Technical Paper

5/RT/97 **October 1997**

Inflation Targeting: A Review of the Issues

by

Máiréad Devine and Daniel McCoy

Paper presented at an internal seminar of the Central Bank of Ireland, August 21st 1997. The authors would like to thank those participants and colleagues who made helpful suggestions on an earlier version of this paper. The views expressed in this paper are not necessarily those held by the Bank and are the personal responsibility of the authors. Comments are welcome.

Economic Analysis, Research and Publications Department, Central Bank of Ireland, P.O. Box 559, Dublin 2.

Abstract

The European Monetary Institute have narrowed down the choice of candidate strategies for a single monetary policy within European Monetary Union to inflation targets or monetary aggregate targets. In practice it is unlikely to be a simple choice between these targets, since all monetary authorities that currently pursue either of these strategies also monitor a wide set of economic and financial variables to inform monetary policy. The choice of target will indicate more about the style of monetary policymaking. This paper focuses on inflation targets which have come to prominence internationally over the last decade. It examines both the theoretical and operational issues arising from the use of inflation targets as part of monetary policy. The theoretical aspects of inflation targeting are developed in a model which uses inflation forecasts explicitly as an intermediate target. These inflation targets provide a guide to policymakers by increasing the ability to establish credibility and commitment to overcome the problem of inflation bias inherent with discretionary monetary policy. The operational aspects of inflation targets stress the role of (i) deciding on the ultimate objective, either price stability solely or in addition to an output goal, (ii) the independence of the monetary authority from political interference, (iii) setting the inflation target value, either for inflation or the price level, (iv) choosing the appropriate time horizon, (v) the choice of instruments to achieve the target and so on. The experiences of those countries that have adopted inflation targets is drawn upon. While this experience has tended to be quite positive, the timespan since their adoption is too short for a conclusive assessment. The decision on whether inflation targeting will eclipse monetary aggregates as the dominant monetary policy strategy will depend on the accuracy of inflation forecasting compared with the predictability of money demand.

Contents

1. Introduction

2. Monetary Policy Framework

3. A Model of Inflation Targeting

4. The Operation of an Inflation Targeting Strategy

5. Conclusions

References

Appendix: The Svensson Inflation Targeting Model

1. Introduction

The objective of this paper is to consider the use of inflation targeting as part of monetary policymaking. Inflation targets have come to prominence in recent years as a primary tool for the conduct of monetary policy as reflected in their adoption in countries like Australia, Canada, Finland, New Zealand, Spain, Sweden and the United Kingdom. Our motivation for this paper is the consideration of direct inflation targeting as a candidate strategy in conducting a single monetary policy in Stage Three of European Monetary Union (EMI, 1997a).

Inflation targeting can be considered to be a new style of monetary management competing with more traditional styles of monetary aggregate targeting and exchange rate pegging (Padoa-Schioppa, 1996). The European Monetary Institute (EMI) has considered five possible strategies in the pursuit of the objective of price stability within EMU. These included interest rate pegging, nominal income targeting, exchange rate targeting, monetary targeting and direct inflation targeting (EMI, 1997b). This list of candidate strategies has now been narrowed down to two: monetary targeting and direct inflation targeting. The reasoning behind the relegation of the first three strategies lies in the difficulty of identifying an equilibrium real interest rate consistent with price stability; the size of the new euro area and the extent of intra currency-area trade which will make exchange rate pegging less effective; while nominal income targeting would be difficult to control by the European System of Central Banks (ESCB) and could be misinterpreted as its ultimate goal, whereas the primary objective is the maintenance of price stability.

The emphasis on monetary aggregate targeting and direct inflation targets has to be seen in the context of current monetary policy conduct within the EU. The larger member countries of the EMS, in particular Germany, have in the past used monetary targeting as the centrepiece of their monetary policy framework. In contrast the smaller member countries, including Ireland, have substituted exchange rate targets for independent monetary targets. The pace of financial innovation and increased concern for exchange rate stability in the 1980s led to a diminution of monetary aggregate

targets in most countries, with the notable exception of Germany[1]. However, monetary aggregates continue to be important policy guides in all countries. In some EU countries a shift over to explicit inflation targets has occurred within the last five years in an attempt to provide a fix for inflation expectations. The experience with inflation targeting so far has tended to be positive but the timespan since their incorporation is too short for a conclusive assessment. Indeed a number of countries, like the United States and Japan, have established credible, low inflation policies without the use of explicit inflation targets over the same time-period. So with variants of both types of monetary policy strategies in use within the EU area, the EMI has chosen to recommend both monetary targeting and direct inflation targeting as options for the ESCB to consider. The decision on the monetary policy strategy in Stage Three will be taken by the ESCB "on the basis of the economic environment and the financial structure prevailing in the euro area" (EMI, 1997a).

Given that exchange rate targeting is no longer on the ESCB agenda, the issue facing the Bank is which of the two strategies under consideration would best serve the objective of price stability in the Irish economy? The purpose of our paper is to inform on one side of this question by focusing on the issues raised by direct inflation targeting. Clearly it will not be just a simple choice between either monetary or inflation targeting, given that all the central banks that currently pursue either of these two strategies monitor a wide set of economic and financial variables as indicators the stance of monetary policy. However, the choice is about the style of monetary policymaking in terms of which strategy is predominant.[2]

In the next section we set out a framework to examine the case for inflation targets as a mechanism in overcoming the problem of inflation bias arising from time inconsistency of policy choice. The relationship between targets, rules and instruments is also considered. In Section 3 we present a theoretical model of direct inflation targeting, based on the work of Svensson (1997a), which uses inflation forecasts as an

[1] While the German Bundesbank have monetary targeting as its stated policy strategy Bernanke and Mihov (1997) conclude that their actions are better described as inflation targeting rather than monetary targeting.

[2] An excellent taxonomic and descriptive account of the strategy issues facing the ESCB is contained in Goodhart and Vinals (1994).

intermediate target. The literature on inflation targeting has tended to highlight that monetary growth and exchange rate targets generally produce higher inflation variability than inflation targeting. As a consequence inflation targets might be considered more desirable for a central bank whose objective is price stability. In Section 4 the issues involved in operationalising an inflation target are discussed referring to recent international experience. The final section concludes with some observations on the applicability and desirability of an inflation target framework.

2. Monetary Policy Framework

Before proceeding to examine inflation targets in more detail, it is useful to consider the reasons why these targets are considered necessary. Among the few core propositions widely accepted in macroeconomics is that monetary policy is neutral in the long run and that persistent inflation is always a monetary phenomenon[3]. As Eichenbaum (1997) points out the consequence of these propositions is that the "primary objective of monetary policy should be long-run price stability or at least a low average rate of inflation". However, two other widely believed propositions are that monetary policy is not neutral in the short run and most shocks to output are not due to monetary policy shocks. These latter two propositions suggest that it might then be welfare-enhancing to be activist in the use of monetary policy to help the economy adjust to non-policy shocks. Hence, a fundamental tension in the conduct of monetary policy can arise in terms of whether it is better to have a short-run activist or a long-run neutral policy stance.

The Problem of Inflation Bias

It is this fundamental tension that led to the seminal contributions of Kydland and Prescott (1977) and Barro and Gordon (1983) which demonstrated that policymakers are unable to commit themselves to a low inflation policy, despite the absence of a long-run trade-off, and this results in excessive inflation. This problem of *inflation bias* stems from the lack of credibility on the part of policymakers. The premise is that

if expected inflation is low then the marginal costs of additional inflation are low, whereas the marginal benefit of pursuing expansionary policy, by pushing output temporarily above its normal market clearing level, is high (Romer, 1996). This provides an incentive to the policymaker to cheat by allowing inflation to rise above expectations and so raising output by surprising agents in the economy. However, if agents realise that policymakers have this incentive they will rationally expect a higher rate of inflation, so the low inflation strategy is not credible. The result is higher inflation with no benefits in terms of higher output.

The problem of inflation bias is that the low inflation monetary policy is time inconsistent. The problems from time or dynamic inconsistency arises from the inability of policy-makers to precommit. Economic agents do not trust policymakers to pursue the low inflation policy knowing they have the discretion to alter the growth of money to engineer a surprise inflation. The solution to the time inconsistency problem of inflation bias is to ensure commitment to the stated policy. The time inconsistency problem is part of the more general debate about *rules versus discretion*. The advocates of rules argue that these are needed to restore credibility by reducing the discretionary powers of policy makers that give rise to the time inconsistency problems. These rules can be *fixed rules*, which remain the same in all circumstances, or *feedback rules*, which allow policy to change in a predictable way as the state of the economy changes[4].

The time inconsistency problem can only be overcome by rules if these are in fact binding. It is not enough just to state that monetary policy will be determined by a rule if the public know that the policymaker has the discretion to circumvent that rule. Indeed this is the crucial point, it is not the discretion *per se* that is the problem, it is

[3] An excellent set of articles on the topic of "Is There A Core Of Practical Macroeconomics That We Should All Believe" is contained in the *American Economic Review*, May 1997.

[4] The k% monetary growth rule proposed by Friedman (1969) is an example of a fixed rule. Two examples of feedback rules which have recently attracted international focus are the **McCallum** (1988) rule and the **Taylor** (1993) rule. Both of these simple rules offer a guide to the Central Bank's discretion in the formulation of monetary policy by adjusting a policy instrument in response to deviations in target objectives. In the case of the McCallum rule the focus is on the nominal growth in the monetary base consistent with a nominal income target, whereas in the Taylor rule the focus is on the nominal interest rate consistent with an inflation target and output target. See Stuart (1996) for an application of these rules.

the agents' knowledge that the policymaker has discretion and their belief that the policy-maker has the incentive to use it to engineer surprise inflations. A number of solutions have been proposed to address the problem of inflation bias. Three microeconomic approaches that have received considerable attention in the economic literature are reputation, delegation and incentive contracts.

Policymakers try to establish a reputation by overcoming agents' uncertainty about their actions in order to lower their inflation expectations (Barro, 1986). Delegation involves the government appointing a central banker that is more adverse than the general public to inflation, described by Rogoff (1985) as the "conservative banker" approach. Another approach proposes structures to ensure that the central banker is rewarded or punished for meeting or exceeding the socially preferred rate of inflation, this is the "optimal contract" approach proposed by Walsh (1995). It is important to note that these approaches are not mutually exclusive in that they share common elements and can be used in conjunction with each other.

Targets and Instruments

Central to all monetary policy strategies is the *targets and instruments* framework associated with the Tinbergen-Theil tradition. In this framework the policymaker controls certain instruments to meet an *ultimate target or objective*. This objective is normally considered to be the optimisation of a social welfare function, which in the literature on this topic is normally cast as the minimisation of a social loss function of deviations in output and inflation from target values. Based on the social welfare function that is being optimised the policymaker must specify *policy* or *intermediate targets.* The policymaker then has to identify the *policy instruments* and establish the *instrument rules* to attain these targets. This framework is a dynamic programming or optimal control type problem whereby policy actions that affect the economy do so with considerable lags and uncertainties. Given these lags and the uncertainties about the impact of policy on targets it is necessary to use *policy indicators*. Intermediate targets and indicators fall between instruments and objectives.

There are several reasons why policy rules may be useful (Taylor, 1996). Firstly, if agents are rational and forward looking then it is necessary to specify future as well as current policy actions, so reducing uncertainty and thereby reducing risk premia in markets. Secondly, policy rules provide a focal point for policymakers to inform their actions on achieving their goals. Thirdly, they are a way to increase the accountability of policymakers. Fourthly, they are an easy way to communicate with market participants and to educate the community at large. Finally, and most importantly in the academic debate, policy rules are a means of addressing the time inconsistency issue.

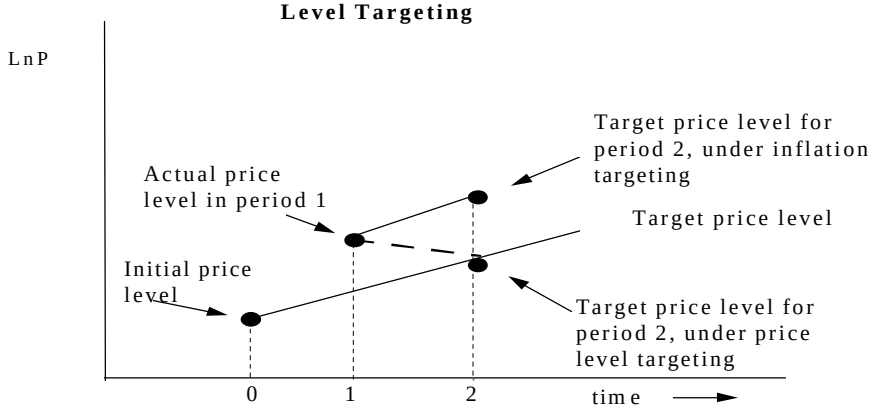
This type of framework requires that policymakers clearly specify the goals of policy, the instruments at their disposal, their model of the macroeconomy and their forecasts of exogenous variables (Blinder, 1997). These goals can either be limited to price stability alone or can in addition include an output/employment stabilisation objective. The attainment of these goals requires a set of efficient target rules for monetary policy that minimises a weighted sum of output variances and inflation variances. Comparison of the different monetary policy strategies discussed in the academic literature is generally based on a trade-off between price (inflation) and output stability. While there is a broad agreement on the goals in this literature, differences emerge in the underlying macroeconomy models, the instruments advocated, the role of expectations and the type of lag structures which make direct comparison difficult. We do not attempt to undertake such a comparison in this paper.

Price Level or Inflation Targets

A related issue in this framework is whether it is better to have a price level target rather than an inflation target, given that most central banks interpret price stability as their primary objective. The literal meaning of price stability is the stability of the average price level, not low inflation (Fischer, 1996). Also it important to note that a price level target is not the same as a zero inflation target. If shocks push the inflation above the average inflation level, with a price level target the policymaker responds by

deflating the economy to below average levels in order to return to the original path. In contrast, even where zero inflation is the target, inflation targeting ignores past failures and tries to continue on the new higher price path. As Figure 1 below demonstrates, the base price level ratchets upwards under inflation targeting.[5]

Figure 1
Inflation Versus Price Level Targeting



Source: Fischer (1996)

There may indeed be a strong case for moving to a target for the price level but most central banks have opted for the more limited objective of a target of low inflation (Kenny and McGettigan, 1997). Price level targets can provide greater certainty about prices in the future because the policymaker attempts to follow a price level path. The conventional wisdom is that price level targeting gives rise to low price level uncertainty but higher inflation and output uncertainty than with inflation targets. The reasoning is that in order to stabilise the price level, higher than average inflation is followed by lower than average inflation, which may mean deflation, so leading to inflation variability. This higher inflation variability then results in higher output variability as a result of nominal rigidities. However, contrary to conventional wisdom Svensson (1996a) argues that price level targets may be better for society than inflation targets by delivering lower inflation variability than inflation targets if there is persistence in unemployment/output. Other authors have argued for price level

[5] Inflation targeting allows base drift in the price level such that the price level becomes non-trend stationary. This implies that the variance of future price levels increase without bounds over the forecasted period. This is far from a literal interpretation of price stability (Svensson, 1996b).

targeting as an alternative to exchange rate targets in reducing output variability (Rodseth, 1996).[6] While there exists considerable support for price level targets, they are not currently on the agenda of most central banks. This is in part a consequence of the true rate of inflation being below the measured rate in all countries, see Boskin *et al.* (1997).

Inflation Targets in the Transition to EMU

Inflation targeting has received some attention in the transition to Stage Three. Canzoneri *et al.* (1997) compared the use of inflation targets within the current EU exchange rate mechanism (ERM) in a theoretical framework. This study addressed the credibility-stabilisation trade-off using two mechanisms. The first mechanism considered is inflation targeting, with Walsh-type inflation penalties, in a modified Barro-Gordon model. This model is modified to include an interest rate bias in addition to the inflation bias that stems from political pressure to keep interest rates low. The second mechanism is exchange rate pegging proposed by Giavazzi and Pagano (1988) for a country to fix their exchange rate to a low inflation currency in order to import credibility, like under the current ERM.

These mechanisms were compared on the efficiency of achieving the credibility-stabilisation trade-off. The Canzoneri *et al.* results were rather heuristic in nature but suggested that inflation targeting is more efficient at reducing the inflation bias than the ERM when political pressure is not distorting the stabilisation effort and when the shocks are primarily regional in nature. However, the ERM performs better in terms of credibility when the delay between action and punishment under inflation targeting is taken into account. The downside of the rapid responsiveness of the ERM to shocks, through asset price adjustments, is that it is then prone to self-fulfilling speculative attacks. This has led De Grauwe (1996) to explore the possibility of using inflation targets to achieve inflation convergence in the transition towards EMU. The results of this paper were in line with the idea of inflation targets being more sustainable than

[6] Rodseth's paper uses the Poole (1970) methodology to demonstrate the conditions favourable to price level targets. These conditions are high volatility and low price elasticity of aggregate demand, low

exchange rate pegging but suffering from a similar credibility problem. The solution proposed recommends combining inflation targets with Rogoff-type proposals on appointing an independent, conservative central banker.

3. A Model for Inflation Targeting

In an inflation targeting framework expected, or forecasted, inflation is compared against an announced target in order to guide policy decisions. In this way the inflation forecast operates as an intermediate target. An examination of the inflation targeting literature indicates there is a distinction between a narrow and broad definition of inflation targeting. In the narrow definition, policymakers try to hit a fixed inflation target as closely as possible, reacting to shocks as soon as they occur. The broad definition allows for gradual adjustment to the inflation target in response to shocks so as to reduce output variability (Ball, 1997). We will consider both the single goal and joint goal cases in the context of the model presented below.

"Direct inflation targeting" in its pure theoretical form has no explicit intermediate target. Actual inflation is the target, and although the conditional forecast is used as a guide to policy it is not an explicit target. As Green (1996) points out this strategy is prone to inflation bias because there is a credibility problem. The bias becomes apparent not as inflation above the desired level but as a wedge between the announced target and the observed inflation. This inconsistency can lead to non-credibility resulting in the target being overshot on average[7]. This problem can be addressed by either assigning price stability as the sole policy goal or a joint goal for inflation and output provided these are consistent.

To examine the theoretical underpinnings of inflation targets we outline a model of inflation targets by Svensson (1997a). An explicit intermediate target is considered to

volatility and high price elasticity of aggregate supply and a high volatility of the foreign price level.

[7] However, this problem may be overstated since monetary policy is a continuous process whereby reputations can be built up over time. Green (1996) notes that agents can understand and accept this inconsistency, as evidenced in the context of Germany where the Bundesbank has retained credibility yet missed the monetary target in 9 out of 21 years.

be the best way to maintain price stability, that is low and stable inflation. A serious difficulty in targeting inflation directly is the imperfect control of inflation that all central banks experience. These imperfections arise from uncertainties about agents' expectations, the underlying models of the economy and the lags between actions and outcomes.[8] The solution proposed by Svensson is to use inflation forecasts as an explicit intermediate target. The model is set up as an optimal control problem with inflation forecasts as the control variable and the interest rate as the control instrument.

The policymaker is assumed to minimise a conventional quadratic social loss function which depends on deviations of π from π^* and y from y*

$$L_t = (p_t - p^*)^2 + l(Y_t - Y^*)^2$$

or

$$L_t = (p_t - p^*)^2 + l(y_t)^2$$

where π_t is inflation between period t-1 and period t, π^* is the long run inflation target, Y_t is output in period t, Y* is potential output and y_t is the output gap. The $\lambda \geq 0$ term is the weight on output stabilisation around the natural output level[9] relative to inflation stabilisation around the long run inflation target. $\lambda = 0$ implies a single goal of inflation stabilisation while $\lambda > 0$ attaches importance to output stabilisation in a joint objective for monetary policy.

The model needs to capture the stylised facts that both inflation and aggregate demand react with long and variable lags to changes in the policymaker's control instrument.[10] The interest rate (i_t) is the control instrument in this model. The lag for inflation is longer than that for aggregate demand (Romer, 1996) and these stylised facts are captured in the two equations below. The model is set out in detail in the Appendix to

[8] See Blinder (1997) for an interesting analogy, using an example of a hotel thermostat, on the impact of lags for monetary policy.

[9] The natural output level is the level consistent with constant inflation. In the long run there is no long-run output target separate from the natural output level. For algebraic convenience this natural rate is normalised to zero in the model.

[10] For expositional purposes the lags in the model presented are deterministic rather than variable.

this paper. The first equation is the so-called *accelerationist Phillips curve* where the change in inflation depends on output lagged one period.

(1) $$\pi_{t+1} = \pi_t + \alpha y_t + \varepsilon_{t+1}$$

where α is a positive constant and ε_t is a serially uncorrelated negative supply shock with zero mean.[11] The second equation of the model is the *IS aggregate demand* relationship where output depends on previous output and the real rate of interest.

(2) $$y_{t+1} = \beta_1 y_t - \beta_2(i_t - \pi_t) + \eta_t$$

where the βs are positive constants and η_t is a serially uncorrelated demand shock with zero mean. The current inflation rate is used as a proxy for expected inflation to derive the real interest rate. Any change in the current interest rate will only affect output with a one period lag and inflation with a two period lag. However, because of the uncertainties due to demand and supply shocks the control of inflation and output will be imperfect. Consequently, the forecasts of inflation will be uncertain (Cecchetti, 1995). Taking expectations of the two period inflation forecast[12]

(3) $$\pi_{t+2|t} = \pi_{t+1} + \alpha y_{t+1} = \pi_t + \alpha y_t + \alpha(\beta_1 y_t - \beta_2(i_t - \pi_t))$$

$$\pi_{t+2|t} = \pi_t + \alpha(1+\beta_1) y_t - \alpha\beta_2(i_t - \pi_t))$$[13]

However, actual inflation in period two will differ from forecasted by the demand and supply shocks that occur in periods one and two.

(4) $$\pi_{t+2} = \pi_{t+2|t} + (\varepsilon_{t+1} + \varepsilon_{t+2} + \alpha\eta_{t+1})$$

The policymaker has to choose the inflation target so as to offset the inflation bias problem inherent with all discretionary monetary policy frameworks. As noted, the

[11] If the lags are variable then the α term will be time varying. This Phillips curve case is the most famous application of the Lucas critique. Lucas (1976) observes that α is high in low inflation environments and low in high inflation environments.

[12] In Svensson's notation the expectation term $E_t(\pi_{t+2})$ is denoted as $\pi_{t+2|t}$. This emphasises that expected inflation is conditional on unchanged policies.

[13] $\varepsilon_{t+i|t}$ and $\eta_{t+i|t} = 0$ by assumption.

control instrument is the interest rate and the objective function is the minimisation of the expected discounted sum of future loss functions, where δ is the social planner's discount rate reflecting the social rate of time preference.

The optimal control model is explained in the Appendix where it is shown that the necessary and sufficient conditions for the case of the single inflation goal ($\lambda = 0$) is

(5) $$\pi_{t+2|t} = \pi^*$$

that is the policymakers should take the two-period inflation forecast as an intermediate target for optimal monetary policy. The interest rate should then be adjusted to make this forecast equal to the inflation target.

The case of joint output and inflation stabilisation goals is more complicated ($\lambda > 0$)

(6) $$\pi_{t+2|t} = C\pi^* + (1-C)\,\pi_{t+1|t}$$

$$\text{where } 0 < C = \frac{\delta\alpha^2 k}{\lambda + \delta\alpha^2 k} \leq 1$$

$$\text{where } k = \frac{1}{2}\left(1 - \frac{\lambda(1-\delta)}{\delta\alpha^2} + \sqrt{\left(1 + \frac{\lambda(1-\delta)}{\delta\alpha^2}\right)^2 + \frac{4\lambda}{\alpha^2}}\right) \geq 1$$

The coefficient C is the rate of adjustment towards the long run target, the higher its value the faster the two period forecast adjusts to the target. It is a weighted average of the long run inflation target and the predetermined one-period inflation forecast. The higher the weight on output stabilisation the slower the adjustment to the long run inflation target.

We can see from this multiple goal case that optimal policy involves a gradual lean towards the inflation target as opposed to opportunistic disinflation (Blinder, 1997).[14]

[14] Some economists would argue that disinflation should be done swiftly with a "short, sharp shock". These include Ball (1994) and Yates and Chapple (1996) who argue that the sacrifice ratio, in terms of lost output, is smaller if a disinflation is carried out quickly.

This model can incorporate solutions to overcome the problems with inflation targeting raised by Green (1996). The **Svensson rule** uses the inflation forecast as an intermediate target. It is either always at the long-run inflation target, in the case of a single goal, or gradually approaching it, in the case of joint goals. The inflation forecast can be considered a good intermediate target in pursuing these goals.

The Svensson model highlights the distinction between *target rules* and *instrument rules.* Setting the interest rate to keep the inflation forecast equal to the inflation target gives rise to an optimal reaction function that is endogenously determined. The target rule is a function of the available relevant information. In contrast instrument rules, like the Taylor and McCallum rules, specify the reaction function in terms of current information. In the context of the model the instrument rule depends on inflation and output where

$$i_t = \pi_t + h(\pi_t - \pi^*) + g y_t$$

$$\text{where } h = \frac{\delta\alpha k}{b_2(1 + \delta\alpha^2 k)} \quad \textit{and} \quad g = \frac{1}{b_2}\left[\left(\frac{\delta\alpha^2 k}{1 + \delta\alpha^2 k}\right) + b_1\right]$$

This instrument rule, which is a variant of the Taylor rule, is more complicated than the target rules set out above since it depends on all the parameters of the model as contained in the h and g terms.[15] The target rule is simpler than the instrument rule in that it depends only on the Phillips curve and the loss function. The target rule also has the virtue that it is more stable, allows more flexibility, is easier to identify and requires less confidence in the structural macroeconomy model.

As Bernanke and Mishkin (1997) in their recent article suggest, inflation targeting should be "construed as a framework for making monetary policy, rather than as a rigid rule". We now turn to the issues involved in the operationalising of inflation targets and the elements of such a framework.

[15] Clarida and Gertler (1996) find that the Bundesbank follows a form of the Taylor rule that is consistent with inflation targeting.

4 The Operation of an Inflation Targeting Strategy

In this section the core issues pertaining to the operation of an inflation targeting strategy are identified and discussed. Table 1 presents a summary of the various frameworks currently employed by those countries pursuing inflation targeting strategies.

Inflation Targeting defined

The EMI (1997a) defines an inflation targeting framework as one "which aims to directly steer the final target variable, the inflation rate, without the use of a separate intermediate target variable". In so doing a "quantitative reference for future inflation aimed precisely at anchoring inflation expectations" is provided. This is in contrast to a monetary targeting strategy where a monetary aggregate is pursued as an intermediate target in the pursuit of the final goal. As outlined in the previous section the inflation forecast can serve as an intermediate variable, while monetary aggregates accompany a wide range of economic and financial indicators in the assessment and formulation of monetary policy actions.

In essence the two frameworks are not entirely dissimilar where they both pursue the same objective of price stability, they are both forward looking and they both, in practice, employ a wide variety of indicators in determining the appropriate stance of monetary policy (EMI 1997a). Hence, while the difference between the two strategies may not have large effects on the actual implementation of policy, each leads to a different presentation to the public of monetary policy actions, which in turn influences inflationary expectations.

The operational framework for an inflation targeting strategy initially involves the announcement by the relevant authority of an explicit inflation target or target range. Using a wide array of information variables, inflation forecasts are estimated to assess the potential range of future inflation under current policies. If it is anticipated that future inflation over a given time horizon will deviate from the desired range then a feedback rule is employed, which directs policy actions to bring the projected inflation

rate back into the target range. These feedback rules are based on deviations between expected inflation (the inflation forecast) and the inflation target[16].

To ensure the effective implementation of an inflation targeting strategy, given the increased potential for monetary discretion, there is a need for credibility enhancing measures, accompanied by an increased commitment to improving the transparency and accountability of the actions of the monetary authority.

The role of inflation forecasts

In an inflation targeting framework, the inflation forecast serves as an intermediate variable in the conduct of monetary policy. It is widely accepted that there are long and variable lags in the transmission of monetary policy actions through to output and prices. Haldane (1995a) cites these lags as the rational for an intermediate variable. He identifies three criteria which an intermediate indicator must satisfy:

- it must be controllable;
- there must be a predictable relationship between it and the final target; and
- it must be a leading indicator of the target variable.

Haldane notes that the Bank of England's inflation projection satisfies all three criteria. Svensson (1996b) takes this argument a step further and advocates the use of an inflation forecast as an intermediate target. He argues that the inflation forecast is an ideal intermediate target based on the fact that it is easier to control and observe than the goal, it is incentive compatible (the monetary authority has the incentive to improve and develop its forecasting and modelling techniques) and it facilitates the transparency of monetary policy where the publication of such forecasts provides the public with a clear and understandable indication of the stance of monetary policy.

While this role for inflation forecasts is conceptually appealing, the actual estimation of such forecasts is prone to significant difficulties. The experience to-date of countries implementing an inflation targeting framework indicates a universal consensus as to the

[16] Examples of such feedback rules include the Taylor and McCallum rules referred to earlier.

"significant degree of uncertainty surrounding inflation projections" (Haldane 1995b). Reasons cited include model uncertainties; 'true' structural shocks and mistakes in projecting exogenous variables. Moreover, inflation forecasting will also be subject to the Lucas critique, whereby agents' inflation expectations will be influenced by the perception of the new regime, which further exacerbates difficulties already inherent in the process[17].

In addressing these difficulties central banks targeting inflation tend to use some form of macro-model in formulating their projections. Sensitivity analysis is then carried out whereby various scenarios concerning exogenous variables are simulated, thus arriving at a probabilistic distribution of possible inflation outcomes. Off-model information is then brought to bear on the decision making process such as policy-makers' judgements and general monetary conditions. Arguably, the use of a broad based information set combined with a probabilistic approach to inflation forecasting, provides a superior feedback rule than a strategy focusing on a single intermediate variable. The publication of inflation reports, as pioneered by the Bank of England, facilitates the transparency of monetary policy actions to the public and clarifies to the public the reasons for such actions[18].

An Independent Central Bank

The operational implications of an inflation targeting framework depend on the institutional and constitutional framework within which the regime operates. A key consideration is the extent to which the monetary authority is free to pursue the goal of price stability independently of political influences. Of the countries currently pursuing inflation targeting regimes three scenarios emerge. The monetary authority sets the target, independently of the government; the target is set jointly between the government and the monetary authority and finally the government sets the target[19].

---

[17] Specifically, the Lucas critique points out that structural parameters, such as α in Section 3, will be affected by policy actions.

[18] Prior to May 1997 the Bank of England lacked autonomy in the setting and implementation of monetary policy. While responsibility for achieving inflation targets resided with the Bank, it was not completely free to choose how best to meet these targets. As such, the need for transparency and credibility was heightened, and hence the production of inflation reports. Furthermore, the publication of the Bank's views and forecasts made it more costly for the Government to contravene the Bank's recommendations in the pursuit of its own agenda.

[19] In many instances a switch to an inflation targeting strategy has been accompanied by institutional and/or constitutional changes which have increased the autonomy of the monetary authority.

Debelle and Fisher (1994) introduce the distinction between monetary authority goal independence and instrument independence. Goal independence refers to the ability of the monetary authority to freely set its inflation targets and other objectives. With instrument independence the goal may be set either jointly with, or solely by, the government, but the responsibility for achieving this goal lies solely with the monetary authority in its choice of instruments and policy actions. In this way the operation of monetary policy is viewed as free from political influence, where this influence may be viewed as contrary to the pursuit of anti-inflationary polices, particularly in the short-run. Furthermore, the accountability of the central bank is maximised in attaining these goals. In a similar vein, Archer (1997) argues that the issue is not so much one of rules versus discretion but rather rules *and* discretion. The "rule" is the final goal of price stability (or the adherence to an inflation target) and the "discretion" lies in the independence of the monetary authority in the instruments and means by which it seeks to achieve that goal.

The Bundesbank can be viewed as being both goal and instrument independent given its autonomy in the implementation and setting of monetary policy. Predating the recent conferral of independence to the Bank of England, it could not be classified as either, where the British Chancellor of the Exchequer retained an influence in the setting of the instruments of monetary policy. In New Zealand the goal is set by the Government and the Reserve Bank of New Zealand (RBNZ) exercises discretion in attaining that goal, the 'ideal' situation envisaged by Debelle and Fisher above. In this scenario the extent to which the RBNZ is accountable to the government means that it is government support rather than the clarity of information to the public which provides flexibility to the system[20].

Furthermore, empirical evidence demonstrates that the average rate of inflation and the variability of inflation tend to decline where a monetary authority has been granted increased independence (McDonough, 1997).

[20] In the New Zealand case, however, it has been argued that the extent to which the RBNZ is accountable to the government directly, rather than to the broader public through increased transparency, can be overly restrictive and may result in damages to credibility even where goals are being adhered to.

In relation to the ESCB, the Maastricht Treaty has, in addition to establishing a clear mandate for price stability as the primary objective of monetary policy, provided for a high degree of autonomy in the ESCB's ability to conduct monetary policy[21]. In preparation for monetary union considerable progress has been made by member states in the convergence of Central Bank legislation and independence towards that encapsulated in the Maastricht Treaty[22].

A single objective?

The overriding objective of an inflation targeting regime is the attainment of a pre-announced inflation target. Other objectives can only be pursued to the extent that they are consistent with the inflation target (Debelle, 1997). An established premise of macroeconomics is the neutrality of monetary policy in the long-run. Hence, the attainment of an inflation target need not conflict with a corresponding objective of full employment. However, short-run trade-offs exist between output stabilisation and inflation targeting. These short-run trade-offs arise where there is an output-stabilisation role for monetary policy in the short-run and a long-run mandate of price stability.

Fisher (1996) argues that emphasising the long-run goal of monetary policy as price stability allows the monetary authority some leeway in pursuing short-term counter cyclical policies. This emphasises the fact that the short- and long-run consequences of monetary policy differ, which may be necessary to assuage political influences from pursuing expansionary rather than deflationary policies. Fisher notes that through an inflation targeting strategy this distinction between the short- and long-run consequences of monetary policy actions is reinforced.

The emphasis on price stability as the sole focus of monetary policy, such as in the case of New Zealand, is based on such facts as: monetary policy affects inflation only in the long run; monetary policy can only deal with one short-run goal at a time; multiple

[21] Statutory provisions include the prohibition of seeking or receiving instruction from government bodies, assured tenure for the members of the governing bodies of the ESCB and strict conditions on amending the Statute in any fundamental way.

objectives lower credibility, raise inflation expectations, and reduce transparency and accountability; the monetary authority's autonomy may be comprised where other government agencies are pursuing the same objectives. In some cases, such as Canada, there is a countercyclical role in the inflation targeting framework, where the monetary authority responds to both price increases and *decreases* which may place inflation outside of the target range. In maintaining inflation within the target range, the central bank implements a stabilising role for monetary policy, where the commitment to adhere to the lower limit of the range (by easing monetary policy where the target is undershot) serves to reassure public fears that the monetary authority might pursue an overly restrictive strategy without regard to developments in the real economy (Mishkin & Posen, 1997).

On an operational level the need to pursue short term countercyclical policies can be addressed by introducing "escape clauses" into the targeting framework. Escape clauses allow the monetary authority to accommodate certain unforeseen shocks by modifying or suspending the inflation target. Provided such escape clauses are made explicit and established *a priori,* there should be no adverse credibility losses. The price index on which the targeting strategy is based can also be constructed in such a way as to reflect the 'underlying' inflation rate as opposed to headline inflation, for example, the exclusion of particularly volatile price items. Similarly, the choice of a target range rather than a single point allows the monetary authority some discretion in coping with adverse shocks. These issues are addressed further below.

The pursuit of a separate inflation target is infeasible where an economy is operating in a fixed exchange rate regime. This arises from the inability of the domestic authority to pursue a monetary policy independently of the country to which its exchange rate is pegged. However, it should be noted that both Spain and Israel continue to adopt an exchange rate objective in conjunction with their inflation targets[23]. In New Zealand

[22] See EMI (1996) for an account of the existing independence status of member state central banks, and the extent to which inconsistencies remain between the Treaty and the statutes of the NCBs.

[23] Ben-Basset (1995) argues that the dual objective pursued by the Bank of Israel diminishes the effectiveness of monetary policy. However, the author notes that to solely focus on an inflation target would be inefficient where the openness of the Israeli economy leads to a reliance on the exchange rate as an anchor for prices, where no stable relationships between inflation and the monetary aggregates can be established. The Banco de Espana's commitment to the stabilisation of the

the nominal exchange rate is seen as a major determinant of inflation outcomes. As such the RBNZ estimates an exchange rate path based on forecasts for inflation where this path is then akin to an intermediate target. However, the outlined path for the exchange rate, while similar to an intermediate target, is a conditional target path rather than an unconditional target level (Archer, 1997). In a similar vein, the Bank of Canada employ a Monetary Conditions Index (MCI) which comprises a weighted average of the exchange rate and the short-term interest rate. This MCI index is often referred to as the short-run operating target, where its role is to provide the monetary authority with a guide and monitor of exchange rate and interest rate developments. However, it does not serve as a nominal anchor or as a rule to stabilise exchange rates.

Another objective pursued by central banks, which is consistent with an inflation targeting framework, is that of financial stability. Mishkin and Posen (1997) note that in ensuring the stability of the financial system, an inflation targeting regime is preferable to an exchange rate peg regime, since unlike an exchange rate peg, the monetary authority is not constrained from acting as lender of last resort. However, while the objectives of price stability and financial stability do not 'conflict' under an inflation rate regime, a fragile banking system may decrease interest rate flexibility and situations may arise where individual institutions can be threatened by monetary policy actions. Systemic risk however, is unlikely to pose a problem except where monetary policy is 'excessively' tight (Debelle, 1997).

Accountability and Transparency

To eliminate the inflationary bias which emerges in the absence of a 'precommitment technology', McCallum (1996) argues that external constraints must be placed on the monetary authority. Inflation targets are one such 'vehicle' for imposing these external constraints. In other words, central banks need to be accountable for their actions in the conduct of monetary policy. The presence of preannounced inflation targets serve as a benchmark on which the performance of the monetary authorities can be evaluated, thereby increasing their accountability. However, difficulties arise due to

---

exchange rate is regarded as crucial in attaining the inflation target but also results in part from economic policies oriented towards convergence with the more stable European countries (see Ortega

the gap between the instruments of monetary policy and the final inflation target, coupled with the long and variable lags of monetary policy transmission, which make it difficult to discern the extent to which deviations from the inflation target can be attributed to policy errors or to shocks which could not have been anticipated.

King (1997) notes that the "most obvious way in which an inflation target can reduce inflation bias is by creating a cost to the monetary authority of deviating from their pre-announced judgement". For a 'precommitment technology' to be effective there must be some mechanism whereby the monetary authority has an incentive to avoid inflation bias. A number of mechanisms have been suggested, notably those involving reputation, delegation and incentive contracts discussed earlier.

It could be argued that the reputation effect has been successfully attained by the Bundesbank and the Bank of Switzerland through their sustained commitment to achieving low inflation over a considerable time frame[24]. The difficulty in applying the delegation or "conservative banker" approach is that a higher output variability in the short-run may ensue. If the 'optimal contract' approach is adopted then this suggests the imposition of some form of penalty equivalent to the level of inflation bias. In practise this generally involves either loss of prestige when inflation is above the target, or it can be reinforced by enforcing some form of monetary penalty such as fixing the monetary authorities budget.

The New Zealand system whereby the tenure of the Governor is conditional on meeting the inflation target is the closest system in operation to that envisaged by Walsh (1995) in terms of an "incentive contract". However, dismissal is not automatic, as evidenced in 1995 and 1996 when despite failing to hit the pre-announced target the governor was not dismissed. This suggests that it is the signal which the penalty conveys, i.e. a commitment to the inflation target, which is important rather than the actual penalty itself. Furthermore, it has been noted that in the event of

---

and Bonilla; 1995).

[24] It is this reputation effect which has enabled the Bundesbank to effectively target inflation, while operating under the auspices of a monetary targeting regime, where the monetary target has been missed on several occasions.

dismissal, which would entail a loss of prestige, the opportunities for re-employment for the Governor in the private sector may well be numerous and well remunerated.

In an effort to increase the accountability of the monetary authority, and to increase the transparency of monetary policy, many of those countries which have introduced inflation targeting have also introduced the publication of regular inflation reports where various analysis of the monetary regime are discussed. A key aspect of such increased communication with the public is that monetary policy actions are explained to the public thereby enhancing both the transparency of monetary policy and the degree of accountability of the central bank[25].

However, while greater policy transparency is desirable, and indeed necessary, for an inflation targeting strategy to be effective, it is not without costs. Notably these include heightened market sensitivity to policy announcements and publications, and the difficulty of reversing transparency once attained. Furthermore, with such heightened accountability there is a danger that a "deflationary bias" may emerge where given the uncertainty attached to actually attaining the inflation target, central bankers may act to reach the target in advance of the specified period, which may conflict with output stabilisation. This may be particularly prevalent where 'incentive contracts' of the nature proposed by Walsh (1995) are introduced[26].

To-date a behavioural shift in private sector expectations has been observed by countries employing an inflation targeting regime. As the increased transparency of monetary authority actions leads to the acceptance by the public that price stability is indeed the focus of monetary policy actions, their inflation expectations are lowered. This in turn helps to increase the impact of monetary policy actions.

[25] The Bank of England, the RBNZ, the Riksbank of Sweden, the Bank of Canada and the Bank of Spain all publish inflation reports. Furthermore, in the UK the minutes of the new independent Monetary Policy Committee are published.

[26] Both the Bank of Canada and the RBNZ attained the requisite inflation target a year before it was actually stipulated. In response to this the Bank of Canada announced a commitment to easing monetary policy when the inflation target was undershot to mitigate public fears concerning an overly conservative central bank.

Technical issues arising in the definition of targets

There are a number of technical issues which arise in the implementation of an inflation targeting strategy. Most notably these include the level that the target rate should be set, the choice of index and appropriate exemptions, the width of the target band, and the horizon of the target.

- *What target value?*

The merits or otherwise of a zero inflation target have been extensively documented where a consensus seems to be emerging that a non-zero inflation target is preferable.[27] Some of the key arguments which emerge in this debate include the possibility of downward rigidity in prices and wages where reductions in real wages can occur only through inflation in the general price level (Akerlof, et. al., 1996), the restrictions imposed by a lower band on nominal interest rates which rules out the possibility of negative interest rates, and the presence of biases in price indices.

If a small positive inflation is the desired objective then should a point or a range target be chosen? Two main arguments emerge in the context of range or point targets (Yates, 1995). Firstly, the use of a target range avoids the need for excessive escape clauses associated with the target, where the wider the band width the fewer escape clauses that are required. The second argument concerns the practical difficulty in steering the inflation rate with such accuracy that it arrives at a particular point, given the lags which arise in the implementation of monetary policy. Finland is currently the only country operating an inflation targeting regime which defines a point target. The motivation is that a single point serves as a better guide for the formulation of inflation expectations where otherwise the upper point in the range may be perceived as being the effective target for monetary policy, thus resulting in inflation bias[28].

- *What band width?*

The choice of an appropriate band width introduces the credibility/flexibility trade-off debate. The need for flexibility in the design of an inflation targeting strategy evolves

[27] See Kenny and McGettigan (1997) for a review of the issues surrounding price stability or low inflation.

from the fact that the monetary authority has committed itself to meeting an objective which it can only partially control, and with a high level of uncertainty concerning policy outcomes. This need for flexibility must be weighted against the credibility which the monetary authority seeks to overcome the difficulties of inflation bias and time inconsistency. If too narrow a range is chosen then the monetary authority risks the possibility that any credibility gained from a narrow target range will be undermined if this target is breached[29]. Hence the trade-off between the credibility enhancing effects of a demanding target and the credibility damaging effects of failing to adhere to the target (Goodhart and Vinals, 1994).

Empirical studies investigating the question of appropriate band widths have employed stochastic simulations of economic models to generate bands that are interpreted as probability intervals. In general the results imply an inflation target band significantly larger than those in operation, where the assumption is that the band should encompass inflation outturns with a reasonable probability. This suggests that existing band widths may be susceptible to frequent breaches arising from inflation uncertainties.

- *What time horizon?*

In choosing an appropriate time horizon within which an inflation target must be met a number of considerations arise. Firstly, the inflation rate at the time of introduction of the new strategy will need to be accounted for in setting the transition time frame. Thereafter, the horizon choice involves a trade off between allowing sufficient time for policy actions to affect the final goal, given the uncertainty regarding lag lengths, and the need for the horizon to be sufficiently short that it is relevant to decision makers.

If the horizon chosen is too short it may result in economic instability as policy makers attempt to attain the target inflation rate within the given time frame. A longer time frame thus reduces the necessity for central bank intervention. A further difficulty with a time horizon which is too long is the danger that the accountability of the central

[28] While a single point target is specified by the Bank of Finland, it is not claimed that this would be met precisely.

[29] A further point against adopting too narrow a band is the risk of inducing instability in the instrument of monetary policy. This may in turn destabilise financial markets, even though the inflation target is being met.

bank is lessened where the longer the time frame the more difficult it becomes to assess the performance of policy makers. This in turn impinges on the credibility gains of setting an inflation target in the first place.

Yates (1995) notes a number of issues which are relevant in deciding on an optimal time horizon. These include the time horizon over which nominal contracts are fixed, an estimation of the time it takes for policy actions to translate to prices, the frequency with which information variables are observed (an upper bound) and observed cycles in prices (a lower bound).

- *Which price index?*

A suitable price index for the purposes of inflation targeting is one which is timely, widely known and understood, and rarely revised. Retail price indices, such as the CPI, satisfy these criteria and are hence generally employed in inflation targeting frameworks.[30] These indices are generally adjusted to exclude various components which are viewed as either excessively volatile, or which may be prone to supply shocks outside the control of monetary policy. Such an adjusted index is referred to as an "underlying rate" rather than a "headline rate" of inflation. However, while such a measure may be appropriate in the conduct of monetary policy if it is not widely known and understood then inflation expectations (and hence wages and prices) may follow headline inflation. In inflation targeting countries exemptions from the price index include food and energy prices (on the basis that they are excessively volatile), indirect taxes (to insulate monetary policy from changes in fiscal policy), and mortgage payments on housing (to avoid increases in the CPI based on deflationary monetary policy actions).

Inflation Targeting: An option for the ECB?

The EMI have narrowed the choice of monetary frameworks to a choice between either monetary aggregate targeting or direct inflation targeting. In assessing the suitability of an inflation targeting regime vis-à-vis the alternatives it is necessary to

envisage two scenarios; where EMU will consist of a "core" group of countries or alternatively where EMU will be more broadly encompassing. At the onset of EMU it is critically important that credibility is established by the newly formed ECB. This in turn becomes the overriding determinant in the choice of an appropriate framework. In the event that a core emerges, it has been suggested that an inflation targeting framework would be more appropriate. In the context of 'monetary cohabitation', i.e. the co-ordination of monetary policy between the 'ins' and the 'outs', Dewatripont et al. (1995) envisage a scenario where the outs co-ordinate their monetary policy with the 'ins' through a mutual system of inflation targets rather than fixed currencies. This argument is reiterated by Persson and Tabellini (1996) who assert that with such a regime there will be an automatic offset of velocity shocks which will be particularly relevant in a monetary union. Inflation targeting, the authors argue, is a more flexible framework, where large shocks can be offset without significant destabilisation effects on prices, output or the real exchange rate. Hence, where the likelihood of large financial shocks to the system is high, monetary aggregates may prove inappropriate. Furthermore, the resultant increase in the accountability of the ECB which is associated with inflation targeting will enhance the political legitimacy of the organisation.

Ramaswamy (1997), in addressing a situation where there is an encompassing monetary union, argues that inflation targeting is appropriate where there is an increased likelihood of a break-down in the money-inflation relationship, thereby negating the possibility for monetary aggregate targeting. In operationalising a system of inflation targeting a set of feedback rules is required, which will revolve around indicators such as bond yields, the yield curve and variations in other asset prices. While this should prove satisfactory in the context of a core union, if a broader union emerges then variations in these indicators could prove significant, leading to difficulties in implementing a union wide set of transparent feedback rules. Hence, where there is significant variability in the cyclical positions of the countries within the union, policy rules, and hence explicit inflation targeting, may be difficult to implement

[30] An alternative target which has been suggested is the GDP deflator. However, the deflator is little known, is published with a lag and is generally subject to significant revisions thereby rendering it less useful than the retail price indices.

in practice. These difficulties need to be assessed in the context of the difficulties which arise when implementing a framework based on targeting monetary aggregates, namely the difficulties in addressing large financial shocks, and the continuing extent to which financial innovation breaks down previously stable money-inflation relationships, and indeed impacts upon the ability of the monetary authority to control monetary aggregates themselves.

Experience to-date indicates that in accordance with the concept put forward by Bernanke and Mishkin (1997), inflation targeting should be seen as a framework rather than a rule. In this regard it is important to note that in operationalising such a regime, a high degree of flexibility is incorporated, which allows the monetary authority to facilitate real output growth and fluctuations without sacrificing credibility. As such the explicit announcement of an inflation target, and the demonstration of a commitment to that target, locks in inflationary expectations, and reduces the persistence of inflation bias in inflationary expectations. Monetary aggregates are not abandoned, *per se*, but they are employed, with a wide variety of other variables, to inform and guide monetary policy actions, rather than functioning explicitly as a monetary policy rule.

5 Conclusions

Inflation targets are increasingly being adopted internationally, or in the context of Stage 3 of EMU being considered, as a means of implementing of monetary policy. Inflation targets play two key roles in the control of inflation:

- provide a transparent and coherent guide to policymaking thereby increasing the ability of a monetary authority to establish credibility and commitment to overcome the problem of inflation bias from time inconsistency
- communicate to the public the objectives of monetary policy so as to influence inflation expectations in wage and price setting arrangements.

Inflation targeting can deliver long-run price stability, that is a low average rate of inflation, by the use of target rules where price stability is either the sole goal or where

there are consistent output and inflation stabilisation goals. The Svensson rule based on expected inflation is a target rule that seems worthy of greater attention in the context of Stage Three than appears to have been the case thus far. Given that monetary policy affects economic activity and inflation with long and variable lags and the monetary transmission mechanism is still much disputed, policymakers need to rely on many different indicators to determine expected inflation.

The distinction between inflation targeting and monetary targeting may be overstated given that both strategies share many common features and both have been successfully applied in practice in the recent past. The main difference at a purely theoretical level would be the use of intermediate targets. However, as we have seen in the model used in this paper, it is in fact a distinction as to whether the intermediate target used is an inflation forecast or a monetary aggregate. The decision as to which strategy is best may come down to a decision about the predictability of money demand compared to the accuracy of inflation forecasting. It is this comparison that probably offers the most fruitful area of research in determining whether inflation targeting or monetary targeting is better suited for the needs of the euro-area.

6 References

Akerlof, G.A., W.T. Dickens and G.L. Perry (1996): "The macroeconomics of low inflation", Brookings Papers on Economic Activity", No. 1 pp 1-76.

Archer, D.J. (1997): "The New Zealand approach to rules and discretion in monetary policy", *Journal of Monetary Economics*, No. 39, pp 3-15.

Ball, L. (1994): "What determines the sacrifice ratio?, in *Monetary Policy* N.G. Mankiw (ed.), University of Chicago Press, pp 155-188.

Ball, L. (1997): "Efficient Rules for Monetary Policy", *Reserve Bank of New Zealand Discussion Paper Series*, G97/3.

Barro, R.J. (1986): "Reputation in a Model of Monetary Policy with Incomplete Information", *Journal of Monetary Economics*, Vol. 17, pp 3-20.

Barro, R.J. and D.B Gordon (1983): "Rules, Discretion and Reputation in a Model of Monetary Policy", *Journal of Monetary Economics*, Vol. 12, pp 101-121.

Ben-Bassat, A. (1995): "The inflation target in Israel: policy and development", in *Targeting Inflation*, A. Haldane (ed.), Bank of England.

Bernanke, B.S. and I. Mihov (1997): "What does the Bundesbank target?", European Economic Review, Vol. 41, pp 1025-1053.

Bernanke B.S. and F.S. Mishkin (1997): "Inflation Targeting: A New Framework for Monetary Policy?", *Journal of Economic Perspectives*, Vol. 11, No.2. pp 97-116.

Blinder, A.S. (1997): "What Central Bankers Could Learn from Academics - and Visa Versa", *Journal of Economic Perspectives*, Vol. 11, No.2., pp 3-19.

Boskin, M.J., E.R. Dulberger, R.J. Gordon, Z. Griliches and D.W. Jorgenson (1997): "The CPI Commission: Findings and Recommendations", *American Economic Review*, Vol. 87, No.2, pp 78-83.

Canzoneri, M.B., C. Nolan and A. Yates (1997): "Mechanisms for Achieving Monetary Stability: Inflation Targeting versus the ERM", *Journal of Money, Credit and Banking*, Vol. 29, No.1.

Cecchetti, S. (1995): "Inflation Indicators and Inflation Policy", *NBER Macroeconomics Annual*, pp 189-219.

Clarida, R. and M. Gertler (1996): "How the Bundesbank Conducts Monetary Policy", *NBER Working Paper*, No. 5581.

Debelle, G. (1997): "Inflation Targeting in Practice", *IMF Working Paper*, WP/97/35.

Debelle, G., and S. Fischer (1995): "How Independent Should a Central Bank Be?", *Goals, Guidelines, and Constraints Facing Monetary Policymakers*, J.C. Fuhrer (ed.), Federal Reserve Bank of Boston, pp 195-221.

De Grauwe, P. (1996): "Inflation Targeting to Achieve Inflation Convergence in the Transition Towards EMU", *CEPR Discussion Paper*, No. 1457.

Dewatripont, M., et. al. (1995): "Flexibile integration - Towards a more effectiev and democratic Europe", *Centre for Economic Policy Research*, London.

Eichenbaum, M. (1997): "Some Thoughts on Practical Stabilization Policy", *American Economic Review*, Vol. 87, No.2, pp 236-239.

EMI (1996): *Progress Towards Convergence 1996*, European Monetary Institute, Frankfurt.

EMI (1997a): *The Single Monetary Policy in Stage Three: Elements of the Monetary Policy Strategy of the ESCB*, European Monetary Institute, Frankfurt.

EMI (1997b): *The Single Monetary Policy in Stage Three: Specification of the Operational Framework*, European Monetary Institute, Frankfurt.

Fischer, S. (1996): "Why are Central banks Pursuing Long-Run Price Stability?", in *Achieving Price Stability*, Papers and Proceedings of a symposium sponsored by the Federal Reserve Bank of Kansas City, Jackson Hole, Wyoming.

Friedman, M. (1969): *The Optimal Quantity of Money and Other Essays*, Chicago Aldine Publishing.

Giavazzi, F. and M. Pagano (1988): "The Advantage of Tying One's Hands: EMS Discipline and Central Bank Credibility", *European Economic Review*, Vol. 32, pp 1055-1082.

Goodhart, C. and J. Vinals (1994): "Strategy and Tactics of Monetary Policy: Examples from Europe and the Antipodes", *Banco de Espana Working Paper* No. 9425.

Green, J. H. (1996): "Inflation Targeting: Theory and Policy Implications", *IMF Staff Papers*, Vol. 43, No.4.

Haldane, A. (1995a): "Inflation Targets", *Bank of England Quarterly Bulletin*, August, pp 250-259.

Haldane, A. (1995b): " "Inflation Targets: An Introduction", in *Targeting Inflation*, A. Haldane (ed.), Bank of England.

Kenny, G. and D. McGettigan (1997): "Low Inflation or Price Stability?: A Look at the Issues", *Central Bank of Ireland Technical Paper* 3/RT/97.

King, M. (1997): "Changes in UK monetary policy: Rules and discretion in practice", *Journal of Monetary Economics*, Vol. 39, pp. 81-97.

Kydland, F.E. and E.C. Prescott (1977): "Rules rather than Discretion: The Inconsistency of Optimal Plans", *Journal of Political Economy*, Vol. 85, pp 473-491.

Lucas, R.E. (1976): "Econometric Policy Evaluation: A Critique", Carnegie-Rochester Conference Series on Public Policy, Vol. 1, pp 19-46.

McCallum, B.T. (1988): "Robustness Properties of a Rule for Monetary Policy", *Carnegie-Mellon Conference Series on Public Policy*, Vol. 29, pp 173-204.

McCallum, B.T. (1996): "Inflation Targeting in Canada, New Zealand, Sweden, The United Kingdom and in General", *NBER Working Paper*, No. 5579.

McDonough, W.J. (1997): "A Framework for the Pursuit of Price Stability", *Economic Policy Review*, Vol. 3, No. 3.

Mishkin, F.S. and A S. Posen (1997): "Inflation Targeting: Lessons from Four Countries", *Economic Policy Review*, Vol. 3, No. 3.

Ortega, E. and J.M. Bonilla (1995): "Reasons for adopting an inflation target", *Targeting Inflation*, A. Haldane (ed.).

Padoa-Schioppa, T. (1996): "Styles of Monetary Management", *BOJ Monetary and Economic Studies*, Vol. 14, No.1, pp 40-63.

Persson, T. and G. Tabellini (1996): "Monetary Cohabitation in Europe," *American Economic Review*, Vol. 86, No. 2.

Poole, W. (1970): "Optimal Choice of Monetary Policy Instrument in a Simple Stochastic Macromodel", *Quarterly Journal of Economics*, Vol. 100 pp 1169-1190.

Ramaswamy, R. (1997): "Monetary Frameworks: Is There a Preferred Option for the European Central Bank?", *IMF Paper on Policy Analysis and Assessment*, PPAA/97/6.

Rodseth, A. (1996): "Exchange Rate versus Price Level Targets and Output Stability", *Scandinavian Journal of Economics*, Vol. 98, No. 4, pp 559-577.

Rogoff, K. (1985): "The Optimal Degree of Commitment to an Intermediate Target: Inflation Gains Versus Stabilization Costs", *Quarterly Journal of Economics*, Vol.100, pp 1169-1189.

Romer, D. (1996): *Advanced Macroeconomics*, McGraw Hill.

Stuart, A. (1996): "Simple Monetary Policy Rules", *Bank of England Quarterly Bulletin*, August.

Svensson, L.E.O. (1996a): "Price Level Targeting versus Inflation Targeting: A Free Lunch?", *Institute for International Economic Studies*, Seminar Paper No. 614.

Svensson, L.E.O. (1996b): "Comment on John B. Taylor, 'How Should Monetary Policy Respond to Shocks while Maintaining Long-Run Price Stability'", in *Achieving Price Stability*, Papers and Proceedings of a symposium sponsored by the Federal Reserve Bank of Kansas City, Jackson Hole, Wyoming.

Svensson, L.E.O. (1997a): "Inflation Forecast Targeting: Implementing and Monitoring Inflation Targets", *European Economic Review*, Vol. 41, pp 1111-1146.

Svensson, L.E.O. (1997b): "Inflation Targeting: Some Extensions", *NBER Working Paper*, No. 5962.

Taylor, J.B. (1993): "Discretion versus Policy Rules in Practice", *Carnegie-Mellon Conference Series on Public Policy*, Vol. 29, pp 173-204.

Taylor, J.B. (1996): "Policy Rules as a Means to a More Effective Monetary Policy", *Bank of Japan Monetary and Economic Studies*, Vol. 14, No. 1, pp 28-39.

Walsh, C.E. (1995): "Optimal Contracts for Central Bankers", *American Economic Review*, Vol. 85, pp 150-167.

Yates, A. (1995): "On the Design of Inflation Targets", in *Targeting Inflation*, A. Haldane, Bank of England.

Yates, A. and B. Chapple (1996): "What determines the short-run output-inflation trade-off?", *Bank of England Working Paper*, No.53

Appendix: The Svensson Inflation Targeting Model

This appendix sets out a model for inflation targeting proposed by Svensson (1996b). The model tries to capture the stylised facts that changes in policy have lagged impacts on aggregate demand and inflation.

The lags in the model are described by the equations

(A1) $$p_{t+1} = p_t + a\, y_t + e_{t+1}$$

where (A1) is an accelerationist Phillips curve, where π is inflation, y is the output gap, α is a positive constant that reflects the speed of adjustment of inflation to the output gap and ε is a serially uncorrelated disturbance term with zero mean which can be interpreted as a negative supply shock,

(A2) $$y_{t+1} = b_1 y_t - b_2 (i_t - p_t) + h_{t+1}$$

where (A2) is an IS/aggregate demand relationship, where *i* is the nominal interest rate, the βs are positive constants and η is a serially uncorrelated disturbance term with zero mean which can be interpreted as a demand shock.

The policymaker is assumed to minimise a conventional quadratic social loss function which depends on deviations of π from π^* and y from y*

(**A3a)** $$L_t = (p_t - p^*)^2 + l\,(Y_t - Y^*)^2$$

or in terms of the output gap

(A3b) $$L_t = (p_t - p^*)^2 + l\,(y_t)^2$$

where π^* is the long run inflation target, Y* is potential output. The $\lambda \geq 0$ term is the weight on output stabilisation around the natural output level relative to inflation stabilisation around the long run inflation target. The $\lambda = 0$ implies a single goal of inflation stabilisation while $\lambda > 0$ attaches importance to output stabilisation in a joint objective for monetary policy. The intertemporal loss function is

(A4) $$E_t \sum_{t=0}^{\infty} d^t L(p_{t+r}, y_{t+r})$$

where δ is the discount rate such that $0 < \delta < 1$.

To solve the model we take a one period control problem initially where the period loss function is

(A5) $$L(p_t, y_t) = (p_t - p^*)^2 + l\, y_t^2$$

and the one period value function that we wish to optimise is

(A6) $$V(p_t) = \min_{y_t}\left(\left(p_t - p^*\right)^2 + \lambda y_t^2 + \delta E_t V(p_{t+1})\right)$$

subject to the constraints in (A1) and (A2) such that substituting for π_{t+1}

$$V(p_t) = \min\left(\left(p_t - p_t^*\right)^2 + \lambda y_t^2 + \delta E_t V(p_t + \alpha y_t + e_{t+1})\right)$$

The first order condition is

(A7) $$\frac{\partial V(p_t)}{\partial y_t} = 2\lambda y_t + \delta\alpha E_t V_p(p_{t+1}) = 0$$

$$where \quad V_p(p_{t+1}) = \frac{\partial v(p_{t+1})}{\partial p_{t+1}}$$

Using an indirect loss function that is quadratic

(A8) $$V(p_t) = k_0 + k\left(p_t - p^*\right)^2$$

where the k_0 and k need to be determined. Using this we can substitute for $V_\pi(\pi_{t+1})$ in (A7) by getting the first order condition of

(A9) $$V(p_{t+1}) = k_0 + k p_{t+1}^2 - 2k p_{t+1} p^* + k p^{*2}$$

(A10) $$V_p(p_{t+1}) = \frac{\partial v(p_{t+1})}{\partial p_{t+1}} = 2k p_{t+1} - 2k p^* = 2k\left[p_{t+1} - p^*\right]$$

substitute this into the first order condition in (A7) above (noting $E_t\pi_{t+1} = \pi_{t+1|t}$) to get

(A11) $$2\lambda y_t + \delta\alpha E_t V_p(p_{t+1}) = 2\lambda y_t + 2\delta\alpha k\left(p_{t+1|t} - p^*\right) = 0$$

Rearranging to (A11) we get

(A12) $$p_{t+1|t} - p^* = -\frac{\lambda}{\delta\alpha k} y_t$$

We can then rearrange (A12) to get a decision rule for y_t

(A13) $$y_t = -\frac{\delta\alpha k}{\lambda}\left(p_{t+1|t} - p^*\right) = -\frac{\delta\alpha k}{\lambda}\left[p_t + \alpha y_t - p^*\right]$$

Rearranging this we get

$$y_t\left(1+\frac{dka^2}{l}\right)=-\frac{da k}{l}\left[p_t-p^*\right]$$

$$y_t=-\frac{da k}{l+da^2 k}\left(p_t-p^*\right)$$

Then using the above for y_t we get

(A14) $$p_{t+1|t}=p_t+ay_t=p_t+a\left(-\frac{da k}{l+da^2 k}\left(p_t-p^*\right)\right)$$

rearranging the terms and adding (π* - π*) we get

$$p_{t=1|t}=p_t-\frac{da^2 k}{l+da^2 k}\left(p_t-p^*\right)+p^*-p^*$$
$$p_{t=1|t}=p^*+\left(1-\frac{da^2 k}{l+da^2 k}\right)\left(p_t-p^*\right)$$
$$p_{t=1|t}=p^*+\left(\frac{l+da^2 k-da^2 k}{l+da^2 k}\right)\left(p_t-p^*\right)$$

(A15) $$p_{t=1|t}=p^*+\frac{l}{l+da^2 k}\left(p_t-p^*\right)$$

In order to identify the parameter k we need to make use of the envelope theorem*. Using (A6) we have

$$V\left(p_t\right)=\left(p_t-p^*\right)^2+ly_t^2+dE_tV\left(p_{t+1}\right)$$
$$V\left(p_t\right)=p_t^2-2p_tp^*+p^{*2}+ly_t^2+dE_tV\left(p_{t+1}\right)$$

Get the first order condition where

(A16) $$V_p\left(p_t\right)=\frac{\P V\left(p_t\right)}{\P p_t}=2p_t-2p^*+dE_tV_p\left(p_{t+1}\right)=0$$

Using $E_tV_p(p_{t+1})=2k(p_{t+1|t}-p^*)$ and $V_p\left(p_{t+1}\right)=2k\left(p_{t+1}-p^*\right)$ we get

(A17) $$V_p(p_t)=2\left(p_t-p^*\right)+2\,dk\left(p_{t+1|t}-p^*\right)$$

Then using (A15)

* The Envelope Theorem states that the total derivative of the value function with respect to a parameter equals the partial derivative when the derivative is evaluated at the optimal level.

(A18) $$V_p(p_t) = 2(p_t - p^*) + 2\,dk\left(p^* + \frac{l}{l + da^2 k}(p_t - p^*) - p^*\right)$$

(A19) $$V_p(p_t) = 2\left(1 + \frac{dlk}{l + da^2 k}\right)(p_t - p^*)$$

Then from (A8) we can identify k from the above as the coefficient on (π_t - π^*)

(A20) $$k = 1 + \frac{d\,l\,k}{l + la^2 k}$$

There is a unique positive solution that fulfills k ≥ 1which can be solved analytically. Multiply both sides of (A20) by $\lambda + \delta\alpha^2 k$ we get

(A21) $$k\left(l + da^2 k\right) = l + da^2 k + dlk$$

Rearranging

$$k\,l + da^2 k^2 - l - da^2 k - dlk = 0$$

and dividing by $\delta\alpha^2$

$$k^2 + \frac{l}{da^2}k - k - \frac{d\,l}{da^2}k - \frac{l}{da^2} = 0$$

we get

(A22) $$k^2 - \left(1 - \frac{l(1-d)}{da^2}\right)k - \frac{l}{da^2} = 0$$

To solve this quadratic equation we use

$$k = \frac{-b + \sqrt{b^2 - 4a.c}}{2a} \quad where \quad a = 1, b = -\left(1 - \frac{l(1-d)}{da^2}\right), c = -\frac{l}{da^2}$$

$$k = \frac{1}{2}\left(1 - \frac{l(1-d)}{da^2} + \sqrt{\left(1 - \frac{l(1-d)}{da^2}\right)^2 + \frac{4\,l}{da^2}}\right)$$

Using $$\frac{4\,l}{da^2} = \frac{4\,l}{da^2} - \frac{4\,l\,d}{a^2 d} + \frac{4\,l}{a^2} = \frac{4\,l(1-d)}{da^2} + \frac{4\,l}{a^2}$$

$$k = \frac{1}{2}\left(1 - \frac{l(1-d)}{da^2} + \sqrt{\left(1 - \frac{l(1-d)}{da^2}\right)^2 + \frac{4\,l(1-d)}{da^2} + \frac{4\,l}{a^2}}\right)$$

Using $$\left(1 - \frac{l(1-d)}{da^2}\right)^2 = 1 - \frac{2\,l(1-d)}{da^2} + \left(\frac{l(1-d)}{da^2}\right)^2$$

we have for the term inside the square root as

$$\sqrt{1-\frac{2\,l(1-d)}{da^{2}}+\left(\frac{l(1-d)}{da^{2}}\right)^{2}+\frac{4\,l(1-d)}{da^{2}}+\frac{4\,l}{a^{2}}}$$

or

$$\sqrt{1+\frac{2\,l(1-d)}{da^{2}}+\left(\frac{l(1-d)}{da^{2}}\right)^{2}+\frac{4\,l}{a^{2}}} \quad = \quad \sqrt{\left(1+\frac{l(1-d)}{da^{2}}\right)^{2}+\frac{4\,l}{a^{2}}}$$

putting this term back in for k we get

(A23) $$k=\frac{1}{2}\left(1-\frac{l(1-d)}{da^{2}}+\sqrt{\left(\left(1+\frac{l(1-d)}{da^{2}}\right)^{2}+\frac{4\,l}{a^{2}}\right)}\right)\geq 1$$

If k ≥ 1 then $\left(1-\frac{l(1-d)}{da^{2}}\right)+\sqrt{\left(1+\frac{l(1-d)^{2}}{da^{2}}\right)+\frac{4\,l}{a^{2}}}\geq 2$

$$\therefore \sqrt{\left(1+\frac{l(1-d)^{2}}{da^{2}}\right)+\frac{4\,l}{a^{2}}}\geq 1+\frac{l(1-d)}{da^{2}}$$

$$\left(1+\frac{l(1-d)}{da^{2}}\right)^{2}+\frac{4\,l}{a^{2}}\geq\left(1+\frac{l(1-d)}{da^{2}}\right)^{2} \quad i.e. \quad \frac{4\,l}{a^{2}}\geq 0 \quad \Rightarrow \quad l\geq 0$$

Taking this one period control problem and extending it to two periods the value function to optimise in this case is expressed as

(A24) $$V(p_{t+1lt})=\min_{y_{t+1lt}}\left[(p_{t+1lt}-p^{*})^{2}+\ ly_{t+1lt}^{2}+\ dE_{t}V(p_{t+2lt+1})\right]$$

subject to

(A25) $$p_{t+2lt+1}=p_{t+1}+ay_{t+1}=p_{t+1lt}+ay_{t+1lt}+(e_{t+1}+ah_{t+1})$$

where we have used (A1) and where using (A2)

(A26) $$y_{t+1lt}=y_{t+1}+h_{t+1}=b_{1}y_{t}-b_{2}(i_{t}-p_{t})$$

Rearranging (A26) we get

(A27) $$i_{t}-p_{t}=-\frac{1}{b_{2}}y_{t+1lt}+\frac{b_{1}}{b_{2}}y_{t}$$

The first order condition in this case can, analogously to (A12), be expressed as

(A28) $$p_{t+2|t} - p^* = -\frac{l}{\alpha k} y_{t+1|t}$$

We make use of the fact that

$$p_{t+2|t} = p_{t+1|t} + a y_{t+1|t}$$
$$p_{t+2|t} = p_t + a y_t + a(b_1 y_t - b_2(i_t - p_t))$$
$$p_{t+2|t} - p^* = p_t - p^* + a(1+b_1) y_t - a b_2 (i_t - p_t)$$

We can use this to solve for (A27) as follows substituting $y_{t+1|t}$ using (A28)

$$i_t - p_t = -\frac{1}{b_2} y_{t+1|t} + \frac{b_1}{b_2} y_t = \frac{\alpha k}{l b_2}\left(p_{t+2|t} - p^*\right) + \frac{b_1}{b_2} y_t$$

and substituting for $\pi_{t+2|t}$ from above

$$i_t - p_t = \frac{\alpha k}{l b_2}\left[p_t - p^* + a(1+b_1) y_t - a b_2 (i_t - p_t)\right] + \frac{b_1}{b_2} y_t$$

Expanding this out and rearranging

$$i_t - p_t = \frac{\alpha k}{l b_2}\left(p_t - p^*\right) - \frac{\alpha^2 k}{l}(i_t - p_t) + \left[\frac{\alpha^2 k}{l b_2}(1+b_1) + \frac{b_1}{b_2}\right] y_t$$
$$\left[1 + \frac{\alpha^2 k}{l}\right]\left[i_t - p_t\right] = \frac{\alpha k}{l b_2}\left(p_t - p^*\right) + \left[\frac{\alpha^2 k}{l b_2}(1+b_1) + \frac{b_1}{b_2}\right] y_t$$

$$i_t - p_t = \frac{\alpha k}{l b_2}\left[\frac{l}{l + \alpha^2 k}\right]\left(p_t - p^*\right) + \left[\frac{\alpha^2 k}{l b_2}(1+b_1) + \frac{b_1}{b_2}\right]\left[\frac{l}{l + \alpha^2 k}\right] y_t$$

$$i_t - p_t = \frac{1}{b_2}\left[\frac{\alpha k}{l + \alpha^2 k}\right]\left(p_t - p^*\right) + \left[\begin{array}{l} \dfrac{l\,\alpha^2 k}{l b_2\left(l + \alpha^2 k\right)} + \dfrac{l\,\alpha^2 k b_1}{l b_2\left(l + \alpha^2 k\right)} \\ + \dfrac{l b_1}{l b_2\left(l + \alpha^2 k\right)} \end{array}\right] y_t$$

$$i_t - p_t = h\left(p_t - p^*\right) + \frac{1}{b_2}\left[\frac{\alpha^2 k}{l + \alpha^2 k} + b_1 \frac{\left(l + \alpha^2 k\right)}{l + \alpha^2 k}\right] y_t$$

$$i_t - p_t = h\left(p_t - p^*\right) + \frac{1}{b_2}\left(\frac{\alpha^2 k}{l + \alpha^2 k} + b_1\right) = h\left(p_t - p^*\right) + g y_t$$

(A29) $$i_t - p_t = h\left(p_t - p^*\right) + g y_t$$

where $$h = \frac{\delta\alpha k}{b_2\left(l + \delta\alpha^2 k\right)} \quad and \quad g = \frac{1}{b_2}\left(\frac{\delta\alpha^2 k}{l + \delta\alpha^2 k} + b_1\right)$$

By (A1) and using $p_{t+2|t+1} = p_{t+1} + ay_{t+1}$ and $p_{t+2|t} = p_{t+1|t} + ay_{t+1|t}$ we get

(A30) $$y_{t+1lt} = \frac{1}{a}\left(p_{t+2lt} - p_{t+1lt}\right)$$

and

(A31) $$p_{t+2|t} - p^* = \frac{l}{\delta\alpha k}\left[\frac{1}{a}\left(p_{t+2|t} - p_{t+1|t}\right)\right]$$

(A32) $$p_{t+2|t}\left[1 + \frac{l}{\delta\alpha^2 k}\right] = p^* + \frac{l}{\delta\alpha^2 k}p_{t+1|t}$$

Bring the bracketed term to the other side we get

(A33) $$p_{t+2lt} = cp^* + (1-c)p_{t+1lt}$$

where $$0 < c = \frac{\delta\alpha^2 k}{l + \delta\alpha^2 k} \le 1$$

The coefficient C will be decreasing in λ and increasing in α. To show that C is increasing in λ we use (A23) for k and divide by λ to get z

(A34) $$z = \frac{k}{l} = \frac{1}{2}\left[\frac{1}{l} - \frac{1-d}{\delta\alpha^2} + \sqrt{\left(\frac{1}{l} + \frac{1-d}{\delta\alpha^2}\right)^2 + \frac{4}{l\alpha^2}}\right]$$

dividing the square root term in (A23) by $\sqrt{l^2} = l$

Let $$z = \frac{1}{2}\left[w - A + \sqrt{(w+A)^2 + 4ABw}\right]$$

where $$w = \frac{1}{l}, \quad A = \frac{1-d}{\delta\alpha^2} > 0, \quad B = \frac{d}{1-d} > 0$$

(A35) $$z = \frac{1}{2}\left[w - A + \frac{1}{2}\left(w^2 + 2Aw + A^2 + 4ABw\right)^{-\frac{1}{2}}\right]$$

Get the first order condition of (A35)

(A36) $$2\frac{\partial Z}{\partial w} = 1 + \frac{1}{2}(w^2 + 2Aw + A^2 + 4ABw)^{-\frac{1}{2}}.(2w + 2A + 4AB) = 0$$

(A37) $$2\frac{\partial Z}{\partial w} = 1 + \frac{w + A + 2AB}{\sqrt{w^2 + 2AW + A^2 + 4ABw}}$$

Given that A, B > 0, $\frac{\partial Z}{\partial w} > 0$ if w > 0 implying that $\lambda > 0$

To show that C is decreasing in α let

(A38) $$v = ak = \frac{1}{2}\left[a - \frac{D}{a} + \sqrt{\left(a + \frac{D}{a}\right)^2 + 4l}\right]$$

Multiplying (A23) by a and the square root term by $\sqrt{a^2} = a$,

where $D = \frac{l(1-d)}{d} > 0$

It is necessary to show that $\frac{\partial v}{\partial a} > 0$

Let

(A39) $$v = \frac{1}{2}\left(a - Da^{-1} + \left(a^2 + 2D + \left(\frac{D}{a}\right)^2 + 4l\right)^{\frac{1}{2}}\right)$$

Get the first order condition

(A40) $$2\frac{dv}{da} = 1 + Da^{-2} + \frac{1}{2}\left(a^2 + 2D + D^2a^{-2} + 4l\right)^{-\frac{1}{2}}.2a - 2D^2a^{-3} = 0$$

$$2\frac{dv}{da} = 1 + \frac{D}{a^2} + \frac{1}{2}\frac{1}{\sqrt{\left(a + \frac{D}{a}\right)^2 + 4l}}2a - 2\frac{D^2}{a^3}$$

$$2\frac{dv}{da} = 1 + \frac{D}{a^2} + \frac{1}{2}\frac{1}{\sqrt{\left(a + \frac{D}{a}\right)^2 + 4l}}2a\left(1 - \frac{D^2}{a^4}\right)$$

$$2\frac{dv}{da} = 1 + \frac{D}{a^2} + \frac{1}{2}\frac{1}{\sqrt{\left(a + \frac{D}{a}\right)^2 + 4l}}2a\left[\left(1 + \frac{D}{a^2}\right)\left(1 - \frac{D}{a^2}\right)\right]$$

$$2\frac{dv}{da} = 1 + \frac{D}{a^2} + \frac{2\left(1+\frac{D}{a^2}\right)a\left(1-\frac{D}{a^2}\right)}{2\sqrt{\left(a+\frac{D}{a}\right)^2 + 4l}} = 1 + \frac{D}{a^2} + \frac{a - \frac{D^2}{a^3}}{\sqrt{\left(a+\frac{D}{a}\right)^2 + 4l}}$$

$$2\frac{dv}{da} = 1 + \frac{D}{a^2} + \frac{\left(a - \frac{D}{a} + \frac{D}{a} - \frac{D^2}{a^3}\right)}{\sqrt{\left(a+\frac{D}{a}\right)^2 + 4l}} = 1 + \frac{D}{a^2} + \frac{\left(1+\frac{D}{a^2}\right)\left(a-\frac{D}{a}\right)}{\sqrt{\left(a+\frac{D}{a}\right)^2 + 4l}}$$

$$2\frac{dv}{da} = \left(1+\frac{D}{a^2}\right)\left(1 + \frac{a-\frac{D}{a}}{\sqrt{\left(a+\frac{D}{a}\right)^2 + 4l}}\right) = \left(1+\frac{D}{a^2}\right)\left(\frac{\sqrt{\left(a+\frac{D}{a}\right)^2 + 4l} + a - \frac{D}{a}}{\sqrt{\left(a+\frac{D}{a}\right)^2 + 4l}}\right)$$

(A41) $$\frac{dv}{da} = \left(1+\frac{D}{a^2}\right)\left(\frac{\sqrt{\left(a+\frac{D}{a}\right)^2 + 4l} + a - \frac{D}{a}}{\sqrt{\left(a+\frac{D}{a}\right)^2 + 4l}}\right) > 0$$

The C decreases from 1 to 0 as λ goes from 0 to ∞.

Table 1: Summary of Inflation Targeting Frameworks

Country	*New Zealand*	*Israel*	*Canada*	*United Kingdom*	*Sweden*	*Finland*
Date first instituted	**March 1990**	**December 1991**	**February 1991**	**October 1992**	**January 1993**	**February**
Current Target	**0-3%**	**8 - 11%**	**1-3%**	**2.5%, +/- 1%**	**2%+/- 1%**	**2%**
Time-frame	**5 years (to 1998)**	**1 year**	**Through end-1998**	**2 years**	**Annual from 1995**	**1996 onwa**
Inflation measure	**Underlying CPI**	**CPI**	**CPI**	**Retail Price Index excl. mortgage interest payments (RPIX)**	**CPI**	**Underlyin**
Factors excluded from CPI	**Interest cost component, indirect taxes, government charges and significant changes in terms of trade.**	**None.**	**Indirect taxes, food, and energy prices (operational exemption).**	**Mortgage interest payments.**	**None.**	**Mortgage interest payments, indirect ta govt. Subs house pric**
Inflation report	**Quarterly since March 1990.**	**No.**	**Half-yearly since May 1995**	**Quarterly since February 1993**	**Quarterly since October 1993**	**No**