MONETARY POLICY WHEN CREDIBILITY MATTERS

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Abstract

Continuos credibility effects are incorporated into a simple model of optimal monetary policy. The resulting model provides explanations for a number of "folk theorems" about credibility in monetary policy. A central bank with low initial credibility pursues a more restrictive policy than a central bank with high initial credibility. It accommodates shocks less and expected inflation more. The higher initial credibility is, the larger is the scope for stabilisation of shocks. Calibrations show that the time consistent inflation rate is drastically reduced when the central bank takes credibility into account.

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1. Introduction

In solutions to the time inconsistency problem in monetary policy, it is often assumed that some kind of commitment technology exists - either in the hands of the central bank or in the hands of the government. The central bank may be able to commit to a preannounced policy or, more frequently, the government may be able to assign a new objective function to the central bank. However, countries pursuing a monetary policy resembling of the optimal one do not appear to posses any particular commitment technologies or minimise artificial objective functions as discussed in the literature. For example, the central banks in Germany, Switzerland and lately the United States manage to keep inflation low on average while doing their best to accommodate shocks to the economies. What distinguishes these central banks from those of other countries is that they have managed to acquire credibility by maintaining low inflation over a period of time. It may be the threat of loosing credibility that restrains central bank from exploiting the expansionary potential of monetary policy. This draws attention to models where credibility is explicitly modelled and can be gained or lost depending on the actions of the central bank.

While credibility is a top priority matter for central bankers, the academic literature has devoted relatively little attention to issues related to credibility. Reputation or a particular type of “bang-bang” credibility is modelled already in Barro (1983). He shows how the time consistent inflation rate is reduced in repeated game where the market punishes an inflating central bank by never believing low inflation announcements again. The central bank has either full credibility, if it has fulfilled its’ inflation target in each period, or zero credibility, if it has deviated from the inflation target. Such reputational equilibria involving punishment strategies are also analysed by Canzoneri (1985) and Garfinkel and Oh (1993), among others.

A second approach, pioneered by Backus and Driffill (1985), the public does not know if the central bank is of a weak type or a tough type. In each period, the public observes monetary policy and updates its information about what type of central bank it is dealing with. This type of model captures several relevant aspects of credibility. The intentions of the central bank are unobservable to the public. It only observes the actions taken by the central bank. However, as time passes by, the public gradually learns what the central bank's preferences look are. Credibility is a continuos variable and a function of monetary policy. In Backus and Driffill (as in Vickers (1986) and Cukierman and Leviatan (1991)), the central bank reveals its preferences in the final period and the game is resolved by backward induction.

A third way to model credibility is to let the preferences of a single central bank change over time instead of having two types of central banks with different preferences. Examples are Cukierman and Meltzer (1986) and Faust and Svensson (1998). Here, the public never finds out what the preferences of the central bank are. The authors avoid the Backus and Driffill framework because of its dependence on end-of-term dynamics, which appears to have little empirical relevance.

In the words of Faust and Svensson (1998), a certain "folk wisdom" concerning the effects of credibility on monetary policy has accumulated, involving claims like the following: Central banks with low credibility conduct a more restrictive policy than central banks with high credibility. Furthermore, a low credibility central bank has less flexibility to respond to shocks than a high credibility central bank. The purpose of the paper is to study (i) whether these two claims go through in the present model and (ii) how the time consistent rate of inflation is affected by the introduction of credibility effects.

While Faust and Svensson (1998) focus mainly on the issue of transparency in monetary policy, they also study how credibility affects the central bank's response to shocks and the restrictiveness of monetary policy. In their model, the first of the claims discussed above goes through but not the second. A low credibility bank creates less surprise inflation on average than a high credibility central bank, with a consequently more contractionary effect on output. However, the central bank's optimal response to shocks is not affected by its credibility. Two important differences compared to this paper are that monetary policy is assumed to be linear in the shocks and linear in credibility, which appears to exclude the possibility that credibility could affect the central bank's response to shocks, and that the public can observe what shocks the economy is hit by.

While the purpose of this paper parallels the (secondary) purpose of Faust and Svensson (1998), the model is more similar to Drazen and Masson (1994) and Masson (1995). They follow Backus and Driffill (1985) in assuming that the central bank can be either weak or tough. The drastic effect of the end-of -term dynamics discussed above is however absent from Drazen and Masson (1994) and Masson (1995), since the economy is hit by unobservable shocks in each period. The public observes monetary policy, but in contrast to the set-up discussed above, it cannot tell if an expansionary policy is a response to a shock or an attempt to affect output systematically. There is a learning process according to which the market gradually finds out what type of central bank it is dealing with. Private agents use Bayesian updating to calculate the probability that the central bank is of the tough type. These two papers focus on explaining the occurrence of devaluations and do not discuss the issues in focus here.

The basic model used in this paper is standard except that the monetary policy instrument is the short interest rate instead of the inflation rate or the money supply. In order to model credibility, there are assumed to exist two types of central banks. The "weak" central bank has a low relative weight on inflation in its objective function and a "tough" central bank has a high relative weight on inflation.

Credibility is defined as the market's subjective probability that the central bank is of the tough type. The central bank has private information about its preferences and also about what shocks the economy is hit by. The market observes monetary policy and thereafter updates the probability that the central bank is tough. If the market observes a low short interest rate, it does not know whether this is a response to a shock or an attempt to stimulate output above its natural level by creating surprise inflation. However, if the short interest rate is lower than expected, credibility falls and vice versa. This results in a continuos dynamic process for credibility as a function of monetary policy. Thereby, the consequences for monetary policy of variations in credibility can be analysed.

The paper is organised as follows. The model is presented in Section 2. In Section 3, some comparative static results are discussed. In particular, we are interested in the consequences of adding credibility effects on the optimal accommodation of shocks, the restrictiveness of monetary policy and the average inflation bias. Section 4 contains a few numerical examples that illustrate how the model works and Section 5 concludes.

2. The model

The economy is described in terms of a supply curve and a demand curve. Solving this two equation system yields output and inflation as functions of expected inflation, the short interest rate and a supply shock. The instrument of the central bank is the short interest rate, which it sets to minimise its loss function. Private agents are uncertain about the preferences of the central bank. Specifically, they do not know whether the central bank is "weak" of "tough". After observing monetary policy, the market updates its beliefs about what type of central bank it is dealing with.

Demand is a function of the short real interest rate determined by the central bank:

$$y_t = -\left(i_t - E_{t-1}\pi_t\right), \qquad t = 1,2 \tag{1}$$

where i_t is the short interest rate and $E_{t-1}\pi_t$ is expected inflation given the information available in *t-1*. There are no demand shocks.

A supply curve links inflation π_t to expected inflation, output and a supply shock:

$$\pi_t = E_{t-1}\pi_t + y_t + z_t \qquad t = 1,2 \tag{2}$$

where y_t is the output gap and z_t is the supply shock, observed by the central bank but not by private agents. The central bank minimises a two period social loss function that is quadratic in the inflation rate and the deviation of output from target:

$$\Lambda = L_1 + E_1 L_2 = \left(y_1 - \bar{y}\right)^2 + \chi^i \pi_1^2 + E_1\left[\left(y_2 - \bar{y}\right)^2 + \chi^i \pi_2^2\right], \; i = T, W \tag{3}$$

where χ^i is the relative disutility of inflation of the type *i* bank and $\bar{y}$ is the output target, assumed to be positive.

For a given type of central bank, there are no intertemporal links between the two periods and the optimal monetary policy is simply found by solving the two equation system (1) and (2), substituting the resulting expression for output and inflation into the objective function (3) and minimising with respect to each period's short interest rate. The optimal short interest rate has the form

$$i_t\left(\bar{y}, E_{t-1}\pi_t, z_t\right) = a^i E_{t-1}\pi_t + b^i \bar{y} + c^i z_t, \; i = T, W \tag{4}$$

where a^i is the accommodation of expected inflation, b^i is the response to the labour market distortion and c^i is the accommodation of supply shocks. For a given type of central bank, i.e. when there are no credibility dynamics, $a^i = \frac{1+2\chi^i}{1+\chi^i}$, $b^i = -\frac{1}{1+\chi^i}$ and $c^i = \frac{\chi^i}{1+\chi^i}$. Substituting (4) into (2) and taking the expected value, expected inflation is found to be $\bar{y}/\chi^i$, which also yields the expected short interest rate $\bar{y}/\chi^i$.

Now, let us make things more interesting by incorporating the two types of central banks. There are no dynamics in the central bank's preferences - a central bank is "born" with a given χ that does not change over time. Instead, the learning process can be thought of as starting over again when a new governor is appointed or some other major change occurs. A new legal framework could for instance induce a new prior probability that the central bank is tough.

Within this model, credibility is defined as the market's subjective probability that the central bank is of the tough type. Cukierman and Meltzer (1986) define credibility as the difference between the central bank's planned monetary policy and the private sectors' beliefs about these plans. As pointed out by Faust and Svensson (1998), this definition implies that the private sector does not know whether the central bank is credible or not since it cannot observe the central bank's plans. In the model of Faust and Svensson, credibility simply equals (minus the absolute value of) expected inflation. Both these definitions are linear transformations of the one used here. As long as the market's subjective probability that the central bank is tough is less than one, the credibility of the tough central bank is imperfect or, in the terminology of Cukierman and Melzter, "inferior". The opposite is true for the weak central bank - it has either zero or excess credibility.

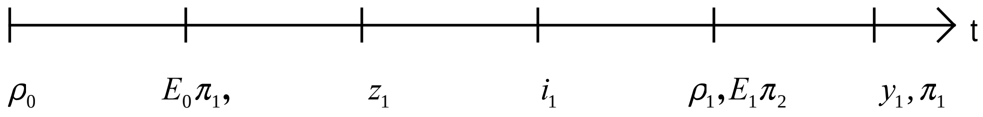
The learning process that gives rise to the credibility dynamics is a simple linear function of the deviation of the short interest rate from its expected value. Private agents start with a prior distribution over the two types of central banks. They believe that they are dealing with a tough central bank with probability ρ_0 and a weak central bank with the probability $(1-\rho_0)$. They then observe monetary policy in the first period but do not know whether a low short interest rate is an attempt to create surprise inflation to stimulate output above its natural level or a response to a shock observed by the central bank but not by private agents. If the short interest is lower than expected, credibility or the probability that the central bank is tough is decreased and vice versa.

$$\rho_1 = \rho_0 + l(i_1 - Ei_1) \quad \text{s t. } 0 \le \rho_1 \le 1 \tag{5}$$

Equation (5) shows how next period's credibility depends on initial credibility, the short interest rate in relation to its expected value and a learning parameter *l*. If monetary policy is more expansionary than expected, credibility falls and vice versa. This is the simplest possible adaptive learning rule, see Evans and Honkaphja (1997) for a survey of the literature. A linear updating process greatly simplifies the model by preserving the linearity of monetary policy. Compared to the model of Faust and Svensson (1998), the assumption of a linear learning process gives rise to a linear optimal monetary policy here, while they assume that monetary policy is linear in the shock, which yields a linear optimal learning process.

After the shock has been realised, the central bank sets the short interest rate to minimise the loss function. In doing this, it takes the effect of its actions on market expectations and second period utility into account. The timing of the different events are shown in Figure 1.

Figure 1: The timing



First, initial credibility ρ_0 is given exogenously. Given the probability that the central bank is tough, private agents form expectations of the first period inflation rate. Then, the supply shock z_1 is realised. Private agents cannot observe the shock. The central bank on the other hand does observe the shock and thereafter sets the short interest rate to minimise its objective function given the inflation expectations. The market observes the short interest rate and updates its subjective probability that the central bank is tough, which affects expected inflation in the second period. Then, first period inflation and output are realised.

When setting a first period short interest rate, the central bank takes the effect on the first period loss and on the expected second loss into account. Output in the first period is affected with a negative sign, i.e. a high short interest rate decreases output. As credibility is increased, the market's expected second period inflation in future periods falls, which reduces the expected second period loss.

Since the second period is the last period, solving for the second period variables are simple. The objective function (3) is minimised with respect to the second period short interest rate. The expected second period loss can then be expressed as a function of the first period short interest rate. The optimal first period short interest rate emerges from the first order condition

$$\frac{\partial L_1}{\partial i_1} + \frac{\partial E_1 L_2}{\partial \rho_1}\frac{\partial \rho_1}{\partial i_1} = 0 \qquad (6)$$

The solution to (6) is an algebraically messy expression even with a simple linear learning rule. The optimal first period interest rate can however be found by letting Mathematica solve (8). It has the form

$$i_1\left(\bar{y}, E_0\pi_1, z_1\right) = a^i E_0\pi_1 + b^i \bar{y} + c^i z_1 , \tag{7}$$

where the analysis of a^i, b^i and c^i is left to the next section.

3. Some comparative static results

Given the optimal monetary policies of a tough central bank and a weak central bank, the model can be solved for expected inflation and the time consistent inflation rate. It can then be compared to the inflation bias when there are no credibility effects, i.e. when the public knows the preferences of the central bank. Furthermore, the influence of variations in credibility on the optimal monetary policy can be studied. The hypotheses to be investigated are the "folk theorems" discussed in the introduction: Whether increased credibility results in better ability to respond to shocks and a less restrictive average monetary policy.

3.1. Optimal accommodation of shocks when credibility matters

A common perception among central bankers is that good credibility facilitates an active monetary policy and vice versa - a central bank with low credibility has less scope for accommodation of shocks. In this model, the reason is that if a high credibility bank sets a low interest rate in order to accommodate a shock, the market finds it likely that the economy has been hit by a shock that motivates the expansionary monetary policy. If the same expansion is observed from a low credibility bank, the market is more prone to interpret this as an attempt to create surprise inflation. If improved credibility results in a better ability to accommodate shocks to the economy, gaining credibility is a more important objective than elsewise.

The accommodation of shocks is the partial derivative of the optimal interest rate with respect to the supply shock - c^i in equation (4) or (7). When there are no credibility effects, i.e. when there is no learning either because the market knows the preferences of the central bank or because the learning parameter l is zero, the optimal accommodation of supply shocks for a tough central bank is $\frac{\chi^T}{1+\chi^T}$. The optimal accommodation of supply shocks when credibility effects are present turns out to be $\frac{\chi^T}{1+\chi^T+C_1^T}$, where C_1^T is positive.[1] It can also be shown that the partial derivative $\frac{\partial C_1^T}{\partial \rho_0}$ is negative, i.e. that supply shocks are accommodated more the more initial credibility the tough central bank has.[2] Hence, the "folk wisdom" that a low credibility central bank responds less to shocks is confirmed in this model.

In Faust and Svensson (1998), credibility does not affect the accommodation of shocks. One reason for this difference is that the shocks are observable in their model. The market is then able to distinguish between an expansionary policy as a response to a shock and an attempt to exploit monetary policy to increase output over and above its natural level. Here, the market does not know whether an observed low interest rate is motivated by a shock or not. This leads the central bank to avoid lowering the interest rate - and it is more cautious the less credibility it has. Second, Faust and Svensson assume that the optimal monetary policy is

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[1] From the (algebraically messy) optimal first period interest rate, i.e. the solution to (7), it is clear that

$$C_1^T = \frac{l^2 \chi^T \left(1+\chi^T\right)\left(1+\chi^W\right)\left(\chi^W-\chi^T\right)^2 \left(3+3\chi^T+\chi^W+\chi^T\chi^W+2\rho_0\left(\chi^W-\chi^T\right)\right)\bar{y}^2}{\left(-\chi^W\left(1+\chi^T\right)+\rho_0\left(\chi^W-\chi^T\right)\right)^4}$$

[2] The derivative of C_1^T with respect to initial credibility ρ_0 is

$$\frac{\partial C_1^T}{\partial \rho_0} = \frac{6l^2\left(\chi^W-\chi^T\right)^3 \chi^T \left(1+\chi^T\right)\left(1+\chi^W\right)}{\left(\chi^W\left(1+\chi^T\right)+\rho_0\left(\chi^T-\chi^W\right)\right)^5} < 0$$

linear in the shock and linear in the reputation of the central bank without allowing for interaction between these two terms. In terms of the present model, c^i is not allowed to depend on ρ_0. Thereby, the possibility that reputation could affect the response to shocks is ruled out by assumption.

3.2. The inflation bias

Expected inflation in this model depends on expected monetary policy from the two types of central banks, which in turn are functions of expected inflation:

$$E_{t-1}i_1^i\left(\bar{y}, E_{t-1}\pi_1\right) = a^i E_{t-1}\pi_1 + b^i \bar{y} \tag{15}$$

where i can be *T* for tough or *W* for weak. The expected short interest rate equals the weighted average of the expected interest rates for the two types of central banks, with the probability of each type as weights:

$$E_{t-1}i_1 = \rho_0 E_{t-1}i_1^T + \left(1-\rho_0\right)E_{t-1}i_1^W \tag{16}$$

Solving this for expected inflation yields:

$$E_{t-1}\pi_1 = \frac{\left(\rho_0 b^T + \left(1-\rho_0\right)b^W\right)\bar{y}}{1-a^W + \rho_0\left(a^W - a^T\right)} \tag{17}$$

First, one needs to find a^i and b^i, i.e. the accommodation of expected inflation and the effect of the labour market distortion for each type of central bank. As long as the output target in the central bank's objective function is positive, there is an inflation bias. For the tough central bank, we have

$$b^T = -\frac{1+C_2^T}{1+\chi^T + C_3^T}, \tag{18}$$

which is smaller than the corresponding effect in the model without credibility iff

$$C_2^T < \frac{C_3^T}{1+\chi^T}. \tag{19}$$

(19) turns out to hold, i.e. the labour market distortion has a smaller influence on inflation for the tough central bank when credibility effects are introduced.[3]

Equilibrium expected inflation also depends on how much the monetary policies of the two types of central banks respond to expected inflation. Without credibility effects, a^i equals $\frac{1+2\chi^i}{1+\chi^i}$ which is larger than one. The central bank increases the short interest with more than the increase of expected inflation to push the inflation towards zero. It can be shown that

$$a^T = \frac{1+2\chi^T + C_4^T}{1+\chi^T + C_5^T} > \frac{1+2\chi^T}{1+\chi^T}, \tag{20}$$

i.e. the tough central bank reacts more to expected inflation when credibility is imperfect than when it is not. It also pushes down expected inflation more the less credibility it has, i.e. creates less surprise inflation or pursues a more contractionary monetary policy on average.[4] Hence, the second of the "folk theorems" discussed by Faust and Svensson (1998) goes through here (as in their model).

[3] From the solution to (7), we have
$C_2^T = \frac{2l\chi^T\left(1+\chi^T\right)\left(1+\chi^W\right)\left(\chi^W-\chi^T\right)\left(1+\chi^T+\rho_0\left(\chi^T-\chi^W\right)\right)\bar{y}}{\left(\chi^W\left(1+\chi^W\right)+\rho_0\left(\chi^T-\chi^W\right)\right)^3}$ and
$C_3^T = \frac{2l^2\left(1+\chi^T\right)\left(1+\chi^W\right)\left(\chi^W-\chi^T\right)^2\left(\left(3+\chi^W\right)\left(1+\chi^T\right)-2\rho_0\left(\chi^T-\chi^W\right)\right)\bar{y}^2}{2\left(-\chi^W\left(1+\chi^W\right)-\rho_0\left(\chi^T-\chi^W\right)\right)^4}$

[4] Analysing the first period optimal interest rate, it can be shown that
$C_4^T = l\chi^T\left(1+\chi^T\right)\left(1+\chi^W\right)\left(\chi^T-\chi^W\right)\left(1+\chi^T-\rho_0\left(\chi^T-\chi^W\right)\right)\bar{y}^2$ and
$C_5^T = l^2\chi^T\left(1+\chi^T\right)\left(1+\chi^W\right)\left(\chi^W-\chi^T\right)^2\bar{y}^2$

The corresponding versions of (19) and (20) hold also for the weak central bank. Hence, the introduction of credibility effects reduces expected inflation for each type of central bank. However, expected inflation given the probability distribution for the two types may be higher or lower than expected inflation for the tough central bank without credibility effects depending on the difference in toughness between the two types.

In the models with a single type of central bank that has either full or zero credibility, the time consistent inflation rate is lower with reputational effects than without (see Barro and Gordon 1983, Canzoneri 1985 and Garfinkel and Oh, 1993).

4. Calibrations

Although the signs of the effects were established in the previous sections, it may also be interesting to know whether these effects are large or not. For instance, if a large increase in credibility allows only slightly more stabilisation, investing in credibility may not be as important as if the effect is large. Table 1 shows what happens to credibility, expected inflation and the accommodation of shocks for a tough central bank given various parameter values. In the first 10 rows, the parameter values are systematically varied as discussed below. The final row illustrate that it is possible to find parameter values for which first period expected inflation is higher when there are credibility effects than when there are not.

Table 1: Optimal stabilisation and expected inflation for specific parameter values

row	χ^T	χ^W	$\bar{y}$	ρ_0	l	$\frac{\partial i_1}{\partial z_1}$	ρ_1	$E_0\pi_1$
1.	2	1	1	0.5	0.05	0.666	0.504	0.362
2.	2	1	1	0.75	0.05	0.666	0.506	0.284
3.	2	1	1	0.5	0.25	0.655	0.506	0.138
4.	2	1	1	0.75	0.25	0.658	0.515	0.101
5.	2	1	1	0.5	0.5	0.631	0.562	0.099
6.	2	1	1	0.75	0.5	0.648	0.798	0.071
7.	3	1	2	0.5	0.25	0.686	0.528	0.141
8.	3	1	2	0.75	0.25	0.706	0.801	0.086
9.	3	1	2	0.5	0.5	0.601	0.570	0.102
10.	3	1	2	0.75	0.5	0.638	0.845	0.046
11.	2	0.5	2	0.5	0.01	0.666	0.514	2.060

If there are no credibility effects (i.e. when the market knows what type of central bank it is dealing with), optimal stabilisation is 0.667 in rows 1 to 6 and 0.75 in rows 7 to 10. A first point to be noted is then that the increased stabilisation as credibility improves is small. Comparing rows 1 and 2, it is clear that an increase in the probability that the central bank is tough from 0.5 to 0.75 affects the optimal accommodation of shocks only to the fourth decimal. A similar comparison of rows 9 and 10, where the difference in preferences between the weak and the strong central bank is larger and the output target is more ambitious, shows that stabilisation now increases by 0.04, which still is small from an economic perspective.

Expected inflation is normally lower the more initial credibility the bank has.[5] In most of Table 1, expected inflation with credibility effects is close to zero and much lower than it would be without credibility effects (0.5 in rows 1 to 6 and 0.67 in rows 7 to 10). The fall in expected inflation as credibility is introduced is not a general result, however. As shown in row 11, it is also possible to get a higher expected inflation if the difference between the two types of central banks is large

[5] This is true as long as a^T and a^W are larger than one, i.e. as long as the central bank sets its short interest rate higher than expected inflation. For extremely large values of l, this is not the case.

enough and the credibility effect is small enough. Given the parameter values in row 11, expected inflation is 1.0 for the tough central bank, 4.0 for the weak central bank and 2.1 in the model with credibility effects.

How fast the market learns or how much credibility increases depends on the learning parameter *l* and also on the difference in inflation bias between the two types of central banks. In Table 1, the expected increase in credibility varies between 0.04 and 0.3. It is mainly the size of this increase, i.e. $\rho_1 - \rho_0$, that governs the results in Table 1.

5. Conclusions

Considerable attention has been devoted to models where the central bank either has (full) credibility, if it has not yet deviated from its inflation rule, or no credibility, if it has cheated. The model in this paper is similar to Drazen and Masson (1994) and Masson (1995) in that there are two types of central banks and credibility is defined as the public's subjective probability that the central bank is of the tough type. Credibility becomes a continuos variable that can be gained or lost gradually. The effects on monetary policy as credibility is varied can then be studied. Faust and Svensson (1998) use a different type of model to study (partly) similar issues. Instead of using the Backus and Driffill (1985) approach involving two types of central banks with different preferences, they follow Cukierman and Meltzer in assuming that the preferences of the (single) central bank change over time.

A first issue to investigate is whether a central bank with high credibility is better able to stabilise shocks to the economy than a central bank with low credibility. The answer turns out to be affirmative in this model – the central bank responds to shocks more if it's credibility is imperfect than if it has full credibility. It can also be shown that it accommodates shocks more the more initial credibility it has. This result contrasts with Faust and Svensson (1998), who find the central bank's reaction to shocks to be independent of credibility. One important difference between the models is that while the public is able to observe the shocks in Faust and Svensson, it is here unable to distinguish between reactions to shocks and systematic attempts to affect output. Furthermore, Faust and Svensson restrict the optimal monetary policy to be linear in the shock *and* linear in credibility, whereby interaction between the response to shocks and credibility appears to be ruled out by assumption.

A second issue is the effect of credibility on the average restrictiveness of monetary policy. According to the "folk theorem" discussed by Faust and Svensson (1998), a central bank with low credibility pursues a more restrictive policy than a central bank with high credibility. It can be shown that given the expected inflation rate, the low credibility bank sets a higher interest rate, which induces a lower inflation rate and a more contractionary effect on output than does a high credibility bank. This coincides with the findings of Faust and Svensson (1998).

A third result is that while expected inflation given each type of central bank falls when credibility effects are introduced, expected inflation given the probability distribution of the two types may be higher or lower than expected inflation given that the central bank is tough. In most other models, the time consistent inflation rate falls as credibility effects are added (see for instance Barro and Gordon 1983, Canzoneri 1985 and Garfinkel and Oh 1993). However, calibrations show that expected inflation is reduced dramatically as credibility dynamics are introduced *unless* the credibility effects are very small *and* the difference in inflation bias between the tough and the weak central bank is very large. Hence, the model yields a very small inflation bias for most parameter values although this cannot be established as a general result. What can be shown as a general result is that the central bank accommodates shocks more and expected inflation less the higher credibility it has. Hence the "folk theorems" discussed by Faust and Svensson (1998) go through in this model.

REFERENCES

Backus, D. and Driffill, J. (1985), "Inflation and reputation", *American Economic Review*, vol. 75, pp. 530-537.

Barro, R. (1983), "Rules, discretion and reputation", Journal of Monetary Economics vol. 12, pp. 101-122.

Canzoneri, M. (1985), "Monetary policy games and the role of private information", *American Economic Review*, vol. 75, pp. 1056-69.

Cukierman, A. and Meltzer, A. (1986), "A theory of ambiguity, credibility and inflation under discretion and asymmetric information", *Econometrica*, vol.54, pp. 1099-1128.

Cukierman, A. and Leviatan, N. (1991), "Optimal accommodation by strong policymakers under incomplete information", *Journal of Monetary Economics*, vol. 27, pp. 99-127.

Drazen, A. and Masson, P. (1994), "Credibility of policies versus the credibility of policy makers", *Quarterly Journal of Economics*, vol. 109, pp. 735-754.

Evans, G. And Honkapohja, S. (1997), “Learning dynamics” in Taylor, J. B. And Woodford, M. (eds) Handbook of Macroeconomics. Elsevier, Amsterdam (forthcomming).

Faust, J. and Svensson, L. (1998), “Transparency and credibility. Monetary policy with unobservable goals”, CEPR Discussion Paper No. 1852.

Garfinkel, M. and Oh, S. (1993), “Strategic discipline in monetary policy with private information: Optimal targeting horizons”, *American Economic Review*, vol. 83, pp. 99-117.

Masson, P. (1995), “Gaining and losing ERM credibility: The case of the United Kingdom”, *Economic Journal*, vol. 105, pp. 571-582.

Vickers, J. (1986), “Signalling in a model of monetary policy with incomplete information”, *Oxford Economic Papers*, vol. 38, pp. 443-55.