MONETARY POLICY GOALS FOR INFLATION IN AUSTRALIA

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ABSTRACT

This paper outlines the inflation objective for monetary policy in Australia, which we describe as seeking to achieve a broad central tendency for inflation of between 2 and 3 per cent over the long run - a "thick point" - rather than a narrow target band. It also provides a more detailed rationale for this objective. In doing so, the paper discusses the issues relevant in determining the appropriate mean inflation rate at which policy should aim, the degree of variation of inflation around that central point, and how policy should respond to shocks. A simple model of the economy is presented which attempts to address these issues in a consistent framework.

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1. INTRODUCTION

An increasing number of countries have adopted targets for inflation over the past five years or so. New Zealand and Canada were the first countries to outline an explicit target path for prices, but a number of others - including the United Kingdom, Finland, Israel, Spain and Sweden - have followed suit.

The gain in popularity of inflation targets can perhaps best be seen as a step in the evolution of monetary policy regimes in countries which have battled to achieve or maintain monetary and price stability in the past couple of decades. A number of the countries concerned have in the past pursued monetary aggregate targets, or exchange rate targets (in a number of instances both) as an intermediate goal along the path to medium-term inflation control. In most cases, experience with such intermediate targets had its disappointments. The announcement of a specific goal for inflation is an attempt to anchor inflationary expectations and develop a measure of confidence in the conduct of monetary policy in much the same way that monetary or exchange rate objectives were designed to do, while avoiding the problems of unstable velocity or being a sitting target for speculative players in currency markets.

It is striking that this trend, unlike the adoption of monetary targets in the mid 1970s, has not been much influenced by academic discussion of the appropriate operational features of monetary policy. Indeed, while the idea of inflation targets is obviously a manifestation of the principle of long-run monetary neutrality, compared to discussion on monetary targets, nominal GDP targets and exchange rate targets, there is a relative paucity of academic literature on operating monetary policy with explicit inflation targets. Instead, the discussion has been driven by central banks grappling with current problems.

While these problems have many common aspects across countries, national differences mean that the exact nature of inflation targets varies as to the rate of price change, width of bands, time period and so on. Implementation of policy

under the targets may well vary even more. Since in many instances the announcement of inflation targets is a relatively recent phenomenon, and no country has yet operated with an inflation target through an entire business cycle, these differences are, almost certainly, not yet as apparent as they will become over the next few years.

In Australia, there is also an announced inflation objective. It is in some ways somewhat less ambitious and hard-edged, less precisely calibrated, than in some other countries. This does not represent, in our view, a lesser degree of commitment to "price stability" as a long-term objective for monetary policy. It reflects, instead, a measure of caution about what Australian monetary policy can claim to be capable of achieving over short periods.

This paper describes the present monetary policy approach, and outlines a rationale for the nature of the stated policy objective. In so doing, it makes few references to other countries, although it ranges over several issues with which other countries almost certainly have had to grapple. The paper is organised as follows. Section 2 outlines the stated price goals for monetary policy in Australia, and gives some background as to their interpretation. Section 3 discusses issues to do with the appropriate specification of the objectives for the mean and variance of inflation over the policy horizon - which we take to be a period of around two but perhaps as long as four or five years - and the response to shocks. Section 4 gives some results of our attempts to put some empirical content to the discussion by developing a simple macroeconomic model of the economy, and using simulation techniques to address the relationship between short-term price and output variance under alternative policy reactions to shocks.

2. THE INFLATION OBJECTIVE IN AUSTRALIA

The inflation objective in Australia is to maintain an average rate of increase in consumer prices, in "underlying terms", of around 2-3 per cent over the medium term. Numbers of that magnitude for average inflation are taken to "equate with reasonable price stability" (Fraser (1994)), in the sense of making any distorting effects of inflation on economic behaviour acceptably small.

The "2-3" should be interpreted as a broad central tendency for inflation, a "thick point", rather than as a narrow "target band", in the usual sense of that term. It is not a range within which the Bank feels inflation must, or necessarily can, be maintained at all times and under any circumstances. Such a narrow band would in our view be much too ambitious, given the difficulties of short-term forecasting and control of inflation - an issue to which we return below. Given some cyclical variation in inflation and the occurrence of myriad minor shocks affecting prices, some deviations will almost certainly occur. The extent and longevity of any deviations which policy might tolerate has not been set out, and cannot be with much precision. (This paper will later seek to discuss this issue empirically, although drawing only tentative conclusions.)

The "2-3" objective does, however, define within reasonably close bounds what an acceptable long-run average rate of inflation is judged to be. **In very simple language, if, some years hence, we can look back and observe that the average rate of inflation has a "2" in front of the decimal place, that will be regarded as a success.**

The process of elevating this objective in public discussion has been evolutionary, rather than revolutionary. It did not come about as a result of a change in legislation governing the Reserve Bank. Nor is it the subject of a formal agreement between the Bank and the Government (although the Federal Treasurer has endorsed it repeatedly as a key medium-term objective).

It was not a response to the need to replace an abandoned explicit target with some other variable.[1] It emerged, as much as anything, as a pragmatic response both to a period in the late 1980s of confusing public debate about the role of monetary policy and, more importantly, to a longer period in which inflation performance was unsatisfactory. Australia was a low inflation country in the 1960s, enjoying a similar average rate of inflation in that decade to Germany. But it suffered high inflation in the 1970s and, for a variety of reasons, less progress was made than in most other countries in reducing inflation in the 1980s. From 1980 to 1989, the average rate of CPI inflation was around 8 per cent. Over recent years, monetary

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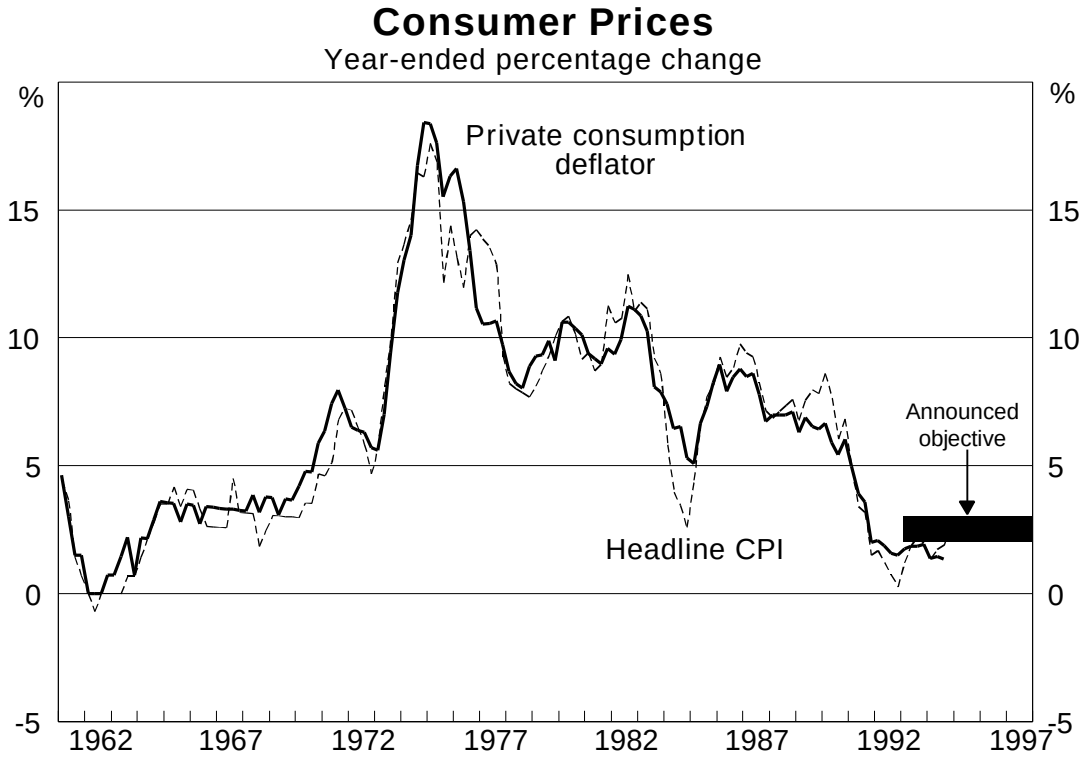
[1] Australia announced targets - or "conditional projections" - for monetary growth between 1976 and 1985. The first enunciation of the present price inflation objective as such by the Reserve Bank was in 1993.

policy has sought to break with this legacy in a decisive way. Inflation was successfully reduced during the early 1990s, amid much public emphasis by the Bank and the Government on the need to make a lasting change in the inflation environment. In contrast to some other countries, which announced targets during the disinflation process, the stronger public focus on a particular number for the inflation objective in Australia came after the big reduction in inflation had been achieved. The ultimate purpose has been the same as elsewhere, however: to condition expectations so as both to help to keep inflation low and to reap as early as possible the gains of low inflation for economic performance.

Graph 1



While the "2-3" objective *per se* was not announced with great fanfare, it has had an increasingly central role in the Reserve Bank's policy statements and other public utterances over the past couple of years. It was particularly prominent in the explanations of increases in interest rates during the second half of 1994. It is fair to say that "2-3" has come to occupy a position of prominence in the thinking of many informed observers (although by no means everyone) when they are considering

monetary policy. Many market analysts, for example, interpret economic data in the light of a perceived Reserve Bank “comfort zone” for inflation.

The objective is specified in "underlying" terms because of the impact on the published Consumer Price Index of factors which do not reflect the demand and supply balance in the economy. One example of such a factor is changes in indirect taxes. Even more important than this, mortgage interest costs are directly included in the CPI in Australia, with a weight of about 6 per cent. Most mortgages are of the variable rate variety. At present interest rates, a one percentage point increase in mortgage rates increases the CPI directly by about 0.6 per cent. Such effects obviously need to be removed in any use of the CPI for purposes of both policy analysis and any form of "target". They also mean there is a need for the Bank to explain clearly what these interest rate effects are, why it abstracts from them for policy purposes, and that there is a requirement that price and wage setters distinguish between headline and underlying inflation rates in their own decisions.

The interpretation of the objective offered above implies, in our view, two important things. The first is that there is a commitment to a *forward-looking* policy: the monetary policy instrument will be adjusted in such a way as to keep the Bank’s *expectation* of the medium-term inflation path consistent with achieving the 2-3 per cent result. The Bank's forecast for inflation at the end of the policy-horizon - allowing for the lags in monetary policy’s effect on prices - should, under other than extreme circumstances, be somewhere between 2 and 3 per cent, or at worst be showing inflation moving quickly towards that level. The upshot of this is that policy should tighten before an anticipated rise in inflation beyond 3 per cent occurs, and not ease until there is a clear, well-based anticipation of a fall back below 3 per cent.

Second, in the event of an *unanticipated* change in inflation - a shock, or a forecasting error - there is a commitment to adjust policy settings in such a way as to achieve a return to the 2-3 per cent level as quickly as feasible. What is feasible cannot be predicted in advance - it depends on the nature of the event, and is a function of, among other things, the slope of the short-run Phillips curve. Apart from the fact that it is common sense to care about the short-term path of the real economy, the Bank’s Charter obliges it to have regard to the consequences of its

policies for employment.[2] At the same time, the interpretation of the price objective means that economic agents should expect that the Bank will not, out of concern for possible transitional effects on activity, permit a shock to the price level to be permanently reflected also in its rate of change.

3. ISSUES IN FORMULATING AN INFLATION OBJECTIVE

There are several key issues which need to be canvassed in formulating a robust and credible medium-term objective for inflation. We take up three of interest to us below.

3.1 What is the Appropriate Mean Inflation Rate?

What rate of inflation is, in Chairman Greenspan's words, sufficiently low that it does not "materially enter business and household financial decisions"?

Opinions on this seem to divide into those who accept that a low single digit inflation rate more or less amounts to "price stability", and those who argue that 0.0 is a unique number - in Milton Friedman's words "a Schelling point - a natural point at which people tend to agree".[3]

Konieczny (1994) takes the latter view. Amongst the arguments used here is the idea that only zero can be a credible target, because any other number leaves too much room for suspicion that a higher number will be adopted the first time the target is tested.

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[2] The Bank's Charter is a broad one - encompassing general goals to do with "the welfare and prosperity of the Australian people", and "full employment" as well as "the stability of the currency". These words were penned half a century ago, and admit somewhat different interpretations now, particularly in the case of full employment. Policy-makers do not believe, of course, in persistent trade-offs between inflation and unemployment. But on any reading, the Bank cannot pursue price goals to the disregard of the short-term outcomes for the real economy.

[3] Friedman (1985), quoted in Jack Selody (1990).

Others have taken a more cautious attitude. Apart from potential difficulties with targeting a zero CPI increase because of likely overstatement of the true rate of inflation by the measured CPI, this caution reflects concerns about perceived nominal rigidities which may impinge on real economic outcomes at crucial times. Fischer (1994), Summers (1991) and Corden (1994), amongst others, argue that such rigidities are sufficient reason to pursue a small single-digit inflation rate rather than "absolute zero". Arguments that the short-run Phillips curve is very flat near zero inflation, so that lowering inflation the last couple of percentage points is increasingly costly, rely on similar ideas.

Some of the elements of these arguments are familiar. If there are downward rigidities in the setting of prices and wages, a small positive rate of inflation may facilitate the necessary adjustments of relative prices or wages. A real wage reduction may be more easily achieved by allowing nominal wages to fall behind inflation, than by an outright fall in nominal wages. Similarly, a firm may be reluctant to cut the nominal price of its product, but might accept a relative decline in its price as the prices of other goods or services grow faster.

This argument assumes that the face value of wages matters to workers as well as the real purchasing power of those wages, a kind of money illusion. Evidence of this has been found in practice (see, for example, Kahneman, Knetsch and Thaler (1986)).[4] It may be argued that this results from the experience of a protracted period of high inflation, where nominal wage rises were the norm, so that the expectation of wage increases would fade in a low inflation environment. An alternative explanation is that the downward rigidity of wages may be due to the motivational aspects associated with the nominal wage and concepts of wage fairness (see Solow (1979)), such that a nominal wage cut may have a negative impact on productivity.

These arguments appear to ignore productivity growth. If productivity is rising, workers can take cuts in their real product wage relative to their marginal product without taking a nominal wage cut. This would mean that nominal wage rigidity is not a good reason to eschew zero price inflation. This still leaves the feasibility of zero inflation as a function of productivity performance, however, and of the

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[4] Kahneman *et al.* also find that nominal wage cuts are acceptable when a firm is losing money or facing bankruptcy.

distribution of sectoral shocks. The problem of nominal rigidity may well be most acute in sectors which are performing badly, where a fall in relative prices and/or wages is appropriate, but which may also be characterised by low productivity growth.

If downward nominal rigidity in prices does exist, then the distribution of price changes when inflation is low should be truncated at zero. Despite a common assumption of nominal rigidities of this nature, the characteristics of price distributions have not been widely studied in Australia. However, a recent study by de Abreu Lourenco and Gruen (1995), using disaggregated data on producer prices, finds no evidence for truncation of the distribution of price changes at zero over the past 20 years. Whether this result extends to consumer prices has not been examined, and wage data in Australia are not sufficiently disaggregated to examine the distribution of wage changes.

A different nominal rigidity is the fact that nominal interest rates are typically bounded at zero. Summers (1991) has argued that a strict zero-inflation regime therefore removes the potential for negative real rates of interest, which might be appropriate at some times - for example, in the depths of a recession - to facilitate recovery. While the need for negative real rates may be infrequent, they could be very important in those rare cases, and arguably should not be ruled out by the adoption of a zero inflation rate target.

Critics of these views about nominal rigidities often respond by invoking the Lucas critique, arguing that nominal rigidities are themselves a result of the policy regime which has produced high inflation, and that they could be expected to diminish in importance as inflation falls to zero. Konieczny (1994) is a case in point. In the case of nominal wages, however, downward rigidity has been a persistent theme in macroeconomic debate even under regimes in which sustained periods of rising prices had not been experienced. This issue was at the heart of the debates of the 1920s and 1930s. The point about nominal interest rates being bounded at zero is also reminiscent of the debates about the "liquidity trap" of that era.

In our view, however, by far the most important fact is that no country has achieved absolute price stability in the past 50 years, and even achievement of low positive inflation over long periods has been quite rare, so our knowledge of empirical behaviour of modern economies in the region of zero inflation is scant. The longest

period of relatively stable low inflation in recent history occurred in Germany from 1954-71 when average inflation was 2.3 per cent with a standard deviation of less than 1 per cent. That is, inflation lay within a 2 percentage point band about two-thirds of the time.[5]

A measure of caution is therefore appropriate. It is a persuasive enough argument in our view that high single-digit inflation rates (or something higher) do matter materially for long-run economic performance. The difference between 2 or 3 per cent inflation on average and something only slightly lower may be non-zero, but it is hard to believe it is quite so crucial. Given that there are costs to reducing inflation further, and that the size of the additional gains is less certain, a practical course, for the time being, in Australia is to direct policy towards maintaining the current low but still positive rates of inflation.

We doubt that this will be the last word on the subject. Success of the present policy strategy in securing some years of experience with quite low inflation, and the experience of other countries in pursuing inflation targets of various kinds, would leave us better equipped to decide on the merits of further efforts towards absolute price stability.

3.2 Variation Around the Mean

Since monetary policy operates on inflation with a lag, probably quite a substantial lag, policy makers must rely on their assessment of the likely future course of inflation in making adjustments to their instruments. But while everyone accepts that it is no use waiting for inflation to rise before responding with changes in the settings of monetary policy instruments, how good are we at forecasting inflation? And how sure are we of the responsiveness of inflation to changes in the instrument?

To formalise this a little, suppose the inflation process is generated as follows:

$$?_t = X_t'? + ?_t \qquad (1)$$

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[5] See Lebow, Roberts and Stockton (1992), who provide a useful review of this history for the G7 economies.

where *X* is a vector of explanatory variables (including the instruments of monetary policy), and ? a random disturbance with mean zero and variance $?^2$.

The central bank has a model of the inflation process:

$$?_t = X_t' b + e_t \tag{2}$$

where *b* is its estimate of ?.

The central bank wants to run policy according to an inflation target. While it hopes that *ex post* inflation will be kept within a certain band, its specific *operational task* is to adjust its policy instrument so as to keep its *expectation* of inflation at a relevant future date, *t+k*, within the band:

$$L < E[?_{t+k}] < U \tag{3}$$

where *L* and *U* have the obvious interpretation. The central bank's forecast of inflation is:

$$E[?_{t+k}] = E[X_{t+k}]' b \tag{4}$$

If X_{t+k} were known, under the standard assumptions for the classical linear regression model the variance of the prediction error would be a combination of the true error variance and the variance of the linear predictor *b*:

$$?^2_f = ?^2 + ?^2 X_{t+k}'(X'X)^{-1} X_{t+k} \tag{5}$$

Since the X_{t+k} are not known, however, but *forecast*, the variance of the inflation prediction error will be larger than this. It will be a (non-linear) combination of the variance of the parameter estimates in *b*, the variance of the error term ?, *and* the variance of the prediction errors for *X* (themselves a function of the variances of the relevant parameters and errors in the process generating forecasts of *X*). If *X* is a single variable, the standard result for the relevant variance is:

$$?^2_f = ?^2 + ?^2 X_{t+k}' (X'X)^{-1} X_{t+k} + ?^2 ?^2_u (X'X)^{-1} + b^2 ?^2_u \tag{6}$$

where $?^2_u$ is the variance of the error in the process generating forecasts for *X* (Pindyck and Rubinfeld (1991), chapter 8). (We will not attempt to write down the expression where *X* is a vector.) All of this assumes that the errors in the

forecasting process for *X* are uncorrelated with those in forecasting ?, which is quite a strong assumption.

In other words, the fact that there is a stochastic element to the price generating process, that the structure of the economy (including its responsiveness to monetary policy) is not known with certainty, and that forecasts for inflation depend on forecasts for a range of other variables, themselves subject to error, all mean that the central bank's forecast for inflation has a confidence interval surrounding it which could well be relatively large.

Examination of models of the inflationary process are a start to gauging the size of this confidence interval. The price equation shown in part 4 of this paper has a standard error of about 0.3 per cent on a quarterly basis, which is fairly typical of price equations in Australia. This model has a 95 per cent confidence interval of about 1.2 percentage points either side of a central forecast of a four-quarter-ended inflation rate over a one to two-year horizon, on the assumption that future values of the regressors are known. Allowing for the fact that the right-hand-side variables in such an equation - labour costs, world prices for traded goods, exchange rates, output gaps and so on - must themselves be forecast, the size of confidence intervals must actually be bigger.

An examination of the forecasting record supports the contention that forecasts have a fairly large margin of uncertainty around them. In Australia, the Federal Government publishes a set of economic assumptions/forecasts with its annual Budget, based on the deliberations of a committee of officials from the Treasury and other Departments as well as the Reserve Bank. Surveys of private sector forecasters are also compiled. Annual forecasts and outcomes are shown below for the past decade.

Table 1: Forecasts of CPI Inflation

year to June	Official forecast#	Private sector "consensus"	Outcome Headline CPI	Outcome+ (adjusted)
1985	5.25	n.a.	6.6	6.6
1986	8.0	8.4	8.5	8.5
1987	7.5	8.4	9.3	9.2
1988	6.0	6.8	7.1	7.4
1989	4.5	5.1	7.6	6.5
1990	7.0	7.6	7.7	6.5
1991	6.0	6.9	3.4	4.3
1992	3.75	4.1	1.2	2.7
1993	3.0	2.7	1.9	2.8
1994	3.5	2.8	1.7	2.3
mean error ($\hat{p} - p$)	-0.23	0.29		
RMSE	1.27	1.21		

\# Announced in August of preceding year.
* Average of private forecasters surveyed by BRW Magazine in September of previous year.
\+ Adjusted for changes in interest rates after 1986.

There is a slight tendency for official forecasts to underestimate inflation on average over this period, while the reverse is true for the private forecasters. Neither of these is statistically significant. The pattern of errors is quite similar, with both sets of forecasts underestimating inflation in the late 1980s, then seriously missing the big fall in inflation in 1991 and 1992, and subsequently tending to be too pessimistic about the prospects for inflation remaining low. The root-mean-square error of both

sets of forecasts is of the order of 1¼ per cent.[6] This is only slightly below what would have been achieved by a naive "no change" forecasting rule.

There is a considerable international literature on the issue of forecasting accuracy which there is no space to review here. For the purpose at hand, however, it is sobering to note that this (admittedly quite rudimentary) analysis suggests that the 95 per cent confidence interval around a central inflation forecast over one year - a period during which monetary policy is unlikely to be able to alter the path of inflation very easily - is of the order of ±2.5 percentage points! It is also worth noting that the above results for Australian forecasts appear to be comparable to those quoted by the OECD (1993) in a study of their own forecasts for G7 countries.[7]

This potentially poses something of a dilemma for the policy makers in announcing a target band. On the one hand, the genuine difficulties in forecasting and controlling short-term movements in inflation suggest a fairly wide band. On the other hand, a band wide enough to encompass all these uncertainties may be so wide as to lack credibility.

There are, of course, reasons to believe that the previous forecasting record will give an overestimate of the relevant confidence interval for forecasts associated with the operation of an inflation target. One is that such forecasts often did not assume, at least not explicitly, that shifts in economic policy settings would take place. In Australia, they have usually also been prepared on the technical assumption that the exchange rate would not change, whereas the Australian dollar has at times shifted substantially during the interval between a forecast being made and the result being

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[6] It is easy to make unfair criticisms of price forecasts given that official forecasts are prepared on a technical assumption that interest rates do not change, whereas the actual outcomes for the CPI almost always are affected by rate changes. In the above, we "back out" these effects from the outcomes in order to provide a more useful comparison between outcomes and forecasts. It is less clear whether private forecasters, who are not constrained to make the same assumption, should benefit from the same adjustment.

[7] The weighted average RMSE of the individual OECD forecasts for the G7 countries over the period 1974-1992 was 1.5 per cent. This result is pushed up by one very large error - the OPEC I inflation of 1974 - and results for later periods are better. Even so, the RMSE's for the individual country forecasts amongst the G7 range from around 0.5 to around 1.5 per cent for the period 1987-92.

observed (at times because of policy changes, and other times provoking policy changes). To the extent that the forecasting process and the policy-adjustment process could be made truly a joint one - as they should be in a strict inflation targeting regime - policy-related factors bearing on inflation (including through the exchange rate) might be incorporated more effectively in forecasts and improve their accuracy (although this would present considerable difficulties for making details of those forecasts public).

3.3 Response to Shocks

A further reason for large *ex post* errors in some years will have been genuine shocks of the kind that no policy regime can cope with easily. Even with good forecasts, shocks - by definition unanticipated - will occur which push inflation out of the target band *ex post*, even though the central bank's unbiased expectation was that inflation would be in the centre of the band. In this situation, how quickly should the central bank try to return to its preferred inflation range? This is, in practice, one of the key operational considerations for policy.

The answer to this question will depend to a large extent on the nature of the shock. In the case where demand, rather than supply, shocks are prevalent there may be relatively little real conflict between the price and output objectives. In a conventional macro model, positive demand shocks push output away from its "natural" level, open an output gap, leading to pressure on inflation (probably with some lag) and raising the equilibrium interest rate. A policy framework which proceeds by adjusting interest rates according to movements in the output gap should also assist in stabilising prices, assuming the regime is sufficiently credible that the demand shocks themselves do not de-stabilise price expectations unduly. It is this world to which an inflation target seems ideally suited.

Where supply shocks occur, on the other hand, monetary policy can only dampen price variability by adding to short-term output variability, so there is a short-term conflict between the two objectives, and a multi-faceted objective function leaves the policy maker with difficult choices. Even if primacy is given to restoring price stability, there are still decisions to be made about the nature of the adjustment path that is to be sought.

Here the slope of the short-run Phillips curve (and potential non-linearities in it), the extent to which inflation affects long-run growth potential, and the responsiveness of inflationary expectations to short-term movements in actual inflation all figure in an assessment of how to respond to the shock.

It is presumably because of this possibility that some of the inflation targets which are in operation have specific "escape clauses" which permit the central bank, in effect, to receive a new set of instructions from the government in the event of a major supply-side shock. Even if the shocks can be assessed in an accurate and timely fashion, and an appropriate adjustment to policy implemented, there will still be questions about the possible effects on the credibility of the policy regime of tolerating a temporary departure from the inflation objective.

In establishing any sort of public objective for inflation, then, a key question is what variance of inflation can reasonably be expected to be achieved, given what we know about the nature of the shocks to which the economy is typically subject. While major, identifiable, supply-side shocks may be a sufficient condition for the suspension of a target, the regime needs to be sufficiently robust to handle more minor shocks of various kinds without being re-cast often; otherwise there will be potential loss of credibility.

In terms of the stylised model above, there will be an irreducible variance in inflation over time which is a function of the various genuine stochastic processes in the model and the model's dynamics (even leaving aside uncertainty about the model's structure). This minimum variance of inflation might not, furthermore, be "optimal" if there are other considerations for the policy-maker - for example, if the variance of output relative to potential is an objective in its own right.

In principle, there will be a schedule relating output variance to inflation variance, for given characteristics of the various shocks, traced out by the different weights on those two variables in the policy reaction function of the central bank - a trade-off of the kind outlined by Taylor (1992). Policy-makers must make their value judgement about what point to choose on this frontier (noting as they do so that, in the best tradition of trade-offs in economics, some short-term choices may cause the nature of the trade-off to shift over time). In the following section, we make a preliminary attempt at examining empirically some of these issues for Australia.

4. A FRAMEWORK

In this section, we develop a simple macro model of the Australian economy in order to examine the trade-off one might expect between output and inflation variability, given the sort of shocks which hit the Australian economy. Consequently we can assess the likely variability in output and interest rates concomitant with maintaining medium-term inflation at a nominated level.

The model of the economy consists of simple equations for output and inflation, and a reaction function for short-term interest rates (the instrument of monetary policy), which is derived from an objective function for monetary policy. This model is simulated, subject to sets of shocks of zero mean but of the same variance as those in the model's estimation period (1980-1994). Each simulation generates a path for inflation and output, and from the collection of these results the inflation/output variability trade-off is derived.

4.1 The Model

The model consists of the following objective function and two reduced-form equations for output and inflation.

$$L = \sum_{t=0}^{T}\left[(1-l)\left(p_t - \bar{p}_t\right)^2 + l\left(y_t - \bar{y}_t\right)^2 + g\left(r_t - r_{t-1}\right)^2\right] \qquad (7)$$

The objectives for monetary policy are to keep (quarterly) inflation ($?_t$) close to the target level for inflation ($\bar{p}_t$), and output (y_t) close to its trend or potential level ($\bar{y}_t$). The parameter ? reflects the relative weight placed on the two objectives. When ?? = 0, monetary policy focuses entirely on maintaining inflation close to its target level, whilst when ?? = 1, monetary policy focuses completely on maintaining an output gap as small as possible. A target level for quarterly inflation of 0.5 per cent was chosen, consistent with an annual target rate of inflation of around 2 per cent.[8]

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[8] The results do not depend on the level of inflation chosen for the inflation target. In practice there is a positive correlation between the variability of inflation and the level of inflation which is not modelled here.

The central bank minimises this objective function by choosing a path of real short-term interest rates $\{r_t\}_{t=1}^{T}$. The first order conditions (derived by minimising the objective function with respect to each interest rate) define a monetary policy reaction function, in which the interest rate depends on the expected future paths of inflation and output.

The final term in the objective function ensures that the path of interest rates is not too unstable. A value for ?, the weight on interest-rate smoothness, of 0.01 was chosen which gives a standard deviation of real interest rates in keeping with historical values for the Australian economy.

4.2 The Equations

The output equation is based on the work by Gruen and Shuetrim (1994). Output growth depends on monetary policy, the weather and foreign output. The equation was estimated using quarterly data from March 1980 to September 1994.

The dependent variable is quarterly GDP growth. Monetary policy (measured by the real cash rate, R) affects output with a lag of two to five quarters. This is consistent with prior evidence of the time lags in the effect of monetary policy on output. The Southern Oscillation Index (SOI) captures the effects of weather.[9] When this variable is positive, rainfall is higher, which has a stimulatory effect on growth in the rural sector and from there on the general economy. The final three variables capture the influence of foreign output. The first of these three variables (together with the lagged level of Australian GDP) generates the co-integrating relationship between Australian and foreign (OECD) output (YF) identified by Gruen and Shuetrim (1994).[10] The final variable measures the short-run effect of variations in foreign output on Australia's GDP growth.

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[9] SOI measures the sea level barometric pressure difference between Darwin and Tahiti.

[10] The t-statistic on the lagged level of Australian GDP can be used to test for co-integration. The actual distribution lies between that of a N(0,1) and Dickey-Fuller, so that here the p-value lies between 1 and 5%.

$$\Delta Y_t = -25.8 + .037\ SOI_{t-1} - 0.190\ R + 0.268\ YF_{t-1} - 0.213\ Y_{t-1} + 0.975\ \Delta YF_t + e_t \qquad (8)$$
$$(-3.67)\ (3.05)\qquad [0.0016]\ (2.92)\qquad (-2.63)\qquad (4.99)$$

$\bar{R}^2 = 0.45$ S.E. of estimate = 0.720.

t-statistics are in parentheses. The coefficient on R is the mean coefficient on lags 2 to 5 of the real cash rate. The number in square brackets is the p-value on the F-test of joint significance. e_t is a white noise error term.

The inflation equation is estimated by regressing the quarterly rate of inflation on its own lags, the growth rate of (tariff-adjusted) import prices, and the output gap. The output gap is the difference between the level of GDP and trend GDP derived from the above output equation, when all explanatory variables are set at their long run averages. In this model, trend output grows at 0.87 per cent per quarter, or around 3.5 per cent on an annual rate, which was about the average rate of growth of the Australian economy in the 1980s.

Lags of inflation are included to capture the effect of inflation expectations. The sum of the coefficients on the lags of inflation and import prices are not significantly different from 1. Accordingly, the equation is estimated with this restriction over the period March 1980 to September 1994. The estimated lag structure suggests that inflation expectations are highly responsive to actual inflation. The sacrifice ratio in this equation is 3.7, a little higher than the range of results for Australia presented in Stevens (1992), but not especially high by international standards.

$$?_t = 0.492\ ?_{t-1} + 0.471?_{t-2} + 0.025\ GAP_{t-1} + 0.036\ IP_{t-1} + g_t \qquad (9)$$
$$(4.23)\qquad (4.11)\qquad (1.86)\qquad (2.62)$$

$\bar{R}^2 = 0.81$ S.E. of estimate = 0.320.

There are three exogenous variables in this system: the weather (SOI), foreign output, and import prices. To simulate the economy, it is necessary to have data generating processes for these exogenous variables. The weather was estimated as an AR(3) process. Foreign output was assumed to be a trend-stationary process, with a trend growth rate of just under 1 per cent per quarter. Import prices are assumed to rise with domestic inflation, but can be pushed off this trend by the stance of monetary policy or import price shocks. This exchange rate channel of monetary policy (not shown here) is calibrated so that the impact on inflation is slightly less than the impact of policy via the output channel over a period of two

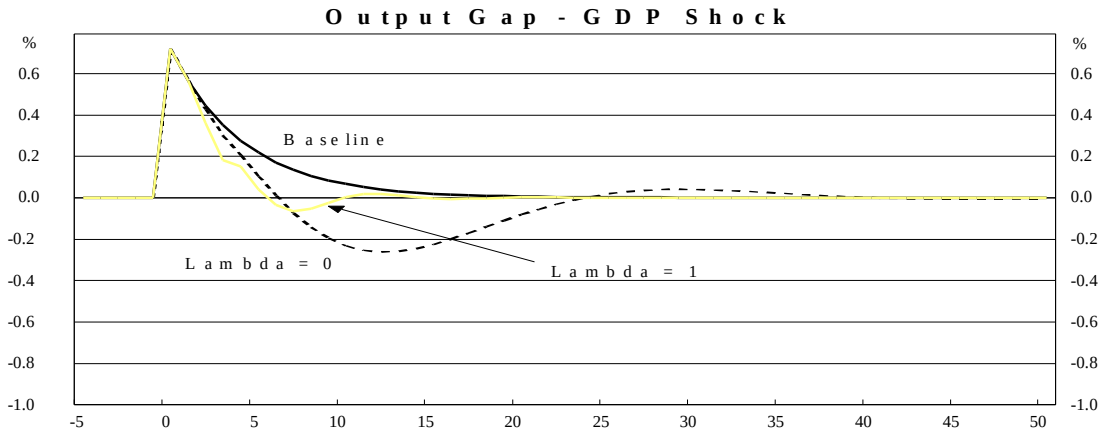
years, which is consistent with other work on the monetary policy transmission process in Australia. This offsets, to some extent, the fact that the coefficient on import prices looks quite low relative to other empirical findings for Australia. This channel takes effect with a lag of one quarter and has a stronger up-front effect on inflation than the output channel.

There are five shocks which can hit the economy each period: a shock to import prices, a shock to foreign output, a shock to the weather, and shocks to output and inflation not covered by the first three channels. All the shocks are uncorrelated contemporaneously and across time. We interpret the price equation shock and the import price shock as "supply" shocks, and the others as "demand" shocks. There are no shocks to potential output, which in this model is a deterministic process.

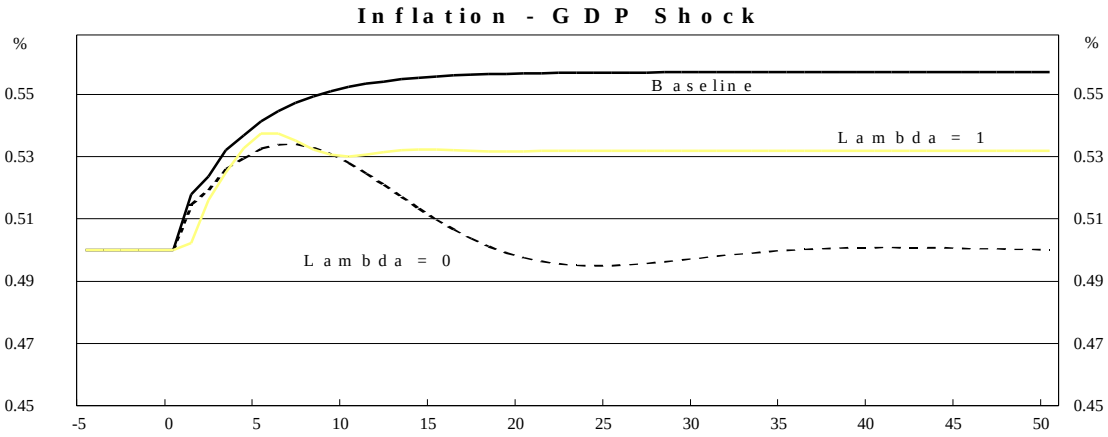
To illustrate the model's properties, we show the responses to a single, one-standard deviation shock to output (demand) and price (supply) in Graphs 2-5.

Lines for $\lambda = 0$ and $\lambda = 1$ are shown, together with a "baseline" case where there is no policy response to the shock at all.

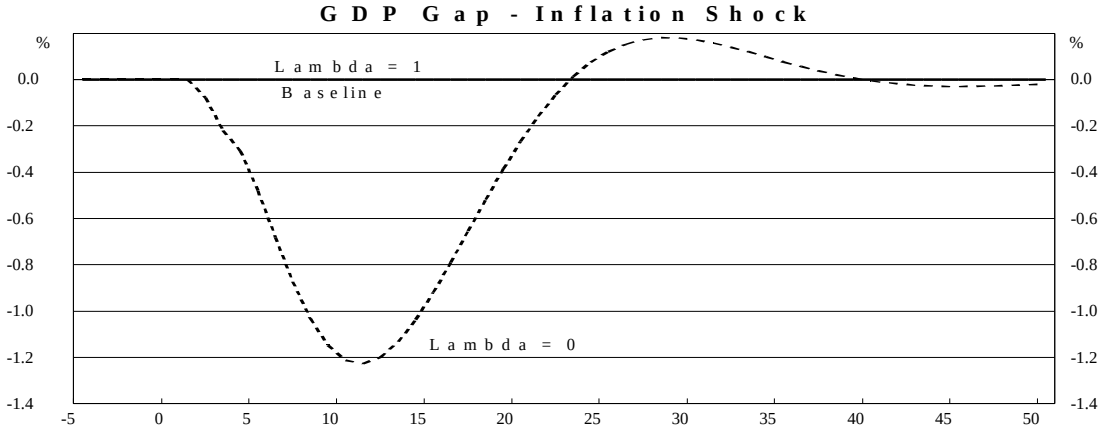
Graph 2



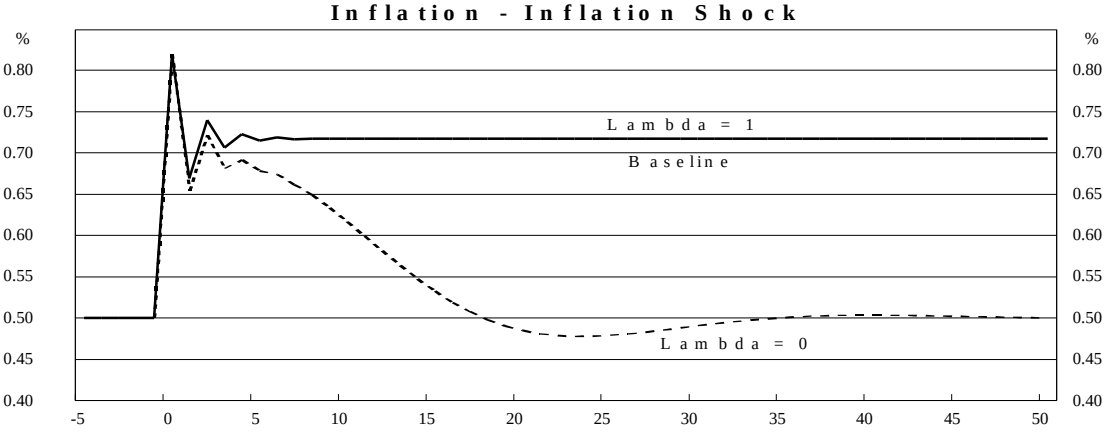
Graph 3



Graph 4



Graph 5



A positive output shock opens an output gap. Since the shock lasts only one period, the gap will subsequently close as the long-run properties of the model assert themselves. A policy response seeking to minimise output variance will close the gap faster. Either of these alternatives leave inflation permanently higher. The policy response which seeks to minimise inflation variance creates a negative output gap, so that the cumulative sum of the gaps is zero, thus bringing inflation back to its original level.

In the case of a price shock, there is no mechanism to bring inflation back in the absence of policy response. Totally output-focused policy does not respond because there is no output gap. Totally price-focused policy pushes output temporarily below potential to return inflation to target.

4.3 Simulating the Economy

The economy is initially in a steady state, where the real cash (overnight) rate is at its model-determined equilibrium level of 4.6 per cent, inflation is at its target rate of 0.5 per cent per quarter, and output is growing at trend. The economy is then subjected to a set of shocks in each period, with mean zero and standard deviation equal to the relevant estimated standard error in history. For example, the output equation is subject to shocks drawn from a normal distribution with a mean of zero and a standard deviation of 0.72. There are no shocks to import prices, which abstracts from one important potential supply shock, but there are still shocks to inflation (other supply shocks which would be hard to identify in practice), output, foreign output and the weather.

The policy-maker is assumed to know perfectly the structure of the economy described in the equations above, but only learns about the shocks in the period that they occur.[11] In each period, the policy-maker chooses the optimal present level and future path for interest rates to minimise the objective function. The model is run over a 25-year period.

To generate the trade-off curve, the value of the trade-off parameter?? ?is varied from 0 (where there is no weight on output) to 1 (where there is no weight on inflation).

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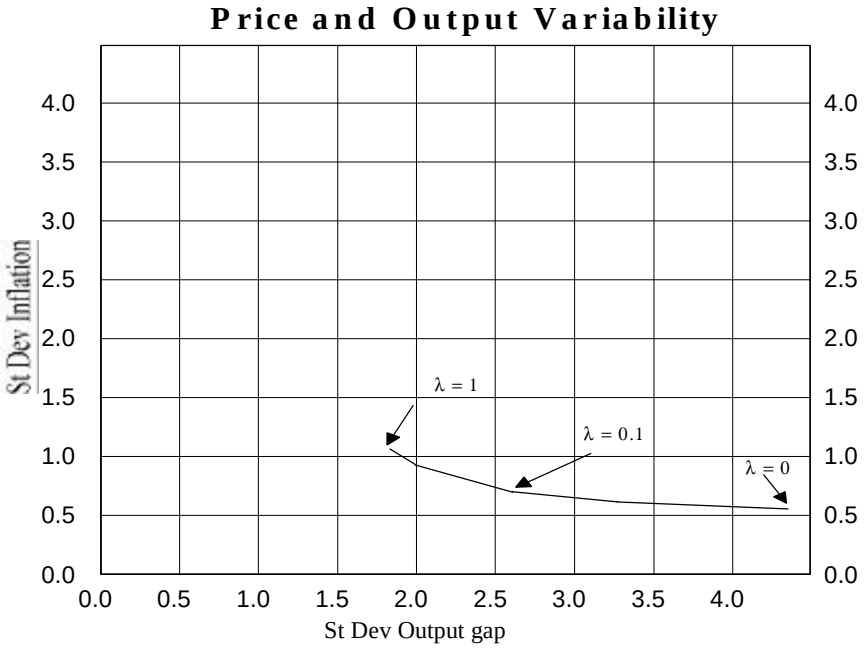
[11] That is, the expected value of all future shocks is zero.

For each value of ?, the deviations of inflation from its target value and output from its trend are calculated. This exercise is repeated for 50 sets of shocks, and the mean values of the 50 realisations of the standard deviations for inflation and the output gap are calculated.

Graph 6



Graph 6 shows such a trade-off curve. The empirical magnitudes in this trade-off are not dissimilar to those in some studies for the US - for example Lebow *et al.* (1992). The graph shows, as expected, that as the weight is increased on the output objective, the variability of the output gap is decreased but the variability of inflation is increased. The trade-offs become increasingly flat: continued reductions in price variability appear to come at increasing cost to output variability and vice versa. When complete weight is placed on prices in the objective function, the standard deviation of the inflation rate is still 0.64 per cent per quarter. This is about double the standard error of the estimate in the inflation equation, and reflects the shocks to other variables (as well as the lag in adjusting policy, and in policy having its effect). This illustrates the point made in Part 3 of the paper about forecast errors.

Table 2: Inflation, Output and Interest Rate variability
(no import price shocks)
standard deviations of series

?	Output gap	Inflation*	Interest Rates
0	4.03	0.64	5.79
	(0.80)	(0.11)	(1.33)
0.025	3.02	0.69	4.10
	(0.49)	(0.13)	(0.92)
0.05	2.67	0.73	3.64
	(0.42)	(0.15)	(0.81)
0.1	2.32	0.79	3.31
	(0.35)	(0.18)	(0.69)
0.2	2.01	0.87	3.18
	(0.29)	(0.23)	(0.57)
0.4	1.75	0.98	3.31
	(0.23)	(0.31)	(0.48)
0.8	1.58	1.15	3.69
	(0.19)	(0.44)	(0.45)
1	1.55	1.21	3.87
	(0.19)	(0.50)	(0.45)

Standard errors of estimates in brackets.
* The standard deviation of inflation is the deviation around the target mean of 0.5.

Interest rate variance increases for extreme values for λ: very ambitious goals for minimum price or output variability increase the activism of policy, which in this model works to the detriment of the performance of the other variable. This high interest rate variability is most pronounced in the case of $\lambda = 0$ (maximum weight on inflation), which one would expect: given the very responsive nature of inflation expectations, a shock to inflation must be countered quite quickly, otherwise it translates quickly into inflation being permanently away from target.

There are, of course, a large number of caveats to this exercise. The model is simple, and numerous complexities of the real world are not captured. This is particularly so with regard to its treatment of the exchange rate. While there is an exchange rate channel of monetary policy, we have not captured the volatile nature of the exchange rate, and its response to shocks to the terms of trade, as well as we would like.

The results are also particularly vulnerable, inevitably, to the Lucas critique: if over time, the regime of inflation targets becomes more credible, one would expect the parameters of the two equations to change. This may be particularly relevant to price expectations. In the extreme, if the inflation target was perfectly credible, shocks to inflation would require a minimal response from monetary policy as inflation expectations would be unchanged. An upward (or downward) movement in inflation would be perceived to be a result of (temporary) inflation shocks rather than a change in the tolerance of the central bank for higher or lower inflation. Inflation would be stationary around the level of the inflation target, in contrast to the current aggregate supply equation, where tight monetary policy (which causes output to fall below trend) is necessary to bring inflation back to its target level after a positive shock. This implies that the sacrifice ratio would decline, with a smaller rise in interest rates (and hence a smaller decline in output) required to reduce inflation.[12] In summary, the trade-off curve above would move in towards the origin.

The speed with which credibility is established may also be dependent on the initial choice on the curve, so that the long-run position of the trade-off curve may be path-dependent. A point chosen which entails lower inflation variability at the cost of higher output variability in the short term might be beneficial in establishing credibility, which would permit lower variability for both inflation and output in the longer term. On the other hand, too ambitious an initial objective for inflation variance might not be credible if there is a risk of general support for the regime being eroded by high output volatility.

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[12] The cross-sectional evidence on the relation between credibility and the sacrifice ratio, however, does not provide much support for this argument. See Debelle and Fischer (1994) and Posen (1994).

Conceding all these points, only very tentative conclusions can be drawn from these preliminary results. We offer two observations.

The first is perhaps stating the obvious, but bears repeating anyway. It is that on the basis of our present state of empirical knowledge of the economy's structure and of the shocks to which it has been subject in the past, it is possible to conceive of a forward-looking monetary policy regime which both ties down the long-run average inflation rate effectively, *and* allows some response to output considerations in their own right (ie a point in the middle of the curve in Graph 6). (It is worth stressing that the output fluctuations here are around a given potential path; it is assumed that policy-makers have an accurate assessment of that path.)

Second, short-term fluctuations in prices (and output) may well still be substantial, driven by shocks - unforecastable price movements not resulting from monetary policy - and innovations to the real economy which influence the short-term path of prices. Even with policy responding appropriately - "optimally" - to these events as they occur, lags mean that short-term inflation control may not be at all close. Accepting substantially higher volatility in output than seen in the past may, on the basis of these results, reduce these short-term fluctuations in prices only a little. This suggests that a degree of modesty is warranted in claims about what monetary policy can do over short periods (something of which central bankers would already be keenly aware).

5. CONCLUSION

This paper has outlined the price objective for monetary policy in Australia, which we suggest can best be characterised as seeking to achieve a broad central tendency for inflation of between 2 and 3 per cent over the long run. This "two-point something" objective should result in an inflation rate that is unlikely to affect seriously resource allocation and long-term growth in the economy.

The degree of variability which is to be expected around this mean has not been spelled out explicitly in Australia. In our view, based on forecasting experience and the empirical work in part 4 of the paper, short-run volatility in inflation might well be substantial, without those deviations meaning that long-term inflation performance was necessarily going off track. If this assessment is correct, it would

be quite difficult to spell out a hard-edged target band which was sufficiently narrow to have some credibility as a serious objective, but yet wide enough to take account of the genuine uncertainties in the forecasting and policy-making process. It would be better to stick with an indicated central number, with the commitment that policy will always be directed towards maintaining expected inflation, and hence long-run actual inflation, at that level.

It could be that this assessment turns out to be too cautious on both counts. If the experience of other countries, with somewhat more stringent inflation targets in many instances, continues to be a relatively successful one in the 1990s, these views would be subject to revision. We would then need to consider whether a lower mean and/or a tighter short-term variance would be in order.

REFERENCES

Corden, W.M. (1994), "Macroeconomic Policy: Some International Lessons for Australia", presented to 23rd Conference of Economists, Surfers Paradise, September.

De Abreu Lourenco, R. and D. Gruen (1995), "Price Stickiness and Inflation", Research Discussion Paper 9502, Reserve Bank of Australia.

Debelle, G. and S. Fischer (1994), "How Independent Should a Central Bank Be?", Center for Economic Policy Research, Stanford University Discussion Paper No. 392.

Fischer, S. (1994), "Modern Central Banking", presented to Bank of England Tercentenary Central Banking Symposium, May.

Fraser, B.W. (1994), "Sustainable Growth in Australia", Reserve Bank of Australia Bulletin, July.

Friedman, M. (1985), "The Case for Overhauling the Federal Reserve", *Challenge*, 28, July-August, pp 4-12.

Gruen, D.W.R. and G. Shuetrim (1994), "Internationalisation and the Macroeconomy" in P.W. Lowe and J. Dwyer (eds) *International Integration of the Australian Economy*, Conference Proceedings, Reserve Bank of Australia.

Kahneman, D., J.L. Knetsch and R. Thaler (1986), "Fairness as a Constraint on Profit Seeking: Entitlements in the Market", *American Economic Review*, 76, pp 728-741.

Konieczny, J.D. (1994), "The Optimal Rate of Inflation: Competing Theories and Their Relevance to Canada" *Economic Behaviour and Policy Choice Under Price Stability*, Bank of Canada, June.

Lebow, D.E., J.M. Roberts and D.J. Stockton (1992), "Economic Performance Under Price Stability", Working Paper No 125, Division of Research and Statistics, Board of Governors of the Federal Reserve System, April.

OECD (1993), "How Accurate are Economic Outlook Projections?", *Economic Outlook*, 53, June, pp 49-54.

Pindyck, R. and D. Rubinfeld (1991), *Econometric Models and Economic Forecasts*, McGraw Hill.

Posen, A., (1994), "Central Bank Independence and Disinflationary Credibility: A Missing Link", *Brookings Discussion Papers in International Economics*, 109, August.

Selody, J. (1990), "The Goal of Price Stability: A Review of the Issues", Bank of Canada Technical Report No. 54.

Solow, R. (1979), "Another Possible Source of Wage Stickiness", *Journal of Macroeconomics*, 1, pp79-82.

Stevens, G.R. (1992), "Inflation and Disinflation in Australia: 1950-91" in A. Blundell-Wignall (ed) *Inflation, Disinflation and Monetary Policy*, Conference Proceedings, Reserve Bank of Australia.

Summers, L. (1991), "How Should Long-Term Monetary Policy be Determined?", *Journal of Money, Credit and Banking*, 23, 3, part 2, August, pp 625-631.

Taylor, J. "The Great Inflation, The Great Disinflation and Policies for Future Price Stability", A. Blundell-Wignall (ed) *Inflation, Disinflation and Monetary Policy*, Conference Proceedings, Reserve Bank of Australia.