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Abstract

This paper examines the concept of monetary policy credibility from both the theoretical and practical viewpoints. It also discusses the advantages of high credibility and explains measures that can be taken to enhance it. The article reviews a number of studies that have examined the credibility of monetary policy making over the past decade. Our main conclusion is that credibility is an elusive thing. The only way to be sure of acquiring it is to earn it by deeds. The existing theoretical literature would benefit a great deal by taking this into consideration.

Keywords: *Monetary Policy, Credibility, Institutions*
JEL Codes: *E31, E52, E58*

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INTRODUCTION

Since the 1980s an important body of literature has grown on institutional arrangements for central banks, with some of the more notable contributions being Rogoff (1985), Cukierman (1992), and Walsh (1995). Specifically, these studies consider alternative arrangements, such as contracts between a nation's government and its monetary authority that might leave the latter free to pursue counter-cyclical stabilization policy while simultaneously forcing it to avoid the inflationary bias of 'discretionary' policymaking as identified by Kydland and Prescott (1977) and Barro and Gordon (1983).

Impressive as this literature is, however, it is the contention of the present paper that it is unrealistic owing to fundamental presumptions of the analysis.[1] These are not technical errors, of course, but inappropriate interpretive mappings between theoretical constructs and the real world. The problem is all these studies treat credibility to be exogenous i.e., expectations adjust along a path that is independent of the inflation rate.[2, 3] Even with an explicit inflation target, stated objectives will not necessarily be believed, owing to either incentives for the central bank to mislead the public or doubts about the competence of the central bank. Otherwise, all central banks could enjoy instant credibility by stating their objectives. Thus, credibility is unlikely to be exogenous. The weight that agents place on the announced target plausibly reacts to developments in the economy.

[1] The attractiveness of these models lies in its simplicity, its apparent plausibility, and its capacity to generate insightful results. Nevertheless, this simplistic elegance remains a rich source of criticism and often makes these models inappropriate for addressing issues pertaining to credibility.

[2] There are exceptions of course (see Backus and Driffill, 1985a, b) for example. However, this literature typically employs 'trigger' mechanisms that assume a quick and complete collapse of credibility after even a minor failure by the policymaker to meet the target. This appears too extreme because agents are surely willing to forgive at least one failure on the part of the policymaker.

[3] In the appendix we illustrate this point with a model which is widely used in the analysis of monetary policy.

For example, targets that are missed on a consistent basis are likely to be down-weighted in the formation of expectations. In other words, credibility is established by outcomes. If past inflation matches the inflation target, then the target is given more weight by the private sector in the formation of expectations of future inflation and *vice versa*. Optimal monetary policy therefore, entails endogenising the learning process of agents and solving the resultant optimal-control problem. To develop this claim and to point out some practical implications are the objectives of the present paper.

The rest of the paper is organised as follows. In the next section we review the concept of credibility and its importance. Next we deal with the measurement issue. This is followed by a review of various measures suggested in the literature to build and enhance credibility. Next we review some of the empirical literature. The final section concludes.

THE CONCEPT OF CREDIBILITY AND ITS IMPORTANCE

In recent years the issue of credibility has become a central concern of the scholarly literature on monetary policy and in practical central banking circles. A search on Econlit - the economic database - reveals that 189 different articles used the word 'credibility' in the title in conjunction with either monetary policy or central banking over the last ten years, while the search reveals only 66 entries in the preceding 20 years. This increasing interest in the credibility of monetary policy pronouncements is in part related to the link between expectations and the effect that a proposed economic policy will have on the economy. The credibility issue of monetary policy focuses also on the resolution of the so called dynamic inconsistency problem in the conduct of monetary policy.

But what is credibility? The Oxford English Dictionary describes credibility as "the quality of being credible, or having a good reputation". In the academic literature or in central banking circles however, there is no generally agreed-upon definition of the term. Alan Blinder (2000), the former Vice Chairman of the Board of Governors of the Federal Reserve System and a distinguished academic at Princeton University, defines credibility as "a central bank is credible if people believe it will do what it says". Thus, a monetary strategy is credible if the public believes that the central bank will actually carry out its stated plans. If their strategy is not credible, monetary authorities will find they have an incentive to accommodate inflation expectations.

However, Blinder's (2000) survey paper based on a questionnaire to the heads of 127 central banks and several academics reveals three broad definitions of the term: 1) strong aversion to inflation i.e., more inflation-averse central banks are in general more credible; 2) incentive compatibility i.e., one way to induce the central bank to carry out its pledge of price stability is for the government to write an incentive-compatible contract, which might penalise the central bank if inflation breaches the target; or 3) pre-commitment towards a low and stable inflation rate i.e., a central bank is not credible unless it is bound by a rule to live up to its word of price stability despite the temptations to 'cheat'.

But why is credibility important for a central bank given that the measures adopted to enhance it limit the policymaker's discretion by tying his hands and constrains him to follow a systematic behaviour in pursuit of recognised goals? From Blinder (2000) it appears that, first of all, economists as well as central bankers agree that greater credibility helps pin down inflation once it is low and reduces the cost of disinflation. Moreover, there is also general agreement that central banks do not have over ambitious output target i.e., there is general agreement

that the long-run Phillips curve is vertical.[4] Furthermore, it helps garner public support for central bank independence.[5]

The first reason - to keep inflation low and to reduce the cost of disinflation - has been examined extensively in the literature (see Ball (1994), for example). A high degree of credibility will also help keep inflation close to target when unforeseen events disrupt the behaviour of prices. Indeed, inflation control is not a precise art, and the inflation rate may diverge from the target rate at any time because of events beyond the control of the central bank. In such a situation, credibility will help to keep expectations focussed on the target. If the public knows that the central bank will do its best to bring inflation back to target, then expectations will not react strongly to fluctuating price trends, and this will tend to reduce the amplitude of fluctuations in the inflation rate, output and in interest rates.

Bernanke *et. al.* (1998) report evidence that credibility, once earned, can provide better subsequent outcomes. After inflation targets have been met successfully for a period of time, inflation expectations remain low, even in the face of a business cycle expansion. As a result, although the gains from inflation targeting are not high in the disinflation phase of inflation stabilisation, inflation targeting does help to anchor inflationary expectations as the new regime becomes established.

[4] In the 1970s the long-run Phillips curve was still the dominant view, offering a permanently lower unemployment rate in exchange for accepting a higher rate of inflation. In the U.S. and elsewhere, the public reacted to the pain caused by the increase in inflation that pushed interest rates up sharply at the end of the 1970s. The public feared that inflation was out of control and might spiral even higher. These concerns and the damaging effects of inflation that had already been sustained provided political support for the painful contractionary policies needed to reduce inflation – Volcker disinflation. But the shift to an anti-inflationary monetary policy was also the effect of the intellectual revolution that had taken place. The economics profession rejected the notion of a long-run Phillips curve and the consensus shifted to the view, advocated by Friedman (1968), that there is no long-run trade off between unemployment and inflation.

[5] Enhanced credibility makes it easier to defend the currency when necessary, i.e., under a speculative attack central banks can readily scare off speculators.

Following a prolonged period of inflation, why should a central bank not move immediately to price stability? The answer is that there are costs of disinflation, and, moreover, the cost increase more than proportionally with the rate of disinflation. Such costs result from a change in the monetary policy regime – because private sector agents cannot easily tell whether the regime has changed or not. Learning takes time and the longer the period during which inflation was high, the longer it is likely to be before the private sector is persuaded that policy has changed. On the other hand, a high degree of credibility will speed up the transition to the targeted inflation rate, because economic agents will give greater weight to this rate in setting wages and prices, and in turn this will lower the disinflation cost.

MEASURING CREDIBILITY[6]

Assessing the effect of policy pronouncements on public's inflation expectations can be used to test credibility. Bernanke *et. al*. (1998) measure inflation expectations in two different ways. The first method (direct) involves a survey, i.e. asking agents in the private sector about their expectations (the Bank of England summarises these measures of inflationary expectations regularly in the Bank's *Inflation Report*). The results show that expectations did not adjust instantaneously after countries have adopted an inflation target. On the contrary, a process of 'learning' in the private sector seems to be taking place.

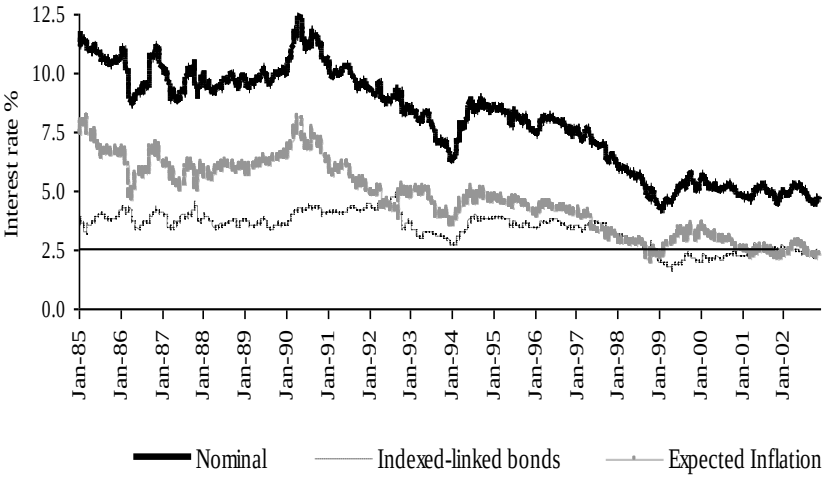
The second method (indirect) is based on evidence from yield spread. This involves considering movements of inflation expectations reflected in the longer-term interest rate. Central banks typically target the short term interest rate with the aim of managing long-term rates which are the average expected level of short rates over the relevant horizon. The difference in the yield spread can be used as an indirect

[6] See King (1995) for a discussion concerning practical issues arising in the measurement of credibility.

measure of expected inflation (abstracting from time varying term premium and default risk). For instance, in the UK for each of the five years following target adoption in 1997, inflationary expectations were higher than the target. Although expectations were revised downward continuously, the fall was not immediate.

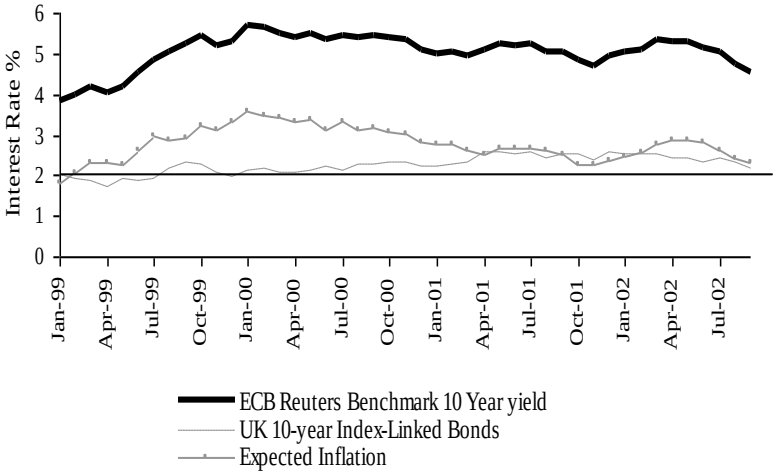
Figure 1 shows the ten-year real and nominal interest rates for the UK derived from index-linked and conventional government bonds, respectively. Also plotted is the difference between them, which measures expected inflation plus any inflation 'risk premium' (ignoring any default risk). As recently as the mid 1990s, the nominal rate was about 8.5 percent, the real rate was around 3.5 percent, and the difference was around 5 percent. The nominal rate in 2002 was around 5 percent, the real rate had fallen below 2.5 percent, and the difference was about 2.5 percent (the Bank of England's official inflation target then). Expected inflation, and perhaps also the inflation risk premium, had fallen very substantially. Although shocks (including sterling's real appreciation) have played a part in subduing inflation, the new regime (Bank of England gained instrument independence in 1997) had surely played the key role in bringing down inflation expectations. It is also clear from the figure that the adoption of an inflation target – a regime change, does not establish immediate credibility for monetary policy. In particular, inflationary expectations are slow to fall to the central bank's long-run target.

Figure 1: UK Inflation Expectations



Source: Bank of England.

Figure 2: ECB Inflation Expectations



Source: ECB and Bank of England.

Figure 2 shows the real UK interest rates (derived from index-linked bonds) and ten-year nominal eurozone bond yield respectively.[7] Also plotted is the difference between them – which measures expected inflation in the eurozone (inflation target of less than 2 percent) plus any inflation 'risk premium' (ignoring any default risk). In January 1999 the nominal rate was about 3.8 percent, the real rate was around 2 percent, and the difference was around 1.8 percent. Since then the nominal yield has shot up significantly and gap between the two has continued to widen till mid-2002, which suggests a lingering lack of confidence in the ECB.

HOW TO CREATE AND ENHANCE CREDIBILITY

The theory of time inconsistency stresses that monetary authorities are often tempted to promise low inflation now and to try to surprise the public with unexpectedly higher inflation later. However, such promises will not be believed by *rational* agents because they understand the policymakers' incentive to inflate for short term economic gains. Therefore, economically plausible outcomes have the property that monetary authorities are not able to surprise the public systematically. This implies that the monetary authority cannot profit from reneging on its announcements. In fact, it can only loose by doing so: expected and realised inflation will often be higher than if the monetary authorities had made a binding commitment. The consequence is a sub-optimal outcome with higher average inflation and no long-term gain in employment.

One way to improve the credibility of monetary policy is to negotiate an official and public agreement between the government and the central bank on an explicit target for inflation i.e., granting instrument independence to the central bank. The case for central bank

[7] Unlike the UK the EU does not issue index-linked securities. Hence real rates are not available for the EU. However, in a world of capital mobility, it would be reasonable to assume that the long-term real interest rate would be very similar across countries. Hence differences in bond yields would reflect differences in monetary credibility.

independence, while not a new one, has been strengthened by a growing body of empirical evidence and by developments in economic theory. The modern case for instrument independence begins from the inflationary bias that would otherwise be present in monetary policy. That there has at times been such a bias in practice can be concluded from the high inflation rates of the 1970s and early 1980s in most industrialised countries.

Other examples of inflationary bias can be found in multi-digit annual inflation rates in both industrialised and developing countries, most spectacularly in hyperinflations.[8] Many researchers have investigated the effects of constitutional design on monetary policy by constructing an index of central bank independence (see for instance Alesina and Summers, 1993). Empirically, central bank independence is generally measured by qualitative indexes based on such factors as how its governor and board are appointed and dismissed, whether there are government representatives on the board, and the government's ability to veto or directly control the bank's decisions. Investigations of the relation between these measures of independence and inflation produce a consistent result: independence and inflation are strongly negatively correlated.

Although institutionalism has produced some empirical evidence in its favour (see also Cukierman, 1992), it can be criticised on two fronts. First, the definitions of independence are themselves influenced by success in keeping inflation down i.e., there is an endogeneity problem.[9] Second, correlation does not necessarily prove causation; it may well be that the public gets so disenchanted with inflation that they decide to set-up an independent central bank.

[8] See Fischer *et. al*. (2002).

[9] Minford and Peel (2002) argue that the Bundesbank which always scores highly on measures of independence have strictly speaking no real independence as it could be nationalised by a simple majority of the lower house of parliament (the Bundestag).

A related literature involves delegating the execution of monetary policy to agents with appropriate incentives to maintain low and stable inflation. For instance, Rogoff (1985) argues that this can be attained by entrusting monetary policy to a person or institution who weights inflation deviations more heavily than in the social-welfare function (weight-conservative central banker). This results in improved overall performance, in which inflation is on average lower and more stable than with a less conservative central banker, but output is more variable. In the alternative principal-agent approach, the inflationary-bias problem is solved by structuring a contract that imposes costs on the central bank when inflation deviates from the desired level. As Walsh (1995) shows, the inflation penalty is linear in inflation in the standard model and is thus conceptually easy to design.[10, 11]

Probably as argued by Blinder (1998) (and the response of majority of central bankers and academics to Blinder's (2000) survey reveals) the most important way to build and enhance credibility is by establishing a history of matching deeds to words.[12] It appears that the respondents feel that central bankers earn credibility with the market participants, more by building a track record for honesty and inflation aversion than by limiting their discretion via commitment technologies or

[10] In the case of New Zealand, such an agreement was enshrined in law – the Reserve Bank of New Zealand Act of 1989. This gives the central bank the mandate to formulate and implement policy for achieving and maintaining price stability. Moreover, the act stipulates that the performance of the central bank governor will be assessed in light of this objective, and dismissal could result if inflation targets are not met.

[11] Reducing the inflation target can remove the inflation bias without increasing output variability (see Svensson, 1997) i.e., the second best outcome.

[12] The methods of building up or creating credibility put forth by Blinder (2000), were (1) A history of living up to its word; (2) Central bank independence; (3) A history of fighting inflation; (4) Openness and transparency; (5) Fiscal discipline by the government; (6) Pre-commitment; and (7) Incentive compatible contracts. When it comes to appraising methods of building or creating credibility, the views of central bankers and economists were closely aligned. Establishing a history of living up to its word was ranked first, by a narrow margin by the central bankers and by a wide margin by the economists. Interestingly, this is at odds with the academic literature which has tended to emphasise the importance of institutions in building credibility.

by entering into incentive-compatible contracts. In other words, institutional arrangements or commitment constraints, although necessary, are not sufficient condition for enhancing credibility.[13]

REVIEW OF EMPIRICAL EVIDENCE

The success of monetary policy in reducing inflation at little or no cost to output and employment relies on the policy being credible. However, there is no clear evidence that a credible policy (which should translate more quickly into lower inflation expectations) built by, for instance adopting an inflation target and/or any other institutional arrangement like an independent central bank, reduces the cost of disinflation. Table 1 shows the difference between consumer price inflation (CPI excluding food and energy prices) in the U.S. measured during the twelve months before the recession and inflation measured during the twelve months after the recession.[14] It is clear that the reduction in inflation after a recession varies a great deal across recessions. These differences reflect the varying severity of the recessions – with deeper recessions typically associated with greater disinflation.

[13] Thus for instance, the Federal Reserve enjoys more credibility now than it did during the 1980s. More importantly it did not acquire this through institutional change.

[14] Alesina and Summers (1993) construct an index of central bank independence for sixteen countries based on both political and economic independence. According to their measure the Federal Reserve enjoys a relatively high degree of independence.

Table 1: The Difference in Inflation before a Recession and Inflation after a Recession

(in percentage points)

Recession	Difference (Peak-Trough) in Inflation
Dec. 1969-Nov. 1970	-2.6
Nov.1973-Mar 1975	+1.9
Jan 1980-July 1980	-0.8
July 1981-Nov. 1982	-6.8
July 1990-Mar. 1991	-1.2

Source: Rudebusch (1996).

Bernanke *et. al.* (1998) examined whether disinflation in countries adopting an inflation targeting regime has been achieved at a lower cost than would otherwise be expected, or whether inflation has declined to a greater extent than can be attributed to normal cyclical factors, domestic and international. To test this, they looked at the response of inflation to the business cycle by considering the so-called 'sacrifice ratio', that is a measure of the output loss that an economy must sustain in order to achieve a reduction in inflation. Their finding shows that disinflation under inflation targeting does not appear to be less costly than it would have been in the absence of inflation targeting. For instance, the sacrifice ratio experienced in New Zealand, Canada and the UK after the introduction of inflation targeting was higher than the average sacrifice ratio of previous disinflations in these countries.

The finding of no 'credibility bonus' (in terms of lower sacrifice ratio) from inflation targeting can also be found in other recent papers where changes in monetary institutions (such as increased central bank independence) do not appear to enhance credibility. For instance, Debelle and Fischer (1994) cite the experience of Germany in the 1980s as evidence contrary to the proposition that central banks with high credibility pay less for disinflation. They find that output forgone in

Germany during disinflationary episodes is no smaller than that forgone in the US during the same period.[15]

Blackburn and Christensen (1989) commenting on the Conservative government's Medium Term Financial Strategy (MTFS) in the UK - a gradualist plan involving the pre-announced tightening of monetary and fiscal policies - point out that disinflation was associated with considerable unemployment costs.[16] For instance, they noticed that between 1979 and 1983, UK inflation fell from 13.4 percent to 4.6 percent while unemployment increased from 5.1 percent to 12.4 percent and so they concluded that the public did not believe the anti-inflation program. However, it is possible to argue that the prospect of high fiscal deficits into the indefinite future and the anticipation of future monetisation could have been sufficient to prevent inflationary expectations from falling. For example, large budget deficits raise the probability that a future government will be tempted to inflate away the burden of debt.

In sum, one is forced to regard the foregoing empirical evidence (on the cost of disinflation) as a rather damning critique of the theoretical literature on the importance of institutions and its design. There appears to be no shortcuts to greater credibility. Policymakers get their credibility the old-fashioned way: they earn it by building a track record for honesty and inflation aversion. There is a strong case for arguing that the existing literature on monetary policy would benefit a great deal by taking this aspect into consideration.

[15] Posen (1995) also does not find evidence that the costs of disinflation are lower in countries with independent central banks.

[16] From the perspective of the credibility and reputation framework reviewed earlier, these events appear odd, especially given the rhetoric that surround the anti-inflationary policies pursued by the Conservative government at that time.

CONCLUSION

Adopting an inflation target as a commitment device or establishing institutions do not necessarily enhance credibility and reduce the cost of disinflation. The mere announcement of a commitment to price stability as the basis for monetary policy is unlikely to generate full credibility quickly. Institutional changes such as central bank independence though necessary are not sufficient to enhance credibility. Because credibility gains are slow to materialise, and because institutional arrangements (such as, for wage and price setting) do not change quickly, such mechanisms do not provide a magic bullet for avoiding the real costs associated with disinflation. In sum, it appears that the only way to gain credibility is to earn it. This can be achieved only after a fairly long period of time characterised by an inflation rate that is close to the announced target and by sound performance of both employment and output.

APPENDIX

Exogenous credibility under commitment

The treatment of inflation targeting under commitment follows Svensson (1997).

The short-run Phillips curve is

$$y_t = \rho y_{t-1} + \alpha(\pi_t - \pi_t^e) + \varepsilon_t \,, \tag{1}$$

where y_t is the output gap in period *t*, α and ρ are constants (α > 0 and 0< ρ <1), π_t is the inflation rate, π_t^e denotes expectations conditional upon information available in period *t-1*, ε_t is iid error, normally distributed with mean zero and variance σ_ε^2. The private sector has rational expectations; that is,

$$\pi_t^e = E_{t-1}\pi_t \,, \tag{2}$$

Now suppose that there is a commitment mechanism in place, so that the central bank can commit to the optimal rule. Under commitment, the optimal rule under inflation targeting is

$$\pi_t = \pi_t^e + b\varepsilon_t \,, \tag{3}$$

where, inflation is independent of the lagged output gap and only depends on the new information that has arrived after the private sector formed its expectations. When the central bank is committed to a state-contingent rule in conducting monetary policy, this implies that the monetary authority internalises the impact of its decision rule on the expectations of the private sector. In other words, the monetary authority takes into account how its actions affect the private sector's expectations. It does this by minimizing its loss function with respect to the private sector's expectations of the inflation rate under the explicit constraint that these expectations are formed rationally.

Thus, equations (1), (2) and (3) represent the constraints facing the central bank. The central bank's objective under 'deliberate' disinflation strategy is to stabilize inflation around a given (long-run) inflation target, π^*, as well as stabilizing the output gap around an output gap target, $y^* = 0$.This can be represented by an intertemporal loss function for the central bank given by

$$E_t\left[\sum_{\tau=t}^{\infty}\beta^{\tau-t}L_\tau\right],$$

(4)

with the period loss function

$$L_t=\frac{1}{2}\left[\left(\pi_t-\pi^*\right)^2+\lambda\left(y_t-y^*\right)^2\right], \quad (5)$$

where $\lambda > 0$ is the relative weight on output-gap stabilization. The central bank is, for simplicity, assumed to have perfect control over the inflation rate π_t. It sets the inflation rate in each period after having observed the current supply shock ε_t. This is a dynamic programming problem with one state variable, y_{t-1}, and two control variables, π_t and π_t^e, and where β is the discount factor.[17] The solution can be obtained by solving the following equation involving the value function $V(y_t)$. Thus, the decision problem of the central bank can be expressed as

$$V\left(y_{t-1}\right)=E_{t-1}\min_{\pi_t^e,\pi_t}\left\{\frac{1}{2}\left[\left(\pi_t-\pi^*\right)^2+\lambda\left(y_t-y^*\right)^2\right]+\beta V\left(y_t\right)\right\}, \quad (6)$$

where the minimization in period t is subject to (1)-(3). For the linear-quadratic problem such as ours, $V(y_t)$ must also be quadratic. Thus, the indirect loss function can be written as

$$V\left(y_{t-1}\right)=\gamma_0+\gamma_1 y_{t-1}+\frac{1}{2}\gamma_2 y_{t-1}^2, \quad (7)$$

[17] Note that if there is no output persistence, the problem of minimizing the intertemporal loss function Eq. (4) is equivalent to the static problem of minimizing the expected period loss function Eq. (5).

so that $V'(y_{t-1}) = \gamma_1 + \gamma_2 y_{t-1}$ and γ_i's are the undetermined coefficients. Using this condition together with Eqs. (1)-(3), we obtain two first-order conditions from Eq. (6) with respect to π_t^e and π_t, respectively:

$$E_{t-1}\pi_t = \pi^* \tag{8}$$

$$\mu = -(\pi_t - \pi^*) - \lambda\alpha(y_t - y^*) - \alpha\beta[\gamma_1 + \gamma_2(y_t - y^*)] \tag{9}$$

where μ is the Lagrangian multiplier on the joint constraint (2) and (3): $\mu(\pi_t - E_{t-1}\pi_t + b\varepsilon_t)$. Note that under commitment inflationary expectations are anchored by π* i.e., expectations are exogenous. The central bank gains immediate credibility once it commits to an inflation target. Taking expectations of (9) and substituting (8) for $E_{t-1}\pi_t$ implies that

$$\mu = -\lambda\alpha(\rho y_{t-1} - y^*) - \alpha\beta[\gamma_1 + \gamma_2(\rho y_{t-1} - y^*)] \tag{10}$$

Substituting (10) in (9) for μ yields:

$$\pi_t = \pi^* - \left[\frac{\alpha(\beta\gamma_2 + \lambda)}{1 + \alpha^2(\beta\gamma_2 + \lambda)}\right]\varepsilon_t \tag{11}$$

Eq. (11) is the optimal feedback rule for inflation under commitment expressed as a function of the parameters of the model and the coefficient, γ_2, which can be easily derived by making use of the Envelope theorem. Differentiating Eq. (6) w.r.t y_{t-1} yields:

$$V'(y_{t-1}) = \gamma_1 + \gamma_2 y_{t-1} = \rho\lambda(\rho y_{t-1} - y^*) + \beta\rho[\gamma_1 + \gamma_2(\rho y_{t-1} - y^*)] \tag{12}$$

Collecting terms in γ_2 yields:

$$\gamma_2 = \frac{\lambda\rho^2}{1 - \beta\rho^2} \tag{13}$$

Therefore, the solution for inflation and output gap under commitment can be expressed as:

$$\pi_t = \pi^* - \left[\frac{\alpha\lambda}{1-\beta\rho^2+\alpha^2\lambda}\right]\varepsilon_t \tag{14}$$

$$y_t = \rho y_{t-1} + \left[\frac{1-\beta\rho^2}{1-\beta\rho^2+\alpha^2\lambda}\right]\varepsilon_t \tag{15}$$

where the average inflation bias, $E(\pi_t)-\pi^*=0$ under commitment. The unconditional variability of both output and inflation will be proportional to the variance of the supply shock.

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