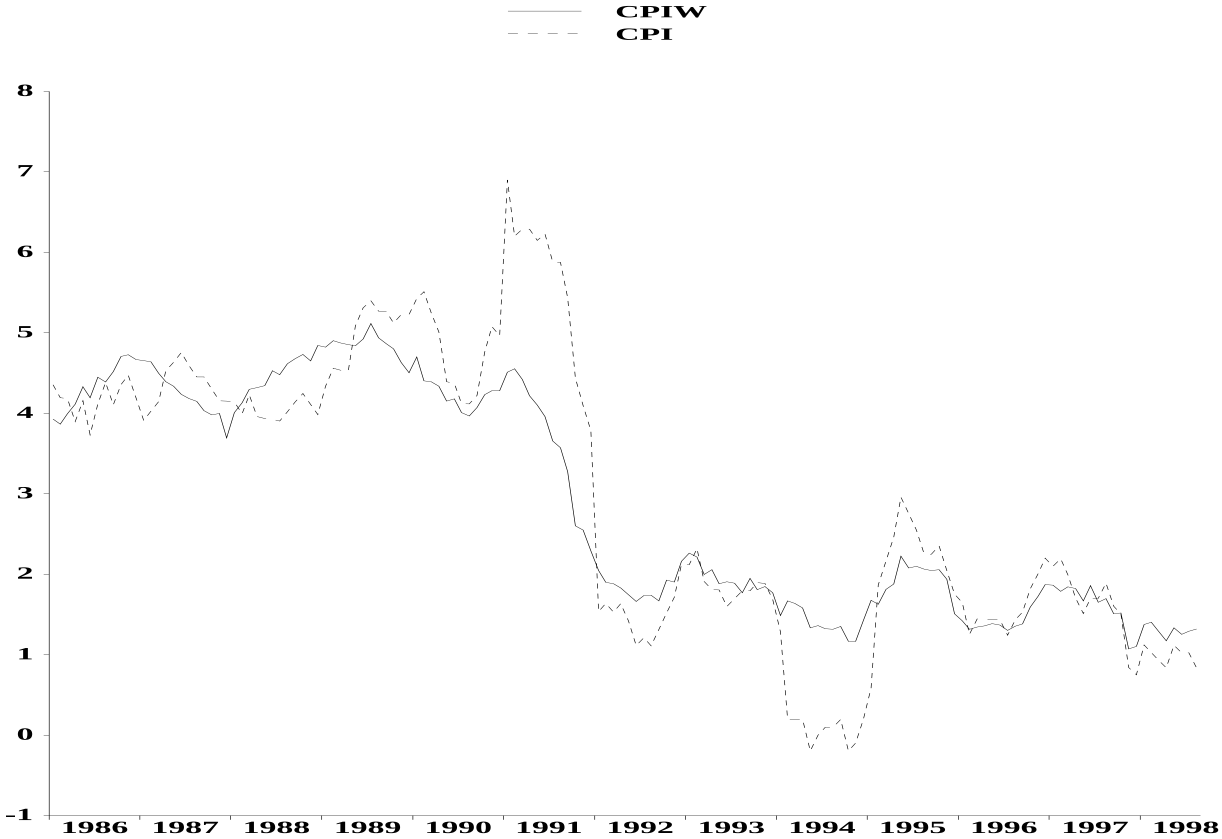


Figure 7: Moving average of weighted mean (Sample 86m1 to 98m8))

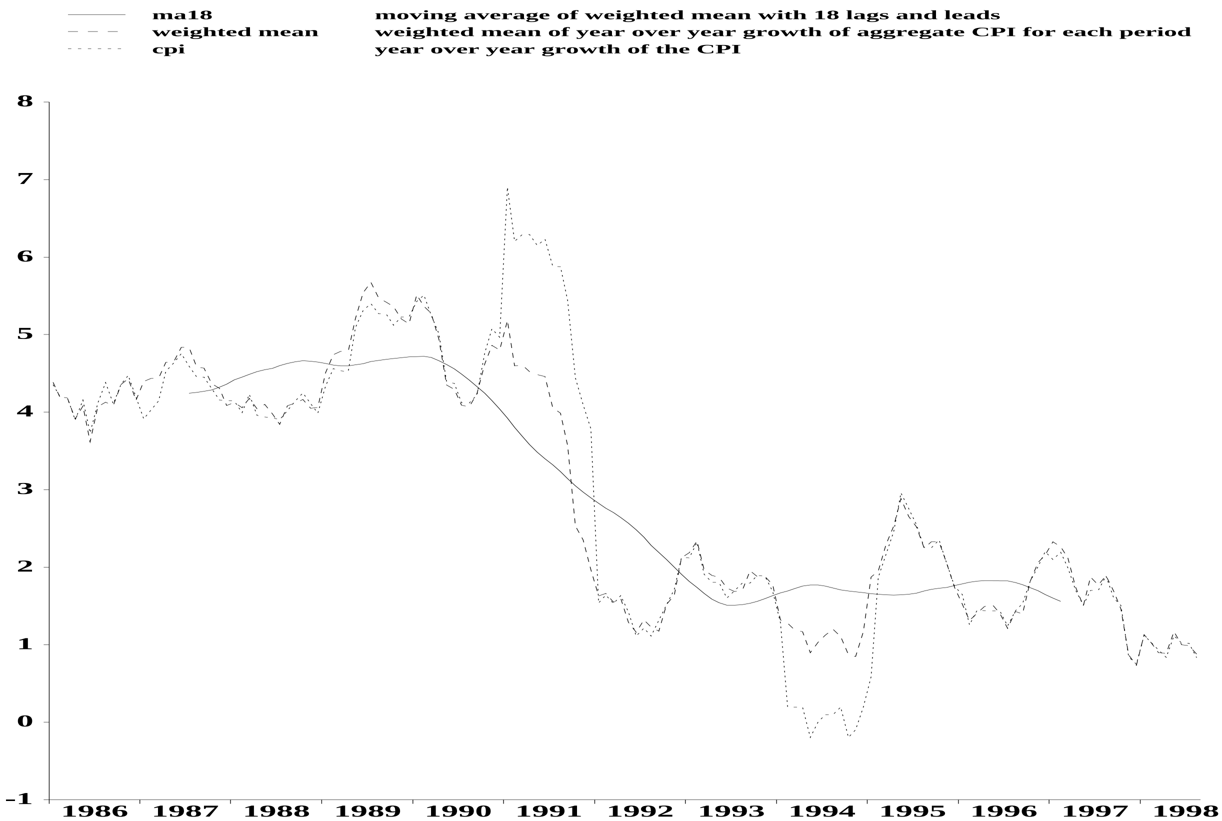
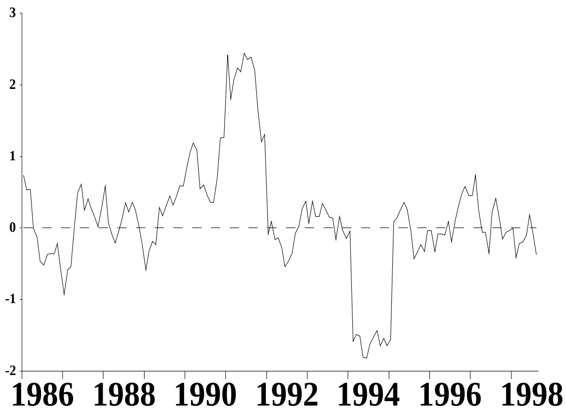
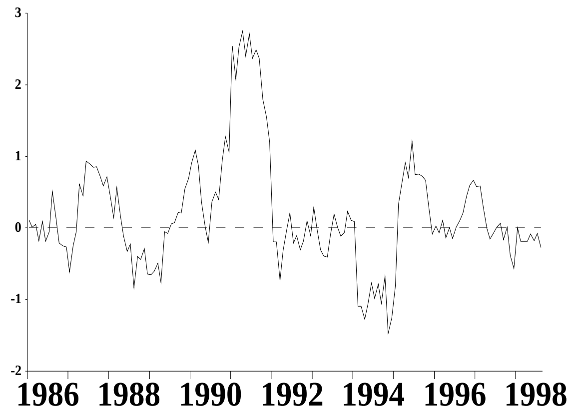


Figure 8: CPI minus core measure (Sample 86m1 to 98m8)

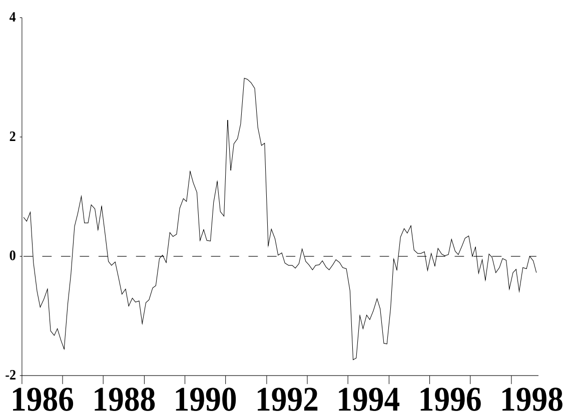
(CPI-CPIXFET)



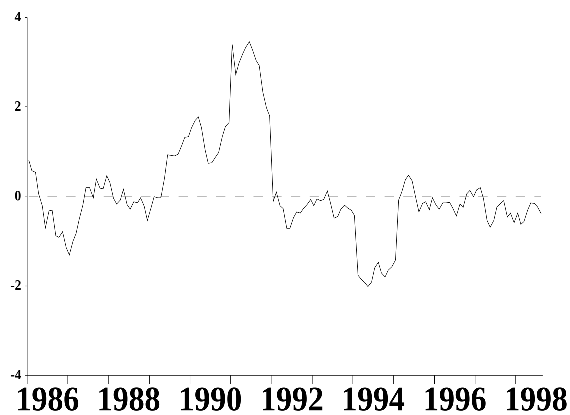
(CPI-WMEDIAN)



(CPI-MEANTSD)



(CPI-CPIX)



(CPI-CPIW)

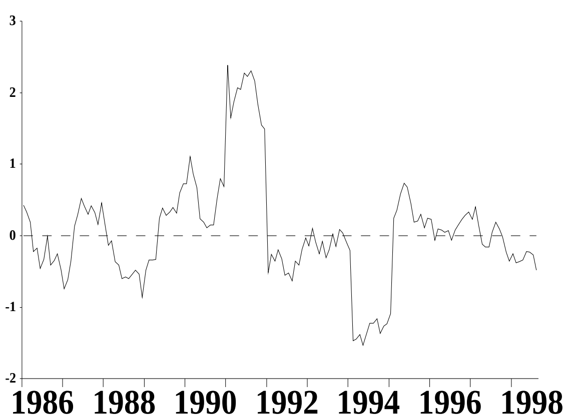


Table 1: Core inflation measures: growth over 12 months
Sample 86m1 to 98m8

	mean	standard deviation	variability (stddev/mean)
CPI	2.96	1.77	0.60
CPIxFET	2.84	1.34	0.47
wmedian	2.76	1.41	0.51
CPIX	2.86	1.20	0.42
CPIW	2.90	1.40	0.48
meantsd	2.90	1.44	0.50

Table 2: Core inflation measures : growth over 12 months
Sample 92m1 to 98m8

	mean	standard deviation	variability (stddev/mean)
CPI	1.43	0.72	0.50
CPIxFET	1.66	0.39	0.24
wmedian	1.52	0.36	0.24
CPIX	1.87	0.34	0.18
CPIW	1.66	0.30	0.18
meantsd	1.64	0.43	0.26

Table 3: Components excluded from the *MEANTSD* measure in August 1998

Component	Growth over 12 months
Natural gas	10.9%
Fuel oil and other fuels	-10.0%
Gasoline	-11.9%
inter-city transportation	6.7%
Travel services	7.0%
Tobacco products	6.6%

Table 4: Root Mean Squared Error and Mean Absolute Deviation
Sample 87m7 to 97m2

Core	RMSE[a]	MAD[b]
WMEAN	0.64	0.56
CPIxFET	0.50	0.40
WMEDIAN	0.51	0.42
CPIX	0.57	0.47
CPIW	0.40	0.34
MEANTSD	0.61	0.52

a. Root mean squared error: $RMSE = \sqrt{\left(\frac{1}{n}\right)\sum_{i=1}^{n}(core_t - ma_t)^2}$

b. Mean absolute deviation $MAD = \left(\frac{1}{n}\right)\sum_{i=1}^{n}\left|core_i - ma_i\right|$

Table 5: Correlation of core measures with future CPIxT inflation
Sample 86m1 to 98m8

	CPIxT[t]	CPIxT[t+6]	CPIxT[t+12]	CPIxT[t+18]	CPIxT[t+24]
CPI	0.92	0.65	0.46	0.49	0.40
CPIxFET	0.93	0.84	0.74	0.71	0.61
WMEDIAN	0.90	0.85	0.75	0.70	0.60
CPIX	0.86	0.85	0.79	0.77	0.75
CPIW	0.93	0.85	0.74	0.70	0.62
MEANTSD	0.89	0.85	0.73	0.70	0.64

Table 6: Correlation of core measures with future CPIxT inflation
Sample 92m1 to 98m8

	CPIxT[t]	CPIxT[t+6]	CPIxT[t+12]	CPIxT[t+18]	CPIxT[t+24]
CPI	0.61	-0.21	-0.62	0.02	0.12
CPIxFET	0.72	0.11	-0.05	0.44	0.17
WMEDIAN	0.43	-0.22	-0.46	0.10	0.29
CPIX	0.79	-0.09	-0.34	0.40	0.31
CPIW	0.57	-0.14	-0.44	0.22	0.42
MEANTSD	0.75	-0.10	-0.56	0.24	0.39

Table 7: Regressions : six months ahead (Sample 86m1 to 98m2)

CPI[t+6]	CPIxFET	WMEDIAN	CPIX	CPIW	MEANTSD
$\bar{R}^2$	0.35	0.40	0.29	0.45	0.39
α	-0.02 (0.10)	0.06 (0.35)	-0.06 (0.31)	-0.06 (0.31)	-0.06 (0.30)
β	0.82 (3.35)	0.90 (4.36)	0.56 (2.68)	1.01 (4.93)	0.80 (3.52)
p-value H_0 : (β=1, α=0)	0.75	0.86	0.07	0.95	0.62

Table 8: Regressions: twelve months ahead (Sample 86m1 to 97m8)

CPI[t+12]	CPIxFET	WMEDIAN	CPIX	CPIW	MEANTSD
$\bar{R}^2$	0.58	0.63	0.50	0.67	0.49
α	-0.06 (0.42)	0.10 (0.69)	-0.12 (0.79)	-0.13 (1.00)	-0.14 (0.85)
β	1.48 (8.31)	1.59 (10.87)	1.03 (6.41)	1.71 (10.81)	1.25 (6.29)
p-value H_0 : (β=1, α=0)	0.02	0.00	0.73	0.00	0.37

Table 9: Regressions: eighteen months ahead (Sample 86m1 to 97m2)

CPI[t+18]	CPIxFET	WMEDIAN	CPIX	CPIW	MEANTSD
$\bar{R}^2$	0.55	0.55	0.52	0.54	0.45
α	-0.19 (2.22)	-0.06 (0.61)	-0.23 (2.55)	-0.27 (2.98)	-0.26 (2.63)
β	1.39 (13.07)	1.42 (13.71)	1.01 (11.75)	1.49 (13.64)	1.16 (10.10)
p-value H_0 : (β=1, α=0)	0.00	0.00	0.03	0.00	0.02

Table 10: Regressions : six months ahead (Sample 92m1 to 98m2)

CPI[t+6]	CPIxFET	WMEDIAN	CPIX	CPIW	MEANTSD
$\bar{R}^2$	0.29	0.29	0.26	0.32	0.20
α	-0.23 (1.25)	-0.12 (0.55)	-0.41 (3.22)	-0.26 (1.37)	-0.23 (1.19)
β	0.81 (3.91)	0.96 (6.57)	0.82 (4.08)	1.00 (5.80)	0.90 (1.94)
p-value H_0 : (β=1, α=0)	0.44	0.79	0.36	0.98	0.48

Table 11: Regressions : twelve months ahead (Sample 92m1 to 97m8)

CPI[t+12]	CPIxFET	WMEDIAN	CPIX	CPIW	MEANTSD
$\bar{R}^2$	0.70	0.50	0.64	0.64	0.41
α	-0.48 (2.98)	-0.20 (1.13)	-0.83 (4.28)	-0.49 (2.76)	-0.43 (2.08)
β	1.63 (11.60)	1.67 (7.13)	1.67 (11.99)	1.85 (10.25)	1.70 (5.21)
p-value H_0 : (β=1, α=0)	0.00	0.00	0.00	0.00	0.03

Table 12: Regressions : eighteen months ahead (Sample 92m1 to 97m2)

CPI[t+18]	CPIxFET	WMEDIAN	CPIX	CPIW	MEANTSD
$\bar{R}^2$	0.66	0.34	0.60	0.46	0.44
α	-0.47 (4.83)	-0.20 (1.67)	-0.73 (6.11)	-0.43 (3.66)	-0.42 (3.55)
β	1.36 (14.55)	1.17 (7.33)	1.37 (16.91)	1.34 (12.06)	1.49 (11.15)
p-value H_0 : (β=1, α=0)	0.00	0.14	0.00	0.00	0.00

Appendix 1: An investigation of the sub-components of the CPI

Table A1: Year-over-year growth of the 54 subcomponents of the CPI

		Full sample 86m1 to 98m8		Sub-Sample 86m1 to 91m12		Sub-Sample 92m1 to 98m8	
Component	**Wt.**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**
Meat	0.0290	2.64	3.85	4.20	4.47	1.21	2.48
Fish	0.0041	3.24	3.61	4.74	3.94	1.88	2.64
Dairy products and eggs	0.0208	2.10	1.61	2.84	1.29	1.44	1.59
Bakery and other cereal products	0.0204	2.71	1.69	3.32	1.46	2.16	1.70
Fruit, fruit preparations and nuts	0.0140	1.26	5.23	3.96	5.23	-1.17	3.89
Vegetables and veg. preparations	0.0125	2.56	9.64	4.68	10.08	0.65	8.85
Other food products	0.0282	1.72	3.00	2.24	2.61	1.25	3.26
Food purchased from restau-rants	0.0498	3.06	1.57	4.60	0.74	1.67	0.37
Rented accommodation	0.0717	2.78	1.31	4.02	0.59	1.67	0.57
Mortgage interest cost	0.0491	0.94	6.02	5.42	5.04	-3.10	3.41
Replacement cost	0.0268	3.12	5.58	6.26	6.75	0.29	1.22
Property taxes	0.0355	4.78	2.59	6.61	1.05	3.14	2.46
Homeowners’ insurance prems.	0.0105	4.09	4.96	6.52	6.06	1.91	1.93
Homeowners’ maint. & repairs	0.0169	1.65	2.56	2.83	1.55	0.59	2.83
Electricity	0.0265	3.42	2.47	4.87	1.63	2.10	2.37
Water	0.0039	5.14	2.73	6.12	3.04	4.25	2.06
Natural gas	0.0102	0.78	5.46	-1.68	3.45	3.00	5.97
Fuel oil and other fuel	0.0058	0.55	11.49	0.68	15.24	0.43	6.61
Communications	0.0279	0.88	2.62	-0.68	2.29	2.28	2.06

		Full sample 86m1 to 98m8		Sub-Sample 86m1 to 91m12		Sub-Sample 92m1 to 98m8	
Component	**Wt.**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**
Child care and domestic services	0.0110	4.37	2.02	5.87	1.23	3.02	1.60
Household chemical products	0.0073	1.51	2.76	3.58	1.44	-0.36	2.31
Paper, plastics and foil supplies	0.0079	2.88	4.73	3.56	2.46	2.26	6.05
Other household goods&serv.	0.0148	2.78	2.36	4.99	1.03	0.78	1.09
Furniture	0.0137	1.82	1.99	3.17	1.62	0.60	1.44
Household textiles	0.0052	1.55	2.65	3.22	2.13	0.05	2.12
Household equipment	0.0164	1.08	1.69	2.17	1.64	0.10	0.98
Services rel. to hh furnishings	0.0033	3.26	1.73	4.51	1.10	2.13	1.39
Clothing	0.0417	2.01	1.83	3.45	1.38	0.72	1.07
Footwear	0.0093	1.85	1.93	3.30	1.32	0.53	1.37
Clothing accs. & jewellery	0.0055	1.40	2.50	3.37	1.44	-0.38	1.83
Clothing mat., notions and ser.	0.0059	2.92	1.57	4.42	0.60	1.58	0.72
Purchase of automotive vehicles	0.0630	3.96	2.75	3.77	3.33	4.12	2.10
Gasoline	0.0393	0.89	9.07	1.88	11.81	-0.01	5.51
Auto. parts, maint. & repairs	0.0230	2.05	2.17	3.68	1.94	0.58	1.01
Other auto operating expenses	0.0398	6.32	2.67	7.42	2.21	5.32	2.68
Local & communter transport.	0.0063	5.45	2.88	6.60	1.58	4.41	3.36
Inter-city transportation	0.0100	6.58	8.90	6.99	11.73	6.21	5.23
Health care goods	0.0085	3.98	3.69	7.29	2.46	0.99	1.25
Heath care services	0.0126	3.43	1.47	4.63	0.42	2.35	1.20
Personal care supplies&equip.	0.0155	1.53	2.04	2.71	1.32	0.46	2.00
Personal care services	0.0095	3.79	1.97	5.53	1.16	2.23	0.99
Recreational equip.&services	0.0206	0.45	2.94	2.81	2.02	-1.66	1.81
Purchase of recreational vehicles	0.0067	4.11	2.22	4.67	2.80	3.60	1.34

		Full sample 86m1 to 98m8		Sub-Sample 86m1 to 91m12		Sub-Sample 92m1 to 98m8	
Component	**Wt.**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**
Operation of recreationl vehicles	0.0041	3.41	3.37	5.54	3.56	1.49	1.55
Home entertain. equip.& services	0.0156	-0.55	1.98	0.35	1.90	-1.35	1.68
Travel services	0.0169	3.48	3.67	3.93	2.93	3.08	4.20
Other recreational services	0.0220	5.09	1.97	6.68	1.42	3.65	1.09
Education	0.0192	7.48	2.83	7.45	3.61	7.51	1.91
Reading mat.&oth. print. matter	0.0075	4.50	2.31	6.04	1.35	3.11	2.11
Served alcoholic beverages	0.0058	3.96	3.05	6.82	1.78	1.39	0.86
Alcoholic beverages from store	0.0130	3.97	2.55	6.02	1.73	2.12	1.55
Tobacco products & supplies	0.0130	8.91	11.17	16.35	9.82	2.21	7.49
Leaserent	0.0082	2.48	5.09	3.47	4.95	1.59	5.09
Other owned accomodation	0.0107	3.42	3.12	6.14	2.15	0.96	1.23

Table A2: Frequency of elimination of the CPI components in the calculation of *MEANTSD* (Sample 1986m1 to 1998m8))

Component	**MEANTSD**	
	#	**%**
Vegetables and vegetable preparations	76	50
Inter-city transportation	74	49
Natural gas	72	47
Fuel oil and other fuel	70	46
Gasoline	69	45
Education	54	36
Tobacco products and smokers’ supplies	53	35

Component	MEANTSD	
	#	%
Mortgage interest cost	51	34
Fruit, fruit preparation and nuts	38	25
Rental and leasing of automotive vehicles	27	18
Communications	26	17
Replacement cost	26	17
Homeowners’ insurance premiums	24	16
Recreational equipment and services	17	11
Other automotive vehicle operating expenses	17	11
Fish and other seafood	17	11
Local and commuter transportation	16	11
Travel services	16	11
Paper, plastics and foil supplies	15	10
Water	14	9
Home entertainment equipment and services	13	9
Health care goods	12	8
Property taxes	12	8
Other food products	9	6
Homeowners’ maintenance and repairs	7	5
Reading material and other printed matter	7	5
Household textiles	6	4
Clothing accessories and jewellery	5	3
Personal care supplies and equipment	5	3
Meat	4	3
Other recreational services	3	2
Electricity	2	1
Household chemical products	2	1
Child care and domestic services	2	1

Component	MEANTSD	
	#	%
Operation of recreational vehicles	2	1
Other owned accommodation expenses	1	0
Furniture	1	0
Footwear	1	0
Purchase of recreational vehicles	1	0
Served alcoholic beverages	1	0

Table A3: Frequency of elimination of the CPI components in the calculation of *MEANTSD* Sample 92m1 to 98m8

Component	MEANTSD	
	#	%
Education	44	55
Mortgage interest cost	36	45
Vegetables and vegetable preparation	35	44
Natural gas	34	43
Inter-city transportation	30	38
Gasoline	24	30
Fuel oil and other fuel	24	30
Tobacco products and smokers' supplies	22	28
Fruit, fruit preparations and nuts	21	26
Rental and leasing of automotive vehicles	18	23
Recreational equipment and services	17	21
Travel services	16	20
Other automotive vehicles operating expenses	16	20
Local and commuter transportation	16	20
Paper, plastics and foil supplies	15	19
Water	12	15

Component	**MEANTSD**	
	#	**%**
Property taxes	12	15
Home entertainment equipment and services	10	13
Other food products	8	10
Homeowners’ maintenance and repairs	7	9
Fish and other seafood	7	9
Reading material and other printed matter	7	9
Household textiles	5	6
Clothing accessories and jewellery	5	6
Personal care supplies and equipment	5	6
Electricity	2	3
Communications	2	3
Child care and domestic services	2	3
Household chemical products	2	3
Homeowner’s insurance premium	1	1
Furniture	1	1
Footwear	1	1
Purchase of recreational vehicles	1	1
Other recreational services	1	1

Table A4: Frequency of elimination of the CPI components in the calculation of *MEANTSD* (Sample 96m12 to 98m8)

Components	MEANTSD	
	#	%
Fuel oil and other fuel	19	91
Inter-city transportation	19	91
Mortgage interest cost	18	86
Education	17	81
Natural gas	14	67
Gasoline	13	62
Vegetables and vegetable preparations	10	48
Home entertainment equipment and services	8	38
Other automotive vehicle operating expenses	7	33
Travel services	6	29
Tobacco	5	24
Fruit, fruit preparations and nuts	2	10
Communications	1	5
Clothing accessories and jewellery	1	5
Rental and leasing of automotive vehicles	1	5

Appendix 2: An investigation of the skewness and kurtosis

It may be that the moments of the distribution of price changes have implications for the methodology to be chosen to measure core inflation. Bryan and Cecchetti (1993b, 1996) and Bryan, Cecchetti, and Wiggins II (1997) offer evidence that the population of price changes is characterized by skewness and kurtosis in the United States. Roger (1997) offers similar evidence for New Zealand. This skewness and kurtosis suggests the choice of an order statistic as a robust and efficient estimator of the central tendency in prices. In this Appendix, we report the skewness and kurtosis of the distribution of price changes for the Canadian CPI. Not surprisingly, we find that the price change distributions for Canada are characterized by skewness and kurtosis. However, the extent of the skewness and kurtosis depends on the horizon used to calculate the price change.

Tables A5-A8 provide summary statistics on the skewness and kurtosis in the Canadian data. To show how these calculations are made, we take the year-over-year case as an example. For each month from 1986m1 to 1998m8, we create a cross-sectional distribution of the 12th-month-over-12th-month price changes of each of 54 subindexes of the CPI.[9] Then, we calculate the skewness and kurtosis of each of the monthly distributions. As suggested by Roger (1998), these statistics take into account the different expenditure weights that were actually used each month in the calculation of the CPI. The resulting measures of weighted skewness and weighted kurtosis are presented in Table A5. Figures A1 to A5 illustrate the time series of the skewness and kurtosis coefficients graphically. Although the discussion in this section focuses exclusively on the weighted measures, we also report the more traditional, equally weighted, measures of the third and fourth moments for comparative purposes (see Table A6). Both methods of calculating skewness and kurtosis produce statistics that suggest similar conclusions.

A2.1 Kurtosis

For the Canadian data, it appears that kurtosis depends on the frequency over which the growth rates are calculated. Below the year-over-year horizon, kurtosis is very large (22.02 for monthly growth rates, 17.57 for quarterly changes). At longer horizons, kurtosis is much lower (7.82 for yearly growth rates, 6.31 for 36 month changes) but remains at problematic levels when compared to the kurtosis of 3 that corresponds to a normal distribution.

Koenecker and Bassett (1978) state that it has long been known that if a distribution is approximately normal, then the sample mean is an unbiased and efficient estimator of the population mean. However, the efficiency is sensitive to kurtosis. High kurtosis and in particular, a leptokurtic distribution, indicate that the mean is a less efficient and less robust estimator of the population or underlying mean price change than an order statistic such as the median. Canadian measures of core inflation are based on the distribution of year-over-year price changes. At a year-over-year frequency, kurtosis averages 7.82, therefore, it is important to consider the weighted median as a robust estimator of the underlying population mean and by extension, as a prospective measure of core inflation.

A2.2 Skewness

Skewness also varies with the frequency over which it is calculated. As the horizon increases, from a monthly to quarterly to yearly basis, skewness falls. On average, skewness does not seem to present a major problem for distribution of year-over-year changes, where the average weighted skewness is 0.15. For longer horizons, however, skewness increases again.

9. We choose 54 subindexes because disaggregation at this level provided us with the longest sample possible. Changes to the prices surveyed and to the basket made it difficult to extend the data back further.

At the top of each of Figures A1-A5, we graph the weighted mean and the weighted median of the Canadian data to emphasize the problem that might be created by skewness. Note that for the month-over-month data, the weighted median seems to capture the central tendency of the data. This also appears to be the case for the 3 month-over-3 month and 12th-month-over-12th-month changes in the CPI. However, for the 24th-month-over-24th-month, the weighted median is increasingly below the weighted mean. In the 36th-month-over-36th-month case, the weighted median consistently underpredicts the weighted mean. This demonstrates how it might be misleading to focus on a weighted median in the presence of skewness. Roger (1997) concludes that although the median is the most robust estimator, it is a biased estimator when the population is skewed. Roger finds that “slightly higher percentile of the price change distribution reliably corrects for the asymmetry of the distribution, while maintaining its efficiency and robustness.” He therefore calculates an alternative order statistic (the 57th percentile) as the most efficient and robust estimator for New Zealand. However, since skewness is not a major problem on average at the year-over-year frequency, there seems to be no need to calculate an alternative order statistic to the 50th percentile for Canada as Roger proposes for New Zealand.

A2.3 Seasonal adjustment

We also seasonally adjust the individual price change series using the ARIMA-X11 procedure. As shown in Table A7, this reduces both the weighted skewness and weighted kurtosis in the monthly and quarterly changes. Seasonal adjustment of the individual price changes reduces the weighted skewness for the 1986-1998 period from 0.36 to 0.19 for the monthly changes and from 0.33 to 0.17 for the quarterly changes. This supports the view that some of the observed skewness and kurtosis reflects seasonality in price changes. Thus, weighted skewness may not characterize the Canadian data even at these higher frequencies. Kurtosis is also reduced although it remains at problematic levels. Kurtosis is 19.41 for monthly changes, as compared to 22.02 in the unadjusted data; and 13.34 for quarterly changes, as compared to 17.57 in the unadjusted data.

A2.4 Changes in the skewness in the Canadian data in the low inflation period

Ball and Mankiw (1995) suggest that if the distribution of price shocks is skewed (and it would likely be positively skewed), then the mean and skewness in inflation will be correlated. This supports the interpretation that the values in the tails of the distribution represent supply shocks and therefore, also supports measures of core inflation which trim the tails of the distribution. If supply shocks represent short- to medium-term fluctuations in inflation then they ought to be excluded from the measure of inflation.

Bryan and Cecchetti (1996) challenge the existence of this positive correlation between the sample mean and sample skewness in the distribution of price changes. Their monte-carlo experiments suggest that this positive correlation is actually due to a large positive small-sample bias. The intuition is as follows. If we have a random draw from a symmetric distribution with mean zero, then draws that deviate from the population mean of the distribution will affect both the first and third moments of the distribution, leading to a correlation between the moments. They suggest that the thickness of the tails of the probability distribution from which the draws are taken will determine the likelihood of an extreme draw.[10] Therefore, the kurtosis determines the size of the small sample bias. Their monte-carlo experiments suggest that kurtosis above 4 results in a significant small sample bias.

10.Note that if you increase the variance of a normal distribution gives the same result.

We do observe a positive correlation between the mean and the weighted skewness in Canadian data. In recent years, the weighted mean of the year-over-year price changes has fallen from 4.4% for the January 1986 to December 1991 period to 1.6% for the January 1992 to August 1998 period. At the same time, the average weighted skewness fell from 0.32 in the first period to 0.00 in the second period (see Table A8). The correlation between the weighted mean and weighted skewness in inflation is quite evident in Figure A3, for example. Interestingly, weighted kurtosis has also fallen from 9.72 in the first period to 6.11 in the second period, though it remains problematic. Moreover, there is much less variation in the measures of skewness and kurtosis (both weighted and unweighted) in the recent period of low inflation, suggesting that skewness and kurtosis may reach problematic levels less often in the current low inflation environment.

Note that the dramatic decline in both weighted skewness and weighted kurtosis in the recent low inflation period would suggest that there is no one underlying population of price changes. The distribution of price changes is evolving over time with the policy environment and the resulting inflation process.

Table A5: Summary statistics for price change distributions of various horizons (Sample 86m1 to 98m8)

	M/M	3M/3M	12M/12M	24M/24M	36M/36M
	Weighted Skewness				
Average	0.36	0.33	0.15	0.59	0.96
Std. dev	3.27	2.71	1.44	0.93	1.03
	Weighted Kurtosis				
Average	22.02	17.57	7.82	6.17	6.31
Std. dev	15.67	12.08	4.19	2.94	4.28

Table A6: Summary statistics for price change distributions Equally weighted price changes (Sample 86m1 to 98m8)

	M/M	3M/3M	12M/12M	24M/24M	36M/36M
	Skewness				
Average	0.29	0.25	0.19	0.46	0.74
Std. dev	2.73	2.27	1.31	0.79	0.89
	Kurtosis				
Average	15.99	13.48	7.31	5.58	5.69
Std. dev	9.45	7.18	3.76	2.23	3.76

Table A7: Summary statistics for price change distributions
Seasonally adjusted data & Weights varied
(Sample 86m1 to 98m8)

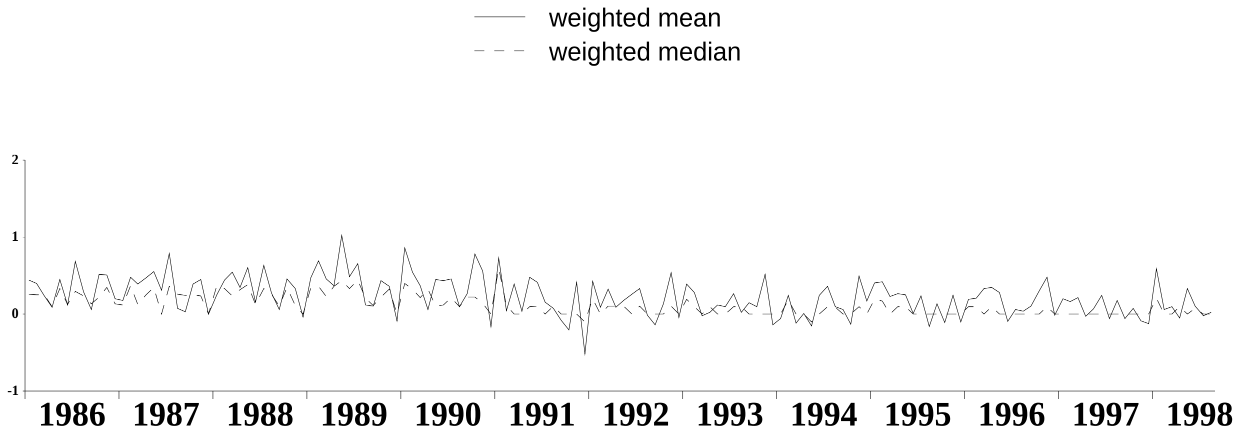
	M/M	3M/3M
	Weighted Mean	
Average	0.22	0.69
Std. dev	0.19	0.45
	Weighted Skewness	
Average	0.19	0.17
Std. dev	3.13	2.35
	Weighted Kurtosis	
Average	19.41	13.34
Std. dev	15.87	10.71

Table A8: Summary statistics for 12M/12M price change distributions

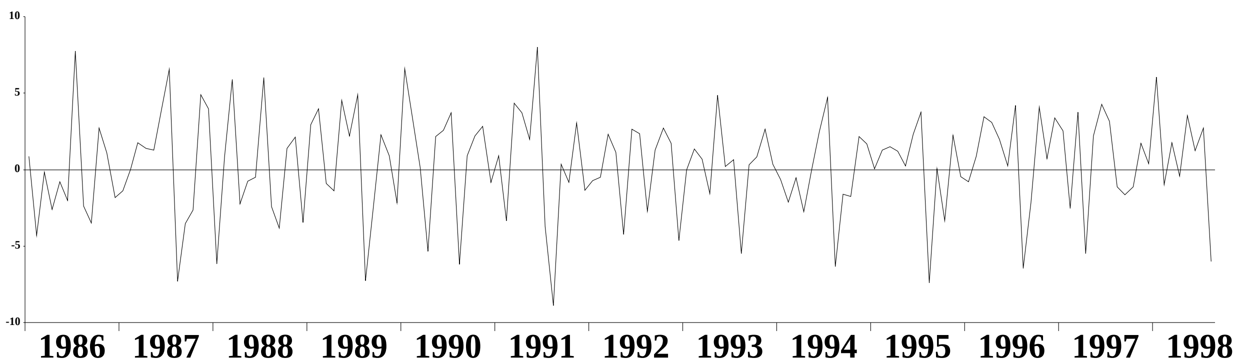
	86m1 to 91m12		92m1 to 98m8	
	Weighted mean			
Average	4.40		1.60	
Std. dev	0.66		0.49	
	unweighted	**weighted**	**unweighted**	**weighted**
	Skewness			
Average	0.07	0.32	0.30	0.00
Std. dev	1.76	1.93	0.68	0.75
	Kurtosis			
Average	9.04	9.72	5.75	6.11
Std. dev	4.23	4.42	2.40	3.12

Figure A1: month-over-month changes

Weighted Mean vs Weighted Median
Month over month growth of CPI, monthly data
Jan. 1986 to Aug. 1998



Skewness over sample
Month over month growth of CPI, monthly data
Jan. 1986 to Aug. 1998



Kurtosis over sample
Month over month growth of CPI, monthly data
Jan. 1986 to Aug. 1998

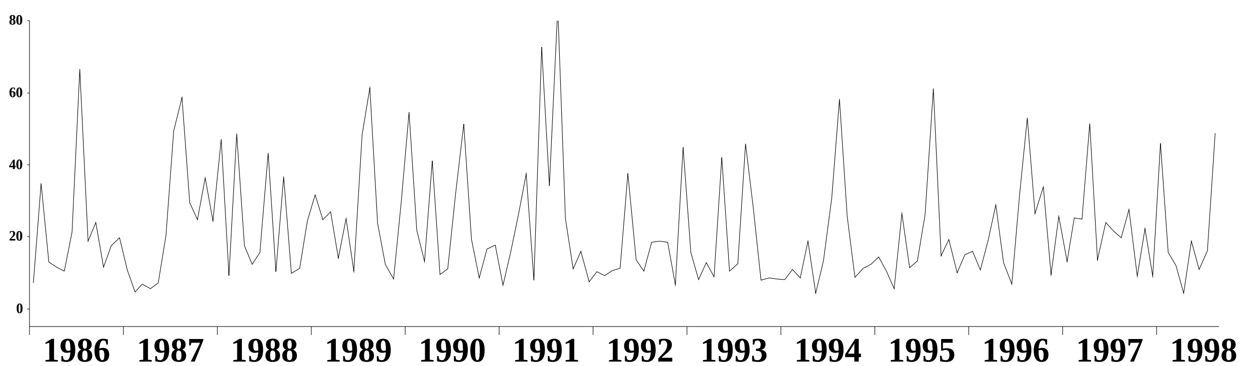
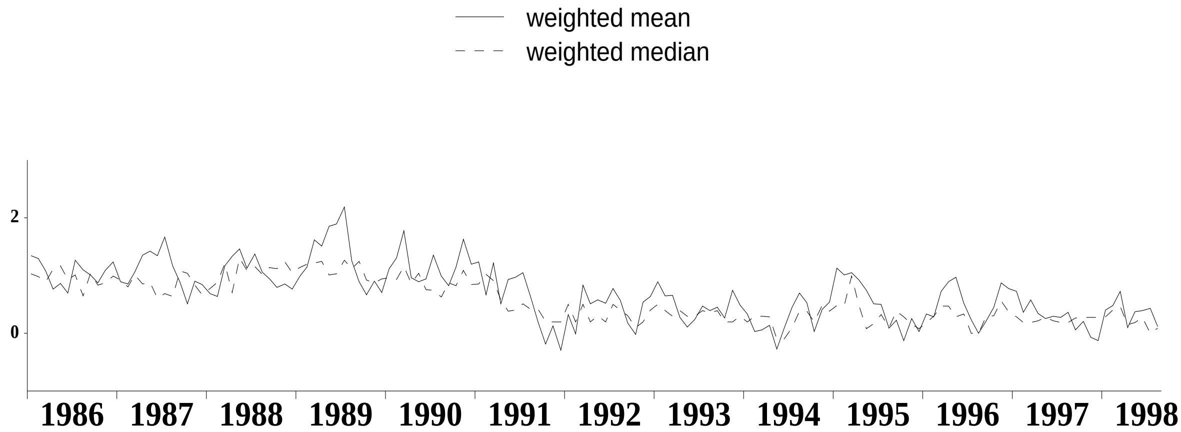
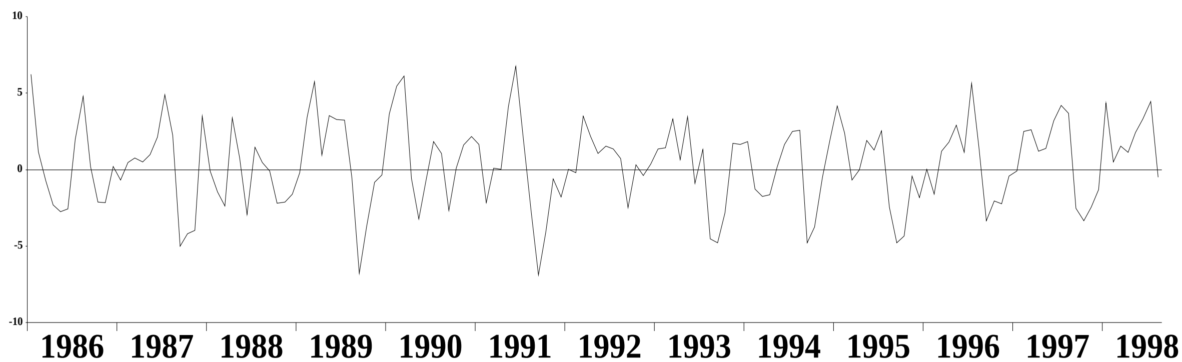


Figure A2: quarter-over-quarter changes

Weighted Mean vs Weighted Median
Quarter over quarter growth of CPI, monthly data
Jan. 1986 to Aug. 1998



Skewness over sample
Quarter over quarter growth of CPI, monthly data
Jan. 1986 to Aug. 1998



Kurtosis over sample
Quarter over quarter growth of CPI, monthly data
Jan. 1986 to Aug. 1998

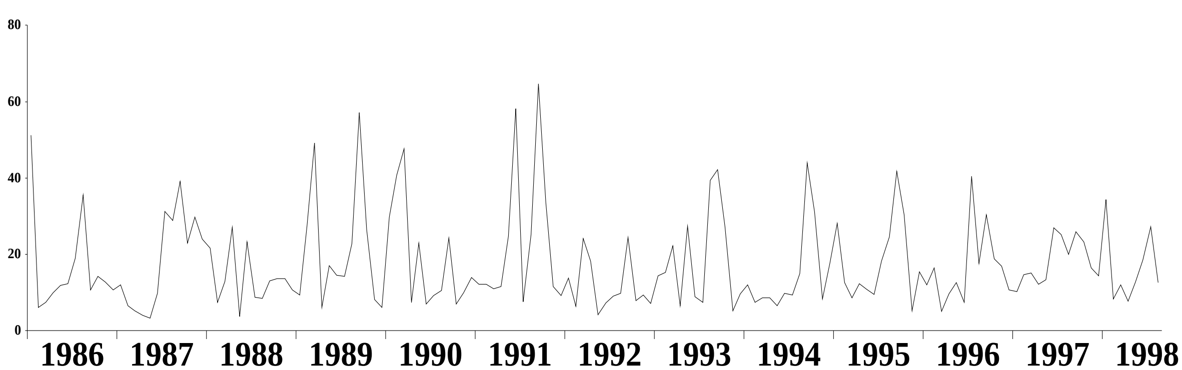
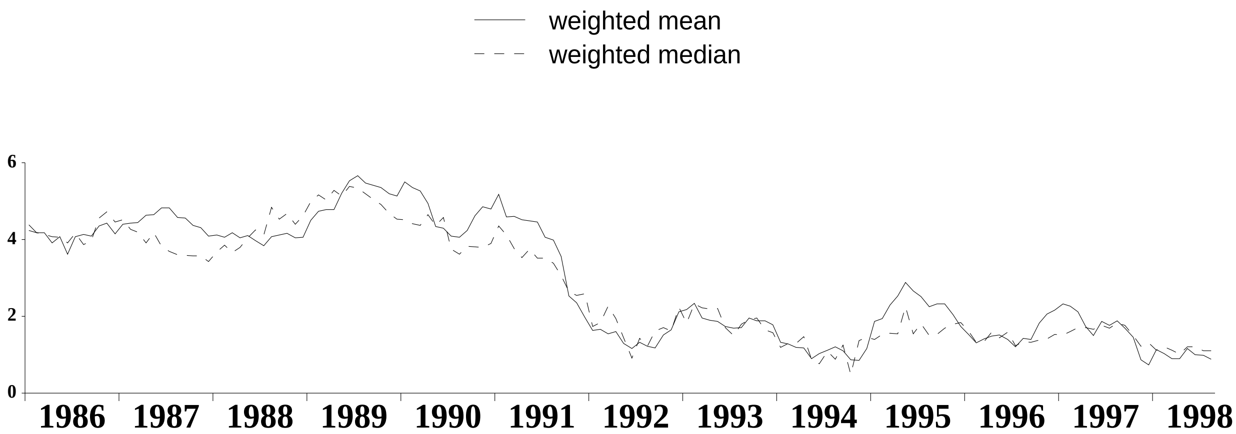
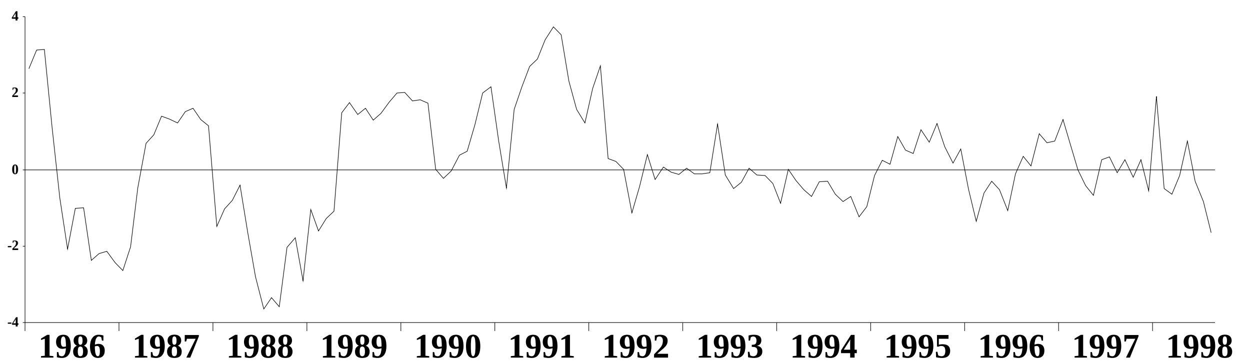


Figure A3: year-over-year changes

Weighted Mean vs Weighted Median
Year over year growth of CPI, monthly data
Jan. 1986 to Aug. 1998



Skewness over sample
Year over year growth of CPI, monthly data
Jan 1986 to Apr 1998



Kurtosis over sample
Year over year growth of CPI, monthly data
Jan 1986 to Apr 1998

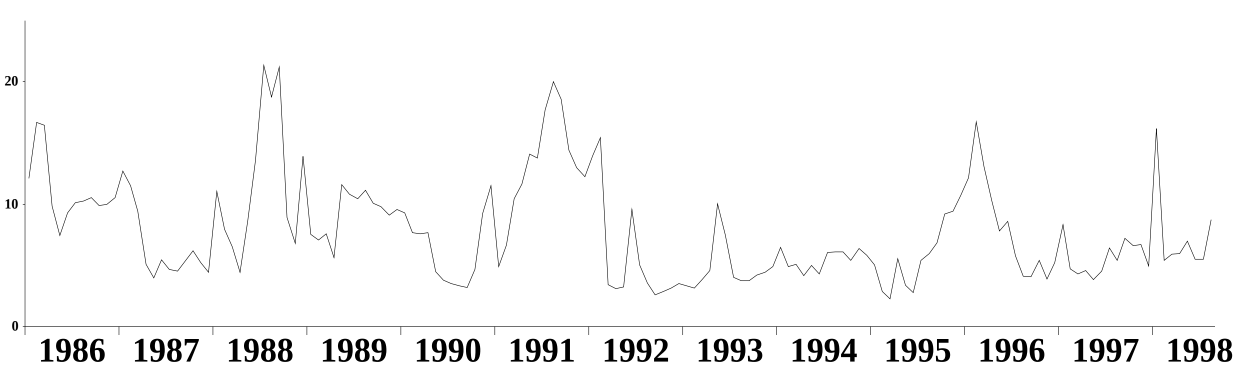
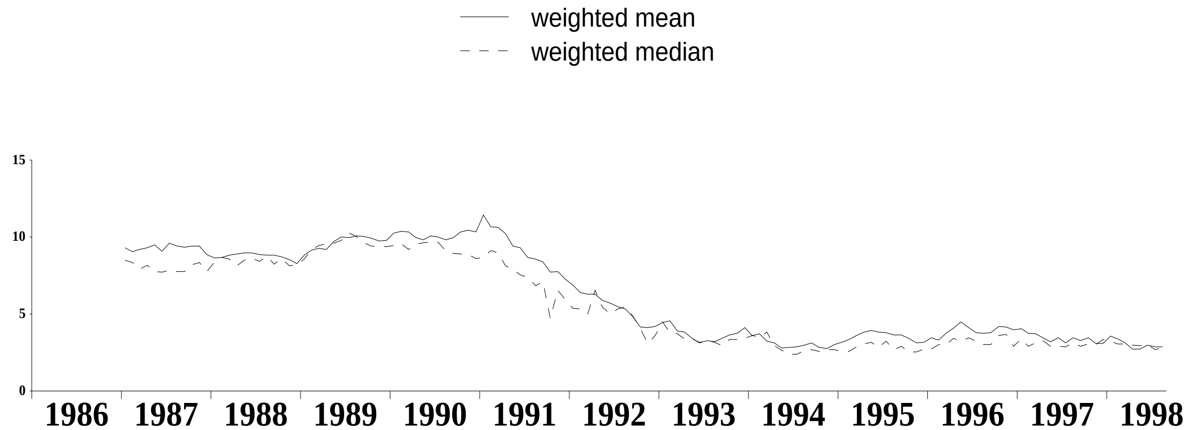
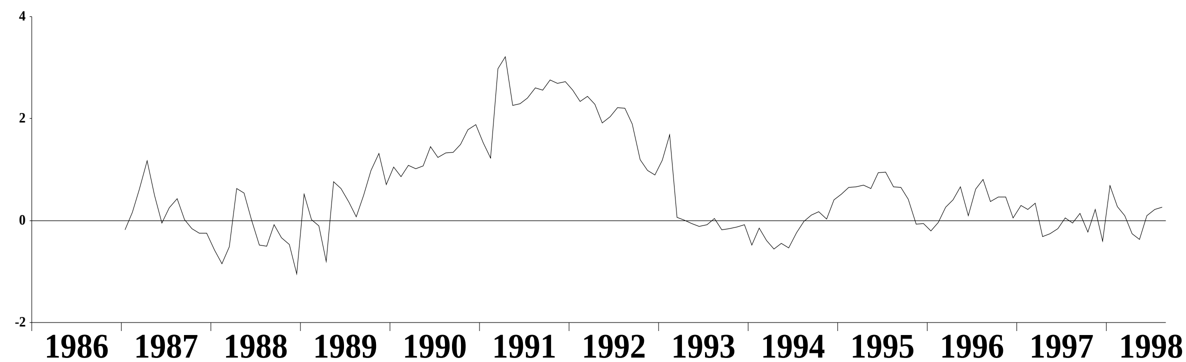


Figure A4: 24-month-over-24-month changes

Weighted Mean vs Weighted Median
24 months over 24 months growth of CPI, monthly data
Jan. 1986 to Aug. 1998



Skewness over sample
24 months over 24 months growth of CPI, monthly data
Jan. 1986 to Aug. 1998



Kurtosis over sample
24 months over 24 months growth of CPI, monthly data
Jan. 1986 to Aug. 1998

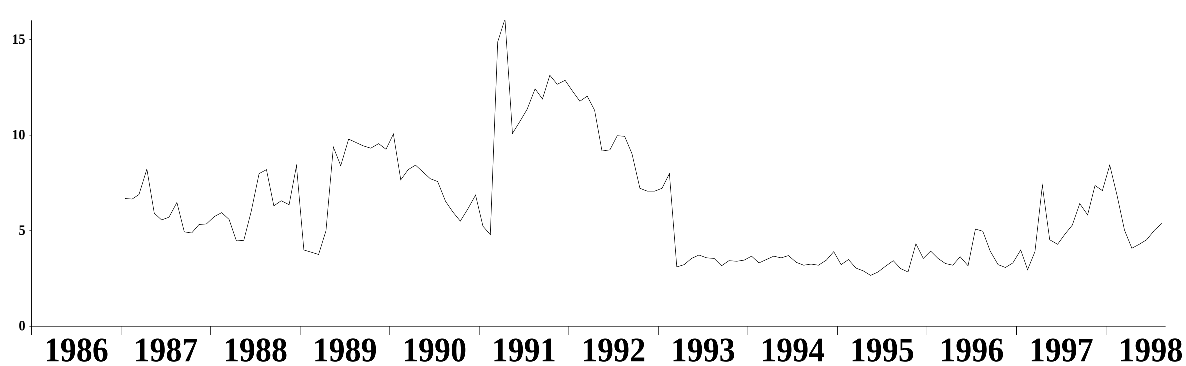
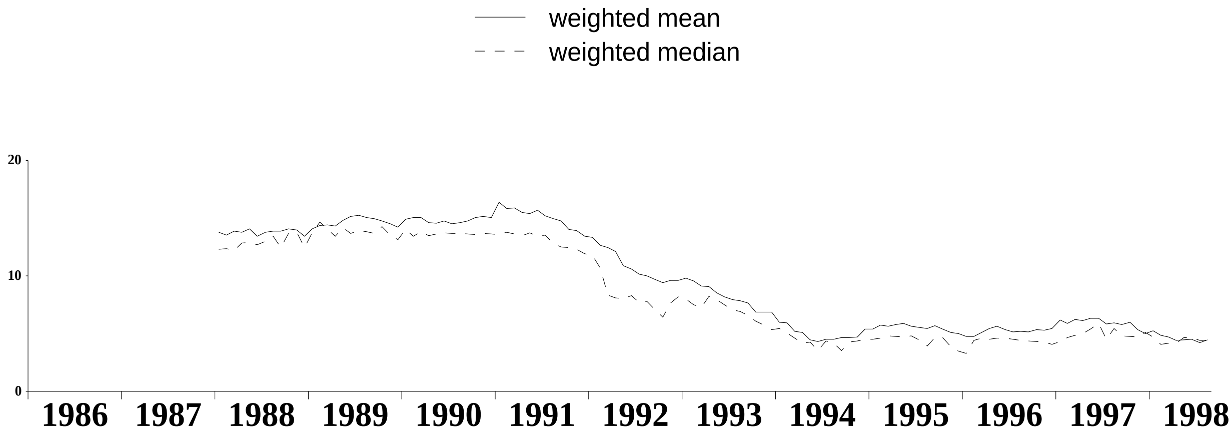
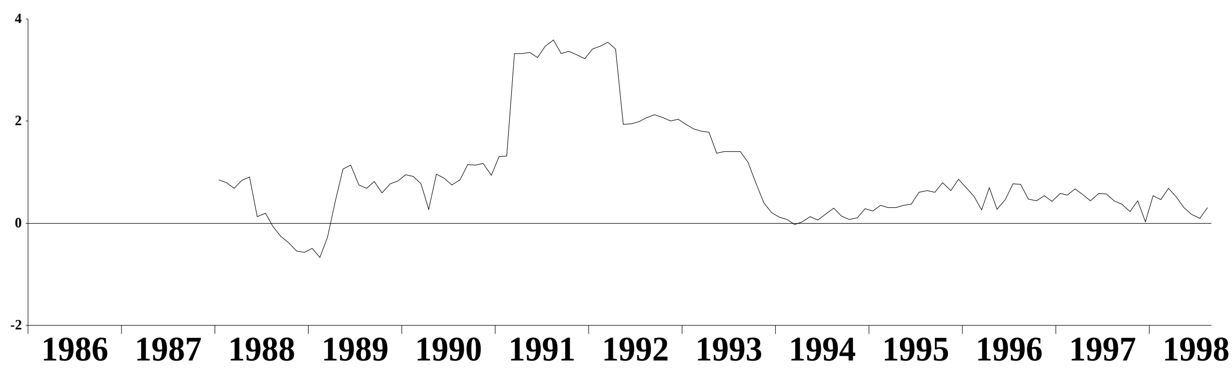


Figure A5: 36-month-over-36-month changes

Weighted Mean vs Weighted Median
36 months over 36 months growth of CPI, monthly data
Jan. 1986 to Aug. 1998



Skewness over sample
36 months over 36 months growth of CPI, monthly data
Jan. 1986 to Aug. 1998



Kurtosis over sample
36 months over 36 months growth of CPI, monthly data
Jan 1986 to Apr 1998