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Power-Sharing in Monetary Policy Committees: Evidence from the United Kingdom and Sweden

Committees may make better monetary policy decisions than individuals; however, the benefits of group decision making could be lost if committee members cede power to a chairman. We develop an econometric model to describe intracommittee power-sharing across members. Estimation of the model permits us to classify monetary policy committees into the typology developed by Blinder (2004, 2007). We estimate our model for the United Kingdom's Bank of England (BOE) and Sweden's Riksbank. Results for the BOE suggest that the Governor has little influence over other committee members, while those for the Riksbank indicate that the Governor is highly influential.

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MONETARY POLICY DECISIONS ARE typically made by committees rather than by single individuals. Recent theoretical and empirical work on the monetary policy decision process supports the argument that committees may make

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better policy decisions than individuals.[1] To put the matter succinctly, when compared to individual decisions, committee decisions seem to offer the well-known benefits of diversification (Blinder 2004). In practice, though, committees have chairmen; if institutional arrangements concentrate power in the hands of the chairman, then some advantages of group decision making could be lost. Blinder (2004, 2007) proposes a typology that is useful for organizing alternative hypotheses about the collective choice mechanisms used by central bank monetary policy committees (MPCs). According to his scheme, committees can be individualistic, autocratically collegial, or genuinely collegial. In individualistic committees, members vote their true preferences without regard to the achievement of a consensual outcome. In autocratically collegial committees, consensus is achieved as committee members coalesce in support of a powerful chairman. Consensus is also achieved in genuinely collegial committees, but the consensus reflects the central tendency of members' preferences rather than the chairman's personal view. On the basis of his expert judgments, Blinder categorizes some of the world's major central banks within this typology.

In this paper, we develop an empirical model that can classify MPCs within the Blinder typology on the basis of econometric estimation. Our model describes the monetary policy preferences of individual MPC members in the form of Taylor rules (Taylor 1993); it also describes the aggregation of those preferences into collective choices via majority voting. The model is sufficiently general to permit enhanced power of the committee chairman or the presence of forces promoting consensual outcomes—model parameters characterize both the power of the chairman and the attraction of centrist positions. In sum, the model offers a logically consistent representation of decision making by a MPC, and it provides microfoundations for aggregate statistical descriptions of monetary policy decisions. Using committee voting records and macroeconomic data, we estimate the model for the central banks of the United Kingdom and Sweden. As we describe later, these two central banks have institutional features and practices that make them ideal candidates for our approach.[2]

We examine sample periods beginning in 1999 for the Bank of England (BOE) and 2000 for the Riksbank. In each case, the start of the sample followed important reforms that established current institutional arrangements. We chose to end our samples in the fall of 2008, when financial panic and a deepening recession led to radically changing policymaking practices. These changes made it impractical or inadvisable to apply the models that were suitable for the preceding period.[3]

1. Blinder (2004, pp. 38–39) offers four reasons why committees may make better policy decisions than individuals. First, when members have different preferences, diversification avoids extreme outcomes. Second, even if members have similar preferences, they might use different models to reach their conclusions. Third, members might use different forecasts or forecasting techniques. Finally, individuals might use different modes of reasoning to approach problems. For additional discussion of the benefits of committee decision making, see the references given in footnote 7 below.

2. As we explain in Section 3, it would at present be impractical to apply our model to the U.S. Federal Open Market Committee (FOMC).

3. Prior to fall 2008, large interest rate moves were rare. Properly modeling the large moves that followed the financial panic would require an increase in the number of discrete choices possible for each

Our work is related to several strands of empirical research on monetary policy decision making. There is an extensive body of literature on central bank reaction functions, most recently focusing on those in the form of Taylor rules. These studies describe how central bank policy instrument choices are empirically related to prevailing or forecasted macroeconomic conditions.[4] Other studies use committee voting data to document and describe differences in policy preferences across members of an MPC.[5] Still others describe how the leadership of a chairman or pressures to achieve consensus might affect committee deliberations and outcomes.[6] Each of these empirical approaches to the modeling of decision making is limited. Reaction function studies implicitly treat the central bank as a single decision maker, ignoring the existence of policy committees. Analyses of committee voting patterns typically fail to explain how differing preferences are resolved to produce committee choices. Studies of the role of the chairman or pressures for consensus often rely on anecdotal evidence or subjective assessments rather than econometric estimation. The econometric model that we develop in this paper unifies and extends these disparate strands of research.[7]

Perhaps most closely related to this paper is the work of Riboni and Ruge-Murcia (2010). Their purpose, like ours, is to characterize the collective choice mechanisms used by MPCs. They develop models in which different collective choice-making procedures have distinct implications for the temporal behavior of a committee's

voter decision. This complication alone could make estimation impractical. In addition, the proximity of a lower bound on rates also became an issue, and properly modeling that boundary in the econometric model would have been problematic. Finally, the use of nontraditional policy options (e.g., quantitative easing) added an extra dimension to policymaking that would be difficult to model.

4. Khoury (1990) surveys the early literature on monetary policy reaction functions for the Federal Reserve. Taylor rule applications for the United Kingdom and Sweden include Adam, Cobham, and Girardin (2005) and Berg, Jansson, and Vredin (2000). Cobham (2006) compares Taylor rules for the European Central Bank, the Bank of England, and the Federal Reserve.

5. Tootell (1991) and Chappell, McGregor, and Vermilyea (2005) estimate reaction functions for individual members of the FOMC. Besley, Meads, and Surico (2008) undertake a similar study of members of the Bank of England's MPC. Harris, Levine, and Spencer (2009) and Harris and Spencer (2011) also investigate voting at the BOE, giving special attention to members' career backgrounds and appointment type. Meade and Sheets (2005) examine the responses of FOMC member votes to regional economic conditions.

6. Woolley (1984), Kettl (1986), Krause (1996), Chappell, McGregor, and Vermilyea (2004, 2005), and Meade (2005) study the influence of the chairman and the importance of consensual decision making at the Federal Reserve.

7. Our analysis also complements a number of papers—primarily theoretical—that consider the issue of appropriate institutional design for monetary policy committees. Blinder and Morgan (2005), Gerlach-Kristen (2006), and Lombardelli, Proudman, and Talbot (2005) argue that committee decisions are superior to individual decisions. Blinder and Morgan (2008) report experimental results from a monetary policy game that suggest that there is no significant difference between the performance of groups with a designated leader and the performance of groups without a designated leader. Blinder (2007) provides a critical survey of recent literature on the advantages of group decision making and the mechanics of monetary policymaking by committee (e.g., the appropriate voting rule and the appropriate communication strategy). Sibert (2006) draws on the social psychology literature for insights about the appropriate size and structure of the ideal monetary policy committee. Berger and Nitsch (2011) take an empirical approach to the issue of MPC size, concluding that the optimal number of members is about five to nine. Matsen and Røisland (2005) and Farvaque, Matsueda, and Meon (2009) show that the welfare effects of membership in a monetary union depend on the decision rule followed by the monetary policy committee of the union central bank.

interest rate target. Specifically, they compare the performance of model specifications reflecting pure majority rule, a dictatorial chairman, an agenda-setting chairman, and consensus seeking (in which a super-majority is required for any move). The consensus model predicts the existence of a bias favoring the selection of the status quo interest rate; that prediction is supported by data from a variety of central banks, including the BOE and the Riksbank. The Riboni and Ruge-Murcia analysis is based solely on aggregate macroeconomic conditions and the interest rate targets selected by MPCs. In contrast, our empirical model links the microlevel voting behavior of individual committee members to adopted rate targets.

Our paper proceeds as follows. In Section 1, we describe monetary policymaking institutions at the BOE and the Swedish Riksbank and we explain why these cases provide appropriate settings for investigating committee decisions. In Section 2, we develop a novel econometric model of committee decision making that can usefully exploit the data provided by these two central banks. We describe our maximum simulated likelihood (MSL) estimation strategy in Section 3 and present our results in Section 4. In Section 5, we illustrate how the model can be used to forecast the policy consequences of changes in the committee's membership. Our conclusions follow in Section 6.

1. MONETARY POLICYMAKING AT THE BOE AND THE RIKSBANK

1.1 Monetary Policymaking at the BOE

Current monetary policy institutions in the United Kingdom are prescribed by the 1998 Bank of England Act. The BOE has independent authority to manage monetary policy through the setting of the official bank rate, a rate at which the Bank lends to financial institutions. The Bank is directed by the government to target inflation, with a current target of 2.0% per year as measured by the consumer price index (CPI).

Interest rate choices are made by a nine-member MPC, including five "internal" appointees and four "external" appointees.[8] By statute, the committee meets every month and makes interest rate decisions by majority vote. Since 1999, the interest rate targets of each committee member in each meeting have been publicly reported. Because decision making is majoritarian, the selected interest rate is always the median of the individually reported desired rates. Individuals' reported rates and adopted targets have normally varied in 25 basis point increments, and rate movements larger than 25 basis points in a single meeting have been rare.[9]

8. The MPC's five internal members are the Bank's Governor, its two Deputy Governors, the Executive Director responsible for monetary policy analysis, and the Executive Director responsible for monetary policy operations. The four external members are those appointed to the MPC by the Chancellor of the Exchequer. These external members are to have expertise in economics and monetary policy, but there are otherwise no specific requirements for them.

9. From January 1999 to August 2008, only 2% of all reported individual rate preferences specified desired moves larger than 25 basis points.

The BOE's website provides this characterization of the committee's decision-making process:

> Each member of the MPC has expertise in the field of economics and monetary policy. Members do not represent individual groups or areas. They are independent. Each member of the committee has a vote to set interest rates at the level they believe is consistent with meeting the inflation target. The MPC's decision is made on the basis of one person, one vote. It is not based on a consensus of opinion. It reflects the votes of each individual member of the committee.[10]

On the basis of these attributes, Blinder (2004, 2007) classifies the BOE's committee as individualistic. In doing so, he contrasts it with the Fed's autocratically collegial FOMC and the genuinely collegial European Central Bank (ECB).[11]

Even though dissent is tolerated and choices are made by majority decision at the BOE, there is evidence that the Bank's Governor plays a role that is different from that of other members. In the period from January 1999 through August 2008, rank-and-file members recorded preferences that differed from the committee's chosen outcome 15.8% of the time, but the Governor's position differed from the committee's choice only twice, or 1.7% of the time. This could mean that the Governor wields influence over his colleagues, or it could mean that the Governor follows the sentiment of the majority of his colleagues; in either case, though, it suggests that the behavior of the Governor differs from that of other committee members.

Recent history provides us with an opportunity to explore this issue. In the period from January 1999 through June 2003, Sir Edward (Eddie) George served as the Bank's Governor. George voted with the majority in every meeting during this interval. Mervyn King served as Deputy Governor during George's tenure. While serving in that capacity, he disagreed with the adopted policy in nine of 55 meetings, preferring a tighter policy (higher bank rate) than the committee in all of those cases. When George left the committee, King replaced him as Governor. Once he became Governor (and MPC chairman), King voted with the minority only twice in 62 meetings, both times preferring a higher rate than the majority.

This sequence of events offers an appealing natural experiment and an opportunity to assess the role of the Governor within the MPC. On average, King preferred tighter policies than George had. When George departed, King dissented much less frequently, suggesting either that King became consensual and followed the committee or that King led the committee and its members followed him. If the committee followed King, then there should have been detectable shifts in the stances of other members, as well as in the adopted policy stance. If King became more consensual as the Governor, the stances of other members should not have changed. Because

10. See http://www.bankofengland.co.uk/monetarypolicy/overview.htm. Bean and Jenkinson (2001) provide a detailed description of the monetary policy formulation process used at the Bank of England.

11. The characterizations of the FOMC and the ECB policy committee are Blinder's (2004, 2007). Hayo and Meon (2011) offer evidence that nationalist considerations play a role in the ECB's policy decisions and that some countries have disproportionate influence in the decision process, results that would call into question the "genuine collegiality" of the ECB.

members' reported policy preferences and committee choices are observable, we have an opportunity to assess the extent of the Governor's influence.

1.2 Monetary Policymaking at the Riksbank

Sweden's Riksbank, founded in 1668, is the world's oldest central bank. In recent years, changes in its institutional arrangements have closely paralleled those in the United Kingdom. Beginning in 1999, revisions to the Riksbank Act led to both greater independence and greater transparency in monetary policy decision making. At that time, the responsibility for monetary policy was transferred to a six-member Executive Board, including a Governor (the MPC chairman) and five Deputy Governors. The MPC is directed to pursue an inflation target as it chooses a setting for a short-term interest rate, the repo rate. The committee has set a target of 2.0% inflation for the CPI, but it has flexibility in how it pursues that goal. Decisions are formally made by a majority vote of the Board, and the Governor has the power to break ties. Because the committee is both small and even-numbered, this power has occasionally been a matter of consequence; specifically, the Governor's tie-breaking vote was pivotal in determining the committee's choice in 4 of the 67 meetings held between January 2000 and September 2008.

Data on committee voting produced by the Riksbank are also similar to those published by the BOE. On average, the Riksbank's committee has met about eight times per year since January 2000. For each meeting, the bank publishes its selected target for the repo rate. Committee members indicate agreement with the majority choice, or they enter a reservation and report a preferred rate. As in the case of the BOE, rate options have varied in discrete 25 basis point intervals, and rate movements of more than 25 basis points have been infrequent.[12] The rate at which rank-and-file members have dissented from the committee choice has been a bit lower for the Riksbank than for the BOE (10.8% versus 15.8%). No Governor has ever dissented from the committee choice.

We have noted that the BOE's MPC is often described as an individualistic committee. It is less clear how the Riksbank's MPC should be classified. Berg, Jansson, and Vredin (2000) refer to the Riksbank's committee as a collegial board but do not provide a detailed explanation for this characterization. Blinder (2004), on the other hand, places the Riksbank into the individualistic category of his typology. Berg and Lindberg (2006) describe the Riksbank's committee as a collegial board in which the chairman has greater influence than the other members on monetary policy decisions, especially in cases in which there are dissenting views. This characterization would be more consistent with an autocratically collegial committee under the Blinder typology. Our empirical analysis should help to provide an appropriate characterization.

12. In 1999, the first year of the new policymaking arrangements, repo rate options did not follow the pattern of discrete alternatives based on 25 basis point intervals that has characterized subsequent behavior. For this reason, we limit our analysis to the period beginning in January 2000.

In the application of our econometric methodology, the Riksbank data have both advantages and disadvantages in comparison to the BOE. One advantage is that, as a practical computational matter, it is helpful to have a smaller committee—this reduces the dimensionality of the multivariate discrete choice model we estimate. A second advantage involves rotation of the Governorship. Since 2000, the Riksbank has had three different Governors: Urban Bäckström, Lars Heikensten, and Stefan Ingves. Observing multiple Governors offers more opportunities for detecting regime shifts associated with leadership changes. A limitation of the Swedish data is that the voting record does not obviously suggest that the three Governors differed from each other as King and George did at the BOE. Thus, the Swedish experience may offer a less appealing natural experiment. Further, because the Riksbank's MPC meets less frequently than the BOE's MPC, we have a smaller sample for the Riksbank. We observe data for 117 committee meetings for the BOE, but for only 67 meetings for the Riksbank.

1.3 Previous Studies of the BOE and the Riksbank

A number of previous studies have investigated voting patterns within the BOE's MPC; however, most previous research has focused on characterizing the monetary policy preferences of the committee's individual members. Gerlach-Kristen (2009) and Spencer (2006) find that external members dissent more often than internal members and that external members are more responsive than internal members to given changes in inflation (relative to target) and the output gap. Brooks, Harris, and Spencer (2007) and Harris and Spencer (2011) confirm the latter finding. Gerlach-Kristen (2009), Harris and Spencer (2011), and Spencer (2006) present evidence that internal members tend to favor higher interest rates than external members. Harris and Spencer (2011) also find that internal members are more likely than external members to vote as a bloc and to be on the winning side in interest rate decisions. Spencer (2006) fails to find significant effects of career experience on MPC members' voting decisions, while Besley, Meads, and Surico (2008) suggest that the observed heterogeneity in MPC voting patterns stems from unobserved individual characteristics. All of these papers have focused attention on individual voting behavior; none has modeled collective choice making.

We are not aware of previous research that characterizes the monetary policy preferences of individual members of the Riksbank's MPC. Jansson and Vredin (2003) and Berg, Jansson, and Vredin (2000), however, have estimated Taylor rules to characterize monetary policymaking in Sweden.

2. THE ECONOMETRIC MODEL

Our econometric model has the following elements:

(i) *A specification of each individual committee member's "true" monetary policy preference*. We employ reaction functions of the Taylor rule form to characterize members' true interest rate preferences.

TABLE 1
MODEL NOTATION: INTEREST RATE VARIABLES

Variable	Observability	Description
R_t^{sq}	Observed	The status quo committee interest rate target prevailing prior to meeting t
R_{it}^*	Not observed	Member i's "true" interest rate preference entering meeting t
$\bar{R}_{it}$	Not observed	A weighted average of member i's "true" rate preference in meeting t and the rate preference of the committee chairman
$\tilde{R}_{it}$	Not observed	Member i's discrete interest rate preference in meeting t that prevails at the time when collective decisions are determined
R_t	Observed	The interest rate target adopted by the committee in meeting t
$\bar{\bar{R}}_{it}$	Not observed	A weighted average of $\bar{R}_{it}$ and R_t
R_{it}	Observed	Member i's formally recorded interest rate vote in meeting t

(ii) *A description of how individuals' policy positions are modified as the committee deliberates.* Our model permits influence from the Governor (the chairman) to rank-and-file members, so members' original preferred interest rates may be modified before collective choice making occurs.

(iii) *A mapping of individual preferences to a committee decision.* Once the influence of the Governor has been exerted, decisions are made by a majority vote. To conform to observed practice, our model assumes that the set of possible outcomes includes discrete alternatives: the status quo interest rate and rates that are higher or lower by 25 basis points.[13]

(iv) *A description of formal voting*. Once a target rate has been selected, formal votes are recorded. At this stage, the model can permit a member who values consensus to alter an earlier position in order to support the committee choice.

As the list above suggests, our proposed model describes how individuals' interest rate preferences are mapped into targets adopted by the committee, it permits individuals' preferred targets to be influenced by the Governor, and it permits formally recorded rate preferences to differ from the preferences that prevailed when collective choices were made. In the rest of this section, we provide details on our modeling of each of these features. The sequence of actions in our model is assumed to mirror that of the following discussion. To facilitate our exposition, Table 1 summarizes the notation for key interest rate variables that appear in the model.

13. Although we have noted that the data for both the BOE and the Riksbank include instances where actual or desired movements in interest rates exceeded 25 basis points, our model collapses the preference data into three discrete categories. This simplification is necessary to keep the econometric model computationally tractable, especially for the BOE. We have estimated a model variant permitting five discrete categories for the Riksbank; this has no substantive effect on our results.

2.1 True Interest Rate Preferences

As a meeting begins, individual MPC members are presumed to have "true" interest rate preferences, R_{it}^{*}, governed by the following reaction function specification:

$$R_{it}^{*} = \alpha_i + \sum_{k=1}^{K} \beta_k X_{kt} + u_t + v_{it}, \tag{1}$$

$$u_t \sim N\left(0, \sigma_u^2\right),$$

$$v_{it} \sim N\left(0, \sigma_v^2\right),$$

$$E(v_{it} v_{jt}) = 0, \text{ for } i \neq j, \text{ and } E(u_t, v_{it}) = 0, \text{ for all } i.$$

Individual voters are indexed by i (where $i = 1, 2, \ldots, M$), meeting dates are indexed by t, and explanatory variables in the reaction function are indexed by k.[14] The elements of X_{kt} will include the policy rate target chosen at the previous MPC meeting (to account for interest-rate smoothing) and contemporaneous, lagged, or forecast values of macroeconomic variables to which the central bank might respond. Also note that members share a meeting-specific error term, but each member also has an independent individual error term component.[15] For notational convenience, the Governor, or MPC chairman, is indicated by the subscript $i = 1$. In our specification, reaction function intercepts (the α_i, regarded as fixed effects) vary across members, but other reaction function parameters do not.[16]

2.2 Modified Interest Rate Positions

Our model permits committee members to modify their positions in deference to the chairman.[17] We assume that members' modified interest rate positions, $\tilde{R}_{it}$, are

14. The Bank of England's MPC has nine members, and the Riksbank's committee has six. Over time, the identities of the individuals occupying these positions change. For simplicity, our notation indexes only the number of voting positions, but our later econometric analysis will also distinguish the individuals occupying the available slots.

15. Inclusion of the shared error term component permits the model to account for the observed tendencies of members to agree on rate movements, without necessarily attributing that observed agreement to influence from the chairman or pressures for consensus.

16. Riboni and Ruge-Murcia (2010) derive reaction functions using an explicit optimization framework. Assuming a specific but plausible form for the utility function, they find that reaction function parameters other than intercepts are the same for all members. This finding supports our admittedly restrictive characterization of differences across MPC members. Perhaps more importantly, our estimation procedure becomes computationally impractical with large numbers of additional parameters.

17. Disagreements inside an MPC may arise because of differences across members in educational and career backgrounds, theoretical perspectives, reputational considerations, or regional interests. The chairman may play key roles in MPC deliberations as a consensus builder and as an agenda setter. He may also gain leverage over the committee if he is responsible for allocating the central bank's resources to rank-and-file members and if he serves as the spokesman for the MPC in political and public arenas. Chappell, McGregor, and Vermilyea (2005) present econometric evidence that the Fed chairman has a disproportionate influence on FOMC decisions. For additional discussion of the power of the chairman and the role of consensus at the Federal Reserve, see the references given in footnote 6 above.

determined in two steps. First, we construct a weighted average of member i's true preferred rate and the chairman's preferred rate:

$$\bar{R}_{it} = \theta R^*_{1t} + (1-\theta) R^*_{it}, \quad \text{for } 0 \leq \theta \leq 1. \tag{2}$$

In this expression, θ is the weight members assign to the chairman's interest rate preference. Second, we map that weighted average into a discrete interest rate choice, where the available options include the status quo interest rate, R^{sq}_t, and upward and downward movements of 25 basis points. Member i will support the discrete interest rate target closest to the weighted average, $\bar{R}_{it}$, as the conditions below indicate (where all interest rates are expressed in percentage points):

Member i supports $\tilde{R}_{it} = R^{sq}_t$ if

$$\left|\bar{R}_{it} - R^{sq}_t\right| \leq \left|\bar{R}_{it} - \left(R^{sq}_t + 0.25\right)\right| \text{ and } \left|\bar{R}_{it} - R^{sq}_t\right| \leq \left|\bar{R}_{it} - \left(R^{sq}_t - 0.25\right)\right|, \tag{3a}$$

member i supports $\tilde{R}_{it} = R^{sq}_t + 0.25$ if

$$\left|\bar{R}_{it} - \left(R^{sq}_t + 0.25\right)\right| < \left|\bar{R}_{it} - R^{sq}_t\right|, \tag{3b}$$

and member i supports $\tilde{R}_{it} = R^{sq}_t - 0.25$ if

$$\left|\bar{R}_{it} - \left(R^{sq}_t - 0.25\right)\right| < \left|\bar{R}_{it} - R^{sq}_t\right|. \tag{3c}$$

For the chairman, $R^*_{1t} = R^*_{it}$, so these conditions imply that $\tilde{R}_{1t}$ is the discrete option that is closest to the chairman's true preferred rate.

2.3 The Committee's Selected Rate

The committee selects a rate, R_t, by majority rule, so we specify that the adopted interest rate target is the median of members' modified supported rates:

$$R_t = \text{median}\left(\tilde{R}_{1t}, \tilde{R}_{2t}, \ldots, \tilde{R}_{Mt}\right). \tag{4}$$

In the event of a tie vote, the committee chairman serves as a tie-breaker.[18]

2.4 Recorded Votes

After the median is determined, formal votes are recorded. At this stage, the model permits committee members to report formal votes that differ from the policies they advocated when the collective choice was made. Specifically, members may choose to support the committee choice in order to produce a vote that reflects a consensual outcome.

18. At both the Riksbank and the Bank of England, the Governor has formal tie-breaking power. At the Bank of England, the monetary policy committee normally has nine members, so ties can occur only when a member is absent or when a vacancy is unfilled. In our sample period, the BOE's Governor never had to vote to break a tie. However, modeling tie-breaking must be a feature of our model, even for the BOE. Later, when we calculate the likelihood that a particular voting outcome will occur in a meeting, we must correctly account for the possibility that nonobserved outcomes might have occurred instead.

In equation (2), we calculated member i's (continuous) preferred rate after deferring to the chairman; this rate was denoted $\bar{R}_{it}$. We now assume that this rate is further adjusted to reflect deference to the committee choice, R_t. We therefore calculate a weighted average of $\bar{R}_{it}$ and R_t:

$$\bar{\bar{R}}_{it} = \omega R_t + (1 - \omega)\, \bar{R}_{it}, \quad \text{for } i \neq 1. \tag{5a}$$

We assume that final recorded votes, the R_{it}, are obtained by making this weighted average discrete in a manner that is analogous to the operation previously described in conditions (3). Because the chairman may value consensus differently than rank-and-file members, we permit a different weighting parameter for the chairman, ω_c, and replace condition (5a) with condition (5b):

$$\bar{\bar{R}}_{1t} = \omega_c R_t + (1 - \omega_c)\, R^*_{1t}. \tag{5b}$$

2.5 Special Cases of the Model

It is useful to consider the implications of certain outcomes of the model's parameters. If $\omega = \omega_c = 0$, there is no deference from committee members to the median, and if $\theta = 0$, there is no deference to the chairman. Therefore, if $\theta = \omega = \omega_c = 0$, we have Blinder's case of an individualistic committee, in which all members act independently. If θ is large and ω is small, we have the case of an autocratically collegial committee. If θ is small and ω is large, the committee is genuinely collegial. If both θ and ω are large, we have a hybrid case combining attributes of genuinely and autocratically collegial committees.

It is also useful to consider how MPC voting data might distinguish these special cases. At both the BOE and the Riksbank, members frequently vote in agreement with the adopted policy directive. This could be because members have similar preferences and independently respond to the same shocks, it could be because they coalesce in support of the Governor, or it could be because they coalesce in support of the central tendency of the committee as a whole. However, these different possibilities have distinct empirical implications. If the Governor dominates, then members' reported rate preferences should shift when the identity of the Governor changes. If there is consensual support for the committee median, then rate preferences should move in response to changes in the committee's composition, but there should not be especially large shifts when the Governorship changes hands. If members behave independently but respond to shared shocks, then their reported policy preferences will not shift in response to changes in either the composition of the committee or the identity of the Governor.

3. ECONOMETRIC METHODOLOGY

As we have noted, both the BOE and the Riksbank have reported selected interest rate targets and rates favored by each committee member in formal meeting votes.

TABLE 2
A Hypothetical Meeting Observation

Policy/member	1	2	3	4	5	6	7	8	9
Rate up		X					X		
Status quo	X		X		X			X	X
Rate down				X		X			

Note: Marked cells indicate voting choices (rows) by members (columns).

These records provide the data that we use to estimate the model described in the preceding section. We treat each committee meeting as an observation, and each observation produces a vector of discrete choices: each member reports a vote for the status quo interest rate or for a rate that is higher or lower. Our purpose is to estimate all of the model parameters, which include the reaction function parameters (the α_i and the β_k), the error term variances (σ_u^2 and σ_v^2), and the weighting parameters (θ, ω, and ω_c). The model we have described is complex and nonlinear, and it includes a number of unobserved variables. However, it is feasible to calculate the likelihood function using simulation-based methods. We describe our MSL estimator in the remainder of this section.[19]

Consider a set of trial values for the parameters of the model. To simulate a single observation (a meeting) in our sample, we first draw values of the random error terms, u_t and v_{it}. Given these simulated error terms, and given the reaction function parameters, we calculate a simulated "true" interest rate preference for each member using equation (1). Then, using conditions (2) and (3), we calculate members' modified rates after accounting for deference to the chairman and the discreteness of policy options. At this point, we use equation (4) to determine the committee median, the majority voting winner over the three discrete alternatives. Finally, using conditions (5) and the requirement that reported rates be discrete, members' formal votes are determined. This simulation sequence produces a vector of discrete interest rate preferences, one for each member in the meeting. The simulated data are analogous to historical data, which also record discrete rate preferences for each committee member.

Table 2 illustrates what a single meeting observation in our historical BOE data set might look like, with the marked cells indicating interest rate positions for each of nine committee members. The likelihood for such an observation is equal to the probability that this precise configuration of reported preferences will occur, given parameter values for the model. The preceding paragraph described the simulation of a single meeting observation. Suppose that we now replicate that simulation repeatedly, drawing new realizations of the model's error terms in each simulated observation. By calculating the frequency with which the simulated meeting outcome matches the

19. The MSL method is described by Train (2003).

outcome observed in the historical data, we obtain a measure of the likelihood for that observation, given the parameter values.

We can use this method to calculate the likelihood for each observation in the sample and, in turn, the likelihood for the complete sample. In order to estimate the model, we must find parameter values that maximize the likelihood function for the sample. The ML PROC routine in the econometric software package TSP is used for this purpose. Because of the complexity of the model and because outcomes are often low-probability events, estimation of the model is computationally burdensome. For example, for a nine-member committee voting on a discrete outcome with three options, there are 19,683 possible configurations of reported preferences that might occur in any given meeting.[20] A single run of the model for the United Kingdom can require several months of computing time. For the 12-member U.S. FOMC, however, the number of possible outcomes in any given meeting would be 531,441, which makes estimation of our model impractical given current computing capabilities. See Appendix A for further discussion of computational matters.

4. MODEL ESTIMATES

4.1 Results for the United Kingdom

For the BOE, our reaction function, equation (1), follows a Taylor rule specification. Members' desired interest rates are explained by a deviation of expected inflation from its target value and by an output gap measure. Our inflation measure is based on a 2-year-ahead inflation forecast derived from the BOE's *Inflation Reports*.[21] Until December 2003, the Bank pursued a target of 2.5% for inflation based on the retail price index excluding mortgage interest payments (RPIX). After December 2003, the Bank switched to a target of 2.0% for inflation based on the CPI.[22] Therefore, the inflation variable we include in our model is measured as the deviation of the RPIX inflation projection from 2.5% for 2000–03 and as the deviation of the CPI inflation projection from 2.0% for 2004–08.[23] Data on output gap forecasts available to the MPC are confidential and not made public, so we have calculated an estimate of the output gap

20. This number of possible configurations implies that some observed outcomes will be low-probability events. Our estimation procedure varies the number of simulated observations over meetings, using more simulations (up to 1 million) when estimated probabilities for the observed outcome are lower.

21. The BOE's *Inflation Reports* are available quarterly, so we follow the approach of Besley, Meads, and Surico (2008) in compiling and interpolating the quarterly inflation projections to obtain a monthly series. We use the Bank's "constant interest rate" inflation forecast, a forecast based on the hypothetical assumption that the current interest rate would be unchanged over the forecast horizon. Evidence presented by Bhattacharjee and Holly (2005) favors using forecasts rather than current values for inflation and output in estimated Taylor rules.

22. According to King (2004), this switch was not intended to change the stance of monetary policy on average; essentially, the difference in targets reflected differences in average inflation as measured by the respective indices.

23. Riboni and Ruge-Murcia (2008) use the retail price index for their entire sample (June 1997–June 2006) and model the change in the inflation target by allowing a break in the reaction function intercept after December 2003. They report that their results are similar if they instead use the retail price index until December 2003 and the consumer price index thereafter.

TABLE 3

MAXIMUM SIMULATED LIKELIHOOD ESTIMATES: UNITED KINGDOM (DATA FROM JANUARY 1999–AUGUST 2008 MPC MEETINGS)

Parameter	Model 1	Model 2	Model 3
$\beta_{\dot{P}}$	0.1703	0.1706	0.2085
β_{gap}	0.1673	0.1673	0.1694
$\beta_{R_{\text{sq}}}$	0.9411	0.9411	0.9411
σ_u	0.0971	0.0971	0.0959
σ_v	0.0362	0.0362	0.0356
θ	−0.0011	0.0000[a]	0.0000[a]
ω	−0.0142	0.0000[a]	0.0000[a]
ω_c	0.2703	0.2700	0.0000[a]
Individual intercepts			
Tim Besley	0.4147	0.4163	0.4206
Andrew Sentance	0.4020	0.4005	0.4067
John Vickers	0.2893	0.2915	0.2881
Andrew Large	0.3392	0.3406	0.3414
Mervyn King	0.3014	0.3024	0.2908
Paul Tucker	0.3014	0.3014	0.3009
David Clementi	0.2506	0.2503	0.2485
Ian Plenderleith	0.2466	0.2461	0.2461
Eddie George	0.2540	0.2536	0.2484
David Walton	0.3016	0.3034	0.2927
Richard Lambert	0.2688	0.2674	0.2646
Alan Budd	0.2734	0.2773	0.2671
Charles Goodhart	0.2485	0.2495	0.2467
Rachel Lomax	0.2741	0.2732	0.2738
John Gieve	0.2782	0.2771	0.2772
Kate Barker	0.2649	0.2630	0.2591
Charles Bean	0.2562	0.2575	0.2536
Willem Buiter	0.2491	0.2506	0.2511
Stephen Nickell	0.2242	0.2236	0.2200
Marian Bell	0.2271	0.2298	0.2202
DeAnne Julius	0.1632	0.1624	0.1568
Christopher Allsop	0.1828	0.1809	0.1752
Sushil Wadhwani	0.1633	0.1622	0.1558
David Blanchflower	0.1558	0.1558	0.1606
Log-likelihood	−362.643	−363.004	−368.931
Sample size	117	117	117

NOTES: The parameters are defined as follows: $\beta_{\dot{P}}$ is the reaction function coefficient on inflation (equation (1)), β_{gap} is the reaction function coefficient on the output gap (equation (1)), $\beta_{R_{\text{sq}}}$ is the reaction function coefficient on the status quo policy rate (equation (1)), σ_u is the standard deviation of the meeting-specific error term in the reaction function (equation (1)), σ_v is the standard deviation of the individual-specific error term in the reaction function (equation (1)), θ is the weight MPC members assign to the chairman's interest rate (equation (2)), ω is the weight MPC members assign to the policy rate target chosen by the MPC (equation (5a)), and ω_c is the weight the chairman assigns to the policy rate target chosen by the MPC (equation (5b)). The "individual intercepts" are the reaction function parameters α_i (equation (1)).

[a]The estimate is restricted to the value shown.

by decomposing real GDP into trend and deviation components using the Hodrick–Prescott filter and then interpolating to obtain a monthly series. As a robustness check (see Section 4.3 below), we use a real-time output gap series that we have obtained from an OECD source. To account for possible inertia in policymaking, we also include the status quo interest rate as an explanatory variable in the reaction function.

Table 3 reports estimates of the model using data from the BOE's committee voting records for the period from January 1999 through August 2008. The first

column of the table reports results for the unrestricted model. The most striking finding is that estimates of θ and ω, the weights that rank-and-file voters attach to the Governor's preference and the committee median, are very close to zero. Estimates in the table's second column impose the restrictions that $\theta = 0$ and $\omega = 0$, but otherwise produce results that are very similar to those for the unrestricted model. A likelihood ratio test confirms that the joint hypothesis $\theta = \omega = 0$ cannot be rejected ($p = 0.3955$).[24] Moreover, we can reject the hypothesis that the two parameters are even moderately large; specifically, the hypothesis $\theta = \omega = 0.15$ is rejected ($p = 0.0400$). In the third column, the model is further restricted by setting $\omega_c = 0$. This restriction implies that the Governor gives no weight to the committee median, but it is strongly rejected ($p = 0.0006$). The point estimate for ω_c in column 2 is 0.27, indicating that the Governor has a tendency to defer to the committee median. This provides an explanation for the paucity of Governors' dissents in the data.

Estimates of other model parameters are similar across the three columns of the table. The individual Taylor rule intercepts, the α_i, characterize differences in policy preferences across members.[25] Estimates of these parameters vary notably, but in ways that are consistent with simple characterizations of members' voting records. In Table 4, we compare members' "net tightness frequencies" with their reaction function intercepts (intercepts in Table 4 are from column 2 of Table 3). The net tightness frequency is defined as the number of times a member prefers a rate higher than the committee choice less the number of times he prefers a lower rate, with the difference expressed as a fraction of total votes. As the table suggests, estimated reaction function intercepts are closely related to the net tightness frequency. To illustrate, we note that Andrew Sentance and Tim Besley were the most frequent dissenters favoring tighter policies, and they also have the largest estimated reaction function intercepts. David Blanchflower dissented most frequently in favor of ease, and he has the smallest reaction function intercept.[26] Governor Mervyn King has a higher intercept than his predecessor, Governor Eddie George, as we would expect from his pattern of dissenting positions while serving under George.

Table 3 reveals that the inflation and output gap measures are correctly (positively) signed; we also find that they jointly differ from zero ($p = 0.0000$). There is considerable inertia in policymaking, as the coefficient on the status quo interest rate suggests.[27] We also find that the variance of the shared error term is large relative to that of the individual-specific error. This shared error component can account for the tendency of members' interest rate preferences to move together over time.

24. Because we sequentially search over subsets of the model parameters, rather than over the complete set of parameters, we do not get an estimate of the complete matrix of second partial derivatives of the likelihood function or, consequently, standard errors. We instead report likelihood ratio tests for selected hypotheses. More details on estimation and hypothesis testing are provided in Appendix A.

25. One member, Spencer Dale, attended only two meetings in our sample period. His intercept is therefore constrained to equal the average value of the intercepts of all other rank-and-file members.

26. Because each likelihood ratio test requires an additional estimation, we have not routinely tested differences across members. However, we have carried out one test, finding that Blanchflower's intercept differs significantly ($p = 0.0023$) from that of Willem Buiter, a centrist member of the committee.

27. This finding is typical of the empirical literature on Taylor rules. See Driffill and Rotondi (2007) for a possible explanation rooted in inertial tendencies in the economy itself.

TABLE 4

REACTION FUNCTION INTERCEPTS AND NET TIGHTNESS FREQUENCIES: UNITED KINGDOM (DATA FROM JANUARY 1999–AUGUST 2008 MPC MEETINGS)

Individual	Net tightness frequency	Intercept	Rank by net tightness frequency	Rank by intercept
Tim Besley	0.4583	0.4163	1	1
Andrew Sentance	0.3913	0.4005	2	2
John Vickers	0.2381	0.2915	3	7
Andrew Large	0.2250	0.3406	4	3
Mervyn King	0.0769	0.3024	5	5
Paul Tucker	0.0667	0.3014	6	6
David Clementi	0.0444	0.2503	7	16
Ian Plenderleith	0.0238	0.2461	8	18
Eddie George	0.0000	0.2536	9 (tie)	14
David Walton	0.0000	0.3034	9 (tie)	4
Richard Lambert	0.0000	0.2674	9 (tie)	11
Alan Budd	0.0000	0.2773	9 (tie)	8
Charles Goodhart	0.0000	0.2495	9 (tie)	17
Willem Buiter	0.0000	0.2506	9 (tie)	15
Rachel Lomax	−0.0167	0.2732	15	10
John Gieve	−0.0323	0.2771	16	9
Kate Barker	−0.0341	0.2630	17	12
Charles Bean	−0.0521	0.2575	18	13
Stephen Nickell	−0.1233	0.2236	19	20
Marian Bell	−0.1389	0.2298	20	19
DeAnne Julius	−0.2903	0.1624	21	22
Christopher Allsop	−0.3103	0.1809	22	21
Sushil Wadhwani	−0.3514	0.1622	23	23
David Blanchflower	−0.5556	0.1558	24	24

NOTES: The "net tightness frequency" is defined as the number of times a member prefers a rate higher than the committee choice less the number of times the member prefers a lower rate, with the difference expressed as a fraction of total votes. The "intercept" for each member is taken from the Model 2 column of Table 3.

Table 5 reports estimates for an extension of our basic model. Previous research has suggested that the behavior of internal and external members of the BOE's policy committee might differ. Of particular interest, Harris and Spencer (2011) find greater cohesiveness (i.e., a tendency toward bloc voting) among internal appointees. If this is the case, it is likely that the Governor, himself an internal appointee, serves as a leader coordinating the behavior of the subgroup. To investigate the possibility of internal-external differences, we have generalized our model to allow θ and ω to differ for insiders and outsiders. In Table 5, θ_n and ω_n are the relevant coefficients for internal appointees, and θ_x and ω_x are those for external appointees. Individual intercept estimates are not shown because they are similar to those reported previously.

The first column of Table 5 replicates column 1 of Table 3, in which θ and ω are constrained to be identical for insiders and outsiders. In the second column, θ, the weight accorded the chairman, is permitted to differ across groups. The estimate of θ_n is 0.16, while the estimate of θ_x, at 0.02, is close to zero. We can reject the hypothesis that the two coefficients are equal ($p = 0.0387$). The key implication is that internal appointees show some deference to the Governor, while external appointees do not. The specification reported in the third column also permits ω_n and ω_x to differ;

TABLE 5

MAXIMUM SIMULATED LIKELIHOOD ESTIMATES: UNITED KINGDOM, INTERNAL AND EXTERNAL APPOINTEES (DATA FROM JANUARY 1999–AUGUST 2008 MPC MEETINGS)

Parameter	Model 1	Model 2	Model 3
θ_n (Internal)	−0.0011[a]	0.1645	0.1493
θ_x (External)	−0.0011[a]	0.0165	0.0290
ω_n (Internal)	−0.0067[b]	−0.0315[b]	−0.0175
ω_x (External)	−0.0067[b]	−0.0315[b]	−0.0368
ω_c	0.2703	0.3386	0.3385
Log likelihood	−362.643	−360.506	−360.335
Sample size	117	117	117

NOTES: The parameters are defined as follows: θ_n is the weight the MPC's internal members assign to the chairman's interest rate, θ_x is the weight the MPC's external members assign to the chairman's interest rate, ω_n is the weight the MPC's internal members assign to the policy rate target chosen by the MPC, ω_x is the weight the MPC's external members assign to the policy rate target chosen by the MPC, and ω_c is the weight the chairman assigns to the policy rate target chosen by the MPC.
[a]The restriction $\theta_n = \theta_x$ is imposed.
[b]The restriction $\omega_n = \omega_x$ is imposed.

however, both coefficients are close to zero and we cannot reject the hypothesis that $\omega_n = \omega_x$ ($p = 0.5587$).

The BOE's policy committee appears to be approximately individualistic. Internal appointees give a small weight to the position of the Governor, and the Governor shows some deference to the majority. However, members primarily vote according to their own preferences, rather than those of the Governor or other members. These findings largely confirm Blinder's subjective characterization of the committee.

4.2 Results for Sweden

For the Riksbank, our reaction function again follows a Taylor rule specification explaining a short-term target interest rate, the repo rate. Explanatory variables include 2-year-ahead expected CPI inflation measured as a deviation from the 2.0% target, the output gap, and the status quo level of the repo rate. We have obtained forecasts of CPI-based inflation from the Riksbank's *Monetary Policy Reports*.[28] We use a measure of the output gap published by Sweden's National Institute of Economic Research.[29] As a robustness check (see Section 4.3 below), we use a real-time output gap series that we have extracted from the *Monetary Policy Reports*.

28. Until October 2007, the Riksbank did not issue a monetary policy report for each of its meetings. We therefore recorded inflation forecasts for the meeting dates for which a report was issued and interpolated to obtain forecasts at other committee meeting dates. Since October 2007, the Riksbank has issued a monetary policy report (or a monetary policy update) for each of its meetings. Also, prior to October 2005, the Riksbank published an inflation rate forecast based on the assumption that the target interest rate would be unchanged over the forecast horizon. From October 2005 onward, the inflation forecast was based on the assumption that interest rates would be endogenously adjusted in a manner consistent with committee objectives. The new forecasting procedure should have produced attenuated inflation forecasts, which in turn should have resulted in a larger coefficient on expected inflation in the estimated Taylor rule. However, when we estimated models allowing a shift in the inflation coefficient, the change was incorrectly signed and did not differ significantly from zero. We have therefore ignored the change in forecasting procedure in the remainder of our analysis.

29. The original data were quarterly, but we have interpolated to obtain output gap estimates at committee meeting dates.

TABLE 6

MAXIMUM SIMULATED LIKELIHOOD ESTIMATES: SWEDEN (DATA FROM JANUARY 2000–SEPTEMBER 2008 MPC MEETINGS)

Parameter	Model 1	Model 2	Model 3
$\beta_{\dot{P}}$	0.0842	0.1087	0.1585
β_{gap}	0.0397	0.1324	0.0723
$\beta_{R_{\text{ECB}}}$	–	–	0.1049
$\beta_{R_{sq}}$	0.8986	0.9837	0.9009
σ_u	0.0356	0.1409	0.0880
σ_v	0.1206	0.0162	0.0551
θ	0.8552	0.0000[a]	0.7260
ω	0.0000	0.0000[a]	0.0000[a]
ω_c	1.0000[a]	1.0000[a]	1.0000[a]
Individual intercepts			
Eva Srejber	0.6119	0.2173	0.5131
Svante Oberg	0.8482	0.2625	0.6142
Urban Bäckström	0.4954	0.2500[a]	0.4240
Lars Heikensten	0.1857	0.1656	0.3148
Stefan Ingves	0.5293	0.1875	0.4273
Lars Svenssen	0.5918	0.2074	0.4769
Villy Bergstrom	0.1626	0.1529	0.2861
Kerstin Hessius	0.1827	0.1599	0.3028
Lars Nyberg	0.2418	0.1620	0.3151
Irma Rosenberg	0.2272	0.1570	0.3028
Barbro Wickman-Parak	0.4227	0.1789	0.3865
Kristina Persson	−0.0406	0.1199	0.1894
Log likelihood	−113.665	−126.843	−110.152
Sample size	67	67	67

NOTES: The parameters are defined as follows: $\beta_{\dot{P}}$ is the reaction function coefficient on inflation (equation (1)), β_{gap} is the reaction function coefficient on the output gap (equation (1)), $\beta_{R_{\text{sq}}}$ is the reaction function coefficient on the status quo policy rate (equation (1)), σ_u is the standard deviation of the meeting-specific error term in the reaction function (equation (1)), σ_v is the standard deviation of the individual-specific error term in the reaction function (equation (1)), θ is the weight MPC members assign to the chairman's interest rate (equation (2)), ω is the weight MPC members assign to the policy rate target chosen by the MPC (equation (5a)), and ω_c is the weight the chairman assigns to the policy rate target chosen by the MPC (equation (5b)). The "individual intercepts" are the reaction function parameters α_i (equation (1)).
[a]The estimate is restricted to the value shown.

Table 6 reports estimates of the model using data from the Riksbank MPC's voting records from January 2000 through September 2008. Because none of the three individuals who served as Governor ever dissented from the majority choice, ω_c cannot be freely estimated. We set $\omega_c = 1.0$ in all of the estimations in the table; this value implies that the Governor always defers to the majority in the formal vote, as we have observed in the data.[30] Column 1 of the table provides estimates of an otherwise unrestricted specification. The estimation results are strikingly different from those for the BOE. The estimate of θ is 0.86, implying that the preferences of the Governor dominate monetary policy outcomes. The estimate of ω is 0.00, implying that members do not defer to the committee median.[31] The second column of the table

30. Similar problems can arise in other discrete choice models. For example, in a standard logit model, if a discrete right-hand-side variable perfectly explains the dependent variable, an infinite coefficient value provides the best fit. In our model, the position of the median perfectly explains the vote of the Governor, and a value of 1.0 for the relevant weight provides the best fit.

31. Given the substantial weight attached to the Governor, the median position would normally track the position of the Governor closely. However, the estimates imply that it is the Governor's preference that drives the committee outcome.

TABLE 7

REACTION FUNCTION INTERCEPTS AND NET TIGHTNESS FREQUENCIES: SWEDEN (DATA FROM JANUARY 2000–SEPTEMBER 2008 MPC MEETINGS)

Individual	Net tightness frequency	Intercept	Rank by net tightness frequency	Rank by intercept
Eva Srejber	0.1930	0.6119	1	3
Svante Oberg	0.1579	0.8476	2	1
Urban Bäckström	0.0000	0.4954	3 (tie)	5
Lars Heikensten	0.0000	0.1857	3 (tie)	9
Stefan Ingves	0.0000	0.5293	3 (tie)	4
Lars Svenssen	0.0000	0.5911	3 (tie)	2
Villy Bergstrom	0.0000	0.1626	3 (tie)	10
Kerstin Hessius	0.0000	0.1827	3 (tie)	11
Lars Nyberg	−0.0294	0.2416	9	8
Irma Rosenberg	−0.0476	0.2274	10	7
Barbro Wickman-Parak	−0.1111	0.4229	11	6
Kristina Persson	−0.1489	−0.0407	12	12

NOTES: The "net tightness frequency" is defined as the number of times a member prefers a rate higher than the committee choice less the number of times the member prefers a lower rate, with the difference expressed as a fraction of total votes. The "intercept" for each member is taken from the Model 1 column of Table 6.

provides estimates of a model imposing the restrictions that characterize individualistic behavior: $\theta = \omega = 0$. These restrictions are soundly rejected ($p = 0.0000$).[32] Based on these estimates, the Riksbank MPC appears to be autocratically collegial rather than individualistic. Other coefficient estimates are generally in accord with expectations. In column 1, the coefficients for the output gap and inflation are positively signed, but fall short of joint significance ($p = 0.1172$). Individual intercepts are broadly consistent with summary statistics on voting tendencies, as Table 7 demonstrates.[33] For example, members Eva Srejber and Svante Oberg frequently dissented for tightness and had the largest intercepts among rank-and-file committee members (intercepts in Table 7 are from column 1 of Table 6).

The estimated intercepts for Governors Bäckström, Heikensten, and Ingves are also revealing. Bäckström and Ingves have high reaction function intercepts, while that for Heikensten is low. The history of policy movements in our sample period provides a plausible explanation for these results. Interest rates were high under Bäckström's tenure, declined under Heikensten, and then rose again under Ingves, as Figure 1 reveals. Our estimation explains this with a finding that Governors were both influential and notably different from one another. This explanation nicely illustrates the logic of the model, but it also suggests that some caution in interpretation is appropriate.

32. We have noted that because none of the Riksbank Governors ever dissented, we impose the restriction that $\omega_c = 1.0$. When we also impose the restriction that $\theta = 0$ in column 2 of Table 6, the model has limited power to identify the intercepts of Governors. For the case of Governor Urban Bäckström, the intercept is not identified—his estimated intercept is sufficiently high that additional marginal increases would never change the committee's median choice or the overall fit of the model. In column 1 of Table 6, where the intercept is not identified, we simply impose the value of 0.25, the smallest value in the indeterminate range.

33. As was the case for the BOE, we have not routinely tested differences across members, but we have carried out one test. We are able to reject the hypothesis of equal intercepts for Governors Svenssen and Bergstrom ($p = 0.0035$).

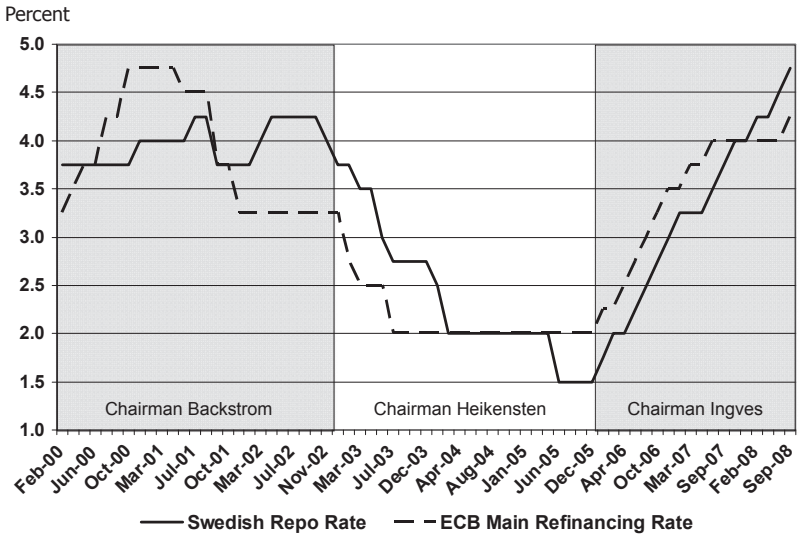

FIG. 1. Target Interest Rates: Swedish Riksbank and ECB, 2000–2008.

NOTES: Each hash mark represents a meeting with an interest rate decision of the Riksbank. The figure shows the paths of the Swedish repo rate and the ECB's main refinancing rate under each Riksbank chairman in the sample.
SOURCE: Archives of the Riksbank and the ECB.

If the policy shifts that occurred when Bäckström and Heikensten left office were coincidental in timing, then our finding that the Governor is influential would also be in question. In fact, Figure 1 reveals that the policy shift associated with Bäckström's exit began two meetings *before* his departure. This shift was broadly associated with a global movement toward monetary ease in response to recessionary conditions in the United States and the September 11, 2001, terror attacks. Figure 1 also suggests that the path of the Swedish repo rate was related to that of the ECB's target rate (the main refinancing rate). Because changes in the Riksbank's Governorship do not determine policy choices at the ECB, it seems likely that coincidence is driving our findings about the power of the Riksbank's Governors.

To investigate this possibility further, we have altered our Riksbank Taylor rule specification to include the prevailing ECB interest rate target (expressed as a deviation from its sample mean) as an additional explanatory variable. The ECB rate is likely to be a good indicator of global conditions not captured by the conventional Taylor rule—global shocks that induce the ECB to lower rates are likely to affect Sweden in similar ways.[34] The third column of Table 6 reports results for this model, which is otherwise identical to the specification of column 2.

34. In several instances, the ECB and Riksbank committees met on the same day. On these occasions, we have assumed that the chosen ECB rate was known to the Riksbank. This may not always have been literally true, but the global conditions that affected the ECB choice should have been observed.

Although modest in size, the estimated coefficient for the ECB rate is positive and significantly different from zero ($p = 0.0080$). The inclusion of the ECB rate also has notable effects on other model parameters. Differences in estimated intercepts for the three Riksbank Governors are now less extreme than before, although their ordering is unchanged. The estimate of θ, the weight members attach to the Governor's preference, is also smaller, falling from 0.86 to 0.73. Qualitatively, these changes are what one would expect if the effects of global economic conditions and Riksbank leadership turnover had been confounded in the original specification. However, the results continue to show considerable power for the committee chairman, and the robustness of our finding that the Governor is influential is not completely surprising. The Riksbank did not normally move in lockstep with the ECB. Figure 1 shows that ECB rates began moving down immediately after September 11, 2001, but the sustained downward movement in Swedish rates did not begin until November 2002, more than a year later. In this instance, the shift in the Riksbank's policy stance was more closely aligned with the change in its leadership than with changes in external conditions. Given this history, our estimate of the Governor's weight is understandable, even if some skepticism about its size is appropriate.

Our results for the Riksbank can be summarized in terms of Blinder's typology. We find no evidence that members attach weight to the committee median, but members appear to be heavily influenced by the Governor. Therefore, our results suggest that the Riksbank's MPC is best characterized as an autocratically collegial committee.

4.3 Robustness Checks

In this section, we discuss the results of estimations that use alternative measures of the macroeconomic variables that appear in the Taylor rule. We consider two alternatives for each of the central banks studied. First, we use real-time estimates of the output gap instead of estimates that were revised *ex post*. Presumably, real-time data—the data actually available to monetary policymakers when decisions were made—are more appropriately included in an empirical model of policymaking.[35] Second, in place of inflation forecasts, we use backward-looking measures of actual inflation. Although forecasts of future inflation are commonly used in Taylor rule estimations, Taylor (2012) advocates using actual historic inflation rates.

Real-time estimates of the UK output gap come from the OECD quarterly output gap revisions database.[36] Real-time estimates of the Swedish output gap come from the series of *Monetary Policy Reports* (formerly called *Inflation Reports*) published

35. Orphanides (2001) notes that this distinction is an important one when analyzing Taylor rule estimates for the Federal Reserve. Gorter, Jacobs, and de Haan (2008) advocate the use of real-time data in Taylor rules for the ECB.

36. The OECD series was available through 2007; we updated the series as needed for 2008 by extrapolating growth of potential GDP and combining that with real-time estimates of actual GDP.

by the Riksbank.[37] Output gaps are typically available with a one-quarter delay, so our new estimations use the first available estimate for the quarter preceding the quarter of a policy meeting. For each country, historic inflation was measured as a 12-month moving average of CPI inflation ending with the month preceding a meeting. These inflation measures were obtained from *Inflation Reports* (for the BOE) and *Monetary Policy Reports* (for the Riksbank).

Estimates of these alternative specifications are reported in Appendix B. The results can be quickly and easily summarized. First, we find that overall model fits are best for the base specifications reported earlier in the paper. For the BOE, the use of real-time estimates of the output gap results in a notably worse fit of the model (as measured by the likelihood function), while the use of historic inflation results in a slightly worse fit. For the Riksbank, the data substitutions result in very small deteriorations in overall fits. In all cases, the coefficients of the economic variables continue to have the predicted positive signs.

Second, implications about the nature of committee decision making are robust across all data changes. Estimates of θ, ω, and ω_c are essentially unchanged when alternative macroeconomic data are employed in the base specifications for each of the two central banks.

5. CHANGES IN THE COMPOSITION OF THE COMMITTEE

Because our model appropriately aggregates from individual preferences to collective choices, it can be used to simulate the consequences of changes in the composition of the committee. When a member with preferences for easy monetary policy is replaced by a member more inclined to tightness, this will affect the overall distribution of preferences in the committee and, at least probabilistically, the resulting policy outcomes. Because our model is based on majority voting, however, all compositional changes affect outcomes by shifting the position of the median voter.

Consider the June 2003 meeting of the MPC. This was the last meeting in which Eddie George served as Governor before he was replaced by Mervyn King. We can assess the consequences of this personnel change by simulating our model under the counterfactual assumption that George had been replaced in the June meeting by a member with an intercept equal to that of King. Using estimates reported in column 2 of Table 5 (in which the Governor has differential influence over internal and external appointees), we first simulate our model under the assumption that George remained on the committee. Over repeated simulations, we calculate frequencies for each of the three possible policy outcomes (lower, unchanged, and higher rates), obtaining the probabilities 0.0896, 0.7918, and 0.1186. When George is replaced, those probabilities shift to 0.0626, 0.7745, and 0.1629. Clearly, there is a modest shift of probabilities

37. For Sweden, the only output gap series available for the complete sample was calculated using the Hodrick–Prescott filter.

away from the easier outcome and toward the tighter one, reflecting our finding that King has a higher estimated reaction function intercept than George.

Now suppose that, instead of King, Besley had been George's replacement. According to our estimates, Besley was the tightest member of the 25 individuals who served in our sample period. In this scenario, the simulated probabilities shift a bit further to 0.0354, 0.7341, and 0.2305. The successive probability changes associated with replacing George with King and then replacing King with Besley are comparable in magnitude, but the second change involved a much more extreme change in preference of the new member. The example illustrates that adding an extreme member does not move the expected median voter position in a proportionally extreme fashion.

For Sweden, a change in the identity of the Governor has the potential to produce much larger effects for two reasons. First, our estimates imply that the Governor has considerable influence over other committee members; second, in a small, even-numbered committee, the Governor is more likely to be a tie-breaker. Consider the February 2003 meeting, the first meeting in which Lars Heikensten served as Governor after replacing Urban Bäckström. A simulation for that meeting (based on estimates from column 3 of Table 6) indicates that probabilities associated with lower, status quo, and higher rate targets were 0.6858, 0.3120, and 0.0022. If we counterfactually assume that Bäckström had remained Governor, those probabilities would have been much different, at 0.3338, 0.6488, and 0.0174.[38] These simulation results suggest that a shift toward ease was quite likely after the change in the Governorship, consistent with our finding that Heikensten's reaction function intercept was lower than Bäckström's. Thus, our model implies that a change in the identity of the Governor could have large effects at the Riksbank.

6. CONCLUSIONS

We have developed an econometric model of MPC decisions and have estimated that model using historical data from two central banks, the United Kingdom's BOE and Sweden's Riksbank. Our model specifies how majority voting outcomes are determined by the preferences and behavior of individual committee members. It also permits special influence for the committee chairman and allows members to support median voter outcomes in the interest of consensus. MSL methods are employed in estimation.

For the BOE, we find that the Governor, who chairs the MPC, has only modest influence over internal appointees and no influence over other committee members. We also find that, except for the Governor, members do not alter their votes to conform to the committee's choice. These results generally confirm the conventional view that

38. The model used in the simulation includes the ECB target rate as an explanatory variable. Given the downward trend in the ECB rate at this time, we see that the chance of a Riksbank tightening was low, regardless of the identity of the Governor.

the BOE's MPC is individualistic—members vote their own preferences, with little regard to the views of the Governor or other committee members. For the Riksbank, our estimates imply that the Governor has considerable influence over other MPC members. In Blinder's typology, the Riksbank's committee is best characterized as autocratically collegial rather than individualistic.

Because the MPCs of the BOE and the Riksbank operate under similar formal institutional arrangements, Blinder (2004) characterizes both as "individualistic." However, committees with similar formal institutions may behave quite differently in practice. Our results suggest that this is the case for the BOE and the Riksbank, providing a useful illustration of the value of an econometric approach to detecting such differences.

APPENDIX A: MSL ESTIMATION

This appendix provides additional details on the estimation of the model described in the text. Specifically, we discuss (i) how we set the number of simulated observations employed to calculate the likelihood for an observation, (ii) how we control the search over parameter values as the maximization algorithm proceeds, (iii) the potential for multiple maxima, and (iv) how hypothesis testing is conducted.

As we have noted, some observed committee voting outcomes are low-probability events. Accurately estimating the likelihood for such events requires large numbers of simulated observations. We initially set a minimum of 100,000 simulated observations for each data point. If 100,000 simulated observations produced fewer than 1,000 matches with the actual outcome, our program increased the number of simulations to 1,000,000. With the Riksbank data set, for the best-fitting specification, it was never necessary to use 1 million simulations. However, with the UK data, several observations did require this many, and a handful of these produced fewer than 100 matches. At final estimated parameter values for the best-fitting model, there were no observations that produced fewer than 20 matches. Before reaching final estimates, trial values of parameters sometimes produced no matches in 1 million trials. In these cases, we assigned an extremely low positive probability (10^{-13}) to the likelihood function, avoiding taking logs of zero while leading the algorithm away from these parameter values.

A standard numerical maximization routine in TSP was used to maximize the likelihood function (the Berndt–Hall–Hall–Hausman algorithm). Because simulations are used to calculate the likelihood function, the resulting function is not strictly continuous. For very small parameter changes, the calculated likelihood function changes in discrete steps (i.e., for a sufficiently small change in a parameter, all simulated observations could be unchanged). In practice, the TSP algorithm worked best when a small subset of parameters was allowed to vary simultaneously. We therefore repeatedly estimated the model, permitting some parameters to vary while holding others fixed. The set of flexible parameters was changed in successive estimations.

We continued to iterate until parameter values and the likelihood function remained unchanged over repeated estimations.

It is possible that a maximization algorithm will converge to a local maximum. To avoid this possibility, we have employed grid searches and used alternative starting values in repeated estimations. Although it is still possible that reported results are local maxima, we have searched extensively to ensure that this is not the case.

Because we have iterated over subsets of parameters (rather than all parameters at once), estimates of coefficient standard errors produced by TSP are not correct. We have instead performed likelihood ratio tests of selected hypotheses, reporting *p*-values for these tests in the text. Because a likelihood ratio test of a model restriction requires estimates of both restricted and unrestricted specifications, performing these tests is computationally demanding. Estimation of a single instance of our model can sometimes take several months of computing time. Therefore, any calculated test statistic for a model restriction requires a significant amount of added computing time. Because of this, we do not report test statistics or *p*-values for all coefficients; instead, we selectively report tests of those hypotheses that are of greatest interest.

APPENDIX B: RESULTS OF ROBUSTNESS ANALYSIS

TABLE B1

MAXIMUM SIMULATED LIKELIHOOD ESTIMATES WITH ALTERNATIVE MACROECONOMIC DATA: UNITED KINGDOM (DATA FROM JANUARY 1999–AUGUST 2008 MPC MEETINGS)

Parameter	Real-time gap	Historic inflation
$\beta_{\dot{P}}$	0.3643	0.0235
β_{gap}	0.0837	0.1995
$\beta_{R_{\text{sq}}}$	0.9404	0.9423
σ_u	0.1082	0.1032
σ_v	0.0378	0.0330
θ	0.0525	0.0298
ω	−0.0188	−0.0186
ω_c	0.2846	0.2922
Log likelihood	−376.095	−366.871
Sample size	117	117

NOTES: The parameters are defined as follows: $\beta_{\dot{P}}$ is the reaction function coefficient on inflation (equation (1)); β_{gap} is the reaction function coefficient on the output gap (equation (1)); $\beta_{R_{\text{sq}}}$ is the reaction function coefficient on the status quo policy rate (equation (1)); σ_u is the standard deviation of the meeting-specific error term in the reaction function (equation (1)); σ_v is the standard deviation of the individual-specific error term in the reaction function (equation (1)); θ is the weight MPC members assign to the chairman's interest rate (equation (2)); ω is the weight MPC members assign to the policy rate target chosen by the MPC (equation (5a)); and ω_c is the weight the chairman assigns to the policy rate target chosen by the MPC (equation (5b)).

TABLE B2

MAXIMUM SIMULATED LIKELIHOOD ESTIMATES WITH ALTERNATIVE MACROECONOMIC DATA: SWEDEN (DATA FROM JANUARY 2000–SEPTEMBER 2008 MPC MEETINGS)

Parameter	Real-time gap	Historic inflation
$\beta_{\dot{P}}$	0.0803	0.0270
β_{gap}	0.0173	0.0438
$\beta_{R_{sq}}$	0.8906	0.8850
σ_u	0.0473	0.1012
σ_v	0.1133	0.0162
θ	0.8572	0.8850
ω	−0.0015	−0.0005
ω_c	1.0000[a]	1.0000[a]
Log likelihood	−113.781	−113.914
Sample size	67	67

NOTES: The parameters are defined as follows: $\beta_{\dot{P}}$ is the reaction function coefficient on inflation (equation (1)); β_{gap} is the reaction function coefficient on the output gap (equation (1)); $\beta_{R_{\text{Sq}}}$ is the reaction function coefficient on the status quo policy rate (equation (1)); σ_u is the standard deviation of the meeting-specific error term in the reaction function (equation (1)); σ_v is the standard deviation of the individual-specific error term in the reaction function (equation (1)); θ is the weight MPC members assign to the chairman's interest rate (equation (2)); ω is the weight MPC members assign to the policy rate target chosen by the MPC (equation (5a)); and ω_c is the weight the chairman assigns to the policy rate target chosen by the MPC (equation (5b)).
[a]The estimate is restricted to the value shown.

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