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ENDOGENOUS MONETARY COMMITMENT

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Endogenous Monetary Commitment¹

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Abstract

The paper examines whether central banks should be committed to achieving price stability (a low-inflation target), and how strong (explicit) their long-term monetary commitment should be. For that purpose we propose a game theoretic framework that enables us to model various *degrees of commitment*, as well as its *endogenous* determination. Our main policy contribution consists in showing that the socially optimal degree of long-term monetary commitment depends on: (i) the potential short-term cost in terms of reduced stabilization flexibility, (ii) the potential benefit in terms of better anchored expectations, (iii) the structure of the economy, (iv) agents' expectations formation, and (v) the degrees of the central bank's conservatism (strictness) and ambition. The latter point implies substitutability between explicit inflation targeting and central bank goal-independence, and offers a possible explanation for the fact that countries with originally low degrees of central bank goal-independence have tended to commit more explicitly to price stability (legislate a unitary or hierarchical mandate rather than a dual mandate).

Keywords: Commitment, price stability, endogenous timing, monetary policy mandate, explicit goals

JEL classification: E52, C72, E61

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1. INTRODUCTION

The literature has long asked whether monetary policy should adopt some kind of commitment, and if so, what the optimal degree of commitment should be. We attempt to contribute to this debate by formally examining the following question: ‘*How strongly, if at all, should monetary policy be committed to long-term price stability (a low-inflation target)?*’⁴

While the paper follows a similar agenda to the influential work by Rogoff (1985), we are interested in a commitment to a different target, and hence our commitment concept also differs. It relates to how *explicitly* monetary policy should commit in the long-run (LR), rather than how *strict (conservative)* the policy should be in terms of short-run (SR) inflation control. An advantage of such approach is the ability to derive the optimal degree (explicitness) of monetary commitment for any given level of monetary conservatism (strictness), and study the relationship between these two aspects monetary policy regimes.

To formalize the distinction between an explicit and a strict monetary regime (see eg Svensson (1999)), we propose a novel game theoretic framework that generalizes the timing of the players’ actions. In contrast to the standard repeated game setup, in which the players move simultaneously every period, the actions of the policymaker and the public only occur with a certain constant frequency. Importantly, these frequencies are allowed to *differ across players*, and be *endogenously* determined, in line with Tobin’s (1982) call.⁵

Specifically, denoting time by t , the public will move (update expectations) every $r_p \geq t$ periods. The central bank will choose the LR (steady-state) inflation level every $r_m \geq t$ periods, and the SR interest rate (that responds to shocks but produces inflation on average consistent with the steady-state level) every $r_c \leq r_m$.⁶

Throughout the paper, our attention is on the LR outcomes, and hence on the effect of r_m rather than r_c . The variable r_m expresses the *degree of LR monetary commitment*. It can also be interpreted as the *degree of explicitness*, with which LR price stability is stated in the central banking legislation/statutes. The underlying assumption behind this interpretation is that an explicit objective can be altered less frequently than an implicit one - for reputational, accountability, and legislative reasons.⁷

⁴In doing so long-term price stability will be broadly defined. We will *not* attempt to identify how exactly it should be specified - whether as a long-run inflation target for consumer prices, or whether it should also include asset prices to some extent. Real world inflation targeting countries have used the former specification (see for example Bernanke et al. (1999) or Blejer, et al. (2000)), but as the current financial crisis highlights the potential problems of ignoring asset prices, we will not restrict our analysis to a specific definition of price stability.

⁵Tobin in his Nobel lecture argued that: ‘*Some decisions by economic agents are reconsidered daily or hourly, while others are reviewed at intervals of a year or longer except when extraordinary events compel revisions. It would be desirable in principle to allow for differences among variables in frequencies of change and even to make these frequencies endogenous. But at present, models of such realism seem beyond the power of our analytical tools.*’

⁶Due to the broad definition of price stability, the term inflation will throughout the paper also have such a broad interpretation, ie it is not necessarily limited to consumer prices.

⁷The fact that we allow for various degrees of the target’s explicitness addresses the criticism of the existing literature on inflation targeting (see eg Gertler (2003)), which has grouped countries into

It will become apparent that our commitment concept can work in conjunction with the various commitment concepts or rules in the literature (eg the timeless perspective concept popularized by Woodford (1999)). This is because our commitment does not make any prescription on how actions should be taken at a certain move, ie it allows for any instrument of targeting rule, as well as for discretion.

To be able to highlight the intuition of the game theoretic analysis, we use a simple reduced-form macroeconomic model of the New Keynesian variety rather than a general equilibrium model. This simplicity enables us, in contrast to Rogoff (1985), to *analytically* derive the optimal degree (explicitness) of LR monetary commitment r_m^* , and show what factors and with what magnitude determine it.⁸

We demonstrate that this degree depends on: (i) the cost of explicit LR commitment, if any, in terms of reduced SR stabilization flexibility, (ii) the benefit of explicit commitment, if any, in terms of better anchored expectations, (iii) the slope of the aggregate supply relationship and the effectiveness of monetary policy, (iv) the way and frequency with which private agents' form expectations, and (v) various aspects of central bank goal-independence, namely how conservative (ie strict) and responsible in terms of output the central banker is.

This implies that the observed explicitness of the price stability objective is likely to differ across countries. Most interestingly, point (v) suggests *substitutability* between explicitly committing to price stability, strictly committing to it, and central bank goal-independence. In other words, countries lacking central bank goal-independence initially (in the late-1980s), and/or placing insufficient weight on inflation stabilization, have had a stronger incentive to make their price stability objectives more explicit in order to ensure their credibility.

In practice, such countries (eg New Zealand, the UK, or Sweden) have explicitly legislated a *unitary or hierarchical mandate*, in which price stability is the sole or primary objective. In contrast, the countries with an initially high degree of central bank goal-independence (most notably the US) have retained the original *dual mandate*.

The rest of the paper is structured as follows. Sections 2 and 3 present the macroeconomic model and the game theoretic framework respectively. Section 4 reports the results. Section 5 summarizes and concludes.

2. THE MODEL

In order to demonstrate the intuition in the most illustrative way and derive analytical solutions we will use a reduced-form New Keynesian model - a simplified version of Clarida et al. (1999). Since the micro-foundations of this framework are well-known (see eg Woodford (2003)), and their presentation would not add new insights, we do not reproduce them here.

two categories only: targeters and non-targeters. This has led to inconclusive and often contradictory empirical findings.

⁸Let us point out that our framework can be used to endogenously derive the optimal degree of commitment in any other micro or macroeconomic context, ie its applicability goes well beyond monetary policy.

2.1. Policy Preferences. The policymaker's single period utility function is as follows⁹

$$(1) \quad u_t = -\alpha(x_t - x^T)^2 - (\pi_t - \pi^O)^2 - c,$$

where $t \geq 0$ denotes (discrete or continuous) time, $\alpha > 0$ denotes (the reciprocal of) the degree of *conservatism (strictness)*, and c is the per-period *SR net-cost* of explicit LR commitment - defined below. The variable π^O denotes a low-inflation target that is consistent with LR price stability.¹⁰ The variable x^T denotes the output gap target, which we for generality do not restrict in any way, $x^T \in \mathbb{R}$.

The literature has identified several possible reasons for $x^T \neq 0$, such as (i) mis-measurement of potential output (eg Orphanides (2001)), (ii) market imperfections (eg Barro and Gordon (1983)), (iii) a shortcut for an asymmetry in the policy preferences (eg Cukierman and Gerlach (2003)), or (iv) political economy reasons on the fiscal policy side (eg Faust and Svensson (2001)).¹¹ In interpreting the results we will adopt justification (iv), and therefore refer to $-|x^T| \leq 0$ as the degree of the policymaker's *responsibility*, with $-|x^T| = 0$ representing a fully *responsible* policymaker.

2.2. Central Bank Goal-Independence. We demonstrate in Appendix A how the monetary policy preferences in (1) arise as some weighted average between the central bank's and the government's preferences - with the weight being the degree of *central bank goal-independence (gCBI)*.¹²

Specifically, it is shown that *gCBI* translates into two aspects of monetary policy preferences - both of which have been used in the literature. In particular, a greater degree of *gCBI* will make monetary policy: (i) more responsible, ie reduce the value of $|x^T|$, and (ii) more conservative (stricter), ie reduce the value of α .

2.3. Economy. Two equations - a Phillips curve and an IS curve - describe the economy, the former having the following form

$$(2) \quad \pi_t = \lambda x_t + e_t + u_t,$$

where the sensitivity parameter λ is positive, e denotes inflation expectations - like inflation broadly defined, x expresses the output gap, and u is an inflation shock with a zero mean. We do not specify a lag structure on the e variable since the timing of e in our analysis will be the focus of the game theoretic analysis. Nevertheless, private agents are assumed to be forward looking and act rationally, and the same is true for the policymaker. Both players are also aware of the rationality of the opponent, and have complete information about all features of the game.

The model further includes an IS curve describing the relationship between the policymaker's SR instrument, the interest rate, and output. Since our attention is on the steady-state outcomes, it will not be postulated here for parsimony. Instead, we will

⁹We will not consider discounting for parsimony - without affecting our conclusions.

¹⁰As explained in the introduction, both terms are broadly defined, ie not necessarily limited to consumer prices.

¹¹In justifications (i)-(iii) both $x^T > 0$ and $x^T < 0$ are possible, whereas in (iv) we would expect $x^T > 0$.

¹²This can be due to direct political pressure, and/or indirect spillovers between the two policies.

treat π directly as the choice variable of the policymaker (see Clarida et al. (1999) for more discussion of such shortcut).¹³

2.4. Short-Term Net-Cost of Long-Term Monetary Commitment. Due to our focus on LR commitment, we will not examine the stabilization of shocks directly in this paper - we do so indirectly through the variable c . In particular, we assume that the SR net-cost of explicit LR commitment c is some function of the degree of commitment r_m , ie

$$\frac{\partial c}{\partial r_m} \neq 0.$$

Academics and central bankers have identified one main potential *SR cost* of explicit LR commitment, namely a possible reduction in the policymaker's *flexibility* to stabilize the real economy, and hence a greater volatility of some real variables (eg Kohn (2003), Greenspan (2003), or Friedman (2004)). For example, Rudebusch and Walsh (1998) argued that:

'Inflation targeting, even without imposing a rigid rule, would unduly reduce the flexibility of the Fed to respond to new economic developments in an uncertain world.'

On the other hand, the potential *benefits* of an explicit LR commitment discussed include an improvement in accountability (eg King (1998), Walsh (2003)), reduction of the private sector's monitoring costs (eg Svensson (1997), Hughes Hallett and Libich (2007)), and most importantly the *anchoring effect* on expectations and wages (eg Gürkaynak, et al. (2005), Orphanides and Williams (2005), Bernanke (2003), or Goodfriend (2003)). To demonstrate, Mishkin (2004) argued that:

'The argument that inflation targeting might increase output fluctuations can be turned on its head. I would argue that inflation targeting can actually make it easier to reduce output fluctuations and probably has done so. First, the presence of an inflation target provides an effective nominal anchor...'

It is beyond the scope of the paper to formally model these possible SR influences of an explicit LR monetary commitment - that are, to a large extent, an empirical matter.¹⁴ Instead, we focus on the steady-state effect, and summarize all these SR effects by $c(r_m)$. If the unmodelled SR cost of LR commitment exceeds the unmodelled SR benefit we have $\frac{\partial c}{\partial r_m} > 0$, and if the reverse is true we have $\frac{\partial c}{\partial r_m} < 0$.

Let us note two issues. First, due to the LR focus $c(r_m)$ is assumed time-invariant, which can be interpreted as some average cost. Second, $c(r_m)$ is likely to be affected

¹³In the standard one-shot (one-period) game our model yields equilibrium outcomes (denoted by asterisk throughout) analogous to Clarida et al. (1999), namely

$$(3) \quad \pi_t^* = \pi^O + \frac{\alpha}{\lambda} x^T + \frac{\alpha}{\alpha + \lambda^2} u_t \quad \text{and} \quad x_t^* = -\frac{\lambda}{\alpha + \lambda^2} u_t,$$

to which we later relate our results.

¹⁴The stabilization flexibility issue is examined formally in Libich (2008a) in a richer model. In order to do so however, the paper truncated the steady-state action sets to two levels for each player (namely the π^O and π^* levels). In this paper we do not impose such a restriction to ensure that the derived optimal degree of commitment is robust to arbitrarily small steady-state surprises.

by the specification of the target in terms of its horizon. Throughout the paper, we assume the policymaker to be targeting LR price stability, ie have a low-inflation target for steady-state (average) inflation, which is the case of most inflation targeters from industrial countries (see Mishkin and Schmidt-Hebbel (2001)). If however the horizon is shorter - for example the two-year specification of the Bank of England - this is likely to increase both the inflexibility cost and the anchoring benefit.

A wide range of specifications of $c(r_m)$ come to mind as plausible. In order to illustrate the intuition we postulate the SR net-cost as a polynomial growth, namely

$$(4) \quad c(r_m) = \gamma(r_m)^k + \delta,$$

where $\gamma, \delta \in \mathbb{R}$ and $k \in (0, \infty)$. This nests both *concave* and *convex* cost growth as well as the most natural two cases: *linear* with $k = 1$ and *quadratic* with $k = 2$. Nevertheless, in Section 4.3 we examine a general $c(r_m)$.

3. TIMING OF MOVES

As specified in the introduction, the public is able to reconsider expectations every $r_p \geq t$ periods. Implicitly, this is in order to reduce various costs related to ‘*changing wage contracts and information-gathering, decision making, negotiation and communication*’ (Mankiw and Reis (2002)).¹⁵

The policymaker’s actions are broken into two components - the steady-state part (ie the LR stance) and the stabilization part. The bank is able to alter the LR stance (steady-state inflation) level every $r_m \geq t$ periods, and the SR interest rate (in a way on average consistent with the LR inflation level) at least as frequently, namely every $r_c \leq r_m$ periods.

Nevertheless, since we focus on the steady-state outcomes these SR policy moves, as well as shocks, become *redundant*. Intuitively, the stabilization of shocks does not effect steady-state output and inflation, and hence steady-state expectations, since the shocks have a zero mean, see (3).¹⁶ Therefore, we will not examine below the SR stabilization moves, and interpret the variable e from now on as steady-state expectations.

To focus on the policy commitment, we will restrict our attention to the case of interest

$$(5) \quad r_m \geq r_p,$$

and later show that allowing for $r_m < r_p$ does not alter any of our results.

Definition 1. *The variable r_m expresses the **degree of long-term commitment** of monetary policy, whereby we will distinguish three main cases: (i) **full-commitment**, $r_m = \infty$, (ii) **partial-commitment**, $r_m \in (r_p, \infty)$, and (iii) **no-commitment**, $r_m = r_p$.¹⁷ The ratio $\frac{r_m}{r_p}$ will be referred to as the degree of **relative commitment**.*

¹⁵Libich (2008b) models this cost and the endogeneity of r_p formally, but since our focus is on the optimal setting of r_m , we will not do so here.

¹⁶While the variable r_c does not affect steady-state outcomes, it will affect the SR stabilization effectiveness of monetary policy. Intuitively, the lower the r_c , the more frequently the central bank can respond to the shock in real time, and the more effective monetary policy becomes in smoothing fluctuations.

¹⁷The no-commitment case (iii) is the lowest considered level of r_m . Therefore, if we also allow for $0 \leq r_m < r_p$, this case is re-defined as $r_m = 0$.

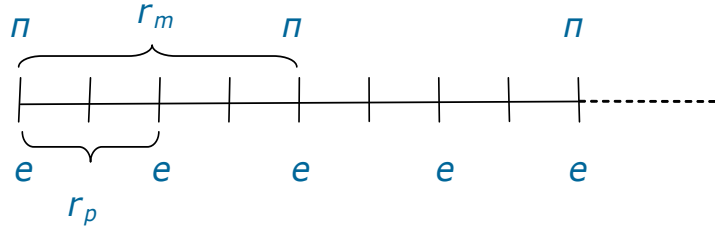


FIGURE 1. An example of the timing with $r_m = 4, r_p = 2$ showing two repetitions of the dynamic stage game (the SR policy instrument adjustable every period has been left out for clarity).

Let us impose two assumptions to make the analysis more illustrative. First, to restrict the amount of asynchrony in the game, and make the game closer to the standard repeated game, we assume

$$(6) \quad r_m = nr_p \text{ where } n \in \mathbb{N}.$$

This implies that the players make a simultaneous move every r_m periods, and the public can also move in between these moves.¹⁸ It further implies that the *dynamic stage game* has length of r_m periods, and is regularly repeated. This is in contrast to the standard *static game* of length t , ie one period only.

Second, to keep the focus on the optimal (endogenous) degree of policy commitment r_m , we will treat r_p as exogenous in this paper. Let us now summarize the timing of LR moves including (5) and (6) - an example of a time line is in Figure 1:

- (1) At the beginning of the game, in period $t = 0$, the policymaker chooses r_m , observing r_p .
- (2) Observing r_m , the public and the policymaker make a simultaneous move of their choice variables e and π in period $t = 0$.
- (3) The public and the policymaker then move every r_p and r_m periods respectively, observing all moves made in past periods (ie a game of perfect monitoring).
- (4) The payoffs accrue every period.

4. RESULTS

In line with the backwards induction solution of the game, this section first examines the effect of explicit commitment on the steady-state inflation outcome, and then, taking it into account, investigates the optimal degree of commitment. In doing so it utilizes the polynomial growth specification of c postulated in (4). It then discusses the results under a general SR net-cost.

¹⁸Libich and Stehlik (2008) formally demonstrate, in a general setting, that this case is representative of the more asynchronous cases with $n \notin \mathbb{N}$.

4.1. Effect of Long-Term Monetary Commitment on Policy Performance. Our first result shows how explicit LR commitment alters the incentives of the central bank, and hence improves the steady-state inflation outcome.

Proposition 1. *A stronger (more explicit) LR monetary commitment reduces the inflation/deflation bias, if any. It is however the degree of **relative commitment**, rather than its absolute level, that has an effect.*

Proof. Restricting our attention to Markov perfect equilibria we can focus solely on the r_m period dynamic stage game. At its beginning, in time $t = 0$, the players move simultaneously, and then the public gets a chance to reconsider its action every r_p , observing the policymaker's initial move. This dynamic stage game finishes just before the players make their second simultaneous moves.

Solving by backwards induction, we know that once the public gets to respond to the policymakers initial move in period r_p , steady-state expectations will be set rationally at that very same level, and will remain at that level for the rest of the dynamic stage game, ie $e_{t \in (0, r_m)}^* = \pi_0$.

It therefore follows, in combination with (2), that $x_t = 0, \forall t \in [r_p, r_m]$. Put differently, the only period of time in which there *may* be an inflation/deflation surprise is the initial $t \in [0, r_p)$. Substituting this information and (2) into (1), the policymaker's utility over the dynamic stage game (r_m periods) can be written as

$$(7) \quad u = -r_p \alpha \left(\frac{(\pi - e)}{\lambda} - x^T \right)^2 - (r_m - r_p) \alpha (-x^T)^2 - r_m (\pi - \pi^T)^2 - r_m c(r_m).$$

Note that unlike the first two components, the last two feature r_m . This is because unlike the potential output benefit of a surprise, the costs of deviating from the price stability target and of explicit commitment accrue for the whole dynamic stage game. Put differently, π is constant (ie not a function of time) on the interval $(0, r_m)$, whereas e is constant on the intervals $(0, r_p)$ and (r_p, r_m) .

Moving backwards, the policymaker takes this into account when making his initial decision. Differentiate (7) with respect to inflation and rearrange to obtain

$$\frac{\partial u}{\partial \pi} = -\frac{2\alpha}{\lambda} \left(\frac{(\pi - e)}{\lambda} - x^T \right) r_p - 2(\pi - \pi^T) r_m.$$

Under rational expectations and complete information we will have no surprise even in the initial period, $e_0^* = \pi_0$, ie steady-state output is always on potential, $x_t^* = 0, \forall t$. Using this and rearranging yields

$$(8) \quad \pi^* = \pi^O + \frac{\alpha x^T}{\lambda} \frac{r_p}{r_m}.$$

The expression shows that the inflation/deflation bias, $|\pi^* - \pi^O| \neq 0$, exists for all $x^T \neq 0$. Specifically, under $x^T > 0$ we have an inflation bias, and under $x^T < 0$ there is a deflation bias. The fact that both biases are, for all parameter values, a decreasing function of the relative commitment of monetary policy, $\frac{r_m}{r_p}$, completes the proof.¹⁹ \square

¹⁹Note that under the standard repeated game specification, $r_p = r_m = 1$, the expression in (8) becomes $\pi^* = \pi^O + \frac{\alpha x^T}{\lambda}$, which is the conventional steady-state value of the New Keynesian model under discretion, see (3).

Intuitively, the potential biases are - for a given strictness α - reduced due to the smaller temptation to surprise inflate/deflate arising from a more explicit LR commitment. This happens since the public now has a better chance to punish the policymaker for such behaviour in comparison to a standard simultaneously repeated game. Importantly, note that this punishment is the public's optimal choice, not an arbitrary rule (trigger strategy) of the Barro-Gordon type.

Also note that the biases, if any, are increasing in α and $|x^T|$. Both parameters are features of $gCBI$ (see Appendix A), which therefore implies that a higher degree of $gCBI$ reduces the average level of inflation through these two channels. This is in line with empirical findings reported by a number of papers, eg Grilli, et al. (1991), Cukierman, et al. (1992), Alesina and Summers (1993), Eijffinger and Schaling (1993), Briault, et al. (1997), and Eijffinger, et al. (1998).²⁰

4.2. The Optimal Degree of Long-Term Commitment. The next proposition reports the main result of our analysis, answering the question posed in the introduction: How strongly, if at all, should monetary policy be committed to LR price stability (a low-inflation target)?

Proposition 2. *Depending on the SR net-cost $c(r_m)$, in equilibrium we may observe full-commitment, no-commitment, or partial-commitment. In the latter case the **optimal degree (explicitness) of long-term monetary commitment**, r_m^* , is decreasing in:*

- (i) the marginal SR net-cost of explicit LR commitment γ ,
- (ii) the inflation-output sensitivity λ ,
- (iii) the frequency of updating expectations $\frac{1}{r_p}$,
- (iv) the degree of policy responsibility $-|x^T|$, and
- (v) policy conservatism/strictness $\frac{1}{\alpha}$.

The relationships in (iv)-(v) imply that an explicit LR commitment is a substitute for central bank goal-independence in reducing a potential inflation/deflation bias.

Proof. All calculations of the proof of Proposition 1, derived under exogenous r_m , still apply under its endogeneity. Now move backwards and consider the optimal choice of r_m . In contrast to (7) where the policymaker's utility is for the whole dynamic stage game (r_m periods), let us write it in single period terms. Using (7) and $x_t^* = 0, \forall t$ we have

$$u = -\alpha(-x^T)^2 - \left(\pi^O + \frac{\alpha x^T}{\lambda} \frac{r_p}{r_m} - \pi^O \right)^2 - c(r_m).$$

Differentiating with respect to the degree of LR commitment we get

$$(9) \quad \frac{\partial u}{\partial r_m} = \frac{2 \left(\frac{\alpha x^T}{\lambda} r_p \right)^2}{r_m^3} - \frac{\partial c}{\partial r_m}.$$

The fact that the first fraction on the right hand side is always non-negative implies that if $\frac{\partial c}{\partial r_m} < 0$ (ie $\gamma < 0$), then $\frac{\partial u}{\partial r_m} > 0$. From this it follows that in such case the policymaker selects full-commitment, $r_m^* = \infty$.

²⁰It should be noted that concerns have been expressed over some of these findings and approaches, e.g. Forder (2000).

Let us now consider the $\frac{\partial c}{\partial r_m} > 0$ (ie $\gamma > 0$) case. Setting (9) equal to zero and rearranging yields

$$(10) \quad \bar{r}_m = \sqrt[k+2]{\frac{2 \left(\frac{\alpha x^T}{\lambda} r_p \right)^2}{\gamma k}}.$$

If this *unique maximum* \bar{r}_m is attained for $r_m \leq r_p$ then the no-commitment outcome obtains as the policymaker will choose this lower bound $r_m^* = r_p$ (see Definition 1). If however $\bar{r}_m > r_p$ then the partial-commitment scenario obtains, and $r_m^* = \bar{r}_m$.²¹ Summarizing these results the equilibrium degree of LR monetary policy commitment can be written as

$$(11) \quad r_m^* = \begin{cases} \infty & \text{(full-commitment)} & \text{if } \gamma < 0, \\ \sqrt[k+2]{\frac{2 \left(\frac{\alpha x^T}{\lambda} r_p \right)^2}{\gamma k}} & \text{(partial-commitment)} & \text{if } \gamma \in (0, \bar{\gamma}), \\ r_p & \text{(no-commitment)} & \text{if } \gamma > \bar{\gamma} > 0, \end{cases}$$

where

$$(12) \quad \bar{\gamma} = \frac{2 \left(\frac{\alpha x^T}{\lambda} \right)^2}{k r_p^k},$$

is the threshold value that solves $\bar{r}_m = r_p$. Inspection of (11), in combination with Definition 1, proves the claims. \square

Figure 2 offers a graphical example of the results in (11). Intuitively, if the SR net-cost of explicit LR commitment is non-positive, $\gamma < 0$ (ie if the potential cost of reduced flexibility is more than outweighed by the benefit of anchored expectations - see Mishkin's (2004) quote above), then explicit LR commitment is a free lunch as there is no SR tradeoff. Obviously, the policymaker commits as strongly as possible in such case. In contrast, if the SR net-cost of explicit commitment is positive and too large, $\gamma > \bar{\gamma} > 0$, then the policymaker will not commit at all. Finally, if the cost is positive but within a certain range, $\gamma \in (0, \bar{\gamma})$, then the policymaker does commit, but only to some extent, which reflects the associated tradeoff.

The above analysis implies that allowing for $r_m < r_p$ will make no qualitative or quantitative difference. The only change in (11) will be the re-specification of the no-commitment outcome from $r_m = r_p$ to $r_m = 0$, see Definition 1. Intuitively, under $r_m < r_p$ both an output gain from an inflation surprise, and the costs of inflation would last r_p periods, ie all the elements of (7) would feature r_p instead of r_m . Therefore, the equilibrium inflation in (8) would not be a function of the degree of LR commitment. In such case, there is no point for the policymaker to ever select values of the interval $r_m \in (0, r_p]$. If the SR net-cost of LR commitment is sufficiently large, $\gamma > \bar{\gamma} > 0$, then the policymaker will select the lowest possible (no-commitment) value, which is now $r_m = 0$.

The last column on the right hand side of (11) in combination with (12) implies that the more goal-independent (ie conservative/responsible) the central banker is, the

²¹Note that due to the technical restriction in (6), r_m^* must be rounded to the nearest r_m satisfying (6).

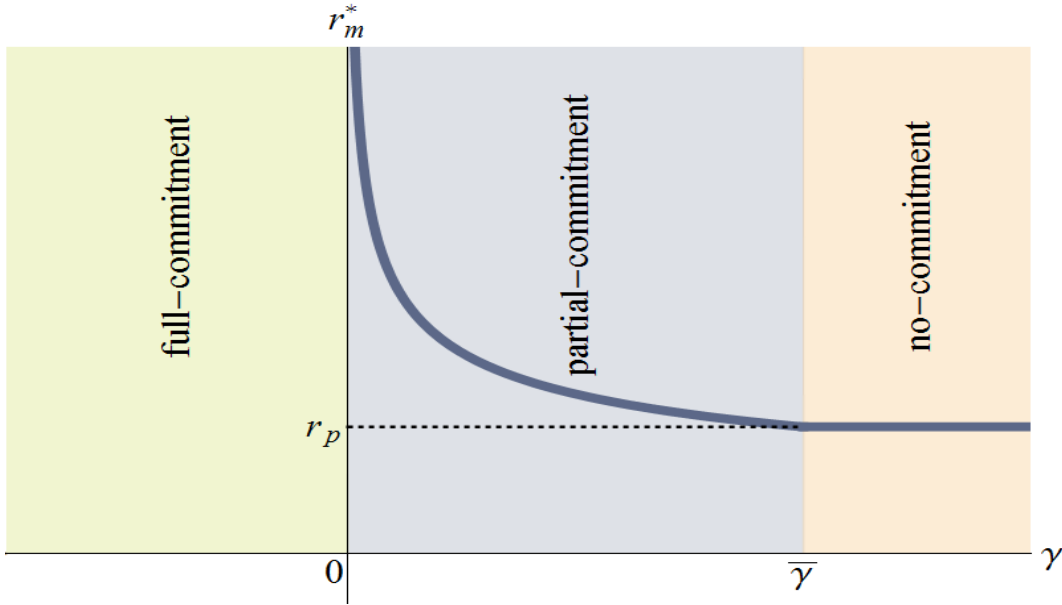


FIGURE 2. A graphical example of the optimal (endogenously determined) degree of long-term monetary commitment, r_m^* , as a function of its marginal short-term net-cost γ - the plot of (11).

smaller the parameter space under which he commits. The first column on the right hand side of (11) implies that even if he does commit, his LR commitment will be less explicit than commitment of central banks with an initially lower degree of $gCBI$.

There exists some empirical evidence of this substitutability between an explicit monetary commitment - proxied by the degree of accountability - and central bank (goal) independence, see eg Briault, et al. (1997), Haan, et al. (1999) and Sousa (2002). Using differently constructed indices for different periods these papers report a negative correlation between (goal) independence and accountability - for more see Libich (2008c) in which this relationship is examined in detail.²²

4.3. General SR Net-Cost $c(r_m)$. The results of the previous two sections have been derived under the polynomial growth specification of $c(r_m)$ postulated in (4). While it is sufficiently general nesting among other linear, convex, and concave cases, let us in this section discuss the results for a more general case.

Proposition 3. *Assume a general SR net-cost function $c(r_m)$ that is continuous and bounded on $(0, \infty)$. While an equilibrium degree of LR commitment always exists, it may not be unique in the partial-commitment case in some specifications.*

Proof. Let us first note that the full-commitment case can still obtain, which follows from the proof of Proposition 2. Since the first fraction on the right hand side of (9)

²²It should however be noted that using indices of these institutional variables is not without potential empirical issues such as the subjectivity bias and a small sample problem. The findings therefore need to be taken as indicative rather than conclusive.

is non-negative for all parameter values, under $\frac{\partial c}{\partial r_m} \leq 0$ we always have $\frac{\partial u}{\partial r_m} > 0$, and hence $r_m^* = \infty$.

In the $\frac{\partial c}{\partial r_m} > \varepsilon > 0$ case (where ε can be arbitrarily small) there exists $\bar{r}_m \in (0, \infty)$ such that $u(\bar{r}_m) \geq u(r_m), \forall r_m$. This is because: (i) $\frac{\partial u}{\partial r_m} > 0$ for small r_m since the first fraction in (9) approaches infinity as r_m tends to zero, and (ii) $\frac{\partial u}{\partial r_m} < 0$ for large r_m since the first fraction in (9) vanishes as r_m approaches ∞ . Therefore, there must exist a maximum of u between 0 and ∞ . Nevertheless, points (i) and (ii) imply that without further restrictions on the function $c(r_m)$ there may exist multiple local maxima on this interval. \square

Various special cases can be considered. For example, it is straightforward to show that if the SR net-cost is positive and strictly convex, $\frac{\partial^2 c}{\partial r_m^2} > 0$, then the policymaker's utility has a unique maximum $\bar{r}_m \in (0, \infty)$, and hence there is a unique optimal degree of LR commitment. In the case of multiple local maxima the optimal degree of LR commitment will be some global maximum, or, if it is attained for $r_m \leq r_p$, then we have the no-commitment outcome, $r_m^* = r_p$.

5. SUMMARY AND CONCLUSIONS

The paper follows in the footsteps of Rogoff (1985) trying to establish whether, and to what extent, monetary policy should be committed. As we are interested in a commitment to (broadly defined) long-term price stability, our game theoretic framework proposes a new concept of commitment.

Specifically, the framework generalizes the timing of the players' moves and allows for the fact that players do not necessarily move every period, and not necessarily in a simultaneous fashion. Naturally, the longer a player is unable to reconsider his previous action, ie the lower the frequency of moves, the stronger the player's commitment.

This form of commitment has three main advantages over the standard game theoretic commitment concept - Stackelberg leadership. First, it allows us to study *concurrent commitment*, whereby all players can be committed at the same time. Second, it offers a way to model *partial commitment*, in which the players can be committed only with a certain degree (that can differ across players). Third, it enables us to consider *endogenous commitment*, ie one optimally selected by the players. Furthermore, our commitment is compatible with the popular macroeconomic concept of commitment - the timeless perspective targeting rule - popularized by Woodford (1999). This is because it does not impose a particular way in which the decisions need to be made.

Using a canonical reduced-form New Keynesian macroeconomic model has enabled us to show circumstances under which the monetary policymaker should and should not commit. In addition, and unlike Rogoff (1985), we have been able to identify several determinants of the *optimal degree (explicitness) of long-term monetary commitment*, showing their direction and magnitude.²³

²³Rogoff examined the case in which the SR net-cost of commitment is positive due to loss of stabilization flexibility (analogous to our $\frac{\partial c(r_m)}{\partial r_m} > 0$). This was because his commitment concept related to the strictness/conservatism of the policymaker. In a more complex macroeconomic setting, he was able to prove that (i) the policymaker will commit, and that (ii) his commitment will be partial (analogous

In particular, this degree is a function of the structure of the economy, the frequency with which agents update expectations, the potential SR costs and benefits of explicit long-term commitment (in terms of stabilization inflexibility and anchoring expectations respectively), and various aspects related to central bank goal-independence.

The latter implies substitutability between explicit long-term commitment and central bank goal-independence, and offers a possible explanation for why it was primarily countries with low degree of central bank goal-independence that have tended to commit more explicitly to price stability, ie legislate a unitary or hierarchical mandate as opposed to the dual mandate, and a numerical inflation objective.

Further research is required to shed light on a number of related issues. Most importantly, the exact specification of long-term price stability is open for further investigation. For the past two decades most industrial countries have specified it as a low-inflation target for average consumer price inflation, with notable success. But this conventional practice - and the potential need to perhaps respond to various asset prices under some circumstances - may have to be re-examined carefully in light of the current financial turbulences.

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to our $r_m^* \in (r_p, \infty)$). However, an optimal degree of commitment and its various determinants could not be derived in his setup, which is why we opted for a simpler reduced-form model.

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APPENDIX A. MODELING CENTRAL BANK GOAL-INDEPENDENCE

Consider a central bank, player b , and a government, player g , with the following period utility functions

$$(13) \quad U_i = -\alpha_i(x_t - x_i^T)^2 - (\pi_t - \pi^O)^2 - c,$$

where $i \in \{b, g\}$. The existing literature on central bank independence implies the following (likely) relationships due to political economy reasons. An independent central banker is, in comparison to the government: (i) more conservative (see eg Rogoff (1985)),

and (ii) more responsible (see eg Faust and Svensson (2001)).²⁴ Formally, this means:

$$0 < \alpha^b < \alpha^g \quad \text{and} \quad 0 \leq |x_b^T| < |x_g^T|.$$

This can be the case due to the government's desire to get re-elected (and the existence of lobby groups, myopia, unionization, naïve voters etc), or due to pre-existing structural fiscal settings that require deficit financing such as unaffordable welfare/health/pension schemes, or high debt servicing.

The monetary policy preferences then depend on who, and to what extent, is in charge of policy decisions. This is arguably a function of the *degree of gCBI* (note that since both aspects relate to the policy preferences, this refers to *goal*-independence, not *instrument*-independence; for this important distinction see DeBelle and Fischer (1994)).

Let us assume *gCBI* to be an index, such as $gCBI \in [0, 1]$, where $gCBI = 1$ denotes full goal-independence (the central bank is solely in charge), $gCBI = 0$ denotes no goal-independence (the government is solely in charge), and $gCBI \in (0, 1)$ denotes partial goal-independence (they both have some influence).

We can then model the resulting monetary policy parameters, α and $|x^T|$, as a weighted average between the central bankers and the government's value, namely

$$\alpha = gCBI\alpha^b + (1 - gCBI)\alpha^g \quad \text{and} \quad |x^T| = gCBI|x_b^T| + (1 - gCBI)|x_g^T|.$$

Rearranging yields

$$\alpha = \alpha^g - gCBI(\alpha^g - \alpha^b) \quad \text{and} \quad |x^T| = |x_g^T| - gCBI(|x_g^T| - |x_b^T|),$$

which implies that the two monetary policy preference parameters in (1) are decreasing in *gCBI*.

²⁴For simplicity, we assume the remaining policy parameters in (13), π^O and c , to be the same for the two policymakers.