

Monetary Policy by Committee: Consensus versus Chairman Dominance

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Abstract

This paper studies the theoretical and empirical implications of monetary policy decision making by committee under two different voting protocols. In the first model, interest rate decisions are made by voting with a super majority requirement for a proposal to pass. In the second model, committee members engage in an agenda-setting game where the chairman has more power than the other members. Both models endogenously generate interest rate autocorrelation and an inaction region where the interest rate remains unchanged even if output and inflation have changed since the last meeting. The models are estimated by the Method of Maximum Likelihood using interest rate decision from four central banks. Preliminary results indicate that the consensus model fits the data more accurately than the agenda-setting model. Either model of committee decision making delivers a smaller Root Mean Squared Error than an alternative model with a single central banker.

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1 Introduction

In many countries, monetary policy decisions are delegated to a committee rather than to a single decision maker. For example, Fry *et al.* (2000) report that in a sample of 88 central banks, all but 9 countries use some form of committee structure to formulate monetary policy. The goal of this paper is to understand the implications of committee decision making on monetary policy. Monetary Policy committees (MPC) are not all alike. They differ in terms of size, composition, frequency of meetings, members' appointment, transparency of their decisions, and in many other dimensions. These differences are all likely to have an effect on monetary decisions.¹ To narrow the focus, this paper analyses the voting procedure followed by MPC and its consequence on policy outcomes.

With respect to their voting procedure, MPC can be divided in two broad categories: committees that hold a formal vote according to simple majority rule (this is the case, for example, in the U.S., the Euro area, the U.K. and Japan) and committees that explicitly operate on a consensus basis (e.g., Canada).² However, this distinction is in practice more ambiguous because some of the committees that hold a formal vote have a preference for making interest rate decisions by consensus rather than by majority vote. The European Central Bank (ECB) is commonly held to function as such a committee.³ In practice, ECB members compromise on one decision, every member ultimately backs the final agreement and dissents are not voiced in public. Concerning the Federal Open Market Committee (FOMC), the general view is that especially under the mandate of Alan Greenspan, consensus was dictated by the chairman.⁴ As Blinder (2007) puts it, "each member other than Alan Greenspan has had only one real choice when the roll was called: whether to go on record as supporting or opposing the chairman's recommendation." Thus, the FOMC chairman

¹In Waller (1992) and Waller and Walsh (1996), the length of committee members' terms of office affects the policy outcome. Waller (2000) shows that increasing the board size reduces policy variability. The partisan influence from the US President or Congress on the Fed's monetary policy decisions through the power of appointment has been investigated by a large empirical literature: see, for example, Chappell *et al.* (1993). The literature has also looked at other dimensions that might affect policy decisions, such as committee members' career background (see, Havrilesky and Schweitzer, 1990, and Gildea, 1990) and regional affiliations (Meade and Sheets, 2005).

²According to the responses provided by various central banks to the questionnaire on monetary policy frameworks circulated by the Bank of England in 1998, as reported by Fry *et al.* (2000), more than half of the monetary policy committees considered in the survey (43 out of 79) make a decision by consensus without the need for formal voting.

³This is confirmed by the following statement by the former ECB President, Wim Duisenberg: "I try to forge a consensus. ... If a discussion were to lead to a narrow majority, then it is more likely that I would postpone a decision." The New York Times, 27 June 2001.

⁴This seems to be the case also for Canada and Australia. See Blinder (2007) who puts them among what he calls the "autocratically-collegial" committees (as opposed to the "genuinely-collegial" committees, such as the ECB).

appears to have an exclusive right to decide the content of the proposal that will be put to a vote against the status quo. As a consequence of the strong agenda-setting power of the chairman, the final voting outcome can in principle be different from the policy that a majority of committee members favor.⁵ However, it would be incorrect to argue that Alan Greenspan was the *de facto* single decision maker in the FOMC. First of all, because the FOMC chairman lacks the formal authority to completely impose his view. Second, because there exists anecdotal evidence that at least to some extent, the final proposal by Alan Greenspan has been modified during the internal debate.⁶

The above discussion suggests that two important features of the voting procedure that may be key in explaining the actual monetary policy outcomes are the degree of consensuality of the decision making process and the distribution of power within the committee. Given a committee and given a set of induced preferences over the interest rate for each committee member, the voting procedure adopted by the MPC defines a political aggregator mapping the set of committee members and their preferences into a policy outcome. In the political economy literature, the most common aggregation makes the policy outcome coincide with the policy preferred by the median committee member. This is the policy that would win in any pairwise vote among all alternatives when simple majority rule is adopted. In this paper, we obtain the political aggregator for different voting protocols by solving the equilibrium outcome of a (non-cooperative) game. We will consider two voting protocols: the consensus model, where votes are taken by supermajority rule and committee members have equal powers, and an agenda-setting model (or veto game), where votes are taken by simple majority rule and the chairman of the committee has an exclusive agenda-setting power. Both protocols feature a gridlock interval, that is an interval inside which the status quo policy, equal to the policy voted in the previous meeting, remains unchanged. In the consensus model and in the agenda-setting model, the width of the gridlock interval depends, respectively, on the degree of consensus that the committee intends to reach and

⁵Blinder (2007) cites two occasions in which Alan Greenspan used his agenda-setting power to go against the will of the majority. The first episode refers to the February 1994 FOMC meeting. The transcripts of that meeting clearly indicates that a majority of members wanted to raise the funds rate by 50 basis points, while Greenspan only favored a 25 basis points increase. Eventually, the committee voted unanimously the Greenspan's proposal. Second, Blinder reports the general opinion that in the late 1990s Alan Greenspan was able to maintain the status quo although most committee members were in favor of an interest rate increase.

⁶On the basis of FOMC transcripts for the period 1987 to 1996, Chappell *et al.* (2005, p. 186) conclude that "there are at least suggestions that Greenspan's proposals were crafted with knowledge of what other members might find acceptable." Along the same lines, Laurence Meyer (Meyer, 2004) remarks on "[Greenspan]'s disproportionate influence on FOMC decisions" and on "his efforts to build consensus around his policy recommendations" (p. 50). However, Mayer also notes that the chairman "does not necessarily always get his way" (p. 52).

on the distance between the preferred policies of the chairman and of the median.

A result of our voting procedures is that the political aggregation crucially depends on the location of the status quo policy.⁷ This creates a dynamic link across periods and endogenously generates autocorrelation in the policy variable. In contrast, the standard model with a single central banker, used to derive the Taylor rule, generates interest rate autocorrelation only from the serial correlation of inflation, unemployment, and/or exogenous disturbances. Since interest rates are highly autocorrelated in the data, the empirical analysis of Taylor rules usually involves the *ad hoc* addition of a lagged interest rates to the theoretical relation.

The remainder of the paper is organized as follows. Section 2 describes the committee and its decision making under two different voting procedures. Section 3 estimates the models by the method of Maximum Likelihood and compares results with those obtained under the assumption that decisions are made by a single central banker. Section 4 concludes.

2 Committee Decision Making

2.1 Composition and Preferences

Consider a monetary policy committee composed of N members, labelled $j = 1, \dots, N$, where N is an odd integer. The assumption that N is odd allow us to uniquely pin down the median committee member and eliminates the complications associated with tie votes. The committee is concerned with selecting the value of the policy instrument in every meeting. The policy instrument is assumed to be the nominal interest rate. The relation between the instrument and economic outcomes is spelled out below in Section 2.2. The utility function of member j is

$$E_{\tau} \left(\sum_{t=\tau}^{\infty} \delta^{\tau-t} L_j(\pi_t) \right), \quad (1)$$

where $\delta \in (0, 1)$ is the discount factor, π_t is the rate of inflation, and $L_j(\cdot)$ is the instantaneous utility function. The instantaneous utility function is represented by the linex function (Varian, 1974),

$$L_j(\pi_t) = \frac{-\exp(\mu_j(\pi_t - \pi^*)) + \mu_j(\pi_t - \pi^*) + 1}{\mu_j^2}, \quad (2)$$

where π^* is an inflation target and μ_j is a member-specific preference parameter. This functional form generalizes the standard quadratic function used in earlier literature and

⁷The evidence cited in note 2 should hint at the importance of the location of the status quo. For example, in the first reported episode Greenspan was able to impose his ideal interest rate because the status quo was even worse than the 25 basis point increase proposed by Greenspan.

permits different weights for positive and negative inflation deviations from π^* .⁸ For example, when $\mu_j > 0$, a positive deviation from π^* causes a larger decrease in utility than a negative deviation of the same magnitude. The reason is that for inflation rates above π^* the exponential term dominates and utility decreases exponentially, while for inflation rates below π^* the linear term dominates and utility decreases linearly. Intuitively, when $\mu_j > 0$, committee member j is more averse to positive than to negative inflation deviations from its target even if their size (in absolute value) is identical. In order to develop the readers' intuition, the quadratic and asymmetric utility functions are plotted in Figure 1. For the asymmetric utility function, the coefficient of relative prudence (Kimball, 1990) is $\mu_j(\pi_t - \pi^*)$, which is directly proportional to the inflation deviation from its desired value with coefficient of proportionality μ_j . The assumption that committee members differ in their preference parameter μ_j is a tractable way of motivating disagreement over preferred interest rates while preserving the idea that all members share the same inflation objective.⁹

We order the N committee members so that member 1 (N) is the one with the smallest (largest) value of μ , that is, $\mu_1 \leq \mu_2 \leq \dots \leq \mu_N$. The median member, denoted by M , is the one with index $(N + 1)/2$ and, for simplicity, her preference parameter is normalized to be zero, that is $\mu_M = 0$. The distribution of μ is assumed to be time-invariant, meaning that even if there are changes in the composition of the committee (for example, as a result of fixed-appointment terms or alternations in voting members), the preference parameters associated with the key voters (see below) remain unchanged.¹⁰

2.2 Economic Environment

As in Svensson (1997), the behavior of the private sector is described by

$$\pi_{t+1} = \pi_t + \alpha_1 y_t + \varepsilon_{t+1}, \tag{3}$$

$$y_{t+1} = \beta_1 y_t - \beta_2 (i_t - \pi_t) + \eta_{t+1}, \tag{4}$$

where y_t is the deviation of an output measure from its natural level, i_t is the nominal interest

⁸To see that the function (2) nest the quadratic case take the limit of $L_j(\pi_t)$ as $\mu_j \rightarrow 0$ and use L'Hopital's rule twice.

⁹In preliminary work, we considered an alternative specification where the instantaneous utility function is quadratic and member disagree in their inflation targets. The solution of both models is basically the same and their reduced-forms are identical. The same is true for an adaptive-expectations version of the standard Neo-Keynesian model where utility depends on both inflation and unemployment, and π^* varies across committee members. All these models share the property that individual reaction functions differ only in their intercept terms but the responses to inflation and unemployment are the same for all members. This means that the results reported below are more general than the simple model used here to motivate the analysis.

¹⁰This assumption is not required for the solution of the model but it is necessary for the identification of the parameters of the interest rate process in Section 3.

rate, $\alpha_1, \beta_2 > 0$ and $0 < \beta_1 < 1$ are constant parameters, and ε_t and η_t are disturbances. The disturbances follow the moving average processes

$$\varepsilon_t = \gamma u_{t-1} + u_t, \quad (5)$$

$$\eta_t = \varsigma v_{t-1} + v_t, \quad (6)$$

where $\gamma, \varsigma \in (-1, 1)$, so that (5) and (6) are invertible, and u_t and v_t are mutually independent innovations. The innovations are Normal white noises with zero mean and constant conditional variance. Equations (3) and (4) are, respectively, a Phillips curve and an aggregate demand curve. Svensson's formulation is attractive because it embodies a stylized mechanism for the transmission of monetary policy and greatly simplifies the analysis by implicitly assuming that the private sector forms expectations adaptatively.

From (3) and (4), after some algebra, one can write

$$\pi_{t+2} = (1 + \alpha_1 \beta_2) \pi_t + \alpha_1 (1 + \beta_1) y_t - \alpha_1 \beta_2 i_t + \varepsilon_{t+1} + \alpha_1 \eta_{t+1} + \varepsilon_{t+2}. \quad (7)$$

As a result of the control lag in this model, the interest rate selected by the committee at time t affects inflation only after two periods *via* its effect on the output gap after one period. This means that the current inflation rate and output gap are predetermined variables.

2.3 Policy Preferred by Individual Members

Consider the member-specific interest rate $i_{j,t}^*$ defined by the solution to

$$\max_{\{i_t\}} \delta^2 E_t L_j(\pi_{t+2}),$$

subject to equation (7). Equation (7) combines the Phillips and aggregate demand curves and summarizes the constraints imposed by the private sector on the policy choices of the committee. The first-order necessary condition of this problem is

$$\delta^2 (\alpha_1 \beta_2) E_t \left(\frac{\mu_j \exp(\mu_j(\pi_{t+2} - \pi^*)) - \mu_j}{\mu_j^2} \right) = 0.$$

which implies

$$E_t \exp(\mu_j(\pi_{t+2} - \pi^*)) = 1. \quad (8)$$

Under the assumption that disturbances are Normally distributed, the rate of inflation (conditional on the information set) is also Normally distributed. Then, $\exp(\mu_j(\pi_{t+2} - \pi^*))$ is distributed Log-normal with mean $\exp(\mu_j(\pi_{t+2} - \pi^*) + \mu_j^2 \sigma_\pi^2 / 2)$ where σ_π^2 denotes the conditional variance of π_t . Since shocks are conditional homoscedastic, it follows that σ_π^2 is time invariant. Then, substituting in (8) and taking logs, we obtain

$$E_t \pi_{t+2} = \pi^* - \mu_j^2 \sigma_\pi / 2.$$

Using (7) and taking expectations, the member j 's reaction function is

$$i_{j,t}^* = a_j + b\pi_t + cy_t + \zeta_t, \quad (9)$$

where

$$\begin{aligned} a_j &= -\left(\frac{1}{\alpha_1\beta_2}\right)\pi^* + \left(\frac{\mu_j}{2\alpha_1\beta_2}\right)\sigma_\pi^2, \\ b &= 1 + \frac{1}{\alpha_1\beta_2}, \\ c &= \frac{1 + \beta_1}{\beta_2} \\ \zeta_t &= \left(\frac{1}{\alpha_1\beta_2}\right)(\gamma u_t + \varsigma v_t). \end{aligned}$$

Note that when preferences are asymmetric (as opposed to quadratic), a prudence motive arises in the conduct of monetary policy and interest rates respond not only to inflation and output but also to inflation volatility. Since members differ in the asymmetry parameter in their utility function, they respond differently to inflation volatility and the intercept in their reaction function is therefore member-specific (hence the subscript j in a_j). On the other hand, the coefficients of inflation and output depend only on aggregate parameters and, consequently, b and c are common to all members. Since the innovations u_t and v_t are white noise, it follows that their linear combination, ζ_t , is white noise as well and its constant conditional variance is $\sigma^2 = (\gamma^2\sigma_u^2 + \varsigma^2\sigma_v^2)/(\alpha_1\beta_2)^2$, where σ_u^2 and σ_v^2 are the variances of u_t and v_t , respectively. When $\mu_j \rightarrow 0$, we obtain the standard result in the literature where, as a consequence of certainty equivalence, the coefficient of σ_π^2 goes to zero.

In the following Sections, we introduce two voting protocols used by the committee to select the interest rate, namely a consensus model and an agenda-setting model. In the consensus model all members are equal and supermajority is required to adopt a new interest rate level. In the agenda-setting model, decisions are taken by simple majority but one member, that is the chairman, has a strong agenda control. Both models endogenously generate interest rate smoothing and autocorrelation, and deliver inaction regions where the committee keeps the interest rate unchanged despite the fact that inflation and output have changed since the previous meeting. However, the model differ in their predictions regarding interest rate adjustment and these differences are exploited in the empirical section of the paper to distinguish econometrically between these models.

2.4 Voting Protocol I: The Consensus Model

Assume that the set of alternatives, I , that can be considered in each meeting is finite and they all come from the continuous and bounded interval $[0, i^{\max}]$. For the sake of the exposition and to avoid unnecessary complications, assume that all alternatives and all member-specific preferred interest rates (from equation (9)) are integer multiples of $\epsilon > 0$.¹¹ Let q_t denote the status quo policy in the current meeting. Assume that the initial status quo coincides with the interest rate i_{t-1} that was selected in the previous committee meeting.

In each meeting, there are two stages.¹² In the first stage, committee members vote by simple majority rule whether the debate in the second stage will involve an increase or a decrease of the interest rate with respect to the status quo. If the committee votes for an interest rate increase (decrease), all alternatives that are strictly smaller (larger) than q_t will be discarded. In the second stage, the committee selects the interest rate among the remaining alternatives through a binary agenda.¹³ Assume that in this stage, the committee makes a decision by supermajority rule. Let $S \equiv (N + 1 + 2K)/2$ denote the size of the smallest supermajority required to pass a proposal. The index K , where $1 \leq K \leq (N - 1)/2$, measures the size of the supermajority. For example, when $K = (N - 1)/2$, unanimity is required and $S = N$. The voting procedure is as follows. Suppose, for example, that the committee decided to consider an increase of the interest rate. The first alternative that is considered is $q_t + \epsilon$, which is put to a vote against the status quo q_t . If $q_t + \epsilon$ does not receive a supermajority approval (*i.e.*, the proposal does not pass), then the meeting ends and the status quo is implemented. If the proposal passes, then it displaces i_{t-1} as the default policy. At the second round, $q_t + 2\epsilon$ is voted against $q_t + \epsilon$. If $q_t + 2\epsilon$ does not pass, the final decision becomes $q_t + \epsilon$, and so on.

Note that the number of possible rounds in the second stage of each meeting is finite. Let r denote the round, with $r = 1, \dots, R$. If the committee keeps accepting further increases, there will be a final round where the committee will have to decide between i^{\max} and $i^{\max} - \epsilon$.¹⁴ We study pure strategy subgame perfect equilibria with the following property: in each period, individuals vote as if they are pivotal. This is meant to rule out equilibria where committee members vote contrary to their preferences. This refinement is standard in the voting literature. Throughout this paper, it is assumed that committee members are forward looking within each meeting (that is, they vote strategically in each round of the meeting

¹¹It is easy to see that when ϵ is sufficiently small and the number of alternatives in I is large, the equilibrium outcome approximates well the one with a continuous set of alternatives.

¹²This voting protocol is similar to the one considered by Dal Bó (2006).

¹³See Austen-Smith and Banks (2005, Ch. 4) for a discussion of binary agendas.

¹⁴Alternatively, if in the first stage of the meeting the committee decides to consider interest rate decreases only, then at the final round of the second stage the vote would be between policies 0 and ϵ .

foreseeing the effect of their vote on future rounds), but they disregard the consequences of their voting decision on future meetings *via* the status quo.¹⁵

Let Ψ denote the political aggregator under a consensus voting protocol. This function, which does not depend itself on the particular t , aggregates for each given state of economy the induced policy preferences into a policy outcome:

$$i_t = \Psi(s_t, q_t, \mathbf{w}_t),$$

where $s_t \equiv (\pi_t, y_t, \zeta_t)$ denotes the state of the economy at time t , including the inflation rate, the output-gap and the disturbance term, q_t is the political state variable, and \mathbf{w}_t is the vector of induced policy preferences over the interest rate for all committee members. The next proposition shows that the protocol we have just described delivers a relatively simple equilibrium outcome. For status quo policies that are centrally located, the committee does not change. When the status quo policy is sufficiently at the extreme of the policy spectrum, in equilibrium the new policy will move toward the centre.

Proposition 1: *The policy outcome in the consensus model is given by*

$$\Psi(s_t, q_t, \mathbf{w}_t) = i_t = \begin{cases} i_{M+K,t}^*, & \text{if } q_t > i_{M+K,t}^*, \\ q_t, & \text{if } i_{M-K,t}^* \leq q_t \leq i_{M+K,t}^*, \\ i_{M-K,t}^*, & \text{if } q_t < i_{M-K,t}^*. \end{cases}$$

Proof: See Appendix A.

Intuitively, for initial status quo $q_t > i_{M+K,t}^*$, committee members initially agree on decreasing the nominal rate and successive proposals are passed until $i_t = i_{M+K,t}^*$. When $i_t = i_{M+K,t}^*$, a further ϵ -decrease would not receive the approval of a super majority. Similarly, for initial status quo $q_t < i_{M-K,t}^*$, committee members initially agree on increasing the nominal rate and successive proposals are passed until $i_t = i_{M-K,t}^*$. When $i_t = i_{M-K,t}^*$, a further ϵ -increase would not receive the approval of a super majority. Finally, for initial status quo $i_{M-K,t}^* \leq q_t \leq i_{M+K,t}^*$ and regardless of the result in the first stage of the meeting, no proposal would pass in the second stage because the super majority requirement is not satisfied and the interest rate remains unchanged. Thus, this protocol features a gridlock interval (that is, a set of status quo policies where policy changes are not possible). The gridlock interval includes all status quo policies $q_t \in [i_{M-K,t}^*, i_{M+K,t}^*]$. The policy outcome

¹⁵Allowing members to internalize their influence on the future status quo is a much more difficult problem to solve. Riboni and Ruge-Murcia (2006) solve this problem for the agenda-setting game in a simpler framework than the one developed here. They show that decision rules derived under fully strategic behavior imply more inertia in policy making than those obtained under myopic behavior, but that they are qualitatively similar otherwise.

as a function of q_t under this protocol is plotted in Panel 1 of Figure 2. Policies on the 45 degree line correspond to $i_t = q_t$. The size of the policy change can be inferred by looking at the vertical distance between the policy rules and the 45 degree line. The next corollary easily follows.

Corollary 1: *The width of the gridlock interval is decreasing in K (the size of the supermajority). When $K = 0$ there is no gridlock and starting from all status quo policy, the committee final decision is $i_{M,t}^*$.*

It is interesting that when votes are taken by simple majority, inertia and path dependence disappear. Within each meeting starting from any status quo policy the interest rate preferred by the median individual is selected. Committee decision making is then equivalent to replacing the single central banker by the median committee member.

2.5 Voting Protocol II: The Agenda-Setting Model

In the agenda setting game, proposals are passed by simple majority rule. The policy space is equal to the interval $[0, i^{\max}]$. Compared with the previous protocol, agents differ in their institutional role. In particular, one member, that is the chairman or agenda setter (denoted by A), makes a take-it-or-leave-it proposal to the other committee members. This assumption is meant to represent the idea that chairmen usually have more power and influence than their peers as a result of statutory prerogatives, additional legal responsibilities, or prestige. Evidence on the dominant role of the chairman in some monetary policy committees (including the FOMC) was presented in the Introduction.¹⁶ In what follows, assume that $\mu_A \neq \mu_M$. Two cases are possible: a hawkish chairman ($\mu_A > \mu_M$) and a dovish chairman ($\mu_M > \mu_A$). In this Section, for the sake of exposition we consider the first case only. The second case is perfectly symmetric.

The voting protocol is as follows: at each meeting, given the current state of the economy and given the current status quo, the chairman proposes an interest rate for period t . No other member is permitted to propose another alternative. The other committee members can either accept the chairman's proposal or reject it. If the proposal passes (*i.e.*, it obtains $(N + 1)/2$ votes), then the proposed policy is implemented and become the status quo for next meeting. If it is rejected, the status quo policy is maintained. At the next period,

¹⁶One might wonder what are the advantages of setting up an "autocratically-collegial" committee, as opposed to delegating policy decisions to a single decision maker. In an experimental paper, Blinder and Morgan (2007) investigate the possibility of a positive effect of leadership on group performance. Riboni (2004) shows that joining a committee by maintaining a strong agenda setting power is a way for a decision maker to commit to a policy that, in absence of committees, is not time consistent.

this procedure is repeated. As in the previous section, players disregard the consequences of their voting decision on future meetings *via* the status quo. Committee members accept a proposal whenever the current utility from the proposal is larger than or equal to the utility with the current status quo and, as in the previous model, individuals vote as if they are pivotal. Among the policies that are acceptable to a majority of $(N + 1)/2$ members, the chairman picks the one closest to her ideal point. The equilibrium outcome of this game is easy to derive and well-known in the political economy literature (see, for example, Romer and Rosenthal, 1978).

The interval of status quo policies where policy change is not possible (*i.e.*, the gridlock interval) is given by $[i_{M,t}^*, i_{A,t}^*]$, that is all the policies between the preferred interest rate of the median and of the agenda setter. If the status quo falls within this interval, policy changes are blocked by either the chairman or a majority of committee members. If $q_t \in [i_{M,t}^*, i_{A,t}^*]$, a majority would veto any increase of the instrument value towards i_A^* and proposing the status quo is then the best option for the chairman. A policy change can only occur when the status quo is sufficiently extreme. In particular, when q_t falls in the interval $[2i_{M,t}^* - i_{A,t}^*, i_{M,t}^*)$, the chairman chooses the policy closest to her ideal point subject to the constraint that M will accept it. The constraint is binding in equilibrium. That is, M will be indifferent between the status quo and the interest rate that A proposes. Since the median has a symmetric induced utility (recall that $\mu_M = 0$), this proposal is the reflection point of q_t with respect to $i_{M,t}^*$. When the status quo policy is either very low or high, the chairman is able to offer and pass a proposal that coincides with her ideal point. Note that the width of the range of inaction $[i_{M,t}^*, i_{A,t}^*]$ is increasing as the preferences of the chairman and of the median become more heterogenous. When the median is also the chairman, starting from any status quo the median outcome prevails. Let Υ denote the political aggregator in the agenda-setting game.

Proposition 2: *The policy outcome in the agenda-setting model with $\mu_A > \mu_M$ is given by*

$$\Upsilon(s_t, q_t, \mathbf{w}_t) = i_t = \begin{cases} i_{A,t}^*, & \text{if } q_t \geq i_{A,t}^*, \\ q_t, & \text{if } i_{M,t}^* < q_t < i_{A,t}^*, \\ 2i_{M,t}^* - q_t, & \text{if } 2i_{M,t}^* - i_{A,t}^* < q_t \leq i_{M,t}^*, \\ i_{A,t}^*, & \text{if } q_t \leq 2i_{M,t}^* - i_{A,t}^*, \end{cases} .$$

Proof: See Appendix B.

The political aggregator as a function of q_t is plotted in Panel 2 of Figure 2. The policy aggregator for the case of a dovish chairman is plotted in Panel 3 of Figure 2. Notice that all political aggregator give similar predictions in terms of size of the policy change when the

status quo policy is relatively moderate (identical predictions, according to Figure 1 because we set $i_{A,t}^* = i_{M+K,t}^*$), while predictions are different when the status quo policy is very low or very high. For example, the agenda-setting model with hawkish (dovish) chairman features more aggressive interest rate increases (decreases) than the other models.

2.6 Implications

A common feature of both voting procedures is the existence of a gridlock interval, that is an interval where it is not possible to change the status quo. A priori, it is difficult to predict which voting procedure features the largest gridlock interval. The comparison depends on the degree of consensus that the committee expects to reach (summarized by K) and on the extent of disagreement between the chairman and the median.

Note that the intersection of the two intervals is non-empty given that $i_{M,t}^*$ must belong to both gridlock intervals. In principle, the gridlock interval in the agenda-setting model could be a subset of the one obtained in the consensus model (if $|\mu_A - \mu_M|$ is sufficiently small and K sufficiently large) but the former cannot include the latter.

When the chairman is a hawk, the comparison of the size of the policy change under the two protocols is unambiguous for $q_t < i_{M,t}^*$. In these cases, the agenda-setting model predicts a larger policy change compared to the consensus model. When instead $q_t \geq i_{M,t}^*$, the comparison is ambiguous and depends on the location of $i_{A,t}^*$ versus $i_{M+K,t}^*$. If the chairman is a dove, the agenda-setting model unambiguously predicts larger policy changes when the status quo is high.

In both models, the endpoints of this interval are stochastic and depend on current state of the economy. An implication of the predicted local inertia is that the relation between changes in the state of nature and in policy is nonlinear. In particular, small changes in the state of economy are less likely to produce policy changes compared with larger ones. Empirically, this would mean, for example, that small variations in the rates of inflation and unemployment are less likely to result in a change in the key nominal interest rate, compared with large movements in these variables. In contrast, the standard model with a single central banker, which underlies the derivation of the linear Taylor rule, predicts a proportional change in the policy instrument for any change in inflation and unemployment regardless of their size.

3 Empirical Analysis

3.1 Data

The data set consists of interest rate decisions by monetary policy committees in four central banks, namely the Bank of Canada, the Bank of England, the European Central Bank (ECB), and the U.S. Federal Reserve, along with the inflation and unemployment rates in their respective countries. Interest rate decisions concern the target values for the Overnight Rate (Canada), the Repo Rate (United Kingdom), the Rate for Main Refinancing Operations (European Union) and the Federal Funds Rate (United States). For the Federal Reserve, the sources are Chappell *et al.* (2005) and the Federal Reserve Bank of New York. For the other central banks, the source are official press releases compiled by the authors. The sample for Canada starts with the first pre-announced date for monetary policy decisions in December 2000 and ends in March 2007. The sample for the United Kingdom starts with the first meeting of the Monetary Policy Committee in June 1997 and ends in June 2007. The sample for the European Union starts on January 1999 and ends in March 2007. For the United States, we study a sample from February 1970 to February 1978 and another one from August 1988 to January 2007. The first sample corresponds to the chairmanship of Arthur Burns, and the second one corresponds to the chairmanships of Allan Greenspan and Ben Bernanke.

Inflation is measured by the twelve-month percentage change of the Consumer Price Index (Canada), Retail Price Index (United Kingdom), Harmonized Consumer Price Index (European Union) and Consumer Price Index for All Urban Consumers (United States).¹⁷ Unemployment is measured by the seasonally-adjusted rate for the civilian workforce.¹⁸

3.2 Formulation of the Likelihood Function

In this section we derive the likelihood function for the consensus and agenda-setting models. For the consensus model, the policy outcome in Proposition 1 implies the following statistical process for the nominal interest rate:

¹⁷After December 2003, the inflation target in the United Kingdom applies to the Consumer Price Index (CPI) rather than to the core Retail Price Index. However, results using the CPI are very similar to the ones reported below and support the same conclusions. These results are not reported to save space but are available from the corresponding author upon request.

¹⁸As it is well known, there are some differences in the age groups covered by national labor-force surveys. Thus, in Canada, the unemployment rate refers to persons 15 year of age and older, in the U.S. to persons 16 years of age and older, and [other countries].

$$i_t = \begin{cases} i_{M+K,t}^*, & \text{if } i_{t-1} \geq i_{M+K,t}^*, \\ i_{t-1}, & \text{if } i_{M-K,t}^* < i_{t-1} < i_{M+K,t}^*, \\ i_{M-K,t}^*, & \text{if } i_{t-1} \leq i_{M-K,t}^*, \end{cases}$$

where

$$\begin{aligned} i_{M+K,t}^* &= a_{M+K} + b\pi_t + cy_t + \zeta_t, \\ i_{M-K,t}^* &= a_{M-K} + b\pi_t + cy_t + \zeta_t. \end{aligned}$$

In what follows, it is convenient to define the variables

$$\begin{aligned} z_{M+K,t}^* &= i_{t-1} - a_{M+K} - b\pi_t - cy_t, \\ z_{M-K,t}^* &= i_{t-1} - a_{M-K} - b\pi_t - cy_t, \end{aligned}$$

and rewrite the interest rate process as

$$i_t = \begin{cases} i_{M+K,t}^*, & \text{if } \zeta_t \leq z_{M+K,t}^*, \\ i_{t-1}, & \text{if } z_{M-K,t}^* > \zeta_t > z_{M+K,t}^*, \\ i_{M-K,t}^*, & \text{if } \zeta_t \geq z_{M-K,t}^*. \end{cases}$$

Written this way, it is easy to see that the density of i_t is akin to that of the standard Tobit model. Define the set $\Omega_t = \{i_{t-1}, \pi_t, y_t\}$ with the variables predetermined at time t and the sets Ξ_1 , Ξ_2 and Ξ_3 that contain the observations where the interest rate was raised, left unchanged, and cut, respectively. Then, for observations in the set Ξ_2 ,

$$Pr(i_t|\Omega_t) = \Phi\left(\frac{z_{M-K,t}^*}{\sigma}\right) - \Phi\left(\frac{z_{M+K,t}^*}{\sigma}\right),$$

where $\Phi(\cdot)$ denotes the cumulative distribution function of the standard normal variable, and for observations in the sets Ξ_1 and Ξ_3 ,

$$Pr(i_t|\Omega_t) = \frac{1}{\sigma}\phi\left(\frac{i_t - a_{M-K} - b\pi_t - cy_t}{\sigma}\right)$$

and

$$Pr(i_t|\Omega_t) = \frac{1}{\sigma}\phi\left(\frac{i_t - a_{M+K} - b\pi_t - cy_t}{\sigma}\right),$$

respectively, where $\phi(\cdot)$ denotes the probability density function of the standard normal variable. Then, log likelihood function of T available interest rate observations is

$$L(\boldsymbol{\theta}) = \prod_{i_t \in \Xi_1} \frac{1}{\sigma} \phi \left(\frac{i_t - a_{M-K} - b\pi_t - cy_t}{\sigma} \right) \cdot \prod_{i_t \in \Xi_2} \left(\Phi \left(\frac{z_{M-K,t}^*}{\sigma} \right) - \Phi \left(\frac{z_{M+K,t}^*}{\sigma} \right) \right) \\ \cdot \prod_{i_t \in \Xi_3} \frac{1}{\sigma} \phi \left(\frac{i_t - a_{M+K} - b\pi_t - cy_t}{\sigma} \right),$$

where $\boldsymbol{\theta} = \{a_{M-K}, a_{M+K}, b, c, \sigma\}$ denotes the set of unknown parameters the likelihood function depends upon.

For the agenda-setting model with a hawkish chairman, the policy outcome in Proposition 2 implies the following statistical process for the nominal interest rate:

$$i_t = \begin{cases} i_{A,t}^*, & \text{if } i_{t-1} \geq i_{A,t}^*, \\ i_{t-1}, & \text{if } i_{M,t}^* < i_{t-1} < i_{A,t}^*, \\ 2i_{M,t}^* - i_{t-1}, & \text{if } 2i_{M,t}^* - i_{A,t}^* < i_{t-1} \leq i_{M,t}^*, \\ i_{A,t}^*, & \text{if } i_{t-1} \leq 2i_{M,t}^* - i_{A,t}^*, \end{cases}$$

where

$$i_{A,t}^* = a_A + b\pi_t + cy_t + \zeta_t, \quad (10)$$

$$i_{M,t}^* = a_M + b\pi_t + cy_t + \zeta_t. \quad (11)$$

Define the variables

$$z_{A,t}^* = i_{t-1} - a_A - b\pi_t - cy_t,$$

$$z_{M,t}^* = i_{t-1} - a_M - b\pi_t - cy_t,$$

$$z_{t,D}^* = i_{t-1} - (2a_M - a_A) - b\pi_t - cy_t,$$

and rewrite the interest rate process as

$$i_t = \begin{cases} i_{A,t}^*, & \text{if } \zeta_t \leq z_{A,t}^*, \\ i_{t-1}, & \text{if } z_{M,t}^* > \zeta_t > z_{A,t}^*, \\ 2i_{M,t}^* - i_{t-1}, & \text{if } z_{t,D}^* > \zeta_t \geq z_{M,t}^*, \\ i_{A,t}^*, & \text{if } \zeta_t \geq z_{t,D}^*, \end{cases} \quad (12)$$

Then, for observations in the set Ξ_2 ,

$$Pr(i_t | \Omega_t) = \Phi \left(\frac{z_{M,t}^*}{\sigma} \right) - \Phi \left(\frac{z_{A,t}^*}{\sigma} \right),$$

and for observations the set Ξ_1 ,

$$Pr(i_t | \Omega_t) = \frac{1}{\sigma} \phi \left(\frac{i_t - a_A - b\pi_t - cy_t}{\sigma} \right).$$

For observations in the set Ξ_3 [to be finished]

The derivation of the likelihood function for the agenda-model with a dovish chairman is very similar to this one and not done here to save space.

3.3 Results

Maximum Likelihood estimates are reported in Columns (1), (2) and (3) in Tables 1 through 5 for the Bank of Canada, the Bank of England, the European Central Bank, and the U.S. Federal Reserve under the chairmanships of Arthur Burns and Allan Greenspan.

The main result is that in all cases, the consensus model delivers small in-sample forecast errors than the agenda-setting model. The reason is that the symmetry in interest-rate changes predicted by the former model seem to be in better agreement with the data than the asymmetric prediction in either version of the latter model. See Figures 3 through 7.

3.4 Comparison with Single Central Banker

The solution to the single central banker's problem is

$$i_{S,t}^* = a_S + b\pi_t + cy_t + \zeta_t.$$

Since inflation and the output are predetermined, OLS deliver consistent estimates of the reduced-form parameters. Results are reported in Columns (4) Tables 1 through 5. We also estimated a version of this reaction function that allows for *ad hoc* interest rate smoothing. That is,

$$i_{S,t}^* = \rho i_{t-1} + a_S + b\pi_t + cy_t + \zeta_t.$$

It is important to stress that smoothing term ρi_{t-1} is not predicted by the theory but is frequently added in the empirical analysis of Taylor rules to account for the fact that in the data the interest rate is highly serially correlated.

Both committee models deliver smaller in-sample forecasts errors than the theory-based Taylor rule. The reason is that Taylor rule fails to capture the autocorrelation of the nominal interest rate and predicts changes in this variable whenever inflation and/or unemployment change. Both predictions are at odds with the data. On the other hand, the Taylor rule with *ad-hoc* smoothing delivers the best in-sample fit of all models considered.

4 Conclusions

Table 1. Bank of Canada

	Committee			Single Banker	
	Consensus	Hawkish Chairman	Dovish Chairman	Taylor Rule	Taylor Rule with <i>ad-hoc</i> Smoothing
	(1)	(2)	(3)	(4)	(5)
<i>A. Parameter Estimates</i>					
a_{M+K}	3.175 [†] (0.422)	—	—	—	—
a_{M-K}	1.357 [†] (0.471)	—	—	—	—
a_M	—	1.313 [†] (0.462)	3.257 [†] (0.414)	—	—
a_A	—	3.162 [†] (0.413)	1.377 [†] (0.461)	—	—
a_S	—	—	—	2.618 [†] (0.354)	0.178 (0.131)
b	0.386 [†] (0.174)	0.381 [†] (0.171)	0.388 [†] (0.171)	0.231 (1.562)	0.055 (0.038)
c	-0.120 (0.303)	-0.112 (0.297)	-0.135 (0.297)	-0.041 (0.262)	0.006 (0.067)
ρ	—	—	—	—	0.895 [†] (0.035)
σ	0.965 [†] (0.123)	0.942 [†] (0.120)	0.941 [†] (0.120)	—	—
<i>B. Model Comparison</i>					
RMSE	0.506	0.631	0.867	0.850	0.216
MAE	0.388	0.502	0.561	0.715	0.173
R^2	—	—	—	0.050	0.939

Notes: The superscript † denotes the rejection of the hypothesis that the true parameter value is zero at the 5 per cent significance level.

Table 2. Bank of England

	Committee			Single Banker	
	Consensus	Hawkish Chairman	Dovish Chairman	Taylor Rule	Taylor Rule with <i>ad hoc</i> Smoothing
	(1)	(2)	(3)	(4)	(5)
<i>A. Parameter Estimates</i>					
a_{M+K}	5.174 [†] (0.699)	—	—	—	—
a_{M-K}	0.912 (0.829)	—	—	—	—
a_M	—	0.947 (0.805)	5.241 [†] (0.685)	—	—
a_A	—	5.133 [†] (0.680)	1.019 (0.810)	—	—
a_S	—	—	—	4.025 [†] (0.363)	0.033 (0.081)
b	0.770 [†] (0.274)	0.764 [†] (0.267)	0.751 [†] (0.269)	0.413 [†] (0.141)	0.044 [†] (0.022)
c	-1.587 (1.338)	-1.575 (1.304)	-1.596 (1.313)	-2.327 [†] (0.694)	-0.056 (0.110)
ρ	—	—	—	—	0.968 [†] (0.014)
σ	1.561 [†] (0.206)	1.512 [†] (0.198)	1.519 [†] (0.199)	—	—
<i>B. Model Comparison</i>					
RMSE	0.286	0.406	0.429	0.979	0.147
MAE	0.217	0.305	0.311	0.836	0.096
R^2	—	—	—	0.268	0.983

Notes: See notes to Table 1.

Table 3. European Central Bank

	Committee			Single Banker	
	Consensus	Hawkish Chairman	Dovish Chairman	Taylor Rule	Taylor Rule with <i>ad hoc</i> Smoothing
	(1)	(2)	(3)	(4)	(5)
<i>A. Parameter Estimates</i>					
a_{M+K}	4.926 [†] (0.884)	—	—	—	—
a_{M-K}	0.325 (0.805)	—	—	—	—
a_M	—	0.351 (0.774)	3.257 [†] (0.414)	—	—
a_A	—	4.789 [†] (0.845)	0.413 (0.772)	—	—
a_S	—	—	—	2.123 [†] (0.309)	0.091 (0.062)
b	0.220 (0.376)	0.237 (0.361)	0.231 (0.360)	0.437 [†] (0.153)	−0.004 (0.027)
c	−1.876 [†] (0.440)	−1.801 [†] (0.418)	−1.812 [†] (0.416)	−1.109 [†] (0.197)	−0.112 [†] (0.037)
ρ	—	—	—	—	0.970 [†] (0.015)
σ	1.363 [†] (0.208)	1.291 [†] (0.195)	1.290 [†] (0.195)	—	—
<i>B. Model Comparison</i>					
RMSE	0.225	0.358	0.240	0.809	0.139
MAE	0.138	0.203	0.152	0.678	0.067
R^2	—	—	—	0.272	0.979

Notes: See notes to Table 1.

Table 4. U.S. Federal Reserve (Burns' Chairmanship)

	Committee			Single Banker	
	Consensus	Hawkish Chairman	Dovish Chairman	Taylor Rule	Taylor Rule with <i>ad hoc</i> Smoothing
	(1)	(2)	(3)	(4)	(5)
<i>A. Parameter Estimates</i>					
a_{M+K}	4.063 [†] (0.338)	—	—	—	—
a_{M-K}	3.056 [†] (0.308)	—	—	—	—
a_M	—	2.929 [†] (0.296)	3.618 [†] (0.284)	—	—
a_A	—	4.007 [†] (0.327)	3.124 [†] (0.284)	—	—
a_S	—	—	—	3.292 [†] (0.296)	0.865 [†] (0.186)
b	0.486 [†] (0.046)	0.485 [†] (0.044)	0.526 [†] (0.042)	0.522 [†] (0.043)	0.040 (0.033)
c	-2.175 [†] (0.165)	-2.123 [†] (0.159)	-2.012 [†] (0.0149)	-1.978 [†] (0.151)	-0.555 [†] (0.104)
ρ	—	—	—	—	0.831 [†] (0.045)
σ	1.033 [†] (0.081)	0.990 [†] (0.077)	0.963 [†] (0.069)	—	—
<i>B. Model Comparison</i>					
RMSE	0.850	1.139	1.188	0.959	0.442
MAE	0.679	0.871	0.969	0.785	0.340
R^2				0.799	0.957

Notes: See notes to Table 1.

Table 5. U.S. Federal Reserve (Greenspan's Chairmanship)

	Committee			Single Banker	
	Consensus	Hawkish Chairman	Dovish Chairman	Taylor Rule	Taylor Rule with <i>ad hoc</i> Smoothing
	(1)	(2)	(3)	(4)	(5)
<i>A. Parameter Estimates</i>					
a_{M+K}	4.355 [†] (0.575)	—	—	—	—
a_{M-K}	0.359 (0.529)	—	—	—	—
a_M	—	0.310 (0.518)	4.326 [†] (0.561)	—	—
a_A	—	4.316 [†] (0.562)	0.325 (0.517)	—	—
a_S	—	—	—	1.775 [†] (0.396)	0.179 [†] (0.069)
b	0.759 [†] (0.162)	0.758 [†] (0.158)	0.787 [†] (0.158)	0.985 [†] (0.126)	−0.016 (0.025)
c	−4.554 [†] (0.685)	−4.465 [†] (0.672)	−4.477 [†] (0.670)	−2.794 [†] (0.506)	−0.395 (0.089)
ρ	—	—	—	—	0.969 [†] (0.013)
σ	1.853 [†] (0.145)	1.811 [†] (0.141)	1.805 [†] (0.140)	—	—
<i>B. Model Comparison</i>					
RMSE	0.745	1.207	1.046	1.538	0.252
MAE	0.547	0.766	0.771	1.291	0.179
R^2	—	—	—	0.485	0.986

Notes: See notes to Table 1.

A Proof of Proposition 1

Note that for each committee member the induced preferences over the interest rate are strictly concave and, consequently, single peaked with peak given by (9). The proof consists of the following steps.

Step 1: Define the undominated set $U(s_t, \mathbf{w}_t)$ of the supermajority relation in set I as the set of alternatives that are not defeated in a direct vote against any alternative in I . This set can be easily characterized: $U(s_t, \mathbf{w}_t) = \{i_{M-K,t}^*, \dots, i_{M+K,t}^*\}$.

Step 2: We claim that if any policy in $U(s_t, \mathbf{w}_t)$ is the default in any round r , that policy must be the final outcome of the meeting at time t . This is obviously true when we are in the final round R . We prove that this is true in any round by induction. Suppose that is true at round $r + 1$, we show that this is true at round r as well. Suppose that at r round an interest rate i belonging to $U(s_t, \mathbf{w}_t)$ is the default and, nevertheless, another policy i' passes and moves to round $r + 1$. There are two cases: either i' also belongs to the undominated set or it does not. In the former case, we know that i' will be the final decision according to our inductive hypothesis. But this would mean that a supermajority prefers i' to i . This contradicts the fact that i belongs to the undominated set. Suppose instead that i' does not belong to the undominated set. Notice that this implies that the alternatives that will be considered in future rounds, including R , will not belong to $U(s_t, \mathbf{w}_t)$. This is the case because the undominated set includes successive alternatives. Then the final outcome must not belong to $U(s_t, \mathbf{w}_t)$. This contradicts the hypothesis that i belonged to the undominated set.

Step 3: By Step 2, we know that if $q_t \in U(s_t, \mathbf{w}_t)$, q_t will be the final outcome. This explains why $i_t = q_t$ if $i_{M-K,t}^* \leq q_t \leq i_{M+K,t}^*$. If instead $q_t \notin U(s_t, \mathbf{w}_t)$, we know that there is only one direction (either an increase or a decrease from the status quo) that allows the committee to eventually reach an alternative in $U(s_t, \mathbf{w}_t)$. It is easy to argue that the committee in the first stage chooses that direction. By doing so, in a finite number of rounds, the committee will vote between either $i_{M+K,t}^*$ and $i_{M+K,t}^* + \epsilon$ or between $i_{M-K,t}^*$ and $i_{M-K,t}^* - \epsilon$. At that round the alternative in the undominated set will pass and will be the final outcome. This explains why if $q_t \leq i_{M-K,t}^*$ (or respectively, $q_t \geq i_{M+K,t}^*$), the committee decides to consider an increase (respectively decrease) of the interest rate that will eventually lead to $i_{M-K,t}^*$ (respectively $i_{M+K,t}^*$) as the final outcome. ◻

B Proof of Proposition 2

The proof consists of the following steps.

Step 1: Let $V_j(\cdot)$ denote the indirect utility of member j as a function of the current interest rate and let x_t denote the current proposal. Member j accepts proposal x_t if and only if $V_j(x_t) \geq V_j(q_t)$. It can be shown that $V_j(x_t) - V_j(q_t)$ is decreasing in μ_j .

Step 2: We show that any proposal $x_t \in [0, i_A^*, i^{\max}]$ is passed if and only if it is acceptable to M . First, suppose that the median accepts proposal x_t . Then, by Step 1, all committee members that are either to the right or to the left of M also accept x_t . Therefore, since M is the median, the proposal is passed. The “only if” part is equally straightforward. By contradiction. Suppose that the proposal is accepted by a majority that does not include the median. This clearly contradicts Step 1.

Step 3: Given the status quo policy q_t and the state of the economy s_t , let $\mathcal{A}(q_t, s_t)$ denote the set of policies that are acceptable to M . By Step 2, this set coincides with the set of policies that the committee would pass, were they proposed. First, when $q_t \in [i_{M,t}^*, i_{A,t}^*]$, we have that $\mathcal{A}(q_t, s_t) = [2i_{M,t}^* - q_t, q_t]$. By single-peakedness of $V_A(\cdot)$, q_t is the chairman’s preferred policy in $\mathcal{A}(q_t, s_t)$. Second, if $q_t \in [2i_{M,t}^* - i_{A,t}^*, i_{M,t}^*)$, the set $\mathcal{A}(q_t, s_t)$ is given by the interval $[q_t, 2i_{M,t}^* - q_t]$. Then, the best proposal in the acceptance set is $2i_{M,t}^* - q_t$, which leaves M indifferent between the status quo and the proposal. Finally, suppose that $q_t \in (i_{A,t}^*, i^{\max}] \cup [0, 2i_{M,t}^* - i_{A,t}^*)$. In such a case, $\mathcal{A}(q_t, s_t)$ includes $i_{A,t}^*$ and, consequently, the chairman is able to offer and pass a proposal that coincides with her ideal point. ◻

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Figure 1: Utility Functions

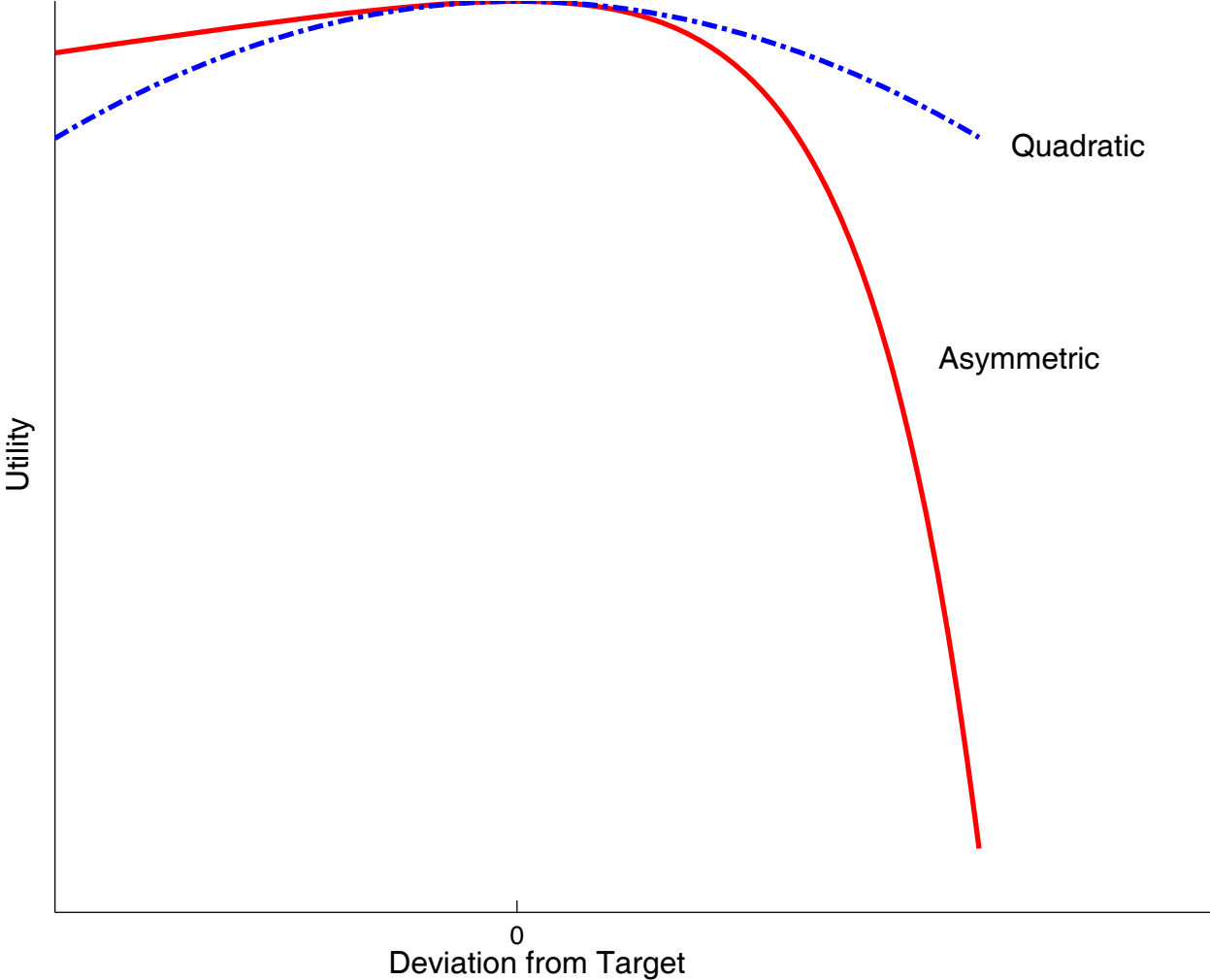


Figure 2: Policy Outcomes

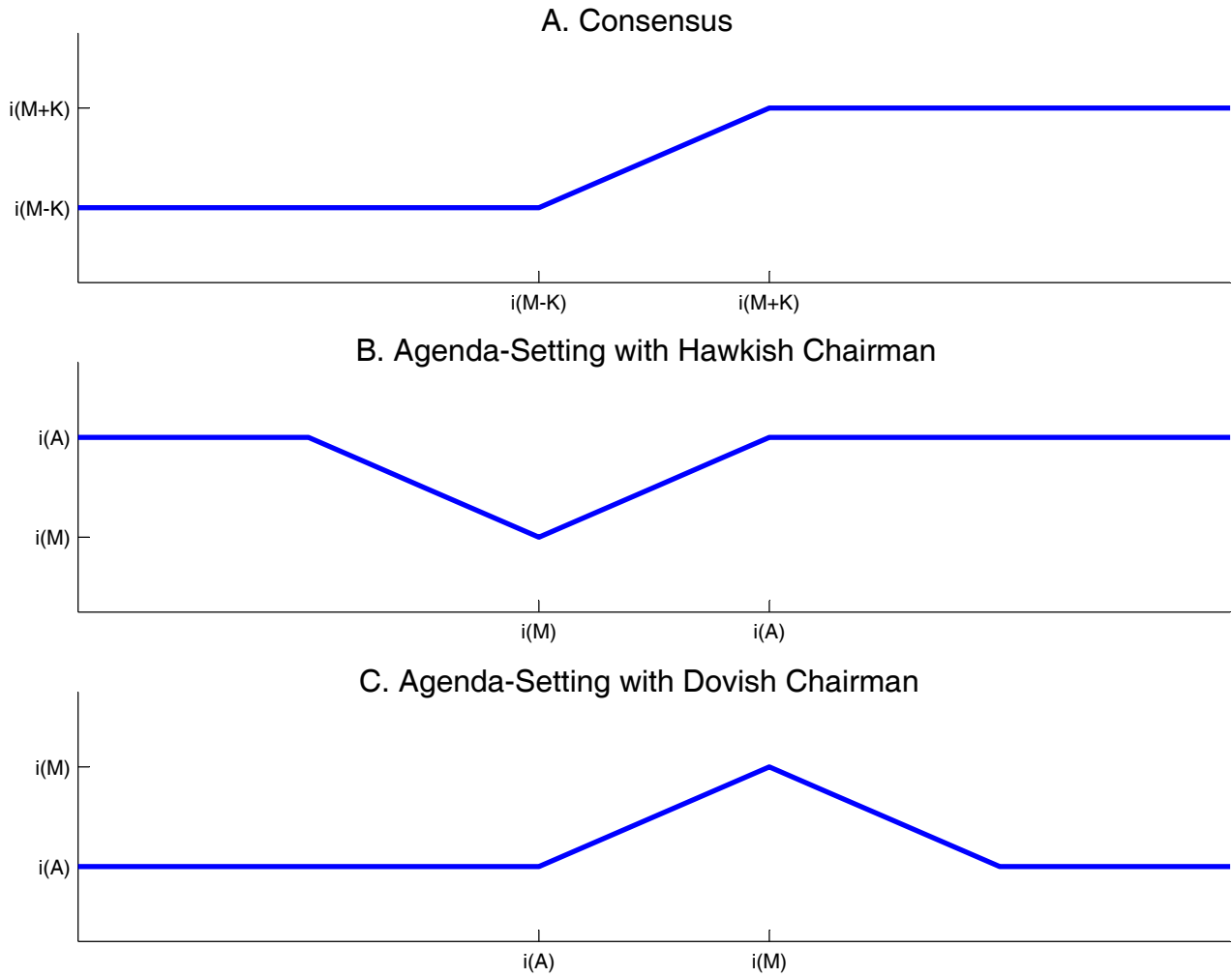
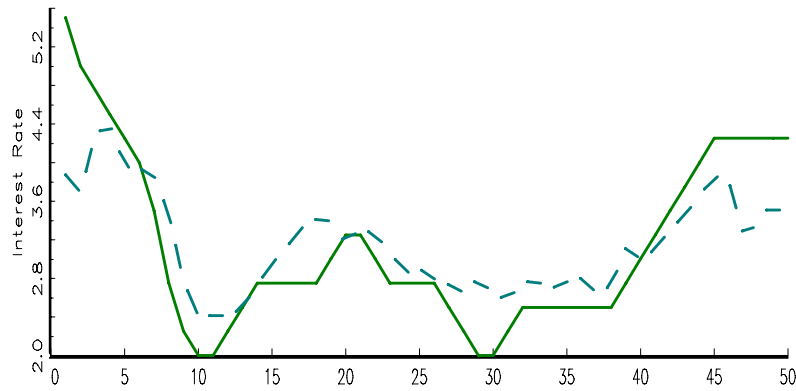
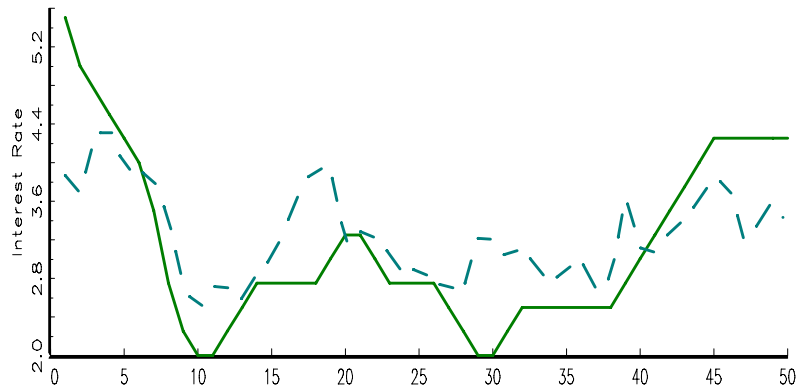


Figure 3: Bank of Canada

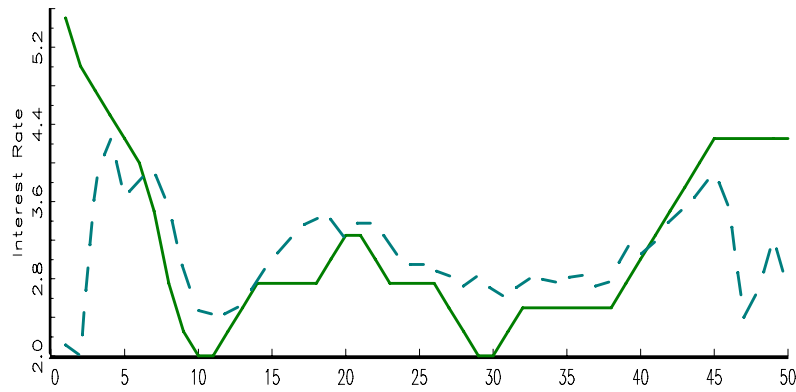
Consensus



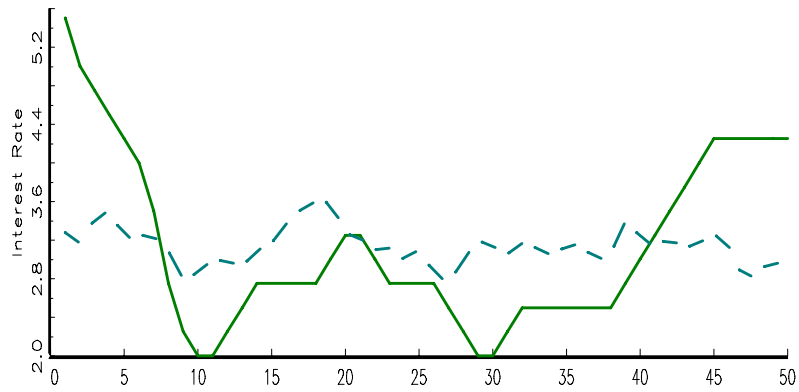
Hawkish Chairman



Dovish Chairman



Taylor Rule



Taylor Rule with ad-hoc Smoothing

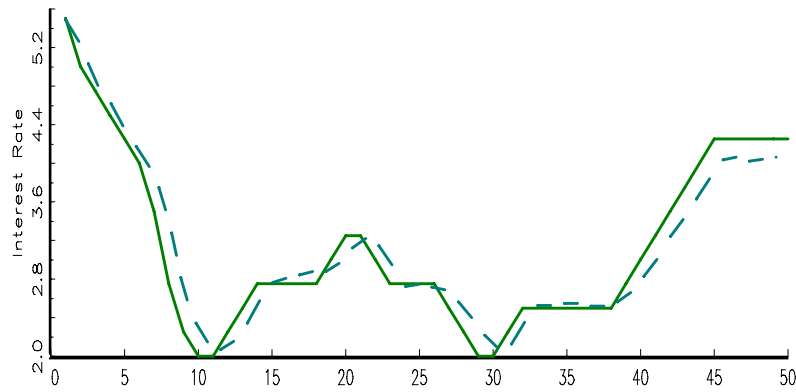
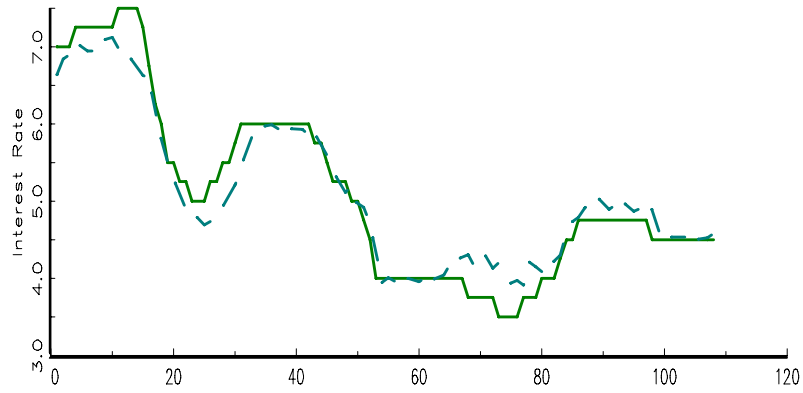
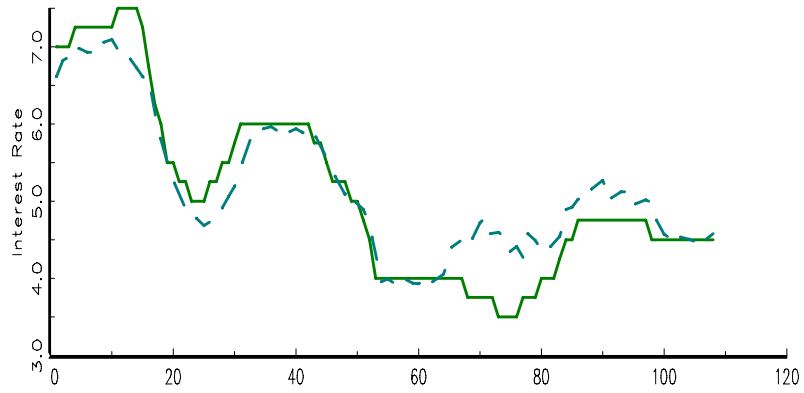


Figure 4: Bank of England

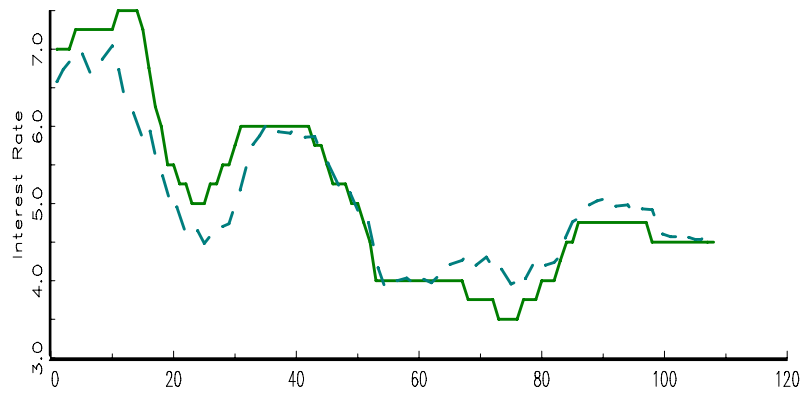
Consensus



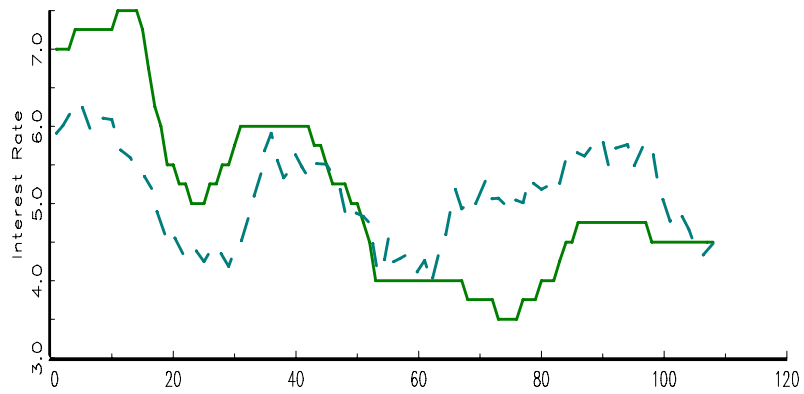
Hawkish Chairman



Dovish Chairman



Taylor Rule



Taylor Rule with ad-hoc Smoothing

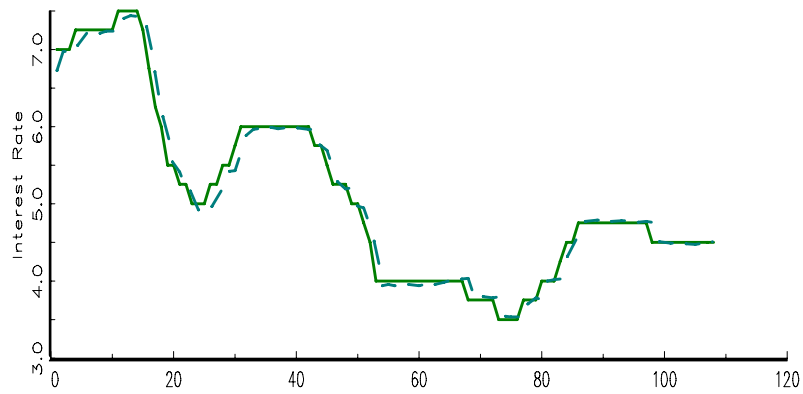
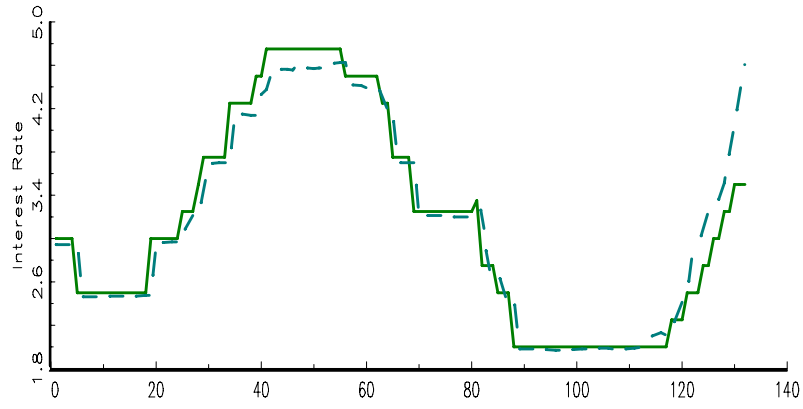
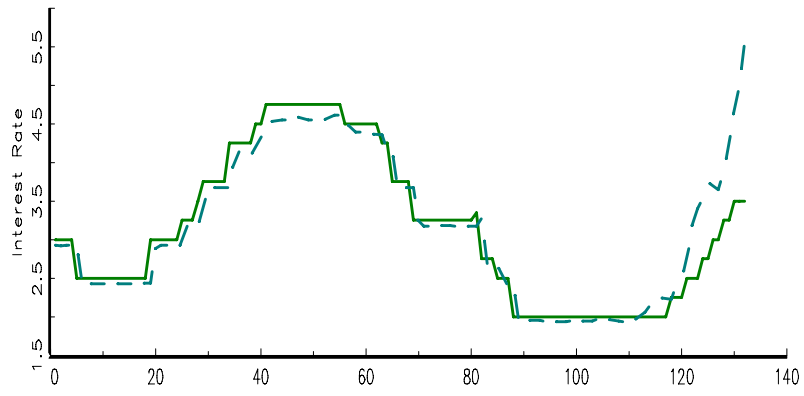


Figure 5: European Central Bank

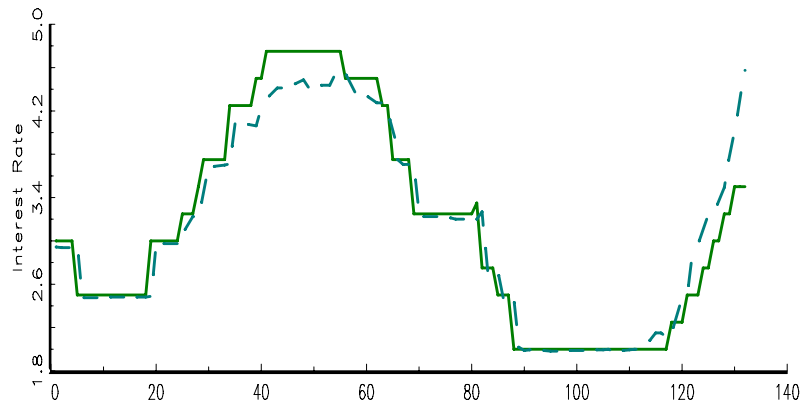
Consensus



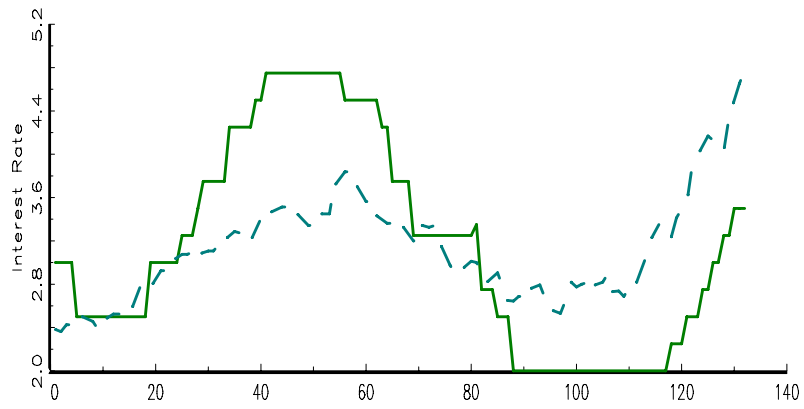
Hawkish Chairman



Dovish Chairman



Taylor Rule



Taylor Rule with ad-hoc Smoothing

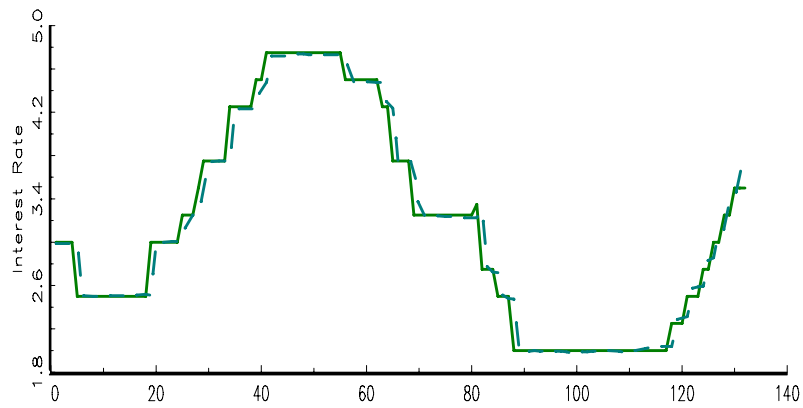
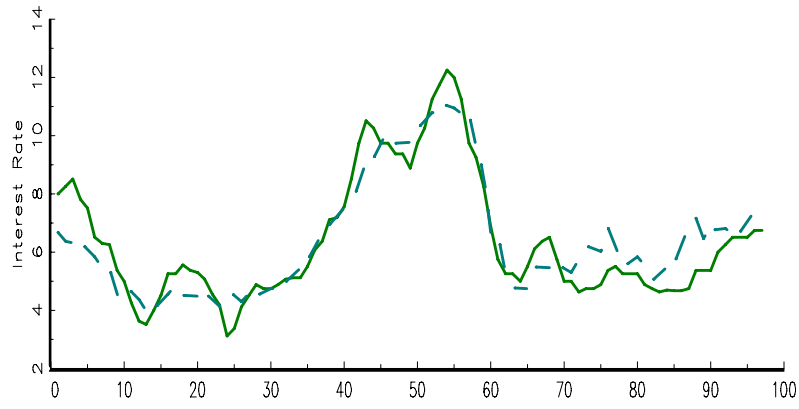
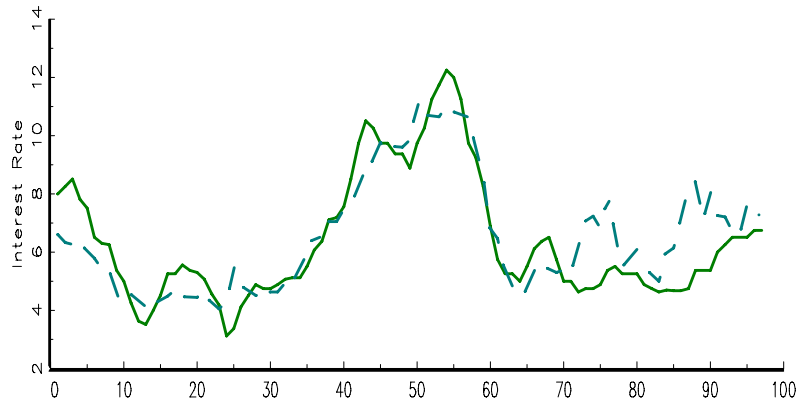


Figure 6: U.S. Federal Reserve (Burns)

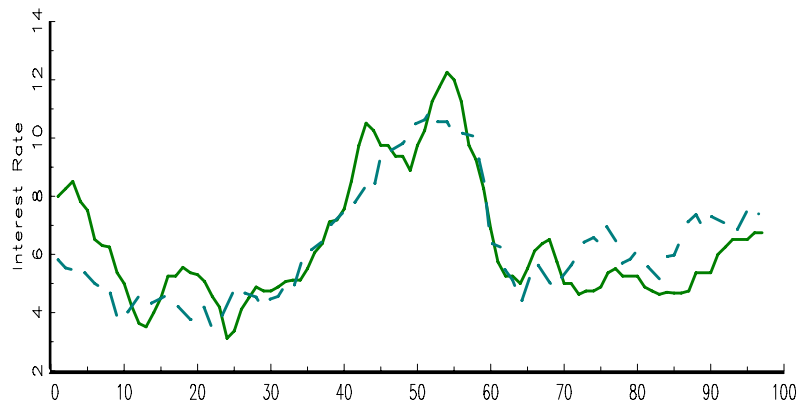
Consensus



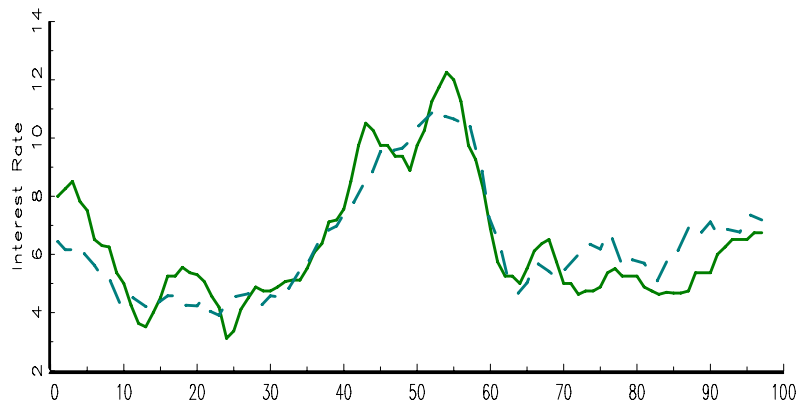
Hawkish Chairman



Dovish Chairman



Taylor Rule



Taylor Rule with ad-hoc Smoothing

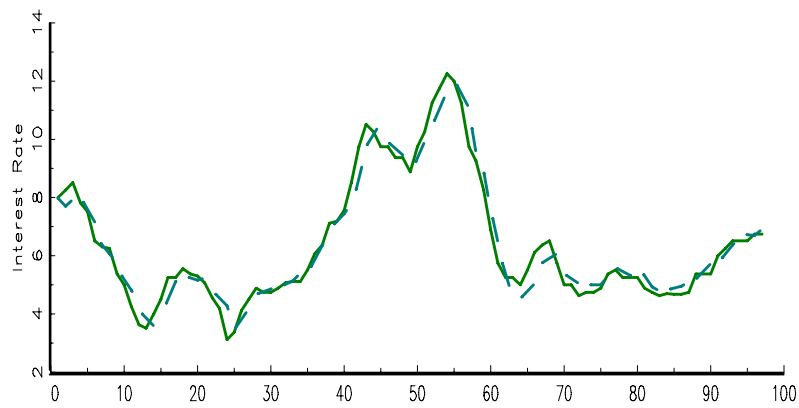
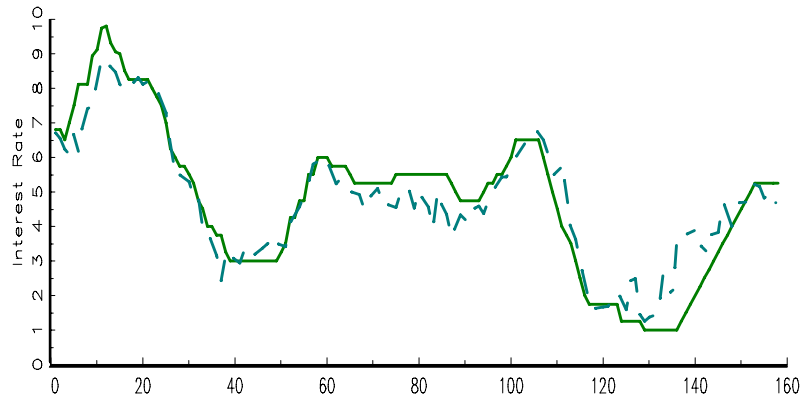
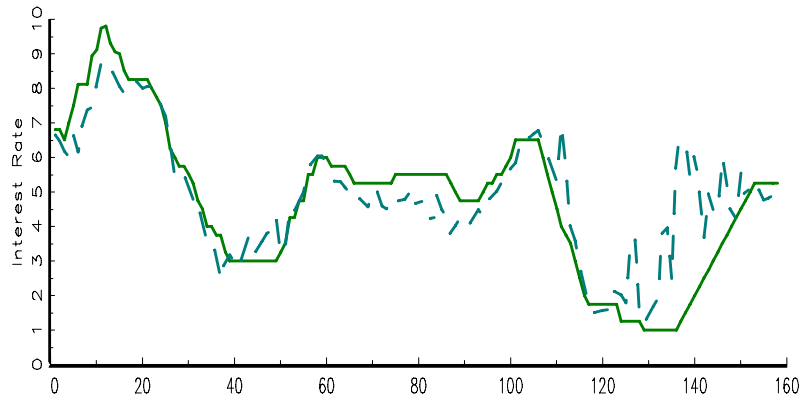


Figure 7: U.S. Federal Reserve (Greenspan)

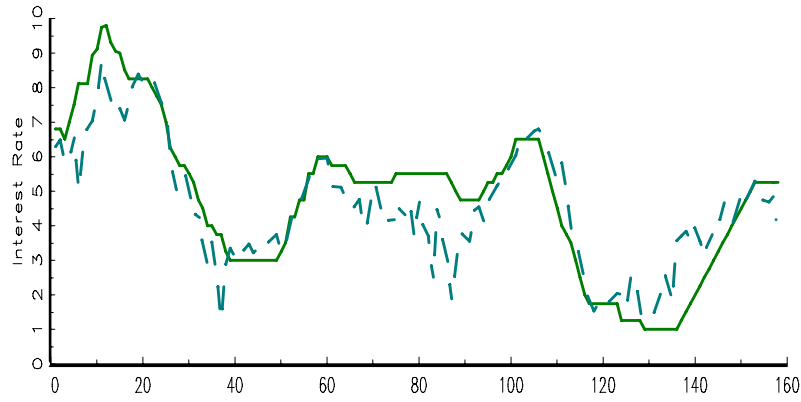
Consensus



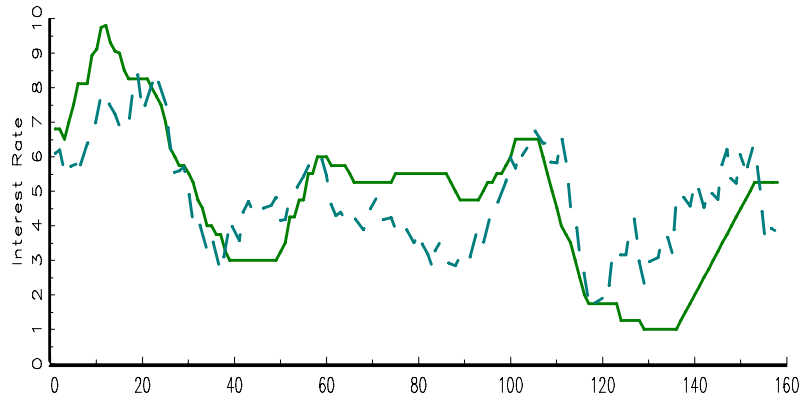
Hawkish Chairman



Dovish Chairman



Taylor Rule



Taylor Rule with ad-hoc Smoothing

