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Designing Monetary Policy Committees

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Designing Monetary Policy Committees*

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Abstract

We integrate monetary policy-making by committee into a New Keynesian model to assess the consequences of the committee's institutional characteristics for inflation, output, and welfare. Our analysis delivers the following results. First, we demonstrate that transparency about the committee's future composition may be harmful. Second, we show that longer terms for central bankers lead to more effective output stabilization at the expense of higher inflation variability. Third, larger committees allow for more efficient stabilization of inflation but for less efficient output stabilization. Fourth, large committees and short terms are therefore socially desirable if the weight on output stabilization in the social loss function is low. Fifth, we show that a central banker with random preferences may be preferable to a central banker who shares the preferences of society.

Keywords: Monetary policy committees, term length, committee size, New Keynesian model.

JEL: E58, D71.

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1 Introduction

In most models of monetary policy, decisions on monetary policy are taken by a single central banker or are described by a mechanical interest-rate rule. By contrast, in most central banks, such as the Bank of England, the Bank of Japan, the European Central Bank, the Federal Reserve, or Sweden's Riksbank, monetary policy is determined by a committee.¹

What are the economic benefits and costs of monetary policy-making by committee?² What effect do committee size and the length of committee members' terms have on the performance of monetary policy? To address these questions, we introduce a monetary policy committee whose members have different preferences into an otherwise standard New Keynesian model.³

In our framework with stochastic preferences of policy-makers, an expectations channel is at work: In line with the New Keynesian Phillips curve, expectations about future policy-making have an impact on current inflation. As future policy-making will be determined by the institutional framework to a significant extent, the expectations channel opens up the possibility for term length and committee size to affect current inflation.

We obtain the following results. First, we derive analytical expressions for inflation, the output gap, and social losses for general decision-making rules and processes governing the evolution of the committee composition. Second, we show that counter to conventional wisdom, uncertainty about future monetary policy may be beneficial, where we interpret uncertainty as ignorance about the realization of given preference shocks as opposed to the introduction of noise to the monetary authority's preferences.

¹A notable exception is New Zealand.

²Gerlach-Kristen (2006) analyzes information aggregation in monetary-policy committees. Blinder and Morgan (2005) conduct an experiment to examine the performance and speed of decision-making in groups. The literature on monetary policy by committee has been nicely reviewed and discussed by Sibert (2006) and Blinder (2007).

³Beetsma and Jensen (1998), Sibert (2002), Gersbach and Hahn (2009), and Hahn (2009) introduce uncertainty about policy-makers' preferences into models of monetary policy and examine the implications of increased transparency for welfare, among other issues.

The underlying mechanism is that a lack of transparency about future monetary policy moderates inflation expectations and thus, in turn, current inflation.⁴

Third, we analyze how monetary policy is affected by term duration. We prove that the preference persistence caused by long terms makes for superior output stabilization but comes at the cost of higher inflation variance. As a result, short terms are desirable, provided that the weight on output stabilization in the social loss function is low.

Fourth, we demonstrate that larger committees involve less persistence in the preferences of the median central banker than smaller ones. This lower degree of persistence leads to improved inflation stabilization but less efficient output stabilization. Hence, if society attaches only a small weight to output stabilization, large committees will be desirable.

Fifth, we compare the welfare implications of a central banker with the same preferences as society with those of a central banker with random preferences that are on average identical to those of society. We show that plausible calibrations exist for which a central banker with random preferences is socially preferable.⁵ While it is well-known since Clarida et al. (1999) that the appointment of a conservative central banker can be socially beneficial in New Keynesian models, even in the absence of a classic inflation bias, our paper demonstrates that the delegation of monetary policy to a central banker with random preferences but the same average degree of conservatism as society may improve welfare as well.⁶

Our paper is related to several previous contributions to the literature on monetary-policy committees. The effects of size and term length on the performance of monetary policy as well as related institutional design questions have been addressed in neoclassical models by Sibert (2003), Mihov and Sibert (2006), Riboni (2010), and Eslava (2010). These papers assess how the design of the committee impacts on the incentives to build a reputation for avoiding the inflation bias and on the effectiveness of

⁴There is an extensive literature on transparency in monetary policy, which has been surveyed by Geraats (2002) and Hahn (2002).

⁵For other plausible calibrations, the opposite result can be achieved.

⁶The work on the delegation of monetary policy to a conservative central banker goes back to Rogoff (1985).

shock stabilization.⁷ In contrast to this work, we use the New Keynesian model as our workhorse, which allows for the possibility that the institutional design of the committee can influence current monetary policy outcomes via its effects on the expectations about future policy-making.

The interaction between the committee's decisions at different dates makes our analysis of monetary policy committees distinct from classic analyses of other committees like juries (see Black (1958)). More specifically, current policy-making is influenced by the committee's future decisions because current inflation depends on expectations about future inflation in the New Keynesian Phillips curve.⁸

Only few papers have integrated committee decision-making into the New Keynesian paradigm. Montoro (2007) finds that interest-rate smoothing may be the outcome of a bargaining process among policy-makers when the previous period's interest rate serves as the status quo in current meetings.⁹ Riboni and Ruge-Murcia (2008) draw on a New Keynesian model to estimate the preferences of monetary-policy committee members of the Bank of England. Both papers do not consider optimal committee design, which is our focus here.^{10,11}

Our paper is also related to papers that examine regime switches in New Keynesian models. Liu et al. (2009) show that the dynamics of inflation are greatly influenced by the possibility of future regime change. Debortoli and Nunes (2014) consider the case where policy-makers choose monetary policy optimally and can commit to future policies up to the point in time where a regime switch occurs. The present paper differs

⁷Utilizing a growth model with overlapping generations, Bullard and Waller (2004) assess the performance of different procedures for aggregating preferences in a monetary policy committee.

⁸The standard New Keynesian model employed here does not feature endogenous state variables. Hence current policy-makers cannot influence the behavior of future policy-makers.

⁹Riboni and Ruge-Murcia (2008) do not consider an explicit model of the economy but assume an exogenous process for members' preferred decisions. Assuming that the previous period's decision serves as the default option in the current decision, they show that committees may lead to dynamic inefficiency.

¹⁰In another paper, Riboni and Ruge-Murcia (2010) consider a backward-looking model to assess how well different voting protocols explain actual central-bank policies. Farvaque et al. (2009) examine how different decision rules impact on the volatility of policy rates.

¹¹Hefeker and Zimmer (2013) employ a two-period New Keynesian model to examine the optimal choice of central bankers' conservatism in a committee setting with ambiguity about the committee's decision procedures.

from these papers in three respects. First, it focuses on optimal monetary policy under discretion. Second, in the present paper changes in term duration affect both the probability of switching from the first regime to the second regime and the transition probability of switching back. By contrast, the papers mentioned above concentrate on the effects of the probability of regime change from the initial regime to the other regime. Third, in contrast with the previous literature, the present paper studies the optimal institutional design of monetary policy committees and the optimal term length of central bankers, in particular. In Section 4, we will explore the relationship of our findings with those in Liu et al. (2009) in more detail.

In a recent contribution, Hahn (2014) analyzes the socially optimal term length for a single central banker. The present paper differs from Hahn (2014) because it focuses on monetary policy committees and because it considers stochastic preferences of central bankers. Thus we assume here that some noise in the preferences of newly appointed candidates is unavoidable.¹² This assumption can be motivated in several ways. First, it may be the case that the government simply makes mistakes in its appointment decision. For example, the candidates' preferences may not be perfectly known to the government when it appoints new committee members. Second, the government may base its appointment decision not only on the candidates' preferences but also on other factors like party membership or personal relationships. Third, the incumbent government may appoint central bankers who share its preferences, but the preferences of the incumbent government may change over time due to elections. This approach to committee formation will be considered explicitly in one of the scenarios analyzed in this paper.

Our paper is organized as follows. Section 2 outlines the model. We derive a general solution to our model in Section 3. In Sections 4 and 5, we apply this general solution to different institutional set-ups. Section 6 concludes.

¹²The importance of preference heterogeneity and fluctuations in preferences for central banking has been confirmed empirically by Tootell (1999) and Meade and Sheets (2005).

2 Model

We take the canonical New Keynesian model as our starting point (see Clarida et al. (1999)). In each period t , the economy is described by the New Keynesian Phillips curve

$$\pi_t = \delta \mathbb{E}_t[\pi_{t+1}] + \lambda y_t + \xi_t, \quad (1)$$

where π_t is the inflation rate, y_t is the (log) output gap, δ is the common discount factor ($0 < \delta < 1$), and λ a positive parameter. We use $\mathbb{E}_t[\pi_{t+1}]$ to denote the rational expectations about inflation in period $t + 1$. Equation (1) can be derived from microeconomic foundations, as explained in detail in Woodford (2003, ch. 3, secs. 2.1 and 2.2). The markup shock ξ_t follows an $AR(1)$ process:

$$\xi_t = \rho \xi_{t-1} + \varepsilon_t. \quad (2)$$

The autocorrelation coefficient ρ is weakly positive and strictly smaller than one, the ε_t 's are independent and normally distributed with zero mean and common variance σ_ε^2 . For completeness, we could introduce an IS curve into our model. However, this would merely complicate the analysis and would not affect our results.

The per-period social loss function, which can also be derived from microeconomic foundations (see Woodford (2003, ch. 6, sec. 2.2)), is given by

$$l_t = \pi_t^2 + a y_t^2. \quad (3)$$

Monetary policy is conducted by a monetary policy committee. Individual committee members' loss functions are identical to (3), but may have a weight on the quadratic term y_t^2 different from a .

We note that we consider the different values for the individual central banker's weights on output stabilization as given. Hence we assume that some uncertainty about the preferences of central bankers is unavoidable. Different institutional designs of the central bank leave these values unchanged but change the way in which individual weights are aggregated and how the composition of the monetary-policy committee changes over time.

The individual preferences of the members are aggregated such that the committee's aggregate loss function in period t is

$$l_t^{CB} = \pi_t^2 + a_{s_t} y_t^2, \quad (4)$$

where a_{s_t} is a function of the central bank's current state s_t , which may take one out of finitely many values $\mathcal{S} = \{1, \dots, S\}$. The state s_t includes the information about the current central bankers' individual preferences. Accordingly, a_{s_t} , viewed as a function from \mathcal{S} to the set of positive real numbers, has the interpretation of an aggregation rule. The committee's expected intertemporal losses are

$$L_t^{CB} = \mathbb{E}_t \left[\sum_{i=0}^{\infty} \delta^i (\pi_{t+i}^2 + a_{s_{t+i}} y_{t+i}^2) \right]. \quad (5)$$

This general formulation allows for many different decision-making rules.

In this paper, we will focus on the case where central bankers decide on the preferred output gap by majority rule.¹³ This procedure leads to the adoption of the median central banker's position, as it would win against any other alternative policy in a pairwise vote. Hence a_{s_t} is given by the median of the different individual weights on output stabilization. It would be straightforward to model various bargaining procedures by considering an appropriate mapping from states s_t to a weighted average of the individual preference parameters. Moreover, one could easily specify a function that treats central bankers differently. In this way, one could assign more influence to a chairman, for example. However, these modifications would not plausibly affect our major findings about the effects of term duration and committee size qualitatively.

For now, we do not specify the set of possible committee states \mathcal{S} and how the committee's composition and hence its effective preferences a_{s_t} evolve over time. We merely assume that its evolution is given by a Markov chain with $S \times S$ Markov transition matrix P and S -dimensional row vector for the initial probabilities of the states. The composition of the committee is independent of the markup shock ξ_t . Later, we will characterize different institutional setups by specific sets \mathcal{S} and transition matrices P .

¹³If we introduced an IS-curve explicitly, we could make the equivalent assumption that members vote on the short-term nominal interest rate.

Because our approach to modeling monetary policy committees is rather abstract at this point, we outline briefly how it can be used to describe committees of arbitrary size, various appointment procedures, both fixed and stochastic term lengths, and arbitrary preference distributions of new central bankers. Suppose for example that the committee size was $N \geq 1$ and each incumbent central banker could be characterized by some weight $a^{(i)}$ from a set of potential weights \mathcal{A} with finitely many elements. Furthermore, let $\tau^{(i)}$ denote the number of periods that member i has been in office. Then the composition of the committee could be described by the state $s = (a^{(1)}, \tau^{(1)}, a^{(2)}, \tau^{(2)}, \dots, a^{(N)}, \tau^{(N)})$. The transition Matrix P could stipulate that, whenever a central banker i 's term ends ($\tau^{(i)} = T$), where T denotes some fixed term length, a new central banker is appointed whose type is drawn from some distribution over \mathcal{A} . Although it would be straightforward to look at fixed terms in this way, we will focus on random dismissal with a constant probability for simplicity (see Sections 4.3 and 5.1). As a consequence, we will not include tenure $\tau^{(i)}$ in the state vector s . Finally, we note that the state s could comprise the current preferences of the government, which might plausibly influence the preferences of new appointees. This strategy will be pursued in Section 5.2.

We extend the concept of discretionary equilibrium (see Oudiz and Sachs (1984) and Backus and Driffill (1986)) to our committee setting in the following way: In each period t , the committee selects the output gap and the inflation rate to minimize (5), subject to the Phillips curve (1), taking the future policy of the monetary policy committee and the public's expectations as given.

An alternative to the discretionary equilibrium is the equilibrium under commitment, which presupposes that the central bank can commit to a policy path for all future contingencies.¹⁴ We adopt the discretionary solution rather than the commitment solution for the following two reasons. First, our model involves conflicts of interest within the committee, which may impede commitment to future policies. Second, the committee composition changes over time, which makes it difficult for current central

¹⁴See, e.g., Clarida et al. (1999) for an exposition of the equilibrium under commitment.

bankers to make binding commitments regarding future monetary policy, in particular due to the fact that future central bankers may pursue different objectives.¹⁵

In the next section, we will derive general analytical expressions for the evolution of inflation and the output gap as well as social losses. These expressions hold for general sets \mathcal{S} , transition matrices P and preference aggregation rules. In Sections 4-5, we will introduce different scenarios, each of which will be characterized by a specific combination of \mathcal{S} , P , and aggregation rule a_{s_t} .

3 General Solution of the Model

In the following, we derive the discretionary equilibrium for a given Markov chain that describes the evolution of the committee's state s_t . The current state s_t is commonly known in all periods t . In each period t , y_t and π_t are chosen to minimize (5), subject to the Phillips curve (1), the shock process (2), and the Markov process for the transition of the committee state. The monetary-policy authority takes inflation expectations, the state s_t , the current shock ξ_t , and its own future policy as given.

Due to the absence of endogenous state variables, the optimization problem in period t involves only the minimization of current-period losses (4) and leads to the condition:

$$y_t = -\frac{\lambda}{a_{s_t}}\pi_t \tag{6}$$

We summarize this important observation in the following lemma:

Lemma 1

The discretionary equilibrium is given by the solution to (1), (2), and (6) for a given Markov chain for the committee state.

Equation (6) is a straightforward generalization of $y_t = -\frac{\lambda}{a}\pi_t$, which is the condition found in the literature for discretionary optimization by a policy-maker whose preferences are characterized by a constant weight on output stabilization a (see, e.g.,

¹⁵It might be interesting to examine a model where individual central bankers can commit to specific individual voting behaviors. This would be different from the approach pursued by Debortoli and Nunes (2014), where commitment is possible for the duration of a regime.

Eq. (3.3) in Clarida et al. (1999)). The additional complication in our model compared to standard analyses is that a_{s_t} is not constant, but evolves in line with the stochastic process for the committee state.

Using (6) to replace the output gap in the New Keynesian Phillips curve and solving for inflation π_t yields

$$\pi_t = \psi_{s_t} (\delta \mathbb{E}_t[\pi_{t+1}] + \xi_t), \quad (7)$$

where

$$\psi_\sigma := \frac{a_\sigma}{a_\sigma + \lambda^2}, \quad \forall \sigma \in \mathcal{S}. \quad (8)$$

As will become clear, it will be useful to introduce

$$\tilde{\psi}_\sigma := \frac{\lambda}{a_\sigma + \lambda^2}, \quad \forall \sigma \in \mathcal{S}. \quad (9)$$

In Appendix A, we show

Proposition 1

In a discretionary equilibrium, inflation and the output gap in period t , conditional on the state being $\sigma \in \mathcal{S}$, are

$$\pi_t = \left(\Psi(I - \delta \rho P \Psi)^{-1} E \right)_\sigma \xi_t, \quad (10)$$

$$y_t = - \left(\tilde{\Psi}(I - \delta \rho P \Psi)^{-1} E \right)_\sigma \xi_t, \quad (11)$$

where $\Psi := \text{diag}(\psi)$, $\tilde{\Psi} := \text{diag}(\tilde{\psi})$, I is the $S \times S$ dimensional identity matrix and E is an S -dimensional column vector of ones.¹⁶

It is important to notice that inflation and the output gap do not only depend on the current state σ , which describes the current preferences of the committee. They are also affected by the possible future preferences of the committee and thus depend on $\psi_{\sigma'}, \tilde{\psi}_{\sigma'} \forall \sigma' \in \mathcal{S}$ and the transition probabilities contained in P .

¹⁶We use ψ and $\tilde{\psi}$ to denote the S -dimensional column vectors with entries ψ_σ , $\sigma = 1, \dots, S$, and $\tilde{\psi}_\sigma$, $\sigma = 1, \dots, S$, respectively. Moreover, we use $\text{diag}(v)$ for some vector v to denote the diagonal matrix with the entries of v on its diagonal.

In our welfare comparisons, we will assume that a unique stationary distribution p_∞ exists and that the probability distribution over the states \mathcal{S} approaches p_∞ asymptotically over time, independent of the initial distribution.¹⁷ These assumptions about p_∞ will be fulfilled in all scenarios considered the following because there will always be some n with $n \geq 1$ for which $(P^n)_{ij} > 0 \forall i, j \in \mathcal{S}$.¹⁸ It is well-known (see Ljungqvist and Sargent (2004), ch. 2) that this property of P guarantees the existence and uniqueness of p_∞ as well as the convergence of the distribution of states towards p_∞ over time.

Together with Proposition 1, these observations immediately lead to the following corollary:

Corollary 1

The unconditional variances of inflation and the output gap are¹⁹

$$\text{Var}_\pi = (\Psi(I - \delta\rho P\Psi)^{-1}E)^T P_\infty (\Psi(I - \delta\rho P\Psi)^{-1}E) \cdot \frac{1}{1 - \rho^2} \cdot \sigma_\varepsilon^2, \quad (12)$$

$$\text{Var}_y = (\tilde{\Psi}(I - \delta\rho P\Psi)^{-1}E)^T P_\infty (\tilde{\Psi}(I - \delta\rho P\Psi)^{-1}E) \cdot \frac{1}{1 - \rho^2} \cdot \sigma_\varepsilon^2, \quad (13)$$

where $P_\infty = \text{diag } p_\infty$.

In the corollary, we have used the fact that the unconditional variance of the markup shock ξ_t is $1/(1 - \rho^2) \cdot \sigma_\varepsilon^2$.

In the following, we will specify different setups. Each setup will be associated with a Markov transition matrix P and a corresponding set of states \mathcal{S} . Using Corollary 1, we will then compute unconditional per-period social losses $\text{Var}_\pi + a \text{Var}_y$ for the respective matrices P and sets of states \mathcal{S} .²⁰ This will enable us to study the welfare implications of different institutional setups.

¹⁷The unique stationary distribution can be computed by solving $p_\infty P = p_\infty$.

¹⁸The only exception will be the thought experiment in Section 4.2.

¹⁹The superscript T denotes the transpose of a matrix.

²⁰Note that unconditional per-period social losses are identical to the unconditional discounted sum of social losses, up to a constant factor $1/(1 - \delta)$.

4 Individual Decision Maker

In this section, the following scenarios are introduced: First, we will consider the benchmark case where the monetary authority's preferences are not stochastic and always conformable with society's objectives. Second, we will use our results for the benchmark case to present a thought experiment on the welfare effects of transparency about the monetary authority's future preferences. Third, we will examine the case of an individual decision maker with random preferences. More specifically, we will consider the case where an individual decision maker is replaced from time to time by a new appointee from a pool of potential candidates with commonly known distribution of preferences. This case will enable us to analyze the optimal term length for the case of a single decision-maker. Finally, we will show that in some situations the delegation of monetary policy to a central banker with random preferences can be desirable over and against the delegation to a central banker who shares the preferences of society.

4.1 Benchmark scenario

In the benchmark scenario, the central bank minimizes social losses on a discretionary basis, i.e. in each period the central bank minimizes expected discounted social losses conditional on the current shock realization ξ_t , taking inflation expectations and future monetary policy as given. In this case, there is only one committee state ($S = 1$, $\mathcal{S} = \{1\}$). We obtain $P = 1$, $P_\infty = 1$, $E = 1$, $\Psi = a/(a + \lambda^2)$, and $\tilde{\Psi} = \lambda/(a + \lambda^2)$. As a result, Proposition 1 yields

$$\pi_t = \frac{a}{\lambda^2 + a(1 - \delta\rho)} \xi_t, \quad (14)$$

$$y_t = -\frac{\lambda}{\lambda^2 + a(1 - \delta\rho)} \xi_t. \quad (15)$$

These equations are identical to the ones obtained in the literature for the discretionary solution when monetary policy is chosen by an individual decision maker with society's preferences (see Clarida et al. (1999, p. 1672)).

In the benchmark scenario, the expressions in Corollary 1 for the unconditional variances of inflation and the output gap collapse to

$$\text{Var}_\pi = \left(\frac{a}{\lambda^2 + a(1 - \delta\rho)} \right)^2 \frac{1}{1 - \rho^2} \sigma_\varepsilon^2, \quad (16)$$

$$\text{Var}_y = \left(\frac{\lambda}{\lambda^2 + a(1 - \delta\rho)} \right)^2 \frac{1}{1 - \rho^2} \sigma_\varepsilon^2. \quad (17)$$

These expressions enable us to compute the unconditional expectation of social losses $\text{Var}_\pi + a \text{Var}_y$, which we use as a welfare measure. With the help of our findings for the benchmark case, we will discuss the effects of transparency about the central bank's preferences in the following. Subsequently, we will turn to more complex committee setups.

4.2 Transparency about the central bank's future preferences

As has been mentioned before, the benchmark scenario is instructive because it can be used to illustrate the impact of transparency about future monetary policy-makers' preferences on current inflation. We will present a simple thought experiment that will highlight the basic mechanism underlying this relationship.

Importantly, in our discussion of transparency we will compare two cases. In the first case, the public does not know the future realization of the central banker's preferences. In the second case, the future realization of the central banker's preferences is known already in the current period. Hence in our thought experiment we keep the distribution of the central banker's preferences fixed and flesh out the effects if the private sector becomes informed about the future preferences of the policy-maker.

Consider the economy in a particular period t . Suppose, without loss of generality,²¹ that $\xi_t = 1$. Monetary policy is currently in the hands of a central banker who shares society's loss function. It is commonly known that from period $t + 1$ on, there is a fifty percent chance of a central banker with weight a_1 taking office and remaining in charge indefinitely. There is also a fifty percent chance of a central banker with weight

²¹To be more precise, the following discussion is applicable for all $\xi_t \neq 0$.

$a_2 \neq a_1$ holding office from period $t + 1$ onward. In line with (14), a type- σ central banker with weight a_σ ($\sigma \in \{1, 2\}$) will entail an inflation rate of $\pi_{t+1} = \kappa_\sigma \xi_{t+1}$, where

$$\kappa_\sigma = \frac{a_\sigma}{\lambda^2 + a_\sigma(1 - \delta\rho)}.$$

If the identity of the future central banker is unknown in period t , the public expects inflation in period $t+1$ to be $\mathbb{E}_t[\pi_{t+1}] = \frac{1}{2}(\kappa_1 + \kappa_2)\rho$, where we have applied $\mathbb{E}_t[\xi_{t+1}] = \rho$. According to (7), the current incumbent chooses monetary policy such that

$$\pi_t = \psi_0 \left(\frac{1}{2} \delta (\kappa_1 + \kappa_2) \rho + 1 \right), \quad (18)$$

where $\psi_0 := \frac{a}{a + \lambda^2}$.

Next suppose that the identity of the future central banker is revealed in period t before inflation expectations are formed. In this case, inflation expectations are $\mathbb{E}_t[\pi_{t+1}] = \kappa_\sigma \rho$, conditional on the future central banker being of type $\sigma \in \{1, 2\}$.

If the type of the future central banker is known to be σ , we obtain

$$\pi_t = \psi_0 (\delta \kappa_\sigma \rho + 1). \quad (19)$$

It is clear from (18) and (19) that information about the future central banker's type does not affect the value of inflation π_t on average. However, it introduces a mean-preserving spread, as, in line with (19), inflation is high for a high value of κ_σ and low for a low value of κ_σ . Consequently, information about the central banker's preferences in the subsequent period increases inflation variance.

One can look at this finding from a slightly different angle by noting that (19) implies

$$\pi_t^2 = \psi_0^2 (\delta \kappa_\sigma \rho + 1)^2.$$

This expression is strictly convex in κ_σ . As a result, additional information about a_σ and thus κ_σ increases the expected value of π_t^2 .

As a next step, we analyze the impact of transparency on output variance. Recall that, according to (6), the output gap in period t is directly proportional to inflation:

$$y_t = -\frac{\lambda}{a} \pi_t$$

This observation has the immediate consequence that transparency about the preferences of the central banker in $t + 1$ also increases the variance of output. As a consequence, irrespective of the weight on output stabilization in the social loss function, transparency about future monetary policy-makers' preferences is harmful from a welfare perspective. Our findings counter the widespread view that predictability of monetary policy leads to a higher degree of policy effectiveness (see, for example, Poole (2005)). From a broader perspective, we contribute to the literature that identifies socially harmful consequences of central bank transparency.²²

4.3 Individual decision-maker with uncertain preferences

In this section, we suppose that a single decision maker selects monetary policy. While the case of an individual decision maker is less common nowadays than it was in the past (see Blinder and Morgan (2005)), the Reserve Bank of New Zealand is an example of a central bank where monetary policy is chosen by a single governor.

For simplicity, we assume that the decision maker may be one of two types, $\sigma = 1$ or $\sigma = 2$, characterized by two different weights a_σ on output stabilization in his loss function. Introducing more than two types would not deliver new insights for the case of a single decision-maker but would make it more difficult to grasp the intuition behind our findings. Without loss of generality, we will assume $a_1 > a_2$ in the following. Hence a_1 corresponds to a dovish regime; a_2 characterizes a hawkish regime. In each period t , the incumbent remains in office with probability p ($0 < p < 1$). With probability $1 - p$, the incumbent central banker is replaced by a new candidate, who is of either type $\sigma \in \{1, 2\}$ with equal probability. The preferences of the central banker who is in office are always commonly known. We note that the expected number of periods that an incumbent is in office is $1/(1 - p)$. Hence, term duration is positively related to the probability of remaining in office, p .

In Appendix B, we show that the following lemma follows from Proposition 1:

²²In a model of union wage setting, Sørensen (1991) was the first to argue that uncertainty may have desirable effects for the macroeconomy.

Lemma 2

For an individual central banker of type $\sigma \in \{1, 2\}$, inflation and the output gap are given by $\pi_t = \nu_{\pi, \sigma} \xi_t$ and $y_t = \nu_{y, \sigma} \xi_t$, where

$$\nu_{\pi, 1} = \frac{2a_1(Ba_2 + \lambda^2)}{2\lambda^4 + (A + B)(a_1 + a_2)\lambda^2 + 2a_1a_2AB}, \quad (20)$$

$$\nu_{\pi, 2} = \frac{2a_2(Ba_1 + \lambda^2)}{2\lambda^4 + (A + B)(a_1 + a_2)\lambda^2 + 2a_1a_2AB}, \quad (21)$$

$$\nu_{y, 1} = -\frac{2\lambda(Ba_2 + \lambda^2)}{2\lambda^4 + (A + B)(a_1 + a_2)\lambda^2 + 2a_1a_2AB}, \quad (22)$$

$$\nu_{y, 2} = -\frac{2\lambda(Ba_1 + \lambda^2)}{2\lambda^4 + (A + B)(a_1 + a_2)\lambda^2 + 2a_1a_2AB}, \quad (23)$$

and

$$A = 1 - \delta\rho, B = 1 - \delta\rho p. \quad (24)$$

It is instructive to compare our findings to Liu et al. (2009). Considering interest rate rules rather than optimal monetary policy-making under discretion like the present paper, they explore what they call expectation effects. In particular, they demonstrate that inflation under a dovish central banker responds less strongly to markup shocks when the possibility of change to a hawkish regime is taken into account compared to the case when the dovish central banker is expected to remain in office forever. This follows from the observation that the possibility that a hawkish central banker will conduct monetary policy in the future stabilizes inflation expectations and thereby also current inflation. Under a hawkish central banker, they find that inflation reacts more vigorously to markup shocks when there is the possibility of regime change. Analogous effects also exist in our model. This is shown formally in the following lemma:

Lemma 3

The higher the probability of the central banker remaining in office, the more strongly (weakly) inflation and output respond to markup shocks under a dovish (hawkish)

central banker, i.e.

$$\frac{d\nu_{\pi,1}}{dp} = \frac{2a_1\lambda^2(a_1 - a_2)(Aa_2 + \lambda^2)\delta\rho}{(2\lambda^4 + (A + B)(a_1 + a_2)\lambda^2 + 2a_1a_2AB)^2} > 0, \quad (25)$$

$$\frac{d\nu_{\pi,2}}{dp} = -\frac{2a_2\lambda^2(a_1 - a_2)(Aa_1 + \lambda^2)\delta\rho}{(2\lambda^4 + (A + B)(a_1 + a_2)\lambda^2 + 2a_1a_2AB)^2} < 0, \quad (26)$$

$$\frac{d|\nu_{y,1}|}{dp} = \frac{2\lambda^3(a_1 - a_2)(Aa_2 + \lambda^2)\delta\rho}{(2\lambda^4 + (A + B)(a_1 + a_2)\lambda^2 + 2a_1a_2AB)^2} > 0, \quad (27)$$

$$\frac{d|\nu_{y,2}|}{dp} = -\frac{2\lambda^3(a_1 - a_2)(Aa_1 + \lambda^2)\delta\rho}{(2\lambda^4 + (A + B)(a_1 + a_2)\lambda^2 + 2a_1a_2AB)^2} < 0. \quad (28)$$

The proof follows immediately from the expressions stated in Lemma 2 as well as $B = 1 - \delta\rho p$ and our assumption that $a_1 > a_2$.

Because we are interested in the optimal term length for an individual central banker, we analyze how changes in p affect the unconditional variances of inflation and output. While the findings from Lemma 3 that $\frac{d\nu_{\pi,1}}{dp} > 0$ and $\frac{d|\nu_{y,1}|}{dp} > 0$ suggest that inflation and output variance should be increasing functions of p , the findings that $\frac{d\nu_{\pi,2}}{dp} < 0$ and $\frac{d|\nu_{y,2}|}{dp} < 0$ suggest the opposite. Therefore it is not a priori clear whether a change in term length increases the unconditional variances of output and inflation or lowers them. In Appendix C, we show

Proposition 2

Longer terms, i.e. larger values of p , lead to an increase in unconditional inflation variance but to a reduction in the unconditional variance of output:

$$\frac{d\text{Var}_\pi}{dp} = \frac{4\lambda^4(a_1 - a_2)^2((a_1 + a_2)\lambda^2 + a_1a_2(A + B))\delta\rho}{(2\lambda^4 + (A + B)(a_1 + a_2)\lambda^2 + 2a_1a_2AB)^3} \frac{1}{1 - \rho^2} \sigma_\varepsilon^2 > 0, \quad (29)$$

$$\frac{d\text{Var}_y}{dp} = -\frac{4\lambda^4(a_1 - a_2)^2(AB(a_1 + a_2) + (A + B)\lambda^2)\delta\rho}{(2\lambda^4 + (A + B)(a_1 + a_2)\lambda^2 + 2a_1a_2AB)^3} \frac{1}{1 - \rho^2} \sigma_\varepsilon^2 < 0. \quad (30)$$

What is the interpretation of the result that larger values of p entail larger values of Var_π ? We observe that the unconditional variance of inflation can be written in the following way: $\text{Var}_\pi = \frac{1}{2}(\nu_{\pi,1})^2 \text{Var}_\xi + \frac{1}{2}(\nu_{\pi,2})^2 \text{Var}_\xi$, i.e. it is the average of the inflation variance conditional on the regime being dovish (a_1) and the respective variance for a_2 , a hawkish regime. Due to $\frac{d\nu_{\pi,1}}{dp} > 0$ and $\frac{d\nu_{\pi,2}}{dp} < 0$, an increase in p leads to an increase in inflation variance conditional on the regime being dovish but a decrease for

a hawkish regime. Because of $\nu_{\pi,1} > \nu_{\pi,2}$, i.e. the stronger response to markup shocks under a dovish regime, the change in $\frac{1}{2}(\nu_{\pi,1})^2 \text{Var}_\xi$ dominates the one in $\frac{1}{2}(\nu_{\pi,2})^2 \text{Var}_\xi$. An analogous explanation can be used to explain the relationship between term length and output variance.

We observe that the effects of term length on inflation variance are broadly in line with Liu et al. (2009) and Debortoli and Nunes (2014), despite the differences between the modeling approaches listed in Section 1. However, our result that output variance is a decreasing function of term length contrasts with the numerical findings reported in Section 4.1 of Liu et al. (2009). Hence their results about the effects of transition probabilities on output variance, which they obtain for interest rate rules, do not extend to the case of optimal discretionary monetary policy studied in this paper.

What is the optimal term length for a single decision-maker? This depends on how strongly society values output stabilization. If a in the social loss function is high, society will benefit from the low variance of output under long terms. By contrast, long terms will be harmful to society if it puts high emphasis on inflation stabilization.

Hence to answer the question about optimal term length, we have to calibrate our model. We adopt the standard values selected by Clarida et al. (2000). For quarterly data, they choose $\delta = 0.99$, $\rho = 0.9$, and $\lambda = 0.3$. The variance of ε_t is not important for our findings and is thus normalized to 1. If the social loss function is derived from microeconomic foundations, we obtain the expression λ/θ for the weight a , where θ is the elasticity of substitution in the Dixit-Stiglitz index of aggregate demand (see Woodford (2003, ch. 6, sec. 2)). The markup under monopolistic competition is $1/(\theta - 1)$ over marginal costs. Assuming a plausible markup of 10% leads to a value of $\theta = 11$ and thus $a = \lambda/\theta \approx 0.03$.

We introduce uncertainty about preferences in the same way as Sørensen (1991). In particular, this approach ensures that the weights of inflation and output in the loss function, normalized to sum to one, are identical in expectations to the respective values in the social loss function ($1/2 \cdot 1/(1 + a_1) + 1/2 \cdot 1/(1 + a_2) = 1/(1 + a)$ and $1/2 \cdot a_1/(1 + a_1) + 1/2 \cdot a_2/(1 + a_2) = a/(1 + a)$). In this sense, the central bankers

Parameter	Value
δ	0.99
λ	0.3
ρ	0.9
a	0.03
a_1	0.0402
a_2	0.02

Table 1: Parameter values

share society’s preferences on average. For the different types of central bankers, we will consider the values $a_1 = 0.0402$ and $a_2 = 0.02$, which satisfy the two conditions stated above for $a = 0.03$.²³ We summarize our standard parameter values in Table 1.

For $a = 0.03$, which is the value indicated by the derivation of the social loss function from microeconomic foundations, an evaluation of (29) and (30) shows that the optimal term length would be as short as possible and thus only one quarter. However, our finding that short terms for central bankers are optimal also holds for the larger value of $a = 0.25$, which would be in line with values based on observed central bank policies (see Cecchetti and Krause (2002)).

4.4 Potential benefits of a central banker with random preferences

We have already mentioned that we consider the possible realizations of central bankers’ preferences as given. Nevertheless it might be of theoretical interest to address the question whether a central banker with random preferences can be socially beneficial. For this purpose, we compare a single decision-maker who shares society’s preferences, i.e. the benchmark scenario from Section 4.1, and a central banker with random preferences that are on average identical to those of society.

Maybe somewhat surprisingly, a central banker with random preferences may be conducive to welfare:

²³While these values are arbitrary to some extent, we have verified that our findings are qualitatively robust to changes in a_1 and a_2 that satisfy the property outlined above.

Proposition 3

Consider a fixed weight a for output stabilization in the social loss function. Suppose that

$$\lambda^2(1 + 3a - 2Aa) + a(Aa + 3A - 2) < 0. \quad (31)$$

Then a value of \bar{a}_1 with $\bar{a}_1 > a$ exists such that, for all weights a_1 and a_2 that satisfy

1. $a < a_1 < \bar{a}_1$ and
2. $1/2 \cdot a_1/(1 + a_1) + 1/2 \cdot a_2/(1 + a_2) = a/(1 + a)$,

the delegation of monetary policy to an individual with random preferences and a term of one period, i.e. $p = 0$, leads to strictly lower unconditional expectations of social losses compared to the case where monetary policy is conducted by a central banker who minimizes social losses.

The proof is given in Appendix D.

While it is well-known since Clarida et al. (1999) that the delegation of monetary policy to a conservative central banker can alleviate the so-called stabilization bias and thereby improve welfare in the canonical New Keynesian model even in the absence of a classic inflation bias (see Rogoff (1985)), we show that delegation to a central banker with stochastic preferences can also improve welfare.

For the values of a , ρ , δ , and λ reported in Table 1, it is immediate to verify that (31) is violated. However, small changes to these parameters ($\lambda = 0.2$, $\theta = 7$ and thus $a = \lambda/\theta = 0.029$) ensure that (31) is satisfied.²⁴ In this case, straightforward calculations reveal that, for a given level of $p = 0$, welfare is maximized by $a_1 = 0.042$ and, correspondingly, $a_2 = 0.016$.²⁵

What is the intuition underlying this finding? Consider $a_1 = a_2 = a$ as a starting point, i.e. the case where both regimes are identical. Next consider a small increase in a_1 and a small decrease in a_2 , compatible with $1/2 \cdot a_1/(1 + a_1) + 1/2 \cdot a_2/(1 + a_2) = a/(1 + a)$.

²⁴A value of θ implies a markup of $1/(1 - \theta) \approx 17\%$ of marginal costs.

²⁵However, it can be shown that the optimal delegation to a conservative central banker with non-stochastic preferences is superior to a decision-maker with random preferences for this parameter constellation.

As a result, the first regime has become more dovish and involves larger inflation fluctuations than before.²⁶ By contrast, the second regime has become more hawkish and therefore implies smaller inflation fluctuations. Proposition 3 depends on the fact that the second effect can dominate the first.

5 Monetary Policy Committees

In this section, we will generalize the previous scenario to the case of a committee comprising an arbitrary odd number of central bankers, who decide on monetary policy using the majority rule. In this scenario, we will re-examine the effects of term length and consider the consequences of committee size for monetary policy and welfare.

In addition, we will consider a scenario in which central bankers are appointed by the incumbent government in a two-party system. At each point in time, one party forms the government. This party can fill any vacancy on the monetary policy committee with candidates sharing its own preferences. This scenario can be used to re-assess the committee design questions addressed in the previous scenarios.

5.1 Committee of arbitrary size

The next scenario is a straightforward generalization of the case considered in the previous section: Monetary policy is not chosen by an individual decision-maker but by a committee comprising N ($N \geq 1$) decision-makers. As has been discussed before, we assume that the level of the output gap that represents the Condorcet winner is implemented. The position of a central banker with the median weight on output stabilization wins any pairwise vote on monetary policy and represents this unique Condorcet winner. Hence a_{s_t} corresponds to the median value of $a^{(i)}$ among all incumbent central bankers. In line with our previous analysis, we assume that each central banker may be one of two types, either having a weight a_1 or a weight a_2 on output stabilization in his loss function.

²⁶Because of the low weight on output stabilization in the social loss function, changes in the variance of output do not influence welfare significantly and can be ignored as a consequence.

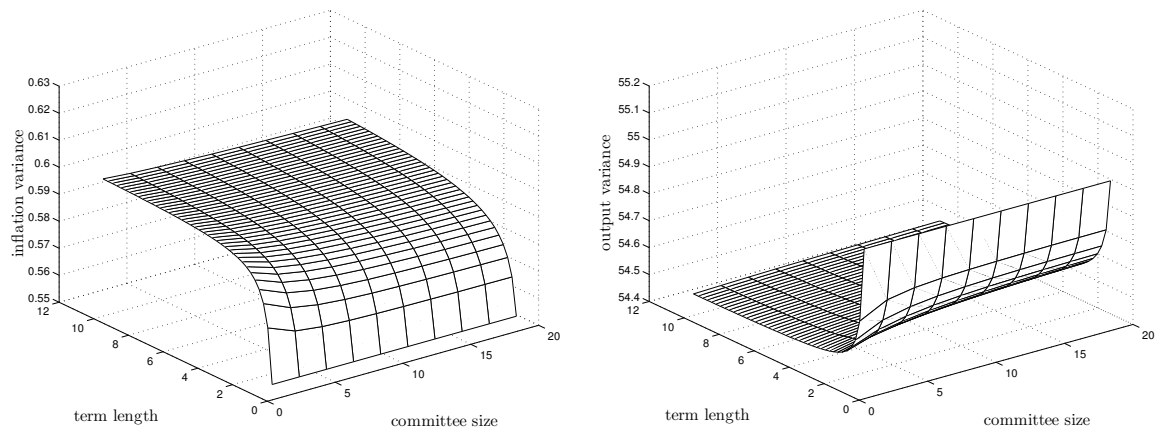


Figure 1: N-member committee: unconditional variances of inflation and output as a function of committee size and term length (in years). Parameters: $\delta = 0.99$, $\rho = 0.9$, $\lambda = 0.3$, $a_1 = 0.02$, and $a_2 = 0.0402$

We have already mentioned in Section 2 that we consider a constant probability of incumbents leaving office because this assumption makes it comparably easy to interpret the effects at work in our model. Thus we assume that, at the beginning of each period, each central banker remains in office with probability p ; otherwise he is replaced by a new candidate. The new candidate is of either type with equal probability. All events of central bankers being replaced are independent. We assume again that, at all times, the current composition of the committee is commonly known. In each period, the policy preferred by a majority of central bankers is adopted. For simplicity, we assume that N is odd. This is not essential but obviates the need to specify a tie-breaking rule to resolve draws. For a committee of size N , there are $S = N + 1$ different states because the committee may comprise $n = 0, 1, \dots, N$ members of type 1 (and $N, N - 1, \dots, 1, 0$ members of the second type accordingly). In Appendix E, we state the matrices necessary to evaluate (10)-(13).

The scenario with N committee members can be used to demonstrate that the trade-off created by longer terms, namely lower output variance at the expense of a higher inflation variance, extends to a committee setting. For this purpose, we display the variances of output and inflation for the parameter values specified in Table 1. These variances are provided as surface plots in Figure 1. The figure also reveals that, compared to term length, committee size has only a small effect on the variances of inflation

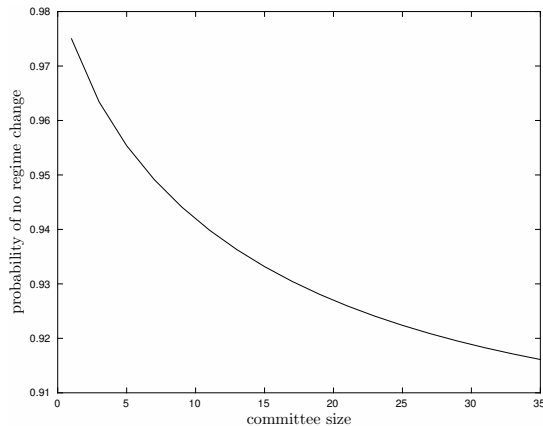


Figure 2: Probability of no regime change as a function of committee size. Parameters: $p = 0.95$

and output and thus on social welfare. Nonetheless, increases in committee size lead to a smaller inflation variance but a higher output variance.

This effect can be attributed to the consequences that committee size has for the persistence of the current regime, a_1 or a_2 . As illustrated by Figure 2, which displays the probability of no regime change between two adjacent periods as a function of committee size for $p = 0.95$ and thus a term length of 5 years, larger committees imply less persistent regimes than smaller ones, although the effect is quantitatively rather small.^{27,28} In line with our previous result from Section 4.3, these lower degrees of persistence involve lower inflation variance but higher output variance.

When the value of a is based on structural parameters and thus very small ($a = 0.03$), the consequences of term length and committee size for inflation variance dominate the welfare comparisons and changes in output variance can be neglected. As a result, very short terms and very large committees are desirable. Hence our model provides a new rationale for monetary policy-making by committee, supporting earlier findings in the literature (see Waller (2000), Blinder and Morgan (2005), and Gerlach-Kristen (2006)).

²⁷We have verified that this relationship is robust to changes in p .

²⁸One might expect the probability of no regime change to be p for $N = 1$. This, however, is not correct as one has to take into account that a central banker may be replaced by a new appointee with the same preferences. Hence, the probability amounts to $p + (1 - p) \cdot 1/2$, which corresponds to 0.975 for $p = 0.95$.

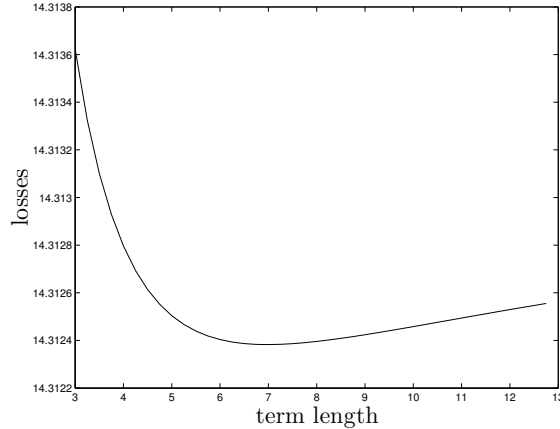


Figure 3: Three-member committee: unconditional losses as a function of expected term length in years. Parameters: $N = 3$, $\delta = 0.99$, $\rho = 0.9$, $\lambda = 0.3$, $a_1 = 0.02$, $a_2 = 0.05$, and $a = 0.25$

Finally, we note that, in principle, the finding about the desirability of very long terms can be overturned for alternative calibrations, e.g. for $a = 0.25$, which is the alternative value for a compatible with Cecchetti and Krause (2002). In Figure 3, we display social losses for a three-member committee as a function of term length. We choose $a_1 = 0.02$, $a_2 = 0.05$, and a larger value of a , $a = 0.25$. In this case, social losses have a minimum at a term length of roughly 7 years. This value optimally balances the costs of long terms, which arise from higher output variance and their benefits accruing from lower inflation variance. So our model is rich enough to yield interior solutions for the optimal term length of central bankers.²⁹

5.2 Government-appointed committee members

In the previous scenario, we considered a committee of N central bankers and assumed that each vacancy is filled with a candidate with random preferences. In particular, each new central banker was one of two types with equal probabilities. This approach did not take into account the fact that, in most countries, central bankers are appointed by elected politicians. This case, which provides an additional motivation for our

²⁹There are also calibrations that result in an optimal committee size that is finite and larger than one.

assumption that randomness in the central bankers' preferences cannot be avoided, is considered now.

We assume that there are two different parties, characterized by two different possible weights a_1 and a_2 . At the beginning of each period, there is a constant probability q ($0 < q < 1$) of the government remaining in office. With the complementary probability $1 - q$, the government is not re-elected and the other party forms the government. The current government fills all vacancies on the committee with candidates sharing its own preferences. Each seat on the committee becomes vacant with probability $1 - p$, the incumbent member continues to hold office with probability p ($0 < p < 1$).

To compute the results for this variant of our model, we have to choose a value for the expected number of consecutive periods that the incumbent party forms the government. For this purpose, we note that the government is elected for four years in many democracies. The empirical literature usually finds an incumbency advantage (see, e.g., Carey et al. (2000), Cox and Katz (1996), and Erikson (1971)). In line with these observations, we assume that the incumbent government is re-elected with a 55% probability, which implies that the expected time during which the government type does not change is $1/(1-0.55) \times 4 \approx 8.9$ years. A government with probability 0.9719 of surviving each quarter holds office roughly for the same expected time. Consequently, we set q to this value.³⁰

In Figure 4, we plot coefficients $(\Psi(I - \delta\rho P\Psi)^{-1}E)_\sigma$ as a function of the number of type-1 incumbents for a committee comprising thirteen members. These coefficients give the responsiveness of inflation to markup shocks. We distinguish between short terms (one year, left hand) and long terms (five years, right hand). Solid lines stand for a current government of type 1 and broken ones for one of type 2.

Several observations are noteworthy. First, the coefficients decrease monotonically in the number of type-1 central bankers. This is plausible because type-1 central bankers are more conservative and thus stabilize inflation more strongly. Second, all lines display a jump between 6 and 7, which is a consequence of the observation that at this

³⁰We have verified that our findings are not sensitive to the particular value of q .

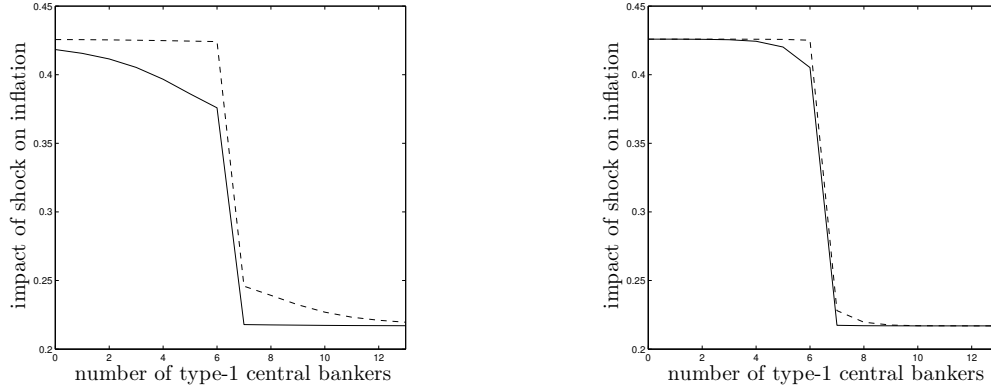


Figure 4: Government appointed committees: impact of markup shock on inflation, conditional on the incumbent government being of type 1 with $a_1 = 0.02$ (solid lines) or type 2 with $a_2 = 0.0402$ (broken lines). The number of type-1 central bankers is displayed on the horizontal axis. Left side: central bankers' term is 1 year. Right side: 5 years. Other parameters: $\delta = 0.99$, $\rho = 0.9$, and $\lambda = 0.3$. Government holds office for 8.9 years on average.

point the majority in favor of a particular policy changes in a committee consisting of thirteen members. Third, the jump is smaller for short term lengths, i.e. on the left-hand side, because in this case a narrow majority for type 2, for example, is unlikely to persist, conditional on the government being of type 1.

The third observation explains why inflation variance is a monotonically increasing function of central bankers' term lengths (see Figure 5). Moreover, Figure 5 shows that our previous finding that longer terms lower the variance of output extends to the scenario of government-appointed central bankers.

To sum up, short terms and large committees lead to low persistence in the median central banker's preferences, which results in a low variance of inflation but a high variance of output. As, based on microeconomic foundations, the weight on output stabilization in the social loss function is very small, the analysis of the scenario with government-appointed central bankers confirms our previous result that socially optimal committees are large and involve short terms for their members.

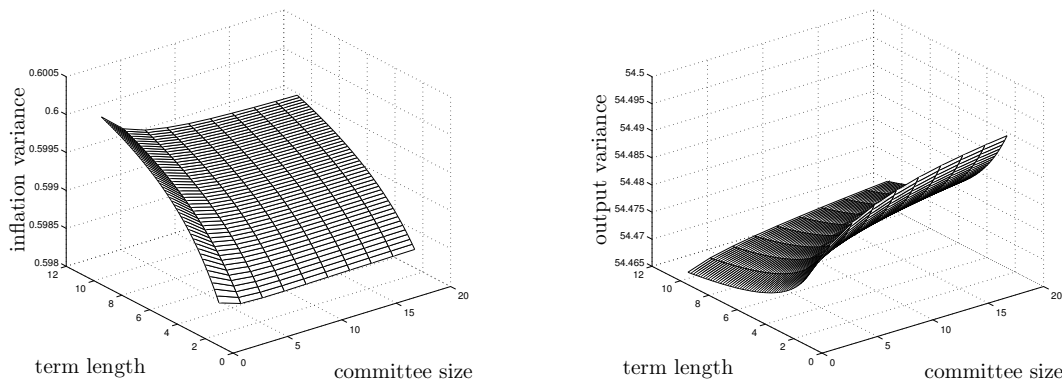


Figure 5: Government appointed committees: unconditional variances of inflation and output as a function of committee size and term length (in years). Parameters: $\delta = 0.99$, $\rho = 0.9$, $\lambda = 0.3$, $a_1 = 0.02$, $a_2 = 0.0402$, and $a = 0.03$. Government holds office for 8.9 years on average.

6 Conclusions

Our model has provided us with several insights about the consequences different characteristics of monetary policy committees have for welfare. We have demonstrated that the institutional parameters of the central bank’s decision-making body have an impact on the outcomes of monetary policy not only through their effect on the current composition of the central bank’s decision-making body. They influence expectations of future monetary policy in addition, which in turn affects current inflation.

This expectations channel may make uncertainty about the future composition of the monetary policy committee desirable, as uncertainty about the future monetary policy stance moderates inflation expectations. Moreover, we have shown that, in the New Keynesian model, more persistent preferences of the median central banker involve a tradeoff: They lead to more effective output stabilization at the expense of higher inflation variability. In our framework, both longer terms of individual central bankers and smaller committees raise the persistence of the monetary authority’s preferences. For the typical calibration of the social loss function based on microeconomic foundations, which assigns only a small weight to output stabilization, optimal committees involve a low degree of preference persistence. Hence, they are large and involve frequent

turnover. Finally, we have shown that the delegation of monetary policy to a central banker with random preferences may be socially desirable.

There are potentially relevant extensions to our model. First, learning on the job would imply an advantage of longer terms. Second, we have abstained from considering heterogeneous information. If information could not be aggregated effectively by consultations between a governor and the staff, then decision-making by committee would involve additional benefits. Third, if we considered more than two different preference realizations for members of a committee, larger committees would lead to more stable preferences of the median voter. However, in line with our results on the delegation of monetary policy to a central banker with stochastic preferences, it is unclear whether such a stabilization of preferences would be socially desirable. Fourth, if we introduced imperfect information about current central banker's preferences, the incentives for reputation building could be studied in our model for different committee designs.³¹ Examining the incentives for reputation-building in a New Keynesian model would be an interesting avenue for future research.

³¹So far, these incentives have only been considered in neoclassical models, as detailed in the Introduction.

A Derivation of Expressions for Inflation and the Output Gap

For convenience, we repeat (7):

$$\pi_t = \psi_{s_t} (\delta \mathbb{E}_t[\pi_{t+1}] + \xi_t)$$

Iterating forward yields

$$\pi_t = \mathbb{E}_t \left[\sum_{t'=0}^{\infty} \delta^{t'} \left(\prod_{i=0}^{t'} \psi_{s_{t+i}} \right) \xi_{t+t'} \right].$$

With the help of $\mathbb{E}_t[\xi_{t'+t}] = \rho^{t'} \xi_t$, this can be formulated as

$$\begin{aligned} \pi_t &= \mathbb{E}_t \left[\sum_{t'=0}^{\infty} (\delta \rho)^{t'} \left(\prod_{i=0}^{t'} \psi_{s_{t+i}} \right) \right] \xi_t \\ &= \psi_{s_t} \mathbb{E}_t \left[\sum_{t'=0}^{\infty} \left(\prod_{i=1}^{t'} \delta \rho \psi_{s_{t+i}} \right) \right] \xi_t, \end{aligned} \tag{32}$$

where we use the convention $\prod_{i=1}^0 \delta \rho \psi_{s_{t+i}} = 1$. We note that

$$\mathbb{E}_t \left[\psi_{s_t} \left(\prod_{i=1}^{t'} \delta \rho \psi_{s_{t+i}} \right) \right] = \left(\Psi (\delta \rho P \Psi)^{t'} E \right)_{s_t} \quad \forall t' \geq 0, \tag{33}$$

where the subscript s_t on the right-hand side denotes the s_t -th component of the S -dimensional vector $\Psi (\delta \rho P \Psi)^{t'} E$ and Ψ and E are defined in Proposition 1.³² Inserting (33) into (32) yields the following expression for inflation

$$\begin{aligned} \pi_t &= \left(\sum_{t'=0}^{\infty} \Psi (\delta \rho P \Psi)^{t'} E \right)_{s_t} \xi_t \\ &= \left(\Psi (I - \delta \rho P \Psi)^{-1} E \right)_{s_t} \xi_t, \end{aligned}$$

which proves (10). The expression for the output gap given in the proposition (see (11)) follows from the above expression for inflation, (6), (9), and $\tilde{\Psi} = \text{diag}(\tilde{\psi})$. \square

³²Eq. (33) can be derived by using the law of iterated expectations, the relationship $\mathbb{E}[\psi_{s_{t+t'}} | s_{t+t'-1} = \sigma] = (P\psi)_\sigma = (P \text{diag}(\psi)E)_\sigma = (P\Psi E)_\sigma$, and $\mathbb{E}[\psi_{s_{t+1}} \phi_{s_{t+1}} | s_t = \sigma] = (P \text{diag}(\psi)\phi)_\sigma = (P\Psi\phi)_\sigma$, which holds for arbitrary S -dimensional column vectors ϕ .

B Proof of Lemma 2

These assumptions imply the transition matrix

$$P = \begin{pmatrix} \frac{1}{2}(1+p) & \frac{1}{2}(1-p) \\ \frac{1}{2}(1-p) & \frac{1}{2}(1+p) \end{pmatrix}. \quad (34)$$

The entries on the diagonal, $1/2 \cdot (1+p)$ result from the observation that the probability of the incumbent remaining in office is p and that the probability of the incumbent being replaced by a new candidate of identical type is $1/2 \cdot (1-p)$. These terms add up to $1/2 \cdot (1+p)$. The off-diagonal entries can be obtained by noting that the entries in both rows have to add up to one.

The unique stationary distribution is given by the row vector $p_\infty = (1/2, 1/2)$. Moreover, we obtain the following expressions for $\Psi = \text{diag}(\psi)$ and $\tilde{\Psi} = \text{diag}(\tilde{\psi})$:

$$\begin{aligned} \Psi &= \begin{pmatrix} \frac{a_1}{\lambda^2 + a_1} & 0 \\ 0 & \frac{a_2}{\lambda^2 + a_2} \end{pmatrix}, \\ \tilde{\Psi} &= \begin{pmatrix} \frac{\lambda}{\lambda^2 + a_1} & 0 \\ 0 & \frac{\lambda}{\lambda^2 + a_2} \end{pmatrix}, \end{aligned}$$

where we have applied definitions (8) and (9). Armed with these expressions and taking into account $E = (1, 1)^T$, we can use Proposition 1 and Corollary 1 to compute inflation, the output gap, and welfare. \square

C Proof of Proposition 2

With the help of (20)-(23), $\text{Var}_\pi = \frac{1}{2}((\nu_{1,\pi})^2 + (\nu_{2,\pi})^2) \text{Var}_\xi$, and $\text{Var}_y = \frac{1}{2}((\nu_{1,y})^2 + (\nu_{2,y})^2) \text{Var}_\xi$, the unconditional variances of inflation and output can be written as

$$\text{Var}_\pi = \frac{2((a_1)^2(Ba_2 + \lambda^2)^2 + (a_2)^2(Ba_1 + \lambda^2)^2)}{(2\lambda^4 + (A+B)(a_1 + a_2)\lambda^2 + 2a_1a_2AB)^2} \frac{1}{1 - \rho^2} \sigma_\varepsilon^2, \quad (35)$$

$$\text{Var}_y = \frac{2\lambda^2((Ba_1 + \lambda^2)^2 + (Ba_2 + \lambda^2)^2)}{(2\lambda^4 + (A+B)(a_1 + a_2)\lambda^2 + 2a_1a_2AB)^2} \frac{1}{1 - \rho^2} \sigma_\varepsilon^2. \quad (36)$$

Taking $B = 1 - \delta\rho p$ into account, it is now straightforward to compute (29) and (36).

\square

D Proof of Proposition 3

Suppose that $p = 0$. According to (35) and (36), per-period unconditional expected losses are

$$\text{Var}_\pi + a \text{Var}_y = \frac{2((a_1 + \lambda^2)^2((a_2)^2 + a\lambda^2) + (a_2 + \lambda^2)^2((a_1)^2 + a\lambda^2))}{(2\lambda^4 + (A + 1)(a_1 + a_2)\lambda^2 + 2a_1a_2A)^2} \frac{1}{1 - \rho^2} \sigma_\varepsilon^2. \quad (37)$$

Solving $1/2 \cdot a_1/(1 + a_1) + 1/2 \cdot a_2/(1 + a_2) = a/(1 + a)$ for a_2 and using the resulting expression to replace a_2 in (37) results in a function of a_1 , which we denote by $f(a_1)$. It is straightforward to compute the first derivative of $f(a_1)$ with respect to a_1 . Evaluated at $a_1 = a$, this derivative is zero, which is plausible and can be readily verified. The second-order derivative, evaluated at a_1 , is

$$f''(a_1)|_{a_1=a} = \frac{2a\lambda^2 [\lambda^2(1 + 3a - 2Aa) + a(Aa + 3A - 2)]}{(1 + a)(a + \lambda^2)(Aa + \lambda^2)^3} \frac{1}{1 - \rho^2} \sigma_\varepsilon^2. \quad (38)$$

As a result, $f(a_1)$ has a local maximum at $a_1 = a$ if $f''(a_1)|_{a_1=a}$ is negative or, equivalently, (31) holds. This implies the claim of the lemma. \square

E Appendix to Section 5.1

In this appendix, we derive the transition matrix P and the matrices Ψ and $\tilde{\Psi}$ for the scenario with N committee members. We start with the $(N + 1) \times (N + 1)$ matrix P . With slight abuse of notation, we write $P(n, n') = P_{n+1, n'+1}$ for the probability of the committee comprising n' members of type 1 in the next period, conditional on it comprising n members of this type in the current period. Moreover, we introduce $r := 1/2 \cdot (1 + p)$ as the probability of a particular seat on the committee being filled by a member of identical type after one period (notice that this expression can be decomposed into p , which is the probability of a member remaining in office, and $1/2 \cdot (1 - p)$, which is the probability of the member leaving the committee but being replaced by a candidate with identical preferences). After these preliminary steps, the

probability of the committee comprising n' type-1 members, given that it contained n members of this type in the previous period, can be stated as

$$P(n, n') = \sum_{\tilde{n}=\max\{0, n'+n-N\}}^{\min\{n', n\}} \binom{n}{\tilde{n}} r^{\tilde{n}} (1-r)^{n-\tilde{n}} \binom{N-n}{n'-\tilde{n}} (1-r)^{n'-\tilde{n}} r^{N-n-(n'-\tilde{n})}. \quad (39)$$

This expression is somewhat involved but can be interpreted in the following way. The sum is over \tilde{n} , which counts the number of experts who were originally of type 1 and who are still of this type one period later. The respective probability is $\binom{n}{\tilde{n}} r^{\tilde{n}} (1-r)^{n-\tilde{n}}$. We are only counting constellations, where the new total number of type-1 central bankers is n' , which means that $n' - \tilde{n}$ of the $N - n$ central bankers who were of type 2 in the previous period have changed their types. The respective probability is $\binom{N-n}{n'-\tilde{n}} (1-r)^{n'-\tilde{n}} r^{N-n-(n'-\tilde{n})}$. Combining these expressions yields (39), which completely characterizes matrix P .

Finally, we need to specify Ψ and $\tilde{\Psi}$. For this purpose, we have to take into account that the median voter's weight on output stabilization is a_2 if n , i.e. the number of type-1 central bankers, is smaller than or equal to $(N-1)/2$. It is a_1 otherwise. This gives

$$\Psi = \text{diag}(\underbrace{\psi_2, \psi_2, \dots, \psi_2}_{(N+1)/2 \text{ times}}, \underbrace{\psi_1, \psi_1, \dots, \psi_1}_{(N+1)/2 \text{ times}}), \quad (40)$$

where again $\text{diag}(v)$ for a vector v is the diagonal matrix with the entries of v on its diagonal. Analogously to Ψ , $\tilde{\Psi}$ is given by

$$\tilde{\Psi} = \text{diag}(\underbrace{\tilde{\psi}_2, \tilde{\psi}_2, \dots, \tilde{\psi}_2}_{(N+1)/2 \text{ times}}, \underbrace{\tilde{\psi}_1, \tilde{\psi}_1, \dots, \tilde{\psi}_1}_{(N+1)/2 \text{ times}}), \quad (41)$$

where we have used the definition of $\tilde{\psi}_\sigma$ in equation (9). Equations (40) and (41) can be plugged into (10)-(13) to obtain expressions for the output gap, inflation and their unconditional variances. \square

F Appendix to Section 5.2

In this appendix, we provide details on how to compute the equilibrium in the scenario where committee members are appointed by the government. As a preliminary step,

we specify the set of states $\mathcal{S} = \{1, \dots, S\}$. The number of states S amounts to $(N + 1) \times 2$, which follows from the observation that there are $(N + 1)$ different committee compositions (there may be $0, 1, \dots, N$ central bankers of type 1) and two different government types. We introduce the following convention for the labeling of states $\sigma \in \mathcal{S}$. If there are n ($0 \leq n \leq N$) members of type 1 and the government is of type $\tau \in \{1, 2\}$, then the state is

$$\sigma := (n + 1) + (N + 1)(\tau - 1).$$

Thus we arrange the (n, τ) 's ($0 \leq n \leq N$, $\tau \in \{1, 2\}$) in the order

$$(0, 1), (1, 1), (2, 1), \dots, (N, 1), (0, 2), (1, 2), (2, 2), \dots, (N, 2).$$

Consequently, the matrices Ψ and $\tilde{\Psi}$ are

$$\begin{aligned} \Psi &= \text{diag} \left(\underbrace{\psi_2, \psi_2, \dots, \psi_2}_{(N+1)/2 \text{ times}}, \underbrace{\psi_1, \psi_1, \dots, \psi_1}_{(N+1)/2 \text{ times}}, \underbrace{\psi_2, \psi_2, \dots, \psi_2}_{(N+1)/2 \text{ times}}, \underbrace{\psi_1, \psi_1, \dots, \psi_1}_{(N+1)/2 \text{ times}} \right), \\ \tilde{\Psi} &= \text{diag} \left(\underbrace{\tilde{\psi}_2, \tilde{\psi}_2, \dots, \tilde{\psi}_2}_{(N+1)/2 \text{ times}}, \underbrace{\tilde{\psi}_1, \tilde{\psi}_1, \dots, \tilde{\psi}_1}_{(N+1)/2 \text{ times}}, \underbrace{\tilde{\psi}_2, \tilde{\psi}_2, \dots, \tilde{\psi}_2}_{(N+1)/2 \text{ times}}, \underbrace{\tilde{\psi}_1, \tilde{\psi}_1, \dots, \tilde{\psi}_1}_{(N+1)/2 \text{ times}} \right). \end{aligned}$$

To derive P , we first compute an auxiliary $(N+1) \times (N+1)$ matrix \tilde{P} , which contains the transition probabilities, given the fixed type of government $\tau = 1$. In particular, for $n = 0, \dots, N$ and $n' = 0, \dots, N$, $\tilde{P}(n, n') = \tilde{P}_{n+1, n'+1}$ gives the probability of the committee comprising n' type-1 members if there were n type-1 members in the previous period, conditional on the government being of type 1. The entries of the auxiliary matrix can be expressed as

$$\tilde{P}(n, n') = \begin{cases} \binom{N-n}{n'-n} (1-p)^{n'-n} p^{N-n'} & \text{for } n' \geq n \\ 0 & \text{for } n' < n. \end{cases} \quad (42)$$

We note that \tilde{P} is upper triangular. This observation follows from the fact that the government will fill every vacancy with a candidate sharing its objectives. As a consequence, the number of type-1 central bankers cannot decrease, conditional on the incumbent government being of type 1.

Example: It is instructive to consider $N = 1$ as an example. In this case, we obtain

$$\tilde{P} = \begin{pmatrix} p & 1-p \\ 0 & 1 \end{pmatrix}.$$

The entries are readily interpreted. In the first row, the first entry (p) gives the probability that, given that the single committee member is not of type 1 (and hence of type 2), he will also be of type 2 one period later. This can only occur when this particular central banker remains in office. Otherwise, the government, which is of type 1, will replace the central banker with someone of its own type (this will occur with probability $1 - p$, which yields the second entry in the first row). In the second row, the entry “1” can be explained by the observation that a central banker of type 1 will always be replaced by a candidate with the same preferences, given that the government is of type 1. If the government were fixed for all periods, then the entry “1” would be associated with an absorbing state $n = 1$.

Let \hat{P} be \tilde{P} , rotated by 180 degrees. Matrix \hat{P} gives the probabilities of transitions from a committee comprising n type-1 members to one of n' type-1 members conditional on the government being of type $\tau = 2$ (rather than type 1 as in the case of \tilde{P}). Because \hat{P} is the result of a 180-degree rotation of the upper triangular matrix \tilde{P} , it is lower triangular.

Example (continued): We use the example with $N = 1$ to illustrate \hat{P} 's properties:

$$\hat{P} = \begin{pmatrix} 1 & 0 \\ 1 - p & p \end{pmatrix}.$$

The interpretation is very similar to the one of \tilde{P} . Conditional on the government being of type 2, a central banker who is of type 2 will always be succeeded by a central banker of the same type. This explains the first row, which gives the transition probabilities for an initial central banker of type 2. The second row implies that a central banker of type 1 will remain in office with probability p . With the complementary probability, he will resign and be replaced by a candidate of type 2.

With the auxiliary matrices \tilde{P} and \hat{P} , we are now in a position to write P as:

$$P = \begin{pmatrix} q\tilde{P} & (1 - q)\hat{P} \\ (1 - q)\tilde{P} & q\hat{P} \end{pmatrix} \quad (43)$$

Example (continued): In the example with a one-member committee, the transition matrix P is

$$P = \begin{pmatrix} qp & q(1-p) & 1-q & 0 \\ 0 & q & (1-q)(1-p) & (1-q)p \\ (1-q)p & (1-q)(1-p) & q & 0 \\ 0 & 1-q & q(1-p) & qp \end{pmatrix}.$$

Consider, e.g., the third entry in the second row, which is $(1-q)(1-p)$. This expression gives the transition probability from $(n = 1, \tau = 1)$ or $\sigma = 2$ (the central banker and the government are of type 1) to $(n' = 0, \tau' = 2)$ or $\sigma' = 3$ (the government and the central banker are of type 2).³³ This transition occurs if the government changes, which happens with probability $1-q$, and the new government immediately has the opportunity to pick a new central banker, which happens with probability $1-p$.

Finally, we note that there are several zero entries in P . This is a result of the fact that transitions in which the government in the next period will be of type τ , while at the same time the number of central bankers sharing its preferences will decrease, are impossible. This follows from the observation that each government fills all vacancies with central bankers sharing its objectives.

However, it is always possible to reach every state $\sigma' \in \mathcal{S}$ from all states $\sigma \in \mathcal{S}$ in two steps, as can be verified formally by computing P^2 .³⁴ This fact is crucial as it guarantees the existence of a unique stationary distribution. Moreover, it ensures that this distribution is reached asymptotically, irrespective of the starting distribution. \square

³³Recall that n and n' give the numbers of type-1 central bankers in a particular period and a consecutive period respectively. This entails, in particular, that the central banker is of type 2 when the number of type-1 central bankers is zero ($n' = 0$).

³⁴To see that all entries in P^2 are strictly positive, one can compute P^2 by using (43). The claim then immediately follows from the facts that \tilde{P} is upper triangular with all entries in the upper-right part (including the diagonal entries) strictly positive and that \hat{P} is lower triangular with all entries in the lower-left part (again including the diagonal) strictly positive.

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