Central Bankers in Government Appointed Committees*

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Abstract

I study the policy choices of members of a central bank committee, who are appointed by the government. Central bankers balance their desire to protect the Central Bank's reputation against their interest to be reappointed. Committees can be more successful than single central bankers at reducing inflation and isolating policy from government pressures. These gains are only achieved if the committee is small, and its members' turnover rate is low. The former implies high probability that a single vote affects policy, while the latter is associated with a low risk of being replaced for not supporting the government's preferred policy.

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1 Motivation

The optimal institutional design of an independent Central Bank (CB) has been a subject of great interest to legislators, central bankers, and academics alike. One of the sticky points concerns how much independence the CB should be given. Although the importance of CB independence is widely recognized, there is also ample agreement that the CB should not be completely isolated from the government. This is in part due to the need for coordination between monetary and fiscal policy, but also because the participation of publicly-elected officials in the determination of policy decisions is a core principle of democratic systems. The dilemma is how to achieve sufficient CB independence to alleviate both inflation bias and ties between monetary policy and the electoral cycle, without completely isolating monetary policy from government influence.

In practice, such a dilemma is frequently addressed by placing the design of monetary policy in the hands of a committee of central bankers, while giving the government some power over the appointment of its members. The idea is that, while the power to make appointments creates a channel for the government to participate in monetary policy decisions, the larger set of decision-making mechanisms and appointment rules available under a committee arrangement can be exploited to make policy more independent from government's pressures than it would be under a single central banker appointed by the government (Bullard and Waller, 2004; Waller, 1989 and 2000; Lohman, 1997; Faust, 1996; and Dal Bó, 2006). For any given position of each individual member, a committee offers the possibility of optimally designing mechanisms through which individual positions are aggregated, in order to keep the influence of the government under control.

Although this argument points to what are certainly important advantages of committee designs, it fails to recognize that central bankers embedded in such a setting may in fact not behave as they would in the absence of government appointments, or in a single central banker framework. Put another way, the policy positions of individual members are not given. This paper brings into the picture the potential effects of collective decision-making and government appointments on the choices of individual central bankers. Accounting for these dimensions makes clear that, under some circumstances, a committee structure may not help isolate monetary policy from the electoral cycle, or reduce inflation bias. In particular, the size of the committee and the fraction of members over whose appointment the government has influence are key determinants of the effects of collective decision-making. and government appointments.

The introduction of collective decision-making and government power over appointments can affect the incentives faced by central bankers in ways that are particularly acute when informational

asymmetries give rise to reputation concerns. As the previous literature has pointed out, central bankers may want to build a reputation for the CB as being tough on inflation (Backus and Driffill, 1985; Barro, 1986). Yet, this is not the only source of reputation-building incentives when appointments to the CB are a privilege of the government. In fact, a central banker may care about the government's perception of him (i.e., how close his preferences are to those of the government, and how loyal to the government he is), as such perception will likely affect his chances of being reappointed. Hence, a central banker may want to establish a reputation of being close to the government.[1]

Moreover, how these reputation-building incentives play into a central banker's decisions depends crucially on whether policy is chosen by an individual or a committee. More specifically, reappointment probabilities are affected by government perceptions of individual central bankers, while inflation expectations are affected by the public's perception of the CB as a whole. In a single policy-maker environment the central banker is equivalent to the CB; hence, there is no difference between the CB's reputation and that of the policy-maker. Under a committee, however, there is a potential dichotomy between *individual members' reputation* and the *collective reputation* of the CB. I argue below that the collective reputation of the CB is affected by actual policy, rather than by the vote of each individual central banker. Since the vote of a central banker may not be reflected in actual policy, each member knows that his vote will only have a limited effect on the collective reputation of the CB. Hence, under a committee, the incentive to show closeness to the government can override the incentive to build a reputation of toughness for the CB, as well as other considerations. The conclusion that a committee design limits the influence of the government on monetary policy may, therefore, not hold in all contexts.

Motivated by these considerations, I study how the reputation-building incentives faced by central bankers are affected by the government's appointment powers and by collective decision-making. I frame my analysis in a two-period model along the lines of Barro and Gordon (1983), where reputation considerations are taken into account (as in Backus and Driffill, 1985). I introduce committee decision-making and the possibility of the endogenous reappointment of CB members. In this setting I address the tension between the CB's collective reputation and members' individual reputations, as discussed above.

The model in this paper shows that, compared to a single central banker setting, one based on a committee design has the potential to both increase the importance a central banker gives to building the CB's reputation as being tough on inflation, and reduce the importance given to reappointment

[1] As an example, Ersenkal et al. (1985), find that the monetary base in the U.S. expands faster in the months preceding the decision as to the reapointment of the Federal Reserve Board chairman.

considerations. The realization of this potential, however, depends crucially on the specific features of the committee design, in particular its size and the fraction of its members the government can replace from one period to the next. An increase in the fraction of members replaced each period reduces the relevance of past inflation for future expectations of inflation, thus making central bankers less wary of raising current inflation. It also increases the risk of a central banker being removed from office if it is believed that his type is different from that of the government, thus generating more incentives to follow the government's preferred policy. As a result, a lower turnover rate leads to both a lower inflation bias and less incentives to please the government by choosing its preferred policy. On the other hand, other things being equal, an increase in the size of the committee reduces the ability of any single central banker to affect actual policy, thus increasing the importance central bankers give to influencing reappointment decisions relative to choosing their preferred policy. Small size committees, therefore, are better suited to reducing the influence of the government (for a given turnover rate).

The effect of collective decision-making on the incentives faced by central bankers has been addressed by Sibert (2003) and Mihov and Sibert (2006). With respect to those studies, the current paper adds an analysis of how government appointments affect the incentives of central bankers. As mentioned, the effect of group policy-making differs when government appointments are brought into the picture. Moreover, these authors assume that expectations about the CB are based on the individual votes of central bankers, rather than on past policy. Therefore, the tension between individual reputations and collective reputation emphasized in this paper does not arise in those previous studies.

My results contribute to the debate on the optimal institutional design of the CB. First, I qualify the conditions under which a committee structure might be preferable to a single central banker, in terms of making the incentives for central bankers consistent with minimal inflation bias and minimal variability of policy over the electoral cycle. Second, the model sheds light on considerations that should play an important role in defining the optimal size of the CB committee and the optimal turnover rate of its members. The optimal size of and turnover rate for a CB committee have been at the center of the policy debate.[2] The literature, however, has still to provide the arguments that should guide this discussion. A first step toward this goal was taken by Waller (1989, 2000) and Waller and Walsh (1996), who show that a lower turnover rate helps to isolate policy from political

[2] Alesina, Carrasquilla and Steiner (2005), for instance, make recommendations for reforming the Colombian CB. They recommend "reduction from the current 5 members of the board to 3 (...), lengthening the term of office of the Governor to seven years" (pp 17-18).

influence, though at the cost of potentially locking bad policies into place. These studies take the positions of central bankers as a given. I add to those studies by analyzing the effect of turnover on a central banker's position and by studying the effect of the committee's size for a given turnover rate.

The paper is divided in six sections, inclusive of this introduction. In section 2, I review some of the relevant literature, and discuss the contributions of this paper in greater detail. Section 3 discusses the general setting of the model, and solves the general problem of a central banker. Section 4 compares how that solution differs between the case of a single central banker and that of a board of directors. Section 5 introduces government appointments. Section 6 concludes.

2 A little perspective: the literature on government appointments and central bank committees

The effects of government appointments on monetary policy, as chosen by a committee, have been previously studied by Lohman (1997) and Waller (1989, 2000). These papers extend Alesina's (1987) model of partisan cycles in monetary policy and output to account for committee decision-making and government appointments to the CB. A central assumption in Waller (1989) and Lohman (1997) is that each government can change some CB's members during its term, and it appoints central bankers who belong to its own party. The only source of uncertainty is which party will win the following elections; the types of central bankers are not private information, and as a result each committee member always votes for the policy preferred by his political principal. The basic result is that a well designed committee can reduce inflation cycles because it generates more stable CB preferences than a single central banker arrangement. This implies less uncertainty about the future decisions of the central bank, thus also reducing output cycles. Waller (1989) shows that lengthening the terms of central bankers (reducing the fraction of members changed at each point in time) further reduces cyclical variations, because it implies even less uncertainty about the future preferences of the CB. The decentralization of appointments is shown by Lohman (1997) to have a similar effect.

Waller (2000) shows another reason why a committee design can reduce the variability of monetary policy over the political cycle: some types of appointment rules available under committee designs can reduce a government's incentives to make partisan appointments. In particular, when central bankers are nominated by the government and confirmed by the congress, the government may have incentives to nominate candidates from the mid-range of the political spectrum rather than members of its own party in order to guarantee confirmation. Confirmation of one's candidate is important not only to

have that candidate rule the CB in the current period, but also because, if the seat is left empty and the incumbent government happens to lose the next election, the seat will be filled with the opposing party's candidate. In contrast, if the incumbent government's candidate is confirmed and his term is sufficiently long, his preferences will govern monetary policy for the duration of the government, and even some time thereafter. Hence, incentives for the government to choose a moderate candidate increase with the length of the term of central bankers (decrease with an increasing central bankers' turnover rate). Since a committee structure permits reducing the turnover rate without locking a single central banker (and thus policy) into place for a very long period of time, it can reduce partisanship without eliminating the flexibility necessary to remove a bad policy-maker from office.

The results in the papers discussed above point to the ability of committee designs to reduce the swings in monetary policy associated with political cycles. These findings support the informal arguments that, in many countries, led to the adoption of boards for directing the respective CBs. In many countries, official statements as well as other accounts concerning the reasons that led to this institutional design, argue that the preferences of a committee CB will evolve more slowly than those of its single-member counterpart, and will therefore be less subject to the influence of political cycles.[3]

The absence of informational asymmetries and related reputational concerns in this literature implies that the policy choices of central bankers are givens and do not depend on the institutional setting. As a result, the only effect of the existence of a committee structure is to aggregate the otherwise unchanged votes of central bankers. By contrast, my approach in this paper is to focus on how a committee arrangement affects the individual decisions of central bankers, rather than on how those decisions are aggregated.

Another strand of literature (Bullard and Waller, 2004; Faust, 1996; and Dal Bó, 2006) documents the ability of a committee structure to reduce inflation bias, in the absence of reputation concerns. These papers take advantage of the fact that a committee provides flexibility in terms of how the positions of its members are aggregated. The basic starting point is that the inflation rate preferred by the median voter is too high, in as much as it imposes inflation costs without generating benefits from surprise inflation. They show that an optimal decision mechanism can be designed such that

[3] For instance, the committee design of the Colombian Central Bank is explained in the Bank's Website as follows: "This system guarantees continuity in Bank policy while safeguarding it from the influences of political change, thus ensuring planning more in view of the long-term and garnering greater credibility with the public" (*El Nuevo ordenamiento del Banco y su Junta Directiva*, in www.banrep.gov.co). On another front, Waller (1989) documents how several historians of the U.S. Federal Reserve "argue that the board structure of the Federal Reserve Board of Governors was, in fact, chosen specifically to minimize the influence of partisan politics on the setting of monetary policy" (pp. 422-423).

a board is less subject to inflation bias than the median voter.[4] In Faust's model, monetary policy is the result of bargaining between members of the CB. Inflation bias is reduced if the representation of anti-inflation groups is disproportionately large relative to their representation in society at large. Meanwhile, in Dal Bó's model, central bankers vote over policy choices. He shows that a less inflationary balance of preferences can be achieved if an optimal supermajority rule is used to choose policy. The supermajority rule can be designed to ensure that the pivotal voter is the optimal conservative central banker that maximizes the median voter's welfare. Bullard and Waller show that, in a committee, a bargaining solution can reduce inflation with respect to a median voter rule, if the anti-inflation types enjoy enough bargaining power. They also show that giving large power to the anti-inflation type is preferred by all types (given the presence of inflation bias), and that a supermajority rule can effectively create such disproportionate power. My results differ from these papers in that, in my model, an appropriately designed board can reduce the inflation bias even when the pro-inflation types are in command of the CB. This arises because reputation concerns affect the choices of these types, and a committee structure can potentially make reputation more relevant.

Finally, the effects of a committee design on the reputation-building incentives of central bankers are addressed by Sibert (2003), and Mihov and Sibert (2006). In their models, as in this paper, the fact that a central banker's vote may not be reflected in the policy outcome changes the reputation-building incentives. These authors do not address the mechanisms for appointing central bankers which, as this paper shows, can be key determinants of the importance central bankers give to reputation-building considerations. Additionally, Mihov and Sibert's models assume that the public obtains and uses information about individual votes in the CB. In this paper, meanwhile, the idea that individual votes are observed only imperfectly is pivotal to the concept of collective reputation. My contention is that people are more likely to form expectations based on actual policy even if individual voting records are available, as observing policy has a lower cost than investigating individual votes. Sibert's paper does analyze the case in which voting records are not published; my results differ from hers even in this case, however, given my consideration of the reappointment process. This is discussed in detail in section 5. My idea of collective reputation is closer to that proposed by Tirole (1996), wherein the reputation of an organization differs from that of each member, as the output of the latter is observed only imperfectly.

Another contribution of this paper with respect to the previous literature is the analysis of the

[4] This contrasts with the approach adopted in Lohman (1997) and Waller (1989), where the committee structure does not affect the "median type" choosing policy at a given point in time, but only the variability of that type over time.

effect of committee size and turnover rate on members' incentives. As discussed in greater detail below, Waller (1989, 2000) looks at the effect of the turnover rate on the monetary policy decided by a committee, though assuming that the individual votes of its members are given. Sibert (2006) reviews experiments on group policy-making that incorporate the possibility that members change their votes based on the structure of the committee; she uses those experiments to make inferences about the optimal size of a monetary policy committee. The theoretical analysis I present in this paper complements Sibert's experimental evidence by analyzing the incentives behind the observed behavior of committee member's, in the specific case of a CB.

3 Model: General setting

The model I present follows the tradition of the Barro-Gordon model (1983), which is probably the most standard framework for modeling the choices of the Central Bank. My analysis relies on previous models of reputation-building by monetary authorities (Backus and Driffill, 1985; and Barro, 1986). I begin by studying the choice of monetary policy without imposing a specific institutional structure, and derive a general solution to the problem of a central banker. Even without further institutional detail, my general approach differs from the traditional setting in that, as is the case with many CB's, a central banker's term can be extended, that is, a central banker can be reappointed. I will later derive from the general solution obtained in this section more specialized ones; those analyze the form that solution takes under boards vs. single central bankers, and under government appointments vs. exogenous appointments.

3.1 The preferences of central bankers

Consider a two-period economy, one with a Central Bank (CB) that rules over monetary policy. The CB is assumed to be independent from the government in that the latter does not participate in the choice of monetary policy. However, under some of the institutional arrangements I consider, the government is given the role of choosing the central bankers.

I assume that the CB has perfect control over the inflation rate, π, which summarizes monetary policy in the model. I also adopt the standard assumption that the preferences of central bankers reflect a trade-off between the costs imposed by variable inflation and the potential benefits of generating inflationary surprises (such as boosting employment in the short run). I assume that central bankers come in two types, which I call hawks and doves. Hawks give more importance to fighting

inflation that do doves. In order to incorporate reputation-building considerations into the model, I assume that a central banker's type constitutes private information– that is, it is known only to the central banker.

A central banker's choice variable is his vote over π, which is equivalent to actual policy in the case of a single central banker, but not necessarily so under a committee arrangement. For simplicity, I make the extreme assumption that a hawk central banker always votes for zero inflation.[5] The preferences of a dove central banker, identified as i, are captured by the following loss function:

$$L_i^d = E\sum_{t=1}^{2}\beta_i^{t-1}\left[\pi_t^2 - c(\pi_t - \pi_t^e) - b * o_{it}\right], \tag{1}$$

where the superindex d refers to a dove, π_t is the inflation rate for period t, π_t^e is the public's expectation of inflation for period t, and $\beta_i \in [0,1]$ is i's discount factor. The discrete variable o_{it} is 1 if i is in office during period t, and 0 otherwise. I allow the discount factor β_i to vary across individual bankers, so that different dove central bankers may care more or less about the future implications of their choices; β_i is characterized by cumulative density function $F(\beta_i)$.[6]

The first term of the loss function (1) implies that a dove central banker cares about driving inflation to its target value of zero (a different target level could be assumed without changing the basic results). The second term reflects a dove's incentives to generate inflation surprises. As in the original formulation of the Barro-Gordon model, I assume a linear functional form. Although this assumption has the shortcoming of ignoring potential output stabilization incentives, it makes the problem of the central banker more tractable; this is important in the context of this paper, as the simultaneous introduction of government appointments, committee decision-making, and possible reappointments expands considerably the set of possible states the central banker must consider.[7] The parameters c and b (where $c > 0$ and $b \geq 0$) capture the value given by a dove policymaker to generating inflation surprises and being in office (relative to driving inflation to its 0 target level), respectively.

Central bankers face uncertainty stemming from two sources. First, if monetary policy is de-

[5] In this model hawks are equivalent to the mechanistic type of central banker in Sibert's (2003) and Mihov and Sibert's (2006) models.

[6] Assuming that β may vary from central banker to central banker is an alternative to assuming that dove central bankers may play mixed strategies. Without any of these assumptions, as will become clear later, there exist circumstances under which a central banker in a committee knows with certainty that his individual vote will not affect policy. These circumstances rule out any concern for the central bank's reputation, which is central to my approach. The strategy in this paper is to consider a more general setting that can generate both equilibria where the probability that a single vote changes policy is zero, and equilibria where an individual central banker has some ability to affect policy.

[7] Some interesting consequences of CB collective decision-making for the ability of the monetary authority to stabilize output are analyzed by Dal Bó (2000) and Waller (1989), although in different contexts.

termined by a committee, each central banker faces uncertainty concerning what types his fellow committee members are. The other source of uncertainty for a central banker comes from the possibility that he will not be reappointed for period 2. I will consider different scenarios for how reappointment is decided.

Notice that, for any individual central banker i in period one, $o_{it=1} = 1$. Moreover, if we define r_i such that $r_i = 1$ if i is reappointed for period 2 and 0 otherwise, we get $E(o_{it=2}) = \Pr(r_i = 1)$.[8] To simplify the notation, I drop the time subindexes, and indicate period 2 variables with a $'$ mark. A dove's loss function can now be rewritten as:

$$L_i^d = E\left\{\pi^2 - c(\pi - \pi^e) + \beta_i\left[(\pi')^2 - c(\pi' - \pi^{e\prime})\right]\right\} - b\left[1 + \beta_i \Pr(r_i = 1)\right]. \tag{2}$$

What is important to note from this loss function is that there are two channels through which the choices of a dove central banker in the first period have intertemporal effects. One such channel is the well known incentive to establish a good reputation for the CB (Backus and Driffill, 1985; and Barro, 1986). High inflation in the first period sends the signal to the public that, with a high probability, the members of the CB are doves, thus increasing future inflation expectations, $\pi^{e\prime}$. A concern for the CB's reputation, therefore, makes a dove central banker wary of increasing π during the first period.

The possibility of government appointments to the CB creates an additional link between today's policy and tomorrow's expected losses. In particular, if the decision to reappoint a central banker lies with the government, the central banker's choice of policy in period 1 is likely to affect his chances of being reappointed. Reappointment is valuable because i derives "ego rents", b, from being in office in period 2; likewise, by being reappointed i has the chance to tilt period 2 policy toward his preferred inflation rate. As a result, when choosing π, a central banker must keep in mind the potential effects of his choice on his chances of being reappointed. Under the assumption that the government favors partisan appointments, central banker i has incentives to choose the government's preferred policy in order to increase his chances of remaining in office.

In short, when choosing policy in period 1, a dove central banker takes into account the potential effect of his choice on three different factors: 1) current inflation, and therefore the central banker's current welfare; 2) next period expected inflation; and 3) his chances of reappointment. Simply put, a dove central banker has a preference for generating an inflation surprise in period 1, but may be

[8] Later I allow the government to choose r_i, in which case $\Pr(r_i = 1)$ may be conditional on central banker i's vote in period 1.

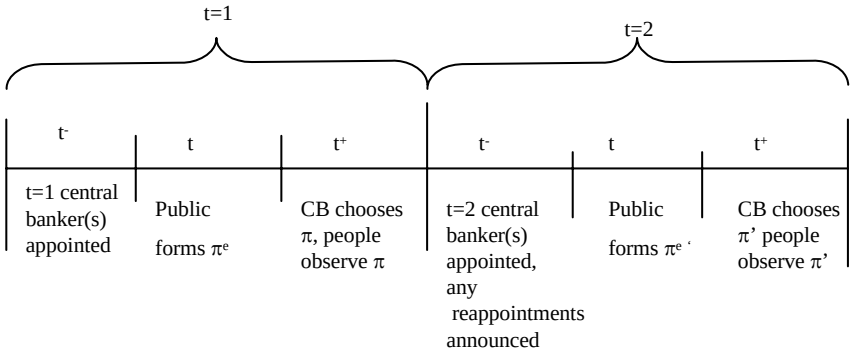

Figure 1: Timing of events

discouraged from doing so because high inflation damages the reputation of the CB, increasing future expectations of inflation. A dove central banker may also avoid high inflation (or stick to it) if it damages his chances of being reappointed (or benefits them). The focus of this paper is on how different institutional arrangements affect the relative size and importance of these incentives.

3.2 Timing and information

The timing of events, summarized in Figure 1, is as follows. There are two periods, $t = 1$, and $t = 2$. Each period t is divided into three "subperiods", t^-, t, t^+. At t^-, central bankers are appointed (e.g., by the government). They can be newcomers, or, for $t = 2$, central bankers that were in office at $t = 1$ and were reappointed. At t, the public forms inflation expectations for the current period.[9] At t^+, the CB chooses π, which is observed by all players.

As for the information structure, in any given period there is uncertainty about the central banker's type (central bankers' types, if the CB is a committee); that type is known only to himself. In period 1, only the unconditional probability that a central banker is a dove (which I denote as ϕ) is known to the public. Given the timing described above, however, in period 2 all players know what policy was chosen in period 1. They also know if a central banker is an incumbent, reappointed at the end of period 1, or a newcomer. This information is used by the public to update beliefs about the types of central bankers in period 2, and ultimately, to form $\pi^{e\prime}$.

[9] Notice that, by assuming that expectations are formed only once during a central banker's term, I am implicitly imposing an equivalence between the length of a central banker's term and the length of nominal contracts. Although relaxing this assumption could have interesting implications for the cycle of monetary policy within a central banker's term, I keep it throughout the paper for the sake of simplicity.

3.3 Solving the problem of a central banker

The equilibrium vote of a central banker in each period maximizes his expected discounted utility, given the public's beliefs about the types of central bankers in both periods. These beliefs, represented in period 1 by the unconditional probability distribution over types of central bankers, are updated at the end of the first period following Bayesian updating. In this section, I analyze the problem of a central banker for a given set of beliefs by the public in this section; left for section 3.4 is the consideration of expectations formation and equilibrium.

Given the preferences outlined before, a hawk will vote for $\pi = 0$ in both periods. The problem of a dove, however, is more involved. Without loss of generality, I address the problem of a specific dove, whom I index with i. I denote i's vote (which equals actual policy in the case of a single central banker) as v_i.

Solving backwards, in period 2 dove i votes for the rate that minimizes his within-period loss function. This is i's preferred inflation rate, which I denote as π^d in the rest of the paper. π^d is given by:

$$v_i = \pi^d = \frac{c}{2}. \tag{3}$$

In period 1, meanwhile, i also considers the implications of his vote on the perceptions of others regarding his type and the "type of the CB", which in turn affect both future expected inflation and, potentially, i's chances of being reappointed. Notice that, since hawks only vote for $\pi = 0$, voting for *any* rate different from $\pi = 0$ will reveal i as a dove to those observing his vote. Choosing any $v_i \neq 0$ could also potentially lead to $\pi \neq 0$, revealing to the public that the committee is dominated by doves. As a result, dove i will consider only two possible votes for period 1, $v_i = 0$ and $v_i = \pi^d$, where the latter is his preferred vote among those revealing his type.[10]

The inflation rate implemented in a given period is the one that receives the most votes, and thus could be either $\pi = 0$ or $\pi = \pi^d$. I eliminate the possibility of a tie by assuming that a CB committee has an odd number of members.

Before discussing the circumstances under which a dove chooses $v_i = 0$ rather than $v_i = \pi^d$, I introduce some additional notation to simplify the exposition. I use $\Pr^p(\pi' = \pi^d \mid \pi)$ to designate

[10] The assumption that a hawk always votes for zero inflation thus reduces the space of possible policies to a binary one, thus simplifying the problem. The greater simplicity comes at the cost of introducing asymmetries between the incentives faced by the two types, and precluding signaling by hawks. This paper, however, focuses on how the institutional environment shapes the incentives of those central bankers who are subject to reputation considerations. The qualitative conclusions, therefore, should not be affected by the asymmetric treatment of the two types.

the probability assigned by the public to $\pi' = \pi^d$, given the realization of π. I use this notation to differentiate the probability assigned by the public to a given outcome from that assigned by the central banker, who knows his own type and can therefore use it as additional information. Note that i is solving his problem before learning whether he will be reappointed and additionally, in the case of a committee, without knowing the types or observing in advance the votes of his fellow committee members. Regarding this point, among the key determinants of a dove's choice will be his expectations as to the impact of his vote on inflation and on his reappointment probability. I thus introduce the notation $\Delta \Pr(x) \equiv \Pr(x \mid v_i = \pi^d) - \Pr(x \mid v_i = 0)$ to denote the impact of i's vote on given outcome x (which could be π, π', or r_i). When $x = \pi'$, $\Delta \Pr(x)$ is defined as a function of v_i' rather than v_i; v_i' is the vote in period 2 of i *or his replacement* if he is not reappointed.

In equilibrium, dove i chooses $v_i = 0$ if and only if $L(v_i = 0) \leq L(v_i = \pi^d)$, and $v_i = \pi^d$ if the opposite is true.[11] Using equation (2) and the notation introduced above, this condition can be written as in the following result:

1. **Result 1** *In period 2 a dove central banker i chooses $v_i' = \pi^d$. In period 1 i chooses $v_i = 0$ if and only if the following condition holds:*

$$\begin{aligned} \beta_i \Delta \Pr(\pi = \pi^d) \frac{E\left[\Pr{}^p(\pi' = \pi^d | \pi = \pi^d) | v_i = \pi^d\right] - E\left[\Pr{}^p(\pi' = \pi^d | \pi = 0) | v_i = 0\right]}{0.5} \\ -\beta_i \Delta \Pr(r_i = 1) \left[\tfrac{4b}{c^2} + (1-\phi)\Delta \Pr(\pi' = \pi^d)\right] \\ \geq \Delta \Pr(\pi = \pi^d). \end{aligned} \tag{4}$$

If condition (4) fails to hold, i chooses $v_i = \pi^d$.

Proof. See part A of Appendix ■

The top row of condition (4) reflects the benefits of voting for $\pi = 0$ in terms of the CB's reputation, derived from the fact that low current inflation would reduce future expectations of inflation and therefore open the door for future inflation surprises. Since i's vote affects the CB's reputation only to the extent that it potentially affects the policy adopted, there are two components to this reputation incentive. The first is i's ability to affect policy, which I call the *representation factor;* it is reflected in $\Delta \Pr(\pi = \pi^d)$. The second component is what I call the *reputation factor*, which is captured by $E\left[\Pr{}^p(\pi' = \pi^d \mid \pi = \pi^d) | v_i = \pi^d\right] - E\left[\Pr{}^p(\pi' = \pi^d \mid \pi = 0) | v_i = 0\right]$; this factor generates an incentive to vote for low inflation. Note that the loss of reputation expected by i depends

[11] I assume that an indifferent dove central banker votes for 0, as I look for circumstances that will permit equilibria wherein the dove does not deviate from voting for 0 inflation. Nonetheless, assuming that the indiferent dove chooses high inflation does not affect the results below in any significant manner.

on his vote, independently of how much that vote affects actual policy, as it may affect $i's$ chances of being reappointed. This is the reason why $i's$ expectation in this term is conditional on his vote.

The middle row captures the benefits of $v_i = 0$ in terms of reappointment; $-\Delta \Pr(r_i = 1)$ is the gain in the probability of reappointment from choosing $v_i = 0$. Note that this term can have any sign, depending on how reappointment is determined. Although reappointment will be discussed in detail below, it is important to note that, if appointments lie in the government's hands, this term likely implies an incentive to vote for the government's preferred rate (that is, $\Delta \Pr(r_i = 1)$ is negative if the government is hawk and positive if it is dove). The term in parentheses, $\left[\frac{4b}{c^2} + (1-\phi)\Delta \Pr(\pi' = \pi^d)\right]$, gives the value of reappointment. Note that $(1-\phi)$ is the probability that i will be replaced by a hawk if he is not reappointed; that is, the probability that $i's$ replacement will not vote for $i\acute{}s$ preferred policy during the second period. The value a dove assigns to being reappointed is not only given by the opportunistic reward of being in office, b, but also by i's desire to shape policy according to his preferences,which is captured by the second part of the expression. Central bankers' incentives to increase their chances of being reappointed are frequently dismissed with the argument that central bankers are not opportunistic. The expression above makes the point that even an altruistic central banker wants to remain in office, in order to see his beliefs about what is optimal for social welfare taken into account in the design of future policies.

Finally, the term to the right of the inequality sign captures the fact that $v_i = 0$ is costly for a dove from the point of view of period 1 since, in the absence of any consideration about the future, he would prefer $\pi = \pi^d$ to $\pi = 0$. As was the case with the reputation incentive, this current loss is only incurred if i's vote is reflected in actual policy; hence, representation also plays a role in this case.

In short, $v_i = 0$ can only result if future reputation and reappointment considerations overcome the current costs zero inflation imposes on a dove central banker. In particular, i expects benefits from voting for zero inflation, as his vote may result in both lower expected inflation tomorrow and an improvement in $i\acute{}$s chances of being reappointed (if the government is hawk). Central banker i will vote for low inflation if the discounted sum of those benefits is greater than the current loss derived from increasing the probability that today's inflation will not be i's preferred rate. It is thus also necessary that the future be highly valued; that is, that β_i is sufficiently high.

3.4 Expectations and equilibrium choices

When forming expectations of inflation for period 2, individuals know that central bankers will correctly represent their types during that period. Therefore, $\Pr^{p}(\pi' = \pi^d \mid \pi)$ depends on people's beliefs about the types of period 2 central bankers. For a newly appointed central banker, the public assigns a probability ϕ that he is dove, as past policy provides no information on that particular central banker. For central bankers reappointed from period 1, the public updates its beliefs using Bayesian updating. If i is reappointed for period 2, the public will assign:

$$\Pr^{P}(i \text{ is a dove} \mid \pi) = \frac{\Pr(\pi \mid i \text{ is a dove}) \Pr(i \text{ is a dove})}{\Pr(\pi)}. \tag{5}$$

Letting $w = \Pr(v_i = \pi^d \mid i \text{ is a dove})$, we get:

$$\Pr(\pi \mid i \text{ is a dove}) = w * \Pr(\pi \mid v_i = \pi^d) + (1 - w) \Pr(\pi \mid v_i = 0). \tag{6}$$

In an equilibrium, w reflects the optimal strategy of doves, as presented in result 1. Using condition (4), w is given by

$$w = \begin{Bmatrix} \Pr(\beta_i < \Psi) = F(\Psi) & \text{if } 1 > \Psi > 0 \\ 1 & \text{otherwise} \end{Bmatrix}, \tag{7}$$

where

$$\Psi = \frac{1}{\frac{E\left[\Pr^{p}(\pi'=\pi^d|\pi=\pi^d)|v_i=\pi^d\right] - E\left[\Pr^{p}(\pi'=\pi^d|\pi=0)|v_i=0\right]}{0.5} - \frac{\Delta \Pr(r_i=1)\left[\frac{4b}{c^2} + (1-\phi)\Delta \Pr(\pi'=\pi^d)\right]}{\Delta \Pr(\pi=\pi^d)}}.$$

Note that w summarizes the solution to this problem. It represents the votes of dove central bankers, where votes are optimal given expected inflation in each period, and expectations of inflation are rational given the optimal strategies of central bankers. The latter is reflected in equation (5). The former is satisfied by w in equation (7) because central bankers are aware of the mechanism of expectations formation just described, and take it into account when evaluating $E\left[\Pr^{p}(\pi' = \pi^d \mid \pi)|v_i\right]$.

Equation 7 reflects the fact that i chooses $v_i = \pi^d$ for small values of β_i, since a small β_i implies that neither reappointment nor reputation considerations are sufficiently valued by i to override his current period incentives to support high inflation. Note also that, although w can take values between 0 and 1, central bankers are not playing mixed strategies. Although this and the solution to i's problem are known to the public, the public can only make an evaluation of the probability that

a dove member will choose $v_i = \pi^d$, since doves differ with respect to β_i. Different discount rates capture sources of heterogeneity across central bankers other than their relative preferences to fight inflation. Note also that any given central banker faces a problem similar to that of the public, in that he cannot observe his colleagues' types. Like the public, he also uses w to evaluate the probability that any other dove central banker will choose $v_i = \pi^d$.

The discussion above presents a general characterization of the equilibrium choices faced by central bankers. I now analyze what these conditions imply in terms of the optimal institutional design of the CB. I present alternative institutional settings and study the choices of central bankers under each. My strategy is to study how institutional design affects the different incentives faced by central bankers (summarized by the three key concepts of reputation, reappointment, and representation, discussed above), and ultimately how they affect w. When discussing the convenience of one or another institutional design, I implicitly assume that CB institutions should seek to minimize both inflation bias and the government's influence over monetary policy. These two goals are frequent motivations for placing monetary policy in the hands of an independent CB; I simply take them as given in the discussion.[12]

4 The institutional dimension I: collective decision-making

As a first approximation, I isolate the analysis of collective decision-making with respect to the consideration of government appointments. I do so by assuming throughout this section that a central banker's reappointment is exogenously given and independent of his vote in the first period, such that $\Delta \Pr(r_i = 1) = 0$. For any $\Delta \Pr(\pi = \pi^d) > 0$, the condition under which a central banker votes for $\pi = 0$ can now be written as

$$\beta_i \frac{E\left[\Pr{}^p(\pi' = \pi^d \mid \pi = \pi^d) | v_i = \pi^d\right] - E\left[\Pr{}^p(\pi' = \pi^d \mid \pi = 0) | v_i = 0\right]}{0.5} > 1. \tag{8}$$

Note that not only do the terms related to reappointment incentives disappear, but the $\Delta \Pr(\pi = \pi^d)$ term does not enter condition (8) either. The reason for this is that, without government appointments, the votes of central bankers only matter if they affect policy. As a result, any $\Delta \Pr(\pi = \pi^d) > 0$

[12] Although I do not provide a formal proof that reducing inflation and cutting governmental influence is optimal, my assumptions about the preferences of central bankers are in fact consistent with social losses that increase with inflation and inflation variability, under the plausible assumption that the preferences of central bankers are similar to those of other individuals in society. Note that political pressures constitute a source of undesirable variability of monetary policy, in that the political cycle imposes changes in policy not warranteed by shocks to economic fundamentals. There is also an underlying rationale for CB independence in my model on the basis of the assumption that, while reputation concerns may restrain the inflationary temptations of central bankers, the government is immune to such concerns.

suffices for policy considerations to be the only factors determining a central banker's choice. Representation, therefore, does not affect the relative importance of reputation-building incentives in the case of exogenous appointment. As will become clear below, this does not mean that representation ceases to play any role at all; the public will value past inflation as a signal of period 1 central bankers' types only to extent that observed inflation reflects at least partially individual votes.

Given condition (8), reputation-building is at the heart of a central banker's choice where there is no government appointment: $v_i = 0$ is chosen if and only if the gain in the committee's collective reputation derived from low inflation is sufficient to overcome the current loss $\pi = 0$ imposes on a dove central banker. With this in mind, I analyze how reputation considerations are affected by the choice of a committee-based CB, as well as some specific characteristics of the committee.

A key argument in favor of committee arrangements, both in the informal tradition and in the literature reviewed above, is that they can be optimally designed to render CB preferences that are more stable than would be possible under a single central banker. The idea is simply that a committee can always be designed to outlive the maximum period a single policymaker can stay in office. This is so because the terms of members can be staggered. Hence, while each member can be assigned a period as long as that of his single policymaker counterpart, the committee can be structured such that when one member leaves office some of his colleagues stay.

There are two potential advantages derived from greater stability in a CB's preferences. First, it reduces the costs derived from inflation and output variability (Lohman, 1997; Waller, 1989; and Blinder, 1998). Second, it may increase the importance given by the public to past policy as a signal of future policy, thus highlighting the collective reputation considerations that lead a central banker to refrain from supporting high inflation. It is the latter aspect that is central to this model, since the focus is on the circumstances that make a dove central banker more likely to vote for low inflation. To retain the feature of greater stability under committees, I focus on the decisions of a policymaker whose term in office ends at the end of t, and compare the incentives he faces under a committee arrangement versus those faced if policy depends solely on his choices. The key insight I obtain from this comparison is that, even if the terms of the committee are staggered to render the CB more stable, the ability of a committee to reduce inflation bias on the basis of reputation considerations is not guaranteed. Success in reducing inflation with respect to a single central banker depends on specific characteristics of the committee– the number of members and the fraction of members replaced at the end of period 1.

4.1 The single central banker

Take the case of single central banker i. Following the discussion above, suppose that i will only stay in office until the end of period 1, and that this is known to i from the beginning of the period. The central banker knows that in period 2 the public will observe his removal from office. As a consequence, expected inflation in period 2 will not depend on inflation in period 1: $\Pr^p(\pi' = \pi^d \mid \pi) = \phi$, independent of the value π takes. Central banker i, therefore, has no incentive to choose $\pi = 0$. A single dove whose term ends at the end of $t = 1$ will always choose $\pi = \pi^d$.

4.2 Reputation-building incentives in a committee setting

Suppose now that monetary policy is decided by a committee, the members of which vote over possible policy choices. Dove member i is identical to the single central banker discussed above: he knows that his term ends at the end of $t = 1$. A key difference, however, arises from our assumption that the public bases inflation expectations on past inflation rather than the past votes of central bankers. To the extent that i's vote affects policy, it will also have an impact on the collective reputation of the committee, even if i is no longer in office. A committee, therefore, may strengthen a dove's reputation incentives to choose low inflation.

Note that the assumption that the public observes π, but not the individual v_i, is central to my approach. In some of the literature (e.g., Sibert 2003), a similar feature appears in the assumption that individual votes are not disclosed, or are disclosed only with a lag. I take these assumptions to be a simplified way of stating a more general phenomenon. The public may base expectations only on past policies even if individual votes are disclosed in the CB's public statements; it is my view that this is a better representation of reality. On one side, while information about monetary policy choices makes the headlines, the positions of individual central bankers receive less attention, often being restricted to specialized media. This creates costs that may prevent the public from getting information about individual votes at the CB. Moreover, tracking the behavior of individual members adds one more layer to the (as we shall see) already sophisticated calculations involved in forming inflation expectations. It seems relevant to question whether the general public, or even the players involved in wage setting, analyze every policy decision with such a high level of sophistication.

To solve i's problem under a committee arrangement, I assume there are $n = 2z + 1$ members in the committee. Policies are decided by a simple majority rule, such that the inflation rate that obtains $z + 1$ or more votes is adopted.[13] I also assume that at the end of period 1 exactly m

[13] By assuming an odd-numbered committee, I avoid tie-breaking rules. I do not address here the question of optimal

members are removed from office, while the remaining $n-m$ are reappointed.[14]

The public knows that in period 2 all the doves in the committee will vote for $\pi = \pi^d$, while all the hawks will vote for $\pi = 0$. The probability that $\pi' = \pi^d$ is therefore given by the probability that $z+1$ or more members of the $t=2$ committee are doves. The public's estimation of this probability is influenced by period 1 inflation, inasmuch as a fraction $\left(1-\frac{m}{n}\right)$ of period 2 central bankers helped choose π. In other words, π contains information about a fraction $\left(1-\frac{m}{n}\right)$ of the committee serving in $t=2$. The public thus follows the following simple rule for the probability that period 2 central banker k is a dove; we denote $\Pr(i \text{ is a dove}|\ \pi = \pi^d) \equiv \phi^+$ and $\Pr(i \text{ is a dove}|\ \pi = 0) \equiv \phi^-$:

$$\begin{aligned} \Pr(k \text{ is dove} \mid \pi = \pi^d) &= \frac{m}{n}\phi + (1-\frac{m}{n})\phi^+, \\ \Pr(k \text{ is dove} \mid \pi = 0) &= \frac{m}{n}\phi + (1-\frac{m}{n})\phi^-. \end{aligned} \tag{9}$$

People's beliefs ϕ^+ and ϕ^- are ruled by :

$$\Pr(i \text{ is dove} \mid \pi) = \frac{\phi w * \Pr(\pi \mid v_i = \pi^d) + \phi(1-w)\Pr(\pi \mid v_i = 0)}{\Pr(\pi)} \tag{10}$$

(see equations (5) and (6)). Since the probability that $\pi' = \pi^d$ is equal to the probability that $z+1$ or more period 2 members are doves, we obtain:

$$\begin{aligned} &\Pr{}^p(\pi' = \pi^d \mid \pi = \pi^d) - \Pr{}^p(\pi' = \pi^d \mid \pi = 0) \\ &= \sum_{x=z+1}^{n} \binom{n}{x} \left[\left(\frac{m\phi+(n-m)\phi^+}{n}\right)^x \left(1-\frac{m\phi+(n-m)\phi^+}{n}\right)^{n-x} - \left(\frac{m\phi+(n-m)\phi^-}{n}\right)^x \left(1-\frac{m\phi+(n-m)\phi^-}{n}\right)^{n-x} \right] \\ &\approx \left(1-\tfrac{m}{n}\right)\left(\phi^+ - \phi^-\right) \sum_{x=z+1}^{n} \left[\binom{n}{x}\phi^x(1-\phi)^{n-x}\left(\tfrac{x}{\phi} - \tfrac{n-x}{1-\phi}\right)\right], \end{aligned} \tag{11}$$

where the last line of equation (11) uses a linear approximation of $\Pr{}^p(\pi' = \pi^d \mid \pi = \pi^d)$ (for the derivation of equation (11), see part B of Appendix). While the results stated below and the figures used to illustrate them are based on the exact form of this reputation factor (i.e. the second line of equation (11)), the linear approximation is useful for discussing the intuition. Note also that we use

voting rules, something the literature has begun to look at (see, for instance, Dal Bó's 2006 paper).

[14] This assumption closely matches the arrangement characterizing the Colombian CB. It is also close to other designs with staggered terms (the cases of Mexico and Venezuela, for instance). In many cases, these arrangements are mixed with caps on the number of times a given member can be reappointed. My assumptions about i can be taken to mean that i has reached that maximum number of periods.

the fact that

$$\begin{aligned} & E\left[\Pr{}^{p}(\pi' = \pi^d \mid \pi = \pi^d)|v_i = \pi^d\right] - E\left[\Pr{}^{p}(\pi' = \pi^d \mid \pi = 0)|v_i = 0\right] \\ = \quad & \Pr{}^{p}(\pi' = \pi^d \mid \pi = \pi^d) - \Pr{}^{p}(\pi' = \pi^d \mid \pi = 0), \end{aligned}$$

since $i's$ reappointment chances do not depend on his vote in this scenario.

Equation (11) captures the cost of high period 1 inflation to the collective reputation of the CB; that is, the reputation loss associated with choosing high inflation in period 1. Choosing high rather than low inflation in the first period increases the probability the public will assign to any period 1 central banker being dove, and effect captured by the difference between ϕ^+ and ϕ^-. However, equation (11) also shows that, in terms of expected inflation, this effect matters only for a fraction $\frac{m}{n}$ of the members, and it matters only to the extent that it can translate into a majority of votes in period 2.

Note that the reputation loss captured by equation (11) depends crucially on the size of the committee and the number of members replaced from one period to the next, represented by the parameters n and m, respectively. An increase in the fraction of members replaced, $\frac{m}{n}$, reduces the amount of information contained in period 1 policy that is relevant for expectations formation in period 2. As a result, the reputation gain from avoiding high inflation in the first period is decreasing in $\frac{m}{n}$, as the first factor in equation (11) shows.

The effect of the size of the committee is dominated by a representation effect. First, representation is lower in larger committees, as the impact of any individual member's vote on policy choices diminishes with the size of the committee. The public learns less from policy about individual members' types when the committee is large, thus reducing the potential reputation gain obtained from choosing low inflation in the first period. In equation (11), the effect of size on representation is reflected on a negative impact of n on $\left(\phi^+ - \phi^-\right)$.[15] In a mechanical sense, policy reveals the votes of the majority, where the fraction of votes constituting a majority is decreasing with the size of the committee. In this sense, the larger the committee, the less policy reveals about the "median member".

It is also the case, however, that n affects the manner in which the difference between ϕ^+ and ϕ^- becomes translated into a difference in the probability assigned by the public that a majority of

[15] Working from equation (5), one can write $\left(\phi^+ - \phi^-\right) = \frac{\phi w(1-\phi)\Delta \Pr(\pi=\pi^d)}{\Pr(\pi=\pi^d)\left(1-\Pr(\pi=\pi^d)\right)}$, making explicit the importance of the representation factor (which appears in the numerator). Note also that this term does not depend on m, as it refers to the probability that a member known to have been reappointed is a dove.

committee members are doves. This effect is nonlinear: the probability that a majority are doves will be decreasing with n if the unconditional probability ϕ is close to 0.5, and becomes increasing with n as ϕ moves away from 0.5. The intuition of this nonlinearity has to do with the law of large numbers, and the relation between ϕ^+ and ϕ^- for different values of ϕ.[16]

The net effect of the size of the committee on the collective reputation effect captured by equation (11) reflects both the lower representation associated with larger committees and the "majority" effect just discussed. For a given value of $\frac{m}{n}$, the loss of the collective reputation derived from choosing high inflation will most frequently be decreasing with n, as the representation effect tends to dominate. However, for values of ϕ sufficiently close to 0.5 such loss can become increasing, provided that w is low enough.[17]

As an illustration, consider the depiction of the reputation incentive in Figure 1 , given by

$$\frac{\left[\Pr{}^p(\pi' = \pi^d \mid \pi = \pi^d) - \Pr{}^p(\pi' = \pi^d \mid \pi = 0)\right]}{0.5},$$

as a function of the ex-ante probability of being a dove, ϕ. The Figure assumes that $w = 0.9$ (which is consistent with plausible equilibrium values, as shown below) and $c = 1$, and depicts each (n, m) combination as a different line. Comparing the cases of $(n = 3, m = 1)$ and $(n = 9, m = 3)$, note that increasing the size of the committee (n) while keeping constant the fraction of members to be replaced reduces the reputation incentive to choose low inflation, as discussed above. On the other hand, comparing $(n = 9, m = 1)$ and $(n = 9, m = 3)$ shows that, as discussed before, the incentive to choose low inflation is also reduced if the fraction of members to be replaced grows while the size of the committee remains constant. These effects hold for any value of ϕ.[18]

As further illustration of the effects discussed above, Table 1 shows equilibrium values for the probability that a dove will vote for high inflation, w, for different combinations of n and m. This

[16] The precise intuition is involved. First, take the probability that, if ϕ^+ represents the probability that one member is dove, the majority are doves. If $\phi^+ > 0.5$, then the probability that a majority are doves will be *increasing* in n, and where the intuition will be close to the law of large numbers: as n grows it is more likely that ϕ^+ will represent the actual fraction of doves, so if $\phi^+ > 0.5$, the probability that the actual fraction is above 0.5 will grow with n. By the same token, if $\phi^+ < 0.5$, then the probability that a majority are doves will be *decreasing* in n. A similar logic applies when ϕ^- represents the probability that one member is a dove, such that the effect of n on equation (11) through this channel depends on how ϕ^+ and ϕ^- compare to 0.5. This "majority" effect of n is positive if $\phi^+ > 0.5 > \phi^-$, but becomes negative when ϕ^+ moves sufficiently away from 0.5 in either direction (such that both ϕ^+ and ϕ^- end up on the same side of 0.5). This is because the increasing or decreasing pattern is less pronounced for more extreme values of the individual probability. Note that $\phi^+ > 0.5 > \phi^-$ occurs when ϕ is sufficiently close to 0.5.

[17] The impact of n on $\left(\phi^+ - \phi^-\right)$ is minimized for a low value of w, which is the reason why the opposing "majority" effect of n may dominate in this case.

[18] As discussed above, if we had assumed a sufficiently low value for w, the reputation incentive would have been increasing rather than decreasing with n, at least for some parameter values. A low value for w, however, is not consistent with the equilibrium values found below.

equilibrium probability is calculated using equation (7), while allowing for β to follow different distributions. In the left panel of Table 1, β is assumed to follow a uniform distribution over the $[0.8, 1]$ interval, while in the right panel of Table 1 a normal distribution is assumed, with a mean of 0.9 and a variance such that 99% of observations fall in the $[0.8, 1]$ interval.[19] Holding n constant at any given value, it is clear that a larger fraction of members to be replaced implies less incentive to vote for low inflation (that is, w takes a larger value). A similar effect is seen when increasing the size of the committee while holding $\frac{m}{n}$ constant. Take, for instance, the highlighted cells of Table 1, which show committees of different sizes, while holding $\frac{m}{n}$ constant at (approximately) $\frac{1}{5}$. The equilibrium probability of voting for low inflation falls (that is, w grows) as the size of the committee increases.[20] Note, however, that the overall effect of changes in n is ambiguous, since n has a direct positive effect on w, as discussed above, and an indirect negative effect through $\frac{m}{n}$, if m stays constant.

In summary, a committee can imply more reputation-building incentives for a central banker than a monolithic arrangement, thus increasing the chances that low inflation is achieved. In particular, a dove who holds his last term in office during period 1 can choose low inflation for that period in a committee setting but not in a single central banker scenario. However, this is only possible if the committee is appropriately designed with respect to m and n; a design that maximizes reputation-building incentives implies choosing a small $\frac{m}{n}$ in order to maximize the persistence of policy, but may also require a small enough committee that past policy is considered informative about individual members' types. A committee that is too large (for a given $\frac{m}{n}$) or exhibits a turnover rate that is too high will be as likely to choose high inflation as a single central banker.

It should also be noted that these results imply a smaller inflation bias associated with a scenario where the public does not base inflation expectations on individual votes. In particular, because inflation expectations are based on past policy, the actions of a central banker can affect the CB's reputation even if he is not reappointed. This makes central bankers who are in their last term in office wary of increasing inflation, which I believe is a fair representation of the actual decisions of central bankers; central bankers are usually highly concerned above eroding the credibility of the CB, even during their last term in office.

The benefits of unobservable individual votes in this model contrast with A. Sibert's (2003) result

[19] If we assume a year-long period (that is, that nominal contracts are set for a year) these assumptions are consistent with an annual discount rate of between 0 and 25%. Also, the patterns discussed are robust to choosing intervals of $[0, 1]$ and $[0.5, 1]$ for the β_i.

[20] This matrix of equilibrium probabilities is useful for analyzing the patterns that w follows as n and m change. The levels of w, however, should not be taken literally, as the extreme assumptions made about the preferences of conservative central bankers affect the overall incentives to choose low inflation (though not, I argue, the way in which those incentives are affected by n and m).

that publishing the votes of central bankers reduces inflation bias. (She assumes that the public does in fact use the published information in its calculation of inflation expectations.) The reason for this difference is that, in her model, the terms of central bankers are of fixed length, and dove central bankers optimize solely over their horizon in office. Hence, either the central banker knows for sure that he will be in office in period 2 for sure, in which case reputation considerations "even if he is not reappointed" are irrelevant, or the central banker does not care about the following period, in which case harming the CB's reputation is of no concern for him.

Before proceeding to an analysis of government appointments, note that the discussion of committee decisions in this section has been based on equation (8), which holds for any $\Delta \Pr(\pi = \pi^d) > 0$. However, there is also another equilibrium where all central bankers vote for low inflation (i.e., $w = 0$); as a result, $\Delta \Pr(\pi = \pi^d) = 0$. This is the case because, if all central bankers vote for the same rate, the probability that any individual member can change policy by altering his vote is zero (since we have assumed committees of three or more members). In this case, representation is zero and no member has an incentive to deviate from voting for low inflation. More generally, if we assume that all central bankers respond to reputation and reappointment incentives (rather than treating hawks as mechanistic), any situation in which all types pool voting for the same rate is an equilibrium, simply because none of them influence policy individually. This is an extreme example of the reduction of what I have called representation in committees, as compared to single central banker settings. As discussed below, this implies that central bankers can potentially be more responsive to considerations other than policymaking when acting within committees. A concern for being reappointed is one of these potential alternative considerations. I postpone discussion of the effect of group policymaking to the end of section 5.

5 The institutional dimension II: government appointments

Consider now the possibility that the appointments (and reappointments) of central bankers are not exogenously determined, but rather are government choices. The government appoints central bankers for period 1, decides whether a central banker is reappointed at the end of that period, and chooses who will replace a central banker that is not reappointed. The president has a seat (but not a vote) on the Central Bank committee; hence, he can observe the votes of the central bankers.[21] As a

[21] It is indeed frequent that the government (for instance the Finance Minister or a member of his staff) participates in the regular meetings of CB committees. However, more than trying to mimick an actual CB design, this assumption is meant to capture the fact that the official in charge of deciding which central bankers stay in office is likely to have more information than the public about the past choices of central bankers. Compared to the general public, this official

result, the reappointment of an incumbent central banker is based on his vote for period 1 policy. As for the appointment of newcomers (at the beginning of period 1, or to replace a retired incumbent in period 2), there is no relevant information available to distinguish one potential central banker from another; thus, the government chooses randomly which candidates fill the vacant spots.

Obviously, in actual practice the previous choices of incumbent central bankers are not the only source of information that governments use to choose central bankers. Governments are likely to appoint newcomers on the basis of their party affiliation and their previous performance in other areas of public service or in the private sector. Although this makes the assumption that new appointments are uninformed decisions unrealistic, my decision to maintain such an assumption reflects this model's interest on the effects of appointments on the decisions of incumbent central bankers. Such an interest translates into a focus on reappointments as opposed to the appointment of newcomers.[22]

My modeling of the government is extremely simple. I leave aside the political process that determines who the president is, and assume that the government's type is known to everybody. I also focus on partisan appointments by assuming that governments want to appoint members of their own type. Since members who vote for high inflation reveal themselves as doves, a dove government tries to reappoint these members. For the same reason, a hawk government tries to *replace* central bankers who vote for high inflation. This strategy on the part of the government is consistent with previous models of government CB appointments. For instance, given the abstraction from presidential elections and congressional approvals of CB appointments, partisan appointments would arise in both Waller's (1992) and Havrilesky's (1995, chapter 9) models. Note that implicit in the assumption that governments are purely partisan is that politicians do not respond to reputation concerns. This provides a rationale for CB independence– politicians do not respond to the considerations that, in this model, might reduce inflation bias and policy variability over the political cycle.

How does the fact that the government chooses CB appointments affect the vote of a dovish central banker during the first period? Consider again the condition under which i chooses $v_i = 0$; that is, equation (4), which I write here in a slightly different form:

$$\beta_i \left(\frac{E\left[\Pr{}^{p}(\pi'=\pi^d|\pi=\pi^d)|v_i=\pi^d\right]-E\left[\Pr{}^{p}(\pi'=\pi^d|\pi=0)|v_i=0\right]}{0.5} - \frac{\Delta \Pr(r_i=1)\left[\frac{4b}{c^2}+(1-\phi)\Delta \Pr(\pi'=\pi^d)\right]}{\Delta \Pr(\pi=\pi^d)} \right) > 1. \qquad (12)$$

faces both lower costs and larger incentives to acquire such information.

[22] For an analysis of the effects of the partisan appointment of newcomers, though in the absence of reputation concerns, see A. Alesina's (1987) model, and the subsequent extensions to the case of committees (e.g., Waller, 1989; Lohman, 1997).

As discussed, the first term inside the parenthesis of the LHS reflects the benefits to CB reputation of choosing $v_i = 0$, while the second term captures potential benefits or losses stemming from the effect of v_i on i's chances of being reappointed. Given the government's reappointment strategy, voting for low inflation increases one's chances of being reappointed if the government is hawk, and decreases them if the government is dove. That is, $\Delta \Pr(r_i = 1)$ is negative (positive) when the government is hawk (dove). The *reappointment* factor thus creates incentives to vote for the rate preferred by the government.

Furthermore, notice from the second term that the value given to reappointment relative to other objectives is decreasing in $\Delta \Pr(\pi = \pi^d)$. This reflects the fact that the probability of being reappointed depends on the central banker's vote, while his other objectives are only affected by the actual choice of policy. Thus, representation now plays the role of determining how much each central banker values reappointment: if each vote has a low impact on the actual choice of policy, the decisions of central bankers will be mainly driven by reappointment incentives. As a result, the influence of the government on monetary policy is greatest when representation is lowest.

I now return to the analysis of specific institutional designs, with an emphasis on how they affect the balance between reappointment and reputation considerations.

5.1 Government appointments and the case of a single central banker

Let us start with the case of a dove, single central banker, denoted as i, who is in office in period t. We focus again on a central banker whose period expires at the end of t, though now giving the government the power to extend that period after $i's$ choice of π has been observed (at the end of the first period).

Remember, first, that the single central banker has perfect power over the choice of policy, such that $\Delta \Pr(\pi = \pi^d) = 1$. If $g = \{h, d\}$ represents the type of the government, then the general reappointment strategy discussed above implies that:

$$\Delta \Pr(r = 1 \mid g = d) = 1$$
$$\text{and}$$
$$\Delta \Pr(r = 1 \mid g = h) = -1.$$

The structure of reappointments affects the incentives faced by central bankers, not only because they value reappointment, but also because current inflation only affects the CB's reputation in the future if the central banker is reappointed. The government's reappointment strategy implies that the central banker knows he will be reappointed if and only if he votes for the inflation rate preferred

by the government. Moreover, if i is reappointed, the public assigns

$$\Pr{}^{p}(\pi' = \pi^d \mid \pi) = \Pr(i \text{ is a dove} \mid \pi) = \left\{ \begin{array}{ll} 1 & \text{if } \pi = \pi^d \\ \frac{(1-w)\phi}{1-w\phi} & \text{if } \pi = 0 \end{array} \right\}, \tag{13}$$

while if i is not reappointed, the public assigns

$$\Pr{}^{p}(\pi' = \pi^d) = \phi.$$

Given the above, the condition under which a dove central banker chooses low inflation is now

$$\begin{array}{ll} \beta_i \left[\dfrac{1}{0.5} \left(\phi - \dfrac{(1-w)\phi}{1-w\phi} \right) + \left(\dfrac{4b}{c^2} + (1-\phi) \right) \right] > 1 & \text{if } g = h \\ \text{and} & \\ \beta_i \left[\dfrac{1}{0.5} (1-\phi) - \left(\dfrac{4b}{c^2} + (1-\phi) \right) \right] > 1 & \text{if } g = d. \end{array} \tag{14}$$

In each case, the first term inside the square parenthesis in the LHS of condition (14) represents the expected reputation loss from choosing high inflation. This varies with the type of government, inasmuch as $i's$ vote will affect his reappointment chances differently under a hawk or a dove government. For instance, if the government is hawk, then $E\left[\Pr{}^{p}(\pi' = \pi^d \mid \pi = \pi^d) | v_i = \pi^d\right] = \phi$, as i knows he will not be reappointed after voting for high inflation, and therefore the public will be faced with a newcomer in period 2. The second term in the square parentheses represents reappointment considerations. As already discussed, the latter increase the incentives to choose $v_i = 0$ if the government is hawk and decrease them when the opposite is the case, as central bankers value being reappointed.

It is clear from this expression that the fact the government chooses CB appointments ties the choices of dove central bankers to the government's preferences, implying a greater probability of low inflation under hawk governments than under dove ones.[23] In fact, under the specific functional forms chosen here, a dove central banker will never choose low inflation if the government is dove. From a broader perspective, when appointments to the CB are the government's choice, the political

[23] The expected reputation loss from choosing high inflation may be larger under a dove government because the central banker will be reappointed precisely after choosing high inflation. However, this does not completely overcome the reappointment incentive to choose the inflation rate preferred by the government, as can be seen from rewriting the LHS of condition (14) as $\frac{(1+\phi w)(1-\phi)}{1-\phi w} + \frac{4b}{c^2}$ when $g = h$, and $(1-\phi) - \frac{4b}{c^2}$ when $g = d$. The latter expression is unambiguously smaller.

cycle can be a source of variability for monetary policy. I turn now to the question of how collective decision-making affects this link between monetary policy and government preferences.

5.2 Collective policy-making and government appointments

Consider now government appointments in the committee case. As is by now familiar, we need to worry about the effect of v_i on reputation-building and reappointment incentives, represented respectively by the first and second terms inside the parenthesis of the LHS in equation (12).

Let us start by discussing the reputation term in equation (12) under a scenario with both committee decision-making and government appointments. Future expected inflation depends on past inflation and on how many members of the committee were reappointed, but not on which specific members were reappointed, as the public has no information on individual period 1 votes. In other words, a central banker knows his vote will affect his reappointment chances, but as long as $\frac{m}{n}$ is fixed he does not worry about whether his being reappointed will affect the reputation of the central bank. This represents a key difference relative to the case of a single central banker. In the latter, the public knows that the observed policy is a perfect reflection of the central banker's vote, meaning that the potential loss of CB reputation from voting for high inflation will only be realized if the central banker is reappointed.

Given the above discussion, the reputation incentive to choose low inflation in the committee case with government-chosen appointments is exactly that obtained when the government has no power over CB appointments. That is,

$$\begin{aligned} & E\left[\Pr{}^{p}(\pi' = \pi^d \mid \pi = \pi^d) | v_i = \pi^d\right] - E\left[\Pr{}^{p}(\pi' = \pi^d \mid \pi = 0) | v_i = 0\right] \\ = \;& \Pr{}^{p}(\pi' = \pi^d \mid \pi = \pi^d) - \Pr{}^{p}(\pi' = \pi^d \mid \pi = 0). \end{aligned}$$

In terms of the reappointment incentive, I continue to assume that the committee has n members and that m of them are to be replaced between period 1 and period 2. The president chooses which members will be replaced. Given his preference to keep central bankers of his same type, the president starts by replacing members who voted for the policy he likes least. For instance, suppose the government is hawk, and let V_{-g} be the number of members *other than* i who voted against the rate preferred by the government (that is, those members who voted for π^d, under the current assumption that the government is hawk). If $V_{-g} \geq m$, the president randomly chooses m members from those who voted π^d and replaces them. If on the contrary $V_{-g} < m$, the president replaces all

those members who voted π^d, and randomly chooses the remaining $m - V_{-g}$ bankers to be replaced from the pool of members that voted for low inflation.[24] As a result, central banker i faces the following probabilities of being reappointed if the government is hawk:

$$\Pr(r_i = 1 \mid v_i = \pi^d, g = h, V_{-g}) = \left\{ \begin{matrix} 1 - \frac{m}{V_{-g}+1} \text{ if } V_{-g} \geq m \\ 0 \text{ if } V_{-g} < m \end{matrix} \right\}$$

and

$$\Pr(r_i = 1 \mid v_i = 0, g = h, V_{-g}) = \left\{ \begin{matrix} 1 \text{ if } V_{-g} \geq m \\ 1 - \frac{m - V_{-g}}{n - V_{-g}} \text{ if } V_{-g} < m \end{matrix} \right\},$$

where $V_{-g} + 1$ in the first of these expressions is the total number of votes against the rate preferred by the hawk government when i votes for π^d and V_{-g} other members vote for π^d as well. The government's strategy and the implied reappointment probabilities when the government is dove are equivalent to the ones just described, only $v_i = 0$ is replaced by $v_i = \pi^d$, and V^{-g} is the number of members other than i who voted for $\pi = 0$. These reappointment strategies imply that $\Delta P(r_1 = 1)$ depends on the probabilities i assigns to the number of votes against the government's preferred rate being above or below m. As for the single central banker, $\Delta P(r_1 = 1)$ is positive if the government is dove and negative if it is hawk.[25]

Take first the reappointment value of voting for the government's preferred rate, given by the absolute value of

$$\Delta \Pr(r_i = 1) \left[\frac{4b}{c^2} + (1 - \phi) \Delta \Pr(\pi' = \pi^d) \right].$$

This can also be seen as the reappointment incentive if $i's$ vote in period 1 is known to determine policy (i.e., if $\Delta \Pr(\pi = \pi^d) = 1$). The relationship between this expression and the committee's size and turnover rate is illustrated in Figure 3. The figure assumes $b = 0$; larger values of b lead to greater incentives to affect reappointment (especially in the case of a single central banker) but do not change the general patterns described below. As above, the figure also assumes that $w = 0.9$.

Note first that this value of reappointment is much smaller for committees than for a single central banker (represented by the thin solid line): This is so because the government has perfect power over the permanence of a single central banker (not so for a committee member), and because reappointment gives a single central banker perfect power over period 2 policy, making the incentive to

[24] If i also votes against the rate preferred by the government, $V_{-g} < m$ implies that there are at most m votes against the government (including that of i). It is thus still the case under $V_{-g} < m$ that the president replaces all members that voted against his preferred rate (including i).

[25] An exact expression for $\Delta P(r_1 = 1)$ is derived in part C of the Appendix.

seek reappointment stronger for a single central banker than for a member of committee. Additionally, comparing the cases of $(n = 9, m = 1)$ and $(n = 9, m = 3)$, it is clear that the value given to voting for the government's preferred rate is increasing with the fraction of members to be replaced. This reflects the fact that $\frac{m}{n}$ ultimately represents the fraction of members over whose appointment the government has power. Finally, the comparison between $(n = 3, m = 1)$ and $(n = 9, m = 3)$ shows that larger committees imply lower reappointment values. This is so because, if reappointed, $i's$ ability to affect π'–one of the attractive features of being reappointed– is reduced in larger committees.

In short, the value given to reappointment is in itself quite small in the case of a committee compared to the single central banker case. For sufficiently low values of b, it is also small with respect to the range of values for the effect of reputation-building, for instance, as seen in Figure 2. This value is further reduced by rules that limit the number of members over whose appointment the government has power.

The ability of collective decision-making to minimize the effect of reappointment considerations, however, is considerably reduced when representation is brought into the picture. A central banker's vote affects his chances of reappointment with a probability of 1 but only affects policy with a probability of $\Delta \Pr(\pi = \pi^d)$. That is, in terms of future expected inflation, a central banker within a committee cares only about the collective reputation of the committee; in terms of his reappointment, meanwhile, it is his individual reputation that matters. A single central banker is not affected by this distortion in the relative importance of different incentives, as there is no difference between his own reputation and that of the CB. As a result, the potential benefit from a committee design in terms of isolating the CB from government pressures is reduced. Once again, the specific design of a committee is critical in determining the extent to which it can indeed reduce government pressures over monetary policy. In particular, everything else being equal, the influence of the government over the choices of a central banker i is decreasing with the potential impact of $i's$ vote on actual policy, which in turn is determined by the committee size. A smaller n increases representation, reducing the importance given to reappointment relative to the CB's reputation.

Figure 4 illustrates the reappointment incentive after taking representation into account (that is, the absolute value of the second term in the LHS of condition (12)):

$$\frac{\Delta \Pr(r_i = 1) \left[\frac{4b}{c^2} + (1 - \phi)\Delta \Pr(\pi' = \pi^d)\right]}{\Delta \Pr(\pi = \pi^d)}.$$

As before, the figure assumes that $w = 0.9$ and $b = 0$. Note that, relative to Figure 3, the reappoint-

ment incentive for members of committees moves closer to that faced by a single central banker. Moreover, the overall reappointment incentive is smaller for lower turnover rates (compare $(n = 9, m = 1)$ and $(n = 9, m = 3)$). Finally, increasing the size of the committee, n, reduces representation with two, opposing, effects: 1) i assigns less probability to being able to influence the CB reputation, thus giving relatively more importance to reappointment incentives; and 2) i assigns less value to being reappointed, because his ability to affect period 2 policy is reduced. In general, the first effect will dominate, implying a smaller reappointment incentive for larger committees (compare $(n = 3, m = 1)$ and $(n = 9, m = 3)$).

We can now consider reappointment and reputation incentives simultaneously. A graphical representation of the terms inside the parenthesis in the LHS of condition (12) is offered in Figure 5, under the same assumptions and conventions used for figures 3 and 4. (A more explicit form of condition (12) for the case of a committee with government appointments is presented in part D of the Appendix.) The set of black lines represents the case of a hawk government, where the incentive to choose low inflation is maximized; the grey lines represent the case of a dove government.

Note first that, even though $b = 0$,for any given combination $(n, \frac{m}{n})$ there is a clear difference between periods when the government is hawk and when it is dove. This is important, as it is frequently argued that central bankers do not act opportunistically, and that this isolates their decisions from incentives to impress the government. From this analysis, it is clear that even purely partisan (i.e., ideologically driven) central bankers want to keep their jobs and are therefore not immune to government pressures. There is of course a fundamental difference with opportunistic central bankers, in that partisan policymakers are driven by a desire to choose the policy they believe is best. It is also the case that opportunistic policymakers have an additional reason for wanting to stay in office, and thus are confronted with a stronger reappointment incentive. However, it is important to highlight that both partisan and opportunistic central bankers have an incentive to please the government.

Figure 5 also shows that, compared to a single central banker (represented by the thin solid lines), a committee design has the potential both to increase the importance of building the CB's reputation as tough on inflation, and to reduce the importance of reappointment considerations. In this figure, this is more clearly observed in the case of a dove government, as under a hawk government increasing reputation-building incentives and reducing reappointment considerations act in opposite directions in terms of what inflation rate i should vote for. Note that, in the case of a dove government, the overall benefit of voting for low inflation, against the preferences of the government, can be larger under a committee than with a single banker. The realization of this potential, however, depends

crucially on the size of the committee and the number of members who remain in office from one period to the next. An increase in the turnover rate, $\frac{m}{n}$, reduces the relevance of past inflation for future expectations of inflation, thus diminishing the ability of reputation considerations to contain inflation bias. It also increases the risk that a central banker will be removed from office if he is believed to be of a different type than the government, thus strengthening incentives to follow the government's preferred policy. In this example, for all values of ϕ, a $(n = 9, m = 1)$ committee generates larger incentives to vote for low inflation than does a single central banker, while a $(n = 9, m = 3)$ committee is frequently associated with a greater inflation bias than is a single banker. Even in cases where a $(n = 9, m = 3)$ committee reduces inflation bias relative to a single central banker, the benefit of choosing low inflation is much smaller than in a committee of the same size where $m = 1$. On the other hand, an increase in the size of the committee, n, reduces the ability of any member to have an effect on actual policy; central bankers thus become more concerned with influencing reappointment than with choosing policy. This is why, keeping $\frac{m}{n} = \frac{1}{3}$, the benefit of voting for low inflation is larger if $n = 3$ than if $n = 9$ for all values of ϕ. In fact, for this turnover rate, a $n = 9$ committee does not reduce inflation bias with respect to a single banker in any important manner, while the $n = 3$ committee does so for most values of ϕ.

Perhaps the most dramatic example that, against common wisdom and the previous literature, a committee structure ends up increasing the influence of the government if the committee is not properly designed, is the possibility of a pooling equilibrium in a committee scenario. Note that under a hawk government there is at least one such pooling equilibrium, where each central banker votes for low inflation, as preferred by the government. This is so because a pooling equilibrium leads to zero representation; if all the other committee members are voting for $\pi = 0$, $i's$ vote will have no impact on policy. Given this, $i's$ vote will only affect his reappointment chances, and i will not want to deviate from voting for the government's preferred rate. Under a more general setting where hawkish central bankers are not mechanistic, but also respond to reappointment incentives, there is a pooling equilibrium where all committee members vote for the rate preferred by the government, no matter what the government's type is. That is, if we allow hawk central bankers to have reappointment incentives, we find a high (low) inflation pooling equilibrium in committees when the government is dove (hawk).

Given the existence of a pooling equilibrium around the government's preferences, can a committee structure reduce the influence of the government? The answer will be affirmative only if there exist other equilibria. In our simplified setting with mechanistic hawks, we thus need to look for equilibria

such that, under a hawk government, $w > 0$. Table 2 shows equilibrium values of w under a hawk government, where values of w other than $w = 0$ exist in equilibrium. As in table 1, it is assumed that $\phi = 0.5$, and that β can follow either a uniform distribution between 0.8 and 1 or a normal distribution with 99% of observations concentrated between 0.8 and 1. Note that equilibria with $w > 0$ exist only for small values of n and $\frac{m}{n}$. This reflects the intuition described above: large turnover rates maximize the influence of the government over the chances a central banker has of staying, while large committee sizes imply that individual central bankers have little power over policy relative to their ability to affect their chances of being reappointed. In summary, a committee design can indeed reduce the influence of the government with respect to a single central banker, but only if the committee is small and its members' turnover rate is low.

The previous literature has analyzed the effects of committee design on the ability of the government to dictate monetary policy. Both Waller (1989) and Lohman (1997) show that, compared to a single central banker, a committee can reduce the variability of monetary policy over the political cycle. Moreover, Waller (1989) shows that the power of the government over these policy choices can be effectively limited by reducing the number of members that can be appointed at any given point in time. The focus of this literature has been on how central bankers' votes become aggregated into policy choices under alternative designs of the CB. A key assumption has been that each central banker votes in line with the government that appointed him. By contrast, the results in this paper refer to the effect of committee designs and government appointments on central bankers' incentives. Key insights are obtained from this complementary approach. First, an incumbent central banker obtains benefits from voting for the policy stance preferred by the government in charge of evaluating his permanence in the committee. Second, in a committee there is a greater probability that the vote of a central banker will affect his reappointment chances that policy. This increases the importance central bankers give to reappointment. In fact, in committees with members that care about being able to affect policy, there are always equilibria in which all members vote in the first period for the rate preferred by the government; in such equilibrium each individual member knows with certainty that he will not be able to affect policy, but that his vote will affect his chances of staying in office. Finally, the influence of the government on a central banker's choices increases with the government's ability to remove members of the committee, given by the turnover rate. As a result of all of the above, the potential ability of committee designs to reduce government influence depends on its specific characteristics in terms of size and turnover rate. The influence of the government grows with the size of the committee (which reduces representation, thus making reappointment relatively more

important), and with the turnover rate.

6 Concluding remarks

Central Bank independence is a popular recipe for freeing monetary policy from both inflation bias and the influence of political cycles. In practice, however, political, philosophical, and economic considerations have moved societies to maintain institutional links between governments and CBs. This gives rise to the question of whether the institutional design of a CB can be adapted to bring out the desired benefits of independence, in spite of independence being, *de facto*, only partial.

In this quest, many countries have turned to committee designs for monetary authorities, as these are considered to be more easily shaped to generate optimal outcomes. Two reasons are usually presented in arguing that a committee is more flexible than an individual policymaker: first, the decision-making mechanism can be designed to tilt the balance of given policy positions in favor of the optimal policy; and second, its members' terms can be staggered to make CB preferences more stable over time. These arguments, however, overlook the fact that collective decision-making also changes the fundamental incentives faced by central bankers when choosing policy.

This paper studies how government appointments and committee design affect the structure of incentives faced by central bankers. I show that, with respect to a single central banker, the flexibility provided by a committee setting can be exploited both to reduce inflation bias and to reduce the influence of the government on the choices of each individual central banker; the opposite can result, however, if the size of the committee and the rate at which its members are rotated are not chosen appropriately. The basic assumption behind these results is that the terms of central bankers can be extended by government decision; that is, central bankers can be reappointed. In this context, so long as at least one central banker remains in office for the following period, policy outcomes affect the reputation of the CB.

The persistence in policy that can result from staggering the terms of committee members can be beneficial, not only because reducing the time variance of policy has a direct positive effect on welfare, but also because it gives more importance to the inter-temporal considerations that can ultimately deter central bankers from excessively inflating. In this sense, an appropriately designed committee, in which a large fraction of members remains in office for at least one additional period, can reduce the inflation bias of monetary policy. By favoring the incentives to choose a conservative monetary policy rather than that preferred by the government, an appropriate committee design may also reduce the link between monetary policy and political cycles.

I also explore the idea that collective decision-making creates a dichotomy between the collective and individual reputations of board members, in a context where the former depends on past policy outcomes, and the latter on the members' individual decisions. Since the individual vote of a member may not be reflected in the policy outcome, the desire to protect the CB's reputation may be dominated by individual reputation considerations. This implies that, if the government makes reappointment decisions based on a central banker's individual reputation, he may give more importance to maximizing his chances of reappointment than choosing the optimal monetary policy. As a result, a committee design may actually end up increasing the influence of the government on monetary policy, if each central banker feels that he has little power to affect the policy outcome. This implies that only a committee of small size, where each member's actions are more likely to have an impact, will have the ability to isolate monetary policy from political cycles.

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Appendix

A Proof of result 1

Since his vote can only take the values of 0 and π^d , the problem of dove central banker i in period 1 can be rewritten as[26]:

$$\underset{\{v_i\}}{Min}$$

$$\begin{aligned}&\Pr(\pi=\pi^d \mid v_i)\left[\left(-\frac{c^2}{4}\right)+\beta_i E\left(L' \mid v_i, \pi=\pi^d\right)\right]\\ &+\Pr(\pi=0 \mid v_i)\left[\beta_i E\left(L' \mid v_i, \pi=0\right)\right],\end{aligned}$$

where

$$\begin{gathered}E(L' \mid v_i, \pi)= \\ \left(-\tfrac{c^2}{4}\right)\left[\Pr(r_i=1 \mid v_i)\Pr(\pi'=\pi^d \mid r_i=1)+\Pr(r_i=0 \mid v_i)\Pr(\pi'=\pi^d \mid r_i=0)\right] \\ +\left(\tfrac{c^2}{2}\right)E\left[\Pr{}^p(\pi'=\pi^d \mid \pi) \mid v_i\right]-b\Pr(r_i=1 \mid v_i).\end{gathered}$$

I have abstracted from the constant terms, and made use of the fact that $\pi^{e\prime}=\pi^d * \Pr^p(\pi'=\pi^d \mid \pi)$.

I now use the specifics of each case (single central banker and a CB committee) to derive a unique expression. For the committee case, as discussed in section 4.2, $E\left[\Pr{}^p(\pi'=\pi^d \mid \pi) \mid v_i\right]=\Pr{}^p(\pi'=\pi^d \mid \pi)$. This is because we assume that inflation expectations depend on past inflation, rather than individual votes, and because the number of members not reappointed is constant. Terms involving solely $\Pr{}^p(\pi'=\pi^d \mid \pi)$ are thus constants in the dove problem. Abstracting from these and other constants, we can re-write the dove problem for the committee case as

$$\underset{\{v_i\}}{Min}$$

$$\begin{aligned}&\Pr(\pi=\pi^d \mid v_i)\left(-\frac{c^2}{4}\right)\\ &+\Pr(\pi=\pi^d \mid v_i)\beta_i\left(\frac{c^2}{2}\right)\left[\Pr{}^p(\pi'=\pi^d \mid \pi=\pi^d)-\Pr{}^p(\pi'=\pi^d \mid \pi=0)\right]\\ &-\beta_i b\Pr(r_1=1 \mid v_i)+\beta_i\left(-\frac{c^2}{4}\right)(1-\phi)\Pr(r_i=1 \mid v_i)\Delta\Pr(\pi'=\pi^d).\end{aligned}$$

[26] Here, I make use of the fact that $c\pi^d=\frac{c^2}{2}$, and $-c\pi^d+\left(\pi^d\right)^2=-\frac{c^2}{4}$

The last term makes use of the fact that, if $r_i = 0$, i's replacement votes for π^d in the second period with a probability of ϕ. Since a dove chooses $v_i = 0$ if $L(v_i = 0) \leq L(v_i = \pi^d)$, result 1 follows, using $\Pr^p(\pi' = \pi^d \mid \pi) = E\left[\Pr^p(\pi' = \pi^d \mid \pi) \mid v_i\right]$ for any v_i.

For the single central banker case, meanwhile, the problem can be written as

$$\underset{\{v_i\}}{Min}$$

$$\Pr(\pi = \pi^d \mid v_i)\left(-\frac{c^2}{4}\right) + \beta_i\left(\frac{c^2}{2}\right)E\left[\Pr^p(\pi' = \pi^d \mid \pi = v^i)|v_i\right]$$
$$-\beta_i b \Pr(r_1 = 1 \mid v_i) + \beta_i\left(-\frac{c^2}{4}\right)(1-\phi)\Pr(r_i = 1 \mid v_i)\Delta\Pr(\pi' = \pi^d).$$

The expression in result 1 follows, taking into account that $\Delta\Pr(\pi = \pi^d) = 1$ for the single central banker case.

B Derivation of equation (11)

Letting k be a given member of the period 2 committee, the public assigns

$$\Pr(k \text{ is a dove} \mid \pi = \pi^d) = \frac{m}{n}\phi + (1 - \frac{m}{n})\phi^+$$
$$\Pr(k \text{ is a dove} \mid \pi = 0) = \frac{m}{n}\phi + (1 - \frac{m}{n})\phi^-,$$

so that

$$\Pr^p(\pi' = \pi^d \mid \pi = \pi^d) =$$
$$\sum_{x=\frac{n+1}{2}}^{n}\binom{n}{x}\left[\left(\frac{m\phi + (n-m)\phi^+}{n}\right)^x\left(1 - \frac{m\phi + (n-m)\phi^+}{n}\right)^{n-x}\right].$$

A similar expression applies if $\pi = 0$, with ϕ^- in lieu of ϕ^+. The difference between these two expressions leads to the second line of equation (11). Taking a first order approximation around $\phi^+ = \phi$ and $\phi^- = \phi$ leads to the third line of equation (11).

C The reappointment incentive in the committee case

Let ρ be the probability assigned by i that any other member votes against the government's preferred rate (ϕw if the government is hawk and $(1-\phi w)$ otherwise). If the government is hawk, then the reappointment incentive is given by

$$\Delta P(r_1 = 1, g = h) = \tag{15}$$

$$\left[\sum_{V_{-g}=0}^{m-1}\binom{n-1}{V_{-g}}\rho^{V_{-g}}(1-\rho)^{n-1-V_{-g}}\left(\frac{m-V_{-g}}{n-V_{-g}}-1\right)+\sum_{V_{-g}=m}^{n-1}\binom{n-1}{x}\rho^{V_{-g}}\rho^{n-1-V_{-g}}\left(1-\frac{m}{V_{-g}+1}-1\right)\right] \tag{16}$$

$$=-\left[\sum_{V_{-g}=0}^{m-1}\binom{n-1}{V_{-g}}\rho^{V_{-g}}(1-\rho)^{n-1-V_{-g}}\left(\frac{n-m}{n-V_{-g}}\right)+\sum_{V_{-g}=m}^{n-1}\binom{n-1}{x}\rho^{V_{-g}}\rho^{n-1-V_{-g}}\left(\frac{m}{V_{-g}+1}\right)\right]. \tag{17}$$

If the government is dove a similar procedure applies, letting V_{-g} equal the number of votes for $\pi = 0$. In general. the change in the probability of i being reappointed can be written as

$$\Delta P(r_1 = 1) = \tag{18}$$

$$\pm\left[\sum_{V_{-g}=0}^{m-1}\binom{n-1}{V_{-g}}\rho^{V_{-g}}(1-\rho)^{n-1-V_{-g}}\left(\frac{n-m}{n-V_{-g}}\right)+\sum_{V_{-g}=m}^{n-1}\binom{n-1}{x}\rho^{V_{-g}}\rho^{n-1-V_{-g}}\left(\frac{m}{V_{-g}+1}\right)\right],$$

where the negative sign is for the case where the government is hawk.

D The explicit form of condition (12) in the committee case with government-chosen appointments

Note that

$$\begin{aligned}\Delta\Pr(\pi=\pi^d) &= \Pr\left(\frac{n-1}{2}\text{ of others vote for }\pi^d\right)\\ &= \binom{n-1}{\frac{n-1}{2}}(\phi w)^{\frac{n-1}{2}}(1-\phi w)^{\frac{n-1}{2}}.\end{aligned}$$

Similarly

$$\Delta\Pr(\pi'=\pi^d) = \binom{n-1}{\frac{n-1}{2}}(\phi)^{\frac{n-1}{2}}(1-\phi)^{\frac{n-1}{2}}.$$

For an explicit form of the condition for choosing $v_i = 0$ in the committee case with government appointments, we plug these expressions together with equations (11) and (15) into condition (12) to obtain:

$$\beta_i \left(\frac{\sum_{x=z+1}^{n} \binom{n}{x} \left[\left(\frac{m\phi+(n-m)\phi^+}{n} \right)^x \left(1-\frac{m\phi+(n-m)\phi^+}{n} \right)^{n-x} - \left(\frac{m\phi+(n-m)\phi^-}{n} \right)^x \left(1-\frac{m\phi+(n-m)\phi^-}{n} \right)^{n-x} \right]}{0.5} \right.$$
$$\left. \pm \frac{\left[\sum_{x=0}^{m-1} \binom{n-1}{x} \rho^x (1-\rho)^{n-1-x} \frac{n-m}{n-x} + \sum_{x=m}^{n-1} \binom{n-1}{x} \rho^x \rho^{n-1-x} \frac{m}{x+1} \right] * \left[\frac{4b}{c^2} + (1-\phi) \binom{n-1}{\frac{n-1}{2}} (\phi)^{\frac{n-1}{2}} (1-\phi)^{\frac{n-1}{2}} \right]}{\binom{n-1}{\frac{n-1}{2}} (\phi w)^{\frac{n-1}{2}} (1-\phi w)^{\frac{n-1}{2}}} \right) > 1.$$

Figure 2: Reputation-building incentive in a committee with an exogenous reappointment probability

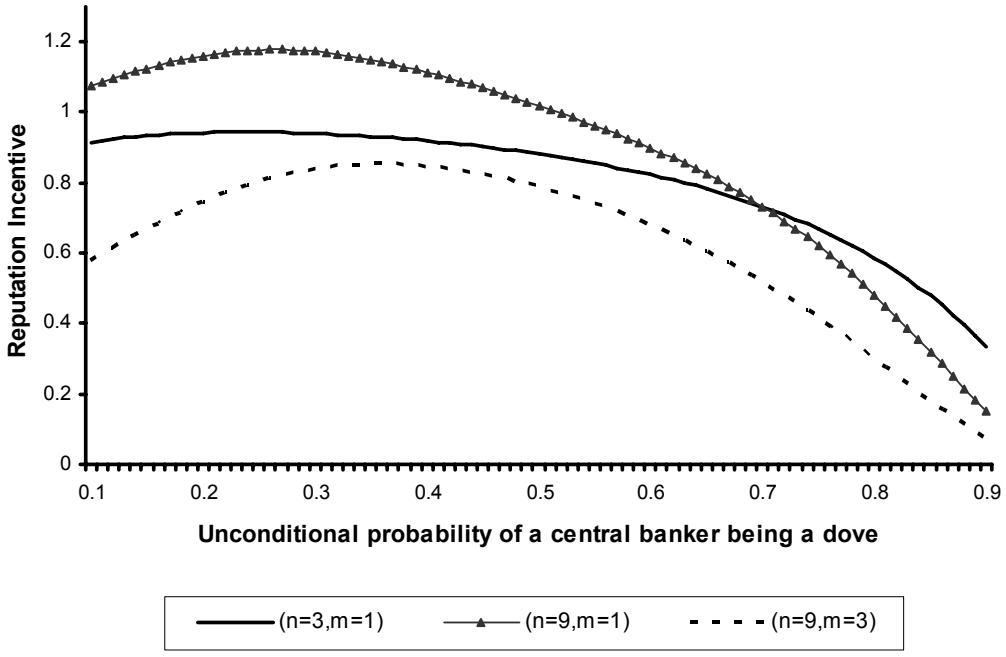


Table 1: Equilibrium probability of a dove choosing high inflation ω in a committe with an exogenous reappointment probability

		m							
		Uniform Distribution				Normal Distribution			
		1	2	3	4	1	2	3	4
n	3	1	1			1	1		
	5	0.9461	1	1	1	0.9672	1	1	1
	7	0.9166	1	1	1	0.9435	1	1	1
	9	0.9022	1	1	1	0.9310	1	1	1
	11	0.8939	0.9815	1	1	0.9236	0.9894	1	1
	13	0.8887	0.9608	1	1	0.9187	0.9777	1	1
	15	0.8851	0.9462	1	1	0.9154	0.9675	1	1
	17	0.8826	0.9354	0.9921	1	0.9131	0.9592	0.9937	1

n is the number of members, m is the number of members replaced from one period to the next.

Φ=0,5.The interval for the distribution of β is (0.8,1). When the distribution is normal, the parameters are chosen so that 99% of the β fall in that interval.

Figure 3: Reappointment incentive if *i* 's vote affects policy

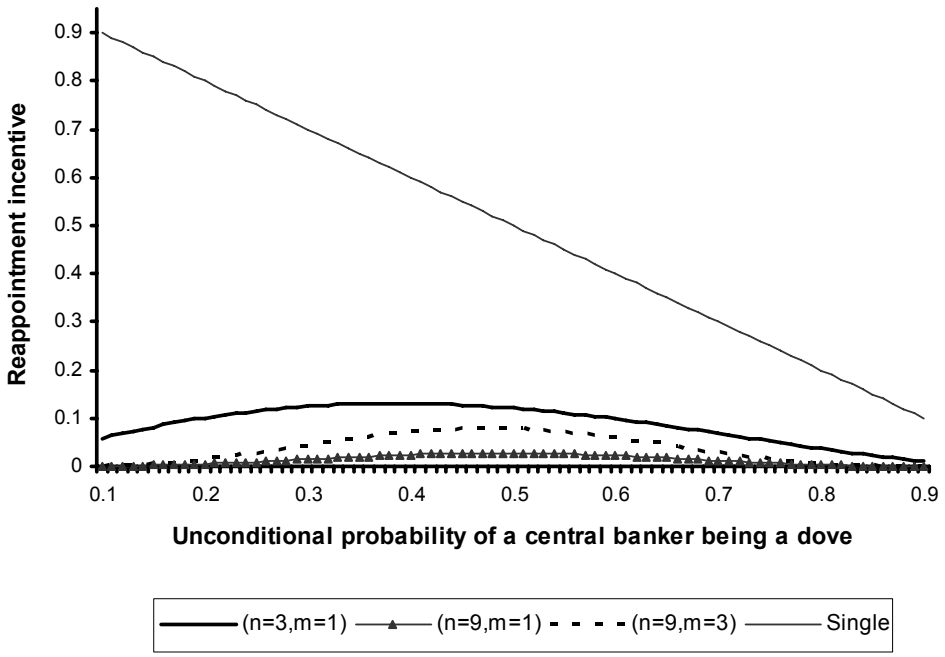
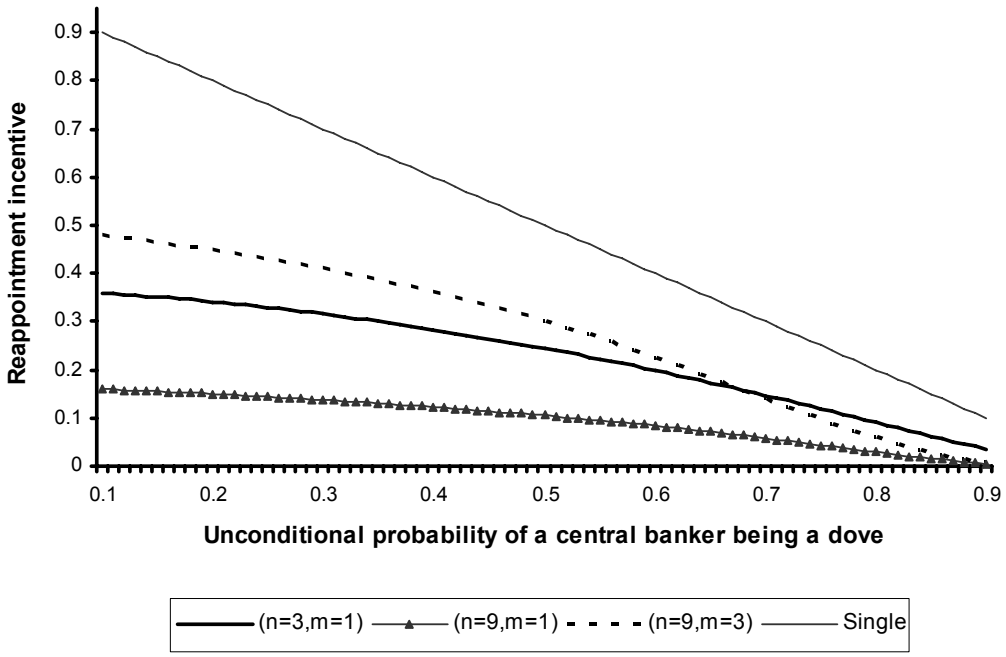


Figure 4: Reappointment incentive



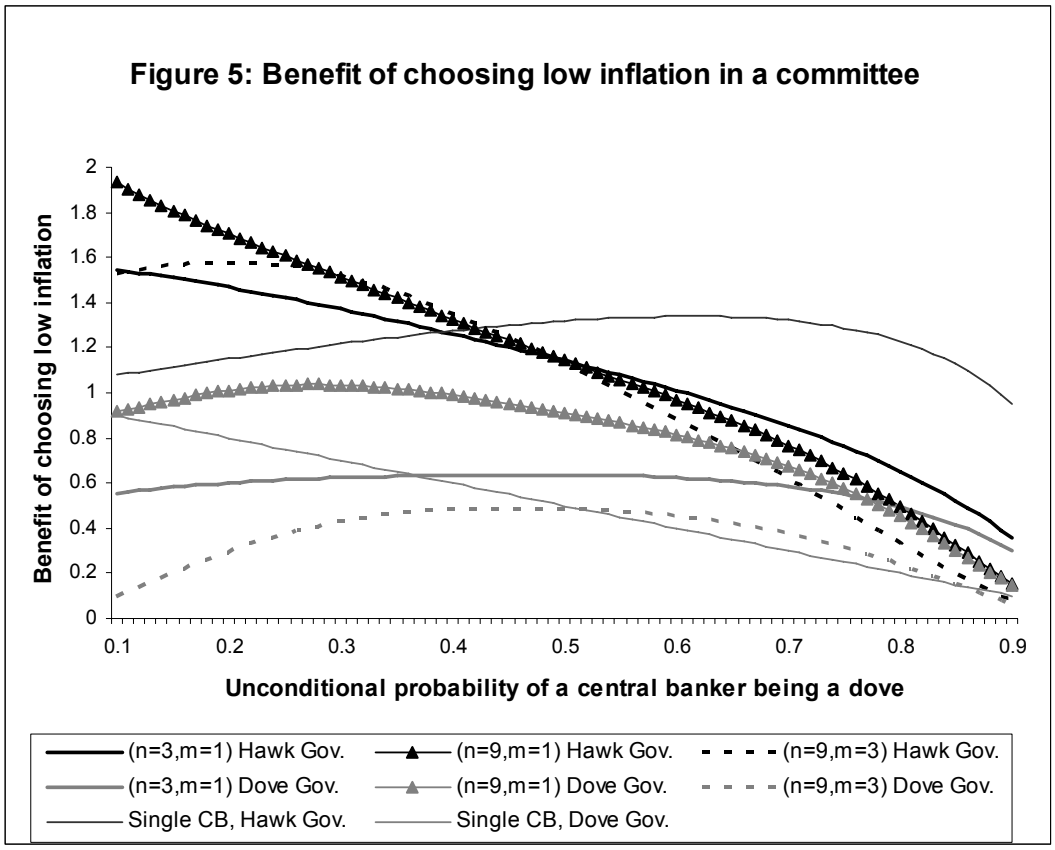


Table 2: Equilibrium probability of a dove choosing high inflation ω (other than ω=0)

		m															
		Hawk Government								Dove Government							
		Uniform Distribution				Normal Distribution				Uniform Distribution				Normal Distribution			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
n	3	0.7070	1			0.7629	1			1	1			1	1		
	5	.	0.7757	1	1	.	0.8619	1	1	1	1	1	1	1	1	1	1
	7	.	.	.	1	.	.	0.894	1	1	1	1	1	1	1	1	1
	9	.	.	.	.	.	.	.	0.9047	1	1	1	1	1	1	1	1
	11	.	.	.	.	.	.	.	.	0.9761	1	1	1	0.9868	1	1	1
	13	.	.	.	.	.	.	.	.	0.9581	1	1	1	0.9757	1	1	1
	15	.	.	.	.	.	.	.	.	0.9455	1	1	1	0.9664	1	1	1
	17	.	.	.	.	0.7253	.	.	.	0.9362	1	1	1	0.9589	1	1	1
Single		0.7178				1				0.7356				1			

n is the number of members, m is the number of members replaced from one period to next. Φ=0,5. A "." indicates there is no equilibrium ω other than ω=0.

The interval for the distribution of β is (0.8,1). When the distribution is normal, the parameters are chosen so that 99% of the β fall in that interval.