

An Investigation of the Gains From Commitment in Monetary Policy*

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Abstract

We propose a simple framework for analyzing a continuum of monetary policy rules characterized by differing degrees of credibility, in which commitment and discretion become special cases of what we call quasi commitment. The monetary policy authority is assumed to formulate optimal commitment plans, to be tempted to renege on them, and to succumb to this temptation with a constant exogenous probability known to the private sector. By interpreting this probability as a continuous measure of the (lack of) credibility of the monetary policy authority, we investigate the welfare effect of a marginal increase in credibility. Our main finding is that, in a simple model of the monetary transmission mechanism, most of the gains from commitment accrue at relatively low levels of credibility.

Keywords: Commitment, Discretion, Credibility, Welfare

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“The key point here is that neither of the two modes of central bank behavior - rule-like or discretionary - has as yet been firmly established as empirically relevant or theoretically appropriate. . . . This position does not deny that central banks are constantly faced with the temptation to adopt the discretionary policy action for the current period; it just denies that succumbing to this temptation is inevitable.” (McCallum, 1999, pp. 1489-1490)

1 Introduction

As first pointed out by Kydland and Prescott (1977), “economic planning is not a game against nature but, rather, a game against rational economic agents.” When agents are rational *and forward-looking*, economic planners face constraints that depend on their own current and future choices, as forecasted by the private sector. Optimal policy therefore needs to internalize the effect of those choices on current private behavior.

Consider for example the case of a central bank confronting a trade-off between inflation and unemployment, in which current inflation also depends on expectations of future inflation.¹ In this environment, the credible announcement of a future policy tightening, in excess of that needed to curb forecasted inflationary pressures, lowers inflation expectations, thereby easing today’s trade-off. Optimal policy should therefore exhaust the net marginal benefit of this announcement. This strategy, however, is time-inconsistent. The same tightening that was once desirable to announce, due to its moderating effect on expectations, becomes regrettable as soon as it delivers the promised recession. For this reason, a benevolent policymaker will be expected to renege on her announcement and avoid the recession. Yet, the credibility of that announcement is a necessary prerequisite for the optimal policy to be feasible.

This highlights an important tension between the optimality of the commitment plan and the ex post incentive to abandon it. On the one hand, central banks can reap the benefits of commitment only if the private sector knows (with probability one) that they will not deviate from their announced plans. Yet, in the absence of a commitment technology, there is no reason for the private sector to believe that deviations will not occur. Moreover, this tension is exacerbated by the binary nature of the choice facing the public. It can either believe the central bank, or not.

In this paper, we propose a way of endowing private agents with the benefit of the doubt. We assume that a new central banker, call her j , is appointed with a constant and exogenous probability α every period. When j takes office (in period τ_j), she reneges on the promises of her predecessor and commits to a new policy plan that is optimal as of period τ_j . Agents understand the possibility and the nature of this change and form expectations accordingly. As a result, the private sector is constantly doubtful of the reliability of outstanding promises.

¹ After the seminal contributions of Kydland and Prescott (1977) and Calvo (1978), applications of the theory of economic planning with rational agents to monetary policy have attracted by far the most attention in the literature. Following this tradition, we illustrate most of our points within a monetary model.

Think of this as an economy with access to a limited commitment technology. Thanks to this technology, policymakers can guarantee their own promises. However, they cannot influence the behavior of their successors, who are therefore expected to formulate their own policy plan. Given this expectation, their best response is indeed to reoptimize upon taking office. Since they know how to keep their own promises though, they will also play the commitment strategy for the duration of their mandate. We refer to the resulting equilibrium, and to the limited commitment technology that supports it, as quasi commitment.

Note that with quasi commitment, even if reoptimizations can be arbitrarily frequent, they are not a source of gains for the policy authority. Since agents anticipate them to happen with the correct probability, on average there is no room “to exploit temporarily given inflationary expectations for brief output gains” (McCallum, 1999). This implies that quasi commitment cannot improve on the (full) commitment solution to the planning problem, since it imposes a restriction on the menu of credible promises available to the planner. However, quasi commitment converges to full commitment for $\alpha \rightarrow 0$. It also converges to discretion when $\alpha \rightarrow 1$. In this framework therefore, we can welfare-rank a continuum of intermediate cases between commitment and discretion, and investigate to what extent our imperfect commitment technology can approximate the optimal equilibrium.

As described above, quasi commitment is a useful modeling device to escape the strict binary logic of the debate on “commitment vs. discretion”, and to connect those two extreme modes of policymaking by a continuum of policy “rules”. In this context, we find it particularly suggestive to interpret α as a measure of the credibility of the central bank, that is of “the extent to which beliefs about the current and future course of economic policy are consistent with the program originally announced by policymakers” (Blackburn and Christensen, 1989). In our model, the public always contemplates the possibility that the current policy plan will be abandoned. The higher the probability attributed to this event, the higher the mismatch between the public’s perceptions and the plan being implemented by the incumbent policymaker, the lower her credibility.² Credibility thus becomes a continuous variable, measuring the probability that a central bank “matches deeds to words.” This is precisely the notion of credibility advocated by Blinder (1998).

Our definition of credibility is quite distinct from the ones previously proposed in the literature. In particular, we do not interpret credibility in terms of the relative weight on output in the central bank’s loss function (Rogoff, 1985), or in terms of the discrepancy between inflation expectations and the central bank’s inflation target (Faust and Svensson, 2000), but rather in terms of the expected durability of policy commitments. In this sense, our notion of credibility is closely related to an empirical measure of actual central bank independence proposed by Cukierman (1992), the observed turnover rate of central bank governors.³ Moreover, by assuming that private agents are

² Credibility and α , the instantaneous probability of a reoptimization, are inversely related. We find it convenient to adopt α^{-1} , the average length of the period between successive reoptimizations, as a direct measure of credibility. We will sometimes refer to the period between successive reoptimizations as “a regime”.

³ Cukierman, Webb and Neyapti (1992) show that central bankers’ turnover rates are correlated with the level

perfectly informed about the nature and objectives of monetary policy, we rule out reputational equilibria based on the public's uncertainty about the preferences of different types of central bankers, of the kind studied for example by Barro (1986) and Rogoff (1989).

We also view our approach to credibility as an alternative to the one built on the game theoretic apparatus of Abreu, Pierce and Stacchetti (1986, 1990).⁴ Differently from that literature, we do not explore the set of competitive equilibria that can be sustained by punishing governments that renege on their promises. In fact, we bypass this issue completely by assuming that policymakers have access to a commitment technology that guarantees (some of) their promises. In our model, credibility is not the attribute of a particular policy plan, the plan which policymakers optimally choose not to deviate from when behaving sequentially. Rather it is a quality of the central bank as perceived by the public. In the reputation literature, policy plans are either sustainable or not, mainly as a function of how harsh a punishment the private sector is able to inflict on a deviating policymaker. Optimal policy therefore never implies deviations from the announced plan (Phelan, 2001). Under quasi commitment on the contrary, different central banks enjoy different levels of credibility, depending on the commitment technology available to them. Therefore, deviations from pre-announced plans are indeed observed in equilibrium, even if they do not generate any systematic surprise for the public.

In this sense, quasi commitment assumes a given level of policy credibility, rather than explaining its origin. Nevertheless, we do not regard this as a shortcoming of the model, since its focus is on the consequences of marginal increases in credibility, rather than on its premises. Just as Calvo pricing is widely regarded as a useful starting point to explore the consequences of sticky prices, even if its time dependent microfoundations are only suggestive of actual pricing behavior, so we propose quasi commitment as a modeling device to explore decisionmaking procedures intermediate between discretion and commitment, along a dimension that can be usefully interpreted as credibility.

The papers in the literature that are closest to ours are Flood and Isard (1988) and Roberds (1987).⁵ The former identifies conditions under which commitment to a simple rule can be improved upon by the addition of a provision for discretionary optimization in the face of “big” shocks.⁶ Our framework can easily be adapted to interpret α as the probability of an extreme draw of the exogenous i.i.d. shocks that buffet the economy. Under this interpretation, policymakers are given free reign in the face of “big” shocks, but differently from Flood and Isard (1988), this optimally results in a new commitment rather than in a reversion to discretion.

Roberds (1987) presents a technical apparatus very similar to the one described below. He solves

and variability of inflation in cross country regressions.

⁴ The seminal papers are Chari and Kehoe (1990) and Stokey (1989, 1991). See Ljungqvist and Sargent (2000, Chapter 16) for an introduction and Phelan and Stacchetti (2001) for a prominent recent example.

⁵ Fischer (1980, pg. 105) could be interpreted as foreshadowing quasi commitment. However, his conjecture that “a randomized policy that is rationally expected may do better than non-stochastic optimal open loop policy” (i.e. full commitment) does not hold true in our framework. Kara (2002) proposes an empirical study of quasi commitment.

⁶ Flood and Isard (1988) consider a commitment to a simple non contingent rule, which, even if credible, does not provide any insulation against shocks. That is why adding an escape clause can improve its performance.

a model in which policy is set by a sequence of administrations whose turnover is determined by i.i.d. Bernoulli draws. Thanks in part to the better understanding of optimal policy problems available today, our solution method is more transparent and more widely applicable than Roberds' (1987), accommodating systems that include non-trivial dynamics for the endogenous state variables and singularities in the contemporaneous relations. On the other hand, we do not treat here the case of asymmetric information between policymakers and the public, which in Roberds' (1987, Section 4) framework gives rise to an interesting class of equilibria with delayed information. Finally, and much more importantly in our view, this paper provides a novel interpretation of the frequency of administration turnover as a measure of policy credibility. As a result, we can exploit the technical apparatus first proposed by Roberds (1987), and further developed here, to address important questions in the still open debate on "rules vs. discretion."

The remainder of the paper is organized as follows. In section 2, we introduce a simple New Keynesian model of the monetary transmission mechanism, which will serve as a laboratory for the study of quasi commitment. This study is undertaken in section 3. First, we solve the model analytically, to provide some intuition on the key steps involved in finding a quasi commitment equilibrium. Second, we illustrate the dynamic behavior of the economy in a calibrated version of the model, under different assumptions on the degree of credibility enjoyed by its monetary authority. Finally, in section 4, we study the distribution of the gains from commitment across different levels of credibility. Section 5 concludes.

2 A Simple New Keynesian Model

This section presents a simple New Keynesian model of the monetary transmission mechanism.⁷ This model is a very useful laboratory for the study of quasi commitment equilibria, for at least two reasons. First, it is the modern workhorse for the qualitative study of optimal monetary policy, both in the academic literature and within central banks. Second, it is a modern incarnation of the expectations-augmented Phillips curve models in Kydland and Prescott (1977) and Barro and Gordon (1983), the two seminal papers in the literature. As such, it greatly facilitates the comparison of our results with those papers' familiar findings.

The model describes an economy populated by a continuum of competitive, optimizing private agents and by a central bank whose objective is to maximize the welfare of the representative consumer. The strategic interaction between the atomistic private sector and the monetary authority leads to the joint determination of interest rates, real output and inflation.

Despite its simplicity, the model contains all the necessary ingredients for an insightful analysis of the stabilization effort of a central bank faced with a trade-off between the volatility of inflation and real activity. In particular, the model's microfoundations naturally result in a forward-looking

⁷ Woodford (2003) contains an exhaustive treatment of this class of models, starting with their microfoundations. See also Clarida *et al.* (1999) and Galí (2001).

private sector. This is the source of a time-inconsistency problem, which makes the quasi commitment constraint on admissible promises binding. As a result, we can study the marginal welfare effects of relaxing that constraint through increased central bank credibility. This is the subject of section 4

At the same time, however, the model is far from realistic, especially in the extremely simplified version with uncorrelated shocks considered in section 3. We have chosen it here for its analytical tractability. For this reason, a separate technical appendix contains a more general treatment of quasi commitment equilibria, in the context of a linear-quadratic model with rational expectations. This is a significant contribution in itself, since the LQ framework provides accurate and useful approximations to a large number of classic optimal monetary and fiscal policy problems in economics, as recently illustrated by Benigno and Woodford (2004a, 2004b, 2004c).⁸

The Economy The demand side of the economy is described by a dynamic IS equation, which is simply a log-linear version of the Euler equation of the representative consumer. We write this equation as

$$x_t = E_t x_{t+1} - \sigma(i_t - E_t \pi_{t+1} - r_t^e), \quad (1)$$

where x_t is the output gap, measured as the deviation of output from its efficient level, π_t is the rate of inflation, i_t is the nominal interest rate controlled by the central bank and r_t^e is the efficient interest rate, the equilibrium real interest rate in the undistorted economy.⁹ All variables are expressed as deviations from their respective steady states. The parameter $\sigma > 0$ is the intertemporal elasticity of substitution in consumption.

The supply behavior of the monopolistically competitive producers in the economy is described by a forward-looking Phillips curve, obtained as a log-linear approximation to the optimal price setting rule under Calvo pricing. This equation reads

$$\pi_t = \kappa x_t + \beta E_t \pi_{t+1} + u_t, \quad (2)$$

where β is the subjective discount factor of the representative consumer, $\kappa > 0$ is a function of structural parameters, including the frequency of price adjustment, and u_t is a “cost-push” shock (Clarida *et al.*, 1999).

This is one of many supply shocks that might buffet this economy. However, it plays a crucial role here because it captures time variation in markups, or more generally, in any distortion that might drive a *time-varying* wedge between the efficient and the natural levels of output. As such, this shock generates a trade-off between output and inflation. Moreover, it is the source of a *stabilization bias* (Svensson, 1997), due to the presence of forward-looking expectations. This

⁸ The technical appendix, along with MATLAB programs for the solution of the LQ model with quasi commitment, is available at <http://nyfedeconomists.org/tambalotti>.

⁹ The microfoundations of the log-linear model presented in this section feature two main distortions. The first one is monopolistic competition. The second one is price stickiness. We refer to the equilibrium that would emerge in the absence of the latter as “natural”, and to the one emerging in the absence of both as “efficient”.

means that the dynamic profile of the responses to this shock in the discretionary equilibrium is suboptimal, as illustrated in section 3.2.

The period objective function of the monetary authority, derived as a second order approximation to the utility of the representative consumer, is of the form

$$L_t = \pi_t^2 + \lambda_x (x_t - x^*)^2, \quad (3)$$

with a positive output gap target, $x^* \geq 0$. This reflects the *average* discrepancy between the efficient and the natural levels of output and is the source of an *average inflation bias*, as in the models of Kydland and Prescott (1977) and Barro and Gordon (1983).

Quasi Commitment Technology The central bank seeks to minimize the expected present discounted value of the loss function (3), under the constraints given by the optimizing behavior of the private sector, as described by equations (1) and (2). However, we assume that the mandate to minimize the loss function is delegated to a sequence of policymakers with tenures of random duration. The length of their tenure, or “regime”, depends on a sequence of exogenous, i.i.d. Bernoulli signals $\{\eta_t\}_{t \geq 0}$, with $E[\eta_t] = \alpha$. If $\eta_t = 1$, a new policymaker takes office at the beginning of time t . Otherwise, the incumbent stays on. All agents observe the realization of η_t , and of $\varepsilon'_t \equiv [r_t^e, u_t]$, at the beginning of the period. Their decisions for that period are therefore conditioned on the information set $\mathcal{I}_t \equiv \{\varepsilon'_s, \eta_s\}_{s \leq t}$.

Finally, we assume that each policymaker can credibly commit to a state-contingent plan for the entire duration of her tenure, but cannot constrain the actions of her successors. As a consequence, private agents expect new policymakers to deviate from the preexisting plan. Given this expectation, the deviation is optimal. Within each regime however, the best strategy is to commit following the intertemporal plan that was optimal from the perspective of that regime’s first period. Of course, this plan is in general time-inconsistent and can only be implemented in the presence of an appropriate commitment technology. We refer to this technology as quasi commitment.

3 Quasi Commitment Equilibrium

Having described the economic environment, we can now turn to the characterization of the equilibrium under quasi commitment. First, we derive an analytical solution to a version of the model with i.i.d. cost-push shocks. This helps to clarify the main steps of the solution and allows us to characterize some of its qualitative features. We then proceed to a quantitative investigation of the model’s dynamic responses to the exogenous shocks and of their dependence on the credibility parameter α . We refer the reader to the appendix for a more formal statement of the optimal policy problem under quasi commitment and for a detailed derivation of its solution.

3.1 Analytical Characterization

The policy problem described in the previous section can be greatly simplified if we note that policymakers can completely insulate the economy from perfectly observed fluctuations in the efficient interest rate, r_t^e , with offsetting movements in the policy instrument, i_t . In other words, the constraint on the maximization problem imposed by the IS equation is never binding. We can then proceed as if x_t were the actual instrument of policy and the Phillips curve the only constraint on policymakers' choices, with equation (1) left to determine the level of the interest rate necessary to bring about the desired path for the output gap.

The planning problem under quasi commitment can then be stated as

$$\begin{aligned} \min_{\{x_t\}_{t \geq 0}} E_0 & \left[\sum_{j=0}^{\infty} \beta^{\tau_j} \left(\sum_{k=0}^{\Delta\tau_j} \beta^k L_{\tau_j+k} \right) \right] \\ \text{s.t.} & \quad \beta\pi_t^e - \pi_t + \kappa x_t + u_t = 0 \\ & \quad (1 - \eta_t) (\pi_{t-1}^e - E_{t-1}\pi_t) = 0, \end{aligned} \quad (4)$$

where $\Delta\tau_j \equiv \tau_{j+1} - \tau_j - 1$ denotes the (random) duration of the j th regime, and $\pi_t^e \equiv E_t\pi_{t+1}$. This formalizes the idea that, in the process of choosing the optimal path for the system, the planner controls all variables, including expectations. Of course, this control is not absolute, but is subject to the constraint that agents behave optimally, and that their expectations are rational. However, under quasi commitment, outstanding promises regarding the future evolution of the economy do not bind incoming policymakers. The rationality constraint therefore drops from the problem at the inception of each regime, namely $\forall t : \eta_t = 1$. Hence the form of the second constraint. Note however that, although new central bankers ignore this constraint, this does not imply that agents are systematically fooled by them, as will soon be clear.

A key implication of the quasi commitment constraint is that it makes the above programming problem recursive “across regimes”. As a result, we can find its solution by solving the Bellman equation

$$\begin{aligned} V(u_{\tau_j}) &= \max_{\{\varphi_{k+1}\}_k} \min_{\{x_k, \pi_k\}_k} E_{\tau_j} \left[\sum_{k=0}^{\Delta\tau_j} \beta^k \mathcal{L}_{\tau_j+k} + \beta^{\Delta\tau_j+1} V(u_{\tau_{j+1}}) \right] \\ \varphi_{\tau_j} &= 0, \end{aligned} \quad (5)$$

where now

$$\mathcal{L}_t \equiv \pi_t^2 + \lambda_x x_t^2 + 2\varphi_{t+1} (\beta E_t \pi_{t+1} - \pi_t + \kappa x_t + u_t)$$

is the Lagrangian for period t .

As for the private sector, we assume that it is aware of the limitations of the commitment technology, and of the frequency of policymakers' turnover. In forming their expectations therefore, price setters systematically contemplate the possibility of a regime change. In this simple model, the

equilibrium inflation rate is known to be a linear function of the current “state”. We parametrize it as

$$\pi_{t+1} = h_0 + h_1 u_{t+1} + h_2 \varphi_{t+1}. \quad (6)$$

Thus, the one-step-ahead expectation can be computed as

$$E_t \pi_{t+1} = (1 - \alpha) E_t^0 \pi_{t+1} + \alpha E_t^1 \pi_{t+1} \quad (7)$$

$$= (1 - \alpha) E_t^0 \pi_{t+1} + \alpha h_0, \quad (8)$$

where $E_t^i \pi_{t+1} \equiv E_t [\pi_{t+1} | \eta_{t+1} = i]$, for $i = 0, 1$. The second line follows from (6), together with the assumption that u_t is i.i.d. and the fact that $E_t^1 \varphi_{t+1} = 0$.

Now, taking first order conditions of the maximization problem on the right-hand side of (5), we obtain, $\forall t \in \{\tau_j, \dots, \tau_j + \Delta\tau_j\}$

$$\lambda_x (x_t - x^*) + \kappa \varphi_{t+1} = 0 \quad (9a)$$

$$\pi_t - \varphi_{t+1} + \varphi_t = 0 \quad (9b)$$

$$(1 - \alpha) \beta E_t^0 \pi_{t+1} + \alpha \beta h_0 = \pi_t - \kappa x_t - u_t \quad (9c)$$

$$\varphi_{\tau_j} = 0. \quad (9d)$$

This system describes the evolution of the endogenous variables within the j^{th} regime.

From equation (9a), we immediately find that

$$\varphi_{t+1} = -\frac{\lambda_x}{\kappa} (x_t - x^*). \quad (10)$$

This suggests that the value of relaxing the forward-looking constraint depends negatively on the difference between the output gap and its target. This formalizes the intuition that the temptation to abandon the optimal plan is stronger, the further away the current output gap from its desired level.

Note also that this temptation is in general not zero, even without an average inflation bias, i.e. when $x^* = 0$. As further illustrated by the impulse responses in section 3.2, the optimal policy calls for promising, and delivering, a protracted recession, even in response to an uncorrelated inflationary cost-push shock. This is true regardless of the value of x^* . That promise is desirable at the time of the shock, because of its moderating effect on expectations, which contributes to a favorable shift of the Phillips curve trade-off. Delivering on that promise, however, requires maintaining a contractionary policy stance, and the ensuing recession, even after all inflationary pressures have dissipated. Hence the temptation to abandon the disinflationary plan, captured by the positive values of the multiplier associated with negative output gaps. This also explains why the multiplier is equal to zero at the beginning of each regime, as indicated by condition (9d). This is when incoming policymakers “succumb to the temptation” and abandon their predecessor’s plan, in favor of their own, thereby implicitly reneging on all outstanding promises.

Now, to explicitly solve for the equilibrium path of all variables, we start by combining equations (9a) and (9b) to obtain

$$\pi_t = -\frac{\lambda_x}{\kappa} \Delta x_t. \quad (11)$$

This expression can then be substituted in (9c) to yield a second order difference equation for x_t

$$(1 - \alpha) \beta E_t x_{t+1} - \left((1 - \alpha) \beta + \frac{\kappa^2}{\lambda_x} + 1 \right) x_t + x_{t-1} = \frac{\kappa}{\lambda_x} (u_t + \alpha \beta h_0), \quad (12)$$

with the “fictitious” initial condition $x_{\tau_j-1} = x^*$. The equation’s characteristic polynomial has roots $\mu_1(\alpha)$ and $\mu_2(\alpha)$ inside and outside the unit circle respectively. Moreover, it can easily be shown that a marginal increase in credibility always decreases both roots, or, more formally, that $\frac{\partial \mu_i(\alpha)}{\partial \alpha} > 0$, for $i = 1, 2$.

We can then solve the difference equation and use (11) to derive an expression for $E_t [\pi_{t+1} | \eta_{t+1} = 1]$ as a function of h_0 . Matching coefficients with (6) produces the equilibrium value of h_0

$$h_0 = E_t^1 \pi_{t+1} = \frac{\kappa \mu_1}{1 - \beta \mu_1} x^*, \quad (13)$$

which substituted back into the solution to equation (12) yields

$$x_t - \mu_1 x_{t-1} = -\mu_1 \frac{\kappa}{\lambda_x} u_t - (1 - \mu_1) \frac{\alpha \beta \mu_1}{1 - \beta \mu_1} x^*. \quad (14)$$

As expected, one-step ahead inflation expectations, conditional on a reoptimization, are increasing in the output target, as well as in the frequency of reoptimizations. This implies that more credible central banks face a more favorable trade-off.

Perhaps surprisingly instead, equation (14) implies that, if no reoptimization ever occurred, x_t would converge to

$$\bar{x} \equiv -\frac{\alpha \beta \mu_1}{1 - \beta \mu_1} x^*, \quad (15)$$

a negative number, whose absolute value is increasing in α . This is easily explained however, if we note that agents always expect a reoptimization to happen with the same positive probability, even if they have not observed one in a long time. Moreover, this reoptimization will result in a positive inflation rate. However, we see from equation (11) that, in the same circumstances, π_t would converge to zero. Hence, inflation expectations must be positive. But this can be consistent with equation (2) only if the output gap is negative.

In other words, in this simple economy, a central banker with a very long tenure should bring inflation as close as possible to zero, irrespective of the central bank’s credibility. This is an important result, which confirms the optimality of long-run price stability in this model, even in the absence of perfect commitment. However, the cost of achieving this objective is higher, in terms of foregone output, the lower the central bank’s credibility.

At this point, it is convenient to define the deviation of the output gap from its “within regime” limiting value as $\tilde{x}_t \equiv x_t - \bar{x}$. We can then solve (14), together with the initial condition $x_{\tau_j-1} = x^*$, to obtain

$$\tilde{x}_t = \mu_1^{t+1} \frac{1 - (1 - \alpha) \beta \mu_1}{1 - \beta \mu_1} x^* - \mu_1 \frac{\kappa}{\lambda_x} \sum_{s=0}^t \mu_1^s u_{t-s}. \quad (16)$$

In this expression, higher credibility (a lower α), decreasing μ_1 , dampens the initial impact of supply shocks on the output gap. It also makes their decay faster.¹⁰ This reflects the beneficial effect of credibility on inflation expectations, which translates into a favorable shift of the trade-off faced by the central bank.

Another interesting feature of this equilibrium is that policy plans are entirely independent of the economic conditions prevailing before date τ_j . This is reflected in the “initial” condition $x_{\tau_j-1} = x^*$. In other words, under quasi commitment, each central banker evaluates alternative plans from a τ_j -optimal perspective, rather than from a timeless perspective (Woodford, 2003). If they adopted the timeless perspective instead, incoming central bankers would behave as if $x_{\tau_j-1} = x_{\tau_j-1+\Delta\tau_{j-1}}$. This would lead them to simply continue the plan initiated by their predecessor—who was indeed assumed to have done the same...—thus eliminating the time-inconsistency that is one of the necessary ingredients of quasi commitment.¹¹

It is important to note, however, that quasi commitment solves one of the logical inconsistencies of t_0 -commitment, in that there is nothing special here about the times at which plans are reformulated. Therefore, the fact that at those times policies would be reoptimized from a conditional, rather than an unconditional, perspective, does not pose any particular logical challenge.¹²

Now, iterating (9c) forward and making use of (14), we can also obtain an equation for the equilibrium inflation rate,

$$\pi_t = \frac{\kappa}{1 - (1 - \alpha) \beta \mu_1} \tilde{x}_t + u_t, \quad (17)$$

as a function of the output gap and of the current shock. In this expression, the coefficient on \tilde{x}_t is decreasing in α . This implies that a more credible central bank can counteract inflationary shocks with relatively smaller movements in the output gap. Once again, this finding conforms to the intuitive notion that credibility makes fighting inflation easier, in the sense of requiring comparatively less sacrifices in terms of output.

Finally, recalling the relationship between the current interest rate and the other endogenous variables given by (1), it is immediate to solve for the sequence of interest rates needed to bring about the optimal combinations of inflation and the output gap described above. This is

$$i_t = \bar{i} + \left[\frac{\kappa(1 - \alpha) \mu_1}{1 - (1 - \alpha) \beta \mu_1} + \sigma^{-1} (1 - \alpha) \mu_1 - \sigma^{-1} \right] \tilde{x}_t + r_t^e, \quad (18)$$

¹⁰ This statement about the rate of decay is conditional on no reoptimization happening after the initial impulse, an event whose ex-ante likelihood is proportional to $(1 - \alpha)^t$. See section 3.2 for more details on this issue.

¹¹ This conclusion would continue to hold even in a more complicated model with physical state variables. In that case, the quasi commitment plan would be an invariant function of the physical state at time τ_j , but with no “memory” of past commitments.

¹² Svensson (1999b) argues that t_0 -commitment is a problematic concept because it makes time t_0 , at which the plan is formulated, arbitrarily special.

where $\bar{\tau}$ is an uninteresting constant. Just as for the case of inflation, the coefficient on the output gap can be shown to be decreasing in α .

In summary, the main finding of this section is that more credible central banks can more easily control the economy. By magnifying the effect of interest rate changes on output, and of output changes on inflation, credibility allows policymakers to reduce inflation with relatively small movements in interest rates, and at the cost of relatively shallow, although protracted, recessions. This finding is indeed consistent with the well known “smoothing” effect of full commitment (Woodford, 2003a). In addition, we have shown that this effect is increasing in the level of credibility. The next two sections further investigate the relationship between credibility and the transmission mechanism, as well as its implications for welfare.

3.2 Impulse Response Analysis

This section provides a graphical illustration of the effect of credibility on the transmission mechanism in a calibrated version of the model. In particular, we focus on the impulse responses of the endogenous variables to inefficient shocks, to make the results more immediately comparable to those in the literature (see especially Clarida *et al.*, 1999 and Chapter 7 in Woodford, 2003).

3.2.1 Calibration

The benchmark calibration follows Woodford (2003, Table 6.1), except for the values of the output gap target, x^* , and of the standard deviation of the cost-push shock, σ_u . It is summarized in the following table

σ	κ	β	λ_x	x^*	σ_u
1.5	0.1	0.99	0.048	0.1	0.013

The model is quarterly, but with interest rates and inflation measured as annualized percentages.¹³ All assumed parameter values are reasonably standard, with the possible exception of the relative weight on the output gap in the central bank’s objective, λ_x . This extremely low number derives from the microfoundations of the loss function as a second order expansion of the representative consumer’s utility. It is therefore consistent with the rest of the structural parameters. As for x^* and σ_u , we chose them to match the first two moments of inflation in the United States in the period 1987-2004, in a quasi commitment equilibrium with expected regime duration $\alpha^{-1} = 2$. This is because, as we will see, the moments implied by this level of credibility are approximately halfway between the two extremes of discretion and commitment, and therefore representative, in a sense, of the entire spectrum of quasi commitment equilibria. In any case, in section 4 we will also document the robustness of our findings on the gains from commitment to changes in all three of these parameters.

¹³ This, and some rounding, explain the discrepancy between our parameters and those in Woodford’s (2003) table.

3.2.2 Types of Impulse Response Functions

The quasi commitment model described above is driven by two types of shocks. First, we have the vector of structural shocks, $\varepsilon_t' \equiv [u_t, r_t^e]$, which enter the model linearly. As already pointed out however, the efficient real rate is not a source of interesting dynamics, since its fluctuations are always perfectly offset by identical movements in the nominal interest rate. For this reason, in the remainder of the section we will focus our attention on the dynamic effects of cost-push shocks.

The second type of shock is the regime-change shock, η_t . Since its effect on the model's dynamics is non linear, its interaction with the additive shocks is not trivial. For this reason, we need to consider four kinds of impulse response functions, each of them highlighting different aspects of the model. All these IRFs describe the responses of the vector of endogenous variables, z_t , to the structural shocks, ε_t . Their formal definitions are summarized in the following table

	Impulse Response Functions
<i>i)</i>	$E_0[z_t \{\eta_t = 0\}_{t>0}] - E_{-1}[z_t \eta_0; \{\eta_t = 0\}_{t>0}]$
<i>ia)</i>	$E_0[z_t \{\eta_t = 0\}_{t>0}] - E[z_t]$
<i>ii)</i>	$E_0[z_t \{\eta_t = \bar{\eta}_t\}_{t>0}] - E[z_t]$
<i>iii)</i>	$E_0[z_t] - E_{-1}[z_t \eta_0]$

The first type of IRFs are what we call “within regime” responses. They are conditional on no reoptimization occurring over the horizon of interest, and correspond to a traditional response from the state space form associated with the solution to system (9). Therefore, they describe what would happen if a central banker survived in office for an unexpectedly long period. Of course, depending on the value of α , the ex ante probability of this scenario declines with the length of the horizon, making the implied path of z_t less and less representative of the expected position of the system.

Responses of type *ii)* are one way of solving this problem. They are computed by conditioning on a particular realization of the sequence of regime-change shocks, $\{\eta_t = \bar{\eta}_t\}_t$. As a consequence, the ex ante probability of the implied path of z_t , although low, is not monotonically decreasing. Another important feature of this type of IRFs is that they are “normalized” by the unconditional mean of z_t . Had we followed the convention, and subtracted instead $E_{-1}[z_t | \eta_0; \{\eta_t = \bar{\eta}_t\}_{t>0}]$, we would have eliminated the “jumps” in z_t associated with $\bar{\eta}_t = 1$, since these are perfectly deterministic once the dates of the reoptimizations are known. But these “jumps” are one of the interesting features of quasi commitment, and as such are worthwhile documenting. A similar consideration also explains the introduction of the IRFs of type *ia)*. More on this in the next section.

Finally, the third type of responses are simply the ex ante averages of all the possible conditional IRFs, integrated over the distribution of the corresponding reoptimization draws. Therefore, they represent the expected evolution of the system following the initial shock. In this sense, they probably capture the most intuitive notion of an impulse response. However, they also “integrate out” most of the interesting properties of quasi commitment. This is why the other types of impulse responses will receive more attention in the next section.

3.2.3 Dynamic Responses to Cost-Push Shocks

With these preliminaries in place, we can now turn to the description of the dynamics of our simple monetary model following a one standard deviation, i.i.d. cost-push shock.

When interpreting these dynamics, it is useful to keep in mind that the IRFs of types *i*) and *iii*) are invariant to the position of the system at the time of the shock, and to the subsequent transition back to the steady state, by virtue of our choice of normalization. As a consequence, they all converge to zero, even if quasi commitment equilibria with different credibility parameters have different “within regime” steady states, and different first moments. Highlighting the distinction between these two concepts is the main role of the IRFs of type *ia*).

We begin our analysis with figure 1. Focus for now on the dotted and the dashed lines in each panel, which depict the paths of inflation, the output gap and the interest rate under discretion and full commitment, respectively. Under discretion, the central bank moves its instrument with the shock, returning the economy to steady state as soon as the effects of the shock have faded. With an i.i.d impulse, this implies driving the economy into a sharp recession, in the attempt to counteract the inflationary shock. The resulting stagflation lasts for only one period. Under commitment instead, the central bank takes advantage of the possibility of lowering inflation expectations at the time of the shock, by promising a protracted mild recession, accompanied by deflation. This can be accomplished with a very limited, although persistent, movement in the interest rate, a clear illustration of the optimality of interest rate smoothing. Naturally, this course of action is time inconsistent, since the central bank would be better off returning to the steady state as soon as the shock has disappeared. This is the same policy a new central banker would choose, when allowed to reoptimize after the shock.

What is the behavior of the economy under quasi commitment? Part of the answer is provided by the continuous lines in figure 1, which represent IRFs of type *i*) under quasi commitment regimes

with expected durations of two quarters and two years respectively. As noted above, this path for the variables is very unlikely *ex ante*, since it is associated with a string of twenty zero realizations of the η shock. Nevertheless, this experiment is instructive. On the one hand, when the average regime duration is eight quarters, the dynamic response of the system is almost indistinguishable from that under commitment. This suggests that relatively low levels of credibility are enough to produce qualitative responses of the economy similar to the optimal one. On the other hand, when the expected duration of the regime is only two quarters, the path of inflation is still very close to that under commitment, but is accompanied by a more pronounced recession. Disinflation is more painful for central banks with little credibility.

A slightly different interpretation of these results comes from thinking of type *i*) IRFs as the equilibrium that would obtain if, at the time of the shock, a new central banker came into office, but refused to validate expectations and did not reoptimize, even in the face of positive realizations of η_t . Of course, there is no room in our model for this sort of behavior. The optimal policy under quasi commitment entails a reoptimization whenever $\eta_t = 1$, and the equilibrium is constructed under the assumption that this will indeed happen. Nevertheless, it is not hard to imagine this as a crude description of what happened under Federal Reserve chairman Paul Volcker. Inheriting a central bank with low credibility in fighting inflation, and faced with inflationary pressures stemming from the second oil price shock, Volcker chose to undergo the high output costs of a painful disinflation. Arguably, his objective was to increase the Fed’s credibility, and hence to avoid another costly trade-off in the face of future shocks. Unfortunately, this investment aspect is not available in our setup, since the central bank’s credibility is a parameter of the commitment technology. Turning this parameter into a choice variable would certainly be a worthwhile extension of our framework.

The analysis of type *i*) IRFs, although quite insightful, is ultimately not very useful for characterizing the “typical” behavior of the economy under quasi commitment. One alternative is to take a stance on the occurrence of regime changes following a positive realization of the cost-push shock. This is accomplished by the IRFs of type *ii*), represented in figure 2 for the case of an expected regime duration of eight periods. The figure also reports the corresponding “within regime” response of type *ia*) and, once again, full commitment and discretion. The main feature of this picture is the seesaw pattern generated by the reoptimizations, which in this particular draw occur at times 5 and 14. In the quasi commitment equilibrium, incoming central bankers abandon the time-inconsistent plan of their predecessor and drop interest rates below average, boosting out-

put and inflation. The initial discontinuity is followed by a deterministic adjustment towards the “within regime” steady state, the equilibrium to which the economy would converge, absent any further reoptimization. The conditionality of this statement explains why this steady state is different from the model’s unconditional mean. In the graphs, the latter is normalized to zero by our definition of the IRFs, while the former corresponds to the limiting behavior of the IRF of type *ia*). In the steady state then, interest rates are above average, while both the output gap and inflation are below. This is the price paid for the central bank’s lack of credibility by a policymaker who happens to draw an unexpectedly long tenure.

Finally, to complete the picture of our economy’s equilibrium dynamics, figure 3 displays IRFs of type iii), for an expected regime duration of two quarters. As we might have expected, the average responses under quasi commitment are, broadly speaking, “intermediate” between those for discretion and full commitment. However, given such a short regime duration, it is surprising that they would not lie much closer to those for discretion. For example, the interest rate hike required to counteract the cost-push shock is cut approximately in half when moving from discretion to quasi commitment. Nevertheless, given the persistence of the policy tightening, this is sufficient to keep inflation in check and to avoid a deep recession. This illustrates quite clearly the “non linear” effect of credibility on the transmission mechanism, in the sense that even small credibility gains away from discretion can provide a reasonable approximation of the commitment dynamics. The next two sections further illustrate this principle by looking at the marginal effects of credibility on average inflation and welfare.

3.3 The Average Inflation Bias

Our discussion so far has focused mainly on the effect of quasi commitment on the dynamic response of policy to shocks, and on how this response affects the shocks’ transmission to the rest of the economy. Our main finding was that even minimal levels of credibility have a significant impact on the ability of the central bank to influence agents’ expectations, hence improving its “grip” on the economy. This is an illustration of how credibility can attenuate the stabilization bias built into the time-consistent policy. The question we have not addressed yet is how credibility affects the average inflation bias, the tendency of discretionary policymakers to cause high inflation while reaching for an “overambitious” output target. Given that this bias affects the first order properties of the equilibrium, its impact on welfare is potentially very significant, as documented in the next

section.

Figure 4 is a clear illustration of the non linearity of the effect of credibility on our economy. It reports the average levels of inflation and the output gap as a function of the expected regime duration.¹⁴ Looking at the corners of the picture along the main diagonal, we first observe that average inflation is zero under the optimal policy, while it is close to 5% under discretion. This is the full extent of the inflation bias. However, the bias drops by almost a half for quasi commitment regimes with an average duration of only two quarters, and further declines to close to 0.5% for expected durations of two and a half years. As for the output gap, it follows a similarly convex pattern, just on a much smaller scale. This is one significant difference between the implications of our forward-looking model and those of more traditional treatments of the inflation bias, in which the increase in average inflation is usually accompanied by no change in output. In our model instead, a discretionary policy authority can in fact push output slightly above its efficient level, on average. However, this comes at the expense of a much larger increase in inflation, whose welfare cost is further amplified by the predominance of the inflation objective in the loss function.

As we will see in the next section, the convexity of the relationship between average inflation (and output) and credibility carries over to the loss function. However, it is not its only determinant. The gains from commitment are in fact concentrated at low levels of credibility even in a model with no average inflation bias, as illustrated by our robustness analysis below, and discussed in more detail in Schaumburg and Tambalotti (2003).

4 The Gains from Commitment

Having documented the effect of policymakers' ability to commit on the model's first and second moments, we are now in the position to investigate the impact of credibility on welfare.

Before doing so though, it is worth commenting on the metric that we will adopt in our welfare analysis. If $y_t^*(\alpha)$ is the vector of equilibrium values for the arguments of the utility function, we can approximate the expected loss at the beginning of the planning horizon as

$$L_0(\alpha) \approx -\Omega E_0 \left[\sum_t u(y_t^*(\alpha)) \right], \quad (19)$$

¹⁴ We do not report the average value of the interest rate since it is identical to that of inflation. This is an implication of the Fischer equation, since all variables are reported as deviations from the log-linearization steady state, which makes the average real rate equal to zero.

where Ω is a constant. The problem in interpreting this value as an ordinal measure of welfare is that any monotonic transformation of u is consistent with the same preference ordering. However, only affine transformations of this function are consistent with a given level of the elasticity of substitution. But, for any given calibration, the change in welfare associated with different levels of credibility, measured as a fraction of the total difference between discretion and commitment, is invariant to affine transformations of u . Therefore, it provides a meaningful measure of the welfare gains of moving from one credibility level to the other. This is the welfare metric we adopt below.

The centerpiece of our analysis is figure 5, which plots the minimum expected loss associated with different quasi commitment equilibria, as a function of their respective levels of credibility. The total difference between discretion and commitment is normalized to one. Evidently, the welfare gains from even minimal levels of credibility are substantial. An expected regime duration of two quarters reduces the loss by approximately 70%. Three quarters are enough to produce more than 80% of the total gains, while 95% of the gains can be obtained with an average regime duration of approximately two and a half years. Especially when measured in terms of welfare then, the effect of credibility on the economy is non linear. It's return is significantly higher at low levels of credibility.

Moreover, this conclusion is robust to changes in the parameters of the loss function, as well as in the distribution of the shocks. Table 1 illustrates the effect of changes in the former on the number of periods needed to achieve at least the fraction of total gains displayed along the rows. We consider values of the relative weight on inflation of up to one, and output targets between zero and 0.2. In the less favorable combination of parameters, $x^* = 0$ and $\lambda_x = 1$, we still find that a quasi commitment expected to last for five years is enough to obtain at least 75% of the gains, while less than two years are enough to cover half of the gap. This evidence points to the very important role of the average inflation bias in generating a concave relationship between credibility and welfare. As shown in the table, increases in x^* tend to concentrate the gains from commitment closer and closer to discretion. This is not too surprising, given the convexity of the effect of credibility on average inflation displayed in figure 4. However, even in the case of $x^* = 0$, the returns to credibility are still decreasing, although at a less dramatic rate.

The robustness of our findings to changes in the distribution of the shocks is illustrated in table 2. The table considers values of the standard deviation of the cost-push shock equal to one half

and two times the benchmark, and autocorrelations of up to 0.7.¹⁵ The changes in the results are minor. In particular, increases in both parameters tend to increase the number of periods needed to achieve 90% or more of the gains, but leave the picture virtually unchanged for fractions of the gains of up to 75%.

Finally, another instructive look at the significant effect on our economy of even limited amounts of commitment, comes from plotting the combinations of output gap and inflation volatilities associated with different levels of α . This is done in figure 6. Moving north-west from the corner occupied by the triangle representing discretion, this figure displays a sequence of crosses corresponding to unitary increases in expected regime duration. For example, the cross corresponding to a standard deviation of inflation of approximately 1% denotes the quasi commitment equilibrium with an expected regime duration of two quarters. Strikingly, in this equilibrium, inflation is half as volatile as under discretion. This reduction however has no visible effect on the standard deviation of the output gap. An average duration of three quarters cuts inflation volatility by another half, while at one year both volatilities are within two basis points of those under commitment.

In summary, according to our analysis, an economy in which policymakers are able to commit on average for at least one year, would be characterized by:

- 1) an average inflation rate within approximately 1% of the optimum
- 2) standard deviations of inflation and the output gap virtually indistinguishable from those in the optimum
- 3) welfare gains of more than 90% with respect to discretion.

5 Conclusion

This paper introduced the notion of quasi commitment, a decisionmaking framework with limited commitment in which policymakers renege on their announced optimal plans with a constant, exogenous probability every period. Assuming that private agents know the probability of renegotiation, and form expectations on the future course of policy accordingly, we can interpret the expected duration of the announced plans as a continuous measure of whether policymakers match deeds to words. This is the notion of credibility proposed by Blinder (1998).

We then apply this framework to a calibrated version of a forward-looking model of the monetary

¹⁵ For the autocorrelated case, we are assuming that the cost-push shock is distributed as an AR(1) process with coefficient ρ_u and standard deviation of the shocks σ_u .

transmission mechanism, and study the effect of credibility on welfare. Our main finding is that most of the gains from commitment accrue at relatively low levels of credibility. In our benchmark calibration for example, a commitment expected to last for one year is enough to bridge 90% of the welfare gap between discretion and commitment. Moreover, we show that the presence of an average inflation bias significantly accentuates the non linearity of the relationship between credibility and welfare.

These findings are important, because they imply that policymakers do not need to convince the public that they will honor their promises forever to reap most of the benefits of commitment. It also suggests a possible explanation for the often remarked obsession of central bankers with their credibility (Blinder, 1998). In our world, an even minor loss in credibility can have significant welfare effects.

This paper represents a preliminary study of the behavior of a particular model economy under quasi commitment. The robustness of our results across different models of the monetary transmission mechanism is an open question, that warrants further investigation. In fact, progress in this direction can be accomplished with a relatively modest effort, given that our solution method has been devised for a general class of DSGE models.

Finally, endogenizing the probability of a change in regime seems an obvious step to increase the empirical plausibility of the model. We could think of two ways of accomplishing this, which we see as complementary. On the one hand, we could allow central bankers to invest in their credibility, for example by refusing to reoptimize when given the option. This would be justified only as long as the private sector could learn about the new frequency of reoptimizations. Comparing the costs of the transition, when inflation expectations are still high, with the long run gains associated with the higher level of credibility, would produce a normative analysis of the transition from low to high credibility regimes. On the other hand, similarly to Flood and Isard (1988), we could assume that the probability of a reoptimization depends on the state of the economy. For example, we could make this probability a function of the vector of predetermined Lagrange multipliers, which measure the temptation to disregard the associated constraints and reoptimize. Even though maybe desirable on the grounds of realism, these extensions would come at the cost of foregoing the linear quadratic structure that makes the model tractable. For this reason, the quasi commitment framework with exogenous reoptimizations provides a useful first step in the direction of expanding the menu of policy choices beyond discretion and commitment.

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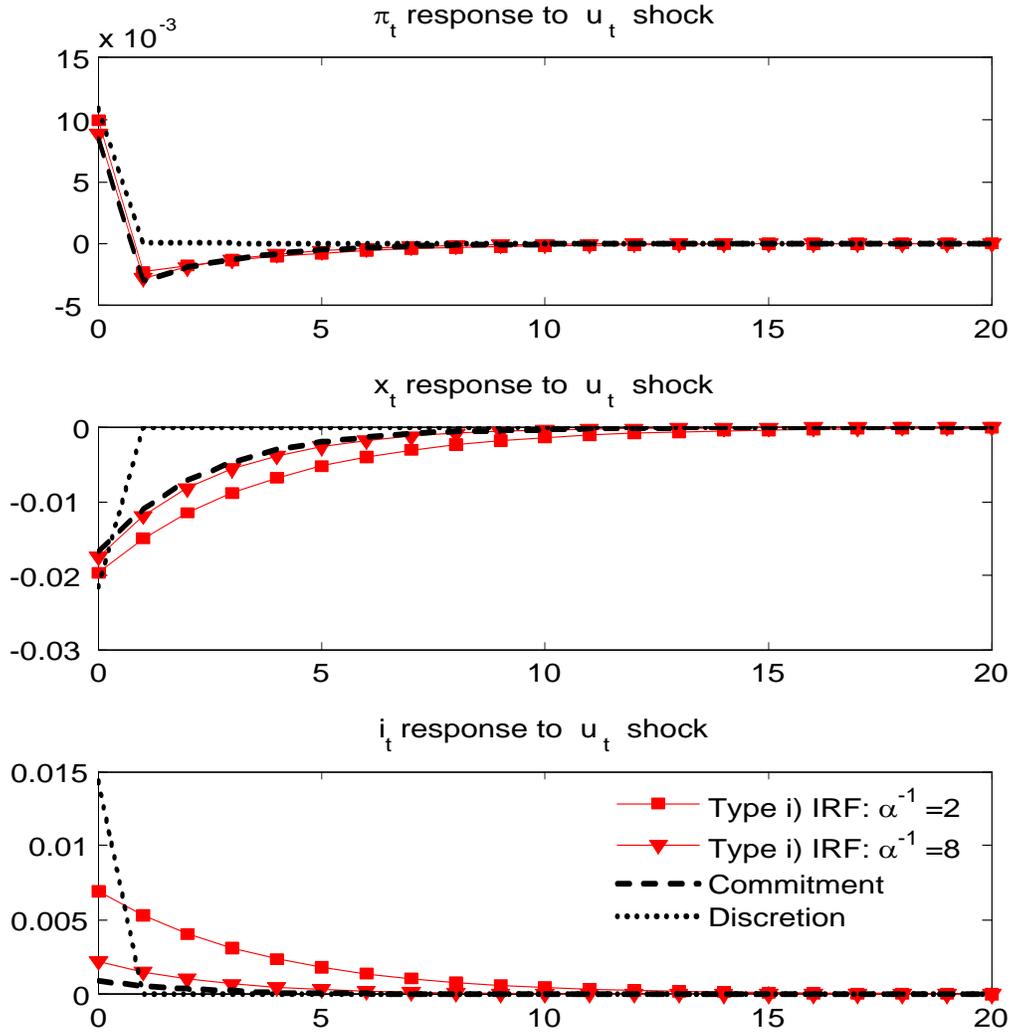


Figure 1: **Impulse response functions of type i** . Impulse responses to a one standard deviation cost push shock at time $t = 0$ under commitment, discretion and quasi commitment regimes with average durations of two quarters ($\alpha^{-1} = 2$) and two years ($\alpha^{-1} = 8$). The quasi commitment responses are conditional on *no reoptimization* (type i). Inflation and the interest rate are expressed as annualized percentages.

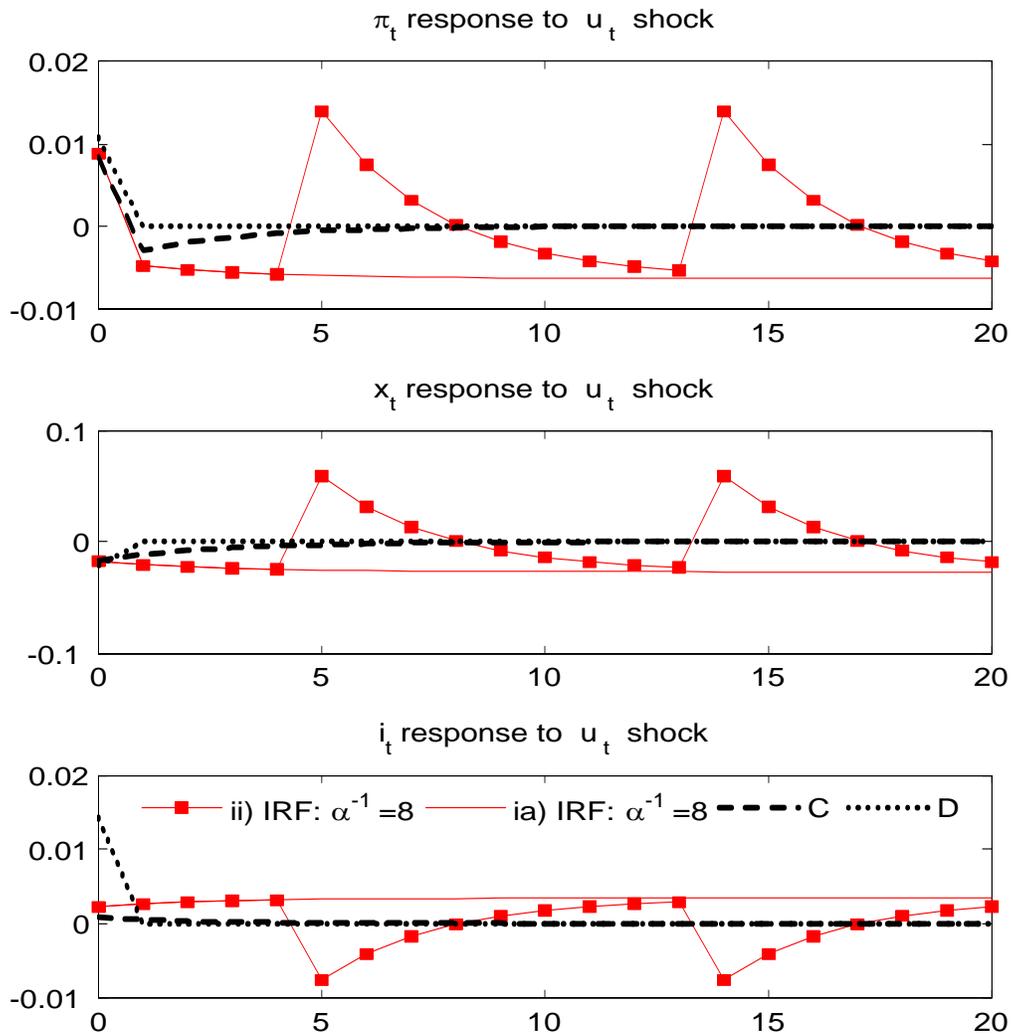


Figure 2: **Impulse response functions of type *ii***. Impulse responses to a one standard deviation cost push shock at time $t = 0$ under commitment, discretion and quasi commitment with an average regime duration of two years ($\alpha^{-1} = 8$). The thin line is the quasi commitment response conditional on *no reoptimization* (type *ia*). The thin line with squares is the quasi commitment response conditional on *reoptimizations at times $t = 5$ and $t = 14$* (type *ii*). At time $t = -1$ the system is assumed to be at its unconditional mean. Inflation and the interest rate are expressed as annualized percentages.

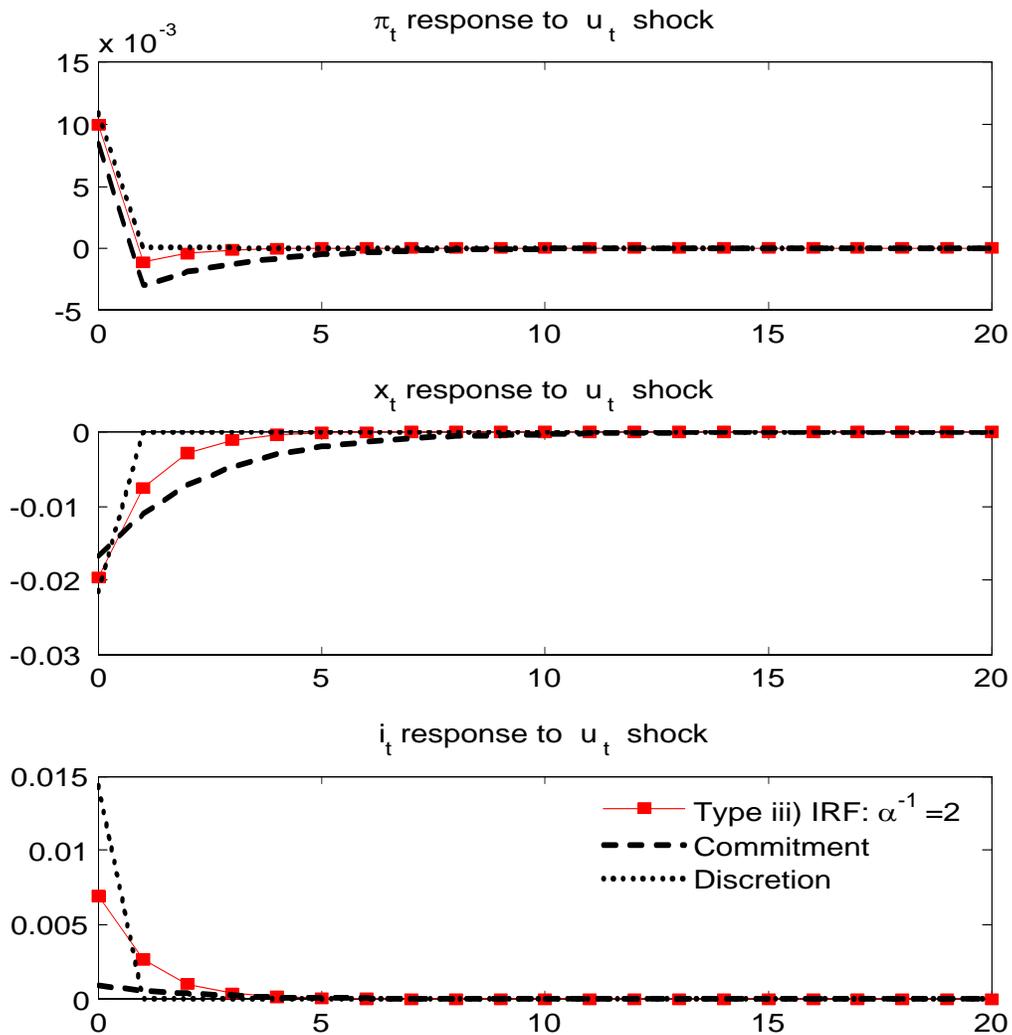


Figure 3: **Impulse response functions of type *iii***. Impulse responses to a one standard deviation cost push shock at time $t = 0$ under commitment, discretion and quasi commitment with an average regime duration of two quarters ($\alpha^{-1} = 2$). The quasi commitment response is an *average* over potential future reoptimizations (type *iii*). Inflation and the interest rate are expressed as annualized percentages.

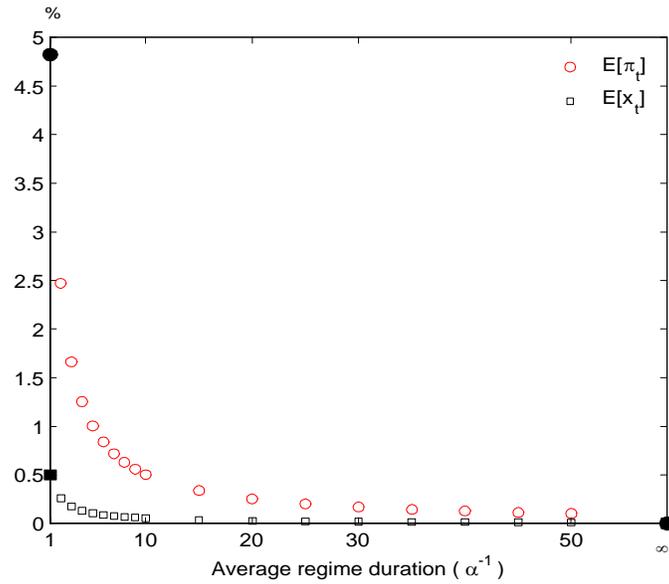


Figure 4: **Unconditional means.** The unconditional means of inflation and the output gap as a function of credibility. Inflation is expressed as an annualized percentage.

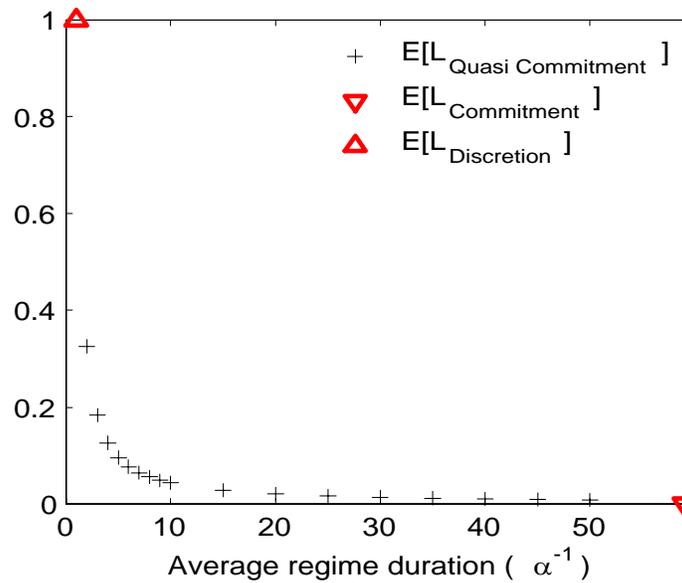


Figure 5: **Expected loss.** The expected loss as a function of credibility. The loss is measured as a fraction of the total difference in welfare between discretion and commitment.

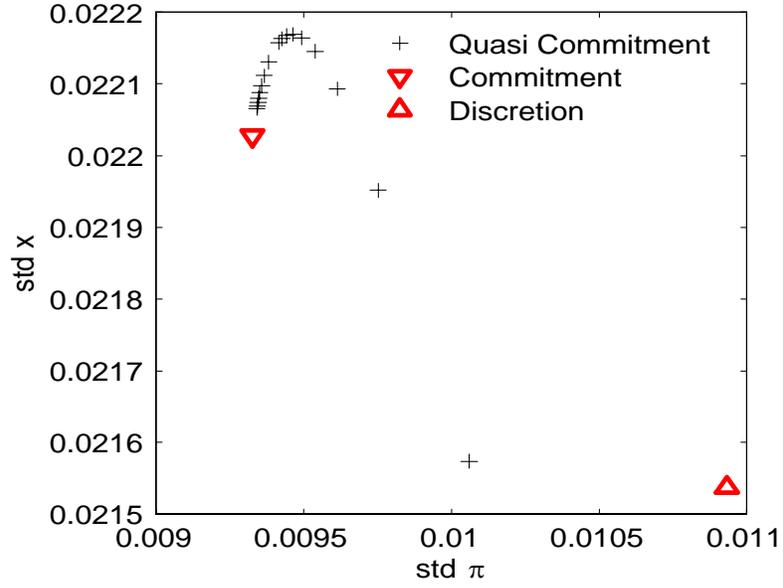


Figure 6: **Unconditional volatilities.** The volatility frontier as a function of credibility. Each cross represents an increase in the average regime duration of one quarter, moving NW from the triangle in the lower-right corner representing discretion.

	$x^* = 0$			$x^* = 0.1$			$x^* = 0.2$		
	λ_x			λ_x			λ_x		
	0.05	0.5	1.0	0.05	0.5	1.0	0.05	0.5	1.0
50%	3	6	7	2	2	2	2	2	2
75%	6	15	20	3	3	4	3	3	4
90%	15	35	50	5	5	6	5	5	6
95%	30	>50	>50	9	8	10	9	8	10

Table 1: **Robustness with respect to the loss function parameters.** The table's entries represent the number of periods the central bank needs to commit for, on average, to achieve at least the percentage of the total gain from commitment displayed along the rows. The table's columns present results for different parameter configurations. Entries in bold refer to the benchmark calibration.

	$\sigma_u = 0.0065$			$\sigma_u = 0.013$			$\sigma_u = 0.026$		
	ρ_u			ρ_u			ρ_u		
	0	0.35	0.7	0	0.35	0.7	0	0.35	0.7
50%	2	2	2	2	2	2	2	2	2
75%	3	3	3	3	3	3	3	3	4
90%	5	5	6	5	6	6	6	6	8
95%	9	9	10	9	10	15	10	15	15

Table 2: **Robustness with respect to the distribution of the cost-push shock.** The table's entries represent the number of periods the central bank needs to commit for, on average, to achieve at least the percentage of the total gain from commitment displayed along the rows. The table's columns present results for different parameter configurations. Entries in bold refer to the benchmark calibration.