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Monetary Policy by Committee: Consensus, Chairman Dominance or Simple Majority?*

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Abstract

This paper studies the theoretical and empirical implications of monetary policy making by committee under three different voting protocols. The protocols are a consensus model, where super-majority is required for a policy change; an agenda-setting model, where the chairman controls the agenda; and a simple majority model, where policy is determined by the median member. These protocols give preeminence to different aspects of the actual decision making process and capture the observed heterogeneity in formal procedures across central banks. The models are estimated by Maximum Likelihood using interest rate decisions by the committees of five central banks, namely the Bank of Canada, the Bank of England, the European Central Bank, the Swedish Riksbank, and the U.S. Federal Reserve. For all central banks, results indicate that the consensus model is statistically superior to the alternative models. This suggests that despite institutional differences, committees share unwritten rules and informal procedures that deliver observationally equivalent policy decisions.

JEL Classification: D7, E5
Key Words: Committees, voting models, status-quo bias, median voter.

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"*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.*" (Wim Duisenberg, former President of the ECB, *The New York Times*, 27 June 2001)

1 Introduction

An important question in economics concerns the implications of collective decision making on policy outcomes. Prominent examples of decisions taken by a group of heterogeneous individuals, rather than by a single agent, include fiscal and monetary policy. Decisions concerning public spending, taxation and debt are taken by legislatures,[1] while the target for the key nominal interest rate is selected by a committee in most central banks.

This paper develops a model where members of a monetary policy committee have different views regarding the optimal interest rate and resolve those differences through voting. First, the equilibrium outcome is solved under various voting (or bargaining) protocols. Then, their respective theoretical and empirical implications are derived, and all models are estimated by the method of Maximum Likelihood using data on interest rate decisions by the committees in five central banks. The central banks are the Bank of Canada, the Bank of England, the European Central Bank, the Swedish Riksbank and the U.S. Federal Reserve. Finally, model selection criteria are used to compare the predictive power of the competing theories of collective choice.[2]

Since there is institutional evidence of heterogeneity in the formal procedures employed by monetary committees to arrive at a decision (see, for example, Fry *et al.*, 2000), we study three voting protocols. Each protocol gives preeminence to different aspects of the actual decision making process. The first protocol is a consensus-based model where a supermajority (that is, a level of support which exceeds a simple majority) is required to adopt a new policy and no committee member has proposal power. The second protocol is the agenda-setting model, originally proposed by Romer and Rosenthal (1978), where decisions are taken by simple majority and the chairman is assumed to control the agenda. These two protocols yield outcomes different from the median policy and predict an inaction region (or gridlock interval) where the committee keeps the interest rate unchanged. In addition, they deliver endogenous autocorrelation and regime switches in the interest rate. However,

[1] Among the theoretical contributions that examine the consequences of legislative bargaining are Baron (1991), Chari and Cole (1993), Persson *et al.* (2000), Battaglini and Coate (2007a, 2007b), and Volden and Wiseman (2007).

[2] Previous literature on monetary committees usually relies on the Median Voter Theorem and focuses on features other than the voting procedure. For instance, Waller (1992, 2000) study the implications of the length of the term of office and of the committee size, respectively.

these protocols generate different implications for the size of interest rate adjustments: the agenda-setting model predicts larger interest rate increases (decreases) than the consensus model when the chairman is more hawkish (dovish) than the median member. The third protocol is a simple-majority model where no member controls the agenda, all alternatives are put to a vote and, consequently, the interest rate selected by the committee is the one preferred by the median member. This protocol is observationally equivalent to a setup where the median is the single central banker.

According to survey results reported in Fry *et al.* (2000), a little more than half of the monetary policy committees in their sample (43 out of 79) make decisions by consensus, while the rest hold a formal vote. Of the five central banks studied in this paper, only one (the Bank of Canada) explicitly operates on a consensus basis while the remaining ones hold a formal vote by simple majority rule. However, the distinction is ambiguous in practice because consensus appears to play a role in the decision making process of committees that (on paper) take decisions by simple majority rule.[3] Committees also seem to differ with respect to the role played by the chairman. In some committees, the chairman can exert leadership, in particular by deciding the content of the proposal that is put to a vote.[4] For example, a prevalent view is that under the mandate of Alan Greenspan, agreement within the Federal Open Market Committee (FOMC) was dictated by the chairman.[5] A consequence of the agenda-setting power of the chairman is that the final voting outcome may sometimes be different from the policy favored by a majority of members.[6] On the other hand, strong leadership does not necessarily mean that the chairman is *de facto* a single decision maker.[7] This discussion suggests that institutional and anecdotal evidence alone cannot unambiguously reveal how monetary policy committees reach decisions.

As an alternative strategy to understand central banking by committee, we pursue instead

[3]See, for example, the interview of Wim Duisenberg with the *The New York Times* cited at the beginning of this paper.

[4]This is case, for instance, in the monetary committees of the Bank of England, the Norges Bank, Reserve Bank of Australia, the Swedish Riksbank, and the U.S. Federal Reserve (see Meier, 2007).

[5]Blinder (2004, p. 47) remarks that "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, which will prevail in any case."

[6]Blinder (2004, p. 47) cites two instances where this appears to have been true for the FOMC. First, transcripts for the meeting on 4 February 1994 indicate that most members wanted to raise the Federal Funds rate by 50 basis points, while Greenspan wanted a 25 point increase. Nonetheless, the committee eventually passed Greenspan's preferred policy. Second, Blinder reports the general opinion that in the late 1990s Greenspan was able to maintain the status quo although most committee members were in favor of an interest rate increase.

[7]For example, former FOMC members Sherman Maisel (1973, p. 124) and Laurence Meyer (2004, p. 52) respectively observe that the Chairman "does not make policy alone" and "does not necessarily always get his way."

the direct econometric analysis of actual policy outcomes and the use of stochastic simulation to derive quantitative predictions which are then compared with the data. Our econometric results show that despite the heterogeneity in the formal procedures followed by the monetary committees in our sample, the consensus-based model describes interest rate decisions more accurately than the alternative models for all five central banks studied. Overall these results suggest that, in addition to the formal framework under which committees operate, their decision making is also the result of unwritten rules and informal procedures that deliver observationally equivalent policy decisions.

The data also show limited empirical success on the part of the median model. One of the reasons is that this model predicts lower interest rate autocorrelation than it is found in the data. Instead, by introducing a status-quo bias, the consensus-based model is better able to capture this feature of the data. This means, in particular, that consensus can provide a politico-economic explanation for the well known observation in that central banks adjust interest rates more cautiously than predicted by standard models.

Finally, regarding the agenda-setting model, the data indicate that even if the chairman has proposal power, his policy recommendation will take into account the preferences of the other committee members. Furthermore, there is very limited empirical support for agenda control on the part of the chairman as modeled by Romer and Rosenthal (1978). This confirms, using actual data, earlier findings based on laboratory experiments (see, for example, Eavey and Miller, 1984).

These results should be of interest to monetary economists concerned with understanding the implications of committees on central banking, as well as to political economists and political scientists interested in testing the implications of competing theories of committee bargaining. Indeed, monetary policy committees provide an ideal setup to study group policy making because voting outcomes and status quo locations are well-defined in the data and decisions concern only one dimension (*i.e.,* the interest rate), thereby reducing the possibility of logrolling.[8]

The remainder of the paper is organized as follows. Section 2 describes the committee and its decision making under the three different voting procedures. Section 3 estimates the models and compares their empirical results. Section 4 concludes.

[8] A few empirical contributions in the area of legislative studies compare different theories of committee decision making. For example, Krehbiel *et al.* (2005) test the predictive power of the pivot and cartel theories of law making in the U.S. Senate using frequencies of cutpoint estimates, that is, estimates of the roll-call-specific location that splits the "yea" side from the "nay" side. However, that literature faces the problems that bargaining is potentially multi-dimensional, that bill and status quo locations are difficult to observe and measure, and that ideal points are not estimated on the same scale as bill locations. To overcome these obstacles, many researchers have turned to laboratory experiments to test theories of committee bargaining. See Palfrey (2005) for a review of the experimental literature.

2 Committee Decision Making

2.1 Composition and Preferences

Consider a monetary policy committee composed of N members, labelled $j = 1, ..., N$, where N is an odd integer.[9] 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, i_t. The alternatives that can be considered by the committee belong to the continuos and bounded set $\mathcal{I} = \left[0, \bar{i}\right]$. The relation between the policy instrument and economic outcomes is spelled out below in Section 2.2.

The utility function of member j is

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

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

$$U_j(\pi_t) = \frac{-\exp\left(\mu_j(\pi_t - \pi^*)\right) + \mu_j(\pi_t - \pi^*) + 1}{\mu_j^2}, \tag{2}$$

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 permits different weights for positive and negative inflation deviations from the target.[10] 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 the 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 this 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

[9] The assumption that N is odd allow us to uniquely pin down the median committee member and eliminates the complications associated with tie votes. Erhart and Vasquez-Paz (2007) find that in a sample of 79 monetary policy committees, 57 have an odd number of members with 5, 7 and 9 the most common observations.

[10] To see that the function (2) nest the quadratic case, take the limit of $U_j(\pi_t)$ as $\mu_j \to 0$ and use L'Hopital's rule twice.

their relative prudence is a tractable way to motivate disagreement over preferred interest rates despite the fact that members share the same inflation target.[11] We order the N committee members so that member 1 (N) is the one with the smallest (largest) value of μ. That is, $\mu_1 \leqslant \mu_2 \leqslant ... \leqslant \mu_N$. The median member, denoted by M, is the one with index $(N+1)/2$ and, for simplicity, his preference parameter is normalized to be zero, that is, $\mu_M = 0$.[12] We will see below in Section 2.3 that heterogeneity in preference parameters implies that indirect utilities, expressed as a function of the policy instrument i_t, attain different maxima depending on μ_j.

2.2 Economic Environment

As in Svensson (1997), the behavior of the private sector is described in terms of a Phillips curve and an aggregate demand curve:

$$\begin{aligned} \pi_{t+1} &= \pi_t + \alpha_1 y_t + \varepsilon_{t+1}, \\ y_{t+1} &= \beta_1 y_t - \beta_2 (i_t - \pi_t) + \eta_{t+1}, \end{aligned}$$

where y_t is the deviation of an output measure from its natural level, $\alpha_1, \beta_2 > 0$ and $0 < \beta_1 < 1$ are constant parameters, and ε_t and η_t are disturbances. The persistence of the disturbances is modeled by means of moving average (MA) processes

$$\begin{aligned} \varepsilon_t &= \gamma u_{t-1} + u_t, \\ \eta_t &= \varsigma v_{t-1} + v_t, \end{aligned}$$

where $\gamma, \varsigma \in (-1, 1)$, so that the processes are invertible, and u_t and v_t are mutually independent innovations. The innovations are Normally distributed white noises with zero mean and constant conditional variances σ_u^2 and σ_v^2, respectively. This specification embodies a stylized mechanism for the transmission of monetary policy and is widely used in the literature on monetary policy committees (see, among others, Bhattacharjee and Holly, 2006, Gerlach-Kristen, 2007, and Weber, 2007). After some algebra, one can write

$$\pi_{t+2} = (1 + \alpha_1 \beta_2)\, \pi_t + \alpha_1 (1 + \beta_1) y_t - \alpha_1 \beta_2 i_t + \varepsilon_{t+1} + \alpha_1 \eta_{t+1} + \varepsilon_{t+2}. \tag{3}$$

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.

[11] We use this modeling strategy because, except for the U.S., all countries in our sample follow inflation targeting regimes. However, our results hold more generally and are robust, for example, to assuming instead quadratic utility and heterogeneous inflation targets.

[12] For the empirical part of this project, we will also require that the cross-sectional distribution of μ is time-invariant, meaning that even when there are changes in the composition of the committee (for example, as a result of alternation of voting members), the preference parameters remain unchanged.

2.3 Policy Preferred by Individual Members

Since monetary policy takes two periods to have an effect on inflation, consider the member-specific interest rate $i_{j,t}^*$ chosen at time t to maximize the expected utility of member j at time $t+2$. That is,

$$i_{j,t}^* = \underset{\{i_t\}}{\arg\max}\ \delta^2 E_t U_j(\pi_{t+2}),$$

subject to equation (3). Equation (3) 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

$$E_t \exp(\mu_j(\pi_{t+2} - \pi^*)) = 1. \tag{4}$$

Under the assumption that innovations are Normally distributed and conditionally homoskedastic, the rate of inflation at time $t+2$ (conditional on the information set at time t) is Normally distributed and conditionally homoskedastic as well. Then, $\exp(\mu_j(\pi_{t+2} - \pi^*))$ is distributed Log-normal with mean $\exp\left(\mu_j(E_t\pi_{t+2} - \pi^*) + \mu_j^2\sigma_\pi^2/2\right)$ where σ_π^2 is the conditional variance of π_t. Then, substituting in (4) and taking logs,

$$E_t\pi_{t+2} = \pi^* - \mu_j\sigma_\pi^2/2. \tag{5}$$

Finally, taking conditional expectations as of time t in both sides of (3) and using (5) deliver member j's preferred interest rate

$$i_{j,t}^* = a_j + b\pi_t + cy_t + \zeta_t, \tag{6}$$

where

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

This reaction function implies that if the current output gap or inflation increase, the nominal interest rate should be raised in order to keep the inflation forecast close to the inflation target. Note, however, that ex-post inflation will typically differ from π^* because of the disturbances that occur during the control lag period. As a result of this uncertainty, the asymmetry in the utility function will induce a prudence motive in the conduct of monetary policy and $i^*_{j,t}$ will also depend on inflation volatility in proportion to μ_j. Hence, the intercept term in the reaction function is member-specific (and hence the subscript j in a_j). Notice, for example that committee members who weight more heavily positive than negative inflation deviations from its target (*i.e.*, those with $\mu_j > 0$) will generally favor higher interest rates.

On the other hand, the coefficients of inflation (b) and the output gap (c), and the disturbance ζ_t depend only on aggregate parameters (and aggregate shocks in the latter case) and, consequently, they are common to all members. Since individual reaction functions differ in their intercepts only, it is easy to see that ordering members according to μ, that is, $\mu_1 \leqslant \mu_2 \leqslant ... \leqslant \mu_N$, translates into an ordering of preferred interest rates, $i^*_{1,t} \leqslant i^*_{2,t} \leqslant \ldots \leqslant i^*_{N,t}$.

Finally, since the innovations u_t and v_t are white noise, then ζ_t is also white noise and its constant conditional variance is $\sigma^2 = \gamma^2\sigma_u^2/(\alpha_1\beta_2)^2 + \varsigma^2\sigma_v^2/(\beta_2)^2$.

2.4 Protocol I: Consensus

In order to model the idea of consensus, this protocol assumes that proposals to adopt a new interest rate require a super-majority to pass. Super-majority is a majority greater than 50 percent plus one of the votes, or simple majority. Under this protocol, no committee member controls the agenda: the set of alternatives that are put to a vote is chosen according to a predetermined rule. Let q_t denote the status quo policy in the current meeting and assume that the initial status quo is the interest rate, i_{t-1}, that was selected in the previous meeting. The state of the economy, which is known and predetermined at the beginning of the meeting, is given by $\mathbf{s}_t \equiv (\pi_t, y_t, \zeta_t)$. There are two stages in each meeting. In the first stage, 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 are immediately discarded.

In the second stage, the committee selects the interest rate among the remaining alternatives through a binary agenda with a super-majority required for a proposal to pass.[13] A binary agenda is a procedure where the final outcome chosen by the committee is the result

[13] The voting protocol used here is similar to the one studied by Dal Bó (2006).

of a sequence of pairwise votes (see Austen-Smith and Banks, 2005, Ch. 4, for a discussion). Let $S \equiv (N+1+2K)/2$ denote the size of the smallest super-majority required for a proposal to pass. The size of the super-majority increases in the index K, where $0 \leqslant K \leqslant (N-1)/2$. This specification includes as special cases unanimity, when $K = (N-1)/2$, and simple majority, when $K = 0$. Since the case where $K = 0$ delivers the median outcome and is equivalent to the protocol studied in Section 2.6, in what follows, we concentrate on cases where $1 \leqslant K \leqslant (N-1)/2$.

The voting procedure is as follows. Suppose, for example, that in the first stage the committee decided to consider an increase of the interest rate. Then, the alternative $q_t + \epsilon$ is put to a vote against the status quo q_t, where $\epsilon > 0$. If $q_t + \epsilon$ does not meet the approval of a super-majority of members, then the proposal does not pass, the meeting ends and the status quo is implemented. If the proposal passes, then $q_t + \epsilon$ displaces q_t $(= i_{t-1})$ as the default policy and the meeting continues with the alternative $q_t + 2\epsilon$ voted against $q_t + \epsilon$. If $q_t + 2\epsilon$ does not pass, the final decision becomes $q_t + \epsilon$. If the proposal passes, then $q_t + 2\epsilon$ displaces $q_t + \epsilon$ as default policy, the alternative $q_t + 3\epsilon$ is voted against $q_t + 2\epsilon$, and so on. For the sake of the exposition and to avoid unnecessary complications, assume that all alternatives and all member-specific preferred interest rates (from equation (6)) are integer multiples of ϵ.

Note that the number of possible rounds in the second stage of each meeting is finite. Let r denote the round, with $r = 1, ..., R$. If the committee keeps accepting further increases, there will be a final round R where the committee will have to chose between $\bar{i}$ and $\bar{i} - \epsilon$.[14] We study pure strategy subgame perfect equilibria with the property that, in each period, individuals vote as if they are pivotal. This refinement is standard in the voting literature and rules out equilibria where a committee member votes contrary to his preferences simply because changing his vote would not alter the voting outcome. Furthermore, 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 foreseeing the effect of their vote on future rounds), but they abstract from the consequences of their voting decision on future meetings *via* the status quo.

Let $\Psi(\mathbf{s}_t, q_t, \boldsymbol{\omega}_t)$ denote the political aggregator under a consensus-based voting protocol, where $\boldsymbol{\omega}_t$ is the vector of induced policy preferences over the interest rate for all committee members. For all states s_t and q_t, the stationary function $\Psi(\cdot)$ aggregates the induced policy preferences into a policy outcome. The next proposition shows that the protocol described above delivers a simple equilibrium outcome. For status quo policies that are

[14] Alternatively, 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 ϵ and 0.

located close to the median's preferred policy, the committee does not change the interest rate. For status quo policy that are sufficiently extreme, compared with the values preferred by most members, the committee adopts a new policy that is closer to the median outcome.

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

$$i_t = \Psi(\mathbf{s}_t, q_t, \boldsymbol{\omega}_t) = \begin{cases} i^*_{M+K,t}, & \text{if} \quad q_t > i^*_{M+K,t}, \\ q_t, & \text{if} \quad i^*_{M-K,t} \leqslant q_t \leqslant i^*_{M+K,t}, \\ i^*_{M-K,t}, & \text{if} \quad q_t < i^*_{M-K,t}. \end{cases}$$

Proof: Note that for each committee member, the induced preferences over the interest rate are strictly concave and, consequently, single peaked with peak given by (6). The proof consists of the following steps.

Step 1: Define the undominated set $\mathcal{U}(\mathbf{s}_t, \boldsymbol{\omega}_t)$ of the super-majority relation in set $\mathcal{I}$ as the set of alternatives that are not defeated in a direct vote against any alternative in $\mathcal{I}$. The set $\mathcal{U}(\mathbf{s}_t, \boldsymbol{\omega}_t)$ contains all alternatives in the interval $\left[i^*_{M-K,t}, i^*_{M+K,t}\right]$.

Step 2: We claim that if any policy in $\mathcal{U}(\mathbf{s}_t, \boldsymbol{\omega}_t)$ is the default in any round r, that policy must be the final outcome of the meeting at time t. This is obviously true 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 round r an interest rate i belonging to $\mathcal{U}(\mathbf{s}_t, \boldsymbol{\omega}_t)$ 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 super-majority prefers i' to i. This contradict 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 $\mathcal{U}(\mathbf{s}_t, \boldsymbol{\omega}_t)$. This is the case because the undominated set is an interval. Then the final outcome must not belong to $\mathcal{U}(\mathbf{s}_t, \boldsymbol{\omega}_t)$. This contradicts the hypothesis that i belongs to the undominated set.

Step 3: By Step 2, we know that if $q_t \in \mathcal{U}(\mathbf{s}_t, \boldsymbol{\omega}_t)$, q_t will be the final outcome. This explains why $i_t = q_t$ if $i^*_{M-K,t} \leqslant q_t \leqslant i^*_{M+K,t}$. If instead $q_t \notin \mathcal{U}(\mathbf{s}_t, \boldsymbol{\omega}_t)$, 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 $\mathcal{U}(\mathbf{s}_t, \boldsymbol{\omega}_t)$. It is easy to see that the committee chooses that direction in the first stage. 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 $q_t < i^*_{M-K,t}$ (or respectively, $q_t > i^*_{M+K,t}$), the committee decides to consider an increase (respectively, a decrease) of the interest rate that will eventually lead to $i^*_{M-K,t}$ (respectively, $i^*_{M+K,t}$) as the final outcome. ¶

Intuitively, for an initial status quo $q_t > i^*_{M+K,t}$, 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 of members and the final decision will be $i_t = i^*_{M+K,t}$. Similarly, for an initial status quo $q_t < i^*_{M-K,t}$, 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 of members and the final decision will be $i_t = i^*_{M-K,t}$. Finally, for an initial status quo $i^*_{M-K,t} \leqslant q_t \leqslant i^*_{M+K,t}$ and regardless of the result in the first stage of the meeting, no proposal would pass in the second stage and the interest rate will remain unchanged, $i_t = i_{t-1}$.

Notice that 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 $q_t \in [i^*_{M-K,t}, i^*_{M+K,t}]$ and its width is increasing in the size of the super-majority, K. The super-majority requirement induces a status-quo bias because it demands the agreement of most members for a policy change. The policy outcome as a function of q_t under this protocol is plotted in Panel A of Figure 2. Policies on the 45 degree line correspond to $i_t = q_t$, meaning that the interest rate remains unchanged after the committee meeting. Since the median outcome occurs only in the special case where the status quo coincides with the policy preferred by the median (that, $q_t = i^*_{M,t}$), it follows that consensus implies deviations from the median outcome.

2.5 Protocol II: Agenda-Setting by a Dominant Chairman

In this model, proposals are passed by simple majority rule but members differ in their institutional role. In particular, the chairman sets the agenda and makes a policy proposal to the other committee members in every meeting. This represents the idea that chairmen have more power and influence than their peers stemming, for instance, from prestige or additional responsibilities.

In what follows, the chairman is denoted by A and the median by M. It is also assumed that $\mu_A \neq \mu_M$.[15] Thus, there are two possible cases: either $\mu_A > \mu_M$ or $\mu_A < \mu_M$. In the case where $\mu_A > \mu_M$ ($\mu_A < \mu_M$), the chairman is hawkish (dovish) in the sense that, conditional on inflation, inflation volatility and the output gap, he systematically prefers a

[15]The case $\mu_A = \mu_M$ is trivial in that it always delivers the median outcome, and it is therefore observationally equivalent to the protocol studied in the next section.

higher (lower) interest rate than M. For the sake of exposition, this Section focuses on the case of the hawkish chairman only, but the dovish case is perfectly symmetric.

The voting protocol is the following. In each meeting, given the current status quo $q_t = i_{t-1}$, the chairman proposes an interest rate i_t under close rule. The other committee members can either accept or reject the chairman's proposal. If the proposal passes (*i.e.*, it obtains at least $(N+1)/2$ votes), then the proposed policy is implemented and becomes the status quo for next meeting. If the proposal is rejected, then the status quo is maintained and $i_t = i_{t-1}$. This procedure is repeated in the next meeting. As in the consensus model, individuals vote as if they were pivotal and disregard the consequences of their voting decision on future meetings *via* the status quo. Thus, members accept a proposal whenever the current utility from the proposal is larger than or equal to the utility from the current status quo, and the chairman picks the policy closest to his ideal point among those that are acceptable to a majority of $(N+1)/2$ members. This voting game is well-known in the political economy literature and was originally derived by Romer and Rosenthal (1978) under the assumption of symmetric preferences. Here instead, the induced utilities of all members other than the median are single peaked but not symmetric. In principle, this lack of symmetry may imply that proposals are accepted by a coalition that excludes the median. The proof of Proposition 2 insures that this is not the case.

Define $\Upsilon(\mathbf{s}_t, q_t, \boldsymbol{\omega}_t)$ to be the political aggregator in the agenda-setting game. The following proposition establishes the policy outcome under this protocol.

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

$$i_t = \Upsilon(\mathbf{s}_t, q_t, \boldsymbol{\omega}_t) = \begin{cases} i^*_{A,t}, & \text{if} \quad q_t > i^*_{A,t}, \\ q_t, & \text{if} \quad i^*_{M,t} \leqslant q_t \leqslant i^*_{A,t}, \\ 2i^*_{M,t} - q_t, & \text{if} \quad 2i^*_{M,t} - i^*_{A,t} \leqslant q_t < i^*_{M,t}, \\ i^*_{A,t}, & \text{if} \quad q_t < 2i^*_{M,t} - i^*_{A,t}, \end{cases} .$$

Proof: The proof consists of the following steps.

Step 1: Let $V_j(.)$ denote the indirect utility of member j as a function of the interest rate and let i_t denote the current proposal. We show that $V_j(i_t) - V_j(q_t)$ is increasing in μ_j for all i_t and q_t such that $q_t \leqslant i^*_{M,t} \leqslant i_t$. The difference of the expected payoff of committee member j associated to interest rates i_t and q_t is

$$V_j(i_t) - V_j(q_t) = \frac{\exp(\varrho_t)\left(\exp(-\mu_j \alpha_1 \beta_2 q_t) - \exp(-\mu_j \alpha_1 \beta_2 i_t)\right) + \mu_j \alpha_1 \beta_2 (q_t - i_t)}{\mu_j^2}$$

where $\varrho_t = (1 + \alpha_1 \beta_2)\, \pi_t + \alpha_1 (1 + \beta_1) y_t + \mu_j^2 \sigma_\pi^2 / 2 + \gamma u_t + \varsigma \alpha_1 v_t$. When $q_t \leqslant i^*_{M,t} \leqslant i_t$, it can be shown that a sufficient, but not necessary, condition for $V_j(i_t) - V_j(q_t)$ to be increasing in μ_j is that $\mu_j^2 \sigma_\pi^2 \geqslant 2$ for all $j > M$. In the rest of the proof we will assume that this condition is verified.

Step 2: First, when $q_t \in (i_A^*, \bar{i}]$, the agenda setter proposes $i_{A,t}^*$, which is accepted by all members j such that $\mu_J \leqslant \mu_A$. This follows from the indirect utility being single-peaked. When $q_t \in [i_{M,t}^*, i_{A,t}^*]$, the agenda setter cannot increase the interest rate. The best proposal among the acceptable ones is the status quo, which is always accepted. When $q_t \in [2i_{M,t}^* - i_{A,t}^*, i_{M,t}^*)$, the set of policies that the median accepts is given by the interval $[q_t, 2i_{M,t}^* - q_t]$. By Step 1, we know that these proposals are accepted by all members j such that $\mu_J \geqslant \mu_M$ and that any proposal greater than $2i_{M,t}^* - q_t$, which is rejected by the median, is also rejected by all members j such that $\mu_J \leqslant \mu_M$. Finally, when $q_t \in [0, 2i_{M,t}^* - i_{A,t}^*)$, the agenda setter is again able to propose i_A^*, which is accepted by the median. By Step 1 this proposal is also accepted by all members j such that $\mu_J \geqslant \mu_M$. ¶

The political aggregator as a function of q_t is plotted in Panel B of Figure 2. The policy aggregator for the case of a dovish chairman is plotted in Panel C of the same figure, and it is easy to see that it is the mirror image of the one derived here for the hawkish chairman. The control over the agenda of the part of the chairman implies deviations from the median outcome. This is due to the fact that the chairman can propose the policy he prefers, among those alternatives that at least a majority of committee members (weakly) prefer to the status quo. Among the acceptable alternatives, there is no reason to expect the chairman to propose the median outcome. Moreover, deviations from the median outcome are systematically in one direction. That is, they will always bring the policy outcome closer to the policy preferred by the chairman.

As before there is an interval of status quo policies for which policy change is not possible (*i.e.*, a gridlock interval). This interval is given by $[i_{M,t}^*, i_{A,t}^*]$, that is all policies between the interest rate preferred by the median and the chairman. If the status quo falls within this interval, policy changes are blocked by either the chairman or a majority of committee members. To see this, note that when $q_t \in [i_{M,t}^*, i_{A,t}^*]$, 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. The width of the gridlock interval is increasing in the distance between the chairman's and the median's preferred interest rates.

A policy change occurs only if the status quo is sufficiently extreme, compared with the members' preferred policies. 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 his ideal point subject to the constraint that M will accept it. This constraint is binding in equilibrium meaning that 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 lower than $2i^*_{M,t} - i^*_{A,t}$ or higher than $i^*_{A,t}$, the chairman is able to offer and pass the proposal that coincides with his ideal point.

In the rest of this Section, we compare the theoretical predictions of the consensus and agenda-setting models. First, both models deliver a gridlock interval where it is not possible to change the status quo. However, it is difficult to predict *a priori* which voting procedure features the largest gridlock interval because the comparison depends on the degree of consensus that the committee requires (summarized by K) and on the extent of disagreement between the chairman and the median. 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 strict subset of the one in the consensus model if $|\mu_A - \mu_M|$ is sufficiently small and K sufficiently large, but the converse cannot happen.

Second, whenever the committee decides to change the status quo, the models deliver different predictions with respect to the size of the policy change. The agenda-setting model with hawkish (dovish) chairman yields more aggressive interest rate increases (decreases) than the other two models. For example, suppose that the chairman is a hawk. Then, when $q_t < i^*_{M,t}$, the agenda-setting model unambiguously predicts a larger policy change compared with the consensus model. Instead, when $q_t \geqslant i^*_{M,t}$, the comparison is ambiguous and the size of the interest rate decrease depends on the location of $i^*_{A,t}$ versus $i^*_{M+K,t}$.

Finally, note that under both protocols, the endpoints of the gridlock 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.

2.6 Protocol III: Simple-Majority Model

The Median Voter Theorem (Black, 1958) dictates that when preferences are single-peaked, N is odd, and the policy space is one-dimensional, there is a unique core outcome, represented by the alternative preferred by the individual whose ideal point constitutes the median of the set of ideal points. In our set-up, which satisfies all the conditions of the theorem, this alternative is represented by

$$i^*_{M,t} = a_M + b\pi_t + cy_t + \zeta_t,$$

where $i^*_{M,t}$ is the interest rate preferred by the median member. In its original formulation, the Median Voter Theorem lacks a non-cooperative underpinning. However, one can show that when its conditions are satisfied, the final outcome of any binary agenda under simple majority (irrespective of the order through which alternatives are put to a vote) will implement the median's ideal point. For instance, policy $i^*_{M,t}$ will be the final outcome of the binary agenda in Section 2.4 as long as one requires simple majority, that is $S = (N + 1)/2$.

It is interesting to note that under 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 always selected. Having a committee is then equivalent to having the median committee member as a single central banker and the reaction function is observationally indistinguishable from a standard Taylor rule derived under the assumption that monetary policy is selected by one individual. The model predicts a proportional adjustment of the policy instrument in response to any change in inflation and unemployment regardless of their size and generates interest rate autocorrelation only from the serial correlation of the fundamentals.

The policy outcome predicted by the median model is plotted in Panel D of Figure 2. In all the panels of this figure, the size of the policy change may be inferred from the vertical distance between the policy rule and the 45 degree line. Notice that the consensus and agenda-setting models imply smaller policy changes than the median model. In this sense, policy making is more conservative under the former two protocols than under the latter.

3 Econometric Analysis

3.1 The Data

The data set consists of interest rate decisions by monetary policy committees in five central banks, namely the Bank of Canada, the Bank of England, the European Central Bank (ECB), the Swedish Riksbank, and the U.S. Federal Reserve, along with a measure of inflation and the output gap in their respective countries. Inflation is measured by the twelve-month percentage change of the Consumer Price Index (Canada and Sweden), Retail Price Index excluding mortgage-interest payments or RPIX (United Kingdom), Harmonized Consumer Price Index (European Union) and Consumer Price Index for All Urban Consumers (United States).[16] The output gap is measured by the deviation of the seasonally-adjusted unemployment rate from a trend computed using the Hodrick-Prescott filter.

[16]Since December 2003, the inflation target in the United Kingdom applies to the Consumer Price Index (CPI) rather than to the RPIX. However, results using the CPI are similar to the ones reported below and are available from the corresponding author upon request.

Interest rate decisions concern the target values for the Overnight Rate (Canada), the Repo Rate (United Kingdom and Sweden), 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 minutes of the FOMC meetings which are available at *www.federalreserve.gov.* For the Riksbank, the source are the minutes of the meetings of the Executive Board, which are available at *www.riksbank.com.* 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, when the ECB officially took over monetary policy from the national central banks, and ends in March 2007. The sample for Sweden starts with the first meeting of the Executive Board on January 1999 and ends in June 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 chairmanship of Alan Greenspan (with a small number of observations from the chairmanship of Ben Bernanke). The number of scheduled meetings per year vary from seven or eight (Bank of Canada, Riksbank and Federal Reserve) to eleven (ECB) and twelve (Bank of England).

There is substantial heterogeneity in the formal procedures followed by the monetary policy committees in our sample. The Governing Council of the Bank of Canada consists of the Governor and five Deputy Governors and explicitly operates on a consensus basis. This means that the discussion at the meeting is expected to move the committee towards a shared view. The Monetary Policy Committee of the Bank of England consists of nine members of which five are internal (that is, chosen from within the ranks of bank staff) and four are external appointees. Meetings are chaired by the Governor of the Bank of England, decisions are taken by simple majority and dissenting votes are public. The decision making body of the European Central Bank consists of six members of the Executive Board of the ECB and thirteen governors of the national central banks. According to the statutes, monetary policy is decided by simple majority rule. The ECB issues no minutes and, consequently, dissenting opinions are not made public. Under the Riksbank Act of 1999, the Swedish Riksbank is governed by an Executive Board, which includes the Governor and five Deputy Governors and decisions concerning the Repo Rate are taken by majority vote, but formal reservations against the majority decision are recorded in the minutes. Finally, the FOMC takes decisions by majority rule among voting members. Voting members include all the seven members of the Board of Governors, the president of the New York Fed and four members of the remaining district banks, chosen according to an annual rotation scheme. The minutes of FOMC meetings are made public however, unlike the Riksbank and the Bank of England, dissenting members in the FOMC do not always state the exact interest rate they would have preferred, but only the direction of dissent (either tightening or easing).

3.2 Formulation of the Likelihood Functions

In this section, we show that the political aggregators derived in Section 2 imply particular time-series processes for the nominal interest rate and derive their likelihood functions under the maintained assumption that shocks are Normally distributed.

First, consider the consensus-based model. Proposition 1 means that the nominal interest rate follows the nonlinear process

$$i_t = \begin{cases} i^*_{M+K,t}, & \text{if} \quad i_{t-1} > i^*_{M+K,t}, \\ i_{t-1}, & \text{if} \quad i^*_{M-K,t} \leqslant i_{t-1} \leqslant i^*_{M+K,t}, \\ i^*_{M-K,t}, & \text{if} \quad i_{t-1} < i^*_{M-K,t}, \end{cases}$$

where

$$i^*_{M+K,t} = a_{M+K} + b\pi_t + cy_t + \zeta_t$$

and

$$i^*_{M-K,t} = a_{M-K} + b\pi_t + cy_t + \zeta_t$$

are, respectively, the preferred policies of the key members $M+K$ and $M-K$. A realization of the interest rate belongs to either of three possible regimes depending on whether the status quo (i_{t-1}) is larger than $i^*_{M+K,t}$, smaller than $i^*_{M-K,t}$, or in between these two values. Recall that the political aggregator in Section 2.4 implies that in the first case the committee cuts the interest rate to $i^*_{M+K,t}$; in the second case, it raises the interest rate to $i^*_{M-K,t}$; and in the third case, it keeps the interest rate unchanged. Since the data clearly show the instances where the committee takes each of these three possible actions, it follows that the sample separation is perfectly observable and each interest rate observation can be unambiguously assigned to its respective regime.

In what follows, it will be convenient to define

$$\begin{aligned} z^*_{M+K,t} &= \left(i_{t-1} - a_{M+K} - b\pi_t - cy_t\right)/\sigma, \\ z^*_{M-K,t} &= \left(i_{t-1} - a_{M-K} - b\pi_t - cy_t\right)/\sigma, \end{aligned}$$

and rewrite the interest rate process as

$$i_t = \begin{cases} i^*_{M+K,t}, & \text{if} \quad \zeta_t < \sigma z^*_{M+K,t}, \\ i_{t-1}, & \text{if} \quad \sigma z^*_{M-K,t} \geqslant \zeta_t \geqslant \sigma z^*_{M+K,t}, \\ i^*_{M-K,t}, & \text{if} \quad \zeta_t > \sigma z^*_{M-K,t}. \end{cases}$$

This formulation makes clear that when shocks are relatively small, the committee does not change its policy. To see this, suppose, for instance, that ζ_t is positive but smaller than $\sigma z^*_{M-K,t}$. In this a case, we know from (6) that the interest rate preferred by all committee members go up. However, since the newly preferred policies by all members $j \leqslant M-K$ are still smaller than i_{t-1}, and since keeping the status quo increases their utility compared to that in the previous period, it follows that all these members would vote against an interest rate increase and so the super-majority requirement would not be met. Only when ζ_t is sufficiently large, will the committee increase the interest rate but only up to $i^*_{M-K,t}$.

Define the set $\Omega_t = \{i_{t-1}, \pi_t, y_t\}$ with the predetermined variables at time t, and the sets Ξ_1, Ξ_2 and Ξ_3 that respectively contain the observations where the interest rate was cut, raised, and left unchanged. Denote by T_1, T_2 and T_3 the number of observations in each of these sets and by T $(= T_1 + T_2 + T_3)$ the total number of observations. Then, for observations in Ξ_1 and Ξ_2,

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

respectively, while for observations in Ξ_3,

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

where $\phi(\cdot)$ and $\Phi(\cdot)$ are respectively the probability density and cumulative distribution functions of the standard normal variable. The density function of i_t under the consensus model is similar to the one studied by Rosett (1959), who generalizes the two-sided Tobit model to allow the mass point anywhere in the conditional cumulative distribution function. In both models, the dependent variable reacts only to large changes in the fundamentals. However, while Rosett's frictional model is static and the mass point is concentrated around a fixed value, the consensus-based model is dynamic and the mass point is concentrated around a time-varying and endogenous value, albeit predetermined at the beginning of the meeting.

Finally, the log likelihood function of the T available interest rate observations is

$$\begin{aligned}
L(\boldsymbol{\theta}) &= -(T_1 + T_3)\sigma + \sum_{i_t \in \Xi_1} \log\phi\left(\frac{i_t - a_{M-K} - b\pi_t - cy_t}{\sigma}\right) \\
&\quad + \sum_{i_t \in \Xi_2} \log\left(\Phi\left(z^*_{M-K,t}\right) - \Phi\left(z^*_{M+K,t}\right)\right) + \sum_{i_t \in \Xi 3} \log\phi\left(\frac{i_t - a_{M+K} - b\pi_t - cy_t}{\sigma}\right),
\end{aligned}$$

where $\boldsymbol{\theta} = \{a_{M-K}, a_{M+K}, b, c, \sigma\}$ denotes the set of unknown parameters. The maximization of this function with respect to $\boldsymbol{\theta}$ delivers consistent Maximum Likelihood (ML) estimates of the parameters of the interest rate process under the consensus model.

Second, consider the agenda-setting model with a hawkish chairman. (The case of the dovish chairman is isomorphic and not presented here to save space.) Proposition 2 means that the nominal interest rate follows the nonlinear process

$$i_t = \begin{cases} i^*_{A,t}, & \text{if} \quad i_{t-1} > i^*_{A,t}, \\ i_{t-1}, & \text{if} \quad i^*_{M,t} \leqslant i_{t-1} \leqslant i^*_{A,t}, \\ 2i^*_{M,t} - i_{t-1}, & \text{if} \quad 2i^*_{M,t} - i^*_{A,t} \leqslant i_{t-1} < i^*_{M,t}, \\ i^*_{A,t}, & \text{if} \quad i_{t-1} < 2i^*_{M,t} - i^*_{A,t}, \end{cases}$$

where

$$i^*_{A,t} = a_A + b\pi_t + cy_t + \zeta_t$$

and

$$i^*_{M,t} = a_M + b\pi_t + cy_t + \zeta_t$$

are, respectively, the preferred policies of the chairman and the median. In this model, a realization of the interest rate belongs to either of four possible regimes, rather than three as in the consensus model. In the case where i_{t-1} is larger than $i^*_{A,t}$, the political aggregator in Section 2.5 shows that the committee cuts the interest rate to $i^*_{A,t}$, and the observation can be unambiguously assigned to the set Ξ_1. In the case where i_{t-1} is between $i^*_{M,t}$ and $i^*_{A,t}$, the committee keeps the interest rate unchanged and the observation clearly belongs to Ξ_3. However, in the case where i_{t-1} is smaller than $i^*_{M,t}$ (for example, as a result of a sufficiently large realization of ζ_t), the agenda setter may propose an interest rate increase to either $2i^*_{M,t} - i_{t-1}$ or $i^*_{A,t}$ depending on whether the acceptance constraint is binding or not. Although the observation can be assigned to Ξ_2, one cannot be sure which of the two regimes (whether $2i^*_{M,t} - i_{t-1}$ or $i^*_{A,t}$) has generated i_t. The reason is simply that on the basis of interest rate data alone, it is not possible to know *ex-ante* whether the acceptance constraint is binding or not. Hence, in the agenda-setting model, the sample separation is imperfect.

Define the variables

$$\begin{aligned} z^*_{A,t} &= (i_{t-1} - a_A - b\pi_t - cy_t)/\sigma, \\ z^*_{M,t} &= (i_{t-1} - a_M - b\pi_t - cy_t)/\sigma, \\ z^*_{D,t} &= (i_{t-1} - (2a_M - a_A) - b\pi_t - cy_t)/\sigma, \end{aligned}$$

and rewrite the interest rate process as

$$i_t = \begin{cases} i^*_{A,t}, & \text{if} \quad \zeta_t < \sigma z^*_{A,t}, \\ i_{t-1}, & \text{if} \quad \sigma z^*_{M,t} \geqslant \zeta_t \geqslant \sigma z^*_{A,t}, \\ 2i^*_{M,t} - i_{t-1}, & \text{if} \quad \sigma z^*_{t,D} \geqslant \zeta_t > \sigma z^*_{M,t}, \\ i^*_{A,t}, & \text{if} \quad \zeta_t > \sigma z^*_{t,D}, \end{cases}$$

Then, for observations in Ξ_1,

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

and for observations in Ξ_3,

$$Pr(i_t|\Omega_t) = \Phi\left(z^*_{M,t}\right) - \Phi(z^*_{A,t}).$$

On the other hand, for observations in Ξ_2, the density is a mixture of the two Normal distributions associated with the processes $2i^*_{M,t} - i_{t-1}$ and $i^*_{A,t}$. Since the disturbance term is the same in both processes, these distributions are perfectly correlated. Then, a simple approach to derive the density is to consider the limit of the mixture of Normals when their correlation coefficient (denoted by ρ) tends to 1.[17] That is, the limit as $\rho \to 1$ of

$$\frac{1}{\sigma}\phi\left(\frac{i_t - a_A - b\pi_t - cy_t}{\sigma}\right)(1 - \Phi(w_{1,t})) + \frac{1}{2\sigma}\phi\left(\frac{i_t - 2(a_M + b\pi_t + cy_t) + i_{t-1}}{\sigma}\right)(1 - \Phi(w_{2,t})),$$

where

$$\begin{aligned} w_{1,t} &= \frac{i_t - 2(a_M + b\pi_t + cy_t) + i_{t-1} - 2\rho(i_t - a_A - b\pi_t - cy_t)}{\sqrt{2\sigma(1-\rho^2)}}, \\ w_{2,t} &= \frac{i_t - a_A - b\pi_t - cy_t - (\rho/2)(i_t - 2(a_M + b\pi_t + cy_t) + i_{t-1})}{\sqrt{\sigma(1-\rho^2)}}. \end{aligned}$$

This density is a weighted average of two Normal densities with weights $(1 - \Phi(w_{1,t})$ and $(1 - \Phi(w_{2,t}))$. Notice that in the limit as $\rho \to 1$, the former weight tends to zero whenever $i_t - i_{t-1} - 2(a_A - a_M) < 0$ and to 1, otherwise, while the converse is true for the latter weight. Hence, the density may be written as

$$Pr(i_t|\Omega_t) = \frac{1}{\sigma}\phi\left(\frac{i_t - a_A - b\pi_t - cy_t}{\sigma}\right) I(w_t) + \frac{1}{2\sigma}\phi\left(\frac{i_t - 2(a_M + b\pi_t + cy_t) + i_{t-1}}{\sigma}\right)(1 - I(w_t)),$$

where w_t is short-hand for the condition $i_t - i_{t-1} - 2(a_A - a_M) < 0$, and $I(\cdot)$ is an indicator function that takes the value 1 if its argument is true and zero otherwise.

[17] The derivation of the density of the mixture of Normal itself follows the standard steps set out, for example, in Maddala (1983) and is omitted here for the sake of brevity.

Finally, the log likelihood function of the T available observations is

$$\begin{aligned} L(\boldsymbol{\vartheta}) &= -(T_1+T_3)\sigma + \sum_{i_t\in\Xi_1}\log\phi\left(\frac{i_t-a_A-b\pi_t-cy_t}{\sigma}\right)+\sum_{i_t\in\Xi_2}\log\left(\Phi\left(z^*_{M,t}\right)-\Phi(z^*_{A,t})\right) \\ &\quad+\sum_{i_t\in\Xi 3}\log\left[\phi\left(\frac{i_t-a_A-b\pi_t-cy_t}{\sigma}\right)I\left(w_t\right)+\frac{1}{2}\phi\left(\frac{i_t-2(a_M+b\pi_t+cy_t)+i_{t-1}}{\sigma}\right)\left(1-I\left(w_t\right)\right)\right], \end{aligned}$$

where $\boldsymbol{\vartheta}=\{a_A,\, a_M,\, b,\, c,\, \sigma\}$ denotes the set of unknown parameters. By maximizing this function with respect to $\boldsymbol{\vartheta}$, it is possible to obtain consistent ML estimates of the parameters of the interest rate process under the agenda-setting model. Notice, however, that the indicator function $I(\cdot)$ induces a discontinuity in the likelihood function and, consequently, this maximization requires either the use of a non-gradient-based optimization algorithm or a smooth approximation to the indicator function. We followed the latter approach here, with ρ fixed to 0.9999, but using the simulated annealing algorithm in Corana *et al.* (1987), which does not require numerical derivatives but is much more time consuming, delivers the same results.

Finally, consider the simple majority model. Since

$$i_t = a_M + b\pi_t + cy_t + \zeta_t,$$

it follows that for all observations

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

and the log likelihood function in this case is

$$L(\boldsymbol{\varphi}) = -T\sigma + \sum_{\forall i_t}\log\phi\left(\frac{i_t-a_M-b\pi_t-cy_t}{\sigma}\right),$$

where $\boldsymbol{\varphi}=\{a_M,\, b,\, c,\, \sigma\}$ denotes the set of unknown parameters. The maximization of this function with respect to $\boldsymbol{\varphi}$ delivers consistent ML estimates of the parameters of the interest rate process under the simple-majority model.

3.3 Empirical Results

Tables 1 through 6 report empirical results for the monetary committees of the Bank of Canada, the Bank of England, the European Central Bank, the Swedish Riksbank, and the Federal Reserve under the chairmanships of Alan Greenspan and Arthur Burns, respectively. Panel A in these tables reports Maximum Likelihood estimates of the parameters of the interest rate process under each protocol. Although some coefficients are not statistically significant, estimates for all protocols are generally in line with the theory in the sense that they imply that committees tend to raise (cut) interest rates when inflation (unemployment) increases.

Panels B and C respectively compare the protocols in terms of standard model selection criteria and in terms of their quantitative predictions. The latter are computed by means of stochastic simulation as follows. Given current inflation and unemployment and the previous observation of the nominal interest rate, we draw a realization of ζ_t from a Normal distribution with zero mean and standard deviation equal to its ML estimate. Then, for each protocol, we compute the preferred policies of the key member(s) using the ML estimates of their reaction function parameters and use the political aggregators in Section 2 to derive the interest rate selected by the "artificial" committee. This algorithm is repeated as many times as the actual sample size to deliver one simulated path of the nominal interest rate. Then, we compute the autocorrelation function and the proportion of interest rate cuts, increases, and no changes from the simulated sample. The numbers reported in Panel C are averages of these statistics over 240 replications of this procedure.

As we will see, results in these two panels show that for all committees in the sample, the consensus model is empirically superior to the other models of collective decision making. Let us start by comparing the consensus and simple-majority models. These two models share the property that no member controls the agenda and primarily differ in the size of the majority required to a pass a proposal. In particular, recall that when the size of the qualified majority reduces to simple majority, the consensus-based model predicts that the committee selects the median's preferred alternative. Panel B in Tables 1 through 6 shows that for all monetary committees, the simple-majority model features larger Root Mean Squared Error (RMSE), Mean Absolute Error (MAE) and Akaike Information Criteria (AIC) than the consensus model. The comparatively poor performance of the simple-majority model can be seen in Figures 3 through 8, which plot the interest rate decisions and the fitted values under all protocols for each committee in the sample. Although the simple-majority model tracks interest rate decisions in broad terms, the quantitative difference between actual and predicted values is the largest among the protocols studied. There are two reasons for this result. First, the simple-majority model generates interest rate autocorrelation only from the serial correlation of inflation, unemployment and the disturbance term. However, the serial correlation of these variables is not large enough to account for the large autocorrelation of the nominal interest rate. To illustrate this point, Figure 9 plots the autocorrelation functions (up to ten lags) implied by each protocol and the one computed from the data, and Panel C reports the first-order autocorrelations. From these figure and panel, it is clear that the simple-majority model generally predicts less interest rate persistence than the consensus model and than found in the data. Second, the simple-majority model delivers a linear reaction function whereby the interest rate changes whenever inflation, unemployment, or the shock realization change. Hence, this model cannot explain the relative large number of instances where the committee keeps the interest rate unchanged despite the fact that fundamentals have changed. From the simulations reported in Panel C, we can see that this model predicts that the proportion of observations where the nominal interest rate remains unchanged is exactly zero, while the consensus model predicts a proportion similar to that found in the data.

These results are consistent with empirical and experimental evidence that committee decisions typically involve qualified, rather than simple, majorities. For example, the voting records of the committees of the Bank of England, the Riksbank and the Federal Reserve show that split decisions are extremely infrequent. The experimental study by Blinder and Morgan (2005) finds than even though their artificial monetary committee is supposed to make decisions by majority rule, in reality most decisions are unanimous. Experimental runs of the divide-the-dollar game show that despite the simple-majority requirement necessary to pass a proposal, the agenda setter does not always select a minimum winning coalition: in some cases (roughly 30 to 40 percent of the experiments in McKelvey, 1991 and Diermeier and Morton, 2005), agenda setters allocate money to all players.

It remains an open question why a committee formally operating under simple majority rule adopts a super-majority rule in practice. The search for consensus might be motivated by the belief that split-votes lead to aggrieved minorities and undermine future cooperation. Another explanation is proposed by Bullard and Waller (2004) and Dal Bó (2006), who argue that a super-majority rule may help overcome time-consistency problems by inducing policy-stickiness.[18]

Now let us compare the consensus and agenda-setting models. These two protocols deliver outcomes different from the median policy, predict a time-varying gridlock interval where the committee chooses to keep the interest rate unchanged, and endogenously generate interest rate autocorrelation from the role of the status-quo as the default policy. However, these protocols generate different implications for the size of interest rate adjustments. More precisely, the agenda-setting model predicts larger interest rate increases (decreases) than the consensus model when the chairman is more hawkish (dovish) than the median. The reason for this is that the chairman controls the agenda in the agenda-setting model while

[18] Alternatively, it might be the case that the initial status quo determines a basic form of entitlement. In a laboratory study, Diermeier and Gailmard (2006) find that subjects are more willing to accept less generous offers if the proposer's reservation value is high, thereby supporting the idea that a favorable initial status quo determines an entitlement to a larger amount of resources. In our context, this would explain why a majority of committee members who dislike the status quo are less willing to push for a policy change.

no member does in the consensus model. Hence, deviations from the median's preferred policy are systematically in the favor of the chairman's in the former model.

From Panel B in Tables 1 through 6, we can see that for all monetary committees, the two versions of the agenda-setting model feature larger RMSE, MAE and AIC than the consensus model. The poorer performance of the agenda-setting model in terms of fit may also be observed in Figures 3 through 8. Note, in particular, that the agenda-setting model with a hawkish (dovish) chairman tends to overpredict the magnitude of interest rate increases (decreases) compared with the consensus model. In terms of the statistics reported in Panel C of all tables and the autocorrelation functions plotted in Figure 9, it also clear that the agenda-setting models is not as successful as the consensus model in replicating the persistence of interest rates and the proportions of interest rate cuts, increases, and no changes observed in the data.[19]

Recall that in the agenda-setting model with a hawkish (dovish) chairman, the agenda-setter proposes an increase (decrease) of the nominal interest rate to either of two possible regimes depending on whether the acceptance constraint is binding or not. As noted above in Section 3.2, it is not possible to know *ex-ante* whether this constraint is binding. However, given the ML estimates, it is possible to construct *ex-post* probability estimates that a given interest rate observation belongs to either regime. We found that in all cases and for all committees in the sample, interest rate increases (decreases) by the hawkish (dovish) chairman are generated by the regime where the acceptance constraint binds. This suggests that even though the chairman has proposal power, he often has to compromise and choose a policy proposal that takes into account the preferences of the other committee members. Based on 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."

In the rest of this Section, we investigate in more detail the reasons why the agenda-setting model is less empirically successful than the consensus-based model. A feature of the agenda-setting model is that the chairman is able to use his proposal power to extract all rents when the status quo is sufficiently far from the median's preferred interest rate. For example, when $i_{t-1} \in [2i^*_{M,t} - i^*_{A,t}, i^*_{M,t})$, the hawkish chairman proposes the policy $2i^*_{M,t} - i_{t-1}$, which is the reflection point of the status quo with respect to the median's preferred interest

[19]When we compare both versions of the agenda-setting model, results in the tables show that, except for the ECB, the version with a hawkish chairman meets somewhat greater empirical success than the version with a dovish chairman. In particular, the former delivers smaller RMSE, MAE and AIC and larger interest rate autocorrelation than the latter. Notice that in both cases the predicted distribution of interest rate changes is asymmetric with proportionally more increases than decreases (decreases than increases) in the hawkish (dovish) case.

rate. The proposed policy leaves the median as well-off as under the status quo and delivers all surplus to the chairman, who has fully exploited his proposal power. In order to test this feature of the agenda-setting model, consider the following statistical model

$$i_t = \begin{cases} i^*_{A,t}, & \text{if} \quad i_{t-1} > i^*_{A,t}, \\ i_{t-1}, & \text{if} \quad i^*_{M,t} \leqslant i_{t-1} \leqslant i^*_{A,t}, \\ (1+\xi)i^*_{M,t} - \xi i_{t-1}, & \text{if} \quad ((1+\xi)i^*_{M,t} - i^*_{A,t})/\xi \leqslant i_{t-1} < i^*_{M,t}, \\ i^*_{A,t}, & \text{if} \quad i_{t-1} < ((1+\xi)i^*_{M,t} - i^*_{A,t})/\xi. \end{cases} \tag{7}$$

where $\xi \in (0,1]$. Note that when $\xi = 1$, (7) is the interest rate process implied by the agenda-setting model with a hawkish chairman. Consider relaxing the restriction $\xi = 1$ so that now $\xi = 1 - \Delta$ for a "small" $\Delta > 0$. Then, when $i_{t-1} \in [((1+\xi)i^*_{M,t} - i^*_{A,t})/\xi, i^*_{M,t})$, the proposed policy would be $(1+\xi)i^*_{M,t} - \xi i_{t-1} < 2i^*_{M,t} - i_{t-1}$.[20] This means that, given the status quo, the proposal is now closer to the median's ideal point than under the original protocol and, consequently, the median collects part of the rents. This simple argument suggests that the implication that the chairman uses his agenda-setting power to extract all rents may be statistically tested *via* a Lagrange Multiplier (LM) test of the restriction $\xi = 1$. The p-values of this test are reported in the last row of Panel B and indicate that the restriction is strongly rejected by the data from all committees. (A similar argument and test, deliver the same result in the case of the dovish chairman.) Thus, the data reject the strong form of agenda control embodied in the agenda-setting model by Romer and Rosenthal (1978), whereby proposals are made under closed rule (that is, with no counter proposals allowed). It is interesting to note that this result also holds for the FOMC despite the common view that its chairman exerts almost undisputed power and evidence from the transcripts and minutes that other committee members usually do not bring forward counter proposals once the chairman has made his policy recommendation.

In what follows, we test whether the chairman is able to at least partially exploit his proposal power. In particular, notice that if we were to empirically find a ML estimate of ξ inside the range $(0, 1)$, this would suggest a form of bargaining between the median member and the agenda-setting chairman. On the other hand, if we were to find that $\xi \to 0$, then the specification (7) would approach the interest rate process implied by the consensus model (with the thresholds appropriately relabeled) where no member controls the agenda. This discussion shows that the specification (7) encompasses both the agenda-setting and consensus models and, consequently, provides a mean for directly comparing both models. In particular, one could imagine estimating (7) using actual data and then testing, for example, whether ξ is statistically closer to 0 or 1. We attempted this strategy

[20]To see this, substitute in $\xi = 1 - \Delta$, write the inequality as $(2-\Delta)i^*_{M,t} - (1-\Delta)i_{t-1} < 2i^*_{M,t} - i_{t-1}$, and simplify to obtain $-\Delta(i^*_{M,t} - i_{t-1}) < 0$, which is satisfied for the range of status quo we are concerned with.

but found that when the encompassing model was estimated, the ML estimate of ξ would converged to 0 in all cases. Since $\xi = 0$ is the lower bound of the parameter space, regularity conditions are violated, and standard tests do not have the usual distributions. However, the fact the data strongly prefer $\xi \approx 0$ compared with $\xi = 1$ constitutes further evidence against the notion that the chairman is able to control the agenda by excluding some alternatives from the vote. Thus, the existence of an inefficient status quo does not appear to represent a sufficient threat that the chairman can exploit to pass a large interest rate change towards his preferred policy. Instead, results suggest that starting, for example, from a low status quo, the committee adjusts the interest rate up to the value preferred by a pivotal member.

Our results are in line with laboratory experiments on committee decision making. For example, Eavey and Miller (1984) test the prediction of the agenda-setting model in a one-dimensional policy space and find that the agenda setter does influence committee decisions and bias the policy outcome away from the policy preferred by the median member. However, contrary to the strong implication of the model, the agenda setter does not seem to select his most preferred policy from among the set of alternatives that dominate the status quo. Recent experimental studies test the predictions of Baron and Ferejohn's (1989) extension of the agenda-setting model and find that the individual selected to make a proposal enjoys a first-mover advantage, as predicted by the theory, but does not fully exploit his proposal power (see McKelvey, 1991, Diermeier and Morton, 2005, Frechette *et al.*, 2005, and Diermeier and Gailmard, 2006). In the empirical literature, Knight (2005) analyzes U.S. data on the distribution of transportation projects across congressional districts. His results support the qualitative prediction that legislators with proposal power secure higher spending in their districts but, in quantitative terms, the estimated value of proposal power is in some cases lower than what is implied by the theory.

Although our findings reject the notion that the chairman controls the agenda in the strong form assumed by Romer and Rosenthal (1978) and in the weaker form examined above, they do not necessarily imply that the chairman has the same power as his peers. For example, a proposal rule similar to the one in Panel A of Figure 2 may arise from a committee that makes decisions according to the consensus-based protocol plus the requirement that the super-majority must include the chairman.

In summary, a robust finding of this paper is that, among the protocols examined, the consensus-based model describes more accurately interest rate decisions than the alternative models, for all committees in our sample. This means that, in addition to the formal rules under which monetary committees operate, their decision making is also the result of unwritten rules and informal procedures that deliver observationally equivalent policy decisions.

4 Conclusions

To our knowledge, all existing studies that estimate interest rate rules abstract from the voting process that lead to policy decisions. A large body of anecdotal evidence hints instead at the importance of strategic considerations in the decision-making process. Committee members differ along various dimensions and, consequently, are likely to have different preferred interest rates. The way committees resolve these differences crucially depends on the particular voting protocol (implicitly or explicitly) adopted. In this paper, we consider three voting protocols that capture some relevant aspects of the actual monetary policy making by committee: the consensus, the agenda-setting and the simple-majority models. The three protocols have distinct time series implications for the nominal interest rate. These different implications are the basis for empirically distinguish among the three protocols using actual data from the policy decisions by committees in five central banks. A robust empirical conclusion is that the consensus model is statistically superior to the other two voting protocols. This result is observed despite the fact that all central banks (except the Bank of Canada) considered in our sample do not formally operate under a consensus (or super-majority) rule. This result is consistent with a large experimental literature on committee decision making that indicates a preference for oversized or nearly unanimous coalitions even in strict-majority rule games.

Table 1. Bank of Canada

	Consensus	Dominant Chairman Hawkish	Dominant Chairman Dovish	Simple Majority	Data
	(1)	(2)	(3)	(4)	(5)
		A. Parameter Estimates			
a_{M+K}	3.175*				
	(0.422)				
a_{M-K}	1.357*				
	(0.471)				
a_M		1.314*	3.257*	2.618*	
		(0.462)	(0.414)	(0.343)	
a_A		3.162*	1.377*		
		(0.413)	(0.462)		
b	0.386*	0.381*	0.388*	0.231	
	(0.174)	(0.171)	(0.171)	(0.143)	
c	−0.120	−0.112	−0.135	−0.041	
	(0.304)	(0.297)	(0.297)	(0.256)	
σ	0.965*	0.942*	0.941*	0.845*	
	(0.124)	(0.120)	(0.120)	(0.085)	
		B. Criteria for Model Selection			
$L(\cdot)$	−58.76	−67.07	−67.53	−62.82	
AIC	127.53	144.14	145.06	133.64	
RMSE	0.506	0.631	0.867	0.850	
MAE	0.388	0.502	0.561	0.715	
Chairman extracts all rents (p-value)		< 0.001	< 0.001		
		C. Quantitative Predictions			
Autocorrelation	0.546	0.397	0.365	0.014	0.873
Proportion of					
Cuts	0.204	0.165	0.267	0.486	0.280
Increases	0.253	0.301	0.194	0.513	0.300
No changes	0.544	0.534	0.539	0	0.420

Notes: The superscripts $*$ and † denote the rejection of the hypothesis that the true parameter value is zero at the 5 and 10 percent significance levels, respectively. The proportion of cuts, increases and no changes may not add up to one due to rounding.

Table 2. Bank of England

	Consensus	Dominant Chairman Hawkish	Dominant Chairman Dovish	Simple Majority	Data
	(1)	(2)	(3)	(4)	(5)
		A. Parameter Estimates			
a_{M+K}	6.511^{*}				
	(1.480)				
a_{M-K}	2.055				
	(1.474)				
a_M		2.070	6.496^{*}	4.262^{*}	
		(1.445)	(1.450)	(0.704)	
a_A		6.451^{*}	2.101		
		(1.451)	(1.443)		
b	0.279	0.281	0.289	0.339	
	(0.609)	(0.598)	(0.597)	(0.299)	
c	-3.390^{*}	-3.366^{*}	-3.352^{*}	-3.303^{*}	
	(1.261)	(1.229)	(1.231)	(0.619)	
σ	1.686^{*}	1.638^{*}	1.636^{*}	1.013^{*}	
	(0.226)	(0.217)	(0.216)	(0.069)	
		B. Criteria for Model Selection			
$L(\cdot)$	−98.20	−105.23	−108.27	−154.66	
AIC	206.40	220.27	226.55	317.33	
RMSE	0.329	0.426	0.536	1.013	
MAE	0.251	0.335	0.369	0.885	
Chairman extracts all rents (p-value)		0.001	< 0.001		
		C. Quantitative Predictions			
Autocorrelation	0.766	0.641	0.638	0.179	0.977
Proportion of					
Cuts	0.113	0.096	0.157	0.492	0.111
Increases	0.135	0.173	0.113	0.508	0.157
No changes	0.752	0.731	0.731	0	0.731

Notes: See notes to Table 1.

Table 3. European Central Bank

		Dominant Chairman		Simple	
	Consensus	Hawkish	Dovish	Majority	Data
	(1)	(2)	(3)	(4)	(5)
		A. Parameter Estimates			
a_{M+K}	4.926^*				
	(0.885)				
a_{M-K}	0.325				
	(0.808)				
a_M		0.351	4.859^*	2.123^*	
		(0.773)	(0.844)	(0.305)	
a_A		4.789^*	0.413		
		(0.845)	(0.773)		
b	0.220	0.237	0.231	0.437^*	
	(0.376)	(0.361)	(0.360)	(0.151)	
c	-1.877^*	-1.801^*	-1.812^*	-1.109^*	
	(0.440)	(0.418)	(0.416)	(0.194)	
σ	1.363^*	1.291^*	1.290^*	0.809^*	
	(0.208)	(0.195)	(0.195)	(0.050)	
		B. Criteria for Model Selection			
$L(\cdot)$	-75.36	-83.07	-78.79	-159.38	
AIC	160.73	176.13	167.58	326.75	
RMSE	0.225	0.358	0.240	0.809	
MAE	0.138	0.203	0.152	0.678	
Chairman extracts all rents (p-value)		< 0.001	0.005		
		C. Quantitative Predictions			
Autocorrelation	0.865	0.806	0.817	0.248	0.988
Proportion of					
Cuts	0.076	0.060	0.096	0.504	0.106
Increases	0.056	0.080	0.047	0.496	0.061
No changes	0.867	0.860	0.858	0	0.833

Notes: See notes to Table 1.

Table 4. Swedish Riksbank

		Dominant Chairman		Simple	
	Consensus	Hawkish	Dovish	Majority	Data
	(1)	(2)	(3)	(4)	(5)
		A. Parameter Estimates			
a_{M+K}	3.578^{*}				
	(0.249)				
a_{M-K}	1.366^{*}				
	(0.260)				
a_M		1.375^{*}	3.716^{*}	2.515^{*}	
		(0.244)	(0.285)	(0.110)	
a_A		3.530^{*}	1.406^{*}		
		(0.233)	(0.270)		
b	0.541^{*}	0.528^{*}	0.348^{*}	0.469^{*}	
	(0.126)	(0.119)	(0.136)	(0.073)	
c	-0.603^{*}	-0.614^{*}	$-0.473^{\dagger}$	-0.477^{*}	
	(0.241)	(0.228)	(0.260)	(0.145)	
σ	0.859^{*}	0.804^{*}	0.936	0.593^{*}	
	(0.122)	(0.113)	(0.137)	(0.047)	
		B. Criteria for Model Selection			
$L(\cdot)$	-63.24	-70.19	-76.57	-70.80	
AIC	136.48	150.37	163.15	149.60	
RMSE	0.255	0.354	0.374	0.593	
MAE	0.180	0.230	0.272	0.457	
Chairman extracts all rents (p-value)		< 0.001	0.001		
		C. Quantitative Predictions			
Autocorrelation	0.821	0.719	0.593	0.369	0.972
Proportion of					
Cuts	0.155	0.122	0.204	0.502	0.177
Increases	0.148	0.190	0.129	0.498	0.139
No changes	0.697	0.688	0.668	0	0.684

Notes: See notes to Table 1

Table 5. U.S. Federal Reserve (Greenspan)

	Consensus	Dominant Chairman Hawkish	Dominant Chairman Dovish	Simple Majority	Data
	(1)	(2)	(3)	(4)	(5)
		A. Parameter Estimates			
a_{M+K}	4.355*				
	(0.575)				
a_{M-K}	0.359				
	(0.529)				
a_M		0.310	4.326*	1.775*	
		(0.522)	(0.560)	(0.392)	
a_A		4.316*	0.325		
		(0.564)	(0.515)		
b	0.759*	0.758*	0.787*	0.985*	
	(0.162)	(0.158)	(0.158)	(0.125)	
c	−4.554*	−4.465*	−4.477*	−2.794*	
	(0.685)	(0.672)	(0.670)	(0.501)	
σ	1.853*	1.811*	1.805*	1.538*	
	(0.145)	(0.141)	(0.140)	(0.087)	
		B. Criteria for Model Selection			
$L(\cdot)$	−218.65	−241.14	−243.50	−292.18	
AIC	447.30	492.28	497.01	592.35	
RMSE	0.745	1.207	1.046	1.538	
MAE	0.547	0.766	0.771	1.291	
Chairman extracts all rents (p-value)		< 0.001	< 0.001		
		C. Quantitative Predictions			
Autocorrelation	0.840	0.711	0.710	0.442	0.989
Proportion of					
Cuts	0.193	0.155	0.246	0.496	0.234
Increases	0.202	0.254	0.160	0.504	0.259
No changes	0.605	0.591	0.594	0	0.506

Notes: See notes to Table 1.

Table 6. U.S. Federal Reserve (Burns)

	Consensus	Dominant Chairman Hawkish	Dominant Chairman Dovish	Simple Majority	Data
	(1)	(2)	(3)	(4)	(5)
		A. Parameter Estimates			
a_{M+K}	4.063*				
	(0.338)				
a_{M-K}	3.056*				
	(0.308)				
a_M		2.929*	3.533*	3.292*	
		(0.296)	(0.284)	(0.282)	
a_A		4.007*	3.175*		
		(0.327)	(0.284)		
b	0.486*	0.485*	0.527*	0.522*	
	(0.046)	(0.044)	(0.042)	(0.042)	
c	−2.175*	−2.123*	−1.996*	−1.978*	
	(0.165)	(0.159)	(0.149)	(0.149)	
σ	1.033*	0.990*	0.962*	0.959*	
	(0.081)	(0.077)	(0.069)	(0.069)	
		B. Criteria for Model Selection			
$L(\cdot)$	−141.20	−165.10	−170.02	−133.54	
AIC	292.40	340.21	350.04	275.08	
RMSE	0.850	1.139	1.188	0.959	
MAE	0.679	0.871	0.969	0.785	
Chairman extracts all rents (p-value)		< 0.001	< 0.001		
		C. Quantitative Predictions			
Autocorrelation	0.872	0.796	0.786	0.776	0.968
Proportion of					
Cuts	0.364	0.295	0.489	0.499	0.433
Increases	0.358	0.417	0.412	0.501	0.402
No changes	0.279	0.287	0.099	0	0.165

Notes: See notes to Table 1.

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Figure 1: Utility Functions

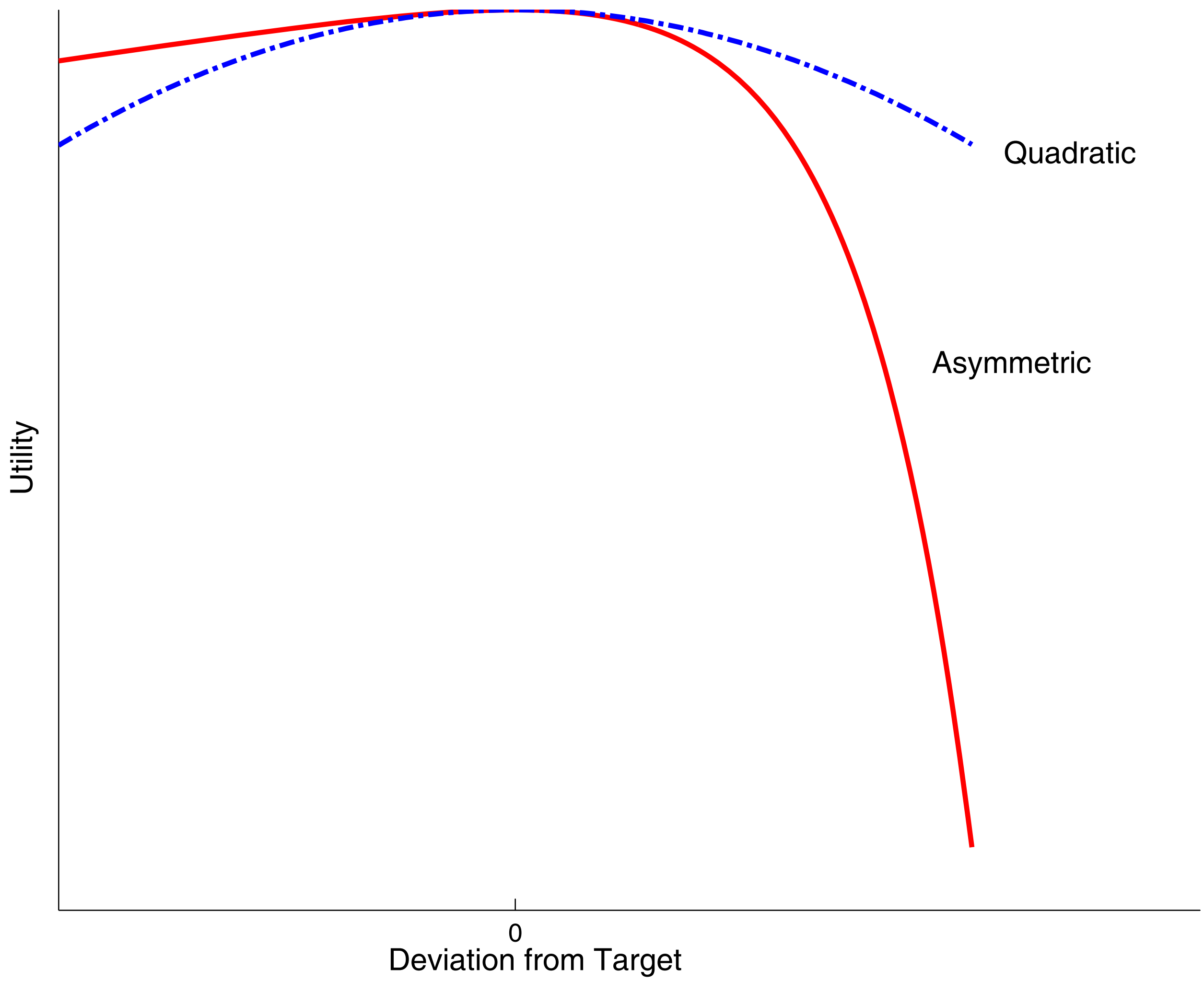

Figure 2: Policy Outcomes

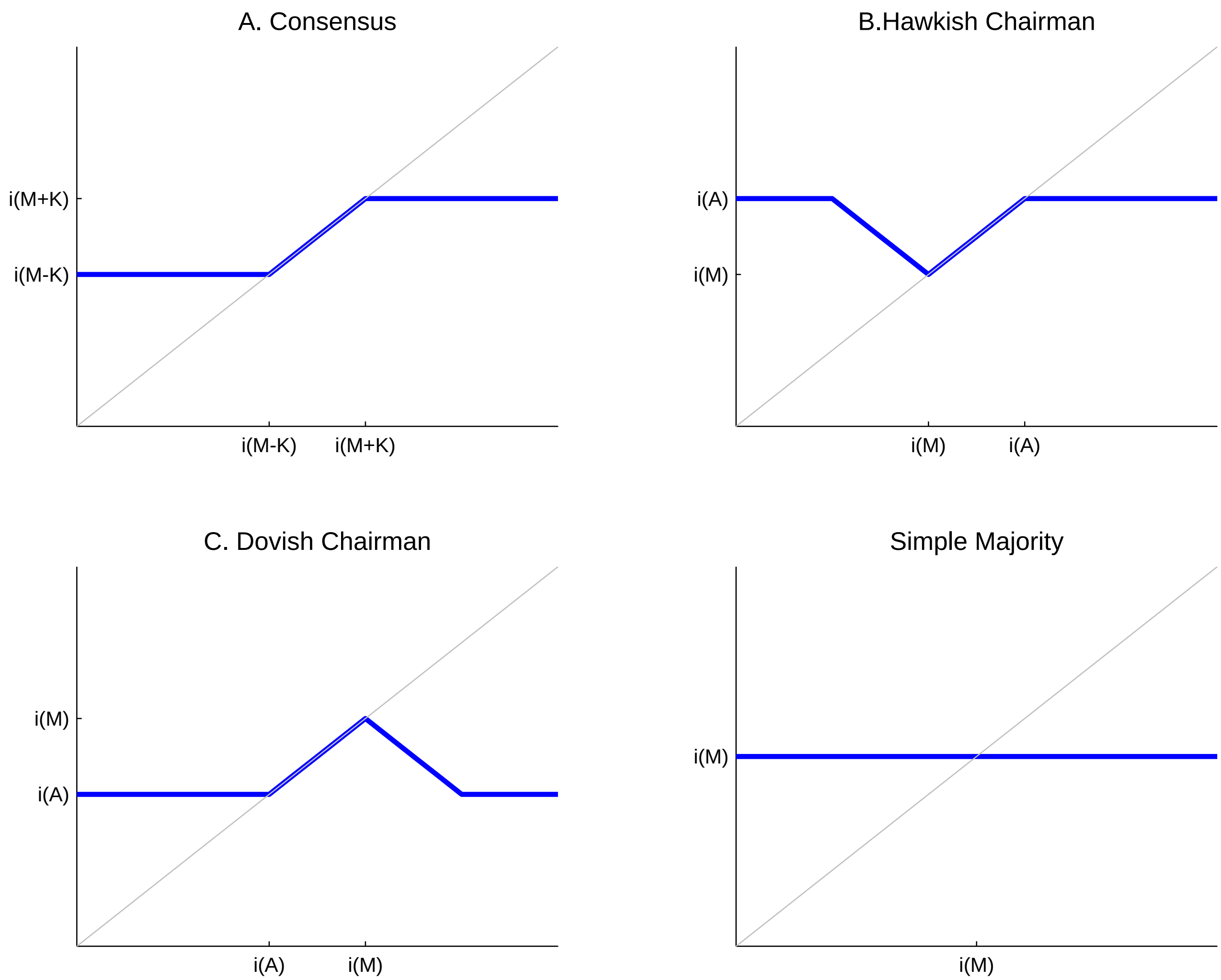

Figure 3. Model Fit. Bank of Canada

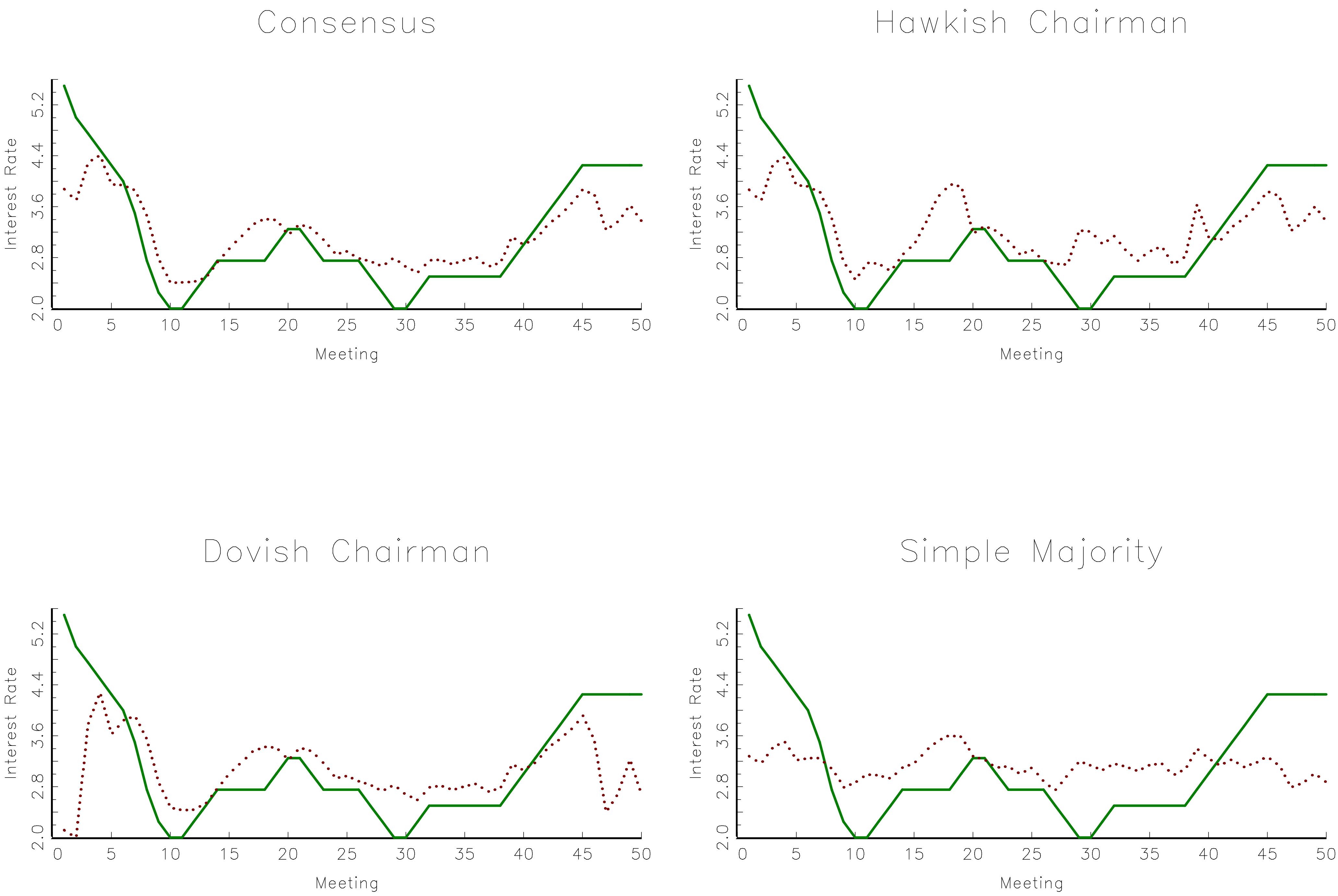

Figure 4. Model Fit. Bank of England

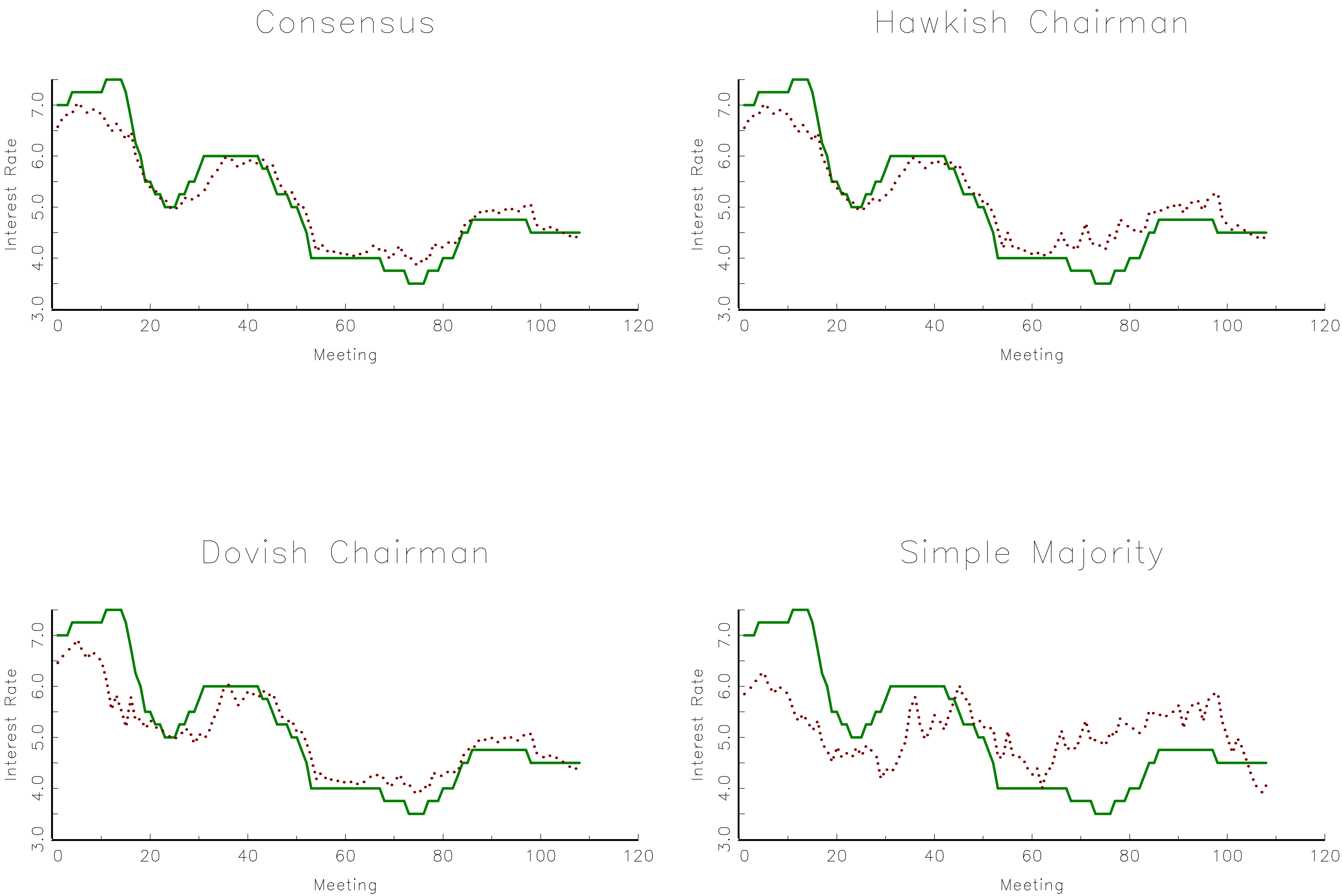

Figure 5. Model Fit. European Central Bank

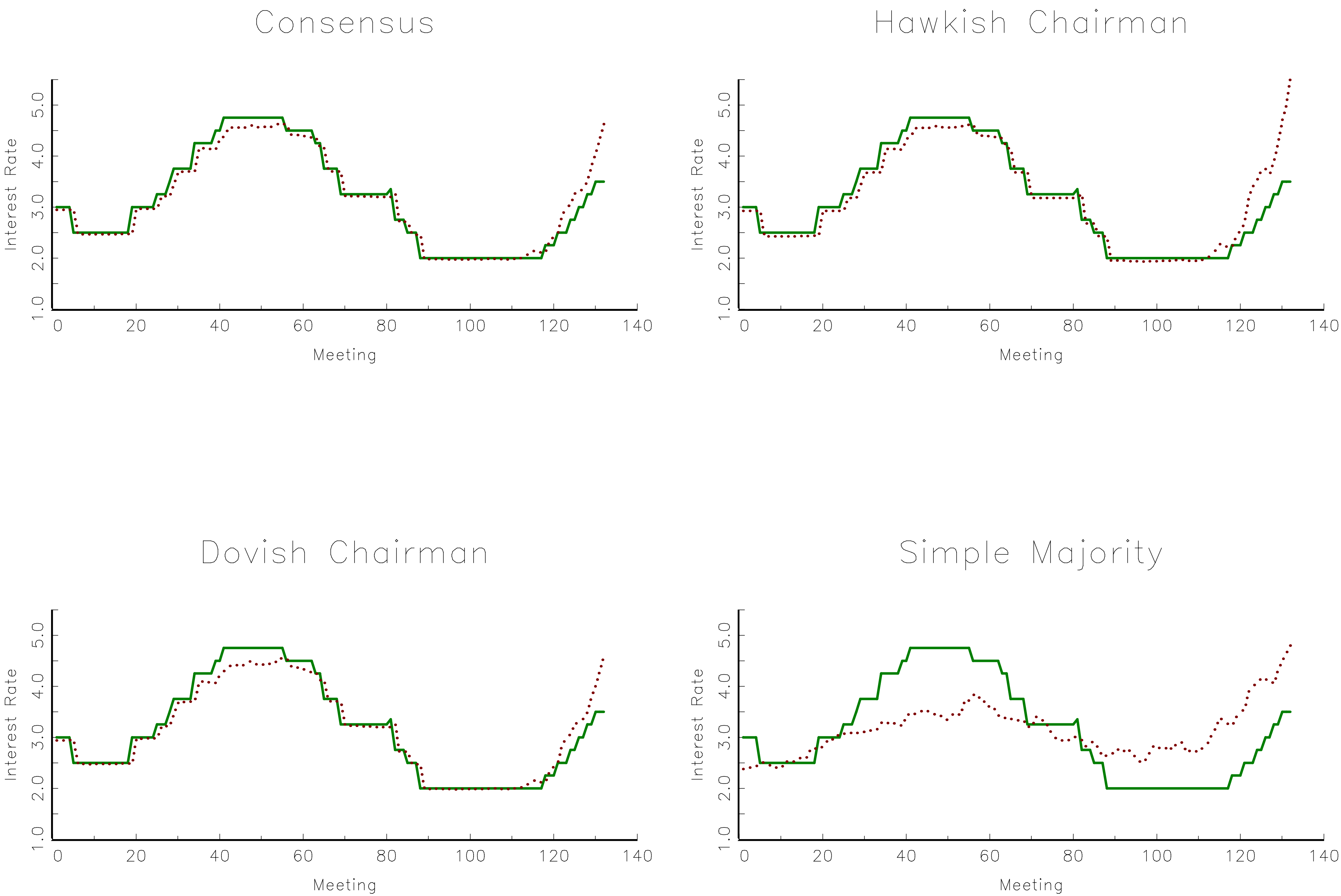

Figure 6. Model Fit. Swedish Riksbank

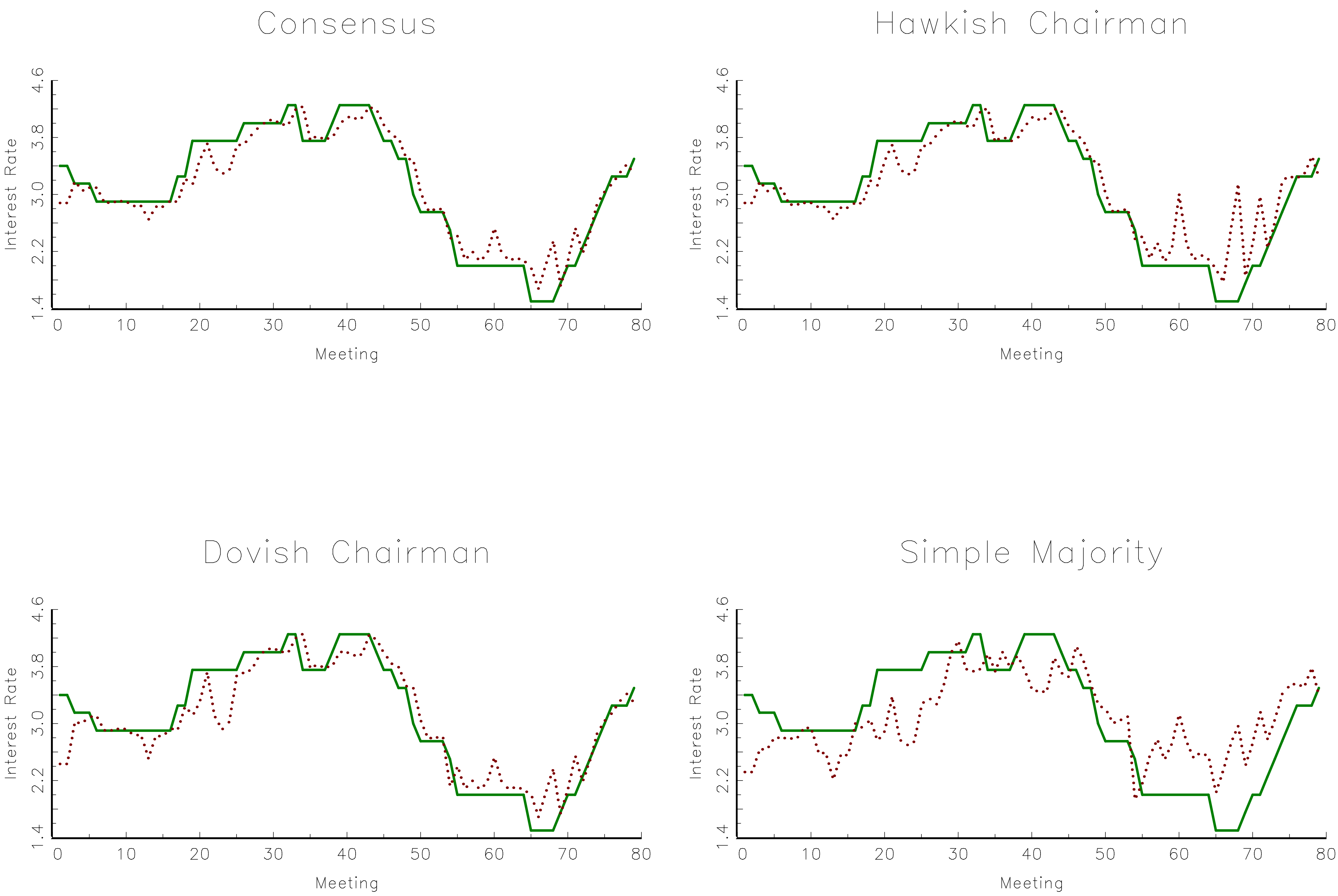

Figure 7. Model Fit. U.S. Fed (Greenspan)

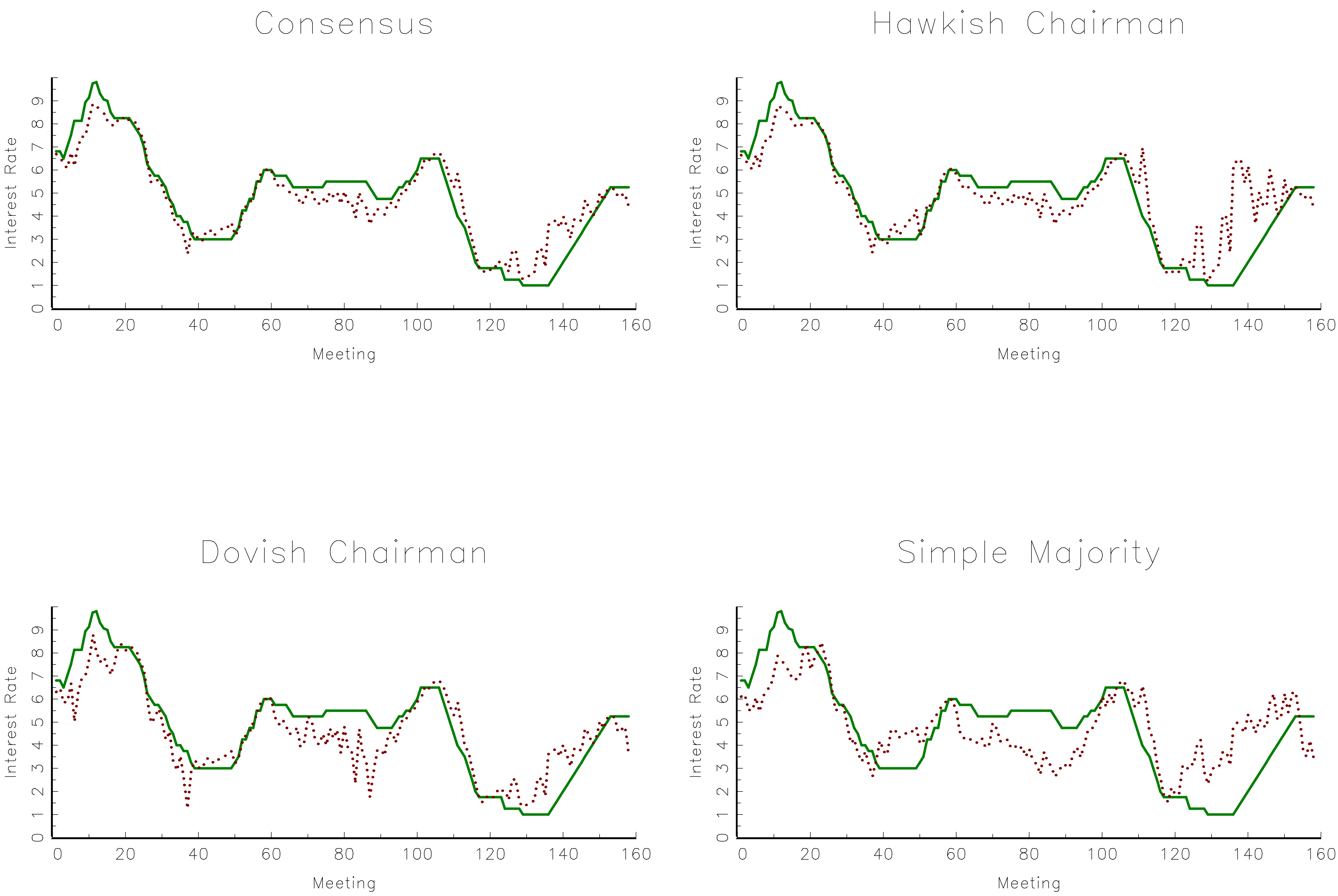

Figure 8. Model Fit. U.S. Fed (Burns)

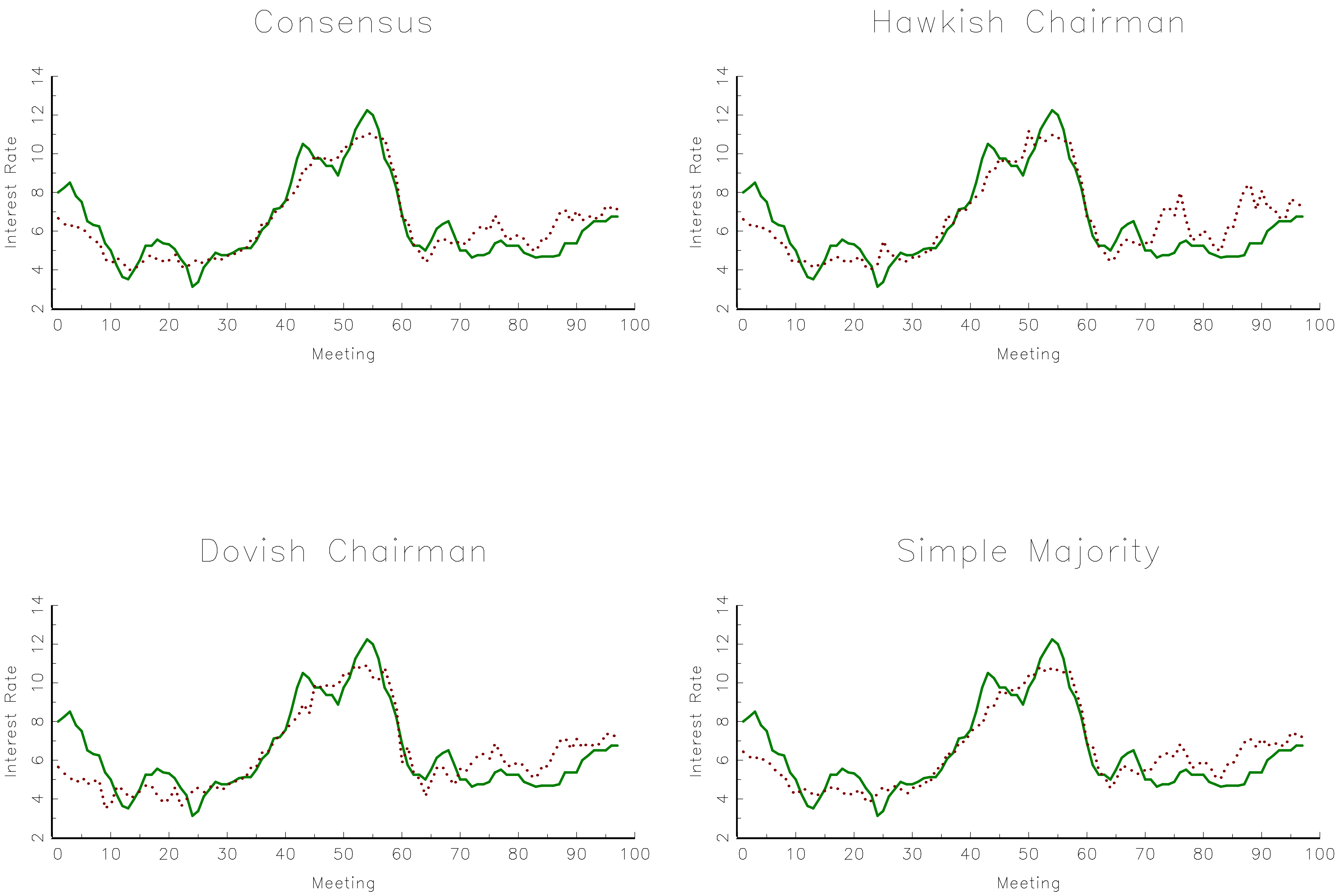

Figure 9. Autocorrelation Functions