Dissent voting behavior of central bankers: what do we really know?

Horvath, Roman; Rusnak, Marek; Smidkova, Katerina and Zapal, Jan

11. November 2011

Dissent Voting Behavior of Central Bankers: What Do We Really Know?

Roman Horvath[a] Marek Rusnak[b,c] Katerina Smidkova[b,a] Jan Zapal[d]

[a]Charles University [b]Czech National Bank
[c]CERGE-EI [d]London School of Economics

November 10, 2011

Abstract

We examine the determinants of the dissent in central bank boards' voting records about monetary policy rates in the Czech Republic, Hungary, Sweden, the U.K. and the U.S. In contrast to previous studies, we consider about 25 different macroeconomic, financial, institutional, psychological or preference-related factors jointly and deal formally with the attendant model uncertainty using Bayesian model averaging. We find that the rate of dissent is between 5% and 20% in these central banks. Our results suggest that most regressors, including those capturing the effect of inflation and output, are not robust determinants of voting dissent. The difference in central bankers' preferences is likely to drive the dissent in the U.S. Fed and the Bank of England. For the Czech and Hungarian central banks, average dissent tends to be larger when policy rates are changed. Some evidence is also found that food price volatility tends to increase the voting dissent in the U.S. Fed and in Riksbank.

JEL Classification: E52, E58
Keywords: monetary policy, voting record, dissent

We thank Jakub Matějů for helpful discussions and Petra Gerlach-Kristen for sharing the U.S. data on the number of dissents of board members. We appreciate the use of Matlab toolbox for Bayesian model averaging developed by Martin Feldkircher and Stefan Zeugner. The views expressed in this paper are not necessarily those of the Czech National Bank. We acknowledge the support from the Grant Agency of the Czech Republic P402/10/0448.

Email contact: roman.horvath@gmail.com.

1 Introduction

Central bankers often have to take difficult policy decisions that cannot be guided fully by available models and simple policy rules and that have to rely on intuition and judgment of individual central bankers (ECB, 2006). It is therefore not unusual to observe dissent when central bankers vote about monetary policy rates. Especially in times of high uncertainty such as during the recent global financial crisis, opinions about appropriate policy measures may differ sharply.

On the one hand, some authors (Issing, 1999) claim that consensual decisions may be superior to those obtained by a majority voting because their communication is easier and they anchor expectations better. In addition, consensual decisions reduce political pressures. On the other hand, other studies (Blinder and Morgan, 2005) illustrate that decisions taken by a group of independent individuals are superior to other decisions. Moreover, several studies (see Gerlach-Kristen, 2004, and Horvath et al., 2010, among others) indicate that a degree of disagreement provides a very useful information about future policy moves. It follows that disagreement among central bankers can be viewed as a useful part of monetary policy practices.

It is therefore surprising that we know relatively little about whether monetary policy decisions around the globe are taken consensually or not and also very little about major factors driving dissent among central bankers. Obviously, one reason for the lack of knowledge about these issues is that most central banks do not release voting records from their monetary policy meetings. Another reason is that existing literature focuses only on selected central banks (typically the U.S. and U.K.) and investigates rather narrow set of possible determinants. Our ambition is to contribute to this small, but growing literature and examine many factors jointly that can in principle contribute to voting dissent.

In comparison to the existing literature, we examine more central banks to give richer international perspective to our research and analyze the determinants of dissent using the voting records for central banks in the Czech Republic, Hungary, Sweden, the U.K. and the U.S. These central banks display a different rate of dissent. While we find that the dissent rate for U.S. Fed is well below 5%, the dissent rate in the Bank of England and Riksbank is around 10% in our sample and the rate of dissent in Czech and Hungarian central banks reaches 15% and 20%, respectively.

On the top of that, since the literature does not give unequivocal theoretical

model for central bankers' dissent behavior, we deal formally with the model uncertainty to understand the robustness of the results on voting dissent in a fuller manner. One major issue is that previous literature does not reach consensus whether the voting behavior is not unanimous because of the heterogeneity in preferences of central bankers, the heterogeneity in information sets of central bankers, or both.

For this reason, we employ Bayesian model averaging (BMA) to analyze rigorously to what extent various macroeconomic, financial, institutional, psychological or preference-related factors (together about 25 different regressors) contribute to voting dissent. One of additional benefits of BMA for applied work is that it gives the posterior inclusion probability for each regressor (e.g. the "probability that given regressor should be included in the correct model of voting dissent") and therefore, allows ranking of various factors affecting the dissent according to their marginal importance. In consequence, we may pinpoint what type of factors typically make the central bankers disagree. In contrast to previous literature, which focused on the internal-external distinction, career backgrounds or other institutional characteristics, we also examine the role of macroeconomic and financial factors.

In addition, BMA allows us examining jointly the importance of factors, which are typically highly collinear such as inflation, inflation squared, inflation forecast or the deviation of inflation from inflation target.[1] For example, the empirical literature on the monetary policy rules often discusses, which of the aforementioned variables are appropriate for modelling central banks' interest rate setting. Our analysis may in principle shed light on this issue by examining, which of these variables matter more for voting dissent.

Our results suggest that only a few regressors are robust determinants of voting dissent. Even though the regressors exhibit the expected coefficient sign, their posterior inclusion probability is rather low. This includes some 'traditional' determinants such as those related to inflation or output. In addition, the determinants of dissent with high posterior inclusion probability are country–specific, to a certain extent. For the U.S. Fed and the Bank of England, we find that difference in central bankers' preferences is likely to be behind different voting record of individual board members. The results suggest that changing policy rate triggers more dissent in Czech and Hungarian central banks. This

[1] See Hoeting et al. (1999) for underlying statistical theory. Montgemery and Nyhan (2010) provide an example in political science, how BMA can be useful in distinguishing the importance of collinear factors in explaining civil wars.

indicates that different board members give different weight to a new signal about the change in unobserved optimal policy rate. In addition, food price volatility is one of the robust determinants of voting dissent in the U.S. Fed and Riksbank.

The paper is organized as follows. Section 2 provides a brief discussion of related literature. Section 3 presents the data. Section 4 introduces Bayesian model averaging. Section 5 gives the empirical results. Conclusions are available in section 6.

2 Related Literature

We briefly survey literature relevant to a question of whether and why members of a monetary policy committee might differ in their opinion about appropriate course of monetary policy.

To start with there is a large literature in social psychology documenting conformity induced by the fact that a person belongs to a group (Cialdini and Goldstein 2004, Baumeister and Vohs, 2007). Usual explanation of the conformity is then either informational influence among the group members or fear of potentially dissenting member of being left out or looked upon negatively by other group members (Brown 2000, chapter 4). In this respect, Berk et al. (2010) find that the differences in voting behavior of internal and external Bank of England's MPC members occur not earlier than after three years in the office.

Still, differences among the monetary decision makers can be given either by their different preferences or by different information they posses. And even with the latter being the same dissent can arise due to a different interpretation of the shared information.

Indeed, there is a large literature documenting different preferences on the part of monetary decision makers. One strand of literature looks at the Bank of England Monetary Policy Committee (MPC) and finds differences among members coming from within the bank (insiders) and those coming from outside the bank (outsiders) (Bhattacharjee and Holly 2006, 2010, Gerlach-Kristen 2003, Harris and Spencer, 2009, Harris et al., 2011**,** Hansen and McMahon 2011). On the other hand, Besley et al. (2008) document little differences between insiders and outsiders (and academic versus non-academic and treasury versus non-treasury members) claiming that the observed individual heterogeneity is driven by personal characteristics unrelated to membership in any of the men-

tioned categories. Interestingly, Besley et al. (2008) also find that a level of disagreement in the MPC is significantly lower immediately after any policy change.

Another strand of literature showing differences in preferences focuses on the US Federal Reserve Federal Open Market Committee (FOMC) (Chappell et al., 1997, Chappell and McGregor, 2000, Chappell et al., 2004, 2005). Typically, the differences are documented via different intercepts of estimated individual reaction functions. Those differences can be further explained by different regional affiliation of the FOMC members (Chappell et al. 2008, Meade and Sheets 2005).

But evidence suggesting that it is different information or different interpretation of the same information that is driving heterogeneous opinions is also relatively easy to find. For example, for FOMC Chappel, McGregor and Vermilyea (2005) provide evidence of not only different intercepts of individual reaction functions, but also of different strength of reaction to economic variables by the FOMC members.

Finally, higher disagreement can be driven simply by a larger committee size and hence purely mechanically. Then any variable with an influence on the committee size will influence disagreement as well. In this respect, Erhart and Vasquez-Paz (2007) in their survey of central bank decision making committees show that countries with larger and more volatile GDP, larger population and larger inflation volatility have larger central bank boards. Berger et al. (2008) find that the countries with more democratic institutions and more independent central bank tend to have larger boards. Berk and Beirut (2011) model the benefits and costs of committee decision-making in central banks and show that communication helps disseminate the knowledge among board members and may effectively work as a substitute to expanding the size of a committee. Horvath et al. (2010) find that different voting protocols (or voting systems) influence the frequency of voting dissent. The democratic voting protocol under which the board members express individualistically their preferences typically generates the higher frequency of voting dissent.

In addition, publicity of debate may decrease the incentives to dissent. Meade and Stasavage (2008) find that once FOMC of the U.S. Fed decided to begin releasing transcripts, the level of dissent has decreased. Meade (2010) adds that the dissent for FOMC members representing larger Fed districts decreased more. As a consequence, this stream of research highlights the importance of institutional factors.

Overall, the literature mentioned above suggests that each monetary policy committee should, due to individual differences, have its baseline disagreement rate. This baseline should be to a certain extent but not fully determined by the size of the committee and different individual preferences that can in fact be a reason for being elected a committee member.. Actual disagreement during a specific meeting should then be determined from the baseline as a function of the time the committee has remained the same, as a function of current economic variables and as a function of previous decision.

3 Data

First, we describe the voting dissent data. Second, we give details on the construction of our explanatory variables. The voting record data are collected from the minutes of monetary policy meetings and are freely available on the websites of respective central banks.[2] The source of other data is the IMF's International Financial Statistics and Eurostat.

Table 1 presents the descriptive statistics of the prevalence of voting dissent in the U.S. Fed, Bank of England (BoE), Riksbank, Czech National Bank (CNB) and Hungarian National Bank (MNB). The total number of votes varies from 554 (for the Riksbank) to 2016 (for U.S. Fed). This reflects not only different time coverage, but also a different number of board members as well as different frequency of monetary policy meetings. The institutional background for monetary policy decisions in these central banks is extensively discussed in Horvath et al. (2010).

We find that the rate of dissent varies across the central banks. It is lowest for the U.S. Fed, which records the rate of dissent of less than 5%. This is likely to be a consequence of voting protocol under Greenspan chairmanship with a low level of dissent. This trend continued under Bernanke chairmanship during the financial crisis. On the other hand, the Czech and Hungarian central banks exhibit the highest dissent rate (15% and 20%, respectively). This likely follows from individualistic voting protocol of these two central banks as well as from a higher number of board members in case of the Hungarian central bank (the average of present board members above 10 in our sample). Interestingly, the rate of dissent in the Czech and Hungarian central banks almost doubles at the policy meetings, when the rates are changed. In addition, the Czech and

[2]We plan to post our data on the website of Central Bank Communication Network, http://www.central-bank-communication.net/, to be freely used by other researchers.

Table 1: Dissent in Monetary Policy Committees, Descriptive Statistics

Central Bank	FED	BoE	Riksbank	CNB	MNB
Total number of votes	2016	1336	554	897	577
Majority votes	1919	1157	509	762	463
% of total	*95.2%*	*86.6%*	*91.9%*	*84.9%*	*80.2%*
Total number of dissents	97	179	45	135	114
% dissents of total	*4.8%*	*13.4%*	*8.1%*	*15.1%*	*19.8%*
Dissents to lower rates	30	101	22	62	74
% lower rates of dissents	*30.9%*	*56.4%*	*48.9%*	*45.9%*	*64.9%*
Dissents to higher rates	67	78	23	75	40
% higher rates of dissents	*69.1%*	*43.6%*	*51.1%*	*54.1%*	*35.1%*
Average dissents - IR changed	0.53	1.11	0.47	1.64	2.67
Average dissents - IR not changed	0.52	1.21	0.47	0.58	1.81
Avg. number of present board members	10.9	8.8	5.8	6.3	10.9
Dissenting governor (no. of meetings)	0	2	0	0	5
Sample	1987:8– 2009:12	1997:6– 2009:12	1999:1– 2009:12	1998:1– 2009:12	2005:10– 2009:12

Hungarian central banks do not only display a greater degree of voting dissent, but the higher number of dissenting members is not uncommon, as Figure 1 indicates. The dissent for higher and lower rates is equally frequent in the Riksbank and Czech National Bank, and in the Bank of England, to a certain degree. On the other hand, dissenting for higher rates is much more common in the U.S. Fed, while dissents for lower rates occur more frequently in Hungarian National Bank.

Next, Figure 2 gives a list of our explanatory variables. All in all, we consider 25 different variables. With some level of simplification, we may divide them into four categories: economic factors, psychological factors, institutional factors and preference related factors.

Economic factors

- It may be more difficult for board members to agree when facing larger uncertainty about inflation developments. Fast reaction to shocks triggers trade-offs for secondary targets such as financial stability or employment and slow reaction is costly in terms of target credibility. The nature of shocks also play a role, while supply shocks typically call for mild response, demand shocks may be a reason for aggressive policy. We capture the uncertainty about inflation developments by several closely related variables: current inflation change, inflation squared, future inflation and difference

Figure 1: The Frequency of Dissent

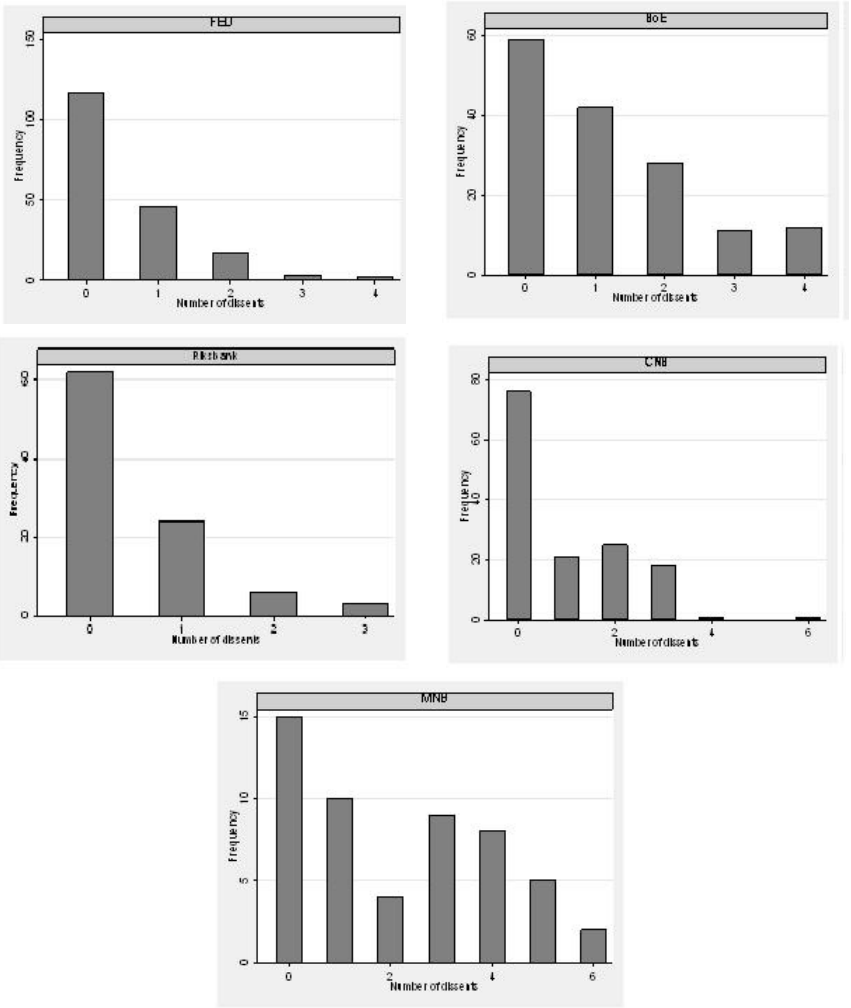

Table 2: The Description of Explanatory Variables

Explanatory variable	Description
inf_change	The change in current inflation over inflation in previous month
inf_gap_sq	The difference between current inflation and inflation target squared
inf_sq	The current inflation squared
inf_forecast	The inflation forecast (actual inflation 12 months ahead)
ip_growth	The industrial production growth
ip_gap_sq	The difference between current industrial production and HP-filtered industrial production squared
u_change	The change in unemployment rate
u_gap_sq	The difference between current unemployment and HP-filtered unemployment squared
m_growth	The growth of monetary aggregate M2
m_gap_sq	The difference between current M2 level and HP-filtered M2 level squared
er_growth	The real exchange rate change over previous year value (positive corresponds to appreciation)
er_gap_sq	The difference between current level of exchange rate and HP-filtered exchange rate squared
oil_growth	The growth of oil prices
oil_gap_sq	The growth of oil prices squared
food_growth	The growth of food prices
food_gap_sq	The growth of food prices squared
fsi	IMF financial stress index (Cardarelli et al., 2011)
governor_change	The dummy takes the value of one for the new governor
ir_change_dummy	The dummy takes the value of one, when monetary policy rate is changed
lag_rate_change	The dummy takes the value of one, when monetary policy rate at previous meeting was changed
fut_rate_change	The dummy takes the value of one, when monetary policy rate at future meeting will be changed
policy_reversal	The dummy takes the value of one, when the sign of policy rate change differs from the sign of previous rate change
no_members	The number of board members voting
team_duration	The number of meetings a particular team is together
team_	The dummy variable takes the value of one, when no board member is replaced.

Note: HP filter with lambda = 14400 is used.

of current inflation from the target. These variables are considerably correlated, but as we explain in the following section, BMA methodology deals with this issue by assigning different weight to different regression models.

- Board members may have different views on monetary policy transmission (alternative to using output gap as a dominant indicator are monetary indicators approximated by money gap and open economy indicators approximated by real exchange rate gap). It is difficult to agree if alternative indicators point in different directions, as different implicit models matter. To gauge these effects, we analyze whether industrial production growth, industrial production gap squared, unemployment rate, unemployment gap, money growth, money gap squared, exchange rate change and exchange rate gap squared matter for the voting dissent.

- Board members may deal with multiple targets, e.g. with secondary targets such as financial stability or economic growth approximated by financial stress index and output gap, respectively. It is difficult to agree how to set interest rates when primary target – price stability – conflicts with secondary ones. For this reason, in addition to the aforementioned measures of economic activity, we also include a comprehensive financial stress index recently developed by the International Monetary Fund (Cardarelli et al., 2011).

- Board members face supply side shocks, which we approximate by oil prices and food prices. It may be more difficult to agree how to react to this type of shocks. The opinions of board members may differ not only about the extent of second-round effects (e.g. to what extent original supply side shock will feed into demand shocks later on), but also on to what extent they wish to tolerate temporary deviation of actual inflation from the inflation target. The deviation may have a negative consequences for central bank credibility.

Psychological factors

- Psychological literature emphasizes that it is easier to dissent, if board member is not newcomer (Cialdini and Goldstein, 2004, Baumeister and Vohs, 2007). Therefore, we include team duration as the additional explanatory variable and expect a positive correlation between team duration and dissent.

- The dissenting governor may induce, given her or his leadership, other members to dissent from majority, too. On the one hand, we could introduce the dummy for dissenting governor and examine its effect. On the other hand, it is clear that this effect would be at least in part mechanical, as governor is a member of the board. This issue is further complicated by the fact that central banks do not disclose the order in which individual board members vote. If the governor votes as the last one, it is not clear whether she or he can induce other members to dissent. On the top of that, the governors dissent very rarely. The governors never dissented during our sample period in the central banks in the U.S., Czech Republic and Sweden, see Table 1. They dissented twice in the case of the Bank of England and five times in the case of Hungarian National Bank. For this reason, we decided not to include the dummy for dissenting governor in our set of regressors.

Institutional factors

- Individualistic voting protocols may induce more dissent (Horvath et al., 2010). Voting protocols may change with new governor and therefore, the dummy for the change in governor post is introduced.[3]

- The probability that at least one members dissent is higher in larger boards. Therefore, larger central bank boards may mechanically induce more dissent (Erhart and Vasquez-Paz, 2007). For this reason, we include the number of board members present at the monetary policy meeting. Interestingly, the absence at the monetary policy meetings is relatively common. Clearly, board members may be absent because of sickness, but also because they are obliged to represent their bank at the meetings with international organizations such as the European Union or International Monetary Fund.

Preferences

- The board members may also disagree about the right time to change the policy rates even if they possess the same information about economic environment. Some board members may rush to change the rates, others

[3]The dummy is perfectly collinear with the variable TEAM and therefore, it is possible to include it only in the case of U.S. Fed. Our sample period covers Greenspan and Bernanke chairmanships and therefore, only one dummy variable is introduced.

may be more cautious. For this reason, we include the dummy for policy rate change as well as for dummy for future policy rate change and dummy for lagged policy rate change. Similarly, the board members may be more cautious about policy reversals (i.e. about changing the interest rate trend).

- Controlling for other relevant factors, board members may exhibit higher dissent rate in case their preferences differ more sharply. To proxy for this effect, we create the dummies for each bank board team. For example, the teams change on at least a yearly basis in the U.S. Fed due to rotating system of regional Fed presidents.

4 Bayesian Model Averaging

This section presents a brief introduction of BMA (see (Koop, 2003, and Koop et al., 2007, and references therein). The BMA is typically employed to evaluate rigorously the robustness of results especially in the environment of model uncertainty and many possible regressors. It has been typically applied to analyze the determinants of long-term economic growth (see Fernandez et al., 2001a, Fernandez et al., 2001b, Feldkircher and Zeugner (2009), Ley and Steel (2009) or Eicher et al., 2011, among others) and so far much less in the other areas of economic research.

Assume we have a dependent variable Y (the share of dissenting votes) with a number of observations n and k regressors $X_1.....X_k$ (the list of our regressors is available in Table 2). Often it is the case that the theory does not give a guidance, which regressors $X_1.....X_k$ should be included in the regression model. Typically, the baseline model with a subset of regressors $X_1.....X_k$ is chosen and additional regressors within the set of $X_1.....X_k$ are subsequently included to assess the robustness of baseline model. However, in many applications, the choice of baseline model and models for sensitivity analysis is done in *ad hoc* manner. In addition, this procedure is prone to overstate the true significance of regression coefficients as well as to suffer from omitted variable bias. The BMA deals rigorously with aforementioned issues and is defined as follows.

Assume that our model of interest is $Y = \alpha_1 X_1 + .. + \alpha_k X_k + e$, where $e \sim N(0, \sigma^2 I)$ (assume for simplicity that X_1 is a constant). Y represents the rate of dissent (the fraction of dissenting members over the total present members at monetary policy meeting), $X_1.....X_k$ are our explanatory variables

capturing various economic, institutional, psychological and preference related factors. In principle, there are $l = 2^k$ subsets of X's that can be considered as regressors and therefore $M_1....M_l$ regression models to be estimated.

Let us denote the vector of parameters of i-th model as $\theta_i = (\alpha, \sigma)$. The likelihood function of i-th model, $pr(D \mid \theta_i, M_i)$, summarizes all the information about θ_i based on available data D. The marginal likelihood, the probability density of the data, D, conditional on M_i can be written as follows

$$pr(D \mid M_i) = \int pr(D \mid \theta_i, M_i)\, pr(\theta_i \mid M_i)\, d\theta_i, \tag{1}$$

the marginal likelihood is therefore a product of the likelihood function $pr(D \mid \theta_i, M_i)$ and prior density $pr(\theta_i \mid M_i)$ integrated over the parameter space. Using $pr(D \mid M_i)$ one can derive the prior probability that M_i is a correct model, which we denote as $pr(M_i)$. Using Bayes's theorem, we receive the posterior model probability of M_i, $pr(M_i \mid D)$.

$$pr(M_i \mid D) = \frac{pr(D \mid \theta_i, M_i)\, pr(M_i)}{\sum_{l=1}^{i} pr(D \mid M_l)\, pr(M_l)} \tag{2}$$

The posterior inclusion probability of given regressor, $pr(\alpha_j \neq 0 \mid D)$, is then obtained by taking a sum of posterior model probabilities across those models that include the regressor. Posterior inclusion probability is of central importance here, since it measures the probability that given regressor belongs to the "correct" model.

Since the model space is typically extremely large, MC^3 algorithm is used to approximate the posterior distribution of model space by simulating a sample from it. It is computationally prohibitive to evaluate all the possible models[4] and we use MC^3 algorithm developed by Madigan and York (1995) to approximate the posterior distribution of model space. In this regard, we use at least 1 000 000 burn-ins and 3 000 000 draws, which typically leads to a sufficiently high correlation (the value above 0.99) between analytical and MC^3 posterior model probabilities. In some cases, we have to use 5 000 000 burn-ins and 5 000 000 draws (in the case of U.S. Fed) to obtain the correlation about 0.99.

[4]For example, the number of regression models for the U.S. Fed is 2^{47}, i.e. more than 140 trillion of regressions to be estimated.

The parameter priors have to be specified before implementing BMA. We use the Unit Information Prior (UIP), since it is commonly used and performs well in forecasting exercises (Eicher et al., 2011, and Ley and Steel, 2009). The UIP is defined as follows.

$$pr\left(D \mid M_i\right) \approx c - 1/2BIC_i, \tag{3}$$

where

$$BIC_i = n \log\left(1 - R_i^2\right) + p_i \log\left(n\right) \tag{4}$$

In (3) and (4), c is a constant, R_i^2 stands the coefficient of determination and p_i for the number of regressors. This prior is typically labeled as UIP.

As for the model prior, we use a uniform model prior, which gives equal prior probability to all models M_i. In consequence, $pr\left(M_i\right) = 1/L$ for each i. We choose the uniform model prior, because it is commonly used in the empirical exercises, when it is not clear whether some regression model is preferable to the other, which is also our case. In addition, Eicher et al. (2011) show that it performs well in forecasting exercises.

5 Results

This section presents our regression results. We use the BMA to assess the robustness of the effect of economic, institutional, psychological and preference factors on the extent of voting dissent. The results are available in Tables 3-7. The tables present posterior inclusion probability and posterior mean for each regressor.[5]

BMA estimates for the U.S. Fed are reported in Table 3. In general, the posterior inclusion probability for all economic regressors is low. This suggests that economic factors are unlikely to have an effect of the voting dissent rate. The exemption is FOOD_GAP_SQ (calculated as the difference between actual food prices and HP-filtered food prices squared) with the PIP of 0.7.[6] The sign of posterior mean is positive suggesting that the deviation of food prices from

[5] Conditional posterior sign is not presented for the sake of brevity, but these results are available from the authors upon request.

[6] Raftery (1995) puts forward that PIP must be greater than 0.5 to be considered as effective determinant of regressand.

Table 3: What Determines Dissent? BMA Results for the U.S. Fed

Variable	PIP	Post M	Post SD	Variable	PIP	Post M	Post SD
inf_change	0.01	0.04	1.56	team1	0.03	0.80	6.89
inf_gap_sq	0.02	0.00	0.40	team2	**0.89**	75.34	36.15
inf_sq	0.20	0.43	0.96	team3	**0.83**	68.94	39.38
inf_forecast	0.03	-0.03	1.41	team4	**0.81**	66.01	39.07
ip_growth	0.01	1.82	94.03	team5	0.02	-0.07	3.86
ip_gap_sq	0.02	-182	2390	team6	**0.92**	74.97	32.19
u_change	0.02	-0.17	2.37	team7	0.23	10.93	22.82
u_gap_sq	0.02	-2.90	78.97	team8	0.08	3.01	12.36
m_growth	0.03	-52.92	390.77	team9	0.02	-0.11	3.11
m_gap_sq	0.14	-13204	38982	team10	0.02	-0.13	3.34
er_growth	0.02	-1.15	40.88	team11	0.01	0.11	3.00
er_gap_sq	0.25	3224	6360	team12	0.13	5.33	16.31
oil_growth	0.03	-1.67	13.27	team13	0.01	-0.09	2.91
oil_gap_sq	0.02	0.57	16.72	team14	0.05	-1.62	8.89
food_growth	0.14	38.19	112.21	team15	0.02	-0.06	2.96
food_gap_sq	**0.70**	1351	1056	team16	0.02	-0.16	3.24
fsi	0.02	-0.01	0.24	team17	0.06	-2.70	12.81
governor_change	0.02	-0.03	1.93	team18	0.24	-13.08	26.85
ir_change_dummy	0.02	-0.15	1.84	team19	0.03	-0.61	5.48
lag_rate_change	0.36	-16.16	25.52	team20	0.02	0.46	4.69
fut_rate_change	0.16	6.98	18.84	team21	0.01	0.02	2.67
policy_reversal	0.02	-0.33	3.66	team22	0.03	0.44	8.11
no_members	0.16	2.55	6.91	team23	0.04	-1.04	7.51
team_duration	0.04	0.10	0.63				

Note: PIP, Post M and Post SD stand for the posterior inclusion probability, posterior mean and posterior standard deviation, respectively. For convenience, posterior means and standard deviations multiplied by 1000. PIP $> .5$ in bold. The abbreviations of regressors are explained in Table 2.

Table 4: What Determines Dissent? BMA Results for the Bank of England

Variable	PIP	Post M	Post SD	Variable	PIP	Post M	Post SD
inf_change	0.31	26.84	46.14	policy_reversal	0.03	1.14	10.85
inf_gap_sq	0.09	1.11	4.64	no_members	0.06	1.32	7.01
inf_sq	0.19	1.39	3.40	team_duration	0.03	-0.03	0.38
inf_forecast	0.03	-0.04	3.16	team2	0.09	-10.11	38.98
ip_growth	0.02	3.64	182.32	team3	**1.00**	124.96	37.54
ip_gap_sq	0.04	853	10532	team4	0.02	0.22	6.34
u_change	0.06	26.27	147.59	team5	**0.95**	202.45	84.87
u_gap_sq	0.03	-32.46	565.53	team6	0.10	7.34	26.77
m_growth	0.06	-0.14	0.74	team7	0.03	0.56	7.26
m_gap_sq	0.03	-1236	12041	team8	0.03	-1.75	15.41
er_growth	0.03	14.04	144.95	team9	**0.94**	135.89	57.32
er_gap_sq	0.07	653	3214	team10	0.06	-2.06	11.33
oil_prices_growth	0.02	-0.29	19.48	team11	0.05	2.55	16.14
oil_prices_gap_sq	0.03	0.61	37.29	team12	0.03	0.93	12.34
food_prices_growth	0.26	209	408	team13	0.02	-0.54	11.88
food_prices_gap_sq	0.03	9.74	210	team14	0.31	20.77	35.73
fsi	0.40	-3.38	5.00	team15	0.06	5.44	31.67
ir_change_dummy	0.02	0.00	3.60	team16	0.08	-8.37	37.10
lag_rate_change	0.03	-0.43	11.03	team17	0.06	-6.27	31.03
fut_rate_change	0.07	-5.57	28.66	team18	0.05	-4.71	29.27

Note: For mnemonics, see Table 3.

Table 5: What Determines Dissent? BMA Results for the Swedish Riksbank

Variable	PIP	Post M	Post SD	Variable	PIP	Post M	Post SD
inf_change	0.39	-29.85	4.47	food_prices_growth	**0.56**	542	58.02
inf_gap_sq	0.12	1.06	0.37	food_prices_gap_sq	0.04	-11.58	33.83
inf_sq	0.29	2.02	0.38	fsi	0.06	0.24	0.20
inf_forecast	0.04	0.09	0.29	ir_change_dummy	0.06	-1.05	0.89
ip_growth	0.04	-2.85	15.05	lag_rate_change	0.04	0.56	1.20
ip_gap_sq	0.06	512	346	fut_rate_change	0.09	5.75	2.54
u_change	0.04	-0.44	0.51	policy_reversal	0.04	-0.88	1.25
u_gap_sq	0.11	-75.81	27.58	no_members	0.05	-0.82	0.75
m_growth	0.10	-102	40.44	team_duration	0.19	0.66	0.17
m_gap_sq	0.44	-26525	3589	team2	0.04	0.25	0.80
er_growth	0.04	12.18	21.77	team3	0.05	-1.16	0.90
er_gap_sq	0.07	681	399	team4	0.05	-0.95	1.10
oil_prices_growth	0.16	-38.60	11.03	team5	0.05	0.18	1.20
oil_prices_gap_sq	0.07	-15.33	8.35	team6	0.12	10.60	3.71

Note: For mnemonics, see Table 3.

Table 6: What Determines Dissent? BMA Results for the Czech National Bank

Variable	PIP	Post M	Post SD	Variable	PIP	Post M	Post SD
inf_change	0.05	0.60	7.02	food_prices_gap_sq	0.07	97.24	546
inf_gap_sq	0.14	0.40	1.25	fsi	0.07	0.80	4.64
inf_sq	0.05	0.02	0.24	ir_change_dummy	**1.00**	156.61	29.76
inf_forecast	0.05	-0.19	2.35	lag_rate_change	0.05	0.27	15.79
ip_growth	0.30	296	535	fut_rate_change	0.07	-3.25	23.46
ip_gap_sq	0.04	-35.17	1617	policy_reversal	0.15	-13.97	41.42
u_change	0.10	-5.65	22.06	no_members	0.05	0.51	4.24
u_gap_sq	0.06	77.49	483	team_duration	0.04	0.00	0.21
m_growth	0.06	-49.56	356	team2	0.33	-39.01	67.16
m_gap_sq	0.41	41887	59624	team3	0.05	-0.84	9.91
er_growth	0.06	-34.21	233	team4	0.04	0.18	6.03
er_gap_sq	0.05	136	1880	team5	0.04	0.06	7.64
oil_prices_growth	0.04	2.48	34.22	team6	0.14	9.37	29.20
oil_prices_gap_sq	0.07	-13.80	82.01	team7	0.06	1.98	14.21
food_prices_growth	0.04	0.01	108				

Note: For mnemonics, see Table 3.

Table 7: What Determines Dissent? BMA Results for the Hungarian National Bank

Variable	PIP	Post M	Post SD	Variable	PIP	Post M	Post SD
inf_change	0.04	0.26	7.75	oil_prices_gap_sq	0.16	84.62	263
inf_gap_sq	0.36	0.35	6.83	food_prices_growth	0.33	334	585
inf_sq	**0.60**	2.23	3.34	food_prices_gap_sq	0.06	68.73	511
inf_forecast	0.07	-0.22	3.61	fsi	0.12	1.01	4.32
ip_growth	0.05	-10.57	183	ir_change_dummy	**0.78**	90.65	63.91
ip_gap_sq	0.15	-1932.90	5989	lag_rate_change	0.06	1.62	12.80
u_change	0.05	2.47	24.41	fut_rate_change	0.27	-22.50	45.10
u_gap_sq	0.09	-793.39	3685	policy_reversal	0.06	-3.35	29.63
m_growth	0.06	67.13	435	no_members	**0.62**	-18.57	17.83
m_gap_sq	0.06	1861.85	14660	team_duration	0.07	0.22	1.29
er_growth	0.05	-15.51	227	team2	0.08	-7.84	42.59
er_gap_sq	0.19	-1907.47	4977	team3	0.19	-35.34	90.51
oil_prices_growth	0.07	-13.77	98.73	team4	0.32	33.94	59.22

Note: For mnemonics, see Table 3.

its trend is more likely to deliver opposing views about appropriate course of monetary policy.

Similarly, the effect of institutional and psychological factors seems to be limited for the U.S. Fed. On the other hand, TEAM2, TEAM3, TEAM4 and TEAM6 exhibit very high PIP above 0.8. As a consequence, it gives some indirect evidence that dissenting behavior is more likely observed due to differences in preferences. This broadly corresponds to previous findings by Besley et al. (2008) and Harris et al. (2011), who stress that the unobserved heterogeneity among central bankers is the cause behind the dissent.

The results for the Bank of England resemble those of the U.S. Fed, to a certain degree. TEAM3 and TEAM9 display a high PIP, but the PIP for the food prices is lower. Interestingly, there is some weak evidence that higher financial stress (FSI) is associated with less dissent.

The results for Swedish Riksbank also indicate that economic factors are typically not a robust determinant of dissent in voting behavior of their management. As for the U.S. Fed, there is a certain evidence that the greater volatility of food prices is more likely to result in more frequent dissenting behavior. The institutional as well as psychological factors seem to be relatively unimportant.

The results for the Czech and Hungarian central banks indicate that average dissent tends to be larger when policy rates are changed, while meetings confirming interest rate level are characterized by smaller dissents. According to this result, changes in policy rates are more difficult for boards. As for the Czech National Bank, there is some weak evidence that the deviation of money growth (M_GAP_SQ) from its trend is associated with more dissent. This suggests that it is somewhat more difficult to agree when alternative indicators such as money growth point in different directions than the baseline models typically based on some measure of output gap. The number of present members at the Hungarian central bank seems to matter for dissent, too, but surprisingly we do not find that the larger boards necessarily deliver more dissent. Nevertheless, the results for the Czech and Hungarian central banks show that economic and psychological factors do not play a role for dissent. There is some evidence that the institutional structure of decision making is behind the central bankers' dissent.

All in all, the BMA results for our set of five central banks suggest that the determinants of dissent are country-specific, to a certain degree, and that there are a few regressors with the robust effect on the dissent.

6 Conclusions

We examine the voting behavior of central bank board members. We use the data for the U.S. Fed, Bank of England, Swedish Riksbank, Czech National Bank and Hungarian National Bank. More specifically, we investigate which factors cause individual central bankers to dissent from the majority. Unlike previous research in this area, our ambition is to examine many possible factors jointly and uncover whether some particular factors (such as economic, institutional, psychological or preference-related) are more important than the others. For this reason, we collect 25 possible determinants of dissent for our 5 central banks to shed the light on this issue. Since the theoretical literature does not give a clear guidance about which model should be empirically tested, we employ the Bayesian model averaging to deal with model uncertainty formally.

Our results suggest that only a few regressors are robust determinants of voting dissent. Even though the regressors exhibit expected coefficient sign, their posterior inclusion probability is rather low. This suggest that they are unlikely to be robustly associated with the voting dissent in our set of central banks. Our results indicate that economic factors typically do not play a role. This includes some 'traditional' determinants such as those related to inflation or output. The exception is the volatility of food prices, which increases voting dissent in the U.S. Fed and Riksbank in a robust manner. We also find that psychological factors proxied by the team duration (to capture the hypothesis that new members are less likely to dissent) and the dummy for dissenting governor (to capture the hypothesis that it is more difficult to disagree with leader) do not drive dissent.

For the U.S. Fed and the Bank of England, we find that difference in central bankers' preferences is likely to be behind different voting record of individual board members. The results for Czech and Hungarian central banks indicate that it is more difficult decision to change the policy rates than to keep them constant.

References

[1] Baumeister, R. F. and Vohs, K. D., 2007. Encyclopedia of Social Psychology. Thousand Oaks: Sage Publications.

[2] Berger, H., Nitsch, V. and Lybek, T., 2008. Central bank boards around the world: Why does membership size differ?. *European Journal of Political Economy*, 24 (4), 817-832.

[3] Berk, J. M., Beirut, B. and Meade, E. E., 2010. The Dynamic Voting Patterns of the Bank of England's MPC, DNB Working Paper no. 261.

[4] Berk, J. M., and Beirut, B., 2011.Communication in a monetary policy committee. *European Journal of Political Economy*, 27(4), 791-801.

[5] Besley, T.; Meads, N. and Surico, P., 2008. Insiders Versus Outsiders in Monetary Policymaking. *American Economic Review*, 98(2), 218-23.

[6] Bhattacharjee, A. and Holly, S., 2006. Taking Personalities out of Monetary Policy Making: Interactions, Heterogeneity and Committee Decisions in the Bank of England's MPC, CDMA Working Paper Series 0612, Centre for Dynamic Macroeconomic Analysis.

[7] Bhattacharjee, A. and Holly, S., 2010. Rational Partisan Theory, Uncertainty and Spatial Voting: Evidence for the Bank of England's MPC, *Economics and Politics*, 22(2), 151-179.

[8] Blinder, A. S., and Morgan, J., 2005. Are Two Heads Better Than One? Monetary Policy by Committee. *Journal of Money, Credit, and Banking*, 37 (5), 798-811.

[9] Brown, R., 2000. Group Processes, Dynamics Within and Between Groups. Oxford: Blackwell Publishers.

[10] Cardarelli, R., Elekdag, S. and Lall, S., 2011. Financial Stress and Economic Contractions. *Journal of Financial Stability*, 7(2), 78–97.

[11] Chappell, H. W., Jr.; Havrilesky, T. M. and McGregor, R. R., 1977. Monetary Policy Preferences of Individual FOMC Members:

A Content Analysis of the Memoranda of Discussion. *The Review of Economics and Statistics*, 79(3), 454-60.

[12] Chappell, H. W., Jr. and McGregor, R. R., 2000. A Long History of FOMC Voting Behavior. *Southern Economic Journal*, 66(4), 906-22.

[13] Chappell, H. W., Jr.; McGregor, R. R. and Vermilyea, T., 2004. Majority Rule, Consensus Building, and the Power of the Chairman: Arthur Burns and the FOMC. *Journal of Money, Credit and Banking*, 36(3), 407-22.

[14] Chappell, H.W., Jr.; McGregor, R. R. and Vermilyea, T. A., 2005. Committee Decisions on Monetary Policy, Evidence from Historical Records of the Federal Open Market Committee. London: MIT Press.

[15] Chappell, H. W., Jr.; McGregor, R. R. and Vermilyea, T. A., 2008. Regional Economic Conditions and Monetary Policy. *European Journal of Political Economy*, 24(2), 283-93.

[16] Cialdini, R. B. and Goldstein, N. J., 2004. Social Influence: Compliance and Conformity. *Annual Review of Psychology*, 55(1), 591-621.

[17] ECB, (2006). A Journey from Theory to Practice, An ECB Colloquium Held in Honour of Otmar Issing, 16-17 MARCH 2006, Frankfurt am Main: European Central Bank.

[18] Eicher, T., Papageorgiou, C. and A. E. Raftery. 2011. Default Priors and Predictive Performance in Bayesian Model Averaging, with Application to Growth Determinants. *Journal of Applied Econometrics* 26(1): 30-55.

[19] Erhart, S. and Vasquez-Paz, J., 2007. Optimal Monetary Policy Committee Size: Theory and Cross Country Evidence. MNB Working Paper Series, No. 6.

[20] Feldkircher, M. and S. Zeugner. 2009. Benchmark Priors Revisited: On Adaptive Shrinkage and the Supermodel Effect in Bayesian Model Averaging. IMF Working Paper 09-202.

[21] Fernandez, C., Ley, E. and M. Steel. 2001a. Model Uncertainty in Cross-Country Growth Regressions. *Journal of Applied Econometrics* 16(5): 563-576.

[22] Fernandez, C., Ley, E. and M. Steel. 2001b. Benchmark Priors for Bayesian Model Averaging. *Journal of Econometrics* 16(5): 563-576.

[23] Foster, D.P. and E.I. George. 1984. The Risk Inflation Criterion for Multiple Regressions. *The Annals of Statistics* 22: 1947-1975.

[24] Gerlach-Kristen, P., 2003. Insiders and Outsiders at the Bank of England. *Central Banking*, 14(1), 96-102.

[25] Gerlach-Kristen, P., 2004. Is the MPC's Voting Record Informative about Future UK Monetary Policy?, *Scandinavian Journal of Economics*, 106(2), 299–313.

[26] Hansen, S. and McMahon, M. F., 2011. How Experts Decide: Identifying Preferences versus Signals from Policy Decisions. The Warwick Economics Research Paper Series (TWERPS) 963, University of Warwick, Department of Economics.

[27] Harris, M., N., Levine, P. and Spencer, C., 2011. A decade of dissent: explaining the dissent voting behavior of Bank of England MPC members. *Public Choice*, 146, 413-442.

[28] Harris, M.N. and Spencer, C., 2009. The Policy Choices and Reaction Functions of Bank of England MPC Members. *Southern Economic Journal*, 76(2), 482-499.

[29] Hoeting, J.A., Madigan, D., Raftery, A.E. and Volinsky, C.T., 1999. Bayesian model averaging: A tutorial (with Discussion). *Statistical Science*, 14, 382–401.

[30] Horvath, R., Smidkova, K. and Zapal, J., 2010. Central Banks' Voting Records and Future Policy". Working Papers 2010/11, Czech National Bank, Research Department.

[31] Issing, O., 1999. The eurosystem: transparent and accountable, or "Willem in Euroland", *Journal of Common Market Studies*, 37 (3), 503-519.

[32] Koop, G. 2003. Bayesian Econometrics. Wiley, Chicester, UK.

[33] Koop, G., D.J. Poirier and J. Tobias. 2007. Bayesian Econometric Methods. Cambridge University Press.

[34] Ley, E. and M. Steel. 2009. On the Effect of Prior Assumptions in Bayesian Model Averaging with Applications to Growth Regression. *Journal of Applied Econometrics* 24(4): 651-674.

[35] Madigan, D. and J. York. 1995. Bayesian Graphical Models for Discrete Data. *International Statistical Review* 63: 1023-1036.

[36] Meade, E. E. and Sheets, N. D., 2005. Regional Influences on FOMC Voting Patterns. *Journal of Money, Credit and Banking*, 37(4), 661-77.

[37] Meade, E. E. and Stasavage, D. 2008. Publicity of Debate and the Incentive to Dissent: Evidence from the US Federal Reserve, *Economic Journal*, 118(528), 695-717.

[38] Meade, E. E., 2010. Federal Reserve Transcript Publication And Regional Representation, *Contemporary Economic Policy*, 28(2), 162-170.

[39] Montgomery, J.M. and B. Nyhan. 2010. Bayesian Model Averaging: Theoretical Developments and Practical Applications. *Political Analysis*, 18, 245-270.

[40] Raftery, A.E., 1995. Bayesian Model Selection for Social Research. *Sociological Methodology*, 25, 111-163.