MEASURES OF INFLATION AND INFLATION TARGETING IN AUSTRALIA

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Abstract

Australia's inflation target has recently been adjusted to be specified in terms of the headline Consumer Price Index, rather than an 'underlying' measure. This followed the recent decision by the Australian Statistician to exclude interest rates from the CPI, thus removing the main obstacle to its use as the focus of the inflation target. The adjustment to the policy target reflected a judgement that the advantages of using the CPI, in terms of public recognition, outweighed the disadvantages in terms of its greater volatility.

The fact that the inflation target in Australia is expressed in terms of a medium-term average means that the distinction between 'core' and CPI inflation does not have a direct operational significance for monetary policy. The main difference is one of presentation. Indicators of core inflation remain useful in assessing and forecasting the trend in inflation, and a number of such indicators are used in policy analysis by the Reserve Bank. This paper summarises the policy context for the use of core inflation measures in Australia and analyses the properties of the main alternative measures.

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1. The Policy Context

Since 1993, monetary policy in Australia has been conducted under an inflation-targeting framework, under which the objective is to achieve a medium-term average rate of inflation of 2 to 3 per cent.[1] This was formalised with the *Statement on the Conduct of Monetary Policy* jointly released in 1996 by the incoming Governor of the Reserve Bank and the Federal Treasurer. The specification of the target as a medium-term average recognises the inherent variability of inflation, and allows some scope for countercyclical policy in the short run to the extent consistent with the target.

The Statement specified the target for inflation in terms of underlying or core inflation.[2] The main reason for this was that the inclusion of interest charges in the headline CPI from 1986 represented a serious impediment to the use of the headline index for the assessment of monetary policy. A secondary consideration was that core measures of inflation were subject to less short-run volatility than the headline measure. Recent changes to the CPI by the Australian Statistician have meant the removal of interest charges from the index from the September quarter 1998 onwards, thus removing the main obstacle to its use as the policy target. The Reserve Bank and the Federal Treasurer have agreed in the light of this change that specifying the target in terms of the *headline* CPI is consistent with the intent of the original Statement on monetary policy.[3]

The primary argument for shifting to the headline rate is that it represents a more widely accepted and understood measure of inflation. Its use is therefore likely to promote accountability, as well as public understanding and acceptance of the targeting framework. One concern in making this change is that the headline rate of inflation still includes changes in prices which are unrepresentative of general inflation and correspondingly tends to be a noisier measure of general price inflation. For this reason, core measures will remain a source of information about the general direction of price inflation. Another secondary source of information will be other indicators of the future direction of inflation such as inflation expectations and growth in unit labour costs.

Specification of the target in terms of the headline rate of inflation does not represent any significant shift in the operation of monetary policy. The medium-term nature of the inflation objective means that policy is not required to respond to unrepresentative short-term price movements or statistical noise in the headline inflation rate. Over longer periods of time, headline and core measures of inflation should be similar on average. It is clear that the Reserve Bank has achieved the inflation objective in the 1990s whether this is assessed in terms of headline or any measure of underlying or core inflation (refer Table 1). Over the 1990s, the difference between the CPI and core measures of inflation is largely explained by interest rates which, on average, fell over the period.

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[1] For a discussion of the specification of the Australian inflation target see Debelle and Stevens (1995).

[2] Although no explicit reference was made in this Statement, the assessment of the inflation target became closely associated with the Treasury measure of 'underlying' or 'core' inflation.

[3] Refer Reserve Bank of Australia (1998).

Table 1
Measures of Inflation
Average annual rate; per cent

	1990-98[(a)]	1993-98[(b)]
Consumer Price Index	2.2	1.9
Core measures:		
Treasury underlying CPI	2.5	2.0
Trimmed mean	2.5	2.0
Median price change	2.4	2.0

(a) Sample period from March 1990 to September 1998.
(b) Sample period from March 1993 to September 1998.

2. Defining Core Inflation

The concept of core inflation appears to have emerged from dissatisfaction with the Consumer Price Index (CPI) as a measure of general inflation. In Australia, the CPI was not designed as a measure of general inflation but rather as a cost-of-living index. Consequently, it includes items whose prices are not determined primarily by market forces in the economy. For example, movements in the price of tobacco are heavily influenced by changes to taxation whilst other prices, such as health and education, are largely set by the government, independent of market forces. Yet, even movements in the other prices included in the CPI will not always be representative of general inflation. Of particular concern is the potential for transitory relative price changes — that is, a market or firm-specific shock to prices — to obscure information about the general direction of inflation.

Measures of core inflation are designed to abstract from these influences on the aggregate or headline measure of inflation. However, there remains no clear consensus on what core inflation should be measuring. The silent debate would appear to be how broadly core inflation should be defined. One standard definition of core inflation relates to the concept of the implied steady-state rate of inflation: where inflation would be if output was consistent with the natural rate and the economy was free of all supply shocks.[4] Alternative definitions also include one or more of the following: the persistence or momentum in inflation, the transitory impact from fluctuations in aggregate demand and/or movements in the real exchange rate.

In the discussion of core inflation, one of two non-mutually exclusive frameworks is generally applied. As noted by Bryan and Cecchetti (1993), these frameworks should not be considered complete theories of inflation as they ignore the policy response to 'price' shocks and therefore are subject to the Lucas critique.

The most common approach taken to discuss the core rate of inflation is to describe it as the persistent or permanent component of inflation. This generally involves inflation, π, being divided in a statistical sense between its trend, π^p, and transitory components, π^t, whereby:

[4] This is the definition of core inflation in Eckstein (1981) and also in Romer's (1996) macroeconomic textbook.

$$\pi = \pi^p + \pi^t \qquad (2.1)$$

This characterisation is seemingly intentionally vague about the determinants of inflation. Correspondingly, this description of inflation affords many interpretations. (For example, compare the interpretations offered by Bryan and Cecchetti (1993), Freeman (1998), Eckstein (1981) and Kearns (1998)). The trend component is usually identified as being at least partially determined by the stance of monetary policy. The transitory component may include fluctuations in aggregate demand as well as supply shocks to inflation.

A second approach is the Phillips curve framework, which may be thought of as a special case of the general framework just described:

$$\pi = \pi^e + \alpha(y_t - \bar{y}) + \beta\Delta e_t + \varepsilon^s \qquad (2.2)$$

Equation (2.2) describes an open-economy version of the Phillips curve[5] where inflation settles down to the level of inflation expectations, π^e, in the steady state when output y is at the natural rate $\bar{y}$, the real exchange rate, e, is stable and the economy is absent of supply shocks, ε^s. A textbook definition in this framework would identify core inflation with the steady-state inflation rate, which is given by inflation expectations.

Core Measures and Monetary Policy

Some of these distinctions in defining core inflation perhaps may be clarified if more was said on the envisaged purpose for the measure of core inflation. For the purposes of monetary policy, the core rate of inflation should reflect the current supply and demand pressures in the economy. The emphasis is on the exclusion of temporary influences on inflation, due to a once-off shift in the price level resulting for example from a change in the tax rate, or due to reversals in large price movements such as may result from extreme changes in weather conditions on food prices. This measure of inflation corresponds to a broad definition of core inflation based on the distinction between transitory and persistent components of the inflation rate. It is this rate of inflation which is referred to as the 'core' measure in this paper. In terms of the Phillips curve framework, this measure would not only include the steady-state component identified with inflation expectations but would also incorporate medium-term inflationary pressures from fluctuations in demand and movements in the real exchange rate as well as any general persistence in the inflation rate. In addition to providing a current measure of inflation, core inflation may be thought of as summarising information about the predictable component of inflation and therefore provide an important input for producing forecasts of aggregate inflation.

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[5] Gruen and Sheutrim (1994) derive an open-economy Phillips curve using this intuitive explanation. Aggregate inflation is determined as a weighted average of domestic and import price inflation: $\pi = \delta\pi_d + (1-\delta)\pi_m$. Domestic inflation is described by a standard Phillips curve: $\pi_d = \pi^e + \alpha(y_t - \bar{y})$. Assume the law of one price for imports, that is, the world price of imports rises with the world inflation rate, π^*. Then the change in the real exchange rate is given by $\Delta e_t = \Delta n_t + \pi_t - \pi^*$ where Δn_t is the change in the nominal exchange rate. The open-economy Phillips curve thus derived as $\pi_d = \pi^e + \alpha(y_t - \bar{y}) - \frac{(1-\delta)}{\delta}\Delta e_t$.

The analysis presented in Section 3 below assesses some alternative methods of operationalising these concepts.

3. Comparing Measures of Core Inflation

Measures of core inflation first appeared in the 1970s as policy makers and academics came to grips with the implications of food and energy price shocks for understanding the general direction of inflation. In the U.S., as in many other countries around the world, 'core' inflation became synonymous with a measure of the CPI excluding food and energy prices. In Australia, the Federal Treasury constructed a measure of 'core' inflation which excluded components of inflation based on a wider set of criteria; the excluded components representing more than 40 per cent of the consumption basket.

In the 1980s, smoothing techniques were adopted as an alternative approach to abstract from temporary influences on inflation. More recently, attention has centred on the implication of skew and kurtosis in the inflation distribution for understanding the efficiency and robustness of the conventional CPI measure of inflation.

Quarterly inflation data is used in the following discussions as this is the highest frequency with which the CPI is published in Australia.

3.1 Measures of Core Inflation

Measures of core inflation are designed to abstract from unrepresentative price movements which may distort the headline measure of inflation. In the literature, considerable emphasis is placed on the potential for relative price changes to give misleading indications of general inflation. Relative price changes relate to market or firm-specific shocks, such as a productivity shock in a particular industry, a bout of bad weather impacting on food prices, or an exchange rate shock impacting on the traded sector of the economy. These shocks may appear as short-lived fluctuations in measured inflation obscuring the general direction of price movements.

In addition, prices which are administered by the government are often set independently of supply and demand considerations. Some prices are also sensitive to changes in fiscal policy. For example, tobacco and alcohol are subject to frequent revision of their excise taxes. Also, price changes in a particular quarter may be unrepresentative if the prices are seasonal or are only subject to infrequent adjustment.

Exclusion-based measures of core inflation are designed to directly identify and explicitly exclude distortionary changes in components of inflation. Statistical measures, on the other hand, use standard statistical techniques to filter large and influential price movements from the core measure of inflation.

The most prominent measure of core inflation in Australia, developed in the 1970s by the Federal Treasury, is a measure based on the *exclusion* of a *pre-defined* subset of the CPI. Components are excluded if they are deemed to be volatile, seasonal or subject to government policy. An exclusion-based measure of core inflation may alternatively exclude different CPI components each period based on *subjective* judgement each period as to which components have moved in a manner

unrepresentative of general inflation.

Statistical approaches to measuring core inflation are generally based on the observation that the moments of inflation are non-normal and that these moments are correlated.

In Australia, it has been observed that the distribution of quarterly inflation rates tends to be both highly skewed and leptokurtic (that is, the distribution has fatter tails than a normal distribution) (Table 2). The skewness in the inflation distribution is still apparent even after the exclusion of policy components and seasonal adjustment of the data.

Table 2: Moments of Inflation[(a)]

	Mean	Standard Deviation	Skewness	Kurtosis
		September 1980 to March 1998		
Original:				
All components	1.35	2.87	0.69	24.97
Excluding policy components[(b)]	1.23	2.45	0.49	31.36
Seasonally adjusted:				
All components	1.35	2.47	0.32	22.27
Excluding policy components[(b)]	1.23	2.06	0.41	29.32
		September 1990 to March 1998		
Original:				
All components	0.70	2.34	0.35	26.65
Excluding policy components[(b)]	0.52	2.06	0.20	37.66

(a) Source: Kearns (1998). The moments are calculated for quarterly data for the components of the CPI basket excluding interest charges.
(b) The excluded components are Government Owned Dwelling Rents; Local Government Rates and Charges; Household Fuel and Light; Postal and Telephone Services; Automotive Fuel; Urban Transport Fares; Tobacco and Alcohol; Health Services; Pharamaceuticals; and Education and Childcare.

Correlations between the moments of inflation are described in Table 3. The mean of inflation is shown to be positively correlated with both the dispersion and skew in the sample distribution of inflation. The skew and kurtosis are also shown to be positively correlated. These observations are not unique to Australia with similar distributional characteristics found for the U.S. (Bryan and Cecchetti, 1993) and New Zealand (Roger, 1997).

Table 3: Correlations of Moments[(a)]

	Mean	Standard Deviation	Skew	Kurtosis
Mean		0.30	0.25	-0.09
Standard Deviation	0.24		-0.12	-0.04
Skew	0.27	-0.07		0.38
Kurtosis	-0.12	-0.05	0.41	

(a) The correlations are for the moments of the CPI basket excluding interest charges. The lower triangle gives the correlations for September 1980 to March 1998 whereas the upper triangle is for September 1990 to March 1998. Source: Kearns (1998)

It is a well-established characteristic of inflation that when inflation is high it is also less predictable.[6] More recently, Ball and Mankiw (1992) have developed a model which supports a positive correlation between the level of inflation and the degree of positive skew in inflation.[7] The Ball and Mankiw model introduces menu costs into the price-setting behaviour of firms. Therefore, in the face of a relative price shock, only firms facing large shocks will find it profitable to change prices in the short term. If these shocks are asymmetrically distributed then 'large' shocks will be concentrated on one side of the distribution. The average rate of observed price changes is now a biased measure of the average of the distribution of shocks. The causal relationship is from the skew in the shocks facing price-setters into a biased measure of the general price inflation when calculated in the standard fashion as the mean of all price changes.

In an extension of the Ball and Mankiw menu cost model to allow for trend inflation, it is the mean inflation which leads to the observed skew in price changes. In this case, the inflation distribution may be skewed even if the distribution of relative price shocks firms face is not. The asymmetry is in the incentive firms have to change prices when faced with positive and negative 'price' shocks. De Abreu Lorenco and Gruen (1995) argue that firms which face large negative 'price' shocks will face a reduced incentive to change prices immediately as they can rely on trend inflation to do much of the work in making the desired relative price change. Whereas firms facing relatively large positive 'price' shocks will have an increased incentive to change prices as the benefits in paying the menu cost will be returned to the firm more quickly. Over a longer horizon, the skew in inflation should diminish as all firms take the opportunity to set their prices optimally.

The standard Ball and Mankiw menu cost model raises the possibility that the mean may not be the most appropriate estimator of the central tendency of a skewed distribution. The extended model introduces a distinction between the 'effectively' discontinuous distribution of shocks facing the firm in the short run versus a symmetric and continuous distribution of shocks over the long run. Therefore, whilst the mean will be both a biased and inefficient measure of the population distribution in the short term, the long-run mean is an unbiased and efficient estimator of long-run inflation. We will return to this distinction in our comparison of the estimators in the next section of the paper.

An argument raised by Zeldes (1994) and others is that an observed skew in the price distribution does not necessarily imply that the mean is a biased measure of inflation. If we believe that inflation is set by the supply and the demand for money and money is neutral, then a large rise in one price implies slower growth in the other components of inflation such that aggregate inflation is unaffected. This argument presented by Zeldes effectively relates to a long-run concept of inflation. Over the short term, inflation would still be subject to demand and supply shocks and therefore these issues concerning the measurement of inflation would remain.

The second observation, that the kurtosis and skew of the sample of the distribution is positively correlated, is unsurprising if the population distribution from which the samples are drawn is leptokurtic. A small sample drawn from a leptokurtic distribution will draw too often from the tails, generating skewness and kurtosis in the sample distribution. Bryan, Cecchetti and Wiggins II (1997)

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[6] Refer Golob (1993) for a review of these models.

[7] Balke and Wynne (1996) provide an alternative explanation for a positive correlation between the mean and skew of inflation by introducing asymmetry into the input-output relationship between sectors in a dynamic equilibrium model.

note that a mixture of random draws from normal distributions with differing variances is sufficient to produce a leptokurtic distribution.

A standard statistical solution to the difficulties associated with skewed and leptokurtic distributions is to use limited-influence estimators. These estimators reduce the weight attributed to extreme price movements compared with the mean and therefore more efficiently estimate the central tendency of the population inflation distribution if that distribution is either leptokurtic or skewed.

The weighted mean is the standard technique for calculating the CPI and can be derived as the estimator which minimises the sum of weighted *squared* deviations. Whereas, the *weighted median*, which is a limited-influence estimator, places reduced weights on extreme observations by minimising the sum of weighted *absolute* deviations. The weighted median is more intuitively calculated as the rate of inflation corresponding to the 50th percentile of the inflation distribution, appropriately weighted by the CPI components.

The *trimmed mean*, as the name would suggest, involves taking a weighted average of a subset of the CPI which trims the most extreme movements in inflation. Following the notation of Bryan, Cecchetti and Wiggins II (1997), the calculation of the trimmed mean involves first ranking changes in the prices of the sub-groups of the CPI, x_i, with their associated weights, w_i, according to size.[8] Let W_i denote the cumulative weight, $W_i \equiv \sum_{j=1}^{i} w_j$. Then the subset of the index to be averaged is given by the set, $\{I_\alpha : \frac{\alpha}{100} < W_i < 1-\frac{\alpha}{100}\}$. The *trimmed mean* which excludes α % of the distribution from each tail is then defined as:

$$\bar{x}_\alpha = \frac{1}{1-2\frac{\alpha}{100}} \sum_{i \in I_\alpha} w_i x_i \qquad (3.1)$$

The weighted average is a special case where none of the tails are trimmed, $\bar{x}_0$, and the weighted median is another special case where 50 per cent of the tails are trimmed from both sides, $\bar{x}_{50}$.

Whilst there are no general analytical results, Bryan, Cecchetti and Wiggins II (1997) demonstrate with a monte carlo experiment that for samples drawn from a mixture of normals with differing variances, the statistically efficient trim increases with the kurtosis. Also in a bootstrapping exercise, it is shown that the efficiency of the mean increases even with small trims from the distribution's tails.

The trimmed mean and weighted median are both unbiased estimators of the population mean if the population from which the samples are drawn is approximately symmetrically distributed. For New Zealand, Roger (1997) has noted a divergence between the long-run average of headline inflation and the weighted median measure of inflation. To produce an unbiased estimator of the 'population' mean as measured by the moving average, Roger promotes asymmetric trimming of the median. Instead of choosing the 50th percentile of the price distribution, to compensate for the positive skew in inflation, some percentile above 50 is chosen to produce an unbiased estimator.[9]

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[8] Refer Kearns (1998) for details of calculations of time-varying weights for the Australian CPI.

[9] Refer Kearns (1998) for details of an asymmetrically trimmed mean measure of inflation for Australia.

3.2 Criteria for Comparison

Whilst the statistical measures described above may represent technical advances in the calculation of core measures of inflation, it is not apparent that these measures will provide the best measure of 'core' inflation in all circumstances. Most inflation-targeting countries specify their target in terms of a headline rate of inflation but still publicly discuss 'core' measures in defence of their policy stance. The public credibility of the core measure in this circumstance earns a higher weight than statistical superiority. Whereas, for internal purposes, policy makers can weigh the information from a variety of core and headline inflation measures — with respect of their relative advantages — in their assessment of domestic inflationary pressures.

Credibility

The desired properties of a credible measure of core inflation would include that the method of calculation be transparent, verifiable, easy to communicate, widely recognised, produced on a timely basis, not subject to revisions and calculated independently of the central bank.

A simple measure which excludes a defined subset of the CPI basket perhaps best meets these criteria. Australia's inflation target was initially specified in terms of core inflation and it was on this rationale that the target came to be closely associated with the Treasury measure of core inflation.

An exclusion-based measure which subjectively excludes components from the CPI is unlikely to hold up as a credible measure of core inflation. The statisticians must first be able to identify significant supply shocks and other unrepresentative movements in inflation. This may involve some arbitrary decisions as to what constitutes a significant shock and therefore which components should be excluded. Unless the statisticians institute specific rules for excluding components, the index will not even be verifiable. Even if such rules are in place, the calculation of the core measure of inflation is not likely to be very easy to communicate as it requires detailed explanations about movements in individual components of inflation in the period.

The statistical measures of core inflation are both transparent and verifiable by independent observers. However, the justification for calculating trimmed means and weighted medians is based on the non-normality of the inflation distribution — at least for high frequency data — and the inefficiency, in a statistical sense, of the mean in these circumstances: concepts not easy to explain to the general public. Consequently, these measures of inflation have held little prominence in public discussions of inflation in Australia. Although the choice of trim for the calculation of the trimmed mean and the choice of percentile for an asymmetrically trimmed median are subjectively made, these measures of core inflation are likely to be fairly robust to these decisions. If statistical measures are able to prove their superiority through consistently providing the most appropriate indications of current inflation then they may potentially become established as credible measures of inflation.

As for timeliness, three out of four of these measures of core inflation can be calculated with no time delay following the publication of the price components of the CPI. The exception is the measure which excludes components based on subjective judgement. Time will be required to assess which components of inflation have been subject to unusually large shocks during the period and whether large movements in the prices of some components of inflation represents information or noise. In addition, the index may be subject to revision as more information becomes available as to the causes of a particular episode of inflation.

Robustness, efficiency and bias

It is also desirable that the estimator of core inflation is robust to distortionary price changes in *any* of the components of the CPI. The prime criticism of the measure of core inflation which excludes a defined subset of the headline price index is that it is not robust to large shocks to components of inflation which are included in the measure. In addition, this index excludes components from the CPI even when they contain useful information about the direction of inflation. The exclusion-based measure which involves subjective judgement is potentially more robust to these criticisms, but this advantage of this measure will rely on the quality of the judgements made.

The statistical measures however, by design, place a reduced weight on large price movements from any source and are therefore more robust to the distortionary impact of large price movements. The advantage is that these approaches do not require any pre-specification of the source of the price disturbance.

However, the danger is that the systematic exclusion of large movements also excludes any information contained in these price changes (Roger, 1994). A particular example is a shock to the exchange rate. The exchange rate change will have a relatively direct impact on the price of imported and import-competing goods. However, this change in the exchange rate will also have a less direct impact on inflation over time as the change in the price of imported intermediate and capital goods feed their way into the price of final domestic products. In a small open economy such as a Australia, the exchange rate is an important source of persistence in aggregate inflation. The statistical criteria provided in Section 3.3 give some indication of the information content in the excluded components of inflation.

It is a more complicated issue as to in what sense the measure of core inflation should be 'unbiased'. The question raised by Roger (1997) is whether the long-run average of core inflation should be an 'unbiased' estimator – in a non-rigorous sense – of long-run headline inflation. The appropriate answer to this question is not immediately apparent. We offer one theoretical reason and one practical reason why the long-run averages of core and headline inflation should be the same.[10]

If we consider the extension to the Ball and Mankiw menu cost model to incorporate trend inflation, then the skew in the observed distribution of price changes is a result of an increased incentive for firms facing positive shocks, over firms facing negative shocks, to change their prices rather than any skew in the underlying distribution of shocks. Given time, firms fully adjust to their optimal nominal price. In this case, despite a persistent skew in quarterly inflation rates, the long-run distribution is symmetric and therefore the long-run average of price movements is the appropriate measure of long-run inflation.

The practical argument is perhaps more compelling. If the central bank has adopted an inflation target with reference to a headline measure of inflation, then it is desirable that core measures of inflation used to inform policy have the same long-run mean as the headline inflation rate. Clearly, any persistent deviations may misinform policy makers about the current and future position of inflation relative to the target rate or band. In addition, persistent deviations between headline and core

[10] Clearly, an array of theoretical models can be envisaged for which the long-run averages of core and headline inflation would differ.

measures of inflation will tend to undermine the credibility of the core measures of inflation as a defence of policy actions.

Conceptually correct

It would seem appropriate to ask at this point, whether these measures of core inflation are actually measuring the desired concept of core inflation as defined in section 2 of the paper. That is, the measure of core inflation should abstract from the direct impact of exogenous shocks and other movements in prices which are unrepresentative of more generalised inflation in the quarter. However, we would like the core inflation measure to still include the persistent influence fluctuations in aggregate demand and fundamental movements in the exchange rate exerts on inflation. The exclusion-based measures are clearly designed to measure this notion of price inflation.

The statistical measures of inflation are designed to identify the centre of the distribution of price changes in the components of the CPI in the period. As such, it is more difficult to match the concept with the calculation. However, since only a cross-section of information is contained in these measures, they will tend to include current inflationary pressures from demand fluctuations and real exchange rate fluctuations, as desired. The simple statistical tests presented below also provide some insight into the relevance of these measures.

3.3 Statistical Criteria

The emphasis in this paper has been on producing measures of core inflation which represent that rate of inflation most useful for the setting of monetary policy. The desired criteria for assessing this measure of inflation therefore does not include minimisation of its variance over time or minimisation of its deviations away from some long-run moving average. Some simple tests can be applied to Australian data to consider how closely the different measures accord with the economic intuition of core inflation.

The excluded component from the CPI would generally be expected not to contain any forward-looking information about core inflation. This is because a preferred measure of core inflation should exclude the temporary impact of 'price' shocks but should include any persistence in inflation arising from these shocks. A simple test of this hypothesis is to conduct a Granger-causality test of the impact of the excluded component on the respective core measure of inflation. Following Roger (1997) the excluded components are referred to as "relative price" shocks, RP_t, and are measured as the difference between the headline CPI and the respective core rate of inflation. The results, presented in Table 4, show that for the statistical measures, the "relative price" shocks do not contain leading information about core inflation. However, for the exclusion-based Treasury measure, the excluded component does contain leading information about this measure of core inflation suggesting that some information is being disregarded when this measure is calculated.

Table 4: Granger-causality Tests

$H_0 : \beta_i = 0,\ i = 1,\ldots,4$ [(a)]

	Measures of Core Inflation[(b)]		
	Treasury	Trimmed Mean	Weighted Median
$\Delta core_t = \sum_{i=1}^{4} \alpha_i \Delta core_{t-i} + \sum_{i=1}^{4} \beta_i RP_{t-i} + \varepsilon_t$	4.81**	0.18	1.04
$RP_t = \sum_{i=1}^{4} \alpha_i RP_{t-i} + \sum_{i=1}^{4} \beta_i \Delta core_{t-i} + \varepsilon_t$	1.84	0.32	0.20
$\Delta CPI_t = \sum_{i=1}^{4} \alpha_i \Delta CPI_{t-i} + \sum_{i=1}^{4} \beta_i \Delta core_{t-i} + \varepsilon_t$	3.43*	1.99#	2.50*

(a) An F-test is performed to test the null hypothesis. **, * and # denote 1%, 5% and 10% level of significance respectively. The sample period for estimation is 1977:4 to 1998:3. The CPI measure excludes interest charges.

(b) The core measure also refers to the measure in the calculation of the "relative price shock" term.

As defined, core measures of inflation can be thought of as summarising information about the future path of aggregate inflation. This is because the component excluded in the calculation of the core measure should represent the temporary movements in inflation and contain little information about future rates after accounting for the core measure of inflation. This intuition is confirmed for both the exclusion-based and statistical measures of inflation considered. That is, the core measure of inflation Granger-causes the headline inflation rate.

Following Roger (1997), we also consider whether, as defined, these "relative price" shocks can be explained in a Phillips curve framework. A desirable property of any definition of core inflation is that it does not exclude price movements that are explainable by the factors incorporated in an aggregate model of the forces driving inflation. To test this hypothesis we estimate an open-economy version of the Australian Phillips curve and test the inclusion of a relative price term (Table 5). A constant is included in these regressions to allow for the persistent bias in the Melbourne Institute measure of inflation expectations which is one of the explanators in the equation. Under the null hypothesis that the core measure excludes only the unexplained component of inflation, the relative price term should have a unit coefficient. This corresponds to the intuition that the relative price shock feeds fully into the headline CPI and that this effect is not captured by the other explanators of inflation. For both statistical measures of inflation, this condition is satisfied, but is rejected in the case of the Treasury measure. These results give some support to the Granger-causality tests in suggesting that the two statistical measures have superior properties. They also lend some support to the notion that the Phillips curve is best specified in terms of core rather than headline inflation. Although it is possible to discriminate between these measures of core inflation on statistical grounds, it is noted below that the differences between the alternative series are quite small in economic terms.

Table 5: Phillips Curve[a]

$$\Delta CPI_t = \alpha + \beta\pi_t^e + \sum_{i=2}^{4}\phi_i ygap_{t-i} + \sum_{i=0}^{1}\gamma_i \Delta pm_{t-i} + \delta RP_t + \varepsilon_t$$

		Measures of "Relative Price" Shocks[b]		
		Teasury[c]	Trimmed Mean	Weighted Median
Constant, α	0.00	0.00**	0.00**	0.00**
	(0.00)	(0.00)	(0.00)	(0.00)
Inflation expectations, π_t^e	0.81**	0.87**	0.85**	0.86**
	(0.10)	(0.06)	(0.05)	(0.05)
Output gap, $ygap_{t-2}$	0.02	0.03	0.08*	0.08*
	(0.06)	(0.03)	(0.03)	(0.03)
$ygap_{t-3}$	0.01	0.03	-0.04	-0.04
	(0.08)	(0.03)	(0.03)	(0.04)
$ygap_{t-4}$	0.12*	0.05#	0.04	0.05
	(0.06)	(0.03)	(0.02)	(0.03)
Import prices, Δpm_t	0.04#	0.01	0.01	0.01
	(0.02)	(0.01)	(0.01)	(0.01)
Δpm_{t-1}	0.05*	0.04**	0.04**	0.03*
	(0.02)	(0.01)	(0.01)	(0.01)
Relative price shock, RP_t		0.77**	1.26**	1.09**
		(0.07)	(0.13)	(0.08)
R^2	0.63	0.87	0.87	0.90
D.W.	2.21	1.36	1.66	1.69
Homogeneity: $H_0: \beta + \sum_{i=0}^{1}\gamma_{t-i} = 1$	1.00	2.52	3.45*	4.48*

(a) The dependent variable is the Consumer Price Index excluding interest charges. The sample estimation is 1977:4 to 1998:2. **, * and # denote significance at the 1%, 5% and 10% level of significance. The standard errors are in parentheses. Inflation expectations is the Melbourne Institute measure of inflation expectations over the coming year divided by four. The output gap is the difference between actual output and smoothed output using a Hodrick Prescott filter. Import prices is the implicit price deflator for endogenous imports.

(b) The relative price shock is calculated as the difference between the CPI inflation rate and the core measure of inflation.

(c) In this regression the standard errors are corrected for serial correlation.

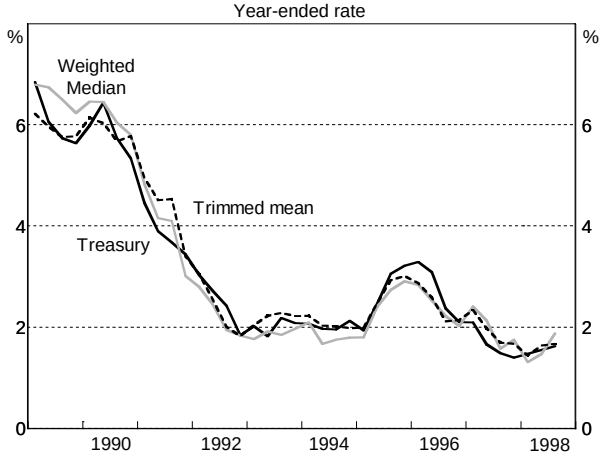
3.4 Which Measure of Core Inflation?

In Australia, the Australian Bureau of Statistics publishes an array of exclusion-based measures of core inflation, of which, the 'Treasury' measure is the most widely recognised. Trimmed mean and weighted median measures are published by the Reserve Bank.

The consistently close relationship between the various core measures of inflation is striking (Figure 1).[11] It is seemingly unnecessary to distinguish between these series on theoretical grounds in particular quarters if they are essentially providing the same information. Consequently, both internal and external discussions have focussed on arguably the more credible Treasury measure of underlying or core inflation, whereas, the statistical measures have held very little prominence.

Since each series has relative advantages and the costs of computation are small, there is good reason to monitor a range of core measures of inflation and to discriminate between these series when differences arise. For example, in September 1995, the Treasury measure of core inflation rose above the trimmed mean and weighted median measures. In this quarter, and also in the preceding, the government had increased wholesale tax rates. These tax increases should result in temporary increases in prices and therefore their impact should ideally be excluded from a core measure of inflation. Seemingly, the Treasury measure was less effective at dealing with this generalised price disturbance than the statistical methods. However, none of the measures are designed to adequately deal with a generalised price shock. There were few exceptional movements in the components

Figure 1
Measures of Core Inflation
Year-ended rate



excluded from the CPI in this quarter,[12] suggesting that the Treasury measure did exclude some components containing information about the general direction of inflation. This is confirmed when we discover that compared to the weighted median, of the components excluded, 60 per cent of their weight was in the left hand tail of the distribution; and only a small portion of the movements in these components were sufficiently extreme to be excluded in the calculation of the trimmed mean — only 8 per cent of their weight was trimmed compared with 15 per cent for the entire distribution.

[11] The trimmed mean shown symmetrically trims 15% from each tail of the CPI distribution.

[12] Large positive movements in components excluded from the CPI included lamb and mutton (5.7%), fresh potatoes (9%) and cigarettes and tobacco (6.3%) covering 4% of the CPI basket and contributing 0.24 percentage points to aggregate inflation. Components in the left-hand tail excluded in the Treasury measure included poultry (-1.8%), fresh vegetables (-2.8%), fabrics and knitting wool (-1.2%), women's footwear (-1.2%), children's footwear (-2.6%) and pharmaceuticals (-2.7%) detracting 0.08 percentage points from the CPI inflation rate.

4. Conclusion

The fact that the inflation target in Australia is expressed as a medium-term average means that the distinction between underlying and CPI inflation (as now defined) does not have a direct operational significance for monetary policy. Over time, core and headline measures of prices can be expected to increase at similar rates. The main advantage of expressing the policy target in terms of the headline rate is that this is likely to be better understood and accepted by the public, although this comes at a cost of greater volatility than core measures.

Core inflation measures remain a useful analytical device for summarising information about the persistent component of the inflation rate, and for isolating temporary factors that are less relevant for monetary policy. Of the two main approaches to constructing core inflation measures – the exclusion-based and the statistical approaches – it is the exclusion-based approach that has in the past had greater prominence in Australia. This partly reflected the existence of an established and independently-calculated exclusion-based measure (the Treasury underlying measure) when the inflation-targeting framework was adopted. The comparative analysis presented in this paper suggests that the statistically-based measures of core inflation, based on trimmed mean and weighted median price changes, have superior properties, but that the economic differences among the alternative measures are not large.

References

Balke, N.S. and Wynne, M.A. (1996), "Supply Shocks and the Distribution of Price Changes", *Federal Reserve of Dallas Economic Review*, First quarter, pp. 10-18.

Ball, Laurence and N. Gregory Mankiw (1992), "Relative-Price Changes as Aggregate Supply Shocks" National Bureau of Economic Research Working Paper No. 4168.

Bryan, Michael F. and Stephen G. Cecchetti (1993), "Measuring Core Inflation", NBER Working Paper No. 4303.

Bryan, Michael F., Stephen G. Cecchetti and Rodney L. Wiggins II (1997), "Efficient Inflation Estimation", NBER Working Paper No. 6183.

Debelle, Guy and Glenn Stevens (1995), "Monetary Policy Goals for Inflation in Australia", Reserve Bank of Australia Research Discussion Paper 9503.

De Abreu Lorenco, Richard and David Gruen (1995), "Price Stickiness and Inflation", Reserve Bank of Australia Research Discussion Paper 9502.

Eckstein, Otto (1981), *Core Inflation*, Englewood Cliffs, Prentice Hall, New Jersey.

Freeman, Donald G. (1998), "Do Core Inflation Measures Help Forecast Inflation", *Economic Letters* 58 (2), pp.143-147.

Golob, J.E. (1993), "Inflation, inflation uncertainty, and Relative Price Variability: A Surveu", Federal Reserve Bank of Kansas City Research Working Paper No. RWP93-15.

Gruen, David and Geoffrey Shuetrim (1994), "Internationalisation and the Macroeconomy" in Philip Lowe and Jacqueline Dwyer (eds.) *International Integration of the Australian Economy*, Reserve Bank of Australia Proceedings of a Conference 11/12 July 1994, pp. 309-363.

Kearns, Jonathan (1998), "The Distribution and Measurement of Inflation", Reserve Bank of Australia Research Discussion Paper 9810.

Reserve Bank of Australia (1998), "The Implications of Recent Changes to the Consumer Price Index for Monetary Policy and the Inflation Target", *Reserve Bank of Australia Bulletin* October 1998, pp. 1-5.

Roger, S. (1994), "Alternative Measures of Underlying Inflation: Further Results", *Reserve Bank of New Zealand Bulletin* 57 (4), pp. 330-338.

Roger, S. (1995), "Measures of Underlying Inflation in New Zealand", *Reserve Bank of New Zealand Discussion Paper* G95/5.

Roger, S. (1997), "A Robust Measure of Core Inflation in New Zealand, 1949-96", *Reserve Bank of New Zealand Discussion Paper* G97/7.

Romer, D. (1996), *Advanced Macroeconomics*, McGraw-Hill, United States of America.

Zeldes, Stephen P. (1994), Comment on Bryan and Cecchetti, 'Measuring Core Inflation' in N. Gregory Mankiw (ed.) *Monetary Policy*, pp. 216-219.