

# Dangers of Commitment: monetary policy with adaptive learning

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September 21, 2005

## Abstract

This paper studies a class of interest rate rules, introduced by Evans and Honkapohja (2001a, 2004), that respond to public expectations and to lagged variables. The policymaker commits to the extent that the interest rate responds to lagged output in an effort to influence public expectations. Simulation results show that full commitment, the commitment optimum under rational expectations, is not optimal under adaptive learning for any reasonable parameter values.

**Keywords:** Learning, Monetary Policy, Interest Rate Rules, Determinacy, Expectational Stability  
**JEL classification:** E52, E31, D84

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# 1 Introduction

The superiority of commitment over discretion for monetary policy has theoretical support going back to Kydland and Prescott (1977) as well as empirical verification from McCallum and Nelson (2004). Under rational expectations, the policymaker should act to influence public expectations to minimize the fluctuations in the endogenous variables. However, if expectations are not rational<sup>1</sup>, it is an open question whether there are gains from commitment. The aim of the present work is to determine the optimal level of commitment for monetary policy when public agents form expectations adaptively.

We study this question in the context of interest rate rules that respond directly to public expectations, as introduced by Evans and Honkapohja (2001a, 2004). These rules have the desirable properties of determinacy, meaning that there are no similar solutions based on extraneous information, and expectational stability, which implies that expectations of agents using a reasonable learning mechanism can converge to the rational expectation. Within this class of rules, commitment implies that the interest rate is a function of lagged output while discretion implies that it is not. Waters (2005) allows for a continuous range of responses to lagged output and, hence, varying levels of commitment, and determines the optimal level of commitment under least squares learning. Following that paper, we refer to the commitment optimum under rational expectations as *full commitment* and a lesser response to lagged output as *partial commitment*.

For public expectations formed with least squares learning, Waters (2005) shows full commitment is optimal, but also demonstrates that the introduction of parameter uncertainty or errors in the policy rule makes partial commitment best. The primary finding of the simulation results in the present work is that, if expectations are formed with the adaptive learning mechanism<sup>2</sup> of Cagan (1956), full commitment is not optimal for any reasonable parameter choices. Comparing these results with those derived using least squares learning and rational expectations shows that more sophisticated methods of expectations formation imply an increased likelihood of gains from commitment. With the backward looking learning rule in this paper, partial commitment is optimal and the gains from that policy over pure discretion are relatively small.

The problem with commitment is the additional persistence in output, while there is little beneficial impact on expectations that are formed adaptively. Under rational expectations, a higher level of commitment raises the persistence in output and moves the system close to the bound for explosive solutions<sup>3</sup>. As one might expect, the policy outcome deteriorates quickly as the response to lagged output increases beyond certain points for adaptive learning, least squares learning and rational expectations.

We verify these results for a wide variety of parameter values found in the literature. The gain is one

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<sup>1</sup>The notion that learning is an important consideration for the formation of monetary policy is present in Howitt (1992), Evans and Honkapohja (2001b) survey learning methods in macroeconomics.

<sup>2</sup>This approach is also discussed in Evans and Honkapohja (2001b, 2004).

<sup>3</sup>Explosive solutions are also not expectationally stable, see Waters (2005) for details.

key parameter measuring the emphasis agents put on recent information. Adaptive expectations can be thought of as a decreasing weighted average of past data, so low gain implies higher persistence. The simulation results show that higher gain implies a higher optimal level of commitment. Increased gain lowers the persistence of the endogenous variables allowing for a higher level of commitment. However, the improvement in the policy outcome for increased commitment is rather small in these cases, so the practical relevance of these results is questionable<sup>4</sup>.

The results are confirmed for parameter values of the reduced form New Keynesian model found in McCallum and Nelson (2004), Clarida, Gali and Gertler (2000) and Woodford (1999a). In this framework, the policymaker has the two goals of stabilizing output and inflation. McCallum and Nelson (2004) compare policy outcomes under commitment and discretion when agents are fully rational. Following their work, we also check our results for different preferences of the policymaker concerning the relative importance of output and inflation stabilization. If the policymaker is primarily concerned with inflation, full commitment is not as bad compared to other levels of commitment, but some level of partial commitment is still optimal.

This paper adds to a rapidly expanding literature on learning and monetary policy. While rational expectations is an important benchmark, the importance of public reactions to policy makes learning an important alternative approach. Honkapohja and Mitra (2001) and Bullard and Mitra (2002) study the expectational stability of a variety of interest rate rules. Orphanides and Williams (2005) provides simulation results for a simple model of monetary policy under least squares learning with constant gain and shows differences in optimal policy under rational expectations and learning. They also discuss the fact that higher gain implies that agents use more lags of the data to form expectations. As noted, Waters (2005) studies the same model as the one in this paper under least squares learning with constant gain. That paper also provides an interpretation of the gain parameter in terms of the credibility of the policymaker. If a policymaker is credible, agents will not be excessively swayed by recent data and will place more emphasis on their previous expectation, implying low gain.

The literature on commitment, discretion and time consistency is extensive, Barro and Gordon (1983) being a prominent example. Woodford (1999b) and Clarida, Gali and Gertler (1999) argue for commitment in terms of a *timeless perspective* for the monetary policymaker. Athey, Atkeson and Kehoe (2005) use a dynamic game theory approach to study the optimal degree of commitment for a policymaker with private information. In their framework, full commitment is optimal when the policymaker has no private information but otherwise some discretion is indicated. Similarly, in the present work, public agents do not use all the information available to the policymaker and full commitment is not recommended.

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<sup>4</sup>These results are also in direct contrast to Waters (2005) who find that higher gain corresponds to a lower optimal level of commitment under least squares learning.

The paper is organized as follows. Section 2 describes the underlying model. Section 3 introduces the expectations based interest rate rules and reviews their properties. Section 4 explains the adaptive learning rule. Section 5 discusses the simulation results, and section 6 concludes.

## 2 The Model

The following model has become standard for many studies of the use of interest rate rules in monetary policy. It has New-Keynesian micro foundations described in Woodford (2003) featuring price stickiness that allows the policymaker to play a stabilizing role in the economy.

$$x_t = -\varphi(i_t - E_t^* \pi_{t+1}) + E_t^* x_{t+1} + g_t \quad (1)$$

$$\pi_t = \lambda x_t + \beta E_t^* \pi_{t+1} + u_t \quad (2)$$

These equations are thought of as expectations augmented IS and Phillip's curve relationships. The variables  $x_t$  and  $\pi_t$  are the deviations of output and inflation from their target values. The notation  $E_t^*$  indicates private sector expectations formed in time  $t$  where the  $(*)$  is used to show that expectations might not be rational. The policymaker controls the nominal interest rate  $i_t$ . The parameters  $\varphi, \lambda, \beta$  are all positive and the discount rate  $\beta$  is such that  $\beta < 1$ . The stochastic terms  $g_t$  and  $u_t$  are both taken to be AR(1) processes.

$$g_t = \mu g_{t-1} + \tilde{g}_t + \hat{g}_t \quad (3)$$

$$u_t = \rho u_{t-1} + \tilde{u}_t$$

The parameters  $\mu$  and  $\rho$  lie in the interval  $(-1, 1)$ , and the shocks  $\tilde{g}_t, \hat{g}_t$  and  $\tilde{u}_t$  are iid with standard deviations  $\sigma_{\tilde{g}}, \sigma_{\hat{g}}$  and  $\sigma_u$ , respectively. The structure of  $g_t$  follows McCallum and Nelson (2004) who decompose this term into a preference shock  $\hat{g}_t$  and an AR(1) process with innovations  $\tilde{g}_t$  that accounts for uncertainty about the evolution of the natural rate that enters into the forecast error for output in the IS equation (1).

The policymaker sets the nominal interest rate to stabilize the endogenous variables. Formally the task is to set  $i_t$  to minimize the loss function

$$L = E_t \sum_{s=0}^{\infty} \beta^s (\pi_{t+s}^2 + \alpha x_{t+s}^2). \quad (4)$$

Minimizing the loss function over  $x_{t+s}$  and  $\pi_{t+s}$  under the constraint given by (2) yields the following first

order conditions.

$$2\alpha x_{t+s} + \lambda\omega_{t+s} = 0 \quad \text{for } s = 0, 1, 2, 3\dots \quad (5)$$

$$2\pi_{t+s} + \omega_{t+s-1} - \omega_{t+s} = 0 \quad \text{for } s = 0, 1, 2, 3\dots \quad (6)$$

$$2\pi_t - \omega_t = 0 \quad (7)$$

The variable  $\omega_{t+s}$  is the Lagrange multiplier on the constraint for each  $s = 0, 1, 2, 3\dots$ . Solving out  $\omega_t$  for  $s = 0$  from the first order conditions yields the following conditions for policy

$$\lambda\pi_t + 2\alpha x_t = 0, \quad (8)$$

using (5) and (7), and

$$\lambda\pi_t + \alpha(x_t - x_{t-1}) = 0 \quad (9)$$

using (5) and (6).

Clearly, both of the above conditions cannot be achieved simultaneously, demonstrating the time consistency issue for this model. If the policymaker uses a discretionary approach, taking future expectations as being fixed and beyond his control, he ignores (6) and sets policy according to the first condition (8). If the policymaker commits to a timeless perspective (Woodford 1999b), he acts to influence expectations, ignoring (7) and setting policy using (9).

Policy under commitment differs from discretion in its response to the previous period's output gap. The reason for this can be seen in (6), where the lagged term appears because the policymaker reacts to the expected inflation in the Phillip's curve (2). Under discretion, however, the policymaker ignores expected inflation and lagged output does not enter the policy condition (8). In practice, the policymaker's ability and desire to impact expectations by responding to lagged endogenous variables should not be restricted to these two extreme cases. We examine policy under a broader condition that allows for varying levels of response to lagged output and therefore varying degrees of commitment.

$$\lambda\pi_t + \alpha(x_t - \kappa x_{t-1}) = 0 \quad (10)$$

The parameter  $\kappa$  shows the degree to which the policymaker responds to lagged output. The discretionary condition (8) and the commitment condition (9) are special cases of (10) for  $\kappa = 0$  and  $\kappa = 1$ , respectively. Henceforth, we refer to the commitment optimum under rational expectations when  $\kappa = 1$  as full commitment and any setting of  $\kappa$  such that  $0 < \kappa < 1$  as partial commitment. Our goal is to examine the determinacy

and stability of the model and the performance of policy for varying levels of  $\kappa$ .

### 3 Expectations Based Interest Rate Rules

Evans and Honkapohja (2001a, 2004) advocate for monetary policy to be conducted with interest rate rules that respond explicitly to public expectations. We can compute the optimal form for the expectations based interest rate rule associated with the policy condition (10).

Using (10) to substitute for inflation in the Phillip's curve (2) gives

$$x_t = \lambda (\lambda^2 + \alpha)^{-1} (\alpha\kappa\lambda^{-1}x_{t-1} - \beta E_t\pi_{t+1} + u_t).$$

Substituting out  $x_t$  in the IS equation with the above expression yields the interest rate rule

$$i_t = \delta_L x_{t-1} + \delta_\pi E_t\pi_{t+1} + \delta_x E_t x_{t+1} + \delta_g g_t + \delta_u u_t \quad (11)$$

where the parameters are

$$\begin{aligned} \delta_L &= -\varphi^{-1} (\lambda^2 + \alpha)^{-1} \alpha\kappa, & \delta_\pi &= 1 + \varphi^{-1} (\lambda^2 + \alpha)^{-1} \lambda\beta \\ \delta_x &= \varphi^{-1}, & \delta_g &= \varphi^{-1}, & \delta_u &= \varphi^{-1} (\lambda^2 + \alpha)^{-1} \lambda. \end{aligned}$$

Note that the extent to which the interest rate responds to lagged output, shown by  $\delta_L$ , depends on  $\kappa$ , but the other parameters in the rule do not. Under discretion  $\kappa = 0$  and  $i_t$  is unaffected by  $x_{t-1}$ , but for any other value, including the full commitment case  $\kappa = 1$ ,  $i_t$  responds directly to  $x_{t-1}$ .

The policy rule (11) has the desirable properties that the associated rational expectation equilibria are non-explosive, determinate and expectationally stable for any parameters and any reasonable choice of  $\kappa$ . To make this statement precise, following Evans and Honkapohja (2001a, 2004) let the rational expectation equilibria be of the form

$$\begin{aligned} x_t &= b_x x_{t-1} + c_x u_t \\ \pi_t &= b_\pi x_{t-1} + c_\pi u_t, \end{aligned} \quad (12)$$

which allow us to solve for the unique minimum state variables (McCallum 1983, 1997) solution for the system with the condition for optimal policy (10) and the expectations augmented Phillip's curve relation

(2). We omit the derivation, see Waters (2005) for details, but note that for the discretionary case  $\kappa = 0$ , the solution includes  $b_x, b_\pi = 0$ , indicating that, under discretion, the solution depends only on the supply shock  $u_t$ . For  $\kappa > 0$  the relevant solution for  $b_x$  is such that  $b_x > 0$  and an important question is whether this parameter is in the range for non-explosive solutions  $b_x < 1$ .

Another important question is the determinacy of the model with (10), (2) and the policy rule (11). Determinacy means that there are no solutions nearby based on extraneous information such as sunspot variables, see Blanchard and Khan (1980) for a full explanation. The exclusion of such equilibria is clearly desirable for a monetary policy rule.

Furthermore, we check the expectational stability of the equilibria, as defined in Evans and Honkapohja (2001b), which is particularly important for the present study with adaptive agents. Expectational stability governs the behavior of a model where agents do not have full rationality. Given a method for updating expectations, expectational stability determines whether these expectations will converge over time to the rational expectations equilibrium values.

We now summarize the results from Waters (2005) for the class of interest rate rules corresponding to different levels of commitment, parameterized by  $\kappa$ .

**Proposition 1** *Given  $\kappa \geq 0$ , for the model with equations (10), (2) and (11), rational expectations equilibrium of the form 12,*

- *there is a non-explosive solution such that  $b_x < 1$  if  $\kappa < 1 + \frac{\lambda^2}{\alpha(1-\beta)}$ .*
- *the equilibrium determinate for  $\kappa < 1 + \frac{\lambda^2}{\alpha}$ .*
- *the equilibrium is expectationally stable for non-explosive equilibria.*

Expectations based interest rate rules yield equilibria that have the desirable properties of non-explosiveness, determinacy and expectational stability for values of  $\kappa$  corresponding to monetary policy set under discretion ( $\kappa = 0$ ), commitment ( $\kappa = 1$ ) and partial commitment ( $0 < \kappa < 1$ ). However, the above proposition does raise concerns, particularly for the commitment case, since the bounds for explosiveness and determinacy could be very close to  $\kappa = 1$  for reasonable parameter values. A major goal of the present work is to check whether policy under commitment could lead to instability in the economy due to the proximity of the associated equilibria to explosive and indeterminate regions.

## 4 Adaptive Agents

This section presents a simplified version of the model, which clarifies the role of expectations and the policymaker. We then specify the adaptive learning mechanism to be used in the simulations and characterize its relationship to other types of learning.

The model with the IS (1), Phillip's curve (2) and the policy rule (11) can be reduced by substituting out the interest rate  $i_t$ , yielding the following system.

$$\begin{aligned} \begin{pmatrix} x_t \\ \pi_t \end{pmatrix} &= \begin{pmatrix} (\lambda^2 + \alpha)^{-1} \alpha \kappa & 0 \\ (\lambda^2 + \alpha)^{-1} \lambda \alpha \kappa & 0 \end{pmatrix} \begin{pmatrix} x_{t-1} \\ \pi_{t-1} \end{pmatrix} \\ &+ \begin{pmatrix} 0 & -(\lambda^2 + \alpha)^{-1} \beta \lambda \\ 0 & (\lambda^2 + \alpha)^{-1} \beta \alpha \end{pmatrix} \begin{pmatrix} E_t x_{t+1} \\ E_t \pi_{t+1} \end{pmatrix} \\ &+ \begin{pmatrix} 0 & -(\lambda^2 + \alpha)^{-1} \lambda \\ 0 & (\lambda^2 + \alpha)^{-1} \alpha \end{pmatrix} \begin{pmatrix} g_t \\ u_t \end{pmatrix} \end{aligned} \quad (13)$$

A number of points are apparent in the above representation. As  $\kappa$  rises toward 1.0, the full commitment value, output shows increasing persistence, which could lead a poor policy outcome. The policymaker acts so that output expectations  $E_t x_{t+1}$  and the demand shock  $g_t$  do not affect output or inflation. The fact that  $u_t$  continues to play a role reflects the trade-off between output and inflation stabilization faced by the policymaker in the presence of a supply shock. Since output expectations do not affect the endogenous variables under this policy rule, we present the learning mechanism in terms of inflation expectations.

Expectations are determined by the following method introduced in Cagan's (1956) study of hyperinflation.

$$E_t^* \pi_{t+1} = E_{t-1}^* \pi_t + \tau (\pi_{t-1} - E_{t-1}^* \pi_t) \quad (14)$$

When making a forecast, agents use their previous expectation  $E_{t-1}^* \pi_{t-1}$ , which embodies past information, and the most recent realization of inflation  $\pi_{t-1}$ . The gain parameter  $\tau$  measures the relative importance agents place on these two pieces of information. An alternative interpretation is that expectations are a weighted average<sup>5</sup> of past values of  $\pi_t$ .

Agents using adaptive expectations are not fully rational, but in a stationary environment, expectations converge to a distribution around the rational expectations equilibrium values, see Evans and Honkapohja

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<sup>5</sup>Formally  $E_t^* \pi_{t+1} = \tau \sum_{j=1}^{n-1} (1-\tau)^{j-1} \pi_{t-j} + (1-\tau)^n E_{t-n}^* \pi_{t-n+1}$  for any integer  $n \geq 2$ . As  $n \rightarrow \infty$  the last term goes to zero.



(2001b) for details. In comparison to the typical implementation of least squares learning<sup>6</sup> adaptive expectations are formed using less information. The adaptive mechanism (14) is equivalent to least squares learning where agents estimate a model with only constant parameters, as opposed to a linear model of the endogenous variables. Furthermore, agents here do not make use of information about the contemporaneous shocks  $u_t$  and  $g_t$ , as in Evans and Honkapohja (2001a, 2004). Whether it is appropriate to assume that public agents have information and calculation abilities equivalent to trained econometricians remains an open question. By comparing the results using adaptive expectations to those in Orphanides and Williams (2005) and Waters (2005) using recursive least squares, we can determine the importance of the specification of the learning mechanism for the study of monetary policy.

## 5 Simulations

Simulations of the model with adaptive learning allow for a comparison of policy outcomes for different levels of commitment, parameterized by  $\kappa$ . The results from proposition 1 show that at higher levels of commitment, the parameter  $\kappa$  approaches its bounds for determinacy and non-explosive solutions under rational expectations. Furthermore, Waters (2005) argues that full commitment is not optimal under least squares in certain circumstances. Hence, there is reason to believe that the full commitment value may not be optimal under the adaptive learning mechanism (14). The overriding conclusion is that full commitment, when  $\kappa = 1.0$ , is not optimal policy for a wide variety of parameter values. There is also a relationship between the gain parameter  $\tau$  and the optimal level of commitment under learning, though there is reason to treat this result with caution.

We report results for parameter choices for the reduced form IS (1) and Phillip’s curve (2) equations from McCallum and Nelson (2004), Clarida, Gali and Gertler (2000) and Woodford (1999a), henceforth MN04, CCG00 and W99, respectively. McCallum and Nelson (2004) compare commitment and discretionary outcome for the present model under full rationality and examine the impact of changes in the policymaker’s preference parameter  $\alpha$ , which measures the relative importance of output versus inflation stabilization. We also check our results for alternative values of  $\alpha$  used by MN04. For all simulations we use the following parameter settings from MN04 determining the behavior of the stochastic elements  $g_t$  and  $u_t$  in (3).

$\mu$	$\rho$	$\sigma_{\tilde{g}}$	$\sigma_{\hat{g}}$	$\sigma_u$
0.95	0.8	0.005	0.02	0.005

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<sup>6</sup>Examples include Orphanides and Williams (2005) and Waters (2005).

The possible parameter values for (1) and (2) are as follows.

	$\beta$	$\varphi$	$\lambda$
MN04	0.99	0.4	0.05
CGG00	0.99	4.0	0.075
W99	0.99	$(0.157)^{-1}$	0.024

Figures 1 and 2 show time series graphs for inflation and output for partial and full commitment, respectively, along with inflation expectations. The parameter values for the figures are from MN04 with  $\alpha = 0.25$ , an intermediate value of the ones used by MN indicating roughly equal weights on output and inflation stabilization. Expectations track inflation closely though their backward looking nature under (14) is apparent. The graph for expectations is quite smooth as well since it embodies many lags of inflation and does not respond to specific stochastic shocks. As anticipated from inspecting the matrix model (13), the full commitment case shows a high degree of persistence in the output gap. In trying to affect expectations by responding to lagged output, the policymaker ends up creating persistent deviations of output from its target. The partial commitment case in figure 2, where  $\kappa = 0.6$ , shows far less persistence in output and a superior policy outcome.

Tables 1 and 2 report computed losses for different levels of commitment over various parameter settings and verifies that full commitment is not optimal under adaptive learning. Each cell is an average of the losses, computed with (4), from runs of 200 periods<sup>7</sup>. Each column shows the losses for  $\kappa$  from 0 to 1, which ranges from discretion to full commitment, for different choices of the gain parameter  $\tau$  and the policymaker preference parameter  $\alpha$ . Orphanides and Williams (2005) use gain parameters equivalent to 0.0125, 0.025 and 0.05 in their study of monetary policy under recursive least squares. The tables in the present work focus on  $\tau = 0.05, 0.1$  and  $0.15$  since the results for lower values of  $\tau$  are very similar to those for  $\tau = 0.05$ , as shown in the first two columns of table 1. The losses in bold show the minimum values for each column.

The primary result is that full commitment is not optimal across all parameter choices for the reduced form model, the policymaker's preferences and the gain. In each column, the loss for  $\kappa = 1.0$  is markedly inferior to all other partial commitment and discretionary policy settings. Furthermore in each column for tables 1 and 2 the optimal setting for  $\kappa$  is between 0.0 and 1.0 indicating some level of partial commitment and the outcome under discretion ( $\kappa = 0.0$ ) is only slightly worse than the optimal value. The last two column of table 1 report results for  $\alpha = 0.01$ , as in MN04, which shows little emphasis on output stabilization. Proposition 1 indicates that the bounds on  $\kappa$  for non-explosive and determinate solutions are looser for a low

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<sup>7</sup>There is also a 20 period starting interval, so the results do not depend on the initial values. The averages are typically computed from 10,000 runs, though sometimes less if the average loss converged quickly.

$\alpha$ , so conditions for commitment might be improved. Here, partial commitment is still optimal<sup>8</sup>, but the policy outcome for full commitment is not as bad, relative to lower values for  $\kappa$ . We conclude that the extra persistence in output is the primary reason for the inferior outcomes under full commitment, as expected. With adaptive agents, attempts by the policymaker to influence expectations have clear pitfalls.

There is a relationship between the value of the gain parameter and optimal policy. For the different parameters choices for (1) and (2) and  $\alpha = 0.25$ , the larger the value of  $\tau$ , the higher the optimal level of commitment. Larger gain implies more persistence in expectations, which directly affects inflation here, so inflation stabilization is relatively more important, and the problems with output stabilization associated with high  $\kappa$  are relatively less of a concern. However, this conclusion should be treated cautiously, since the improvement in the loss from the higher  $\kappa$  is rather small. In the context of least squares learning, Waters (2005) argues that, because the policy outcome deteriorates so sharply as  $\kappa$  increased beyond a certain level, a lower setting for  $\kappa$  is safer given the parameter uncertainty for this model.

## 6 Conclusion

The optimal degree of commitment depends on how public agents form expectations. The results from the present work in the context of related results demonstrate that commitment is more likely to succeed with informed, sophisticated agents. Under rational expectations, full commitment is best, but under least squares learning, parameter uncertainty or errors in the policy function, partial commitment is optimal. For adaptive learning examined here, partial commitment is optimal for any reasonable parameter values.

Our results are in the context of interest rate rules that respond to expectations and lagged output. The degree of response to lagged output corresponds to the level of commitment. Higher commitment leads to greater persistence in output, but the policymaker has difficulty affecting expectations formed adaptively, so the benefits of commitment are mitigated. The simulation results are robust to a wide variety of parameters from the literature.

Naturally, the importance of these results depends on one's view of the appropriate way to model expectations. Rational expectations is the dominant paradigm, though some empirical work in the present context, such as Roberts (1997) and Gali and Gertler (1999), raises doubts about assuming full rationality. Furthermore, the assumptions about the available information and calculating ability of agents required by rational expectations are difficult to justify, which has spawned a large and growing literature on learning in macroeconomics, see Evans and Honkapohja (2001b). The possible presence of backward looking agents is a serious reason to question the wisdom of full commitment.

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<sup>8</sup>We also check the case where  $\alpha = 1.0$  and find that the optimal  $\kappa$  is even lower than for lower  $\alpha$ 's, as anticipated.

An important topic for future research is to determine the most appropriate way to model the formation of expectations. This is a difficult question involving a number of different mechanisms, some with free parameters to be estimated. However, to gain a deeper understanding of public reactions to policy, even partial answers are beneficial.

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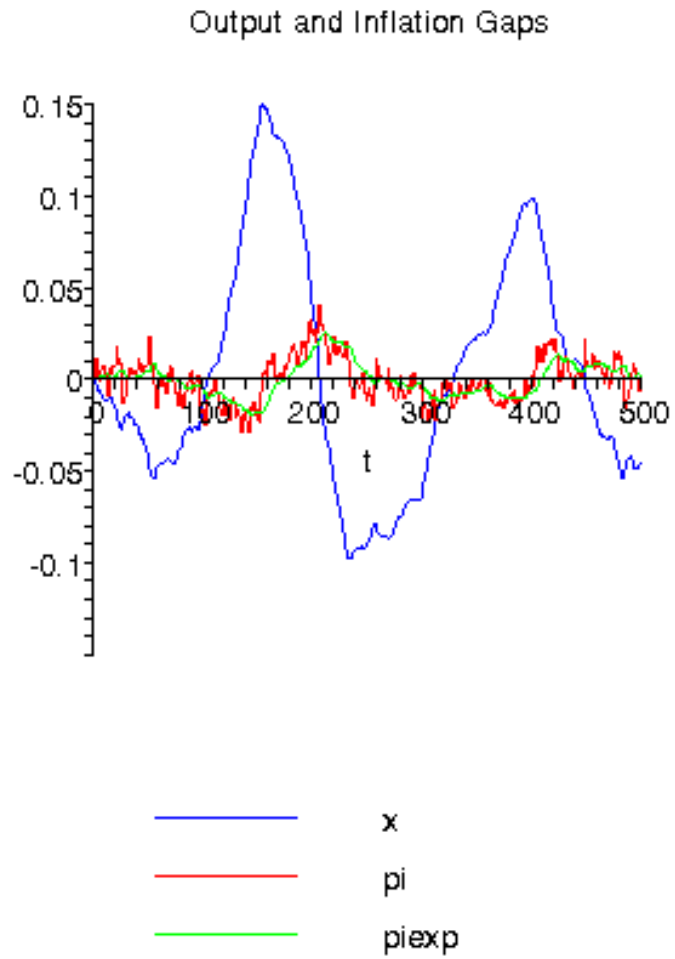
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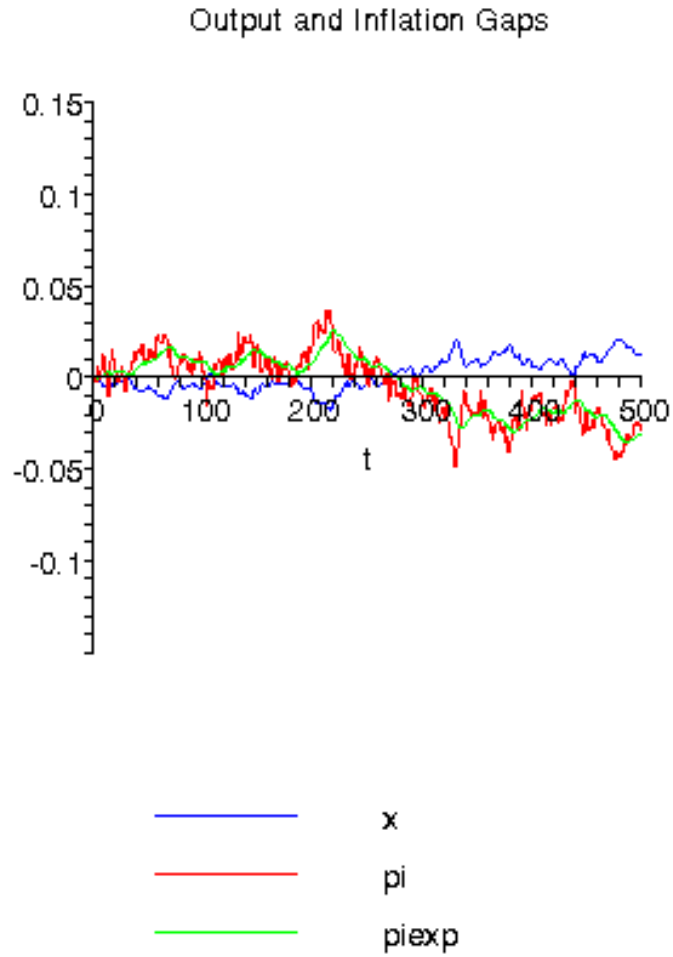
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Figure 1



For this simulation, the value of  $\kappa$  is  $\kappa = 1.0$ , the value for full commitment. The value of the gain parameter is  $\tau = 0.1$ .

Figure 2



For this simulation the value of  $\kappa$  is  $\kappa = 0.6$ , corresponding to partial commitment. The value of the gain parameter is  $\tau = 0.1$ .

Table 1

$\kappa$	$\delta_L$	$\alpha = 0.25$				$\alpha = 0.01$		
		$\tau = 0.025$	$\tau = 0.05$	$\tau = 0.1$	$\tau = 0.15$	$\delta_L$	$\tau = 0.05$	$\tau = 0.15$
0.0	0.000	0.7317	0.9910	1.8814	3.3355	0.000	0.6571	1.1149
0.2	-0.495	0.7249	0.9854	1.8506	3.2270	-0.400	<b>0.6303</b>	1.0670
0.4	-0.990	<b>0.7221</b>	<b>0.9793</b>	1.8436	3.2045	-0.800	0.6574	0.9910
0.6	-1.485	0.7239	0.9893	<b>1.8039</b>	3.0217	-1.200	0.6864	<b>0.9861</b>
0.8	-1.980	0.7903	1.0303	1.8340	<b>2.9552</b>	-1.600	0.8756	1.1482
1.0	-2.475	3.9291	5.8461	9.5409	13.5700	-2.000	1.6741	1.9886

Losses are computed from an average of runs of 200 periods and multiplied by 100. Parameter values are from MN04. The parameter  $\kappa$  represents the level of commitment and the parameter  $\delta_L$  is the policy function parameter on lagged output. Numbers in bold are the minimum values for the column



Table 2

$\kappa$	$\delta_L$	CGG00			$\delta_L$	W99		
		$\tau=0.05$	$\tau=0.1$	$\tau=0.15$		$\tau=0.05$	$\tau=0.1$	$\tau=0.15$
0.0	0.000	0.9719	1.7556	2.9896	0.000	1.0144	1.9833	1.4988
0.2	-0.049	<b>0.9483</b>	1.7418	2.9279	-0.031	1.0042	1.9829	1.4936
0.4	-0.098	0.9487	1.7048	2.7284	-0.063	<b>0.9970</b>	1.9606	1.4788
0.6	-0.147	0.9507	<b>1.6485</b>	2.5615	-0.094	0.9998	<b>1.9361</b>	1.4680
0.8	-0.196	1.0527	1.6943	<b>2.5101</b>	-0.125	1.0297	1.9595	<b>1.4946</b>
1.0	-0.244	4.9804	7.2844	9.7369	-0.157	4.9522	10.7041	7.8281

Losses are computed from an average of runs of 200 periods and multiplied by 100. Parameter values are from CGG00 and W99. The policy preference parameter is  $\alpha = 0.25$ . The parameter  $\kappa$  represents the level of commitment and the parameter  $\delta_L$  is the policy function parameter on lagged output.