Monetary Policy Committees and Interest Rate Smoothing*

Carlos Montoro†
LSE

December 21, 2006

Abstract

We extend the New Keynesian Monetary Policy literature relaxing the assumption that the decisions are taken by a single policymaker, considering instead that monetary policy decisions are taken collectively in a committee. We introduce a Monetary Policy Committee (MPC), whose members have different preferences between output and inflation variability and have to vote on the level of the interest rate.

This paper helps to explain interest rate smoothing from a political economy point of view, in which MPC members face a bargaining problem on the level of the interest rate. In this framework, the interest rate is a non-linear reaction function on the lagged interest rate and the expected inflation. This result comes from a political equilibrium in which there is a strategic behaviour of the agenda setter with respect to the rest MPC's members.

Our approach can also reproduce both features documented by the empirical evidence on interest rate smoothing: a) the modest response of the interest rate to inflation. and output gap; and. b) the dependence on lagged interest rate. Features that are difficult to reproduce alltogether in standard New Keynesian models. It also provides a theoretical framework on how disagreement among policymakers can slow down the adjustment on interest rates and on "menu costs" in interest rate decisions.

JEL Classification: E43, E52, D72

Keywords: Monetary Policy Committees , Interest Rate Smoothing, New Keynesian Economics, Political Economy

---

*I would like to thank Chris Pissarides, Gianluca Benigno, Wouter Denhaan and participants at the Macroeconomics Student Seminar at LSE and the BCRP for their comments and help. The views expressed herein are those of the author and do not necessarily reflect those of the Banco Central de Reserva del Perú. Any errors are my own responsibility.

†Banco Central de Reserva del Perú and LSE. E-mail: c.h.montoro-llamosas@lse.ac.uk

1 Introduction

An existing puzzle in the optimal monetary policy literature is why, in practice, central banks change the interest rate less often than the theory predicts. This feature is called interest rate smoothing and it is well documented for many central banks[1]. For instance, Lowes and Ellis (1997), in a study for different countries, listed as the common patterns in official interest rates set by central banks: they change rarely, they are made in a sequence of steps in the same direction, and they are left unchanged for relatively long periods of time before moving in the opposite direction.

Regarding interest rates reaction functions, Taylor (1993) proposed a policy rule for the interest rate, modeled by a linear combination of output gap and inflation, as a rough description of the monetary policy for the USA during the chairmanship of Alan Greenspan. On the other hand, some authors, such as Judd and Rudebusch (1998), Clarida and others (1999) and Orphanides (2003), have pointed out that, empirically, the monetary policy rule that best captures the data has the following form:

$$i_t = (1-\rho)\left(\bar{i} + \phi_\pi \pi_t + \phi_x x_t\right) + \rho i_{t-1} + \epsilon_t$$

where $\bar{i}$ is a constant, interpretable as the steady state nominal interest rate. π_t and x_t are the inflation and output gap, respectively. $\rho \in [0,1]$ is a parameter that reflects the degree of lagged dependence in the interest rate. In these estimations, interest rate smoothing is present in two ways. Firstly, the estimated coefficients ϕ_π and ϕ_x are typically smaller than the optimal rule would suggest; and secondly, the partial adjustment to movements in π_t and x_t is reflected by the presence of i_{t-1}. In other words, the empirical form of the official interest rate is a weighted average of some desired value that depends on the state of the economy and on the lagged interest rate. Also, the estimates of ρ are on the order of 0.7 or 0.9 for quarterly data, which indicates a very slow adjustment in practice.

The existing literature that explains interest rate smoothing has three branches. The first explanation relies on the effects of uncertainty on the policy decisions. Uncertainty about the structure and the state of the economy can lead to lower response of the interest rate to shocks. An early work by William Brainard (1967) showed that uncertainty on the parameters of the economy's equations reduces policy activism, which means a more cautious response to shocks. In more recent papers the actions taken by policymakers are those with outcomes that they are confident about. For that reason, they delay action until they collect enough information about a shock. On the other hand, Clarida and others (1999) argue that model uncertainty may help to explain the fairly low variability of interest rate in the data. However, they consider that it does not capture the feature of strong lagged dependence in the interest rate.

A second explanation, given by Rotemberg and Woodford (1997) can help to explain the lagged dependence feature. Their argument is based on the effects of the short-term interest rates on the aggregate demand through the effect on long-term interest rates. Being long-term interest rates those that affect aggregate demand. Lagged dependence in short-term interest rates allows the central bank to manipulate long-term rates with more modest movements in the short-term rate than otherwise needed. Therefore, the central bank may care about avoiding excessive volatility in the short-term interest rate in pursuing its stabilisation goal. In the same context, Goodhart (1999) and Woodford (1999) argue that inertial monetary

[1] See Sack and Wieland (2000) for a discussion on interest rate smoothing.

policy makes the future path of short-term interest rates more predictable and increases policy effectiveness. These authors provide a reasonable explanation for lagged dependence on interest rate. However, it is still to be seen if this story can account as well for the empirically modest response of the short-term rate to inflation and output gap.

A third explanation is based on financial markets stability. It considers that large movements in the interest rate are avoided because they destabilise financial markets (Goodfriend 1991). Therefore, by changing policy rates gradually central banks can reduce the likelihood that a change in policy triggers excessive reactions. In a forward-looking environment with rational expectations, concern about the variance of the interest rate induces interest rate smoothing.

Among other explanations, Clarida and others (1999) argue that disagreement among policy makers is another explanation for slow adjustment rates. However, they consider that this story has not yet been well developed and this is where we want to provide an alternative framework. The current literature on interest rate smoothing, as well as most of the literature on optimal monetary policy, relies on the assumption that policy decisions are taken by a single policy maker that maximises some measure of social welfare. However, in real life this is not the case, because in practice monetary policy decisions are taken mostly collectively, in committees.

This paper intends to explain interest rate smoothing giving more structure to the decision-making process, in which policy decisions are made through a Monetary Policy Committee (MPC), whose members have different preferences. This chapter helps to explain interest rate smoothing from a political economy point of view, in which members of an MPC have a bargaining problem on the interest rate. In this framework, the political equilibrium interest rate is a function of the lagged interest rate and expected inflation. We have found that when the difference between expected inflation and its long run value is relatively high, the interest rate reacts as the optimal monetary policy predicts. However, the smaller the difference, the interest rate reacts less than the optimal or does not react at all.

The literature on Monetary Policy Committees is fairly new and it has focused mainly on how the structure of an MPC can affect the policy decisions. It has two branches, the first branch considers the case of members with different preferences and how this affects expectations formation and policy outcomes[2]. The second branch of the literature of MPCs has focused on the differences in skills among members and how it interacts with different voting rules[3].

Considering the existing literature on MPCs, this research is closer to Riboni's (2003). In Riboni's model, a committee with heterogeneous preferences can work as a substitute of a commitment technology when there is dynamic bargaining among members. In this model, the member in charge of setting the agenda to vote is less willing to deviate from the optimal time-consistent inflation level, because it will reduce her negotiation power next period. This

[2] Aksoy, De Grauwe and Dewachter (2002) and Von Hagen and Süppel (1994) have worked on the case of a monetary union in which, because of nationality, the members have different goals regarding the level of inflation and output gap. Riboni (2003) and Silbert (2004) show that in a committee with members with different inflation targets, the policymaker's capacity to bring about surprise inflation is reduced. Waller (1989) showed that assigning the task of conducting monetary policy to a committee with staggered membership enhances continuity in expectations formation and reduces inflation.

[3] Gersbach and Hahn (2001) showed that less skilled policymakers in general want to abstain from voting. If a voting record is published, they try to mimic their more skilful colleagues; therefore voting records can be undesirable. Karotkin (1996) analysed the performance of different voting rules in committees in which individual skills differ. Berk and Bierut (2003) introduce the effects of learning on the performance of voting rules. In a new strand of the literature, Gerlach-Kristen (2003b, 2004, 2006a) studies the effects of uncertainty about the state of the economy when the members have the same skills.

model has a voting mechanism similar to ours, in which there exists an agenda-setter that every period submits a policy to vote, but it differs from us in the type of heterogeneity. Riboni works on heterogeneity in inflation goals, whilst we work on heterogeneity in the relative weights in the preferences between output gap and inflation among members. Also, Riboni's model is dynamic from a political economy point of view, but its economic structure is static since there are no shocks that affect the economy differently every period. Therefore, it would be difficult to disentangle whether the results of a reduction in inflation come from an effective reduction of the time-inconsistency problem or just that the policy decision is sluggish in equilibrium, that is interest rate smoothing.

Our model relaxes the traditional assumption that monetary policy decisions are made by a single policy maker and introduces strategic decisions in an MPC with heterogeneous preferences. This approach is new in the interest rate smoothing literature and helps to explain this problem through a different channel, from a political economy point of view. It also provides a theoretical framework on how disagreement among policymakers can slow the adjustment on interest rates and on adjustment costs or "menu costs" in interest rate decisions.

Moreover, this model can also reproduce altogether both features of interest rate smoothing, which are the modest response of the interest rate to inflation and output gap and the lagged dependence. These are features that other models fail to reproduce at the same time. In our model, when lagged interest rates are close to the current period optimum, they do not change because it is costly to have an agreement among members. Only when the size of the shocks is such that it is sub-optimal to keep the interest rate, it will be changed. However, in other cases the change will be below the optimal, in the exact size necessary to obtain a coalition for passing the new interest rate, or equal to the optimal, when the expected inflation is high enough that make the status quo sub-optimal.

The structure of this chapter is as follows. The second section presents the benchmark model in the spirit of the New Keynesian monetary economics. The third section introduces the policy decision problem in an MPC with members with heterogeneous preferences and solves the political economy problem. The fourth section presents some stylised facts on the voting process for some MPCs in relation with its effects on interest rate adjustments. The last section concludes.

2 Benchmark Model

During the past years, it has been a broad use of theoretical models of monetary policy based on the techniques of general equilibrium theory. On this literature, the New Keynesian approach departs from the real business cycle theory with the explicit incorporation of nominal price rigidities. These models are fairly simple and have some qualitative core features that are suitable to evaluate monetary policy. In order of being able to compare our results with the existing literature, we depart from a baseline framework for the analysis of monetary policy based on a New Keynesian perspective. In this section we develop our benchmark model with a single policymaker, which follows closely Clarida, Gali and Gertler (1999) and Woodford (2003). In the next section we will analyse the policy problem under a Monetary Policy Committee with members with heterogeneous preferences in which the interest rate is determined in a political equilibrium.

We assume a closed economy; all the variables are expressed as log deviations from the steady state. The economic equilibrium in this economy is given by the intersection of the aggregate demand (AD) and the aggregate supply (AS). As in any standard macroeconomic model, the aggregate demand is determined by "IS" and "LM" equilibrium. In our model the "IS" relates the output gap inversely to the real interest rate and the "LM" is represented by the nominal interest rate chosen by the central bank as policy instrument. The aggregate supply (AS) is represented by the Phillips curve, which relates the inflation positively to the output gap. These two equations can be obtained from a standard general equilibrium model with price frictions. We can summarise the economy by two equations, the "IS" and the "AS", that have the following form[4]:

$$x_t = -\varphi \left[i_t - E_t\pi_{t+1} - r_t^n\right] + E_t x_{t+1} \tag{IS}$$

$$\pi_t = \lambda x_t + \beta E_t \pi_{t+1} + u_t \tag{AS}$$

where π_t and x_t are the period t inflation and output gap i_t and r_t^n are the nominal and the natural interest rate [5]. All the variables are expressed as log-deviations from their long-run level. According to the IS, lower real interest rate and higher future output increases current output. On the other hand, in the Phillips curve the output gap variable captures movements in marginal costs associated with changes in excess demand and the shock u_t captures anything else that might affect expected marginal costs. u_t is usually named as a "cost push" shock and it is related to supply shocks that do not affect the potential output. Moreover, u_t gives a trade-off between inflation and output gap stabilisation. We assume the disturbance term u_t follow:

$$u_t = \rho u_{t-1} + \varepsilon_t$$

where $0 \leq \rho \leq 1$ and ε_t is an i.i.d. random variables with zero mean and variance σ_u^2.

We assume, following much of the literature on optimal monetary policy, that the policy objective is a quadratic function of the target variables x_t and π_t and takes the form of:

$$W = -\frac{1}{2} E_t \left\{ \sum_{s=0}^{\infty} \beta^s \left[\alpha x_{t+s}^2 + \pi_{t+s}^2\right] \right\} \tag{1}$$

where the parameter α is the relative weight on output deviations. This loss function takes potential output and zero inflation rate as the targets for the deviations of output and inflation from the deterministic long-run trend. As we discuss in Chapter 3, during the past years have been some works on deriving the policy problem from first principles. Rotemberg and Woodford (1997) and Woodford (2003) show that an objective function of the form of (1) can be obtained as a quadratic approximation of the utility-based welfare[6]. Though, this works rely on some assumptions, like representative agent economy, which can be a restrictive representation of how the preferences over inflation and output gap really are. However, they are useful to establish the policy problem from the welfare criterion. Moreover, Woodford (2003) shows

[4]The IS equation can obtained from log-linearising the Euler equation from the household's optimal consumption decisions. The Phillips curve can be obtained from aggregating the log-linear approximation of the individual firm pricing decisions. The price friction in this model comes from staggered nominal price setting in the essence Taylor (1979). The most common formulation of staggered price setting in the literature comes from Calvo (1983), in which he assumes that in any given period a firm has fixed probability of keeping its price fixed during the period.

[5]The natural interest rate is defined as the equilibrium real rate of return in the case of fully flexible prices.

[6]In these works the output gap is included in the welfare function, because the volatility of income reduces welfare. On the other hand, inflation is included because, as firms face uncertainty on the time when they are going to be able to adjust their price, higher aggregate inflation increases the volatility of the individual price and income.

that the weight α is a function of the primitive parameters of the model, such as the slope of the Phillips curve and the degree of monopolistic competition.

2.1 The Policy Problem for a Single Policymaker

In this part we assume that the policy decisions are taken by a single policymaker. We further assume the policymaker is unable to commit their future policies; therefore he cannot change the private sector expectations with policy announcements over future policy decisions. In each period the policy maker chooses the policy instrument to maximise the welfare function subject to the IS and the AS. The policymaker's problem can be summarised by maximising the Bellman equation:

$$\max_{\{x_t,\pi_t\}} W_t = -\frac{1}{2}\left[\alpha x_t^2 + \pi_t^2\right] + \beta E_t \overline{W}_{t+1}$$

subject to

$$\begin{aligned} x_t &= -\varphi\left[i_t - E_t\pi_{t+1} - r_t^n\right] + E_t x_{t+1} \\ \pi_t &= \lambda x_t + \beta E_t \pi_{t+1} + u_t \end{aligned}$$

where $E_t\overline{W}_{t+1}$ is taken as given by the Policymaker, since her cannot credibly manipulate beliefs in the absence of commitment. Moreover, in order to obtain tractability on the problem, we focus on the optimum within a simple family of policy rules, which is a linear function of expected inflation.

Proposition 1 *The optimal feedback policy for the interest rate, within the family rules mentioned above without commitment, is :*

$$i_t = r_t^n + \phi_\pi E_t \pi_{t+1}$$

where $\phi_\pi = 1 + \frac{(1-\rho)\lambda}{\rho\varphi\alpha} > 1$.

See appendix D for a derivation. According to this policy rule, the nominal interest rate should rise in response to a rise in expected inflation, and that increase should be high enough to increase real rates. In other words, in the optimal rule for the nominal interest rate, the coefficient on expected inflation should exceed unity (that is $\phi_\pi > 1$)[7].

Moreover, in this policy rule, the interest rate is adjusted to perfectly offset shocks that affect the natural interest rate, but to partially offset cost-push shocks (that is $\partial\pi_t/\partial u_t > 0$).. Therefore, when "cost-push" shocks are present, the optimal policy rule incorporates convergence of inflation to its target over time. Also, the relative weight between output and inflation stabilisation is given by the parameter alpha.

[7]In contrast, in the case of a single policymaker that can commit to a policy rule, and if the policy rule is linear on the shocks, the optimal feedback policy rule has the following form:

$$i_t = r_t^n + \gamma_\pi^c E_t \pi_{t+1}$$

where $\gamma_\pi^c = 1 + \frac{(1-\rho)\lambda}{\rho\varphi\alpha^c} \geq \gamma_\pi$ because $\alpha^c = \alpha(1-\beta\rho) < \alpha$. See Clarida and others (1999) for a derivation. Therefore, commitment increases the effectiveness of monetary policy, reducing expected inflation.

3 The Policy Problem in a Monetary Policy Committee

The traditional approach on the optimal monetary policy literature relies on the assumption that decisions are taken by a single policymaker. However, in real-life this is not the case, because in practice monetary policy decisions are taken mostly collectively in a committee. In this section we introduce a Monetary Policy Committee (MPC) in charge of the monetary policy decisions. Also, we assume that the members in the MPC differ in their preferences. More precisely, they have different relative weight between output and inflation stabilisation in their policy objectives [8].

We assume the MPC has three members [9], $j = \{1, 2, 3\}$, each one with different preference parameters: $\alpha^1 < \alpha^2 < \alpha^3$. The first (third) member is the most (least) conservative, while the second has moderate preferences over inflation and output gap. Therefore, the aggressiveness in the response of the interest rate to expected inflation decreases with the index of each member.

3.1 Bargaining problem

We assume the policy decision is a bargaining problem in the spirit of Baron and Ferejohn (1989), which is closer to how the interest rate is decided in practise by an MPC. In every period the interest rate is determined by the following game: one member, the agenda setter, proposes a new interest rate. Then, the members of the MPC vote. We assume that it is necessary a simple majority to have the new interest rate approved. Then, the new interest rate is implemented if at least two out of three members of the MPC approve it, otherwise the last period interest rate is maintained.

In this voting system the status quo is given by last period interest rate, it means that this is the default interest rate if the members do not accept the new interest rate proposed by the agenda setter. Moreover, because the agenda setter makes a take-it-or-leave-it proposal, she has a first mover advantage, which in this setup gives her more bargaining power than to the other MPC's members. Therefore, the agenda setter can strategically set to vote an interest rate that maximises her own utility constrained by the reaction of other members. Denote the identity of the agenda setter by A, her optimisation problem becomes:

$$\max_{\{i_t\}} W_t^A = -\frac{1}{2}\left[\alpha^A x_t^2 + \pi_t^2\right] + \beta E_t \overline{W_{t+1}^A} \tag{2}$$

subject to

$$\begin{aligned} x_t &= -\varphi\left[i_t - E_t\pi_{t+1} - r_t^n\right] + E_t x_{t+1} \\ \pi_t &= \lambda x_t + \beta E_t \pi_{t+1} + u_t \end{aligned} \tag{3}$$

and to

$$\begin{aligned} W_t^A(i_t) &\geq W_t^A(i_{t-1}) \\ W_t^j(i_t) &\geq W_t^j(i_{t-1}) \text{ for at least one } j \neq A \end{aligned} \tag{4}$$

[8]We work on the heterogeneity in the weights but not on heterogeneity on the targets. Heterogeneity on targets gives different inflation bias among members, whilst the degree of adjustment of the interest rate to shocks is the same for every member. In other words, with heterogeneity on targets the members only differ on the level of the interest rate, and this difference is independent of the type and size of shocks

[9]We assume a committee of three members because this is the minimum odd number of members in order to have a conflict.

The problem for the agenda setter is similar to the benchmark model, but with an extra constraint. Within an MPC, the agenda setter has to choose an interest rate such that also obtains the majority needed for approval. This problem includes some participation constraints on the behaviour of the other members. According to these participation constraints, the new interest rate should give at least the same utility than the status quo for the agenda setter and at least one additional member.

Since MPC members have different preferences over output and inflation stabilisation, there is a conflict on the size of the adjustment of the interest rate to "cost-push" shocks. For this reason, the political economy solution will depend on the size and direction of the shocks. When shocks affecting the natural rate are big relatively to "cost-push" shocks (u_t), there is no conflict among members since their preferred interest rates are similar. However, in the opposite case, when the "cost-push" shock are big relatively to shocks affecting the natural rate, the MPC's members have different preferences on the policy instrument. In that case, the political economy solution will depend on the state variable i_{t-1} and the shocks. For simplicity, in order to describe easily the mechanism, we will focus in the case where there are no shocks affecting the natural rate, that is we assume $r_t^n = 0$.

3.2 MPC members' reaction functions

Since MPC's members cannot credibly manipulate beliefs in the absence of commitment, they take private sector expectations as given when solving their optimisation problem[10]. Therefore, as in the case of section 5.2, the private sector forms beliefs rationally conditional on the MPC's reaction function. Given absence of commitment, member $j's$ preferences are given by

$$W_t^j = -\frac{1}{2}\left[\alpha_j x_t^2 + \pi_t^2\right] + \beta E_t \overline{W}_{t+1}^j$$

where $E_t\overline{W}_{t+1}^j$ are taken as given. Therefore, similar to the case of the previous section, her preferences are maximised by i_t^{j*}, *the member-j optimal rate:*

$$i_t^{j*} = \phi_\pi^j E_t \pi_{t+1}$$

where $\phi_\pi^j = 1 + \frac{(1-\rho)\lambda}{\rho\varphi\alpha^j}$[11]. This optimal rate is similar to the rate in the single policymaker case for $\alpha = \alpha^j$. Moreover, given the ordering of the preference parameter α^j, the responsiveness of the interest rate to expected inflation diminishes with the index j : that is $\phi_\pi^3 < \phi_\pi^2 < \phi_\pi^1$. Then, the more conservative a MPC member is, the stronger she prefers the interest rate to react to expected inflation.

Conditional on the shocks, the welfare function for every MPC member is strictly concave in the interest rate, which is maximised at the *member-j optimal rate* $i_t = i_t^{j*}$. The concavity comes from the quadratic preferences. Because of this concavity it is possible to define $\overline{i_t^j}$, *the member-j participation rate*, the interest rate that would make member j indifferent between this rate and the status quo interest rate (i_{t-1}):

[10]This assumption also allow us to simplify greatly the problem, since expectations are taken as fixed by the MPC members, the political equilibrium doesn't depend on the rational expectations economic equilibrium. If this were not the case, the fixed point problem would be more difficult to solve and the uniqueness of the equilibrium is not guarantied.

[11]The member-j optimal rate without commitment has the following form: $i_t^{j*} = \phi_\pi^j E_t\pi_{t+1} - \frac{1}{\psi}\frac{\lambda}{\alpha}\frac{1}{\rho}\left(E_t\pi_{t+1} - \rho\pi_t\right)$. However, to get the simplest result as possible, we have assumed the second element is zero, as in the single-policymaker case when expected inflation is a linear combination of the shocks. The results don't change if we include the more general policy rule, but notation gets more complicated.

Proposition 2 *Given last period interest rate, i_{t-1}, member j will be indifferent between $\overline{i_t^j}$ and i_{t-1} for*

$$\overline{i_t^j} = 2i_t^{j*} - i_{t-1}$$

See proof in appendix D. The member-j participation rate $(\overline{i_t^j})$ gives to her the same utility than last period rate, that is $W_t^j\left(\overline{i_t^j}\right) - W_t^j\left(i_{t-1}\right) = 0$. Figure 5.1 shows the preferences over the interest rate for member j. As we mentioned before, the welfare function is concave on the interest rate and it is maximised at the member-j optimal rate, i_t^{j*}. The graph shows a case where the last period interest rate is lower than the optimal rate (that is $i_{t-1} < i_t^{j*}$). According to this case, the participation rate is higher than the optimal rate. Then, any rate between last period's and the participation rate will give her higher utility than the status quo. That means that member-j will be willing to accept a rate different than the optimal rate in order to be better off than the status quo. We can also generalise the opposite case: when last period's rate is on the right of member-j optimal rate, the participation rate will be on the left of last period's rate and any rate in between will give her higher utility than the status quo.

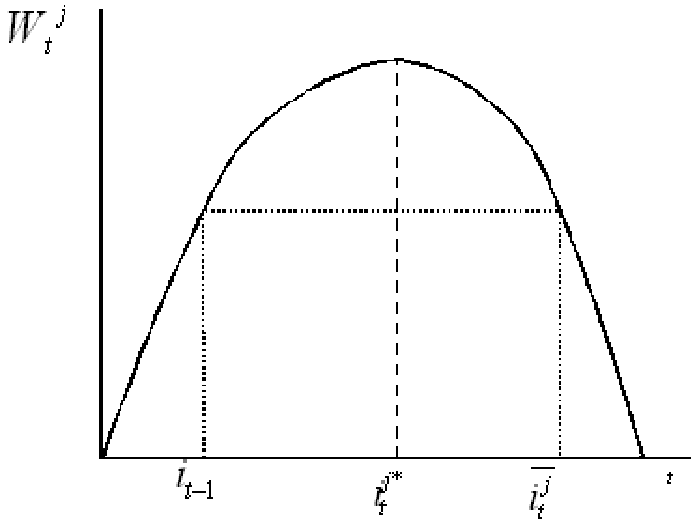

Figure 1: Welfare function

3.3 The policy problem

The agenda setter has a first mover advantage, because she can influence other member's decisions through the interest rate she sends to vote. In figure 5.2 we show one example of how she can influence the vote of a member j. Let's assume the status quo interest rate (i_{t-1}) is below the agenda setter's optimal rate (i_t^{A*}). The panel on the left (right) shows a case when the agenda setter's optimal rate is lower (higher) than member-j participation rate. In this example the initial interest rate is low and there is an increase in expected inflation (most likely because of a "cost-push" shock). Both members j and A want an increase in the policy rate, but A prefers a higher increase than j. If the agenda setter's optimal rate is not too high, as in the case on the left, member-j will accept it. However, if it is too high, as in the case on the right, it violates member-j participation constraint and the best the agenda setter can do is to set $\overline{i_t^j}$ that makes the constraint binding.

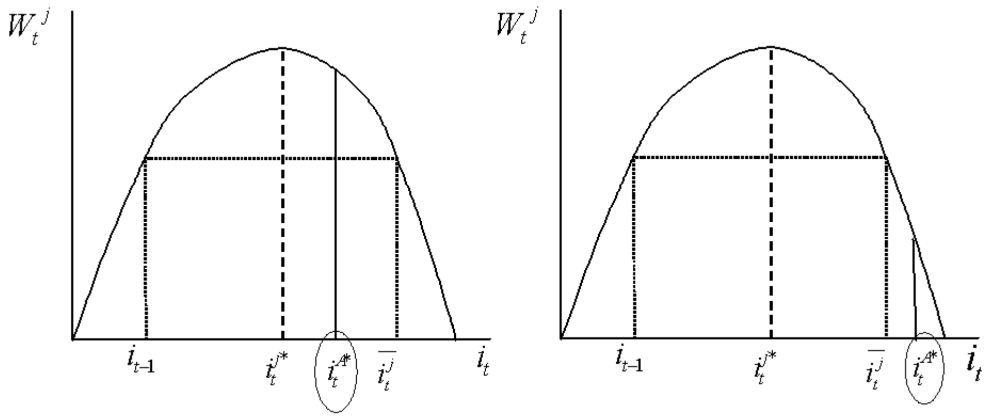

Figure 2: a) Policy problem when: $i^{A*} < \overline{i^j}$. b) Policy problem when: $i^{A*} < \overline{i^j}$.

In this subsection we analyse the optimisation problem for the agenda setter and its implications for interest rate smoothing. We show that what matters for interest rate smoothing is the identity of the agenda setter, the degree of heterogeneity of preferences among members and the size of the shocks. In brief, we observe interest rate smoothing only when the agenda setter is either the first or the third member, and not when she is the second member. The following propositions summarise our results taking into account the identity of the agenda setter.

Proposition 3 *When the agenda setter is the member with median preferences, member 2, there is no interest rate smoothing*

The policy problem when the agenda setter is the second member satisfies the median voter theorem. In this case, she is always able to form a coalition with either the first or the third member, to support her most preferred rate. Therefore, there is not interest rate smoothing when the agenda setter is the member with median preferences.

Member 1 prefers a more active interest rate to reduce deviations of inflation around its long–run value, while member 3 prefers a less active policy to reduce deviations in output gap. The agenda setter tends to form a coalition with the first member when she needs to adjust the interest rate because of a new shock, for instance an increase in expected inflation. But as the shock vanishes, she tends to form a coalition with the third member to return the interest rate closer to its neutral level.

Therefore, coalitions in the MPC vary with the sign of expected inflation and the state variable i_{t-1}. When expected inflation is positive the agenda setter will look for a coalition with the more conservative member (member 1) if the initial interest rate is too low. However, if the initial interest rate is too high, she forms a coalition with the less conservative member (member 3). A similar analysis applies when expected inflation is negative. Also, when the size of the shocks is too high, both other members of the MPC agree with the agenda setter to change the interest rate as her wish.

Being the agenda setter the member with median preferences would prevent interest rate smoothing from a political economy point of view. However, this is not always the case, since often the most conservative member is appointed as the agenda setter. As Barro and Gordon (1993) have pointed out, assigning the monetary policy decision task to a conservative policy-maker can help to reduce the time inconsistency problem. However, if the decisions are taken in an MPC, it will also induce to interest rate smoothing. We show this in the next proposition:

Proposition 4 *When the agenda setter is the more conservative member, member 1,there is interest rate smoothing and the policy function is given by:*

$$\begin{array}{ll} i_t = i_{t-1} & when\ i_{t-1} \in [i_t^{2*}, i_t^{1*}]\ or\ i_{t-1} \in [i_t^{1*}, i_t^{2*}] \\ i_t = \overline{i_t^2} & when\ i_{t-1} \in [2i_t^{2*} - i_t^{1*}, i_t^{2*}]\ or\ i_{t-1} \in [i_t^{2*}, 2i_t^{2*} - i_t^{1*}] \\ i_t = i_t^{1*} & otherwise \end{array}$$

According to this proposition, the policy function can take three different functional forms. We present the thresholds defining the areas for those functions in terms of the optimal rates for MPC members. These optimal rates are function of expected inflation, which at the end also depend on the shocks and the policy decision. Therefore, the functional form of the policy function depends on last period interest rate and the shocks.[12]. In the first functional form the interest rate doesn't change, in the second one the participation constraint for member 2 is binding and in the third one the interest rate responds the same than member-1's optimal.

In the third area, there will be always a member that will prefer the agenda setter's optimal rate (i_t^{1*}) than the status quo rate (i_{t-1}). The agenda setter can obtain from the voting process the same interest rate that maximises her unconstrained utility, because the participation constraint is not binding for at least one other member. This is possible because she has the first moving advantage in the voting process and the change in expected inflation is such that makes the last period rate sub-optimal for the other members in comparison with i_t^{1*}.

In the second area, the agenda setter sets an interest rate such the participation constraint is binding for one of the members. She chooses to make binding the participation constraint for member 2 because she has the closest preferences to hers. In such area, the agenda setter cannot obtain from the voting process her preferred rate, but she can obtain a rate that maximises her utility subject to the participation constraint of member 2.

The first area defines an area of inaction, where the participation rate of any member does not satisfy the participation constraint of the agenda setter. That means, any rate that satisfy the participation constraint of any other member would make the agenda setter worst off than last period's rate. Then, the agenda setter by any means would prevent to have the interest rate changed. This area is defined when last period's rate is between the optimal rate for members 1 and 2. In this area, the gains from changing the rate are small in comparison to the cost of having an agreement, so MPC members would prefer to leave it unchanged[13].

The interest rate reaction function has a piecewise form with 2 thresholds and 3 zones, and the form depends on the sign of future expected inflation. When expected inflation is

[12]In each row the thresholds on the left correspond to the case when expected inflation is positive ($E_t\pi_{t+1} > 0$), because in that case $i_t^{2*} < i_t^{1*}$. Similarly, the thresholds on the right are for the case when expected inflation is negative.

[13]In this area, the optimal strategy for the agenda setter is to set to vote an interest rate that violates both participation constraints of the other two members, then from the voting process the i_{t-1} is maintained. However, this strategic voting seems unrealistic, because the agenda setter could lose credibility requesting those policies rates. We could also think about a more complex game, where if none of the other members agree with the agenda setter to maintain the rate unchanged, they will have to start again a new meeting which involves a cost. Even a small cost to keep arguing, different from zero, can make MPC members to maintain the rate unchanged.

positive (negative), the individual member's optimal rates are also positive (negative) and $i_t^{1*} > i_t^{2*} > i_t^{3*}$ ($i_t^{1*} > i_t^{2*} > i_t^{3*}$). The reaction function is summarised in figure 5.3. The graph on the left shows, given positive expected inflation, in the bold line the interest rate reaction function and in the light line the unconstrained optimal interest rate at i_t^{1*}. Similarly, the graphs on the right shows, also given positive expected inflation, in the bold the change in the interest rate in period t, and in the light one the optimal change in the unconstrained case, that is $\Delta i_t = i_t^{1*} - i_{t-1}$.

Both graphs show that there is interest rate smoothing when $i_{t-1} \in [2i_t^{2*} - i_t^{1*}, i_t^{1*}]$, because the interest rate change less than the optimum. In this area we have two degrees of interest rate smoothing: when $i_{t-1} \in \left[i_t^{2*}, i_t^{1*}\right]$ the interest rate does not change at all and when $[2i_t^{2*} - i_t^{1*}, i_t^{1*}]$ the interest rate changes less than the optimal. In the former case, negotiating in the MPC imposes a menu cost that makes not optimal to do small changes to the interest rate. In the latter, the agenda setter present to vote a change smaller than the optimal, to obtain a coalition with one of the other members, member 2.

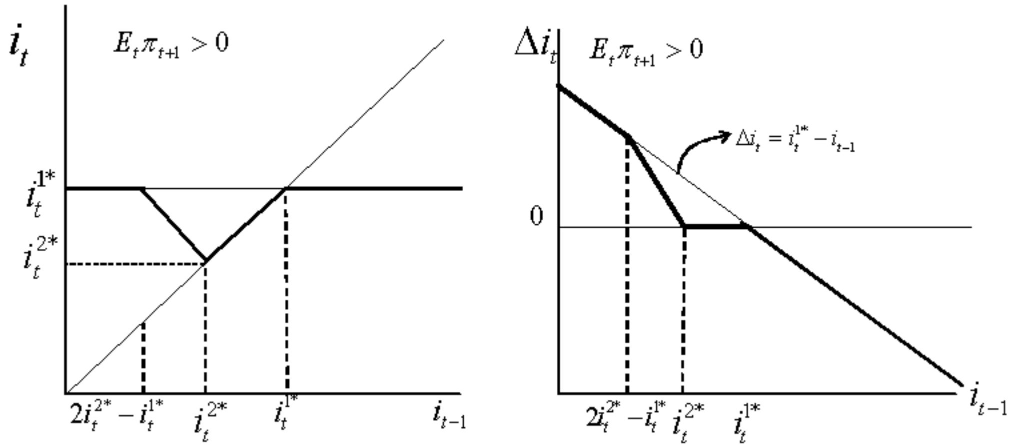

Figure 3: Interest rate reaction function: a) i_t, b) Δi_t

In these graphs it is possible to see that the political economy solution can explain both features of interest rate smoothing: the modest response of the interest rate to inflation expectations and the lagged dependence. The reaction function has a smoothing area where the interest rate either has partial adjustment or it is completely fixed. Moreover, the type of smoothing depends on the difference between the optimal rate and the lagged interest rate. When the difference between i_t^{1*} and i_{t-1} is small, the interest rate is fixed. However, when this difference takes intermediate values the interest rate change but less than the optimal. When this difference is big enough, the change will be equal to the optimal. Moreover, in the absence of cost-push shocks that give a trade-off between inflation and output volatility, the interest rate reaction function converges to i_t^{1*}, the optimal reaction function for the agenda setter. This is equal to the benchmark case with a single policymaker.

We can obtain a similar result in the opposite case, when the less conservative member is appointed as the agenda setter we have:

Proposition 5 *When the agenda setter is the less conservative member, member 3, there is* *interest rate smoothing and the policy function is given by:*

$$
\begin{array}{ll}
i_t = i_{t-1} & \textit{when } i_{t-1} \in [i_t^{3*}, i_t^{2*}] \textit{ or } i_{t-1} \in [i_t^{2*}, i_t^{3*}] \\
i_t = \overline{i_t^2} & \textit{when } i_{t-1} \in [i_t^{2*}, 2i_t^{2*} - i_t^{3*}] \textit{ or } i_{t-1} \in [2i_t^{2*} - i_t^{3*}, i_t^{2*}] \\
i_t = i_t^{3*} & \textit{otherwise}
\end{array}
$$

The proof follows the same steps as proposition 5.4. This policy function has features similar to the previous case. There is an area where the interest rate is completely fixed and another where there is partial adjustment. Also, the coalitions are made with member 2, who has preferences closer to the agenda setter. However, the direction of the smoothing is different. For example, for positive expected inflation, in the smoothing area the interest rate change more than the optimal for member 3.

In this model we have interest rate smoothing when the agenda setter is either the first or the third member, and the reaction function is non-linear on the lagged interest rate and expected inflation. An important issue in this model is to determine if this non-linear policy rule can guarantee the existence of a rational expectations equilibrium. The following proposition shows that the determination properties of the rational expectations equilibrium are satisfied.

Proposition 6 *A sufficient condition for the determinacy of a rational expectations equilibrium with the reaction functions described in propositions (5.4) and (5.5) is that* $\phi^1 < 1 + 2\frac{1+\beta}{\lambda\varphi}$.

The proof is in the appendix D. The intuition behind this is that, as the response in the reaction function to expected inflation is bounded between the optimal response for members 1 and 3. And also, since each of those optimal responses satisfy the conditions for the existence of an equilibrium, this also guarantees the existence of the equilibrium in the context of voting on a MPC. From the political economy equilibrium it can be some sluggishness on the response of the interest rate, but this response always will be high enough in order to control inflation.

4 Economic Equilibrium

In this section we solve for the rational expectations equilibrium of inflation and output gap, given the interest rate reaction function of proposition (5.4). However, since the reaction function is non-linear and the solution doesn't have a closed solution, we need to approximate it by a non-linear method.

4.1 Methodology

We obtain a numerical solution to the rational expectations problem using a collocation method, which allows us to obtain an approximate solution of the problem with a high degree of accuracy. The collocation method consists on finding a function that approximates the value of the policy functions of the problem at a finite number of specified points[14]. This sub-section describes the procedure we have used. The system of endogenous equations is the following:

$$
\begin{aligned}
x_t &= -\varphi \left[i_t - E_t \pi_{t+1} \right] + E_t x_{t+1} \\
\pi_t &= \lambda x_t + \beta E_t \pi_{t+1} + u_t \\
i_t &= f \left(E_t \pi_{t+1}, i_{t-1} \right)
\end{aligned}
$$

[14] See Judd (1998) and Miranda and Fackler (2002) for discussion on collocation methods.

for the IS, the AS and the non-linear reaction function. The system can be written as:

$$F\left(X_t, E_t\left(X_{t+1}\right), S_t\right) = 0 \tag{5}$$

where $X_t = [x_t, \pi_t, i_t]$ are the endogenous variables and $S_t = [u_t, i_{t-1}]$ are the state variables, that evolves according to:

$$S_{t+1} = g\left(X_t, e_t\right) = [\rho u_{t-1} + e_t, i_{t-1}] \tag{6}$$

We approximate the expected value of the rational expectations solution of the model as a non-linear function on the states:

$$EX_{t+1} = Z\left(S_t\right) \tag{7}$$

which is unknown. The rational expectations equilibrium satisfies:

$$\begin{aligned} F\left(X_t, Z\left(S_t\right), S_t\right) &= 0 \\ S_{t+1} &= g\left(X_t, e_t\right) \end{aligned} \tag{8}$$

The collocation method consists on finding a function of the states, $\Phi\left(S_t\right)_{1xn}$, evaluated in at S_{nx1} nodes[15] to approximate $Z\left(S_t\right)$ by:

$$Z\left(S\right) = \Phi\left(S\right) C \tag{9}$$

where C is a $nx1$ matrix of coefficients. We need to solve for the matrix of coefficients C in (9) such that satisfy (8). We use linear splines evaluated at 200x200 points as a basis for the projection method. To calculate the expected value we use numerical integration based on Gauss-Legendre quadrature evaluated at 5 points. We select splines as the basis function in order to have enough flexibility in the approximation function to capture the non-linearities of the solution. Similarly, we choose to approximate the expected value of the endogenous variable because it is smoother than the solution for the endogenous variable.
The algorithm has two steps:

Step 1: Since the interest rate reaction function is non-differentiable in the thresholds which makes difficult to apply the numerical methods to solve for (9), we use a first guess the following non-linear function for the interest rate:

$$i_t = f\left(E_t\pi_{t+1}, i_{t-1}\right) = i_t^{1*} - \frac{\left(i_t^{1*} - i_{t-1}\right)\left(2i_t^{2*} - i_t^{1*} - i_{t-1}\right)}{i_t^{2*} - i_t^{1*}} \exp\left(-\tau\left(\frac{i_t^{2*} - i_{t-1}}{i_t^{2*} - i_t^{1*}}\right)^2\right)$$

where i_t^{1*} and i_t^{2*} are member's 1 and 2 optimal rates, and τ is chosen such that it minimises the approximation error. We select this non-linear form, because it captures many of the properties of the original reaction function: the values of the reaction function at the thresholds and at extreme values are the same. It also preserves the shape of the original reaction function, but it is smoother at the kinks. We compare the original with the smoothed reaction function in the following graph:

As we can see, this smoothed reaction function captures the two characteristics of the original one: lagged dependence and modest response. Features that we want to evaluate in a general equilibrium framework.

Step 2: We use the solution for $Z\left(S\right)$ from step 1 as a first guess for the real piecewise reaction function and estimate it again the policy function using the collocation method.

[15]The system is evaluated at $n = n_1 * n_2$ nodes, n_1 and n_2 for the state space of u_t and i_{t-1}, respectively.

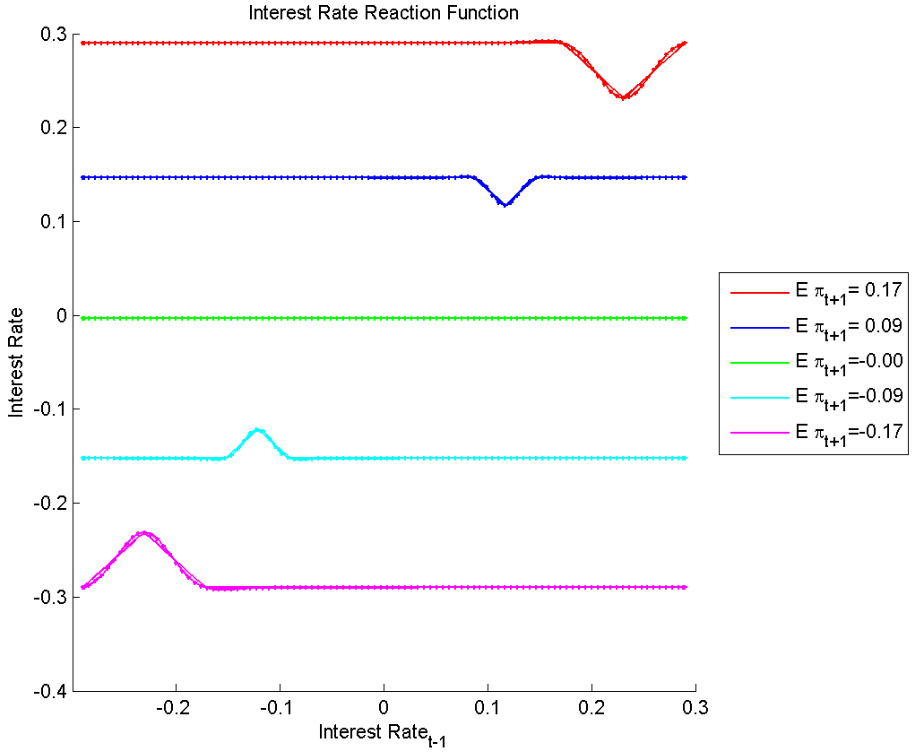

Figure 4: Interest rate reaction function (original vs. smoothed function)

The algorithm converges after a total of 140 iterations with a degree of tolerance of $10E-8$. We consider the following parameterisation: the discount factor $\beta = 0.98$, the intertemporal elasticity of substitution $\varphi = 1/5$, the slope of the Philips Curve $\lambda = 0.2$, the preference parameters for member 1 and 2 are $\alpha_1 = 0.5$ and $\alpha_1 = 1$, the autocorrelation of the "cost-push" shock is $\rho = 0.75$ and its shock is normally *iid* with mean 0 and standard deviation of 0.01.

4.2 Policy functions

In this subsection we describe the solution of the endogenous variables as a function of the state variables, u_t and i_{t-1}, We focus on the effects that the interactions within the MPC have on the interest rate and expected inflation. As we see in the next graphs, the political equilibrium problem generates lagged dependence, lower response to shocks and an increase in expected inflation.

Figure 5.5 shows the policy function for the interest rate. We show in the panel on the left the interest rate as a function of the lagged interest rate for different values of the cost-push shocks. It shows that the interest rate has areas where it is independent of its lagged values, but there are areas where the response depends on its lagged value, when such lagged value is close to the optimal. Also, these areas increase the higher the size of the shocks. Similarly, we show in the panel on the right the interest rate as a function of the cost-push shocks for different values of the lagged interest rate. We observe that there is no interest rate smoothing when the initial interest rate is close to its neutral value (that is $i_{t-1} = 0$). However, there is a lower response when the interest rate is closer to its optimal value.

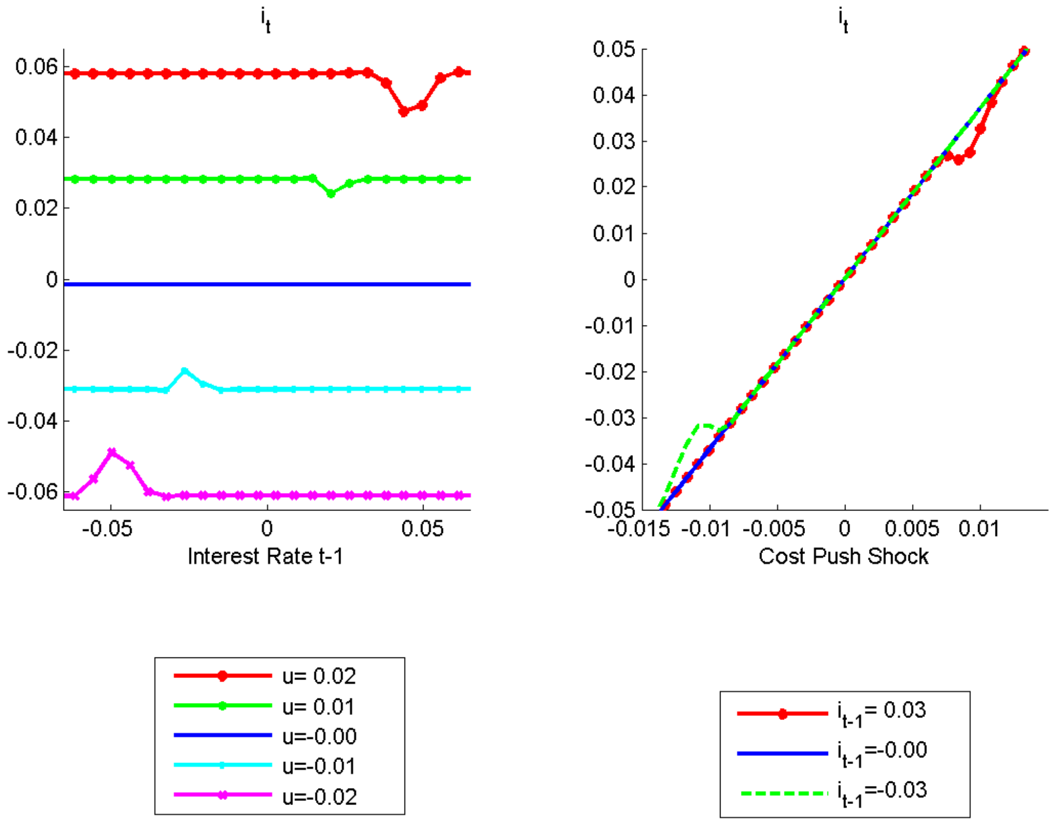

Figure 5: Interest rate policy function.

In the model the MPC takes as given expected inflation because there is a lack of commitment. However, the interactions within the MPC generate interest rate smoothing and the economic agents internalise this, which also has an effect in expected inflation. In the next graph we compare the expected inflation policy function of our the model with that of the single unconstrained policymaker. We show that the inertial behaviour of the interest rate increases expected inflation proportional to the size of the cost-push shock, but independently on the lagged interest rate. **Under our benchmark parameterisation, a cost push shock has an additional effect on expected inflation of 4.5 percent.** This effect is independent of the lagged interest rate, because the solution takes into account the distribution of the shocks, which smoothes the effects of the shocks. As economic agents internalise that the decisions of the MPC have an inertial component, they consider this effect in their expectations. Therefore, the more heterogeneous the preferences in an MPC are, the effect cost-push shocks on expected inflation.

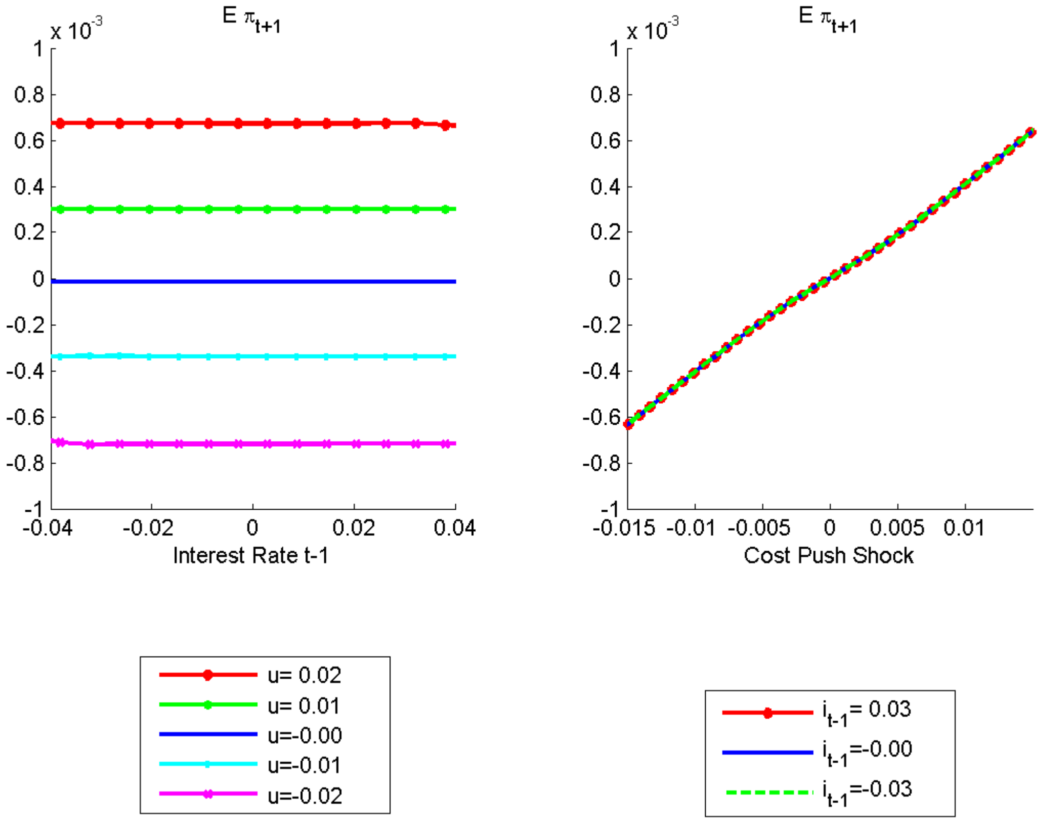

Figure 6: Change in expected inflation (benchmark model vs. MPC model)

4.3 Impulse response to ”cost-push” shocks.

Figure 5.7 shows the effect of a shock of 1 standard deviation in the cost-push shock, for different values of the initial interest rate and for the case of the unconstrained policymaker. The initial interest rate takes values that can be high (3%), medium (2%) or low (1%). We see that the expected response of the interest rate is different depending on the starting point. If the interest rate is close to the optimal, it almost doesn't change. However, for the case when the initial interest rate is low, the change is higher and closer to the unconstrained case. For the intermediate value, the new rate is in between. We can also see that this effect is transitory, as in period 2 the response is very similar for the four cases. However, since this is the expected path of the interest rate, it is taking into account that other shocks would arrive in the next period, which reduces the expected effect of interest rate smoothing.

Similarly, figure 5.8 shows the expected responses for inflation and output gap. We can observe here the trade-off between output and inflation volatility. The higher the initial interest rate, the more interest rate smoothing and the less volatility of output in relation with inflation.

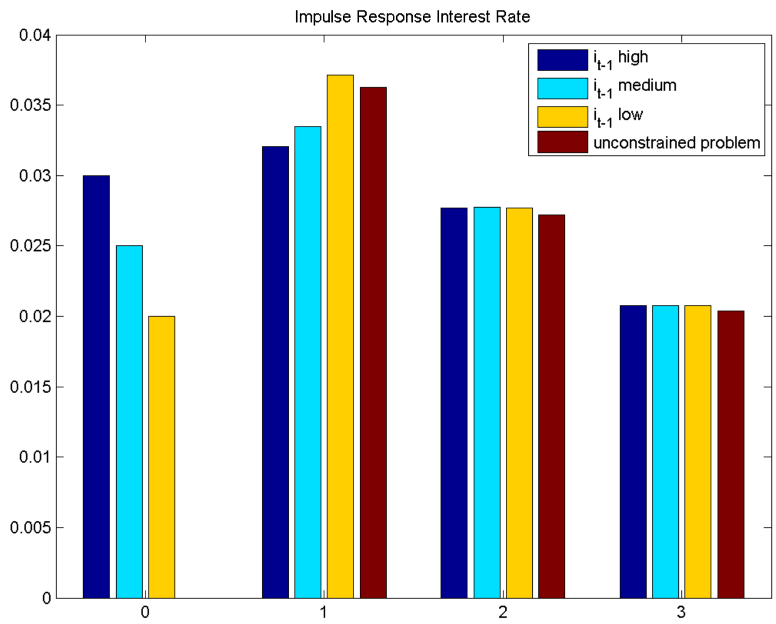

Figure 7: Impulse response to a cost-push shock: interest rate

5 Empirical Implications

The model that we develop in section 5.3 has some empirical implications. In this section we analyse if those implications are consistent with what is observed in the data. According to the model, more interest rate smoothing will be observed when the preferences among MPC members are more unequal, the agenda setter has preferences that are not in the median of the MPC members, and the size of the shocks is small. Moreover, this result comes from the assumption that the agenda setter can influence other members and there is an strategic game within the MPC. We analysed in this section whether these stylised facts are consistent with the path of the official rates for the USA, UK, EMU, Canada, Sweden and Switzerland, and with the published voting record of the Bank of England.

Stylised fact 1: Agenda setter influence on the other members

When the MPC members vote, they express their own view about the economy. However, we argue that in the voting process, the agenda setter can influence the votes of some members to obtain a policy that is closer to its own optimum. Also, the other members influence the decision of the agenda setter, because she needs the votes of other members to have the policy approved. The final outcome in the voting process is a political equilibrium. There are some open questions about this: Does this strategic behaviour take place? Has the Chairman/Governor/President of the MPC more power and influence than her peers?

Regarding the first question, we can see from the voting record of the MPC at the Bank of England that in almost all cases, from when the MPC started in July 1997 until May 2006, the final policy outcome is the same as the voting record for the Governor[16] . In other words,

[16] The exception was the meeting of August 2005, in which the Governor – Mervyn King invited members to vote on the proposition that the repo rate should be reduced by 25 basis point. Five members of the committee

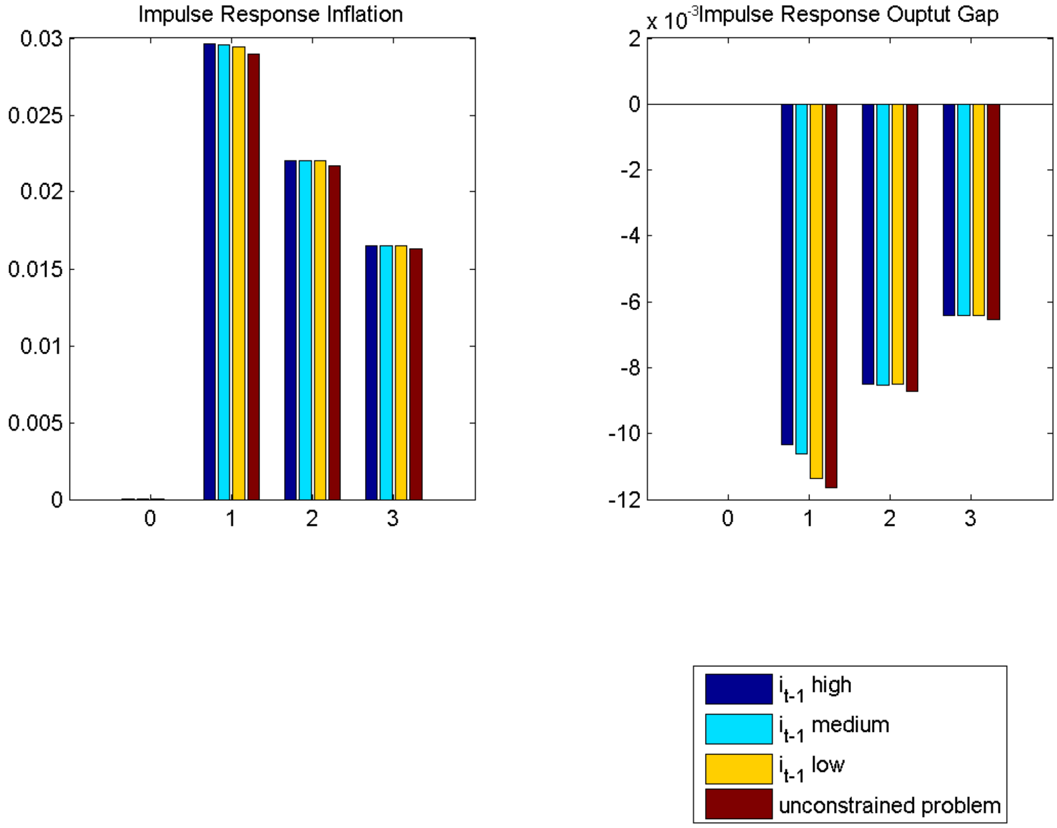

Figure 8: Impulse response to a cost-push shock: inflation and output gap

the agenda setter never loses. This indicates a strategic behaviour from the agenda setter, in order to obtain the coalition needed to have a policy passed.

Also, there is evidence that the person in charge of the MPC meeting has more power and can influence other members' decisions; however the final product is a political equilibrium. Laurence Meyer, Board Governor of the FOCM from 1996 to 2002, remarks on "the chairman's disproportionate influence on FOMC decisions" and on "his efforts to build consensus around his policy recommendations"[17]. Similarly, Sherman Maisel, who was a member of the Board during Burns' chairmanship also points out that "while the influence of the Chairman is indeed great, he does not make policy alone"[18]. Then, the interest rate decisions come from the interaction between the agenda setter ant the other members of the MPC.

Stylised fact 2: Heterogeneity in the preferences

The model relies on the assumption that MPC members have different preferences. This heterogeneity, together with strategic behaviour of the agenda setter, causes interest rate smoothing. How heterogeneous are the preferences among members? Do they really think

vote in favour, whilst the other four members, among them the Governor, preferred to maintain the rate.

[17]Meyer (2004), p.50.

[18]Maisel (1973), p.124.

differently? We take as an indicator of this heterogeneity the dissenting record of each member with respect to the agenda setter. We construct this indicator using the information of the voting record for the Bank of England, which is available for the period since the MPC was established in July 1997.

Gerlach-Kristen (2003) analyses the voting record of the BoE since the introduction of the MPC. She characterise the MPC member in four groups: the first group, the agenda setter, always vote with the majority; the second group, the "doves", when dissenting always favoured a level of interest rates lower than that set by the majority; the third group, the "hawks", always favoured a tighter monetary policy when dissenting; and the fourth group doesn't show a systematic preference to higher or lower rates. We can classify the members of the third (second) group as those that are more (less) conservative than the agenda setter.

In table 5.1 and 5.2 we classify the MPC members in the four categories as Gerlach-Kristen (2003a) for both, the governorship of Sir Edward George and Mr. Mervyn King. For this classification we consider if the preferred rate when dissenting was higher or lower than the voted rate, and how frequent they dissent. We have considered only those members with at least ten votes in the record and those that show systematic preferences to either lower or higher rates. Also, we have also classified the members as internal or external depending on the way they are appointed[19].

Table 5.1 shows the classification during the Governorship of Sir Edward George from July 1997 to June 2003, and table 5.2 for the Governorship of Mr Mervyn King from July 2003 to June 2006. The members are classified by its conservativeness degree, being those at the top the more conservative[20]

According to this classification, we can see some differences on MPC members preferences across sub-samples. First, Sir George has been on average closer to the median preferences than Mr. King does. Second, we can see more dispersion among MPC member's preferences during Mr King's governorship than during Sir Edward George's Governorship. Third, the MPC members internally appointed show a tendency to be more conservative than those appointed externally. According to these features, our model predicts under Mr. King's governorship, *ceteris paribus*, more interest smoothing than under Sir King's governorship. Effectively, during Mr King's governorship, the official rate has been maintained 80 percent of the time, in comparison to 68 percent in Sir Edward George's governorship.

[19]The MPC at the Bank of England was established in June 1997. It has nine members, five full-time Bank executives (the Governor and two Deputy Governors, the Chief Economist and the Markets Director) and four external members, who are appointed for a three-year term by the Chancellor of the Exchequer.

[20]For instance, according our classification Sir Budd has been the most conservative during Sir George Governorship, since he has preferred proportionally more times a higher rate than the Governor.

	Frequency of dissents	of which for higher rate	Appointment
The most conservative			
Sir Alan Budd	22.2%	100.0%	External
John Vickers	17.9%	100.0%	Internal
Mervyn King	16.2%	100.0%	Internal
Charles Goodhart	8.3%	100.0%	External
Paul Tucker	7.7%	100.0%	Internal
Sir Edward George (Governor)	**0.0%**	**0.0%**	**Internal**
Charles Bean	2.9%	0.0%	Internal
Kate Barker	11.5%	0.0%	External
Sushil Wadhwani	35.1%	0.0%	External
DeAnne Julius	28.9%	0.0%	External
Christopher Allsopp	29.7%	0.0%	External
Marian Bell	25.0%	0.0%	External
The least conservative			

Table 1: Classification MPC members: Sir George's governorship

	Frequency of dissents	of which for higher rate	Appointment
The most conservative			
Sir Andrew Large	25.8%	100.0%	Internal
Paul Tucker	11.4%	100.0%	Internal
Rachel Lomax	2.9%	100.0%	Internal
Mervyn King (Governor)	**0.0%**	**0.0%**	**Internal**
Kate Barker	2.9%	0.0%	External
Richard Lambert	3.0%	0.0%	External
Charles Bean	8.6%	0.0%	Internal
David Walton	9.1%	0.0%	External
Marian Bell	12.5%	0.0%	External
Stephen Nickell	25.7%	11.1%	External
The least conservative			

Table 2: Classification MPC members: Mr. King's governorship

Stylised fact 3: Dispersion of preferences and interest rate smoothing

The model predicts that the more heterogeneous the preferences are, if the agenda setter is not the median member, *ceteris paribus* will be more interest rate smoothing. To analyse this fact, we compare the paths of the official interest rate for the European Central Bank (ECB) and the Swiss National Bank (SNB). We expect those economies to have similar paths for interest rate decisions, since the main trading partners for Switzerland are the members of the EMU and those economies are hit by similar shocks. However, the pattern of the official interest rate for the SNB is more dynamic than for the ECB. On average, the changes of the interest rate had a duration of five months for the SNB in comparison to seven months in the ECB. Also, the SNB has changed the interest rate by higher amounts than the ECB, the mode in the change of the interest rate is 0.5 percent for the SNB in contrast to 0.25 percent for the ECB. This would be explained by how the MPCs are formed in both central banks. At the ECB, the Governing Council is formed by the six members of the Executive Board, plus the governors of all the national central banks (NCBs) from the 12 euro area countries, while at the SNB, the Governing Board in charge of monetary policy decisions is formed of only three members.

In table 5.3 we show some rough indicators about the dynamics of the official interest rate for six countries. The first indicator is the average duration of a change in the interest rate; we expect that the easier it is to have an agreement within the MPC, the lower the interest rate smoothing and the more frequent the adjustment in the rate. The second indicator is the mode of the change in the interest rate, the easier it is to have an agreement within the MPC, the higher the changes in the interest rates.

Country	Data since:	Change Rate Mode	Avg. duration (Months)	Number of members MPC	Number of meetings per year
Canada	Abr-96	0.25	2.4	6	8
United Kingdom	Jun-97	0.25	3.3	9	12
USA	Ene-96	0.25	3.3	12	8
Switzerland	Ene-00	0.50	5.4	3	12
EMU	Ene-01	0.25	7.0	18	11
Sweden	Jun-94	0.25	2.2	6	8-9

Table 3: Dynamics of Official Interest Rate

According to the first indicator, Canada and Sweden have the more active central banks, where a change in the interest rate lasts on average two months, followed by the United Kingdom and the USA with three months. While according to the second indicator, Switzerland is more active with a mode in the changes of the interest rate of 0.5 percent, a difference from the other countries whose interest rates usually change by 0.25 percent. Both indicators also suggest that the central bank with more interest rate smoothing is the ECB, which changes the interest rate every seven months on average, at steps of 0.25 percent. As we mentioned before, these results are related to the composition of the MPC. The MPC in Switzerland has only 3 members, and Canada and Sweden 6; in contrast to the MPC in the USA and the EMU, which they have 12 and 18, respectively. The more members an MPC has, the more likely that their the preferences will differ and the more difficult it is to have an agreement.

6 Conclusions

This chapter helps to explain the existing puzzle in the optimal monetary policy literature of interest rate smoothing: why in practice do central banks change the interest rate less frequently than the theory predicts? In doing this, we extend the New Keynesian Monetary Policy literature relaxing the assumption that the decisions are taken by a single policy maker, considering instead that monetary policy decisions are taken collectively in a committee. We introduce a Monetary Policy Committee whose members have different preferences between output and inflation stabilisation and have to vote on the level of the interest rate. Also, there is one member in charge of setting the agenda of the meeting, which can be the Chairman/Governor/President of the MPC.

We explain interest rate smoothing from a political economy point of view, in which MPC members face a bargaining problem on the level of the interest rate. In this framework, the interest rate is a non-linear reaction function on the lagged interest rate and the expected inflation. This result comes from a political equilibrium in which there is a strategic behaviour of the agenda setter with respect to the other MPC members in order to maximise his own policy objective.

According to the model, there is not such interest rate smoothing when the agenda setter is the member with median preferences. As in the median voter theorem, she can always get a coalition to have her most preferred (lagged independent) interest rate. However, when the agenda setter is either one of the most or the least conservative members, it will be interest rate smoothing from a political economy point of view. Also, interest rate smoothing is higher when the preferences among the MPC members are more heterogeneous.

The size of the shocks is also important for interest rate smoothing. We find that the interest rate will adjust in the same magnitude as in the single policymaker case when the size of the shocks is high enough. However, when the size of the shocks is of intermediate size, we have found that the interest rate adjusts partially in order to form a coalition between the agenda setter and at least one of the other two members. Also, when the size of the shocks is small, it is preferred to maintain the interest rate unchanged.

We present this explanation of interest rate smoothing as an alternative approach in order to reproduce altogether both features documented by the empirical evidence of interest rate smoothing: the modest response of the interest rate to inflation and the lagged dependence. These are features that other models fail to reproduce at the same time. Our model also provides a theoretical framework on how disagreement among policy makers can slow the adjustment on interest rates and on 'menu costs' in interest rate decisions.

We also present some evidence based on the official interest rate path for five central banks and the voting record at the Bank of England. We show that this information is consistent with the assumptions of the model and with the results. We observe in the data that central banks whose members have more heterogeneous preferences adjust the interest rate less frequently, as in the case of the European Central Bank and the FED. Central banks with fewer members adjust the interest rate more aggressively, as in the case of the Swiss National Bank, the Bank of Canada and the Bank of Sweden. Also, according to the voting records at the Bank of England, there is also evidence of heterogeneity in the voting preferences among the members of the MPC, which is positive related to the degree of interest rate smoothing.

We do some quantitative exercises to show how interest rate smoothing in our model affect the economic equilibrium. We show that interest rate smoothing increases the effects of cost-push shocks on expected inflation by 4.5 percent given our benchmark calibration. As economic agents internalise the inertial component of the MPC decisions, they also consider this effect when forming expectations.

.

References

[1] Aksoy, Yunus, Paul De Grauwe and Hans Dewachter (2002), Do asymmetries matter for European monetary policy?, European Economic Review 46(3), 443-469.

[2] Baron and Ferejohn (1989), Bargaining in Legislatures, American Political Science Review 83, pp. 1181-1206.

[3] Brainard, William (1967), Uncertainty and the effectiveness of Policy, American Economic Revie 57, Papers and Proceedings, 411-25.

[4] Berk, Jan Marc and Beata Bierut (2003), Committee Structure and its Implications for Monetary Policy Decision - Making, Tinbergen Institute Discussion Paper TI 2003-053/2

[5] Berk, Jan Marc and Beata Bierut (2004), The effects of learning in interactive monetary policy committees, mimeo

[6] Clarida, Richard, Gali, Jordi and Mark Gertler (1999), The Science of Monetary Policy: A New Keynesian Perspective, Journal of Economic Literature 37: 1667-1707.

[7] Clarida, Richard, Gali, Jordi and Mark Gertler (1999b), Monetary Policy Rules in Practice: some international evidence, NBER Working paper 6254.

[8] Calvo, Guillermo (1983), Stagerred Prices in a Utility-Maximizing Framework, Journal of Monetary Economics 12: 383-398, 1983.

[9] Gersbach, Hans and Volker Hahn (2001), Should the individual voting records of central bankers be published?, Bundesbank Diskussionpapier 02/01.

[10] Goodfriend, Marvin (1991), Interest Rates Smoothing and the conduct of monetary policy, Carnegie-Rochester Conference Series on Public Policy 34:7-30, 1991.

[11] Goodhart, Charles (1999), Central Bankers and Uncertainty, Bank of England Quearterly Bulletin: February 1999.

[12] Goodhart, Charles (2004a), The Monetary Policy Committees's Reaction Function: an exercise in estimation, mimeo FMG-LSE.

[13] Goodhart, Charles (2004b), Gradualism in the adjustment of the Official Interest Rates: some partial explanations, mimeo FMG-LSE

[14] Judd, John and Glenn Rudebusch (1998), Taylor's Rule and the Fed: 1970-1997, Federal Reserve BAnk of San Francisco Economic Review 1998 (3), pp. 3-16.

[15] Karotkin, Drora (1996), Justification of the Simple majority and chairman rules, Social Choice and Welfare 13, 479-486.

[16] Lowes, Phillip and Luci Ellis (1997), The Smoothing of Official Interest Rates

[17] Meade, Ellen and Nathan Sheets (2002), Regional Influences on U.S. Monetary Policy: Some Implications for Europe, CEP-LSE working paper.

[18] Orphanides, Athanasios (1998), Monetary Policy Evaluation With Noisy Information, Board of Governors of the Federal Reserve System, mimeo.

[19] Orphanides, Athanasios (2001), Monetary Policy Rules Based on Real-Time Date, American Economic Review 91: 964-985.

[20] Gerlach-Kristen, Petra (2003), Monetary Policy Commitees and Interest Rate Setting, mimeo University of Basel.

[21] Gerlach-Kristen, Petra (2004a), Interest-Rate Smoothing: Monetary Policy Inertia or Unobserved Variables, mimeo.

[22] Gerlach-Kristen, Petra (2004b), Too little, too late - Interest rate setting and the cost of consesus, mimeo.

[23] Riboni, Alessandro (2003), Time consistency in dynamic bargaining: the role of committees as substitutes for commitment.

[24] Rotemberg, Julio and Michael Woodford (1997), An Optimization-based econometric Frameork of the Evaluation of Monetary Policy, NBER Macroeconomics Annual, 12:297-346.

[25] Rudebush, Gleen (1999), Is the Fed too timid? Monetary policy in an uncertain world, Review of Economics and Statistics 83, 203-217.

[26] Sack, B.(1998), Does the Fed Act Gradually?, A VAR Analysis, Board of Governosr of the Federal Reserve System. Finance and Economics Discussion Series , 98-34.

[27] Silbert, Anne, Monetary Policy Committees: Individual and Collective Reputations, Review of Economic Studies.

[28] Srour, Gabriel (1999), Why do central banks smooth interest rates?, Bank of Canada working paper 2001-17

[29] Sack, B. and V. Wieland (2000), Interest-Rate Smoothing and Optimal Monetary Policy: A Report on Recent Empirical Evidence. Board of Governors of the Federal Reserve System. Manuscript.

[30] Taylor, John (1999), Monetary Policy Rules, University of Chicago Press.

[31] Von Hagen, Jurgen and Ralph Suppel (1994), Central Bank constitutions for federal monetary unions, European Economic Review 38, 774-782.

[32] Waller, Christopher (1989), Monetary Policy Games and Central Bank Politics, Journal of Money, Credit and Banking 21 (4), 422-431.

[33] Woodford, Michael(1999), Optimal Monetary Policy Inertia, NBER working paper 7261.

[34] Woodford, Michael (2003), Interest and Prices: Foundations of a Theory of Monetary Policy, The Princeton University Press.

D Appendix: Proof of propositions

D.1 Proof of proposition 5.1:

We divide the proof in two steps: first the policy-maker chooses x_t and π_t to maximise her welfare subject to the aggregate supply. Then, conditional on the optimal values of x_t and π_t, she determines the value of i_t implied by the IS.

The first step of the policymaker's problem is given by maximising the bellman equation:

$$\max_{\{x_t,\pi_t\}} W_t = -\frac{1}{2}\left[\alpha x_t^2 + \pi_t^2\right] + \beta E_t W_{t+1}$$

subject to

$$\pi_t = \lambda x_t + \beta E_t \pi_{t+1} + u_t$$

Since the policymaker cannot credibly manipulate beliefs in the absence of commitment, she takes private sector expectations as given when solving her optimisation problem. Then, conditional on the policymaker's optimal rule, the private sector forms beliefs rationally. Therefore, the policymaker takes $E_t W_{t+1}$ and $\beta E_t \pi_{t+1}$as given in her optimisation problem.

The solution to the first stage problem yields the following optimally condition:

$$x_t = -\frac{\lambda}{\alpha}\pi_t \tag{D-1}$$

According to this condition, whenever inflation is above target, the policymaker contracts demand below capacity by raising the interest rate; and vice versa when it is below target. The aggressiveness of the policymaker depends positively on the gain in reduced inflation per unit of output loss, λ, and inversely on the relative weight placed on output losses α.

In order to obtain the reduced for expression for x_t and π_t, we combine the first order condition with the PC, and then impose that private sector expectations are rational to obtain:

$$\begin{aligned} x_t &= -\varpi u_t \\ \pi_t &= \frac{\alpha}{\lambda}\varpi u_t \end{aligned} \tag{D-2}$$

where $\varpi = \frac{\lambda}{\lambda^2+\alpha(1-\beta\rho)}$ is a decreasing function of the preference parameter α. From the second step, the optimal feedback policy for the interest rate is found by inserting the desired value of x_t in the IS:

$$i_t = r_t^n + \phi_\pi E_t \pi_{t+1}$$

where $\phi_\pi = 1 + \frac{(1-\rho)\lambda}{\rho\varphi\alpha} > 1$.

D.2 Proof of proposition 5.2:

Replace the IS and the AS in the welfare function of member j and operate:

$$W_t^j(i_t) = -\frac{1}{2}\left\{ \begin{array}{c} \alpha^j\left[-\varphi\left(i_t - E_t\pi_{t+1} - r_t^n\right) + E_t x_{t+1}\right]^2 \\ +\left[\lambda\left(-\varphi\left(i_t - E_t\pi_{t+1} - r_t^n\right) + E_t x_{t+1}\right) + \beta E_t\pi_{t+1} + u_t\right]^2 \end{array}\right\} + \beta \overline{W}_{t+1}^j \tag{D-3}$$

Subtract the welfare function evaluated at i_{t-1} :

$$W_t^j(i_t) - W_t^j(i_{t-1}) = -\frac{1}{2}\left\{ \begin{array}{c} \alpha^j\varphi\left(i_t - i_{t-1}\right)\left[\begin{array}{c} \varphi\left(i_t + i_{t-1}\right) \\ -2\left(\varphi\left(E_t\pi_{t+1} + r_t^n + \frac{1}{\varphi}E_t x_{t+1}\right)\right) \end{array}\right] \\ +\lambda\varphi\left(i_t - i_{t-1}\right)\left[\begin{array}{c} \lambda\varphi\left(i_t + i_{t-1}\right) - \\ 2\left(\lambda\varphi\left(E_t\pi_{t+1} + r_t^n + \frac{1}{\varphi}E_t x_{t+1}\right) + \beta E_t\pi_{t+1} + u_t\right) \end{array}\right] \end{array}\right\} \tag{D-4}$$

factorise $\varphi\left(i_t - i_{t-1}\right)$ and rearrange the terms that are similar:

$$W_t^j\left(i_t\right) - W_t^j\left(i_{t-1}\right) = -\frac{1}{2}\varphi\left(i_t - i_{t-1}\right)\left\{\begin{array}{c}\left(\alpha^j + \lambda^2\right)\varphi\left(i_t + i_{t-1}\right)\\ -2\left(\alpha^j + \lambda^2\right)\left[\varphi\left(E_t\pi_{t+1} + r_t^n + \frac{1}{\varphi}E_t x_{t+1}\right)\right]\\ -2\lambda\left(\beta E_t\pi_{t+1} + u_t\right)\end{array}\right\} \tag{D-5}$$

Member j optimal rate satisfies:

$$x_t^{*j} = -\frac{\lambda}{\alpha^j}\pi_t^j \tag{D-6}$$

also the optimal rate for member j is

$$i_t^{j*} = r_t^n + E_t\pi_{t+1} - \frac{1}{\varphi}\left(x_t^j - E_t x_{t+1}\right) \tag{D-7}$$

replace (D-7) in (D-5) and factorise the term $\left(\alpha^j + \lambda^2\right)$, we obtain:

$$W_t^j\left(i_t\right) - W_t^j\left(i_{t-1}\right) = -\frac{1}{2}\left(\alpha^j + \lambda^2\right)\varphi\left(i_t - i_{t-1}\right)\left\{\begin{array}{c}\varphi\left(i_t + i_{t-1}\right)\\ -2\left(\varphi i_t^{j*} + x_t^j\right) - 2\frac{\lambda}{\alpha^j+\lambda^2}\left(\beta E_t\pi_{t+1} + u_t\right)\end{array}\right\} \tag{D-8}$$

make use of the AS and (D-6) to eliminate some terms. The condition can be written by:

$$W_t^j\left(i_t\right) - W_t^j\left(i_{t-1}\right) = -\frac{1}{2}\varphi^2\left(\alpha^j + \lambda^2\right)\left(i_t - i_{t-1}\right)\left\{\left(i_t + i_{t-1}\right) - 2i_t^{j*}\right\} \tag{D-9}$$

We have that $W_t^j\left(i_t\right) = W_t^j\left(i_{t-1}\right)$ when either $i_t = i_{t-1}$ or $i_t = 2i_t^{j*} - i_{t-1} = \overline{i_t^j}$

D.3 Proof of proposition 5.4

Let's analyse the case when $E_t\pi_{t+1} > 0$, the proof for the opposite case is similar. When inflation expectations are positive, we have the following ordering for each member preferred interest rate:

$$i_t^{1*} > i_t^{2*} > i_t^{3*}$$

We will analyse three possible cases: when the agenda setter can set the interest rate equal to her most preferred rate $\left(i_t^{1*}\right)$, to the participation rate of either member 2 $\left(\overline{i_t^2}\right)$ or 3 $\left(\overline{i_t^3}\right)$, or the status-quo $\left(i_{t-1}\right)$. **Case 1:** when member 2 or member 3 accept agenda setter's preferred rate $\left(i_t^{1*}\right)$? The utility of member j in comparison with the status quo is:

$$W_t^j\left(i_t^{1*}\right) - W_t^j\left(i_{t-1}\right) = -\frac{1}{2}\varphi^2\left(\alpha^j + \lambda^2\right)\left(i_t^{1*} - i_{t-1}\right)\left\{\left(i_t^{1*} + i_{t-1}\right) - 2i_t^{j*}\right\}$$

This is positive for member 2 when $i_{t-1} < 2i_t^{2*} - i_t^{1*} < i_t^{2*} < i_t^{1*}$ or when $i_{t-1} > i_t^{1*}$. Similarly, this is positive for member 3 when $i_{t-1} < 2i_t^{3*} - i_t^{1*} < i_t^{3*} < i_t^{1*}$ or when $i_{t-1} > i_t^{1*}$. Then, since $i_t^{3*} < i_t^{2*}$, when either $i_{t-1} \leq 2i_t^{2*} - i_t^{1*}$ or $i_{t-1} > i_t^{1*}$ at least one member will accept i_t^{1*}. **Case 2:** when the agenda setter will prefer to attract the vote of member 2 with $i = \overline{i_2}$ instead of the vote of member 3 with $i = \overline{i_3}$?

Compare the utility of the agenda setter under both rates:

$$\begin{aligned} W_t^A\left(\overline{i_t^2}\right) - W_t^A\left(\overline{i_t^3}\right) &= -2\varphi^2\left(\alpha^A + \lambda^2\right)\left(i_t^{2*} - i_t^{3*}\right)\left\{\left(i_t^{2*} + i_t^{3*} - i_t^{1*}\right) - i_{t-1}\right\} \\ &= (-)\,(+)\,(?) \end{aligned}$$

She will prefer to attract the votes of member 2 with $i = \overline{i_2}$ when $i_{t-1} > i_t^{2*} + i_t^{3*} - i_t^{1*}$, otherwise she will prefer to attract the votes of member 3 with $i = \overline{i_3}$.

The agenda setter will always prefer to set i_t^{1*}. However, when it is not possible to obtain the votes for i_t^{1*}, she can obtain the votes of either member 2 or 3 setting the participation rate. But, we still need to compare if the agenda setter can be better-off with the status quo than with the participation rate. As the agenda setter has the first moving advantage, she can influence the votes of the other members if she prefer to maintain the rate unchanged. **Case 3:** when the agenda setter prefer the status quo to either $\overline{i_2}$ or $\overline{i_3}$? Compare the utility of the agenda setter under both cases:

$$W_t^A\left(\overline{i_t^j}\right) - W_t^A\left(i_{t-1}\right) = -2\varphi^2\left(\alpha^A + \lambda^2\right)\left(i_t^{j*} - i_{t-1}\right)\left\{i_t^{j*} - i_t^{1*}\right\}$$

for $j = 2 : W_t^A\left(\overline{i_t^2}\right) < W_t^A\left(i_{t-1}\right)$ when $i_{t-1} > i_t^{2*}$. Similarly, for $j = 3 : W_t^A\left(\overline{i_t^3}\right) < W_t^A\left(i_{t-1}\right)$ when $i_{t-1} > i_t^{3*}$.

Then, when $i_t^{2*} < i_{t-1} < i_t^{1*}$: the agenda setter will prefer the status quo to rate necessary to obtain the votes.

In the remaining area ($2i_t^{2*} - i_t^{1*} < i_{t-1} < i_t^{2*}$), since $2i_t^{2*} - i_t^{1*} > i_t^{2*} + i_t^{3*} - i_t^{1*}$, the agenda setter can attract the votes of member 2 setting $i_t = \overline{i_t^2}$. This define four areas of the interest rate reaction function when $E_t\pi_{t+1} > 0$.

D.4 Proof of proposition 5.6

Consider F as the forward operator, the Phillips curve equation and the IS equation can be expressed as:

$$\begin{aligned}(1-\beta F)\,\pi_t &= \lambda x_t + u_t && \text{(D-10)}\\ (1-F)\,x_t &= -\varphi\left(i_t - F\pi_t\right) && \text{(D-11)}\end{aligned}$$

where i_t is function of expected inflation. Multiply (D-10) by $(1-F)$ and subtract (D-11):

$$(1-F)(1-\beta F)\,\pi_t + \lambda\varphi\left(i_t - F\pi_t\right) = (1-F)\,u_t \quad \text{(D-12)}$$

In order to have a stable rational expectations equilibrium, we need that the roots of F in the left hand side of (D-12) being outside the unit circle.

Let's analyse first, the determinacy for member-j preferred policy rule:

$$i_t^* = \phi^j E_t\pi_{t+1} = \phi^j F\pi_t$$

The condition for determinacy is that root to the problem

$$\lambda\varphi\left(\phi^j - 1\right)F = -(1-F)(1-\beta F) \quad \text{(D-13)}$$

being outside the unit circle. The value of ϕ^j at the boundary $F = 1$ is $\phi^j = 1$. Similarly, the value at the boundary $F = -1$ is $\phi^j = 1 + 2\frac{1+\beta}{\lambda\varphi}$. Then, any value of $\phi^j \in \left[1, 1 + 2\frac{1+\beta}{\lambda\varphi}\right]$ satisfies the determinacy condition. As $\phi^1 > \phi^2 > \phi^3 > 1$, a sufficient condition for determinacy is that $\phi^1 < 1 + 2\frac{1+\beta}{\lambda\varphi}$.

To analyse the roots of F in (D-12) for the policy rule in proposition (5.4) or (5.5), note that it is bounded by preferred rate for member 1 and 3,that is: $i_t \in \left[\phi^3 F\pi_t, \phi^1 F\pi_t\right]$. Then

$$\begin{aligned}\left[-q(F) + \lambda\varphi\left(\phi^3 - 1\right)F\right]\pi_t &\leq q(F)\,\pi_t + \lambda\varphi\left(i_t - F\pi_t\right) && \text{(D-14)}\\ &\leq \left[q(F) + \lambda\varphi\left(\phi^1 - 1\right)F\right]\pi_t\end{aligned}$$

where we have defined the polynomial $q(F) \equiv -(1-F)(1-\beta F)$. In the following figure we graph the polynomial $q(F)$ and the two lines $\lambda\varphi\left(\phi^3-1\right)F$ and $\lambda\varphi\left(\phi^1-1\right)$, which satisfy the determinacy condition. The intersection of each line with $q(F)$ give the value for the root of F. On the other hand, the root for the policy function i_t is located on the segment of $q(F)$ between both lines. Also, note that any point in that segment satisfies the determinacy condition, and the exact position will depend on the last period interest rate.

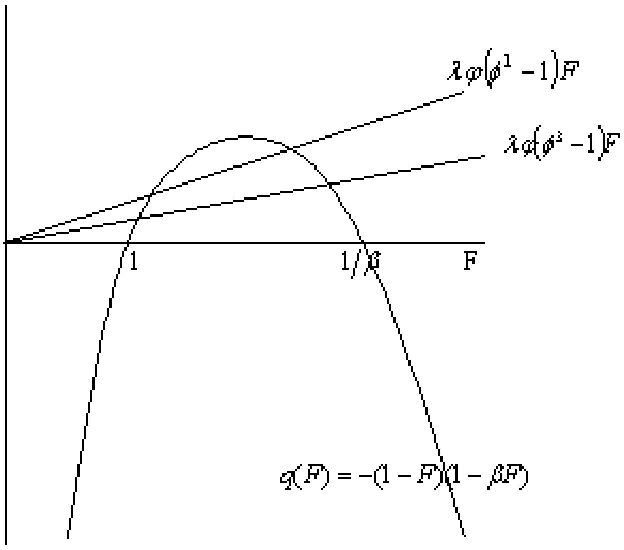

Figure D.1: Determinacy condition