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## **Core inflation: concepts, uses and measurement<sup>1</sup>**

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### **Abstract**

Over the last decade central banks have tended to accord increased importance to controlling inflation and fostering policy credibility. The concept and measurement of core inflation has an important role to play both in the formulation of policy aimed at controlling inflation and in providing policy accountability. In practice, however, the concept of core inflation has tended to be ill-defined, and a wide range of different techniques have been used in trying to measure the concept.

This paper reviews the concept of core inflation, focusing on the alternative interpretations of core inflation as the persistent or generalised element of inflation. The role of a core inflation measure in policy formulation, communication and accountability is also discussed. The paper also outlines and comments on alternative empirical approaches taken to measuring core inflation.

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# 1 Introduction

Over the past decade an increasing number of central banks have set the achievement and maintenance of low rates of inflation as their primary objective. In several countries, including New Zealand, Canada, Sweden, Finland, the United Kingdom, Spain and Australia, central banks have gone as far as adopting explicit inflation targets. Coupled with the increased emphasis on controlling inflation has been an increased awareness of the importance of central bank credibility and stabilisation of inflation expectations in achieving inflation objectives without incurring significant costs in terms of output. This has led to increased efforts to provide effective policy transparency and accountability.

Both developments have spurred research into the issue of how to define and measure inflation for the purposes of monetary policy formulation, communication and accountability. The purpose of this paper is to provide an overview of issues relating to the conceptualisation and relevance of core inflation for monetary policy formulation and accountability, as well as an assessment of alternative approaches to measuring the concept.

The paper is organised as follows. In section 1, the concept of core inflation is reviewed. In section 2, the uses of a core inflation in policy formulation, policy accountability and forecasting are discussed, and these considerations are used in setting out desirable properties of a practical measure. Section 3 then considers the pros and cons of a range of alternative empirical approaches to measuring core inflation. This is followed by concluding comments.

## 2 The concept of core inflation

In general, core inflation tends to be defined in terms of the particular method used to construct a practical measure rather than in terms of what the measure is trying to capture. Nonetheless, virtually all practical efforts to measure core inflation can be seen as trying to quantify one of two broad concepts. One concept views core inflation as the *persistent* component of measured inflation. The second concept views core inflation as the *generalised* component of measured inflation. In both conceptions, however, core inflation is generally associated with expectations and demand pressure components of measured inflation and excludes supply shocks.

### 2.1 Core inflation as persistent inflation

A convenient starting point for discussion is Milton Friedman's definition of inflation as a "...steady and sustained increase in the general price level".<sup>2</sup> Friedman emphasises the distinction "...between a steady inflation, one that proceeds at a more or less constant rate, and an intermittent inflation, one that proceeds by fits and starts...".<sup>3</sup> The importance of the distinction, according to Friedman is that the steady or persistent element of inflation will tend to be incorporated into expectations and, consequently, will be comparatively benign. Intermittent or transient inflation, however, will be much less benign, precisely because it will be less readily anticipated.

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2 Friedman (1963), p 1.

3 Friedman (1963), p 25.

Similarly, Laidler and Parkin's definition of inflation as "...a process of continuously rising prices, or, equivalently, of a continuously falling value of money"<sup>4</sup> also emphasises the persistence or continuity of changes in prices as a defining characteristic of inflation.

One conception of core inflation is based on the distinction between the steady or persistent component of measured inflation, and intermittent or transient inflation. The definition of core inflation as the persistent element is reflected in a common tendency to describe core inflation and *trend* inflation as essentially synonymous, or to draw a distinction between *price level* shocks (having only a temporary impact on measured inflation) and more persistent *inflation* shocks.

In keeping with the conception of core inflation as the persistent element of inflation, Quah and Vahey (1995, p. 1130) define core inflation "...as that component of measured inflation that has no medium- to long-term impact on real output". For this component of inflation to be output neutral over the medium to long term, it must be the component of inflation that feeds into or reflects inflation expectations. This definition excludes the impact of supply shocks that may have a permanent impact on the price level, but no lasting impact on the rate of inflation. Depending to some extent on how one chooses to define the distinction between the short and medium term, however, the Quah and Vahey definition of core inflation does include cyclical movements in inflation associated with excess demand pressures.

In other words, if the short-run aggregate supply curve is given by:

$$\Pi_t = \Pi_t^R + g(X_{t-1}) + v_t$$

where:

- $\Pi_t$  is the aggregate inflation rate in period  $t$
- $\Pi_t^R$  is the long-run or trend inflation rate (which may be time varying)
- $X_{t-1}$  is a measure of cyclical excess demand pressure
- $v_t$  is a measure of transient disturbances to inflation

then the Quah and Vahey definition of core inflation can be characterised as:

$$\Pi_t^c = [ \Pi_t - v_t ] = \Pi_t^R + g(X_{t-1})$$

While non-core inflation is:

$$\Pi_t^{nc} = v_t$$

The Quah and Vahey definition of core inflation differs somewhat from the original definition of the term by Eckstein (1981). Eckstein defined core inflation as "...the trend increase of the cost of the factors of production"<sup>5</sup>, and observed that this notion of core inflation "...originates in the long-term expectations of inflation in the minds of households and businesses, in the contractual arrangements which sustain the wage-price momentum, and in the tax system." (p.7). Eckstein distinguished this element of measured inflation

<sup>4</sup> Laidler and Parkin (1975), p 741.

<sup>5</sup> Eckstein (1981), p 7.

from inflation resulting from (a) supply shocks; and, (b), cyclical changes in inflation arising from aggregate demand changes.

The key difference with the Quah and Vahey definition of core inflation is that Eckstein explicitly leaves out cyclical influences on inflation. Thus, in terms of the earlier equations, Eckstein's definition amounts to:

$$\Pi_t^c = [ \Pi_t - g(X_{t-1}) - v_t ] = \Pi_t^{LR} = \text{the long-run or trend inflation rate}^6$$

while non-core inflation,  $\Pi_t^{nc}$ , is:

$$\Pi_t^{nc} = g(X_{t-1}) + v_t$$

Quah and Vahey's and Eckstein's definitions have quite different implications for the properties of core and non-core inflation. In the Quah and Vahey definition, the difference between core inflation and non-core inflation is essentially the difference between anticipated and unanticipated inflation. In principle, changes in non-core inflation should display very little serial correlation, while core inflation will be distinctly cyclical. By contrast, in Eckstein's definition, core inflation should not show any strong cyclical tendency, unless long-run inflation expectations are strongly adaptive, while non-core inflation will be distinctly cyclical.

With regard to output, the two definitions of core inflation are a little less distinct. In a perfectly flexible price world, both definitions of core inflation, being anticipated, should be output neutral. In other words, current conventional wisdom suggests that only the unanticipated component of non-core inflation should be correlated with output. In a sticky price world where, for example, contracts prevent changes in expectations translating immediately into action, anticipated inflation may not be fully output neutral except over the medium to long term. In such circumstances, the Quah and Vahey definition of core inflation should be fairly strongly correlated with output in the short term. Even in a sticky price world, however, Eckstein's definition of core inflation should be approximately output neutral.

The differences between the two definitions should not be over-drawn. In reality, there is likely a continuous spectrum of degrees of persistence in disturbances to inflation, so that the distinctions made between transient, cyclical and long-term influences on inflation is a somewhat artificial simplification. In such circumstances, the choice of definition of core inflation should primarily reflect the length of the policy-maker's horizon: if the policy-maker focuses on a medium-term horizon in setting the stance of policy, then Quah and Vahey's definition is appropriate. Alternatively, if the relevant policy horizon is longer, then Eckstein's definition of core inflation may be more relevant.

In both definitions, however, disturbances having only a transient impact on inflation – usually associated with supply disturbances – are outside the definition of core inflation. In principle, therefore, the core inflation rate – whether Eckstein's version or Quah and Vahey's – should exhibit more persistence or less variability than the aggregate measured inflation rate.

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<sup>6</sup> This result is derived more rigorously by Parkin (1984) who goes further to show that Eckstein's core inflation rate converges to the steady-state inflation rate.

Whether, supply disturbances can, in fact, be characterised as having a mainly transient impact on inflation will, in principle, depend on the nature of the monetary policy regime. In an inflation-targeting regime, the central bank may accommodate the initial price level consequences of supply shocks, but it should act to prevent any long duration impact on the inflation rate. In other policy regimes, however, the impact of a supply disturbance on the inflation rate may be far more persistent.<sup>7</sup>

## 2.2 Core inflation as generalised inflation

An alternative conception of core inflation focuses on the *generality* of movements in prices, and is reflected in Arthur Okun's definition of inflation as "...a condition of generally rising prices"<sup>8</sup> and in John Flemming's definition of inflation as "...the rate at which the *general level of prices* in [the] economy is changing"<sup>9</sup> In this conception, measured inflation is viewed as comprising a generalised or core inflation component, associated with expected inflation and monetary expansion, plus a relative price change component, mainly reflecting supply disturbances.<sup>10</sup> Relative price disturbances are regarded as 'noise' blurring the more general or 'underlying' evolution of prices. In practice, most central bankers tend to talk about core inflation in such terms, defining core inflation as the aggregate inflation excluding a variety of items whose price movements are deemed likely to distort or obscure the more general trend of other prices.

It can be noted that whether the relative price changes are fundamentally temporary in character (eg as a consequence of, say, seasonal influences on fresh food prices) or long-lived (eg as a result of technology changes), the impact on the measured inflation rate should be temporary unless monetary policy validates the change in inflation rather than just the change in the price level arising from the shock. Consequently, relative price disturbances should typically be associated with transient changes in inflation, while the generalised or common component should tend to be more persistent.

The notion that relative price movements driven by supply shocks may 'distort' the aggregate inflation rate has been controversial for almost as long as aggregate price measures have existed. Fundamentally, objections to the notion of relative price movements affecting the general price level are rooted in the quantity theory of money. Basically, it is argued that, unless there is monetary accommodation, rises in some relative prices should be offset in terms of the impact on the aggregate price level by falls in other relative prices. If they are not, this must reflect genuine, core inflation.<sup>11</sup>

For three reasons, however, relative price movements may well affect the measured aggregate inflation rate in practice.

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<sup>7</sup> For example, with a strict money supply rule, a permanent shock to productivity growth would tend to have a permanent impact on the inflation rate unless the money growth target was adjusted.

<sup>8</sup> Okun (1970), p. 3.

<sup>9</sup> Flemming (1976), p.5.

<sup>10</sup> The identification of generalised inflation with 'core' inflation rate is by no means a recent one; Fase and Folkertsma (1996), for example, indicate that the notion of the 'inner' value of money in the work of Carl Menger in the 1920s essentially corresponds to the generalised component of inflation.

<sup>11</sup> See, eg, Fisher (1911), chapter 9, and Keynes (1930), vol. 1, chapter 6.

First, as Keynes notes “[c]hanges in relative prices may, of course, affect partial index-numbers which represent price changes in particular classes of things, e.g. the index of the cost of living of the working classes.”<sup>12</sup> Since all price indices produced by statistical agencies can be regarded as ‘partial’ indices in relation to the super-aggregate price measure relevant to the quantity theory, there is no reason why relative price changes should be neutral except in the hypothetical super-aggregate index.

Second, even if there was no problem of incomplete coverage of prices in the index, the appropriate price measure should allow for substitution in purchases. Existing standard price indices do not do so. Failure to allow for such substitution effects means that the aggregate price index will be affected by relative price movements.

Third, prices may not be fully flexible in the short run. In particular, if there are costs associated with adjusting nominal prices, relative price changes may not cancel out in terms of their effect on the aggregate price level.<sup>13</sup> The rise in the general price level need not reflect monetary accommodation. It could instead be associated with a fall in output (i.e. in the context of what would normally be described as a supply shock) or with a shift in money velocity.

A second important objection to the identification of core inflation with generalised price movements is that it implicitly presumes that movements in relative prices primarily reflect supply disturbances, whereas it is conceivable that disturbances to core inflation could be responsible for relative price changes.<sup>14</sup> If so, a clean distinction cannot be made between generalised and relative price movements. The real issue, however, is not whether relative price movements reflect supply disturbances alone, or demand disturbances alone, but whether the supply disturbances are the predominant influence on relative price changes.

Implicitly, advocates of core inflation as generalised inflation take the view that supply shocks are the most important source of relative price changes. In this case, the conception of core inflation as generalised inflation corresponds closely to the definition of core inflation as persistent inflation, since supply-driven relative price changes affecting the aggregate inflation rate should only have a transient impact on the aggregate inflation rate. At the end of the day, therefore, the difference in conceptual approaches to core inflation may not be very different in terms of substance. The principal practical difference will tend to be in the approaches taken to measuring core inflation.

### **3 Uses and desirable properties of a measure of core inflation**

Most central banks, especially those with explicit inflation targets, are concerned with both the cyclical tendency of inflation as well as its steady-state or long-run expected value. Central banks do, however, seek to distinguish between persistent and transient, or generalised and relative price inflation.

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<sup>12</sup> Keynes (1930), pp. 81-82.

<sup>13</sup> See, eg, Tsiddon (1993) or Ball and Mankiw (1994).

<sup>14</sup> See, eg, Parks (1978).

A measure of core inflation has two somewhat distinct uses for monetary policy purposes. One role is in setting or formulating policy. The second is in providing policy accountability. These uses also largely determine the desirable properties of a measure of core inflation.

### 3.1 Core inflation and policy formulation

A central bank's ability to achieve its policy objectives – whatever they may be – depends heavily on its understanding of how the economy works. One of the key relationships involved in almost any formal attempt to model the working of the macroeconomy is a short-run aggregate supply schedule.

In practice, however, the estimation of the short-run aggregate supply schedule is complicated by the problem of distinguishing between movements in output and inflation as a consequence of shifts in the aggregate demand schedule as opposed to shifts in the aggregate supply schedule. If the two cannot be effectively distinguished, then the estimation is likely to be both biased and inefficient.

A standard method for ameliorating this problem is to include 'dummy' variables, or particular relative prices (eg the relative price of oil) in the estimated equation to account for or proxy known shocks to supply.<sup>15</sup> In principle, a measure of core inflation should offer an improvement on the use of supply shock dummies or proxies by offering a quantitative estimate of the size of transient shocks to the inflation rate. By including in the estimated supply schedule the measure of supply shocks to prices implicit in the difference between the aggregate and core inflation measures, the supply schedule should be better identified. This, in turn, should lead to improved parameter estimates, improved projections, and, ultimately, to better policy.

An obvious question is why central banks should aim to differentiate between transient and persistent changes in inflation or, alternatively, between supply shocks and demand shocks affecting the measured rate of inflation. Fundamentally, the reason is that virtually all central banks – even those with explicit inflation targets – care about the evolution of output as well as inflation.<sup>16</sup> In the event of demand disturbances, monetary policy actions to counter the inflationary or disinflationary consequences will also tend to dampen deviations of real activity around the trend or potential level of output, at least to the extent that they are unanticipated in contractual arrangements in the private sector.

By contrast, in the event of supply disturbances, policy actions to counter the impact on the aggregate price level will tend to accentuate the output effects of the disturbances (as long as the short-run aggregate supply schedule is not vertical), generating a short-run conflict between the central bank's inflation and output objectives. This drawback with targeting a measure of inflation that includes the effect of supply shocks is one reason why nominal income rules (including nominal GDP and inflation plus output growth rules) are frequently advocated as preferable to strict inflation targeting as the basis for monetary policy.<sup>17</sup> An attractive property of nominal income or nominal income growth targets is

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<sup>15</sup> See, eg, Gordon (1985).

<sup>16</sup> See, eg, Stevens and Debelle (1995), pp. 90-91; Andersson and Berg (1995), p. 211.

<sup>17</sup> It may be noted that the Bryant *et al* (1993) study of alternative monetary policy regimes did not even consider strict inflation targeting. This omission may well have partly reflected the likelihood that

that they typically lead to less monetary policy response to supply shocks, since the price and output effects tend to be offsetting.

From this perspective, an inflation targeting regime in which the focus is on a measure of core inflation, minimising or excluding the influence of supply shocks, can be seen as leading to policy adjustments similar to those that would occur under a nominal income targeting regime. More specifically, basing monetary policy on developments in core inflation should not prevent attainment of the inflation objective over time, but it should allow the inflation objective to be achieved with less variability in both output and in the monetary policy instruments.

In this context, it may be noted that New Keynesian style macroeconomic models typically involve no long-term trade-off between the *level* of output and the *level* of inflation, but do feature a long-term trade-off between the *variability* of output and the *variability* of inflation.<sup>18</sup> Essentially this trade-off arises from the existence of supply disturbances to output and inflation. An important consequence of this feature is that, typically, such models suggest that central banks should generally formulate policy in a way that puts some weight on minimising the variance of output around trend, even if their ultimate objective is only with respect to inflation. However, as Goodfriend and King (1997, p. 276) observe, if the central bank focuses policy on a measure of core inflation, then the New Keynesian trade-off between output and inflation variability evaporates. That is, when policy is aimed at minimising the variability of core inflation it will also minimise output variability.

It may be argued that the case for focusing on a core inflation measure in policy formulation loses some or all of its force if policy is set on the basis of inflation projections rather than on the basis of recent inflation outcomes and if the central bank seeks to return inflation towards the target only quite gradually.

Even if a supply shock shifts the price level in the current period, for example, the impact on the aggregate annual inflation rate should disappear within 12 months. If the central bank adjusts the stance of policy in response to its projections for inflation beyond 12 months ahead, then, at least in principle, it should make little, if any, difference whether the focus is on aggregate or core inflation – the two will be the same.

Alternatively, even if the central bank adjusts policy in response to inflation outcomes or projections inclusive of supply shocks, as long as it does not seek to return inflation to target rapidly, then the response to the supply shock to inflation will be inconsequential.

Neither of these arguments is very solid. The first argument implicitly presupposes that the central bank has already been able to distinguish between the temporary impact on inflation from the supply disturbance and the ongoing element that will reassert itself 12

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strict inflation targeting would have been found to be dominated by nominal income targeting in the models considered. Haldane and Salmon (1995) do compare inflation targeting with nominal income targets and find that the latter tend to outperform the former in terms of inflation, output and instrument variability. Their model, it should be noted, is essentially backward-looking and does not use underlying or core inflation. Implicitly, therefore, their model assumes that all monetary policy actions are unanticipated, and that the central bank pursues ‘strict’ inflation targeting. It is scarcely surprising, therefore, that inflation targeting is found to be inferior to nominal income targeting.

<sup>18</sup> Goodfriend and King (1997) provide an accessible overview of the key features of the New Keynesian style models.

months down the road. In reality, unless the central bank uses a measure of core inflation in its projections, the projection for inflation even beyond 12 months is likely to be influenced by recent inflation outcomes including the effect of the supply shock. In other words, a part of the transient movement in inflation is likely to be mistaken for a more persistent change in inflation. Implicitly, this exactly what happens in New Keynesian style models.

The weakness of the second argument is that the speed with which the central bank seeks to return inflation to the target is unlikely to be completely independent of its ability to distinguish between supply and demand shocks to inflation. If the central bank could distinguish between the two in a timely manner, the appropriate response in general would be to respond fairly rapidly to eliminate the demand-induced changes in inflation, while reacting much more gradually (if at all) to the changes in inflation generated by supply shocks.<sup>19</sup> If the central bank is unable to distinguish between the shocks, a middle course of gradual adjustment may be appropriate, but it will generally result in poorer economic performance than if the shocks could be distinguished. In other words, the 'efficient' inflation-output variance frontiers of New Keynesian style models will be less efficient than could be attained by focusing policy on a core inflation measure.

A more substantive argument against the use of a measure of core inflation in policy formulation arises if the monetary policy target is specified in terms of a path for the price level rather than in terms of the inflation rate. In the case of an inflation target, the usefulness of a measure of core inflation is essentially in deciding which price movements to ignore in setting policy.

By contrast, if the central bank targets a path for the price level, it will eventually need to reverse deviations of the price level from the target path, whether the deviations reflect supply disturbances or not. Consequently, the issue for policy would become how quickly to reverse deviations from the target level of prices, regardless of the cause of the deviation. Indeed, in such circumstances, the most useful measure of core inflation would be one that distinguished between *ex ante* transient and permanent changes in the aggregate price *level*.

### **3.2 Policy transparency and accountability**

A feature of all explicit inflation targeting regimes is an emphasis on policy transparency and accountability. Although transparency and accountability are not essential features of such a regime, they are seen as helpful. The basic idea is that the credibility of the central bank's commitment to the inflation target should be enhanced if the bank's policy actions in relation to attainment of the inflation target are clearly related.

Perhaps the most important element of this openness is that it should help insulate the central bank from external pressures to pursue other objectives. Transparency regarding the central bank's approach to formulating policy and clear accounting for inflation outcomes should minimise any output benefits from monetary surprises and, therefore, the incentive to spring them. At the same time, transparency and greater policy credibility

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<sup>19</sup> If the short-run aggregate supply schedule is linear, gradual responses to demand-induced changes in inflation will tend to increase the variance of output, but not the mean. If the supply schedule is non-linear, then both the mean and variance of output will be affected. The case for reacting promptly in response to demand-induced changes in inflation is elaborated by Laxton, Meredith and Rose (1995).

should also minimise the output consequences of policy actions to correct deviations of inflation from the target.

In an inflation targeting regime, policy accountability essentially requires that the central bank provide, at minimum, an explanation for deviations of inflation outcomes from the target. Deviations may occur for a variety of reasons, and the basic function of such accounting is to distinguish between deviations that result from unanticipated shocks or the limitations of forecasting technology and those that result from policy misjudgements. Transparency can go a step further by providing forward-looking accountability. In other words, the central bank can also indicate what adjustments to the stance of policy, in its estimation, will be required to correct any deviation of inflation from the target, or to maintain inflation on target.

A measure of core inflation has two valuable roles to play in building or sustaining policy accountability and credibility. The first is that such a measure can be very helpful in the backward-looking accounting for deviations of inflation from the target as a result of supply disturbances. In other words, if a deviation occurs as a result of a supply shock, a measure of inflation that identifies such shocks will help avoid the public misinterpreting the deviation as indicating a weakening of the central bank's commitment to the target. That will minimise the risk of the shock feeding through into inflation expectations.

Second, a measure of core inflation can also play a helpful role in forward-looking policy accountability, by minimising confusion in situations where supply shocks give a perverse indication of the trend of inflation. For example, an adverse supply shock might mask a falling trend in core inflation. In such circumstances, the appropriate course for policy might be an easing of the policy stance. However, if the official inflation rate were rising as a result of the supply shock, an easing by the central bank could be misinterpreted as a weakening of the bank's commitment to the inflation target. By being able to point to a measure of core inflation that showed falling inflation, the central bank would find it easier to adjust the stance of policy in the appropriate direction without damaging its credibility.

### 3.3 Desirable properties of a measure of core inflation

The various uses of a measure of core inflation outlined above also point to a number of properties that the measure should have to be fully effective.<sup>20</sup> In particular, the measure should be:

**Robust and unbiased.** A measure of core inflation that does a poor job of distinguishing between persistent (expectations and demand-related) and transient (supply-related) movements in inflation will not serve any role well. It is also important, both in policy formulation and in providing policy accountability, that the measure not be significantly biased relative to the target measure of inflation. If the measure shows a persistent bias, its credibility in providing a public accounting for inflation performance will be jeopardised.

**Timely.** For virtually any use, it is important to have a measure of core inflation that is timely. In this context, it may be noted that if the measure of core inflation is subject to significant revision over time, this is equivalent to delay in its availability.

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<sup>20</sup> See also Roger (1995), pp. 15-19 for a discussion of desirable properties of a core inflation measure.

If the measure of core inflation is not timely, appropriate policy adjustments based on the information conveyed by the measure will be delayed, with adverse consequences for the variability of activity and inflation. Alternatively, policy adjustments will be made without regard to the measure, in which case the measure will be of little or no value in policy formulation. Moreover, if the relationship between excess demand and core inflation is non-linear, delay in responding to indications of changes in core inflation will also have adverse consequences for the average level of activity.

Timeliness is also important for the use of a core inflation measure in providing meaningful policy accountability. If the measure of core inflation becomes available only well after the official or ‘headline’ measure of inflation is released, then for the practical purposes of explaining current policy or accounting for inflation outcomes, the core measure will have little real value.

**Credible.** The measure of core inflation will be severely handicapped in a policy accountability role if the measure does not itself have much credibility. Credibility will be enhanced if the measure is either externally calculated or at least readily able to be verified externally.<sup>21</sup> If the measure is not readily verifiable by an independent agent (such as the national statistical agency), the effective accountability of the central bank will be significantly diluted. In principle, this will be the case even if the central bank has no wish to manipulate the figures and has shown no obvious tendency to do so. The fact would remain that the central bank, or, indeed, its principal (typically the finance ministry) would retain the option to manipulate the figures. The price of that option would almost certainly be reflected in a higher inflation premium built into interest rates than would be the case for a verifiable measure not susceptible to manipulation.

Credibility will also be enhanced if the measure is reasonably easily understood by outside agents. Although it is probably not essential that the technical construction of the measure be widely understood (just as the intricacies of the construction of the CPI are not widely understood), it probably is quite important that the basic approach taken to construct the measure be able to be conveyed in a non-technical way. Perhaps even more important is that deviations of the core measure from the ‘headline’ measure should be able to be explained in fairly tangible terms.

## 4 Empirical approaches to measuring core inflation

In order to translate the concept of core inflation into a practical measure, two basic issues must be addressed. The first issue is the selection of the domain of prices considered to be most relevant for monetary policy. The second is how to distinguish between persistent and transient inflation or, alternatively, between generalised and relative price influences on the aggregate price index.

### 4.1 The inflation target price domain

Most national statistical agencies produce an array of different price indices which aggregate prices over a particular domain or subset of all the prices in the economy.

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<sup>21</sup> This is one of the reasons why, in late 1997, the Reserve Bank of New Zealand discontinued calculation of its measure of underlying inflation, which was not able to be verified externally.

Typically the alternatives include, at least, a consumers price index (CPI), some form of producer price index and deflators for the national accounts.

In all the countries that have adopted explicit inflation targets to date, the inflation target has been specified in terms of some subset of the domain of consumer prices. The reasons for focusing on consumer prices are both theoretical and practical.

From a theoretical perspective, it can be argued that the ultimate concern of monetary policy is with maximising the welfare of individuals in the country. It is logical, therefore, to focus on the price index most closely resembling a consumer cost of living index, and this is more closely approximated by the CPI than by a producer price index or a national accounts deflator.

In addition, it is generally accepted that one of the main costs of inflation relates to the effects of uncertainty about future prices. Since there are far more consumers than firms in an economy, and since consumers are generally less well able to protect themselves against future price uncertainty than firms, monetary policy can minimise the uncertainty costs of inflation most by stabilising consumer price inflation rather than producer price inflation.

Perhaps most importantly, inflation expectations almost everywhere appear to be primarily related to consumer price inflation. This suggests that, in order to maximise the public credibility of the central bank's commitment to controlling inflation, and in order to minimise the output consequences of stabilising the inflation rate, the central bank should target consumer prices.

From a practical perspective, also, there is a strong case for using the CPI as the basis for an inflation target. In virtually all countries, the national statistical agency tends to put far more resources into construction of its CPI than into its other price indices. Consequently, the CPI is almost always of higher quality and more timely than the other price indices.

It is probably fair to say that most inflation targeting central banks have found the practical arguments in favour of the CPI, together with the credibility argument in favour of the CPI, to be the over-riding considerations.<sup>22</sup>

Even if the domain of consumer prices is accepted as a basis for inflation targeting and the measurement of core inflation, some particular adjustments to the CPI domain may be appropriate, depending on the conceptual definition of the CPI employed by the national statistical agency. Most CPIs are based on one of three definitions, each involving a slightly different domain of prices: a consumption-based approach; an expenditure approach based on household outlays; and an expenditure approach based on household acquisitions.

For most goods and services represented in the CPI, acquisition, outlays and consumption (including depreciation) are virtually coincident, so that differences in definition are immaterial. There are a few areas, however, in which these alternative definitions of the CPI are quite different, notably in the treatment of household expenditure on durable goods (particularly housing) and on debt service.

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<sup>22</sup> See, eg, Reserve Bank of New Zealand (1996) p. 21; Freedman (1995) p. 26; Åkerholm and Brunila (1995) p. 94.

Under the acquisitions approach, the acquisition prices of goods and services are represented in the CPI, regardless of when the goods are consumed or paid for. In the case of durable goods, such as housing, this means that the capital cost of the goods is included in the CPI, regardless of how the purchase is financed. Household expenditure on debt service is not included, since this expenditure relates to past acquisitions.

Under the outlays approach, outlays for consumption are represented in the CPI, regardless of when the goods and services were acquired or consumed. In the case of a house purchased using borrowed funds, for example, the capital cost of the house would be included only to the extent that household's own capital was used. But household outlays on interest payments would be included.

Under the consumption approach, the implicit cost of consuming goods and services would be included in the CPI, regardless of when the goods were actually acquired or how they were paid for. In the case of owner-occupied housing, both the capital value and interest payments would be excluded, while the cost of consuming the shelter services of housing would be represented either by the user cost of housing (including maintenance costs and a measure of the opportunity cost of capital) or by a rental equivalence measure of the opportunity cost of owning rather than renting accommodation.

The inclusion of interest rates in the CPI is problematic for central banks seeking to control inflation, and especially awkward for those with explicit inflation targets. This is because the inclusion of interest rates in the CPI leads to monetary policy actions having a perverse impact effect on the measured inflation rate. For example, if monetary policy is tightened to counter rising inflation, the increase in interest rates will initially boost measured inflation. If the inflation target is specified in terms of a CPI measure including interest rates, therefore, the central bank may delay tightening policy in order to avoid the initial perverse effect, or may over-tighten in response to the perverse impact of earlier tightening.

Consequently, most countries with explicit inflation targets either define the domain of the inflation target to exclude interest cost components (mainly mortgage rates) represented in their CPIs (New Zealand (since late 1997), the United Kingdom) or, alternatively, exclude them from the core inflation measure used in policy accountability (Sweden, Finland, New Zealand (until late 1997), Australia).<sup>23</sup>

The case for excluding asset prices, and especially house prices (in cases where the CPI is based on an acquisitions approach), from the domain of prices appropriate for monetary policy is less clear cut. It can be argued that monetary policy should be concerned with the evolution of asset prices in so far as they contain implicit information about future inflation, and are relevant for inter-temporal consumer welfare maximisation.<sup>24</sup> If one takes this line of reasoning to its logical conclusion, however, the domain of prices relevant to monetary policy should probably be composed *solely* of asset prices (including not only house prices but also equity prices, bond prices and so on) and exclude all current *flow* prices.<sup>25</sup>

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<sup>23</sup> In principle, the Canadian CPI is also exposed to an interest rate problem. However, Statistics Canada's measure of the effective mortgage rate involves a moving average of mortgage interest rates that is long enough to substantially dampen the impact of movements in current mortgage rates.

<sup>24</sup> See, eg, Alchian and Klein (1973) and Goodhart (1994).

Most central banks, however, would probably favour the opposite approach, defining the measure of core inflation solely in terms of *flow* prices and excluding all asset prices. Excluding asset prices from the domain of the inflation target or the core inflation measure, however, does not preclude taking asset prices into account in the formulation of monetary policy.

In practice, most industrial countries (at least) do not include house prices (or other asset prices) in the definition of the CPI. Most national statistical agencies use an estimate of the flow cost of owner-occupied shelter (either rental equivalence or user cost), or exclude housing from the CPI altogether. In no country does the central bank broaden the domain of prices in the core inflation measure to include additional asset prices.

## 4.2 Empirical measures of core inflation

Once the basic domain of prices in the inflation target is established, the next step is to define the distinction between the aggregate inflation rate based on this domain and the measure of core inflation.

As discussed earlier, there are two broad conceptions of core inflation – one as the persistent component of inflation and the other as the generalised component – and most empirical measures can be seen as being based on one or other of the approaches. The distinction between the two is not pure, however. In most cases, measures of core inflation are actually based on a hybrid of both approaches.

### 4.2.1 Persistent inflation measures

There are two main approaches measuring the persistent element of inflation. The first is based on univariate time series statistical methods to distinguish trend inflation from shocks. The second uses multivariate methods, conditioning the estimate of core inflation on information contained in other variables, in line with economic theory. In both cases, however, the emphasis is placed on identifying the persistent element of inflation.

#### *(a) Univariate methods*

Univariate time series approaches basically rely on smoothing techniques to identify some kind of trend inflation rate. This can involve something as simple as averaging over time (e.g. quarterly or annual inflation rates rather than monthly rates). A somewhat more sophisticated smoothing technique involves the use of fixed or moving seasonal adjustment factors applied either at the aggregate price level, or at a disaggregated level.

#### ***Comments:***

Neither method of smoothing can be considered to be very satisfactory from the standpoint of inflation targeting except, possibly, as a starting point for further filtering. The use of moving averages for inflation, or 12-month percentage changes does tend to reduce the volatility of the resultant series, and may better reflect the persistent element of inflation, but it also reduces the timeliness of information on core inflation, since the averaged series will be dominated by past rather than current inflation.

This criticism should not be stretched too far. Given the lags associated with monetary policy, the loss of timeliness associated with a 3-month measure of price change is probably immaterial, and more than compensated by improvement in the signal-to-noise ratio. Moreover, major adjustments of monetary policy are typically based on forecasts using quarterly data, so 3-month inflation measures are probably more appropriate than monthly data for practical purposes. The loss of timeliness with 6-month or 12-month inflation measures, however, probably is potentially damaging, especially if the gain in the signal-to-noise ratio over a 3-month measure is marginal. Cecchetti (1996) argues quite persuasively in favour of the use of 3-month inflation measures.

Seasonal adjustment techniques, of course, are only geared to dealing with the effects of transient shocks displaying regular seasonality and magnitudes. Consequently, the technique is not robust to the wide range of other transient shocks of irregular magnitude or timing. Indeed, the seasonal adjustment can be badly thrown off by irregular or outlier data points. The importance of atypical seasonality should not be understated. Seasonally adjusted data, or year-over-year price changes will still be open to distortion if the seasonal influences on prices are stable and predictable. If anything unusual occurs, these methods will fail. In short, they are not robust.

It is worth noting, however, that seasonal adjustment is a procedure that is well-accepted by the public in the sense that the reasons for seasonal adjustment are generally understood, even though the precise techniques are not. To some extent the acceptance or credibility of seasonal adjustment may reflect (i) the fact that the statistical agency is the producer, not the user, of the price series; (ii) the ability of the agency to specify precisely the adjustment methodology; and (iii) the fact that the seasonally-adjusted data are not revised (even if, perhaps, they should be!).

A second point to note is that these smoothing techniques may be more appropriate to price level targeting than to *inflation* targeting. In the case of price level targeting, the central bank should be concerned mainly with permanent innovations to the aggregate price level. Seasonal adjustment techniques and the use of moving averages of the price level may well eliminate a good deal of the transient or self-reversing innovations in the aggregate price level.

### ***(b) Multivariate methods***

In contrast with the univariate time series methods described above, Quah and Vahey (1995) employ a multivariate approach in which economic theory is brought to bear in distinguishing between core and non-core inflation.<sup>26</sup> Aggregate inflation is decomposed into a measure of core inflation that is not associated with medium- or long-term movements in output and a residual element that is associated with persistent effects on output.

The decomposition is based on a structural VAR, including the measured CPI inflation rate and a measure of aggregate output, together with restrictions on the properties of disturbances to the system. In the Quah and Vahey model, two kinds of disturbances are posited. Both are serially and contemporaneously uncorrelated at all leads and lags. Core inflation shocks are permitted to affect both output and inflation in the short-term, but are

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<sup>26</sup> See also Fase and Folkertsma (1996) and Claus (1997).

constrained to be output neutral in the long run.<sup>27</sup> Non-core inflation shocks affect output permanently, but are constrained to have no impact on the core inflation measure. In short, the time series decomposition of measured inflation is assisted by information on persistence in associated output effects.

**Comments:**

The Quah and Vahey approach is very appealing in principle. Most inflation-targeting central banks would be unlikely to object in any fundamental way with the concept of core inflation embodied in the VAR restrictions. Difficulties, however, arise in the translation of the concept into a practical measure of core inflation.

Quah and Vahey are themselves somewhat cautious about their methodology. In particular, they note that it may not be appropriate to treat all non-core inflation disturbances identically. As observed by Fase and Folkertsma (1996, p.10), “The assumption that all other changes in *measured* inflation and output may be explained by a single type of shock which invariably influences the endogenous variables in the same way may be seen as no more than an approximation.” In this regard, the models of Claus (1997) and of Gartner and Wehinger (1998) are an advance in so far as they include other variables in the VAR, allowing for somewhat different dynamics depending on the nature of the shocks. However, if the additional variables include relative price terms (eg the terms of trade), then the distinction between persistent versus transient and generalised versus relative price inflation becomes seriously blurred.

Fase and Folkertsma also note that, when the VAR is estimated in first differences (as is the case for the Quah and Vahey’s and Claus’s VARs), the models do not actually identify the *level* of core inflation, only changes in the level.<sup>28</sup> Obviously, for a central bank with a target level for inflation, this is a non-trivial problem. From an accountability perspective, the indeterminacy of the level of the inflation rate is clearly problematic. Even more importantly, because it is the business of an inflation-targeting central bank to render the inflation rate stationary, if the Bank does its job even moderately well an inflation model predicated on non-stationary inflation will eventually break down.

Beyond the technical problems noted above, the methodology involved in the approach would fail to satisfy most of the practical requirements of a measure of core inflation, for a variety of reasons:

- The choice and number of variables included in the VAR is at the discretion of the modeller and, therefore, open to question. Quah and Vahey choose as their price variable the CPI, while Fase and Folkertsma use an equally-weighted average of prices.<sup>29</sup> With the activity variable, Quah and Vahey choose industrial production, Claus uses capacity utilisation, and Gartner and Wehinger use real GDP. And so on.

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<sup>27</sup> The Bank of Spain uses the Quah and Vahey methodology to construct a measure of core inflation as well as a measure of ‘permanent’ inflation. The permanent inflation measure appears to be the long-run core measure (ie after the demand influences on inflation have worn off) and thus should correspond closely to Eckstein’s core or expected steady state inflation definition.

<sup>28</sup> Gartner and Wehinger (1998) estimate their VARS assuming trend-stationarity in the level of inflation and, therefore are immune to this criticism *if* their assumption is valid. They note that the VAR results are highly sensitive to the assumptions in this regard.

<sup>29</sup> Fase and Folkertsma argue that an expenditure weighted average of prices may not be appropriate, but offer no rationale for substituting an equally-weighted average.

Such variations in the choice of variables will alter the results of the VAR and the measure of core inflation. Similarly, adding other variables to the system will alter the VAR estimate of the core inflation rate.

- For any given choice of variables, the results of the VAR – including the inferred measure of core inflation – will vary according to the sample period involved. As the VAR is updated, so too will be the estimated core inflation rate over the entire sample period. A difficulty with the estimates presented by Quah and Vahey, Fase and Folkertsma, Claus, and Gartner and Wehinger is that they all focus on the within-sample performances of the VARs. None consider either the out-of-sample performance, or how the estimates of core inflation would have changed through the sample period as the model was re-estimated to take into account new or revised data.
- The difference between the input measure of inflation and the inferred estimate of core inflation cannot be readily explained in terms of identifiable shocks. Typically the authors identify periods in which exchange rate movements appear to have had a role in explaining divergences between the core and official measure of inflation, but there is no hard evidence presented to corroborate this, nor is there any explanation given for other divergences. The basic difficulty is that, in order to be tractable, the VAR approach must be very simplified; but this simplicity also prevents the models from being very transparent as to the sources of shocks to inflation.

#### 4.2.2 Generalised inflation measures

An alternative approach to distinguishing core from non-core inflation focuses on the degree of generality in price changes at a disaggregated level rather than on the time series behaviour of the aggregated price index. Variants on this approach involve re-weighting or modifying the constituent prices in the relevant price domain in order to highlight the more persistent general trend of prices and diminish the influence of more transient relative price shocks.

##### *(a) Specific adjustment*

This approach involves adjusting price changes for the estimated effect of particular price shocks considered to be of a one-off nature and, therefore, having only a temporary impact on the measured aggregate inflation rate. This approach has typically been applied to the impact of changes in indirect taxes, subsidies or various government levies,<sup>30</sup> but in some cases has extended to cover the impact of international trade price shocks (New Zealand), or the impact of exceptional exchange rate movements (Sweden).

##### *Comments:*

The main attraction of this approach is that differences between the core inflation rate and the headline inflation rate are very clearly related to particular disturbances. However, there are difficulties, both conceptual and practical, that make it unsuitable except in very particular circumstances.

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<sup>30</sup> The Bank of Canada, Reserve Bank of New Zealand (until late 1997), Swedish Riksbank and Bank of Finland all make adjustments to their principal measures of core inflation for the impact of indirect taxes. See Bank of Canada (1991b), Spolander (1994). The Bank of England also reports a measure of core inflation excluding the impact of indirect tax changes (RPIY).

First, criteria are needed to establish which types and magnitudes of shocks to make adjustments for, since it is not feasible to make adjustments for all relative price shocks. Such criteria are unavoidably subjective. Moreover, because the approach must limit the range of relative price shocks considered, it cannot be robust to all the kinds of shocks that ought to be ignored in a measure of core inflation.

Second, when an adjustment is made, determining the impact of the shock unavoidably calls for an assessment of what the inflation rate for a particular price series or group of series would have been in the absence of the shock. Again, a large element of subjectivity is unavoidable.

Finally, if a threshold is applied to the cumulative magnitude of shocks before adjustments are made, this will tend to result in retroactive adjustments to the measure of core inflation for shocks that have an impact on the price level spread over more than one period.

These sorts of difficulties suggest that the method of specific adjustment will generally be most suitable to circumstances in which there is a price shock that is readily quantifiable over a readily specified range of items in the CPI and over a clearly identifiable period of time at the retail price level.

Such considerations may largely account for the tendency of central banks to apply the approach mainly to changes in indirect tax rates. In principle, however, there is no reason why specific adjustment should only be applied to indirect tax changes. Basically, the rationale for making adjustments for indirect taxes is that such changes tend not to bear any reliable relationship to the general rate of inflation or excess demand pressures on inflation.

But the same argument can be applied to any number of other price shocks. Fundamentally, there is no good reason why the central bank should treat the direct impact on the price level of a change in indirect taxes any differently than, say, the impact of, say, a price 'war' between firms resulting from a change in market structure, or the decision by a discriminating monopolist to cease cross-subsidising consumers. The legal identity of the originator of the price shock is not material. In practice, however, it would be extremely difficult to apply specific adjustment to such price shocks without intimate knowledge of particular market structures and even the financial structure of individual firms.

Even in the case of indirect taxes, the practical problems in making specific adjustments will often be insurmountable. A good example is provided by the introduction of the Goods and Services Tax (GST) in New Zealand in 1986. This tax was introduced at a clearly specified rate, on a clearly specified date, and with exceptions that corresponded quite closely to particular sub-components of the CPI. On this basis, Roger (1996) was able to make a fairly precise, verifiable estimate of the direct impact of the GST introduction on the price level. But, at the same time as the GST was introduced, a wide range of other taxes, at the retail and wholesale level, were eliminated. Specific adjustments for these other tax changes simply could not be made with any degree of confidence in their accuracy. The upshot is that the adjustment for the entire package of tax changes can only be regarded as very partial and clearly biased. In a similar vein, Åkerholm and Brunila (1995) describe the difficulties involved in trying to estimate the impact on the price level of changes in subsidies in Finland.

The specific adjustment method, therefore, may be a useful method of adjustment in particular circumstances. But the heavy reliance on judgement, the difficulty of implementation, and the lack of robustness to different kinds of shocks, all mean that it has severe drawbacks as a general approach. These sorts of problems with the approach led to its abandonment as a measure of core inflation by the Reserve Bank of New Zealand in late 1996.

*(b) Systematic re-weighting of price series*

The most common method of defining a measure of core inflation is by modifying the normal, expenditure-based, weighting system in the CPI to systematically down-weight or exclude particular price series that are believed to be primarily determined by supply conditions and, implicitly, up-weight the remaining elements considered to be less prone to supply shocks.

Many countries publish measures of core inflation based on systematically excluding (i.e., zero weighting) prices of items that are either particularly volatile or that are regarded as primarily supply-determined. Typically, the excluded items involve energy and fresh food prices. An extreme version of this approach is the Australian Treasury measure of ‘underlying’ inflation, which excludes roughly half of the components of the CPI.<sup>31</sup>

A more sophisticated version of this approach avoids the simplistic dichotomy of inclusion or exclusion. Instead, the re-weighting (or, more accurately, double-weighting) of CPI sub-component series is related systematically to the relative volatility of the different series.<sup>32</sup> This approach has recently been used to define a measure of core inflation by the Bank of Canada,<sup>33</sup> and also by the Bank of Peru.

A further approach, developed by Bryan and Cecchetti (1993, 1997) and Dow (1994), seeks to identify a common trend in CPI component price series using the time series methodology of Stock and Watson (1991). Bryan and Cecchetti describe this measure as a ‘Dynamic Factor Index’. In this approach, individual price series are posited to share a common component, subject to common disturbances, as well as an idiosyncratic component reflecting relative price disturbances and, possibly, a systematic drift relative to the common component. The disturbances to the common inflation component and idiosyncratic relative price shocks are assumed to be uncorrelated either contemporaneously or serially, at all leads and lags. The resulting core inflation measure weights prices according to their determination by common as opposed to idiosyncratic shocks, rather than according to CPI basket weights.

***Comments***

The re-weighting methods outlined above have potentially significant advantages over the specific adjustment approach in terms of the ease of calculation, transparency and verifiability.<sup>34</sup> But there are also a number of difficulties with such measures, as well as some significant differences between them.

In each of the methods there is either an implicit or, in the case of the DFI, an explicit assumption that relative price changes primarily represent supply disturbances uncorrelated with the persistent or general tendency of inflation. The validity of this assumption is

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<sup>31</sup> Reserve Bank of Australia (1994).

<sup>32</sup> Wynne (1996) reports such a measure for the United States and notes that this approach was earlier suggested by Dow (1994).

<sup>33</sup> Lafèche (1997b).

<sup>34</sup> This is less true of the ‘Dynamic Factor Index’, especially if the weights are allowed to be time varying.

obviously open to question. The empirical evidence suggests that such measures do tend to improve upon the expenditure weighted mean of prices as an indicator of the persistent component of inflation, at least within sample. The various papers cited, however, tend not to consider the out-of-sample performance of these measures as indicators of the general tendency of inflation, even though this is of critical importance for monetary policy formulation. This is the crux of Blinder's (1997) criticism of re-weighting of the CPI in inverse proportion to the variability of CPI sub-components.

A second difficulty with these methods is that they may not be reliable over time. The weighting in each method is sensitive, in principle, to the choice of sample period. With each of the approaches, the re-weighting of the various CPI sub-components in the core inflation measure reflects the array of relative price disturbances over a particular sample period. In the Dynamic Factor Index there is also an exposure to changes in the order of integration of the price series as well as changes in the trend rate of drift of the relative prices of different series. As consequence, the various measures may provide a poor out-of-sample performance and lead to substantial revision of past estimates of core inflation.

These sorts of problems are particularly likely to arise when the economy is undergoing significant structural change and when the definitions of the CPI sub-components change with the periodic CPI basket revisions. Structural changes involving, say, the exposure of particular sectors of the economy to international competition, or privatisation or price deregulation of particular industries can lead to dramatic changes in the time series properties of particular prices. Redefinitions of price series, through re-weighting at low levels of aggregation, re-categorisation of particular prices, or the addition or deletion of various prices, means that the time series properties of particular CPI sub-component series may change markedly, even if the labels attached to the price indices remains unchanged.

A major additional problem is that the re-weighting of the CPI sub-components can lead to the resulting measure of core inflation having a different trend than the official measure of inflation. This will occur if the price series, either excluded or down-weighted, have a different trend than the CPI as a whole. In this event, the core inflation measure will not only exclude temporary disturbances to inflation, but also a part of trend inflation. The common trend approach should be less subject to this problem, to the extent that it allows for different trends in CPI sub-components, but a problem will still exist if trends in relative price movements change over time.

This difficulty is likely to be particularly problematic for the treatment of so-called 'non-market' prices substantially determined by government regulation or set directly by public sector institutions. Such prices typically show persistent, non-cyclical trends together with infrequent (often annual) discrete jumps. They thus contain a strong element of what would be classified as core inflation according to both the Quah and Vahey or Eckstein definitions, as well as a pronounced transient element that may or may not show up in changes in the annual inflation rate. A volatility-based measure may well lead such prices to be excluded. So might a measure in which government influenced prices are excluded on the basis of being non-cyclical. In the process, however, the information such prices carry regarding the long-term inflation rate is also eliminated. This would be innocuous if not for the fact that such prices often have a trend that is significantly different from other prices.

Finally, there is the issue of the level of aggregation of prices at which re-weighting is applied. The common measure of core inflation as the CPI excluding food and energy

applies the re-weighting at a very high level. Laflèche (1997a) and Bryan, Cecchetti and Wiggins (1997), however, examine the volatility of CPI sub-components at a lower level of aggregation. Interestingly, they find that within the food group, restaurant meals are one of the least volatile elements in the CPI in both the United States and Canada. At the same time, some highly volatile sub-components effectively have their weight increased by being retained in the core inflation measure. This highlights the danger that re-weighting of the CPI at a highly aggregated level may well end up throwing out the baby with the bath water. In other words, signal as well as noise will tend to be discarded, so that the resulting measure of core inflation could actually be less informative than the original CPI. Re-weighting at a lower level of aggregation lessens this risk, but will tend to magnify the risk that the re-weighting scheme will be rendered obsolete by changes in the time series properties of the more specific items.

### *Stochastic methods*

As with each of the other measures of core inflation based on the concept of generalised inflation, the stochastic approach also involves down-weighting outlier price changes. However, in contrast with the other approaches, stochastic approaches do not re-weight particular price series according to whether they are judged to be more or less representative *over time* of the general trend of inflation. Instead, stochastic methods involve a systematic approach to re-weighting the basket of prices on a period-by-period basis to down-weight the outlier price changes in a given period.

Like the Dynamic Factor Index approach outlined above, the stochastic approach presupposes that individual price changes involve a common, generalised inflation component plus idiosyncratic relative price shocks. If the cross-sectional distribution of relative price shocks is close to the normal distribution, then the CPI, which is almost invariably based on an arithmetic mean of prices, will be an efficient estimator of the common inflation component. However, the distribution of consumer price changes is almost always found to be highly kurtotic. In such circumstances, a variety of measures such as the median or trimmed-means will be far more efficient as estimators of the general tendency of price changes than the CPI mean-based estimator. Essentially this reflects the susceptibility of the mean to the influence of outlier price movements.

The stochastic approach to core inflation measurement is by no means new. Diewert (1995) notes that Jevons, Edgeworth and Bowley, amongst others, championed the use of the median as a measure in the late 19th and early 20th century.<sup>35</sup> And, much earlier, Laplace and Dirichelet also recognised the median as the appropriate measure of central tendency for peaked distributions.

The revival of the stochastic approach to inflation measurement has been spurred by two congruent lines of analysis. One has been the New Keynesian analysis of the roots of apparent ‘stickiness’ in price changes, particularly in a downwards direction. This analysis suggests that the price changes should not be expected to be normally distributed.<sup>36</sup> The second line of analysis has focused on efficient measurement of the central tendency of price change.<sup>37</sup> This line of analysis suggests that, given the high kurtosis typically

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<sup>35</sup> Folkertsma and Fase (1996) also note that Menger suggested the use of the median.

<sup>36</sup> See, eg, Tsiddon (1993) and Ball and Mankiw (1994).

<sup>37</sup> See, eg, Clements and Izan (1987), Roger (1997), and Bryan, Cecchetti and Wiggins (1997).

characterising the distribution of CPI price changes in most countries, robust or ‘limited influence’ estimators, such as trimmed-mean or median-based measures, will more accurately reflect the true or core central tendency of inflation.

In recent years, numerous central banks have begun to investigate such measures of core inflation and some, including New Zealand, Australia, Sweden and the United Kingdom now regularly report on them.<sup>38</sup>

### *Comments*

The pros and cons of the use of estimators such as the median have been argued, off and on, for well over a hundred years, as shown in Diewert (1995). In the debates over 50 years to the 1930s, the debate largely revolved around the use of the median as opposed to various formulations of the mean as a measure of the general price *level*. Keynes (1930), quite dogmatically, and Fisher (1911 and 1922), far less so, more or less settled the debate in favour of the mean.<sup>39</sup> It is much less clear that these earlier arguments concerning the measurement of the price level carry so much weight in the current context of targeting of the rate of inflation, since this implicitly accords no importance to the price level *per se*.

What does matter from a monetary policy perspective is whether measures such as trimmed-mean and median-based measures do tend to filter out stochastic supply disturbances, or whether they are as likely to filter out more persistent disturbances to inflation. On this score the robust or limited influence estimators appear to perform quite well. Ball and Mankiw (1992), Bryan and Cecchetti (1994), and Roger (1997) all find that such measures significantly improve either Phillips curve or monetary representations of the inflation process.

Ball and Mankiw (1992), Bryan and Pike (1991), Roger (1996), Shiratsuka (1997) and Taillon (1997b) also find that the relative price shocks derived from these measures correspond well to particular episodes of identifiable supply shocks, despite the diverse sources of these shocks. Fundamentally, this reflects one of the greatest strengths of such measures – that they do not require any pre-specification of the sources of relative price shocks. The other major strength of such measures is that, since they are based on the cross-sectional distribution of price changes, they are not, in principle, subject to revision and should be able to be computed as rapidly and as verifiably as the CPI itself.

As with any of the other measures that are based on the conception of generalised inflation as core inflation, however, the measures based on the stochastic approach are not guaranteed to distinguish infallibly between transient and persistent inflation disturbances. Indeed, Roger (1996) provides a clear, if unusual, example in which the stochastic approach fails – a generalised but, nonetheless, transient shock to the inflation rate.

An additional difficulty with such measures is that, because they are non-linear, the values of the measures will be affected by temporal and inter-temporal aggregation in a way that mean-based measures - which are linear - are not. For example, the median of monthly CPI changes need not equal the median of three-monthly price changes. Similarly, the

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<sup>38</sup> Among the other central banks that have been investigating robust measures of core inflation have been the Federal Reserve in the United States (beginning with Bryan and Pike (1991)), the Bank of Canada (Lafèche (1997a)), and the Bank of Japan (Shiratsuka (1997)).

<sup>39</sup> Fisher (1911) was well-disposed towards the median. Fisher (1922) was much less favourable except in the event that price levels or expenditure weights were measured with error.

median of price changes calculated for the CPI disaggregated into, say, two hundred sub-components need not equal the median of the CPI disaggregated into only thirty sub-components. If a central bank is to use a robust measure of core inflation for public accountability purposes, therefore, it must pre-specify the temporal and inter-temporal basis of aggregation.

The stochastic measures also share with the measures based on re-weighting the CPI a potential for systematic bias relative to the CPI. The difficulty is that the cross-sectional distribution of CPI price changes is, typically, not only kurtotic but also skewed. In this case, standard stochastic measures such as the median or trimmed-mean need to be modified to take the skewness into account.<sup>40</sup> Depending on the source or stability of such skewness, however, this may be difficult.

Finally, as with a number of other potential measures of core inflation, the robust measures of core inflation are not readily understood by the public at large. It is difficult to judge how difficult a problem this would be in practice. The construction and concepts underlying the CPI itself are not well understood by the public at large. Perhaps it is not so vital that the construction of the measure be well-understood. Of greater importance may be (a) the independent verifiability of the measure; and, (b), the ability of the public to relate measured ‘shocks’ to price developments with which they can reasonably readily identify.

## 5 Concluding comments

In principle, monetary policy focused on a measure of core inflation should be able to outperform – both in terms of output and inflation variability – a policy focused on a measure of inflation that is more influenced by supply shocks. A verifiable measure of core inflation or, equivalently, of unanticipated supply shocks to the inflation rate, should also be of considerable value in communicating policy and providing policy accountability.

Nonetheless, the reality is that cleanly and reliably distinguishes between transient and persistent influences on inflation in a way that fully meets the various desirable characteristics of a core inflation measure is probably impossible. All the techniques discussed above have drawbacks of one kind or another. In such circumstances, it is probably sensible for central banks, and perhaps also for those monitoring central banks, to pay attention to a variety of core inflation measures.

But if the concept of core inflation is to play a meaningful role in explaining monetary policy or in policy accountability, the use of multiple measures of core inflation may do more to obscure and sow doubt than to clarify or build credibility. There will naturally be pressure for the central bank to ‘tie its colours’ to one mast. Even for internal central bank forecasting purposes, there will tend to be a natural inclination to focus on a single measure of core inflation (or, equivalently, a single measure of relative price or supply shocks) for econometric purposes.

The review of alternative measures above suggests that some methods are better than others in certain important respects, and that to some extent, different approaches can be combined.

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<sup>40</sup> Roger (1997) outlines an approach to dealing with the skewness problem.

For most purposes, 3-month measures of inflation are probably more useful for monetary policy forecasting and decision-making as well as public communication than monthly measures. As a result, it may be more sensible to base a measure of core inflation on quarterly CPI data than on monthly data.

The time series approaches to core inflation measurement developed by Quah and Vahey, Bryan and Cecchetti and Dow are quite appealing in certain respects, but have significant practical drawbacks. Because they are econometric measures built on particular assumptions about the time series properties of the variables included, they are unavoidably exposed to the risk of changes in the time series properties of the data. This means that such measures are subject to significant revision over time, which undermines their usefulness, particularly in providing effective policy accountability. This weakness of the econometric approaches probably should rule out their use as a principal measure of core inflation, particularly if significant structural changes in the economy and in the monetary policy regime can reasonably be expected to change the time series properties of the data.

At least as problematic for the public role for a measure of core inflation is the difficulty of matching the transient disturbances or supply shocks identified econometrically with very tangible factors or events that lend public credibility to a measure of core inflation.

In this respect, the specific adjustment technique has an advantage and may be useful in quite particular circumstances. But on almost any other grounds, the specific adjustment technique must be regarded as inferior to approaches that allow the technique of adjustment to be set out in a pre-specified manner capable of independent calculation and verification.

The re-weighting approach currently used by most central banks to define a measure of core inflation has the important advantage of being able to be pre-specified and readily verified. It also results in a measure where relative price shocks can be readily described in tangible terms to the public. These are likely the main reasons why the approach is so commonly used. However, it is also apparent that the implementation of this approach can almost certainly be significantly improved upon by applying the re-weighting at a somewhat less aggregated level of price series than is currently common practice.

The chief drawback to the re-weighting approach is that the measure of core inflation is quite exposed to supply shocks from abnormal sources and to changes in the time series properties of the data. As with the time series econometric approaches, this vulnerability will be particularly problematic in an economy experiencing significant structural change.

The robustness to shocks from diverse sources is one of the most appealing characteristics of the stochastic measures of core inflation. In a public accountability role, the ability to pre-specify and independently verify the measure and its freedom from revision are all very desirable properties. It is for these kinds of reasons that almost all inflation-targeting central banks have been investigating and, in several cases, publishing stochastic measures of core inflation along side the more traditional measures based on re-weighting.

In developing countries, including the relatively developed countries of the East Asian region, the stochastic measures may be particularly useful for a number of reasons:

- In many developing countries, only modest amounts of resources may be devoted to construction of official price indices. As result, both CPI basket weights and prices may be measured with less accuracy than in many industrial countries.
- Moreover, as these countries develop rapidly, consumption patterns also change rapidly. As a result, even the best measured CPI weights will become incorrect quite rapidly.
- CPIs in most developing countries are much more dominated by food prices which are either quite volatile or government-regulated. Consequently, CPIs will be quite susceptible to transient disturbances in many categories.
- Rapid structural change, notably including reduced protection from international competition, reduced price regulation by governments, and privatisation of state-owned enterprises all means that the time series properties of both individual prices and activity are also changing quite rapidly.

These considerations suggest that median and trimmed-mean based measures (corrected for persistent bias), may be particularly useful in the developing country context in view of their robustness to measurement errors as well as to significant relative price shocks to almost any component of the CPI, and because they are much more robust than the volatility-based or time-series based measures to structural economic changes affecting the time series behaviour of different prices.

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