Policymakers' Interest Rate Preferences: Recent Evidence for Three Monetary Policy Committees*

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This paper estimates (pooled) Taylor-type rules based on real-time information for three monetary policy committees: the FOMC, the Bank of England's MPC, and the Riksbank's Executive Board. Tests for heterogeneity among committee members provide new empirical evidence on the distribution of policymakers' interest rate preferences and their individual reaction patterns to economic shocks. For all three committees we find preference heterogeneity to be systematic over the last decade. Policymakers' preference distributions are found to be consistent with an underlying symmetric normal distribution. Disagreements among members mainly relate to their short-run response to shocks. Additional cluster analyses exploiting individual response parameters to shocks from the reaction functions show that the membership status (chairman, internal member, external member) explains some of the heterogeneity in members' preferences and responses.

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1. Introduction

Today, it is widely established practice that monetary policy decisions are made by monetary policy committees and not by individuals. In their confidential deliberations, policymakers may disagree on what constitutes the most appropriate policy response given circumstances. As illustrated by the popular hawk-doves analogy, members of a committee may have different preferences. A small but growing literature documents that monetary policy deliberations by committees are characterized by considerable heterogeneity among policymakers. An important question is whether such diversity in monetary policy committees is beneficial or hampers the decision-making process. Several authors have contributed to a better understanding of the workings of monetary policy committees (see, e.g., the work by Sibert 2002, Meyer 2004, Gerlach-Kristen 2006, Blinder 2007, Blinder et al. 2008, and Moutot, Jung, and Mongelli 2008). Few authors have provided quantitative evidence on voting patterns in monetary policy committees. They have mostly focused on a specific committee. For example, Chappell, Havrilesky, and McGregor (1997), Meade and Sheets (2002, 2005), and Chapell, McGregor, and Vermilyea (2005) examine the Federal Open Market Committee (FOMC), and Bhattacharjee and Holly (2006) and Riboni and Ruge-Murcia (2008) provide results for the Monetary Policy Committee (MPC). The study by Besley, Meads, and Surico (2008) finds that several characteristics that are not captured by conventional reaction functions (e.g., the membership status, tenure, and academic background) can explain heterogeneity in monetary policy committees. A recent international comparison of five central banks by Riboni and Ruge-Murcia (2010a) suggests that despite the existence of institutional differences across committees, factors such as internal procedures and informal rules may have contributed to more consensual voting patterns.

The present paper aims to provide new empirical evidence on the distribution of policymakers' interest rate preferences in committees and on their individual reaction to economic shocks for three central banks. First, it sets up a real-time database for key economic indicators and information on policymakers' votes from published voting records. Second, it tests for the existence of heterogeneity among policymakers in three monetary policy committees:

the FOMC, the Bank of England's MPC, and the Riksbank's Executive Board. These tests include pooled reaction functions and cluster analyses. Third, it provides individual reaction parameters for the members of the three monetary policy committees.

The paper contributes to the literature on monetary policy committees in two ways. First, it estimates (pooled) empirical reaction functions which capture both the short-run and long-run responses of members to incoming information. The present analysis reveals that, over the last decade, preference distributions in all three committees considered are consistent with an underlying symmetric normal distribution. Disagreements among members mainly relate to their short-run response, and less so to their long-run response, to shocks. Second, it performs cluster analyses by which the influence of so-called unobserved factors (such as membership status, tenure, and members' background on heterogeneity) can be captured. These analyses exploit individual response parameters to shocks from the reaction functions and suggest that, for the FOMC and the MPC, the status of members (chairman, internal member, external member) explains some of the heterogeneity in members' preferences and responses.

The paper is organized as follows. Section 2 briefly discusses what voting records may suggest about diversity in the three monetary policy committees: the FOMC, the Bank of England's MPC, and the Riksbank's Executive Board. In order to examine diversity evident from policymakers' voting records, section 3 compares evidence for the three committees by estimating pooled Taylor-type reaction functions and by analyzing the parameter distributions using cluster analyses. Section 4 concludes. A separate appendix contains information on data sources and data properties.

2. What Do Voting Records Tell Us about Diversity in Committees?

2.1 General Remarks

In the literature, the view prevails that (attributed) voting records contain useful information on diversity in a monetary policy committee. A recent study by Horváth, Smidková, and Zápal (2012) finds that voting records may contain valuable information about future

interest rate moves. Voting records contain quantitative information on the occurrence of disperse views by policymakers in committees. The balance of votes reports dissent and agreement on the interest rate decision by members. Such voting records give the public a sense on diversity in the committee. Some central banks publish (attributed) voting records with detailed information on agreement and dissent by member after each meeting. Examples are the Federal Reserve, the Bank of England, and the Swedish Riksbank.

Voting records have shortcomings as a source for diversity. They neither provide readily accessible information on policymakers' individual preferences nor are they unbiased indicators of these policy preferences. For example, members could have strategic considerations when they vote (Havrilesky and Gildea 1991, McCracken 2010, and Tillmann 2011). In committees with individual accountability (Bank of England's MPC, Riksbank's Executive Board), members may have a strong incentive to reveal accurate information on their preferences within the voting records. By comparison, in committees with collective accountability, voting records may understate differences in views among members relative to what they express at the meeting. In addition to consensus-building activities at the meeting, informal rules may reduce members' incentive to dissent. For example, the Federal Reserve's "bias statement" gave concessions to members when drafting the bias statement by allowing them to signal dissent in a non-attributed manner. Chappell, McGregor, and Vermilyea (2007) find evidence for this behavior during the period 1987 to 1992, but not for the period 1993 to 1999.

In the case of the FOMC and other central banks with collective accountability, better sources on diversity can be extracted from transcripts and minutes of the meetings.[1] Interest rate preferences from voting records tend to underestimate the true dissent in the FOMC's deliberations. The transcripts provide a richer picture on diversity of views in the committee than the voting record. FOMC transcripts record individual interest rate preferences revealed during the second-round discussions. They are closer

[1]Since the October 2007 meeting, FOMC minutes include four times a year a new section on diversity of participants' views on forecasts. The information provided is not attributed to individual members, but only shows the distribution in the committee.

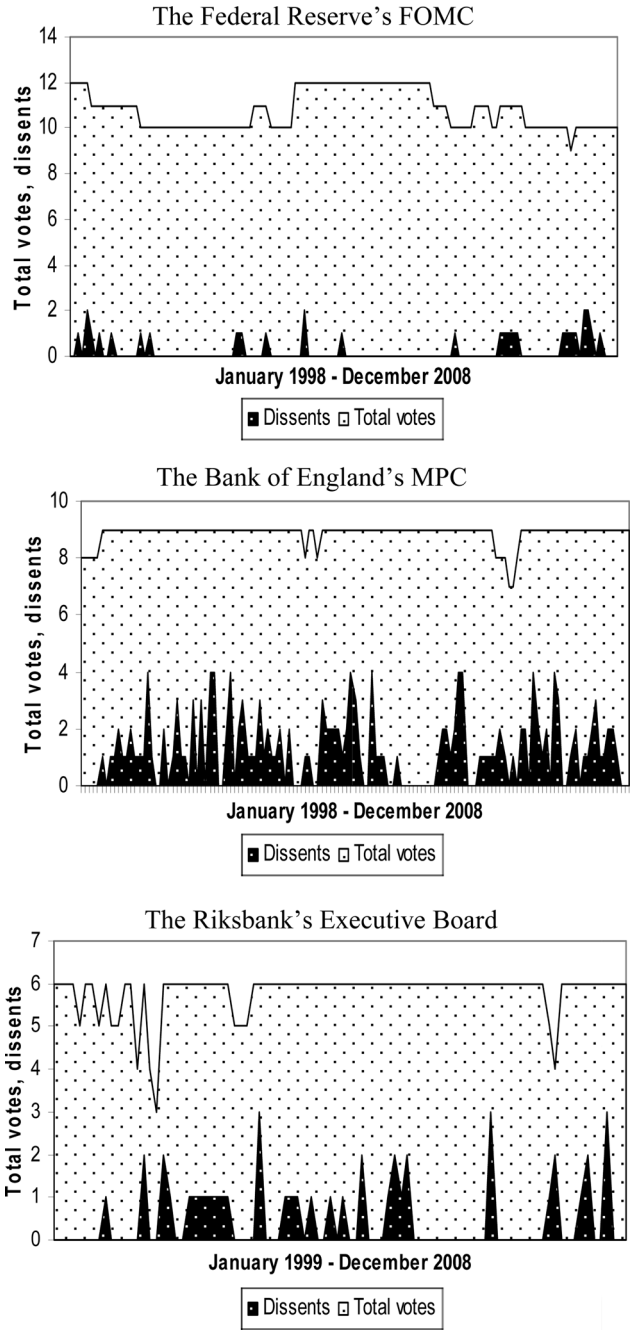
to the true preference of a member, because they do not reflect the consensus-building process during the meeting. At the same time, transcripts often leave ample scope for guesswork when mapping qualitative information into quantitative information. Moreover, transcripts are only published with considerable delays of usually five years. That is why most researchers have used (attributed) voting records for the analysis of preference heterogeneity in a monetary policy committee and only few have attempted to map information from transcripts into interest rate preferences (see Chappell, McGregor, and Vermilyea 2005 and Meade 2005).

2.2 Some Clues on Diversity from the Voting Records

Figure 1 shows the balance of votes for three monetary policy committees (FOMC, Bank of England's MPC, and Riksbank's Executive Board) for the period 1998–2008. FOMC members seem to have made decisions in a highly consensual manner. Dissenting was infrequent, and the dispersion of Board members' and regional presidents' votes was low, but later, during the financial crisis, dissents picked up somewhat.[2] In almost all meetings, a broad majority of members or all members supported the chairman's proposal on interest rates. By comparison, in the 1970s and 1980s, dissenting in support of tighter and looser policy was much more common (see Chappell, Havrilesky, and McGregor 1997). Meade and Sheets (2006) observe a peak in FOMC dissenting during the late 1970s and early 1980s. Paul Volcker's chairmanship was an era associated with an unusually high degree of dispersion, whereas dispersion during the Greenspan era was low. This suggests that the intensity by which FOMC policymakers dissent is time varying and influenced by other factors such as the leadership of the chairman. The Great Moderation, which reduced volatility, and the "new consensus" on U.S. monetary policy (Goodfriend 2007) provide further explanations for why the FOMC voted with a high degree of agreement over past years. A host of other factors were potentially responsible for it, including increased transparency on the monetary policy process, a strong ability of

[2]Transcripts show that FOMC members on occasion expressed more diversity of views during the internal assessment. Moreover, changes in policymakers' published forecast ranges suggest that views in the FOMC on occasion have been more diverse than indicated by the balance of votes.

Figure 1. Voting and Dissenting in Monetary Policy Committees (1998–2008)



Sources: U.S. Federal Reserve, Bank of England, and Swedish Riksbank (see description in the appendix).

the chairman to forge consensus in the committee (under Chairmen Greenspan and Bernanke; see Meyer 2004, p. 40), improvements in the sharing of information among policymakers, and the popularity of the "Taylor rule" as a tool for policy evaluation.

By comparison, judging from the voting records, over the recent decade monetary policy decisions of the Bank of England's MPC and the Riksbank's Executive Board have remained somewhat less consensual (see Riboni and Ruge-Murcia 2010b). The presence of split interest rate decisions for the two inflation-targeting central banks signals that on occasion disagreement among members was strong (see Riboni and Ruge-Murcia 2010a, p. 401). The following examples illustrate this point. First, the Bank of England's MPC recorded about ten occasions when a thin 5:4 majority supported the interest rate proposal. Governor Mervyn King "famously" dissented and was outvoted on three occasions (namely August 2005, June 2007, and again in August 2009). Second, the Executive Board of the Riksbank had a tie on four occasions (namely July 5, 2001; December 1, 2005; May 3, 2007; and September 3, 2008), and the Governor's casting vote determined the outcome.

2.3 Popular Hypotheses on Heterogeneity

In a seminal study of the FOMC voting records, Meade and Sheets (2002, 2005) propose the presence of a regional bias in federal central banking systems. Their study finds that FOMC policymakers take into account regional unemployment rates when deciding on interest rates.[3] In this respect, regional Federal Reserve Bank presidents are more likely to cast dissenting votes for tighter than for easier monetary policy. This depends on whether regional unemployment rates are below or above the national average. While regional considerations appear to have affected individual members' decisions to dissent, they had little systematic effect on the total number of dissents. A variant of this is the insider-outsider hypothesis, which suggests that members appointed from within the central bank know the monetary policy process better and therefore vote more in synch

[3]Hayo and Neuenkirch (2013) examine communications of Federal Reserve Bank presidents and find that the influence of regional variables has increased during the financial crisis.

with the chairman than outsiders. As shown by Gerlach-Kristen (2003, 2006), Fujiki (2005), and Bhattacharjee and Holly (2006), outsiders (or "external" members) more often show disagreement with the policy decision than insiders (or "internal" members). It is sometimes observed that outsiders during the early phase of their term show more extreme reaction patterns and are less predictable than insiders who are involved in the monetary policy process on a daily basis. Because members can learn, outsiders eventually adapt and, after some time, they become indistinguishable from the insiders. A study by Berk, Bierut, and Meade (2010) suggests that differences between insiders and outsiders are mainly related to the end of their tenure. In the FOMC, tenure effects could arise because Bank presidents have on average longer tenures than Board members (see Kohn 2008). However, measuring these effects is complicated by the existence of a rotation system that limits the number of observations for all regions except the Federal Reserve Bank of New York, which has a permanent seat in the FOMC.

The career-background-effects hypothesis establishes a link between the background of policymakers and their interest rate preferences. Accordingly, members with an academic background, members with a finance background, and members appointed from the government can behave differently in their voting patterns. The partisanship hypothesis proposes that the government may use the appointment process to actively influence the decision-making process. Some authors (see Havrilesky and Schweitzer 1990 and Chappell, Havrilesky, and McGregor 1995) have suggested that working for the government prior to appointment would imply a more dovish monetary policy preference. However, in many cases, throughout their careers members of a monetary policy committee may have worked in several areas, so a distinction along this line is often blurred.

3. An Econometric Analysis of Diversity in Three Monetary Policy Committees

This section estimates (pooled) Taylor-type reaction functions for the FOMC, the MPC, and the Riksbank's Executive Board and examines the individual reaction parameter by means of a cluster analysis. Diversity in monetary policy committees is an important

phenomenon and its intensity may differ across central banks and time. Owing to the confidential nature of the policy process, an analysis of the sources of heterogeneity is subject to data limitations. The approach of this paper is to estimate (pooled) Taylor-type reaction functions which use information on individual interest rate preferences from published voting records and macroeconomic data that were available to policymakers in real time. Relative to other conceivable approaches, this framework has the advantage that it provides for a structural interpretation of the estimated parameters. Differences in reaction parameters across monetary policy committees and across members allow us to assess different sources of heterogeneity across committee members. An important caveat is that individual forecasts of inflation and output by members should ideally be incorporated in the estimations, but for reasons of confidentiality they are not available, so the estimated individual parameters only extract information on diversity from the voting records.[4]

The study by Besley, Meads, and Surico (2008) was the first to conduct such an approach for the Bank of England's MPC for the sample mid-1997 to mid-2007.[5] The present paper applies their approach, provides some methodological refinements, and extends the coverage of monetary policy committees to include the FOMC, the MPC, and the Riksbank's Executive Board. For selected Central Eastern and European (CEE) inflation-targeting countries, the paper by Jung and Kiss (2012) reports the results of a similar exercise. We provide a clear estimation strategy—identification of the reaction functions and testing for equality of parameters—and report results from hypotheses testing using conventional tools (i.e., Hausman tests, Wald tests). The present study also addresses a concern by Gerlach-Kristen (2009) that the approach by Besley, Meads, and Surico (2008) suffers from a pure focus on the long-run responses of members to the inflation and the output gap. By separately estimating the empirical reaction functions with and without imposing the long-run restriction from the inertia, we can distinguish between the short-run and long-run responses of members to

[4] A separate analysis estimating individual reaction functions using individual forecasts of FOMC members during 1992 to 2000 is in preparation.

[5] In order to show that the results for the MPC are comparable with them, we provide estimates for the MPC for the sample 1998 to 2007 (see under unconstrained reaction functions).

incoming information. Section 3.1 addresses issues related to the real-time data for the FOMC, the MPC, and the Riksbank. Section 3.2 describes the tests for heterogeneity in three monetary policy committees. Section 3.3 provides test results of the (pooled) reaction functions and the cluster analyses of the reaction parameters.

3.1 A Real-Time Database for Three Monetary Policy Committees

The database used for the present study comprises data on published voting records and real-time data on interest rates, inflation gap, and output gap (see the appendix for details on data sources and on their properties). Why is it important for the present analysis to use real-time data in the reaction functions? These data correspond to the data set available to policymakers at the time of their policy decision. Economic data are often subject to sizable and extended revisions after their first release, and this constitutes an important source of data uncertainty. Moreover, there can be substantial lags between the first release and the final release of a data set. In fact, for some economies (e.g., the United States) it can take several years until the data revision process is finalized. Using final data in these reaction functions would be misleading when analyzing preference parameters, because it would mean assuming that policymakers made their decisions under perfect foresight about the data, which in fact they didn't.[6]

When estimating (pooled) Taylor rules with real-time data and interest rate smoothing, we include a numerical value that denotes the monetary policy committees' inflation target or understanding of its price stability objective (see Svensson 1997 and Issing 2005). In the present analysis, this value enters directly into the

[6]Whether final or real-time data should be used depends on the purpose of the analysis. As explained by Bernanke (2010), a comparison of the actual federal funds rate and the Taylor rule gives a different message when using a Taylor rule with real-time forecasts of inflation instead of final values. Orphanides (2003) shows that Taylor-rule parameter estimates using real-time data can be sensitive to the vintage of data and the concept of the gap variables. Taylor (2010) emphasizes that final data should be used whenever the research interest is to assess the setting of the monetary policy stance with the benefit of hindsight. Orphanides (2001) and Svensson (2010) suggest using real-time data when assessing the performance of monetary policy committees given their genuine constraints (data and model uncertainty).

calculation of the inflation gap (for details, see the appendix). For the inflation-targeting central banks, we use the official inflation target. For the FOMC, we use a notional value, which is in line with recent clarifications by the Federal Reserve on its long-run inflation goal within the dual mandate. It is a proxy that is used by other researchers (see Taylor 1993), and it is not to suggest that FOMC members individually or collectively have shared this value for policy purposes.

While Taylor-type reaction function estimates are typically obtained using quarterly data, we provide a monthly version (see, e.g., Rudebusch and Woo 2008 and Hamilton, Pruitt, and Borger 2011). Compared with the use of the meeting frequency, which is different across committees (eight FOMC meetings per year, monthly MPC meetings, six meetings of the Riksbank's Executive Board per year), the monthly version makes the empirical reaction functions more homogeneous in time and more comparable across committees. It thereby addresses concerns about the presence of serial correlation, which may arise in the presence of unscheduled meetings and if meetings are not distributed homogeneously in time. A disadvantage of this approach is that for those months at which there is no meeting, the individual observations are not updated in view of incoming information, but simply replicate those data from the previous committee meeting.

An important question is whether the forecasting assumption of the projections used in this study could give rise to an endogeneity problem. We argue that this is not the case, because we use real-time forecasts, which are subject to considerable uncertainty, and because throughout the sample all three central banks widely reported forecasts based on the constant interest rate assumption. For the FOMC, the present study considers two alternative sources for the inflation forecast, which were available to FOMC policymakers in real time. One is the FOMC's Greenbook forecast, which is based on "appropriate monetary policy." In fact, it is not fully clear what this assumption means de facto. Anecdotal evidence suggests that, in the period considered, it was wide-spread practice to use the constant interest rate assumption subject to judgmental adjustment (see Bullard 2009). A second one is the Survey of Professional Forecasters (SPF), which is a survey and therefore not fully homogeneous in terms of the forecast assumption across respondents. As pointed out by Romer and Romer (2000), Greenbook forecasts are superior

to other sources, so it would be preferable to use this source. However, they are currently only available until December 2007, and for the SPF there are no such restrictions. The MPC's inflation forecasts used in this study are those conditioned on an interest rate held constant at the latest value. This forecast is part of the information set that MPC policymakers observe in real time.[7] While the conditioning path for interest rates is unlikely to generate the best forecast, particularly at long horizons, it is the only forecast for which longer time series are available. The use of this path also facilitates a comparison with Besley, Meads, and Surico (2008). The Riksbank's CPI inflation forecasts are conditioned on the assumption used in the main scenario of the Inflation Report which was subject to changes. Until autumn 2005, the Riksbank conditioned staff inflation forecasts on constant interest rates, then changed to a path implied by market expectations. Since 2007 it has used the Riksbank's own forecast of the future interest rate, which is not an unconditional commitment for monetary policy. These changes to the conditioning path for interest rates were aimed to generate the best possible forecast, given information available at the time of the decision. A study on inflation forecasts from various sources (see Svensson 2010) suggests that the change in the forecast assumption has not removed uncertainty about the interest rate path finally chosen by the Board.

3.2 Testing for Heterogeneity in Monetary Policy Committees

When estimating the reaction functions, we use the inflation gap derived from a two-year-ahead inflation forecast (π_{t+24}) at time t and the (contemporaneous) output gap.[8] The horizon of two years

[7]Note that the Bank of England's MPC also uses forecasts conditional on market expectations, because a constant interest rate path may be less informative when policymakers consider changing the monetary policy stance. At MPC meetings, policymakers always evaluate information available from both inflation forecasts.

[8]For reasons of confidentiality and hence lack of data availability, it is generally not possible to feed individual forecasts of members into the reaction functions and to attribute different forecast horizons to different members. An exception is the United States for the period 1992 to 2000, for which individual forecasts have been made available (see Romer 2010). These data will be exploited in a follow-up study for the FOMC during the Greenspan era (see El-Shagi and Jung 2012).

ahead corresponds to the policy horizon which these central banks normally would have in mind (i.e., in the absence of longer-lasting shocks such as asset-price shocks). Where inflation forecasts with shorter horizons were available and for contemporaneous inflation, tests indicated that the regression properties deteriorated. By contrast, for the output gap for which normally high uncertainty exists in real time, in general better results were obtained using a contemporaneous measure. Here, when one- and two-year-ahead measures were used, separate tests showed that the estimated parameter for the output gap deteriorates both in terms of significance and correct sign.

An aggregate Taylor rule with interest rate smoothing explaining the final outcome of the committee's deliberation is given by[9]

$$i_t = (1-\rho)(\alpha + \beta(\pi_{t+24} - \pi^*) + \gamma y_t) + \rho i_{t-1} + \nu_t, \qquad (1)$$

where i is the (nominal) policy rate, π is the inflation forecast, π^* is the target inflation rate, y is the output gap, and t denotes the time operator. Like the other explanatory variables, the interest rate is a continuous variable, even though monetary policy committees normally typically change their policy rate in multiples of 25 basis points. In this specification, the equilibrium real interest rate is given by $r^* = \alpha - \pi^*$. For central banks with a numerical inflation target it can be directly observed, whereas for other central banks only the nominal natural rate is determined.

The above specification of the reaction function is in line with the literature (see, e.g., Besley, Meads, and Surico 2008). It incorporates the output gap in levels but not in differences. The output gap and the inflation gap are both stationary variables, so proper identification requires including interest rate inertia. Orphanides (2003, 2007) includes the output gap both in levels and in differences. This is not needed here, because variables in differences have no impact on the long-term relationship. When modeling policymakers' reactions to new incoming information, anecdotal evidence suggests that policymakers would not take changes in the output gap in a systematic

[9]The Taylor principle recommends that monetary policy moves a (nominal) key interest rate by more than one-for-one with inflation. The reaction functions in this paper satisfy the Taylor principle.

manner into account but, at most, would occasionally refer to it. In fact, the literature emphasizes the high uncertainty surrounding the output gap itself as a useful indicator for monetary policy decision making.

Pooled regressions with fixed and random effects and with random coefficients are then estimated. Pooled regressions with fixed effects capture the possibility that each committee member has a different interest rate preference (i.e., is more "hawkish" or "dovish" than the committee mean). The fixed-effects regression takes the following form:

$$i_{n,t} = (1-\rho)(\alpha_n + \beta(\pi_{t+24} - \pi^*) + \gamma y_t) + \rho i_{n,t-1} + \varepsilon_{n,t}, \qquad (2)$$

with n denoting individual members.

The random-effects model is similar to (2) in that slope parameters (β, γ) are the same for all members, but differences in policymakers' preferences (α) are random (where α comprises the mean and τ is a random deviation by member):

$$i_{n,t} = (1-\rho)((\alpha + \tau_n) + \beta(\pi_{t+24} - \pi^*) + \gamma y_t) + \rho i_{n,t-1} + \omega_{n,t}. \qquad (3)$$

This model is used as a benchmark for comparison with the fixed-effects model when applying the Hausman test (see tables 1 and 2). In order to estimate member-specific slopes, a random-coefficients model is specified. The random-coefficients model has the following representation:

$$i_{n,t} = (1-\rho)((\alpha + \tau_n) + \beta_n(\pi_{t+24} - \pi^*) + \gamma_n y_t) + \rho i_{n,t-1} + \eta_{n,t}. \qquad (4)$$

It has been observed that committee members may also disagree on the smoothing parameter. Members who dissent frequently may have a lower smoothing parameter than other members who vote more consensual. Disagreement on the smoothing parameter may also show up in our regressions, if members have a different notion about the goal of monetary policy and therefore disagree with the staff inflation forecast. In order to check whether there is empirical support for this behavior, we estimate an additional version of

Table 1. Unconstrained Reaction Functions for Three Monetary Policy Committees

Sample	Coefficients: Equation	$\alpha(1-\rho)$	$\beta(1-\rho)$	$\gamma(1-\rho)$	ρ	Prob.	Adj. R^2	Obs.	Pooled Obs.
FOMC									
1993 to 2003	**Aggregate**	0.287 (0.027)	0.175 (0.015)	0.043 (0.005)	0.936 (0.006)		0.99	132	—
	Fixed Effects	0.279 (0.029)	0.150 (0.016)	0.051 (0.005)	0.938 (0.007)		0.99	132	1,371
	Random Effects	0.278 (0.030)	0.159 (0.016)	0.046 (0.005)	0.940 (0.006)	<0.01	0.99	132	1,371
1998 to 2008	**Aggregate**	0.129* (0.011)	0.255 (0.023)	0.031* (0.001)	0.945 (0.003)		0.99	132	—
	Fixed Effects	0.202* (0.022)	0.198 (0.041)	0.038* (0.002)	0.938 (0.006)		0.99	132	1,373
	Random Effects	0.180 (0.025)	0.205 (0.041)	0.036 (0.002)	0.940 (0.005)	<0.01	0.99	132	1,373
MPC									
1998 to 2007	**Aggregate**	0.164* (0.012)	0.116* (0.011)	0.061* (0.004)	0.971* (0.003)		0.98	120	—
	Fixed Effects	0.337* (0.031)	0.256* (0.022)	0.122* (0.009)	0.933* (0.006)		0.98	120	1,049
	Random Effects	0.319 (0.029)	0.236 (0.018)	0.121 (0.008)	0.936 (0.005)	<0.01	0.98	120	1,049

(continued)

Table 1. (Continued)

Sample	Coefficients: Equation	$\alpha(1-\rho)$	$\beta(1-\rho)$	$\gamma(1-\rho)$	ρ	Prob.	Adj. R^2	Obs.	Pooled Obs.
MPC									
1998 to 2008	**Aggregate**	0.129* (0.016)	0.162* (0.012)	0.124 (0.004)	0.971* (0.003)		0.97	132	—
	Fixed Effects	0.363* (0.038)	0.302* (0.025)	0.119 (0.008)	0.938* (0.007)		0.96	132	1,156
	Random Effects	0.137 (0.030)	0.167 (0.023)	0.120 (0.008)	0.977 (0.006)	<0.01	0.97	132	1,156
Riksbank's Executive Board									
1999 to 2007	**Aggregate**	0.074* (0.017)	0.111* (0.021)	0.086 (0.007)	0.970* (0.005)		0.97	107	—
	Fixed Effects	0.183 (0.068)	0.312 (0.082)	0.072 (0.024)	0.931 (0.020)		0.94	107	226
	Random Effects	0.177* (0.064)	0.328* (0.080)	0.078 (0.023)	0.932* (0.019)	0.68	0.94	107	226
1999 to 2008	**Aggregate**	0.108* (0.024)	0.190* (0.029)	0.123 (0.010)	0.950* (0.007)		0.94	119	—
	Fixed Effects	0.309* (0.101)	0.355* (0.115)	0.160 (0.036)	0.877* (0.029)		0.84	119	244
	Random Effects	0.323 (0.103)	0.401 (0.117)	0.153 (0.037)	0.868 (0.029)	0.02	0.84	119	244

Notes: Standard errors are in brackets. Prob.: The Hausman specification test selects the random-effects model, if the probability exceeds 5 percent; otherwise, the fixed-effects model is sufficient. *Wald tests reject that parameters are equal at the 5 percent level.

Table 2. Constrained Reaction Functions for Three Monetary Policy Committees

Sample	Coefficients: Equation	α	β	γ	ρ	Prob.	Adj. R^2	Obs.	Pooled Obs.
FOMC									
1993 to 2003	**Aggregate**	4.449 (0.304)	2.706 (0.613)	0.715 (0.143)	0.939 (0.018)		0.99	131	—
	Fixed Effects	4.551 (0.116)	2.271 (0.267)	0.877 (0.066)	0.943 (0.006)		0.94	130	1,394
	Random Effects	4.553 (0.108)	2.959 (0.292)	0.701 (0.060)	0.943 (0.006)	0.946	0.94	130	1,262
1998 to 2008	**Aggregate**	2.374 (0.789)	4.599 (1.611)	0.569 (0.116)	0.946 (0.018)		0.99	132	—
	Fixed Effects	3.055 (0.034)	2.984 (0.523)	0.592 (0.034)	0.933 (0.005)		0.97	132	1,381
	Random Effects	2.632 (0.262)	4.115 (0.619)	0.562 (0.038)	0.942 (0.005)	<0.01	0.97	132	1,323

(continued)

Table 2. (Continued)

Sample	Coefficients: Equation	α	β	γ	ρ	Prob.	Adj. R^2	Obs.	Pooled Obs.
MPC									
1998 to 2007	**Aggregate**	5.150 (0.301)	4.944 (1.584)	2.364 (0.538)	0.950 (0.015)		0.98	126	—
	Fixed Effects	5.485 (0.113)	4.183 (0.508)	1.947 (0.189)	0.936 (0.006)		0.96	125	992
	Random Effects	5.006 (0.113)	4.058 (0.488)	2.080 (0.158)	0.942 (0.005)	0.046	0.97	125	1,046
1998 to 2008	**Aggregate**	5.285 (0.336)	6.196 (1.881)	2.666 (0.595)	0.948 (0.015)		0.98	138	—
	Fixed Effects	5.487 (0.233)	5.663 (0.592)	2.068 (0.195)	0.935 (0.006)		0.96	137	1,187
	Random Effects	5.181 (0.109)	5.438 (0.585)	2.388 (0.188)	0.942 (0.005)	<0.01	0.96	137	1,187
Riksbank's Executive Board									
1999 to 2009	**Aggregate**	2.057 (0.427)	3.706 (1.680)	2.472* (0.800)	0.949* (0.024)		0.96	132	—
	Fixed Effects	1.924 (0.335)	2.576 (0.771)	1.340* (0.230)	0.875* (0.023)		0.90	132	381
	Random effects	2.613 (0.230)	1.937 (0.786)	1.370 (0.275)	0.865 (0.029)	<0.01	0.88	132	249

Notes: Standard errors are in brackets. Prob.: The Hausman specification test selects the random-effects model, if the probability exceeds 5 percent; otherwise, the fixed-effects model is sufficient. *Wald tests reject that parameters are equal at the 5 percent level.

the random-coefficients model (4) which allows for differences of the smoothing parameter ρ across members:[10]

$$i_{n,t} = (1 - \rho_n)((\alpha + \tau_n) + \beta_n(\pi_{t+24} - \pi^*) + \gamma_n y_t) + \rho_n i_{n,t-1} + \vartheta_{n,t}. \quad (5)$$

In the reaction functions, in principle all committee members are included, and it is possible to distinguish them individually in the pooled functions. Owing to new appointments and staggered contracts, the composition of committees changes over time. Therefore, the present study uses an unbalanced panel to take this into account. In comparison to approaches using individual reaction functions for each member, the unbalanced panel has the advantage to estimate longer runs of observations regardless of new appointments. When estimating the random-coefficients model, members with short terms are excluded, because this system would otherwise not be solvable. This approach allows both to consider heterogeneity on the slope parameters across members and to check whether the interest rate smoothing parameter ρ is different across members (see equation (5)).

Data for the individual (interest rate) preferences by committee members as available from the voting records are included in the individual or pooled reaction functions in the form of interest rate levels. As concerns the inflation gap and the output gap, all members are thought to base their vote on the staff forecast available at the time of the decision. By means of a Hausman test for correlated random effects, it is checked whether model parameters with fixed and random effects are statistically different. A rejection of the random-effects model is a first condition for systematic differences in the intercept (i.e., the preference parameter) across committee members, because in that model the distribution of individual preferences around the mean is random. Then, by means of Wald tests it can be checked whether parameters in aggregate regressions (1) and the corresponding pooled regressions ((2) and (3)) are statistically equal. If coefficients across specifications are equal, heterogeneity is either absent or may still relate to sub-groups of the

[10]For the FOMC, a paper by El-Shagi and Jung (2012) estimates individual reaction functions during the Greenspan era using individual forecast data.

committees (clusters) according to other unobserved factors (such as membership, backgrounds, and tenure).

A comparison of the parameters of (1) with panel regressions ((2) to (5)) can in principle provide information on four sources of heterogeneity in committees. First, members may share the committee's assessment of the macroeconomic situation but may be systematically biased regarding the policy response—i.e., be more hawkish or dovish than the mean voter in the committee (see Riboni and Ruge-Murcia 2008). Preference heterogeneity defined that way implies different intercepts (α). Second, policymakers may disagree on the response to the inflation forecast or inflation gap (see Berk and Bierut 2005). This form of heterogeneity would imply different slope coefficients (β). Third, policymakers may have different views on how to respond to the output gap (see Gerlach-Kristen 2006). This form of heterogeneity would imply different slope coefficients (γ). Fourth, if individual policymakers are less inertial than the committee when making interest rate decisions (see Blinder 1998), this would imply differences in the coefficient ρ.

Heterogeneity in a monetary policy committee may be also attributable to a combination of these factors. For instance, policymakers may assign different weights to inflation control and output smoothing, given different interpretations of the central bank's mandate. If policymakers have a different focus on the maintenance of price stability or if the focus changes over time, it would imply that they have a different ratio between inflation control and output smoothing (see Sibert 2002). The sacrifice ratio can be used to describe whether policymakers are in a "hawk" or "dove" regime (see Owyang and Ramey 2004). Then, the sacrifice ratio $\sigma(= \beta/\gamma)$ could give a supplementary indication on policymakers' preferences for a certain regime or chairmanship.

Furthermore, some heterogeneity that results from factors not modeled in the above function may not be captured by the intercept and slope parameter estimates. First, committee members may distance themselves from the staff forecast for inflation and output (see Kohn 2008).[11] Second, other factors may affect the dynamics of

[11]The ranges in the regularly published forecasts by the policymakers of the FOMC and the Bank of Japan illustrate this point. Unfortunately, the published forecasts are not attributed to individual members, but only provide a central tendency and the complete range.

committee deliberations, but the reaction function does not model them as separate sources of heterogeneity. Examples include other indicators of the monetary policy stance such as exchange rates, different modes of leadership in a monetary policy committee (Blinder and Morgan 2007), and disagreements among policymakers on the "true" objective function of monetary policy.

3.3 Reaction Functions for the FOMC, the MPC, and the Riksbank's Executive Board

When estimating the reaction functions, it is assumed that new information from the inflation forecast regularly becomes available at the meeting of its publication; i.e., the latest publicly available forecast is used. In practice, policymakers meet at a higher frequency and therefore have a richer data set at their disposal, including a sensitivity analysis of the effects of changed forecast assumptions for inflation and output. The Bank of England's MPC and the Riksbank's Executive Board publish their projections once each quarter, whereas the FOMC has a set of new projections for each meeting.

In general, the present econometric analysis focuses on the sample 1998 to 2008.[12] In order to check for robustness across time and data sets, the paper reports estimates covering alternative samples. In the case of the FOMC, an earlier sample (1993 to 2003) is used for which Greenbook data were available, whereas for the sample 1998 to 2008, real-time data were taken from the SPF and the Federal Reserve Bank of Philadelphia. For the MPC, the paper also reports results for the period 1998 to 2007 and for the Riksbank's Executive Board for 1999 to 2007.

In dynamic panels, the model estimates could suffer from autocorrelation. Orphanides (2001) makes the point that it is appropriate to use OLS estimates when real-time data are used.[13] Applying a

[12]Because members of monetary policy committees have staggered contracts, some members can only contribute very few observations to the panel analysis. The following members were not included when estimating the panel regressions: FOMC members Duke and Phillips, MPC members Dale and Sir Budd, and Riksbank's Executive Board member Ekholm.

[13]Orphanides (2003) applies both OLS and IV estimates (with four lags of the interest rate and of both gap variables) to address a possible simultaneity bias, and concludes that the results for the United States are similar.

GMM technique (see Arellano and Bond 1991) could have the advantage of providing unbiased estimates of the slope coefficients in a dynamic panel, but it is not necessary here given that the sample does not suffer from a small-sample bias in the time dimension.[14] In the following, results of pooled regressions are obtained from OLS and from generalized least squares (GLS) random-effects coefficient estimates (applying the Swamy-Arora estimator; for details see Baltagi 2001). Concerning the aggregate regressions (1), we check for heteroscedasticity and apply White's (1980) correction in order to compute heteroscedasticity-consistent standard errors.

Besley, Meads, and Surico (2008) compute the long-term response from the unconstrained regressions, whereas this paper includes the long-term response directly in the constrained reaction functions. It allows for improvements in the consistency of the parameter estimates. Section 3.3.1 reports the results for the unconstrained reaction functions that measure the short-term response for the three committees considered. Section 3.3.2 reports the results for the constrained reaction functions for them. Section 3.3.3 presents a cluster analysis to check for the possible existence of unobserved factors.

3.3.1 Unconstrained Reaction Functions

Table 1 shows that pooled and aggregate regressions have a high explanatory power and parameters are significant at conventional levels. In these regressions, the policy rate reacts positively to an inflationary shock and to shocks that widen the output gap. Slope coefficients are significant and have the expected sign. The Hausman test favors the fixed-effects model, which is an indication of systematic preference heterogeneity among committee members (the only exception is the sub-sample 1999 to 2007 for Sweden). Hence, the fixed-effects model is in general the benchmark for comparing parameters with the aggregate function of the committee.

[14]Note that in dynamic pooled regressions, the use of a lagged endogenous variable may imply the possibility that regressors are biased, if standard OLS panel regression techniques are applied. Besley, Meads, and Surico (2008) provide results for the MPC with the Arellano-Bond estimator. Moreover, when applying the Arellano-Bond method (not reported here for brevity of the exposition), results turn out to be broadly similar, but the intercept converges to zero.

A number of interesting results emerge from the estimates. First, in relation to the study by Besley, Meads, and Surico (2008), the paper finds that results for the MPC are broadly similar. However, using a real-time measure for the contemporaneous output gap instead of a forward-looking measure improves the estimates in terms of the significance of the coefficient and ensures the correct sign.[15] Second, for all three committees, Wald tests indicate measurable differences in the intercept (α) and thereby provide a further indication of preference heterogeneity. However, during the sample 1993 to 2003 for which Greenbook data are available, Wald tests for the FOMC regressions indicate the absence of differences in the intercept and, in line with the Hausman test, reject preference heterogeneity for that sample. Therefore, these results have to be further scrutinized, and we do so by using constrained reaction functions. Third, the high value of ρ suggests that a large part of the level of interest rates at time t is attributable to inertia in interest rates. It is explained by the fact that at a policy meeting, changes in interest rates are made by small amounts of usually 25 or 50 basis points (on rare occasions 75 basis points and more). Differences in smoothing coefficients between aggregate and pooled regression could be attributable to Blinder's (1998) supposition that committees are more inertial than individual policymakers. Here, Wald tests indicate such differences in inertia for the two inflation-targeting central banks, but not for the FOMC. Fourth, within a committee, policymakers can have different views on the transmission mechanism. This is supported by Wald tests which indicate differences of slope coefficients between corresponding aggregate and pooled reaction functions (with the exception of the FOMC during 1993 and 2003). Here, for the FOMC, differences of views mainly relate to the output gap, while for the two inflation-targeting committees, measurable differences of views relate to the inflation forecast or inflation gap. The different behavior could be attributable to the mandate of the central banks. The dual mandate requires FOMC members to explain their decisions both in terms of the risks for

[15]Besley, Meads, and Surico (2008) use a twelve-months-ahead forecast for the output gap. Their parameter estimates for the MPC show an output-gap coefficient with the wrong sign which is not significant.

inflation and economic growth, whereas inflation-targeting central banks focus mainly on inflationary risks.

When interpreting these results, it should be borne in mind that differences in the slope coefficients may also be attributable to the possibility that, contrary to our assumptions, some committee members may not share the staff forecast (or the inflation target). Gavin (2003) and Banternghansa and McCracken (2009) suggest that differences in individual members' forecasts on future inflation and output can be observed. Moreover, there could be disagreement on the usefulness of certain indicators. Meade and Thornton (2012) document substantial disagreement in the FOMC on whether the output gap in real time was a useful indicator to provide guidance for policy decisions.

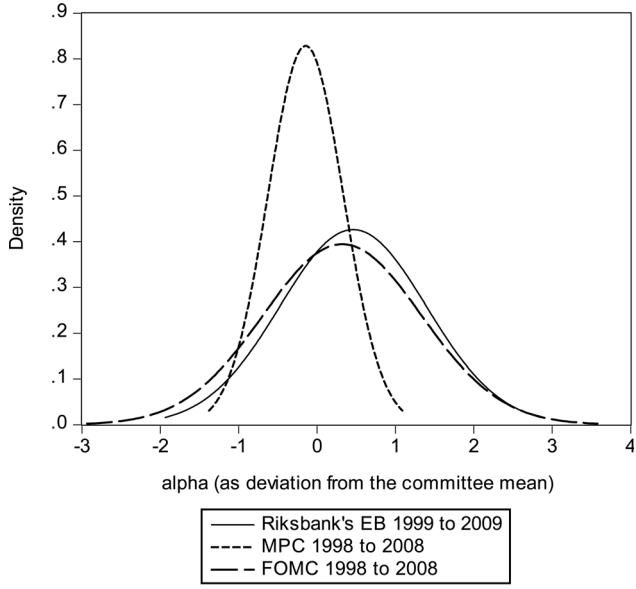
3.3.2 Constrained Reaction Functions

Table 2 shows the results of the constrained reaction functions for the three monetary policy committees. Again, pooled and aggregate regressions have a high explanatory power and parameters are significant at conventional levels. The policy rate reacts positively to an inflationary shock and to shocks that widen the output gap. Slope coefficients are significant, have the expected sign, and can be meaningfully interpreted. With the exception of one sample (FOMC during 1993 and 2003), the Hausman test selects the fixed-effects model and thereby gives an indication for the presence of systematic preference heterogeneity.

A number of interesting results emerge from the estimates. First, Wald tests find no statistically significant differences in the intercept (α) across regressions, even though the fixed-effects model is generally favored by the Hausman test. The finding suggests that preference heterogeneity for the committees as a whole is systematic but small. It does not exclude the possibility of measurable heterogeneity in sub-groups of members. Second, as illustrated in figure 2, policymakers' discrete preference-parameter distributions in all three committees are consistent with an underlying symmetric normal distribution.[16] Third, the high value of ρ confirms that

[16]The discrete distributions have been computed by deducting the committee mean from the individual α_i and by estimating the underlying continuous normal distribution.

Figure 2. Distributions of the Preference Parameter in Three Monetary Policy Committees



Notes: Estimates from constrained fixed-effects model. The above distribution has been estimated based on the discrete observations by members.

a large part of the level of interest rates at time t is attributable to inertia in interest rate, but differences between aggregate and pooled regressions are only significant for Sweden. Fourth, Wald tests find no statistically significant differences of slope coefficients between corresponding aggregate and pooled reaction functions for the FOMC and the MPC. In the case of Sweden, diversity of views concerning the output gap is detected in conjunction with diversity in inertia. It suggests that members disagree on how to respond to changes in the output gap. The different responses by members in the short and longer term as evident could be attributable to the financial crisis which led policymakers to express stronger concern of policymakers for output losses.

The (long-run) estimates of α can be interpreted in terms of the natural rate of interest. Using a hypothetical inflation target of 2 percent for the FOMC would yield (implied) estimates of the

natural (real) rate of interest r^* in a range of 0.4 percent to 2.5 percent, depending on the specification and sample. For comparison, Laubach and Williams (2003) provide an estimate for the natural real rate of about 3 percent for mid-2002 and a range of 1 percent to 5 percent for a forty-year sample. For the United Kingdom, using the current inflation target of 2 percent in terms of the CPI provides (implied) estimates of the natural real rate of interest r^* in a range of 3.0 percent to 3.5 percent. It is broadly in line with conventional estimates. Larsen and McKeown (2004) provide a mean estimate of the natural real rate of interest of 3.7 percent (with a standard deviation of 0.6 percent, sample 1992 to 2002). Benati and Vitale (2007) estimate the natural rate to have declined from 2.5 percent to 1.6 percent, as it has been influenced by demographical factors such as aging over recent years. For Sweden, using the inflation target of 2 percent in terms of the CPI provides (implied) estimates of the natural (real) rate of interest r^* in a range of 0 percent to 0.5 percent. These (ex ante) estimates of the natural real rate of interest are somewhat below what has been observed for Sweden. For comparison, Benati and Vitale (2007) estimate the natural real rate to be close to 2 percent.

Tables 3–5 show the estimated parameters by members for the three monetary policy committees. These results were obtained from the random-coefficients models (4) and (5) focusing on the last decade. The parameter estimates of both versions of the random-coefficients model are broadly similar, and all members shown appear to respect the Taylor principle. It implies that committee members pay full attention to threats to price stability.

For the FOMC, table 3 shows that preference heterogeneity (α) is more pronounced for the Federal Reserve Bank presidents than for the members of the Board of Governors. It is in line with available evidence (see Meyer 2004 and Meade 2005) that the Federal Reserve Bank presidents are less consensual with the chairman than the other members. However, in terms of response to economic shocks, it appears that all members differ substantially in their response to the inflation gap but show smaller differences in response to changes in the output gap.

For the monetary policy committees of the inflation-targeting central banks, tables 4 and 5 tend to show that preference

Table 3. Parameter Estimates by Members of the FOMC

Member	α	β	γ	Memo σ	β	γ	ρ	Memo σ
Sample 1998 to 2008	**Eq. (2)**	**Eq. (4)**			**Eq. (5)**			
Greenspan	3.25	4.47	0.51	8.83	4.23	0.51	0.90	8.29
Bernanke	3.00	2.84	0.40	7.07	2.85	0.45	0.94	6.36
Kohn	3.03	3.30	0.41	8.10	3.53	0.46	0.94	7.66
Bies	3.13	3.96	0.49	8.16	2.66	0.43	0.87	6.21
Ferguson	3.23	4.45	0.51	8.79	4.20	0.51	0.91	8.22
Gramlich	3.23	4.43	0.51	8.76	4.22	0.51	0.91	8.24
Olson	3.29	4.18	0.48	8.70	3.24	0.45	0.89	7.21
Kroszner	3.04	3.30	0.40	8.17	3.55	0.46	0.94	7.76
Rivlin	3.81	5.08	0.34	15.09	4.68	0.43	0.93	10.78
Meyer	3.10	4.85	0.60	8.12	4.65	0.54	0.89	8.68
Kelley	3.10	4.94	0.62	7.95	4.69	0.55	0.89	8.54
New York	2.90	3.50	0.46	7.67	3.21	0.54	0.94	5.94
Atlanta	3.34	4.59	0.42	10.83	4.69	0.46	0.94	10.14
Boston	2.88	3.20	0.46	6.88	3.06	0.46	0.90	6.60
Chicago	3.04	3.40	0.41	8.22	3.34	0.46	0.92	7.25
Cleveland	3.12	4.19	0.49	8.63	4.08	0.57	0.95	7.19
Dallas	2.85	3.82	0.54	7.13	85.84[a]	10.60[a]	1.00	8.09[a]
Kansas	2.87	2.91	0.42	6.97	2.80	0.42	0.90	6.61
Minneapolis	3.15	4.30	0.53	8.13	9.87[a]	1.14[a]	0.97	8.69[a]
Philadelphia	2.96	3.92	0.53	7.47	13.12[a]	1.59[a]	0.98	8.23[a]
Richmond	3.47	4.83	0.44	11.03	4.79	0.46	0.93	10.36
San Francisco	3.26	4.42	0.43	10.31	4.48	0.47	0.95	9.45
St. Louis	2.67	2.79	0.47	5.94	2.75	0.45	0.89	6.10

Note: For members Mishkin and Warsh, only insignificant parameters with wrong signs were obtained.
[a]Reported parameter estimates were not significant at the 10 percent level.

heterogeneity (α) is small; i.e., there seems to be broad agreement on the goals of monetary policy and on the natural rate of interest. In these committees, the tests indicate quite some differences of views on how to react to both changes in the inflation gap and in the output gap. As indicated by the sacrifice ratio, members of these committees may be hawkish or dovish to varying degrees. In the case of the MPC, four members are identified to be particularly

Table 4. Parameter Estimates by Members of the MPC

Member	α	β	γ	Memo σ	β	γ	ρ	Memo σ
Sample 1998 to 2008	**Eq. (2)**	**Eq. (4)**			**Eq. (5)**			
Sir George	5.39	3.74	2.25	1.66	3.63	2.14	0.93	1.70
Sir King	5.21	4.35	2.33	1.87	4.67	2.36	0.94	1.98
Lomax	4.79	4.15	1.66	2.50	4.71	1.89	0.95	2.49
Sir Large	4.96	3.40	1.56	2.18	4.34	2.49	0.96	1.74
Tucker	5.11	4.80	2.23	2.16	4.31	1.68	0.92	2.57
Bean	5.19	4.04	2.33	1.73	4.28	2.32	0.94	1.85
Barker	5.17	4.13	2.30	1.79	4.05	1.97	0.93	2.06
Nickell	5.00	3.83	1.89	2.02	4.89	2.25	0.95	2.17
Allsopp	5.21	3.42	2.14	1.60	4.68	2.10	0.95	2.22
Bell	4.87	4.10	1.66	2.48	4.98	2.44	0.95	2.04
Lambert	4.79	4.37	1.52	2.88	5.44	2.10	0.95	2.59
Buiter	5.66	3.60	2.34	1.53	2.62	1.91	0.90	1.37
Goodhart	5.54	4.23	2.50	1.70	3.84	2.29	0.93	1.68
Vickers	5.28	5.92	2.91	2.04	4.60	2.39	0.92	5.00
Julius	5.37	4.08	2.28	1.79	3.96	2.17	0.93	4.26
Wadhwani	5.38	3.03	1.88	1.61	1.94	1.28	0.89	2.19
Plenderleith	5.52	3.50	2.22	1.58	3.28	2.07	0.93	3.54
Clementi	5.40	3.78	2.29	1.65	3.24	2.04	0.92	3.52
Walton	4.92	0.00[a]	1.05[a]	0.00[a]	−0.21[a]	1.20	0.94	−0.23[a]
Sir Gieve	5.04	7.63	1.85	4.13	4.71	1.04	0.89	5.32
Blanchflower	4.98	10.48	1.28	8.21	4.93	0.65	0.86	5.75
Besley	5.25	9.52	1.68	5.68	3.57	0.55	0.80	4.49
Sentance	5.19	8.26	1.84	4.50	3.42	0.67	0.81	4.20

[a]Reported parameter estimates were not significant at the 10 percent level.

hawkish (Sir Gieve, Blanchflower, Besley, and Sentance). In the case of the Riksbank's Executive Board, two members (Bäckström and Hessius) appear to be more hawkish than the others, whereas one member (Rosenberg) seems more dovish than the others.[17]

[17]Some caution is warranted when interpreting the results, because not all individual beta and gamma coefficients passed the 10 percent significance level, in part due to the rather small number of available observations.

Table 5. Parameter Estimates by Members of the Riksbank's Executive Board

Member	α	β	γ	Memo σ	β	γ	ρ	Memo σ
Sample 1999 to 2009	**Eq. (2)**	**Eq. (4)**			**Eq. (5)**			
Bergström	2.95	2.14[a]	0.93	2.31	2.21[a]	0.98	0.91	2.25[a]
Bäckström	3.01	3.07	0.61	5.06	2.84	0.61	0.90	4.64
Heikensten	2.89	3.03	0.85	3.55	2.60	0.82	0.89	3.18
Hessius	3.24	3.24	0.71[a]	4.56	7.94[a]	1.49[a]	0.96	5.33[a]
Ingves	3.10	5.94	2.41	2.46	1.85[a]	1.18	0.77	1.57[a]
Nyberg	2.89	3.69	1.30	2.84	3.02	1.24	0.89	2.43
Wickman-Parak	3.54	5.14[a]	2.00	2.56[a]	1.54[a]	1.04[a]	0.90	1.49[a]
Persson	3.01	4.19	1.61	2.61	3.81	1.54	0.89	2.47
Rosenberg	3.19	3.63[a]	3.16	1.15	2.98[a]	2.57[a]	0.65	1.16[a]
Srejber	2.97	2.13[a]	0.60[a]	3.53[a]	2.69[a]	0.65[a]	0.93	4.11[a]
Svensson	3.05	6.20[a]	2.62[a]	2.36[a]	1.49[a]	1.13[a]	0.73	1.31[a]
Öberg	3.13	5.44	2.15[a]	2.53	1.66[a]	1.09	0.77	1.52[a]

[a]Reported parameter estimates were not significant at the 10 percent level.

The random-coefficients model (5) is a robustness check for (4) and provides further insights into the dispersion across members of the three committees, because it is able to track differences in individual smoothing parameters. A noteworthy point is that for the FOMC and the MPC, differences in the smoothing parameters across members are small. It suggests that members' dissenting behavior does not appear to be linked to their individual smoothing parameters, but mainly relates to the other factors (i.e., intercept and slope parameters). This finding is in line with the results based on the estimation of individual reaction functions using individual real-time forecasts for the Greenspan era (see El-Shagi and Jung 2012). Still, as shown there, differences across FOMC members in terms of persistence may exist when a committee member dissents publicly. In the case of the Riksbank's Executive Board, however, differences in smoothing parameters are measurable and could explain why members dissent in that committee. Typically, members with smaller smoothing parameters are those who are more dovish than the others.

3.3.3 Cluster Analyses of Unobserved Factors

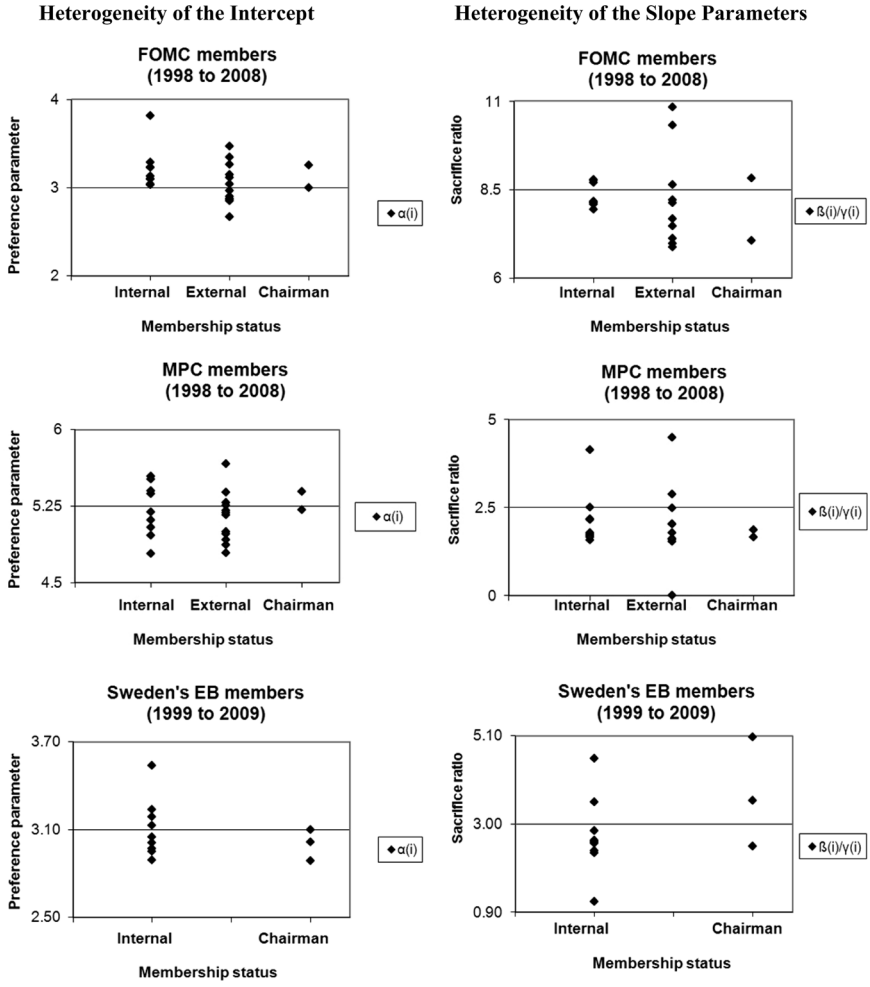
Members of monetary policy committees may vote differently because of a number of factors that are not captured by the reaction functions. Factors such as membership status, members' professional backgrounds, and tenure (and reappointment motives) may have a separate influence on voting patterns. In order to examine whether these unobserved factors capture heterogeneity in the three committees considered, we conduct separate cluster analyses. As discussed in section 2.3, the insider-outsider hypothesis suggests that internal committee members could behave more hawkishly than external committee members. Moreover, because of his leadership role and his prominent role in communications, the chairman of the committee could behave differently. We therefore distinguish three modes of membership (chairman, internal member, external member) for the FOMC and the MPC, and two modes for the Riksbank (chairman, internal member).[18] In order to examine the career-background hypothesis, we generate a "background" variable from the resumes of the members and use information from Harris, Levine, and Spencer (2010) for the MPC. The background variable refers to the main working experience of a member prior to joining the committee and takes three modes: academia, finance, and government. In order to examine (static) tenure effects, we generate a "tenure" variable from the membership history which distinguishes between three groups of members based on the ex post knowledge about the number of years they stayed in office (relative to their regular appointment): those who resigned prior to the end of their term (resignation), those who stayed six years or until the end of their term (expiration), and those who were reappointed for another term (reappointment).[19]

We check clusters of the individual preference parameters (α_i) and of their slope parameters (β_i, γ_i) from the (constrained) reaction functions and plot them by variable for each policymaker (see figures 3–5). For each committee, the fixed-effects models (2)

[18]In the case of the Federal Reserve, members of the Board of Governors are considered to be the internal members and the Federal Reserve Bank presidents to be the external members (members of the Board of Governors are appointed by the U.S. President, and Bank presidents by their Reserve Bank's board of directors).

[19]See Berk, Bierut, and Meade (2010) for an analysis of dynamic tenure effects for the MPC.

Figure 3. Membership Clusters of Committee Members in the Three Monetary Policy Committees



Notes: Left side: Estimates from (constrained) fixed-effects model. Right side: Estimates from (constrained) random-coefficients model. A solid, horizontal line shows the average preference parameter for these members.

from the constrained regressions provide estimates of individual preference parameters α_i (by members). Similarly, individual slope parameters β_i and γ_i are obtained from the (constrained) random-coefficients models (4).

Figure 3 (left-hand side) shows a plot of the individual preference parameters (α_i) for the FOMC, the MPC, and the Riksbank's Executive Board grouped according to three different modes of membership (chairman, internal member, external member). Over the past decade, the membership status explains some differences in preferences for the FOMC but not for the MPC. Estimates of the preference parameters of Federal Reserve Bank presidents were more disperse than those of members of the Board of Governors (even though they are both fairly symmetric around the committee mean).[20] In the case of the MPC, the preference-parameter distributions for internal and external members show a fairly similar width and are symmetric around the mean.[21] Also, the preference distribution of the Riksbank's Executive Board was symmetric around the mean. Moreover, in all three committees the chairmen were in a position close to neutral, which facilitates the role of a consensus builder within the monetary policy committee.

Members with broadly similar preferences may still differ in their views on how aggressively the committee should respond to economic shocks. One question, which arises in this respect, is whether members responded more (less) aggressively to changes in the inflation and output gap. The sacrifice ratio of the individual slope parameters (β_i/γ_i) provides a measure for the individual trade-offs by members in response to incoming or forecasted inflation and output data. Some authors have used it as an alternative measure for the "hawkishness" or preferences of members (see Sibert 2002 and Owyang and Ramey 2004).

Figure 3 (right-hand side) shows a plot of the sacrifice ratio by members for the FOMC, the MPC, and the Riksbank's Executive Board grouped according to the three different modes of membership (chairman, internal member, external member). The individual

[20]It should be noted, though, that membership and tenure are not fully independent factors in the case of the Federal Reserve. Hence, the observed differences may in part reflect tenure effects, because, as Kohn (2008) points out, Federal Reserve Bank presidents can be distinguished from Board members in that they have on average a longer tenure. At the same time, they have limited voting rights because of the rotation system.

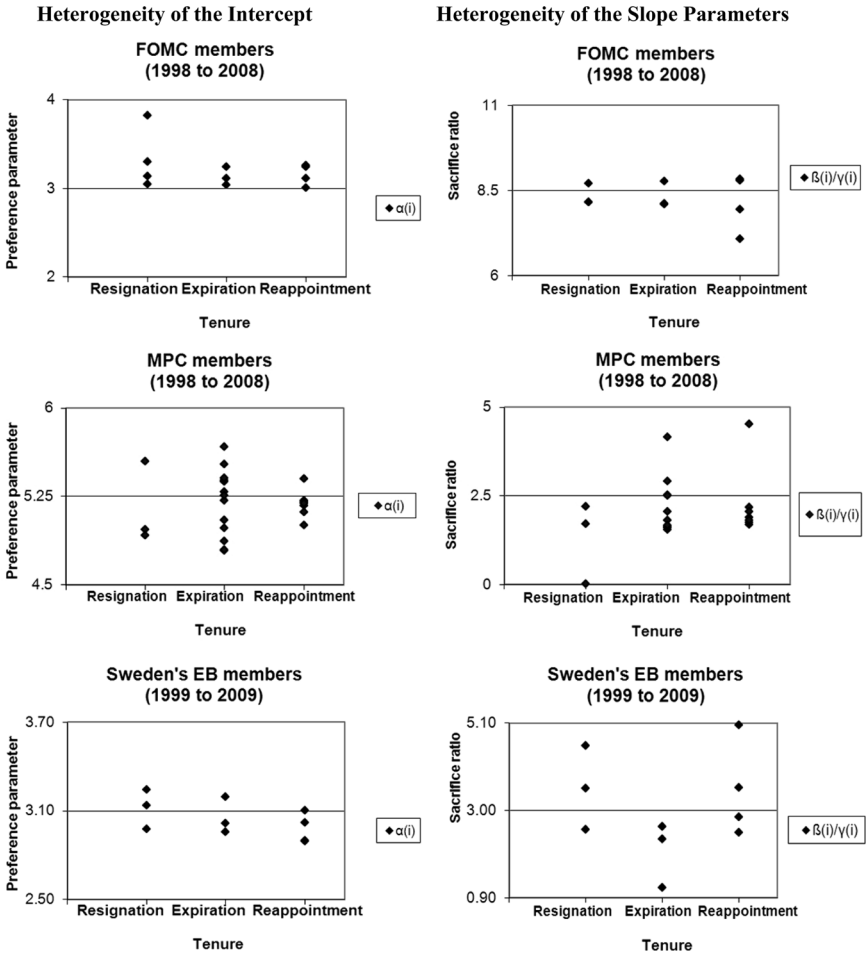
[21]Here also, membership and tenure are not fully independent factors, because this time internal members have a longer tenure of five years, whereas external members are appointed for three years (both subject to possible reappointment).

slope ratios of the parameter β_i (not shown here) indicate that members in all three committees respect the Taylor principle ($\beta > 1$). This is what would be expected from members of a central bank committee which aims to anchor inflation expectations in line with a primary price stability objective. A sacrifice ratio exceeding unity indicates that members tend to place more emphasis on changes in the inflation gap than on the output gap. With one exception, the sacrifice ratio (β_i/γ_i) exceeds unity, suggesting that members react more strongly to changes in the inflation gap than in the output gap.

The evidence presented in figure 3 (right-hand side) shows that for the FOMC, the membership status explains some of the differences in the reaction to economic shocks. It is interesting that estimates of the sacrifice ratios of Federal Reserve Bank presidents are by far more disperse than those of members of the Board of Governors. Similar observations can be made for the MPC. Here the distributions of the sacrifice ratios of the external members are also more disperse than those of the internal members. For the Riksbank's Executive Board, the distribution of the sacrifice ratios was fairly disperse. Concerning the specific role of the chairman, we find that FOMC Chairman Greenspan took a neutral position within the FOMC, and Chairman Bernanke was at the less aggressive side of the distribution. Similarly, both MPC chairmen (George, King) were at the less aggressive side of the distribution. In Sweden, two chairmen (Bäckström, Heikensten) were at the more aggressive side of the distribution and one chairman (Ingves) was in a neutral position. Overall, the picture that emerges from the comparison of slope ratios across committees is that the width of the dispersion around the mean of Federal Reserve Bank presidents and of external MPC members in both directions is greater than for members of the Board of Governors and internal members, respectively.

Next we address the question of whether the distinction between members' backgrounds and tenures explains heterogeneity. The cluster analysis allows exploring these characteristics: i.e., the partisanship hypothesis according to which the government may use the appointment process to actively influence the decision-making process and the career-background hypothesis according to which working for the government prior to appointment leads to more dovish behavior. Figures 4 and 5 provide additional clusters for all three committees, where plots for the FOMC refer only to the

Figure 4. Tenure Clusters of Committee Members in the Three Monetary Policy Committees



Notes: Left side: Estimates from (constrained) fixed-effects model. Right side: Estimates from (constrained) random-coefficients model. For the FOMC, the above results apply to the members of the Board of Governors. A solid, horizontal line shows the average preference parameter for these members.

members of the Board of Governors (because they can be identified individually and are appointed by the U.S. President).

Figure 4 shows the distribution of individual preference parameters (α_i) and of individual sacrifice ratios (β_i/γ_i) relative to

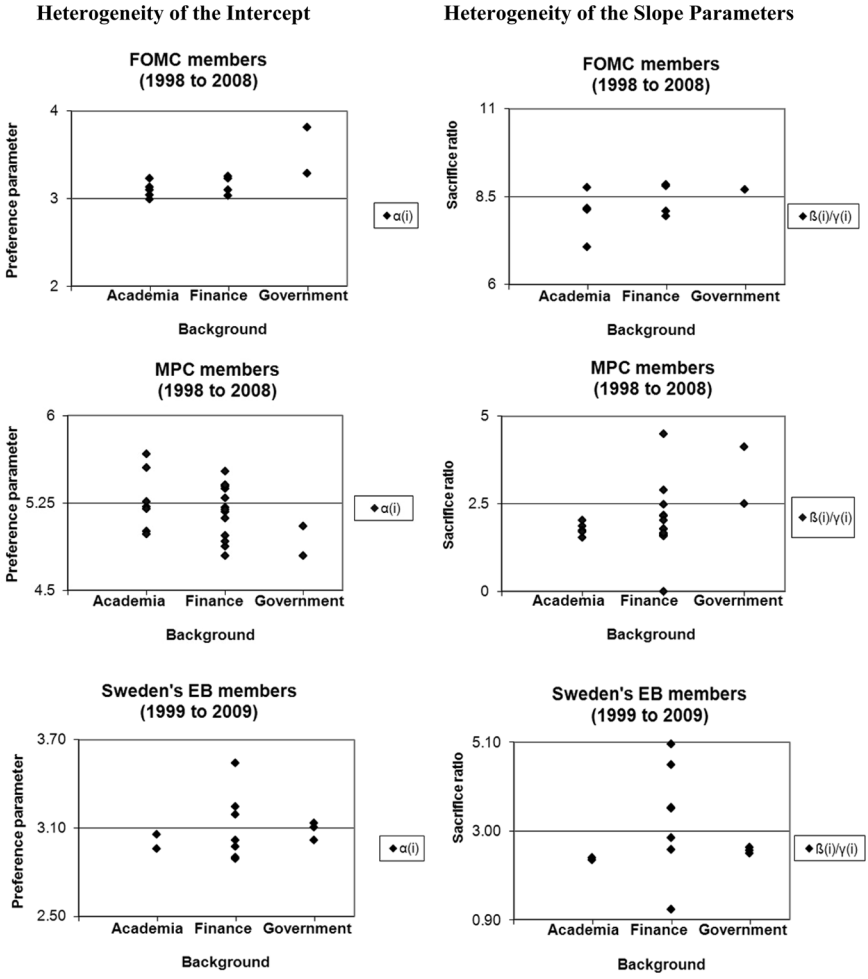
members' tenure variable. In all three committees considered, several members were reappointed or resigned before their contract expired. The results suggest that tenure, as defined above, does not explain systematic differences across committees. Strikingly, most of the dispersion is attributable to members who stayed in office until the end of their tenure. Moreover, for the three monetary policy committees, it cannot be shown that members with more dovish (hawkish) preferences or members who respond less (more) aggressively to economic shocks seem to have better chances of being reappointed (are more likely to take an early resignation). Overall, the evidence presented is in contrast to the partisanship hypothesis.

Figure 5 shows the distribution of individual preference parameters (α_i) and of individual sacrifice ratios (β_i/γ_i) relative to members' background variable. For the FOMC and the Executive Board of the Riksbank, the patterns were not systematic. In the case of the MPC, members with a career background in the government sector were somewhat more dovish than other members, though in contrast to the hypothesis, these members reacted more aggressively to economic shocks. Overall, this suggests that the career-background effect is not systematic in all three committees.

4. Conclusions

This paper provides new evidence on the drivers of diversity in monetary policy committees in an international comparison. Detecting diversity in monetary policy committees is hampered by the confidential nature of the policymaking process. While acknowledging the potential shortcomings of minutes as a source of diversity, we exploit information contained in published voting records from three monetary policy committees and combine them with real-time information on economic variables from official sources (such as Inflation Reports). This paper conducts an indirect measurement of policymakers' individual preferences and responses to incoming data in real time. We estimate empirical reaction functions for three monetary policy committees (the FOMC, the Bank of England's MPC, and the Riksbank's Executive Board) over the last decade. Empirical reaction functions serve as benchmarks for comparing differences in members' responses within and across committees, and

Figure 5. Background Clusters of Committee Members in the Three Monetary Policy Committees



Notes: Left side: Estimates from (constrained) fixed-effects model. Right side: Estimates from (constrained) random-coefficients model. For the FOMC, the above results apply to the members of the Board of Governors. A solid, horizontal line shows the average preference parameter for these members.

not as policy rules which aim to provide policy prescription. Using this approach, the paper detects differences in policymakers' preferences and views on the transmission mechanism in three monetary policy committees.

This paper finds evidence in favor of preference heterogeneity among committee members and identifies several possible sources for its occurrence. Over the last decade, we find preference heterogeneity to be systematic, but possibly small, in all three committees. A possible exception is the FOMC during 1993 to 2003, where preference heterogeneity is found to be random, and, more like in the CEE inflation-targeting countries (see Jung and Kiss 2012), members' disagreement about the response to shocks dominated. More specifically, unconstrained reaction functions that measure members' short-term response to shocks show that preference heterogeneity and some diversity of views on the inflation and economic outlook was present in all committees. During 1998 to 2008, for the FOMC, measurable differences of views relate to the output gap but not to the inflation gap. For the two inflation-targeting committees, measurable differences of views relate to the inflation forecast or inflation gap, but not to the output gap. This different behavior could be attributable to the mandate of the central banks which includes a more explicit concern for economic growth in the case of the Federal Reserve. By contrast, constrained reaction functions that measure members' long-term response to shocks find that evidence in favor of preference heterogeneity in all three committees is systematic but hardly measurable (i.e., it mainly relates to the selection of the fixed-effects model). Preference distributions in all three committees were fairly symmetric around the respective mean, and diversity of views on the output gap was only observed in the case of Sweden when including the financial crisis episode.

Separate cluster analyses exploiting individual response parameters to shocks from the reaction functions suggest that among several unobserved background characteristics (membership, tenure, background), the membership status (chairman, internal member, external member) is a potentially relevant factor that may explain some of the differences for the FOMC and for the MPC. These differences relate both to preferences and to views on the transmission. Dispersion of Federal Reserve Bank presidents' preferences are larger than those of the members of the Board of Governors, whose preferences are fairly similar. In part, as suggested by information from FOMC transcripts, this finding may be the result of strong consensus-building efforts in the Board prior to the vote. In the case of the MPC, preference heterogeneity is systematic but similar

for internal and external members. However, when comparing how they react to shocks, it also turns out that, overall, internal members react more uniformly to the inflationary consequences of shocks than external members.

Clearly, the present approach has known limitations. First, when making decisions, policymakers refer to a much broader set of indicators, and their understanding of the transmission mechanism may differ from the simple reaction function used in this paper. Second, policymakers could be more averse to deflationary than to inflationary shocks. Mainly, because of important data constraints, these two important points have to be left for further research.

Appendix. Data and Sources

Table 6 provides an overview on the sources of the data used in this paper. Voting records for the FOMC are from the Federal Reserve's web site: www.federalreserve.gov/monetarypolicy/fomccalendars.htm. Real-time data for the Federal Reserve are available from the web site of the Federal Reserve Bank of Philadelphia: www.philadelphiafed.org. The database includes real-time series for the output gap as reported in the Greenbook (until end-2007), inflation projections from the Greenbook, and from the Survey of Professional Forecasters (SPF). Real-time data for the Bank of England are available from spreadsheets on their web site: www.bankofengland.co.uk. The database includes voting records, and real-time inflation projections are from the Bank's Inflation Report. Real-time data for the Swedish Riksbank are available from their web site: www.riksbank.com/. The database includes voting records, and real-time inflation projections are from the Bank's Monetary Policy Report.

Properties of the Data

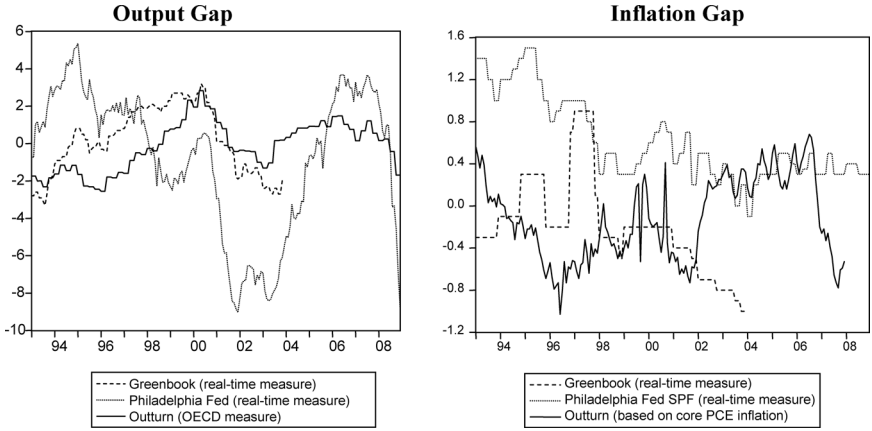
The FOMC

The inflation gap is computed as the difference between the inflation forecast two years ahead and a (notional) numerical target of 2 percent (as advocated by Taylor 1993). The assumed numerical value is consistent with longer-run forecasts of inflation by FOMC

Table 6. Data Sources

	United States	United Kingdom	Sweden
Voting Records	Extracted from FOMC minutes	Spreadsheet from the web site of the Bank of England since June 1997	Spreadsheet from the web site of the Riksbank since January 1999
Inflation	(a) PCE core deflator (b) CPI (source for both: web site of the Federal Reserve Bank of Cleveland)	CPI headline, available from 1996	CPI (source: Statistics Sweden, and available from the Riksbank's web site)
Inflation Forecast	(a) Greenbook data, chain-weighted GDP price index (until end-2003) (b) Survey of Professional Forecasters (CPI) (source for both: web site of the Federal Reserve Bank of Philadelphia)	CPI headline, based on constant interest rates, until February 2004 the RPIX was used (extracted from the Bank of England's Inflation Reports)	CPI headline, based on constant rates until autumn 2005, then on market rates, and since 2007 on the bank's interest rate path (extracted from various Monetary Policy/Inflation Reports of the Riksbank)
Output Gap (Outturn)	(a) From FRED (source: Federal Reserve Bank of St. Louis database) (b) From the OECD (OECD database)	(a) Based on HM Treasury data (web site of HM Treasury) (b) From the OECD (OECD database)	Computations by the Riksbank (source: Statistics Sweden)
Output Gap (Real Time)	(a) Greenbook data (until end-2003) (b) Recursive estimate from Federal Reserve releases on capacity utilization (source for both: Federal Reserve Bank of Philadelphia)	Recursive estimate, calculated from the Bank of England's GDP real-time forecasts	HP measure (extracted from various Monetary Policy/Inflation Reports of the Riksbank)
Policy Rate	Federal funds target rate (Federal Reserve web site)	Bank Rate (Bank of England web site)	Repo rate (Swedish Riksbank web site)

Figure 6. U.S. Data

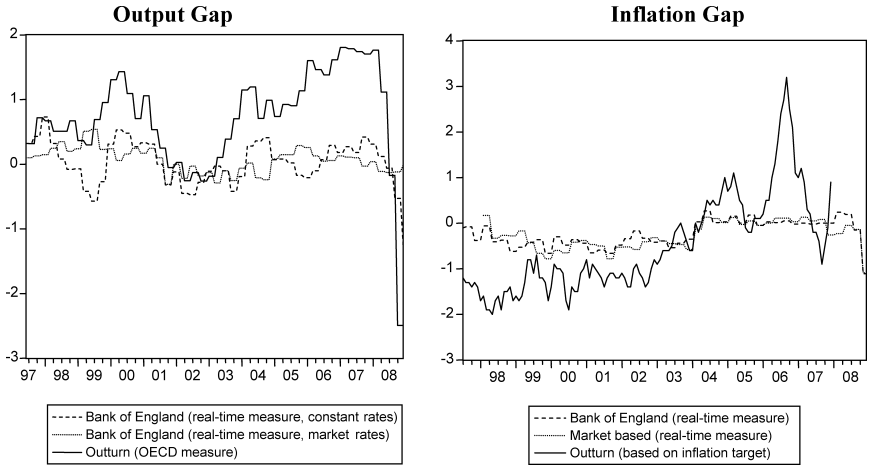


Sources: See table 6.

members conditional on appropriate monetary policy, and with past outturns (for the sample 1993–2008, inflation, as measured by the PCE (core) deflator, was on average 1.97 percent), and with recent clarifications on the long-run goal of the Federal Reserve. A plot (see figure 6) shows that for 1993 to 2001, both real-time measures of the inflation gap tend to overestimate its outturn, and for 2001–03, the Greenbook measure underestimates it. Prior to the deflation scare, the Federal Reserve's internal Greenbook real-time measure is closer to the outturn than the SPF measure. After the deflation scare and until the outbreak of the financial crisis, the inflation gap based on the SPF real-time measure (which is based on headline CPI inflation) is reasonably close to the outturn. Anecdotal evidence suggests that the FOMC indeed overestimated the risk of deflation during the deflation scare of 2002–03 (see U.S. Federal Reserve, Bluebook, June 2003).

Concerning the output gap, the study considers two measures: the real-time measure from the Greenbook and a real-time measure recursively estimated from Federal Reserve Bank of Philadelphia real-time data on capacity utilization. The Congressional Budget Office (CBO) reports an alternative measure, which depends on the estimate of the natural rate of unemployment. It therefore may have exaggerated cycles over past years, in particular during the financial

Figure 7. UK Data



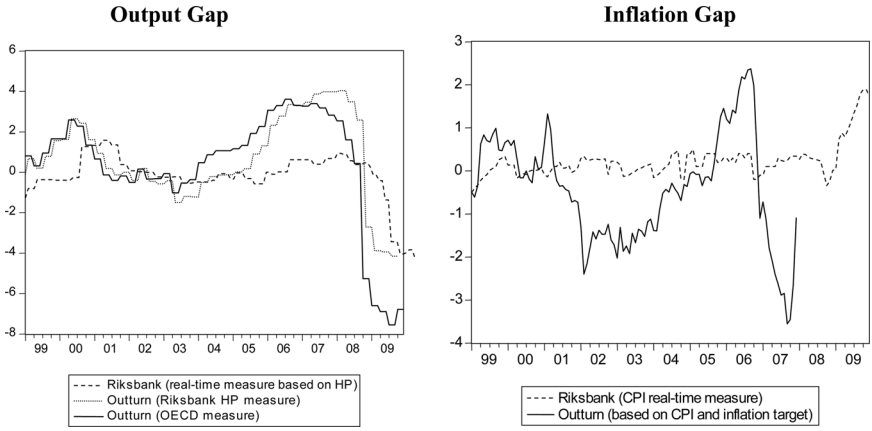
Sources: See table 6.

crisis (see Weidner and Williams 2009). Alternatively, the (final) output-gap series from the OECD could be used. It is rather smooth around turning points. Figure 6 shows that the Greenbook estimates track outturns quite well, whereas the recursive measure reacts more strongly around turning points (i.e., similar to the measure from the CBO).

The MPC

When computing the inflation gap, a change in the Bank of England's inflation target is taken into account. The inflation target was initially 2.5 percent for the RPIX, and then changed to 2.0 percent in terms of the CPI (see King 2004). In its inflation projections, the Bank has used the CPI since February 2004, and before that date it reported forecasts based on the RPIX. Figure 7 plots inflation gaps for the United Kingdom. It suggests that the MPC may have systematically overestimated the inflation gap in real time. In this respect, the Bank of England's inflation forecasts seem to closely track the inflation target at the two-year policy horizon. Moreover, in 2006–07 the MPC was apparently taken by surprise when an oil and commodity price shock hit the economy and caused the inflation gap to widen.

Figure 8. Swedish Data



Sources: See table 6.

A set of recursive estimates for the real-time output gap is computed based on real-time GDP forecasts conditioned on constant interest rates, and a forward-looking measure based on market expectations (with GDP forecasts two years ahead). For comparison, (final) output-gap data from the OECD's production function approach is used. The measure is similar to the Treasury's trend point measure (see HM Treasury 2010).

The Riksbank's Executive Board

The (real-time) inflation gap for the CPI is the difference between the (two-year-ahead) inflation forecast and the inflation target of 2 percent (and similarly for outturns). Figure 8 shows inflation gaps for Sweden. The real-time measure of the inflation gap hovers around zero for most of the sample and then picks up at the end of it. Like the Bank of England, the Riksbank forecasts inflation to be close to its inflation target of 2 percent for the CPI at the two-year (ahead) policy horizon. Forecast errors are significant around the turn of economic cycles and during recessions (see Svensson 2010).

The Riksbank uses a number of indicators to measure resource utilization in the economy (see Svensson 2010). One of these measures is the output gap, calculated as the percentage difference

between GDP and an estimated trend. For the output gap, the Riksbank publishes a measure computed on the basis of an HP filter which is considered at Board meetings. This series is available for the full sample. The output gap according to the HP method is, however, not a summary indicator on policymakers' views on resource utilization. Policymakers always monitor a set of alternative measures constructed with different tools, thereby accounting for uncertainty about the output gap. The real-time measure from the Riksbank and the outturn show a close co-movement with some deviations over past years (see figure 8). Like the Bank of England's MPC, in real time the Riksbank's Executive Board somewhat underestimated the output gap (see Svensson 2010).

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