International Network for Economic Research

Working Paper 2012.6

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TITLE PAGE

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(version 9. October 2012)

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JEL codes: C15, C53, D72, D83, E58

Keywords: FOMC, leadership, collective decision-making, real-time data, individual reaction functions, bootstrap.

[1] The authors thank J.M. Berk, M. Ehrmann, F.P. Mongelli, S. Giesen, an anonymous referee, and participants from a session at the Western Economic Association International in San Francisco for useful comments and suggestions. The views expressed by Jung are his own and do not necessarily reflect those of the ECB. The authors remain responsible for any errors or omissions.

DOES THE GREENSPAN ERA PROVIDE EVIDENCE ON LEADERSHIP IN THE FOMC?

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Abstract

This paper provides new empirical evidence on the presence of chairman dominance in the FOMC. It uses a novel data set with information on individual forecasts of FOMC members in the 1990s. The approach of this paper is to estimate individual Taylor-type reaction functions for FOMC participants based on their interest rate preferences and economic information in real-time. A bootstrap analysis, which exploits information contained in these reaction functions, constructs counterfactual distributions of disagreement among FOMC members. By comparing these distributions with the observed dissenting behaviour, we find empirical evidence in favour of an "*invisible hand*", which influenced policy-makers' preferences towards the consensus view during the committee deliberations. While several explanations for this behaviour are conceivable (e.g. informal rules, consensus tradition, joint paradigms, bias statement), during the Greenspan era the presence of a dominant chairman is the most plausible explanation for it.

JEL codes: C23, C53, D78, E58

Keywords: FOMC, leadership, collective decision-making, real-time data, individual reaction functions, bootstrap.

"*In practice, it is the making of monetary policy that dominates the Fed, the Federal Reserve Board that dominates the reserve banks, and the chairman of the Federal Reserve Board that dominates the system.*" (Donald F. Kettl, 1986, p.4)

1. INTRODUCTION

For most monetary policy committees, evidence on leadership is scant. The Federal Reserve seems to be an exception in this respect. Some authors document the prominent role of the chairman of the FOMC (e.g. Kettl, 1986; Chappell, McGregor, and Vermilyea, 2004 and 2005; Meade, 2005; Blinder, 2007). Several authors have described the chairman of the FOMC as having a disproportionate influence on FOMC decisions (e.g. Kettl, 1986; Meyer, 2004; Kohn, 2008). This leadership role has often been understood as a reflection of his outstanding role in communications. For example, Ehrmann and Fratzscher (2007) find that communications by the chairman of the Board of Governors generate relatively more public attention than speeches by other governors or presidents. It is also a reflection of the internal monetary policy decision process. First, Kettl (1986, p. 14-15) suggests that the formal powers of the FOMC chairman include several legal and extralegal privileges: spokesperson, point man, but also manager, agenda-setter, coalition-builder.[2] Second, Kohn (2008) emphasises that "*effective Chairmen cannot operate independently of the sentiment on the Committee*". The capacity of the chairman to build a consensus in the FOMC on monetary policy decisions is therefore a critical factor when accomplishing the Fed goals.

Only few authors have examined the empirical relevance of dominant chairman influence in a monetary policy committee (see Blinder, 2004; Riboni and Ruge-Murcia, 2008 and 2011). For the FOMC, the Greenspan era is a case in point. Meyer (2004, p. 50) comments about Greenspan's leadership in the FOMC: "*the chairman's disproportionate influence on FOMC decisions, his efforts to build consensus around his policy recommendations before FOMC meetings, and the strong tendency*

[2] The following excerpts from the FOMC rules of organization document the prominent role of its chairman. Section 3 states "*the chairman presides at all meetings of the Committee and performs such other duties as the Committee may require. The vice chairman performs the duties of the chairman in the absence of the chairman*." Section 272.3 of the FOMC rules of procedure states that "*meetings are held upon the call of the chairman of the Board or at the request of any three members of the Committee*", and that "*the secretary, in consultation with the chairman, prepares an agenda of matters to be discussed at each regularly scheduled meeting*". Moreover, Section 272.4 explains procedures related to policy actions between two meetings, if special circumstances arise. Whether special circumstances apply is left to the chairman's judgement.

for Committee members to support the majority view – all these were secrets of the temple that I learned at my first FOMC meeting.” While there has been strong consensus in the FOMC during the Greenspan era, it is not clear whether this consensus was a result of Greenspan’s outstanding leadership skills or was due to other factors including increased transparency in monetary policy decision-making and the Great Moderation which made monetary policy decisions less controversial.

Our paper extends the literature by providing new empirical evidence on the presence of a “*chairman-effect*” in the FOMC during the Greenspan era, i. e. we examine whether Greenspan’s leadership was the explanation for reduced dissenting in the FOMC. More specifically, our empirical approach shows that the high degree of consensus in interest rate preferences of the Federal Reserve Bank Presidents is inconsistent with the heterogeneity in their individual forecasts and policy reaction functions.

This paper uses a novel data set with information on individual forecasts of FOMC members in the 1990s. The approach of this paper is to estimate individual Taylor-type reaction functions for FOMC participants based on their interest rate preferences and economic information in real-time. A bootstrap analysis, which exploits information contained in these reaction functions, constructs counterfactual distributions of disagreement among FOMC members, assuming there is no factor that enforces consensus. By comparing these distributions with the observed dissenting behaviour, we find strong empirical evidence in favour of an “*invisible hand*”, which influenced policy-makers’ preferences towards the consensus view during the committee deliberations. Several explanations for this behaviour are conceivable (e.g. informal rules, consensus tradition, joint paradigms, bias statement). However, since our findings allow to rule out some alternative explanations, and given the anecdotal evidence from the Greenspan era, chairman dominance is the most plausible explanation for this “*invisible hand*”.

The paper is organized as follows. Section 2 reviews the literature on leadership in monetary policy committees including the FOMC. Section 3 deals with data and methodological issues. Section 4 provides empirical results on FOMC members’ individual reaction functions for the 1990s. Section 5 presents a novel bootstrap analysis to measure consensus-building in the FOMC. Section 6 concludes.

2. LEADERSHIP IN MONETARY POLICY COMMITTEES: A BRIEF SURVEY OF THE LITERATURE

In this section, we summarise main findings from available studies on leadership in monetary policy committees in general and for different FOMC chairmen. A popular meaning of leadership is the capacity to organize a group of people to achieve a common goal. In the literature, a variety of alternative leadership concepts exist. Most of them have originated from psychological or organisational research. Leadership has also been characterised as: "*the process of social influence in which one person can enlist the aid and support of others in the accomplishment of a common task*" (Chemers, 1997). In his seminal work, Weber (1947) introduces the concept of charismatic authority: "*resting on devotion to the exceptional sanctity, heroism or exemplary character of an individual person, and of the normative patterns or order revealed or ordained by him*". Etzioni's (1968) concept of a "*controlling overlayer*" emphasises that in cybernetic systems informal leadership may be of special relevance. Leadership may not necessarily originate from the hierarchical position (e.g. chairman of a committee), but it always depends on the ability of a group member to influence the inputs of the other members and thereby to indirectly influence their decisions.

Section 2.1 gives a brief survey of the literature on leadership in monetary policy committees. Section 2.2 summarises studies on leadership which have implications for the FOMC. Section 2.3 takes stock of studies discussing leadership skills of different FOMC chairmen.

2.1 Leadership in monetary policy committees

What is the meaning of leadership in the context of a monetary policy committee? Leadership in the interactions of the committee may facilitate the agreement of the members and should contribute to selecting the best possible policy option given circumstances. In a monetary policy committee the roles between the chairman (leader) and the other members of the group are typically clearly defined by means of a binding document (central bank statute). Blinder (2007) describes the monetary policy committee as a "*check on the chairman*". Its veto power ensures that whatever the preference of the chairman might be, he/she cannot deviate too much from the majority's point of view. The chairman of a monetary policy committee is often characterized as the first among equals ("*primus inter pares*"), because of his/her specific privileges. First, he/she is responsible for chairing the meeting, and is in charge of setting the agenda, and may have a casting vote. Second, he/she moderates the discussion and makes sure that at the end of the day the committee takes a decision. Third, the chairman is often in charge of communicating and explaining the decision to external audiences on behalf of the committee. Fourth, the central bank statute may grant other special rights to the chairman, which have no immediate impact on voting, but strengthen his/her position within the committee. This relates to direct access to staff information and decisions on the allocation of member's portfolios, and to the possibility that the chairman can call extraordinary meetings. A specific responsibility of a chairman is awareness of the prevailing majorities in the committee. Based on this knowledge the chairman can ensure that he/she is on the winning side: either by convincing sufficient members of the force of his/her arguments or by skilfully adopting the majority view as his/her own without signalling to other members his/her readiness to change preference.

In the empirical literature an open question is whether gains from a committee interaction depend on how well the leader encourages an open exchange of views in the group prior to taking a decision. Gerlach-Kristen (2008) develops a model to study the role of the chairman of Bank of England's MPC. In this framework, consensus building depends on the skills and the credibility of the chairman, and the leadership style (i.e. whether or not the chairman cares about the committee's broad support). Laboratory experiments have been conducted to learn about the committee interaction and the role of the chairman in a real-life environment. Lombardelli, Proudman, and Talbot (2005) suggest overwhelmingly that committees perform better than their best member or the average member of the committee. Assessments from laboratory experiments may be in sharp contrast to what most other studies suggest. For example, experiments by Blinder and Morgan (2008) suggest that leadership in monetary policy committees has no impact on group performance. An exchange of information may not help to make better monetary policy decisions.

A further line of research proposes the existence of alternative leadership styles, which are the result of the philosophy, personality, and experience of the leader. Across committees and individuals, the chairman's authority in a group may vary substantially. Some committees seem to be dominated by their chairman, while others take decisions in a genuinely democratic manner, i.e. by consensus or majority vote. Blinder (2004) distinguishes three basic leadership styles in monetary policy committees. First, in an individualistic committee the chairman's views carry no special weight, and members vote according to their views and are individually accountable for their views (e.g. Bank of England's MPC). Second, a genuinely collegial committee strives for consensus decision and the chairman communicates the joint outcome (e.g. Governing Council of the ECB). Third, an autocratically collegial committee tends to adopt the interest rate proposal by the chairman who is in charge of communicating this decision to the public on behalf of the committee (e.g. FOMC under chairman Greenspan).

More recently, researchers have attempted to incorporate insights from psychology in the theoretical analysis of leadership in monetary policy committees. Claussen, Matsen, Røisland and Torvik (2009) assume that the psychological phenomenon of "*overconfidence*" plays a prominent role in the interaction of monetary policy committees. Accordingly, decision-makers tend to overestimate the precision of their knowledge, which makes it more difficult for the committee as a whole to agree unless there is leadership. In their model it is assumed that the chairman has better access to staff information than other members and that dissenting against the chairman proposal has costs to be borne by the individual member. Their model is able to capture why in some committees (e.g. the FOMC) dissent by members is rare. However, the model is silent about the potential costs of a policy error, if the committee follows the chairman's proposal when another option would be the better choice.

2.2 Leadership in the FOMC

Meyer (2004) explains that the chairman of the FOMC is expected to behave differently from the other members. By tradition, the chairman should be on the winning side in committee interactions, and if not, he even might be expected to resign. From Meyer's (2004) insider's view it is apparent that chairman Greenspan was particular strong in his consensus-building efforts prior to the interest rate decision. First, he had the habit to visit other Board members in bilateral consultations in advance of FOMC meetings to signal his views on the outlook and the implied policy response. Second, during the FOMC meeting he signalled his interest rate preference first before the other FOMC members disclosed them (most other chairmen revealed their preferences at the end of the discussion). Third, at the end of each FOMC meeting his interest rate proposal was always adopted. According to Chappell et al. (2005), it is therefore difficult to empirically give proof that he behaved in a non-dictatorial manner.

Nevertheless, these elements may explain why during the Greenspan chairmanship members of the Board of Governors voted similar on monetary policy decisions.

In fact, judging from the voting records FOMC voting during the past two decades (and excluding the financial crisis episode) was highly consensual. Evidence for the FOMC is that Board members are much less likely to dissent than the Presidents of the (regional) Federal Reserve Banks. In this respect, the Vice-chairman is often found to be one of the most consensus oriented members of the FOMC. Some authors (see Meade, 2005; Banternghansa and McCracken, 2009) find that contrary to what FOMC voting records suggest, there was in fact substantial and possibly more hidden disagreement among them. This applies particularly to the interactions between the chairman and the Regional Bank Presidents on how to respond to the inflation forecast.

In addition to the reduction of volatility during the Great Moderation, a host of factors related to the monetary policy process may have been responsible for the observation that FOMC members have voted in a highly consensual manner over the last two decades. Goodfriend (2007) suggests that a "*new consensus*" on US monetary policy has emerged. Gerlach-Kristen and Meade (2010) find that the existence of informal rules limit dissent in the FOMC (the voting process can be characterized as "*a game of musical chairs*"). Chappell, et al. (2007) emphasise that other elements of Fed's communications like the existence of a bias statement may have contributed to more consensual voting in the 1990s. Furthermore, leadership could be an important factor that has contributed to more consensual voting.

2.3 Leadership skills of FOMC chairmen

Economic theory has contributed to shaping Fed policy-makers' views on the economy. Romer and Romer (2004) find that Fed chairmen have had different beliefs on how the economy works. Likewise this argument of different beliefs also applies to the other members of the FOMC. A consensus-building chairman may want to align member's views with his own. While this requires also the support from other FOMC members which are influential, changes in paradigms have occurred. In the 1960s and 70s the Phillips-curve was a popular paradigm. It took until the 1980s for most policy-makers to subscribe to the primacy of a price stability goal within the Fed's dual mandate. Before 1979 inflationary go-stop monetary policies were dominating the picture. Meade and Sheets (2006) observe strong disagreement among FOMC policy-makers during the late 1970s and early 1980s. The question how aggressive monetary policy should be tightened to bring down high inflation to more moderate levels in view of strong divergences in regional unemployment rates divided the committee.

In the 1990s, Meade and Thornton (2012) find a decreasing relevance of the Phillips-curve as a guide to US monetary policy. It was the time, when the Fed showed a stronger focus on price stability and when the Taylor rule enjoyed increased popularity in the mind of policy-makers (Goodfriend, 2005). Most members subscribed to a definition of price stability by chairman Greenspan which was intended to be vague. "*Price stability is best thought of as an environment in which inflation is so low and stable over time that it does not materially enter into the decisions of households and firms*" (see Greenspan, 2002). The agreement on a quantitative benchmark shared by most members (the so called "*comfort zone*", see Bernanke, 2002) and more recently on a numerical long-term inflation objective has helped to bring more clarity about the Fed's goals (see FOMC, 2012). Since 2007, with the outbreak of the financial crisis, the FOMC underwent a further paradigm shift and gave more emphasis on financial stability aspects in its monetary policy considerations. For fear of deflation, it introduced massive non-standard monetary policy measures including quantitative easing (see Blinder, 2010).

In the post-Bretton-Woods era, most chairmen of the FOMC appear to have had exceptional leadership skills. Available evidence suggests that leadership skills in the FOMC have varied greatly from one chairman to the other (Kettl, 1986; Romer and Romer, 2004; Chappell, McGregor and Vermilyea, 2005) and this had implications for the conduct of monetary policy. In one of the first empirical studies on the power of the FOMC chairman, Chappell, McGregor, and Vermilyea (2005) find evidence supporting the presence of leadership under FOMC chairman Burns. He is found to have influenced other FOMC members' interest rate preferences in a non-dictatorial manner. Blinder (2007) argues that in the history of the Federal Reserve, Alan Greenspan's leadership stands out. Chappell et al. (2005) explain that during the Greenspan era it can be shown that the chairman's preferences were greatly matched by the majority of members, whereas during the Volcker era it was not the case.

Several authors have compared the Fed's monetary policy response under different chairmen using (aggregate) empirical reaction functions. In their empirical analysis, Lindsey, Orphanides, and Wieland (1997) find that under chairman Greenspan and under chairman Volcker the policy reaction functions differ markedly. Judd and Rudebusch (1998) find that the dynamic Taylor-type reaction functions estimated during the Burns, Volcker, and Greenspan periods, appear to have differed in important ways from one another. Similarly, Fair (2007) finds that for five different chairmen alternative objective functions apply. A "*hawkish*" regime applies to chairmen Volcker and Greenspan and Miller, whereas for chairmen Miller and Burns the "*dovish*" regime applies. Moreover, using a Taylor rule with an inflation gap and an unemployment gap, Blinder and Reis (2005) find that the reverse sacrifice ratio for chairman Greenspan was much higher than for chairman Volcker. This confirms anecdotal evidence that the "*Greenspan Fed*" was different from the "*Volcker Fed*" in that it paid considerable attention to developments in the real economy, whereas the latter was mainly concerned with price stability.

3. DATA AND METHODOLOGICAL ISSUES

3.1 Data requirements

Data availability is one of the main obstacles when attempting to empirically trace a "*chairman-effect*". First, we need to estimate genuine individual reaction functions, which capture the heterogeneity of FOMC participants. They may give clues on whether a dominant chairman influence was present in the FOMC (see Chappell, McGregor and Vermilyea, 2004). Data limitations such as lags in the publication of transcripts and the confidentiality of individual policy-makers' forecasts may substantially hamper their estimation.

Second, when estimating reaction functions, real-time data should be used, because they proxy the information set that is available to policy-makers at the time of the decision. Using final data in these reaction functions would be misleading when analysing preference parameters, because it would mean to assume that policy-makers made their decisions under perfect foresight about the data, which in fact they didn't.[3] Since data revisions can be substantial in the US, the use of real-time data captures

[3] 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) emphasises 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).

genuine data uncertainties faced by policy-makers at the meeting. Estimating reaction functions with aggregate real-time forecasts has known limits. Since FOMC policy-makers could distance themselves from the Greenbook forecast for inflation and output (see Kohn, 2008), estimated parameters in these reaction functions could be biased. Where possible, it is therefore preferable to use individual data by policy-makers for their economic forecasts.

Third, while Taylor-type reaction function estimates are typically obtained using quarterly data, monthly data is better suited for our research question (see e.g. Rudebusch and Woo, 2008; Hamilton, Pruitt and Borger, 2010). Compared to the use of the meeting frequency (of eight FOMC meeting per year), which is also often done in the literature, the monthly version makes the empirical reaction functions more homogeneous in time. For example, it addresses concerns about the presence of serial correlation, and the issue that meetings are scheduled at somewhat uneven intervals (i.e. not exactly every 8 weeks) and there may be unscheduled meetings as well. A disadvantage of the approach is that for those months at which there is no meeting, the individual observations are not updated, as they ideally should be.

When estimating individual reaction functions, we include in principle all members from the Board of Governors and all Federal Reserve Bank Presidents. Given new appointments in the FOMC and in view of the rotation of voting rights among Federal Reserve Districts, the number of observations for some members may be rather small. For the Board of Governors, we do not report the estimates for these members, because the results are not statistically meaningful. Though, we address this issue for the Federal Reserve Bank Presidents by estimating reaction functions for their Federal Reserve Districts (and not for the individual President). Thereby, we ignore possible preference changes owing to new appointments.

In line with previous approaches, we use real-time data, i.e. information available to policy-makers at the time of the meeting (see Table A.1 in the appendix for a summary of the data and sources). For each meeting of the FOMC, individual interest rate preferences can be derived from information available in the minutes and the transcripts on members' votes (the transcripts also contain information on non-voters).[4] We use two alternative measures for the policy-makers' interest rate

[4] These preferences are available from the FOMC meeting transcripts in the form of agreement and dissent with the decision, and need to be transformed into an interest rate level. In addition, communications by FOMC

preferences: (a) as is standard in the literature, we use the interest rate preferences in levels constructed from information at the end of the meeting (final votes, which are recorded in the voting record of the FOMC minutes), and (b) as in Meade (2005), we use the interest rate preferences in levels constructed from the FOMC internal policy go-around (second round preferences), which are recorded in the FOMC transcripts. In this respect, we use the data set from Meade (2005) for the period from 1989 to 1997 and extend her data set to cover all meetings until end-2000. Several authors (e.g. Meade, 2005, and McCracken, 2010) suggest that it is preferable include policy-makers' interest rate preferences revealed in the policy go-around (b) when analysing preference heterogeneity in the FOMC. First, these data include all FOMC participants, whereas the voting records only include the voting members. Second, after the policy go-around members may change their preferences in light of the discussion, and are therefore closer to the initial preferences at a specific meeting. To be clear, also these individual preferences may have been influenced by some form of consensus-building prior to the meeting or because FOMC members meet repeatedly in the same composition.[5]

Like in a growing number of recent studies (see Banternghansa and McCracken, 2009; Tillmann, 2010 and 2011; and Tillmann and Rülke, 2011), we include individual forecasts by FOMC participants. More specifically, we include individual members' forecasts for inflation, output and unemployment in our data base.[6] Individual forecasts released by the Federal Reserve are the final forecasts that it publishes for each Monetary Policy Report, and not the initial forecasts. These data are currently available from 1992 to 2001 from the Federal Reserve of Philadelphia (i.e. they are published with a ten-year lag). Data are for the voting and non-voting members except the chairman and for the biannual frequency only, i.e. for the Monetary Policy Reports in February and July each year (for a detailed description of the data set see Romer, 2010). The horizon is for 6, 12 and 18 months, depending on

members prior to FOMC meetings are a further potential source on disagreement. A study by Hayo and Neuenkirch (2012) constructs an index for FOMC participants, which allows assessing whether a member is in a hawkish (dovish) mood.

[5] For the Burns years, Chappell, McGregor and Vermilyea (2012) reject the hypothesis that later speakers are influenced by earlier speakers in the policy go-around. As mentioned there, these results may not carry over to the Greenspan years, because the policy go-around became shorter and more cryptic and, unlike other FOMC chairmen, Greenspan spoke at the beginning of the deliberations and not at the end.

[6] Ideally, individual forecast data should be independent observations, but they may not be fully independent for the following reasons. One is that FOMC members meet regularly so that interactions from previous meetings may have a bearing on the latest meeting. Another is the possible existence of strategic forecasting of FOMC members (see McCracken, 2010). Tillmann (2011) finds this point to be possibly relevant for non-voting members of the FOMC, but not for its voting members. According to this study, non-voters systematically overpredict (underpredict) inflation relative to the consensus forecast when favouring tighter (looser) policy.

whether the release is in February or July.

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. For the FOMC, the present study considers forecasts, which were available to policy-makers in real time. These are based on the technical assumption of "*appropriate monetary policy*", and not on an own interest rate path. In fact, all forecasts are supposed to be conditional on each member's own judgement of the "*appropriate policy*" path over the forecast horizon, but in practice it is not quite clear what this would imply for the interest rate assumption, because it is not reported. Anecdotal evidence suggests that, in the period considered, it was wide-spread practice in the FOMC to use the constant interest rate subject to judgemental adjustment (see Bullard, 2009).

As forward looking measures of the inflation and the real economic stance, our study employs the individual FOMC members' forecasts of inflation and unemployment (see Romer, 2010). Federal Reserve Bank Presidents are often found to behave differently from members of the Board of Governors, because they care more about economic developments in their region, in particular the inflationary consequences of the regional unemployment situation (see Meade and Sheets, 2005). Replacing the output gap, which is traditionally used when estimating Taylor-type rules (see Taylor, 1993; Orphanides, 2003 and 2007), with an unemployment variable (similar to Blinder and Reis, 2005; Orphanides and Wieland, 2008) has several advantages for the purpose of the present analysis. First, using an unemployment gap instead of an output gap should provide better rules of thumb than the classic Taylor (1993) rule (see Poole, 2007). Second, anecdotal evidence from the FOMC transcripts suggests that policy-makers shifted their focus from output growth to unemployment indicators following the Volcker era (see Lindsey, Orphanides and Wieland, 1997). Third, Taylor rules with an unemployment variable as a proxy for the level of economic activity are not affected by output gap uncertainty that makes the output gap a critical choice as driving force of policy making (see Orphanides, 2003). Still, the outcome could be sensitive to non-linearities of the unemployment term and to structural changes of the NAIRU (see Meyer, Swanson and Wieland, 2001). We address these points by including alternative specifications such as the year-over-year growth of the unemployment rate and the difference between the individual unemployment forecast and the (Greenbook) NAIRU estimate.

We compute forward-looking measures of the inflation gap as the difference of the individual inflation forecast and a notional numerical inflation goal for each member. The notional value is in line with recent clarifications on the price stability goal by the FOMC (2012). It is a proxy that is used by other researcher (see Taylor, 1993), and it is not to suggest that FOMC members individually or collectively have shared this value for policy purposes. Between 1989 and 2000 the FOMC's economic projections for inflation were based on the CPI index and thereafter it switched to the PCE index. Given that we focus on the sample 1992 to 2000, this switch does not affect the estimated relationships. We also compute forward-looking measures for the unemployment gap for each member. Our proxy of the unemployment gap assumes that members share the aggregate measure of Greenbook estimates of the NAIRU. Meade and Thornton (2012) observe that FOMC members differ in their individual NAIRU forecasts. But, in real-time individual NAIRU estimates by members are not available. As is evident from the real-time series of the NAIRU (see Figure 1) there was a decline from about 6 percent to 5 percent during the sample and policy-makers were aware of this change. Moreover, policy-makers faced elevated uncertainty about the productivity effects of the new economy, as documented in the FOMC transcripts. Our unemployment gap measure is therefore a simplification, because it only captures diversity as contained in individual unemployment forecasts.

3.2 Interpolation of FOMC participants' projections

In this subsection, we address important shortcomings of the Romer (2010) data set for our application. First, individual policy-makers' forecasts (excluding the chairman) are reported at the biannual frequency instead of for each meeting. Second, the forecasts published in February and in July have a different forecast horizon. The February Monetary Policy Reports (formerly Humphrey-Hawkins testimony) include forecasts for the present year (i.e. three quarter ahead), the July reports include forecasts for the current year (1 quarter ahead) and for the following year (5 quarter ahead). We apply a two-step interpolation procedure in order to derive monthly forecasts with a constant horizon. It calculates individual forecasts at a monthly frequency with consistent 3-quarter ahead forecast horizon. This transformation of biannual forecasts of inflation and unemployment into quarterly (monthly) data makes use of the dynamics implied by the corresponding Greenbook forecasts with an identical horizon.

In a first step we generate constant-horizon forecasts following Orphanides and Wieland (2008) and the explanations provided therein. Like them we proxy the 3-quarter ahead unemployment forecast for the July meetings by the mean of the 1- and 5-quarter ahead forecast. For inflation forecasts, we exploit the fact that in July two forecasts are reported with a horizon of 1-quarter and 5-quarter ahead. First we decompose policy-makers' 1-quarter ahead forecasts into the observation component and the true forecasting component (for the second part of the year). Then, using the pattern from the Greenbook forecast, we decompose 5-quarter ahead forecasts into two separate forecast components: those for the first half and those for the second half of the next year. We obtain 3-quarter ahead inflation forecasts by combining the forecast component of the 1-quarter ahead forecast for the current year with the forecast component of the 5-quarter ahead forecast for the first half of the next year. In a second step we generate forecasts with a monthly frequency. The procedure interpolates the (biannual) individual 3-quarter ahead forecasts using the pattern from available Greenbook forecasts with identical horizon.

In order to compute FOMC members' forecasts for inflation and unemployment at the quarterly frequency, we use a state space model interpolating the dynamics of the individual, biannual forecasts with the dynamics of quarterly Greenbook forecasts. This model comprises the signal equation:

$$\hat{x}_{t,i} = \overline{x}_{t,i} \tag{1}$$

and two state equations:

$$\begin{aligned} \overline{x}_{t,i} &= \beta_0 \overline{x}_{t-1,i} + \beta_1 \hat{x}_t^{staff} + v_{t,i} \\ v_{t,i} &= v_{t-1,i} + u_t, i \end{aligned}, \tag{2}$$

where $\hat{x}_{t,i}$ is the forecast of interest (i.e. the unemployment or inflation forecast) of member *i* at time *t*, $\overline{x}_{t,i}$ is the corresponding latent variable (that models the forecasts at times where the true forecast is not available), $\hat{x}_t^{staff}$ the Greenbook forecast, *u* is an error term, and *v* is the error term of the first state equation (this means that we model the forecast as an ARMAX(1,1) process where the exogenous variable is the staff forecast). Since the true forecast and its interpolation should be identical in all periods where a forecast is available, the signal equation does not include an error term. The system is estimated using a Kalman filter (with ML estimation) where Kalman updates are only performed when a signal is available.

4. FOMC MEMBERS' INTEREST RATE REACTION FUNCTIONS

In this section, we estimate FOMC members' reaction functions in the form of individual Taylor-type rules with interest rate smoothing only and with interest rate smoothing and inertia. Relative to other conceivable approaches, this framework has the advantage that it provides for a structural interpretation of the estimated parameters. These reaction functions link the individual interest rate preference to several factors on which members may disagree when deciding on the appropriate interest rate. These factors are the natural interest rate, the expected inflation gap and the expected unemployment rate (or an output gap). Members may also disagree on the smoothing parameter. For example, members who dissent frequently may have a lower smoothing parameter than other members who vote more consensual. The usual caveats apply to this form of analysis. Policy-makers set interest rates in real-time and consider various aspects that cannot be captured by means of a simple rule. For example, they typically consult a broad range of indicators and a suite of models in their assessments of inflationary risks. The reaction functions in the present study are therefore used as benchmarks, and it is not assumed that policy-makers de facto would follow a simple rule.

Previous studies (see Besley, Meads, Surico, 2008; Jung, 2011; Fendel and Rülke, 2012) have reported pooled empirical reaction functions based on real-time data using unbalanced panels. The present approach is different in that we estimate genuine individual interest rate reaction functions for FOMC participants instead of reaction functions within a panel. Using individual reaction functions in the present analysis is necessary, since our approach requires that we capture the major potential sources of disagreement at the individual level.

When estimating individual reaction functions, we follow Orphanides (2001) who makes the point that it is appropriate to use OLS estimates when real-time data are used. 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 US are similar. Moreover, we check for heteroscedasticity and apply White's (1980) correction in order to compute heteroscedasticity-consistent standard errors.

Policy-makers' individual reaction functions with interest rate smoothing take the following form:[7]

$$i_{n,t} = (1-\rho_n)((\alpha_n + \beta_n(\pi_{n,t+h} - \pi^*) + \gamma_n x_{n,t}) + \rho_n i_{t-1} + \varepsilon_{n,t} \qquad (3)$$

where i_n is the interest rate preference of policy-maker n, i is the (nominal) policy rate in levels, π_n is the individual inflation forecast of policy-maker n at horizon h which we set to 12 months, π^* is a notional inflation target and is set to 2%, x_n is the forward looking indicator of the real economic stance. With u_n denoting the individual forecast of the unemployment rate three alternative proxies for the activity variable x are conceivable: (a) the h period ahead unemployment forecast ($u_{n,t+h}$) of member n, (b) the annual change of the unemployment forecast ($\Delta_{12}u_{n,t+h}$), and (c) the difference of the unemployment forecast and the (staff) estimate of the NAIRU ($u_{n,t+h} - u_t^*$).[8] The results show that the specification, which uses the forecasted unemployment gap based on the NAIRU, offers the most meaningful results when explaining individual interest rate preferences, whereas the other specifications (based on (a) and (b)) give rather mixed results in terms of significance, sign and size of individual reaction parameters in response to the inflation gap and the unemployment variable. Therefore we only report and discuss the results using the specification (c) with the unemployment variable measured as difference between the unemployment forecast and the (staff) estimate of the NAIRU.[9]

An alternative way to handle interest rate smoothing when dealing with individual reaction functions is to account separately for inertia in the interest rate preference. In the literature, monetary policy reaction functions of committee members are either estimated with a lagged interest preference (inertia) or with the lagged policy rate in order to account for an interest rate smoothing motive. Both interest rates could be highly collinear so that it makes sense to take just either of the two variables. When explaining individual interest rates, the difference between both may matter when policy-makers disagree at several consecutive meetings and not only at one meeting. In order to account for this

[7] Results for the other specifications are available from the authors upon request. We also estimated the unrestricted versions, as suggested in Jung (2011) and Besley et al. (2008), but discuss in the following on the restricted versions, because the values of the parameter are better interpretable.

[8] A specification that uses a forward-looking unemployment gap with the NAIRU would be preferable to the other versions. See Orphanides and Wieland (2008).

behaviour, which at times is relevant for some FOMC members, we estimate both traditional Taylor rules with interest rate smoothing and a variant that additionally includes the difference between the lagged interest rate preference of a member (inertia) and the lagged interest rate (interest rate smoothing motive). This allows us to separately test for the inertia of preferences and the presence of a smoothing motive. In both cases the dependent variable in the Taylor rules is an individual interest rate in levels. Like for the other explanatory variables, it is a continuous variable, even though the FOMC normally has changed its federal funds rate in steps of a multiple of 25 basis points.

Policy-makers' individual reaction functions with interest rate smoothing and inertia take the following form:[10]

$$i_{n,t} = (1-\rho_n)(\alpha_n + \beta_n(\pi_{n+h} - \pi^*) + \gamma_n x_{n,t}) + \rho_n i_{t-1} + \theta_n(i_{n,t-1} - i_{t-1}) + \upsilon_{n,t} \quad (4)$$

with the notations as above.

Table 1 to 3 show the characteristics of the FOMC members' individual reaction functions. Overall, it appears that individual regressions which use the second round preferences have better statistical properties than those which use final votes. In part, this finding is attributable to the larger number of observations in these regressions. Voting records provide only data on interest rate preferences for those members who actually vote, while FOMC transcripts may also provide indications of the preferences of the non-voting members (though not always consistently). A further point is that the two measures of interest rate preferences have a different quality as a proxy for individual preferences. Final votes appear to underestimate the true dissent in the FOMC's deliberations (see also Meade, 2005). Some members appear to change their interest rate preference during the internal deliberations and give up their initial dissent with a view to consensus building. Such changes are observable between the policy go-around and the final publication of votes (see Figure 2). Differences between the regressions with two alternative measures of interest rate preferences could be meaningful as well, because they may provide indications on whether consensus building happens during different stages of the monetary policy process.[11]

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[9] Results for the other specifications are available from the authors upon request.

[10] We also estimated the unrestricted versions, as suggested in Jung (2011) and Besley et al. (2008), but discuss in the following on the restricted versions, because the values of the parameter are better interpretable.

[11] While two factors in part explain this behaviour (i.e. the existence of a bias statement and the informal rule that a maximum of two dissenters shall be reported in the voting record), a third factor could play a role here (i.e. the

Differences in the constants across members can give indications on preference heterogeneity. The estimates of α can be interpreted in terms of the natural rate of interest. Abstracting from different notions about the price stability goal over the medium term and using the long-run inflation target of 2% for the FOMC as a whole gives (implied) estimates of the natural (real) rate of interest r*.[12] As indicated by the estimated values of α, most members would see the natural (real) rate in a range between 0.5 and 2.5 percent. In line with other studies, these estimates suggest that there is some disagreement about the natural rate of interest. The range appears to be in line with other studies. Laubach and Williams (2003) provide an estimate of about 1% to 5% for the aggregate natural real rate for a forty-year sample. In sum, this suggests that even in the absence of significant shocks, members will disagree on the interest rate, because they have different notions about the natural rate (and/or the Fed's inflation goal). The finding applies to both members of the Board of Governors and to Federal Reserve Bank Presidents, and it is robust to the use of alternative specifications.

Differences in slope parameters across FOMC members can provide indications on different desired responses in response to shocks. In most instances parameters for the forecasted inflation gap and the forecasted unemployment variable are significant and have the correct sign. FOMC members individually follow the Taylor principle (ß > 1) and, as evident from the high and significant ß coefficients (see Table 2 and 3). An exception is Governor Lindsey for whom the estimate is not significant, presumably owing to the too small number of observations. We interpret this as showing that FOMC members take the price stability goal within the Fed's dual mandate quite seriously and respond in the same direction. In this respect, the Federal Reserve districts of Atlanta, Cleveland and Governor Phillips appear to have reacted in a somewhat dovish manner compared with the others. All members also react to the unemployment gap, but there could be quite some disagreement across Federal Reserve districts on how strong the response to economic shocks impacting on the labour market should be. This is in line with the finding by Meade and Thornton (2012) who show that FOMC members had considerable disagreement on how to respond to the NAIRU during the 1990s. Moreover, the sacrifice ratio σ (ratio of beta over gamma), which better captures the unemployment-inflation

leadership skills of a chairman). From the results it is, however, not possible to make an inference of the kind that the dispersion of coefficients using final votes and those using second round preferences is essentially different.

[12] Because the individual inflation goal is unknown and may differ from the Fed's long-run goal, translating the estimates into an individual natural real rate ignores the possibility that members disagree on the inflation goal, which they did during the 1990s. The finding of heterogeneity in α in part reflects heterogeneous views of FOMC

trade-off, illustrates that the Federal Reserve districts have assessed trade-offs between inflation and unemployment quite differently. This heterogeneity in the individual reaction functions implies that in particular disagreement on how to respond to the unemployment gap (or what is similar here, the output gap) will be an important driver of disagreement in the FOMC whenever shocks in the labour market (or output shocks) become significant.

Individual FOMC members may have different preferences concerning interest rate smoothing. For example, 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. As shown, in all regressions interest rate smoothing is an important factor, as demonstrated by the high and significant values of ρ. A large part of the interest rate preference measured in levels at time t is explained by the interest rate set by the committee at the previous meeting (at t-1). Moreover, at the FOMC policy meetings interest rates are either unchanged or changes have been made by amounts of usually 25, 50 and seldom 75 basis points or more, i.e. these changes are small relative to the interest rate level (note in exceptional circumstances such as the financial crisis the FOMC changed rates by more than 75 basis points and interest rates approach the zero lower bound). A noteworthy point is that for the FOMC differences in the smoothing parameters across members are small. It suggests that members' dissenting behaviour does not appear to be linked to their individual smoothing parameters, but mainly relates to the other factors (i.e. intercept and slope parameters).

A possible point of concern is that in the above regressions, we do not distinguish between the effects attributable to interest rate smoothing and those attributable to inertia. When accounting for it using equation (4), we find that the persistence parameter Θ is different across FOMC participants (see Table 3). This parameter has something to say about how quickly individual members adjust to situations when their individual preference differs from the committee's consensus. A low (high) value of Θ implies that the dissent of the individual policy-maker is weakly (strongly) persistent. In the absence of consensus-building forces within the FOMC, we would expect members to be persistent in their dissents and the parameter Θ to be high for all members. Persistence of dissent could be relevant for the assessment of leadership in the FOMC. It is conceivable that individual members and not the

members about the Fed's goal.

chairman influence the committee's overall assessment. Members with strong persistence in their dissent are likely candidates to lead the committee, at least on occasion. It is striking that only few FOMC participants have a very high value of θ. For example, the Fed Philadelphia turns out to be quite persistent. The Fed New York, which traditionally votes similar to the chairman, the observation of a single episode suffices to detect persistence in this test. By comparison, two regional banks (Fed Atlanta, Fed Kansas City) for which the effect is not significantly different from zero seem to adjust very quickly towards the consensus view. Other than that most districts behaved more persistent than the members from the Board of Governors which are in our sample. In line with the view that under chairman Greenspan, the Board of Governors was very consensus-oriented, we would expect low values of Θ. One possible exception in this respect appears to be Governor Kelley who dissented in a more persistent manner than the other two Board members in our sample.

5. A BOOTSTRAP ANALYSIS TO MEASURE CONSENSUS-BUILDING IN THE FOMC

In order to test for the presence of a consensus enhancing factor – i.e. most likely leadership by chairman Greenspan – in the FOMC we conduct a bootstrap analysis. We strive to prove that the second round preferences are inconsistent with a preference generating mechanism where consensus building does not play a strong role. The general idea of the bootstrap is to provide a counterfactual exercise which simulates the distribution of a test statistics under the null hypothesis of "*no chairman-effect*" (i.e. absence of a consensus building factor) and to compare the outcome with the test statistics derived from actual observations.

Measuring consensus-building efforts owing to the chairman is complicated by the fact that we cannot directly observe the efforts of the chairman given the confidentiality of FOMC deliberations. Since we believe that a chairman reduces the extent of dissent in the FOMC, we choose as test statistics for our bootstrap analysis the extent to which there is disagreement about the preferred federal funds rate. Because the second round preferences of FOMC participants are closer to their initial preferences than the published voting records, we use these data for the bootstrap analysis. Given that these preferences are not published and are not subject to informal rules, members more freely express their dissent than in the voting record. Unlike in the FOMC voting records, we define "*disagreement*" as the standard deviation of the difference of individual interest rate preferences from the policy go-around and the final policy rate after the meeting (in levels).

In our bootstrap, we assign forecasts of FOMC participants with randomly selected estimated reaction functions to simulate the null hypothesis. To simulate a set of counterfactual preferences, randomly selected residuals from the estimated reaction functions are added to the results obtained from the recombination of preferences and expectations (i.e. forecasts). While we treat residuals differently in several specifications of the bootstrap, both the sets of forecasts issued by an individual member and the reactions functions are each considered to be inseparable entities. This makes sure that every member of the counterfactual committee has consistent forecasts and preferences.

By repeating the simulation for a large number of counterfactual committees (or more precisely the districts of the Regional Bank Presidents) we are able to obtain a distribution of dissent that is implicit in the members simulated interest rate preferences. We interpret the outcome of our test as indicating a "*chairman-effect*", if the dissent of the data is below the first percentile of the simulated distribution.

The counterfactual comparison could also capture other coordination efforts between FOMC participants that are not related to the chairman, including learning behaviour or informal rules. To see, why this bootstrap helps to identify leadership imagine two alternative situations. First, if FOMC participants voice their initial interest rate preferences at the meeting, the coefficients of the estimated reaction functions would be unbiased and efficient estimates of their individual coefficients. Moreover, if unaffected by a chairman aiming to generate homogeneity in policy preferences, individual interest rate preferences should mirror the individual economic forecasts (i.e. neither the coefficients nor unbiased estimates of those coefficients should correlate with any statistical property of the forecasts). In this case, rearranging the reaction function between FOMC participants should not affect the statistical properties of the preferences – namely their cross member standard deviation measuring disagreement. Second, if a (consensus-seeking) chairman imposes his interest rate preference on the other FOMC members prior to the policy meeting, this would imply that their interest rate preferences voiced at the end of the internal discussions are a compromise between their initial preference and the interest rate preference of the chairman. In this case, since we do not know the true interest rate preferences, we will not estimate the true reaction parameters of the members. But, the residuals obtained from the reaction function estimates will contain information about compromising. This behaviour will create a structure in the residuals that is removed when resampling (i.e. randomly reassign the residuals in the simulations).[13]

Section 5.1 presents a counterfactual disagreement distribution among FOMC participants from the baseline bootstrap. Section 5.2 provides checks for robustness of the results. Section 5.3 applies limited randomization in order to analyse possible sources for dissent among members.

5.1 A counterfactual disagreement distribution form the baseline bootstrap

The baseline bootstrap provides a counterfactual disagreement distribution among FOMC participants, which can be compared with the observed distribution of their disagreement (see Figure 3). We compute the counterfactual disagreement distribution under the null hypothesis "*no chairman-effect*" by simulating the bootstrap samples for a 108 month period (i.e. the full sample length). To simulate the interest rate preferences of one counterfactual committee we draw (with replacement) 12 expectation time series, one for each of the 12 members (districts of the Presidents) that we consider. To guarantee that each set of expectations is consistent we jointly draw inflation and unemployment expectations. We then match these expectations with 12 randomly drawn reaction functions. These combinations are used jointly with the residuals to produce latent interest rate preferences. In the baseline bootstrap we assume residuals are fully idiosyncratic under the null hypothesis. This assumption is relaxed in the robustness tests.

A notional set of resampled interest rate preferences for the FOMC member *a* in bootstrap simulation number *b* is generated following the equation:

$$i_{a,b,t} = x_{l,t}\hat{\psi}_n + \hat{\varepsilon}_{m,s}\,, \qquad (5)$$

where $\hat{\psi}_n$ denotes the estimated reaction function coefficient vector of member *n*, $x_{l,t}$ denotes the regressors included in the reaction function of member *l* at time *t*, and $\hat{\varepsilon}_{m,s}$ denotes the residual from the estimation of member *m*'s reaction function at a random time *s*. All three *l*, *m* and *n* are random integers between 1 and 12.

[13] Note that we do not need to assume fully idiosyncratic residuals. Reproducing the cross member correlation and dynamics of residuals that might be caused by an omitted variable in the reaction function can be captured in our bootstrap simulations. While our baseline bootstrap assumes full idiosyncrasy of residuals, this is done in the

All simulations are first run with the number of bootstraps *B* determined endogenously following Davidson and MacKinnon (2000). Their approach overcomes the problem that the distribution of the test statistic produced by the bootstrap samples is only an approximation of the true distribution of the test statistic under the null hypothesis if the number of bootstraps is finite. Therefore, we increase *B* until we can reject $p^*(\hat{\tau}) < \alpha$ or $p^*(\hat{\tau}) > \alpha$ at a significance level β, where $p^*(\hat{\tau})$ is the true (i.e. not bootstrapped) p value of the test statistic estimated from the data, α is the significance level that is used for testing the original hypothesis (i.e. in our case whether or not there is chairman dominance), and β is an arbitrarily chosen parameter determining the precision of the bootstrap. We set β to 0.001 and α to 0.01, that is, if we reject the null hypothesis in our bootstrap at a 1% significance level, we are 99.9 % certain that we would also reject at this level using the true distribution. We only consider values of *B* that allow exact testing at a 1 percent significance level, that is $\alpha(B+1)$ has to be integer (see Dufour and Kiviet, 1998). The highest number of bootstraps necessary that is obtained for any model using this method is 699. All bootstraps are then rerun with 999 iterations to obtain comparable results for all models.

Table 4 presents the results from the baseline bootstrap. Column 3 shows that the mean dissent in the bootstrapped distribution is significantly in excess of what would be expected under the null hypothesis of "*no chairman-effect*" (column 2). Hence, a force exists which reduces dissent among FOMC members relative to what would be expected, if they based their interest rate preferences on the reaction functions. Several explanations for this coordination behaviour are conceivable such as informal rules, consensus tradition, joint paradigms, a bias statement and a dominant chairman. Moreover, in all simulations presented in this paper, rounding to the next feasible federal funds target rate step (i.e. multiple steps of 25 basis points) produces the final (notional) set of interest rate preferences in levels. Such rounding behaviour can also be observed from the way interest rate preferences are recorded in FOMC meetings. Table 4 also reports the mean dissent (standard deviation of preferences) without rounding. It shows that the impact from rounding is small, and does not change the results.

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robustness tests.

5.2 Checks for robustness

This section provides two checks for robustness of the results. One of the key questions when designing the bootstrap for the null hypothesis is the interpretation of residuals of the original models. In the baseline bootstrap we interpret the residuals as part of the actual interest rate preference. This is not necessarily true. For example, deviations from the estimated reaction functions might mainly be due to the requirement to report reasonable interest rate targets which are discrete rather than continuous. In this case our original treatment of residuals in the simulation would introduce unwarranted volatility to preferences. Therefore, we run a robustness test where no residuals are added to the reaction functions ("*Zero residuals*"). This assumption means that members do not deviate from their individual Taylor-type rules, but fully trust their individual forecasts and their reaction parameters when forming their interest rate preference. In the counterfactual simulations we adjust equation (5) to:

$$i_{a,b,t} = x_{l,t}\hat{\psi}_n \ . \qquad (6)$$

As we exclude here the possibility that residuals are, at least partly, due to a further (unobserved) source of heterogeneity in the preferences, this simulation imposes increased homogeneity under the null.

As a second check for robustness, we report the outcome under the assumption that one or several common unobserved decision factors are possibly present ("*Unobserved factor*"). Residuals from the individual reaction functions may partly reflect the impact of some information that systematically affects interest rate decisions, which is not captured by the reaction function. The existence of such a common factor is not necessarily reflecting a generally omitted variable in the reaction function, but might represent the ad hoc emergence of a factor that is considered to be important at the specific meeting due to groupthink. Such a common factor would cause positive cross individual correlation of residuals when assessing the reaction functions, and would reduce the extent of disagreement among them. To account for this issue, we modify the bootstrap so as to ensure that the residuals used for resampling match the cross member correlation found in the original sample. This could be achieved by drawing all residuals used to simulate a specific period in a single bootstrap sample from the same observation period.

However, at the same time, we would like to capture the original dynamics of the residuals. Autocorrelation and heteroscedasticity properties of the residuals may matter, if the residuals do not only reflect time specific issues that affect the interest preference only once, but rather an omitted variable in the reaction function. In this case, the dynamics of the omitted variable (or rather its impact on interest rate preferences) would be captured by the residuals.

Thus, we adjust a moving blocks bootstrap (see Künsch, 1989; Fitzberger, 1997) to our needs. That is, rather than randomly selecting the residuals used to create a bootstrap sample independently, we take sequences (blocks) of residuals and use them in the same order for resampling. We use a block length of 12 that should be sufficient to capture the main dynamics of any macroeconomic indicator that might be missing in the reaction function. Since both the indicators and the importance assigned to a missing indicator might differ between members, the residuals used to resample the behaviour of a single member are taken from one member for all periods. This procedure guarantees that we do not artificially induce variation (and thus disagreement) to the bootstrap, by implicitly assuming a behavioural change in the middle of the sample. We adjust equation (5) to:

$$i_{a,b,t} = x_{l,t}\hat{\psi}_n + \hat{\varepsilon}_{m(b,t),s(b,t)}, \qquad (7)$$

where

$m(b,t) = m(b,t-1)$ if $t \notin \{1, 13, 25, 37, ..., 97\}$ and

$s(b,t) = s(b,t-1) + 1$ if $t \notin \{1, 13, 25, 37, ..., 97\}$.

Table 4 presents the results of the checks for robustness. Column 3 shows that different assumptions on how the null hypothesis is implemented imply that the mean dissent in the bootstrapped distribution is different. But, all additional bootstraps still indicate highly significant dissent measures in excess of what would be expected under the null hypothesis of "*no chairman-effect*" (column 2). The finding is in particular robust to the fairly restrictive assumption that the errors are mostly driven by an indicator that is not included in our reaction function and simultaneously affects all policy-makers. Our finding is also robust to the specification of the estimated reaction function that we use, i.e. with interest rate smoothing only and with interest rate smoothing and inertia. The evidence presented in this section confirms the finding that an "*invisible hand*" contributed to reducing dissent among FOMC members between their internal discussion and the final release of the voting record. Consensus-building at the meeting is most likely the result of chairman influence, because other factors which explain reduced dissent among FOMC members would unlikely impact on dissent in the (internal) policy go-around,.

5.3 Limited randomization

To better understand the sources underlying dissent among committees members in our simulations, we run three additional bootstraps, where we limit the randomization. In these simulations, we only randomise one of the three aspects of the interest rate preference by member at a time: the residuals, the reaction function or the forecasts. In all simulations conducted in this section, the residual time series obtained from the estimation of a reaction function is considered to be an inseparable entity. Thereby, the requirement defined in our second set of robustness tests (i.e. that the autocorrelation and heteroscedasticity of residuals in the simulation matches the original sample) can be met even though these additional simulations are by far more restrictive. The equations defining our data generating processes are given by:

$i_{a,b,t} = x_{l,t}\hat{\psi}_l + \hat{\varepsilon}_{m,t}$ (residuals are randomized) (8)

$i_{a,b,t} = x_{l,t}\hat{\psi}_n + \hat{\varepsilon}_{l,t}$ (reaction function is randomized), and (9)

$i_{a,b,t} = x_{l,t}\hat{\psi}_n + \hat{\varepsilon}_{n,t}$ (forecasts are randomized) (10)

Simulations with "*Random residuals*" based on equation (8), i.e. combining the forecasts and reaction function from one member with residuals obtained from another member, produce substantially more (mean) dissent than those with "*Random reaction functions*" and "*Random forecasts*" based on equations (9) and (10) respectively. But, as far as the standard deviation of the dissent distribution is concerned (column 5), simulations using equations (8 to 10) produce fairly similar results, albeit applying (10) gives the largest value.

From the perspective of detecting leadership in the FOMC, these results provide further interesting insights. If FOMC members were to report forecasts which are strongly biased towards the achievement of a consensus and are based on their true reaction function, we would expect that residuals in the reaction function are small. In other words, resampling of residuals in this exercise should have little effect on the members' decision to dissent. Our results indicate that FOMC members tend to report preferences that are inconsistent with their individual forecasts to achieve consensus rather than adjusting their forecasts. This might be an additional indication that leadership actually plays a more important role in achieving a consensus on policy rates than alternative explanations including groupthink.

6. Conclusions

Using a novel data set with information on individual forecasts of FOMC members in the 1990s, we have provided new empirical evidence on the presence of chairman dominance in the FOMC. The empirical approach in this paper has been to estimate individual Taylor-type reaction functions for FOMC members with real-time data. A bootstrap analysis, which exploits information contained in these reaction functions, constructs notional distributions of disagreement among FOMC members. A comparison of these counterfactual distributions with the observed dissenting behaviour, has allowed to assess whether during the internal FOMC deliberations policy-makers' preferences have been influenced towards the consensus view during the committee deliberations. We caution that our analysis does not exploit anecdotal information based on communications by individual FOMC members on whether or not they may have been influenced by chairman Greenspan prior to the policy rate decision. Typically such information, if available, only relates to specific episodes.

Overall, our results confirm that during the Greenspan era an "*invisible hand*" existed and contributed to reducing dissent among FOMC members between their internal discussion and the final release of the voting record. While several explanations for this behaviour are conceivable (e.g. informal rules, consensus tradition, joint paradigms, bias statement), during the Greenspan era the presence of chairman dominance is the most plausible explanation for this kind of coordination. The analysis of individual reaction functions also provides some insights into the dispersion across FOMC members, and documents how members differently reacted to incoming data concerning the inflation and unemployment gap. In this respect, the analysis reveals that during the 1990s FOMC participants differed in terms of persistence of their dissent, and it is possible that on occasion leadership on interest rate decisions originated from a very persistent Regional Bank President and not always from the FOMC chairman.

An important factor that may be always present in the deliberations of monetary policy committees is groupthink (see Sibert, 2006; Bénabou, 2012). Janis (1972) defines groupthink as "*as the psychological drive for consensus at any cost that suppresses disagreement and prevents the appraisal of alternatives in cohesive decision-making groups.*" The danger of groupthink is that the group may fail to consider viable alternatives thereby increasing the likelihood of making a serious policy error.

Using empirical methods, as is done in this study, it is difficult to disentangle leadership and groupthink for the FOMC, in particular in an episode when policy-makers appear to have made no major policy error in achieving the Fed's dual mandate. Both phenomena appear to be two sides of the same coin, because they contribute to consensual voting on policy decisions. Such a drive for consensus under chairman Greenspan's tenure can be documented by the voting record which shows that the FOMC usually took decisions by unanimity and never reported more than two dissenting votes. Recent studies by Blinder (2009) and Ball (2012) provide anecdotal evidence in favour of the presence of groupthink in the FOMC both under chairman Greenspan and also under chairman Bernanke. This suggests that other socio-psychological phenomena might also have contributed to the measured reduction in dissenting between the policy go-around and the final votes. Admittedly, to the extent that groupthink has occurred in a way that members may have distanced themselves from the assumed reaction function or individually may have followed a different interpretation of the dual mandate, our analysis cannot separate how much of the measured effect is attributable to groupthink and how much to leadership.

APPENDIX

A.1 Data and sources

Indicators	**Sources**
Policy rate	Fed funds target rate (Fed website, Board of Governors)
FOMC policy-makers' interest rate preferences	data base by Meade (2005) and updates based on FOMC transcript voting records extracted from FOMC minutes
FOMC policy-makers' forecast ranges: - inflation (CPI, PCE) - nominal output - real output	data base by Gavin (2003) and updates based on Fed website (various semi-annual Monetary Policy Reports to the Congress)
Greenbook staff forecasts : - inflation (CPI) - nominal output - real output - unemployment	ALFRED data base Fed St. Louis
Individual forecasts of FOMC policy-makers: - inflation (CPI) - nominal output - real output - unemployment	data base by Romer (2010) and real-time website Fed Philadelphia
Other variables: - NAIRU - Forecast uncertainty (SPF)	all from real-time website Fed Philadelphia - real-time estimates from the Board of Governors - Fed Philadelphia real-time measures of cross-sectional forecast dispersion for the Survey of Professional Forecasters (SPF)

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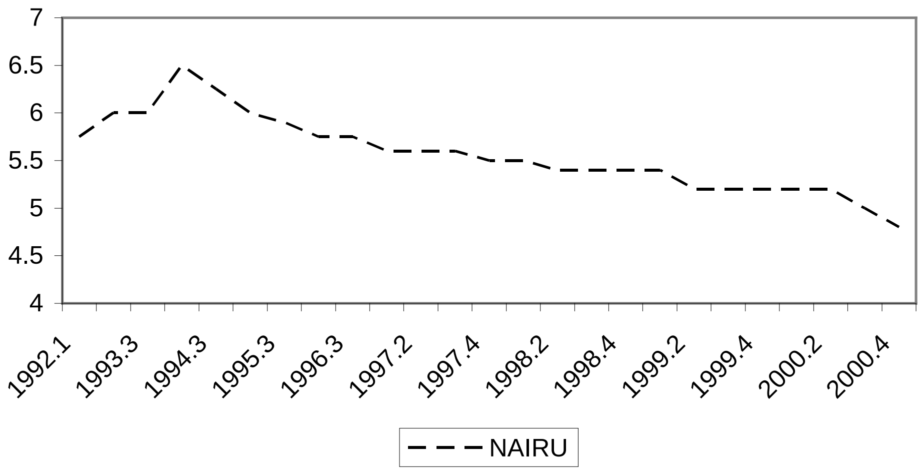
FIGURES AND TABLES

FIGURE 1: Real-time data for the NAIRU from the Greenbook

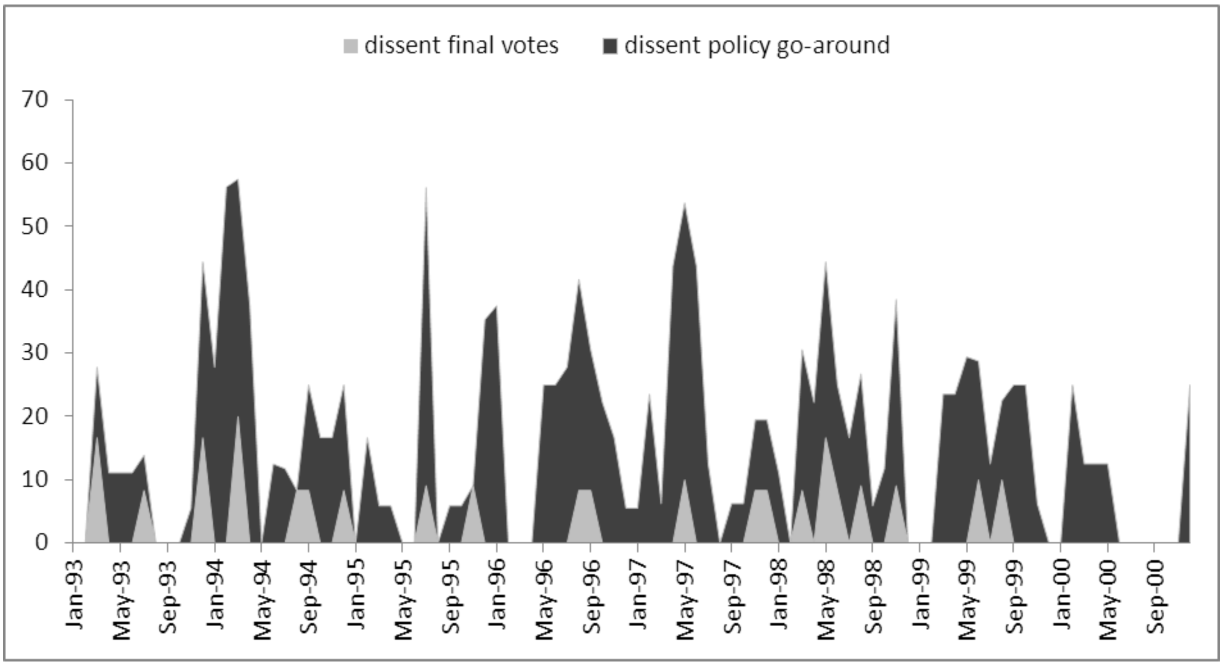
(in annual percentage changes)



Source: Real-time data base Fed Philadelphia.

FIGURE 2: Dissent by FOMC members at the policy go-around and from final votes

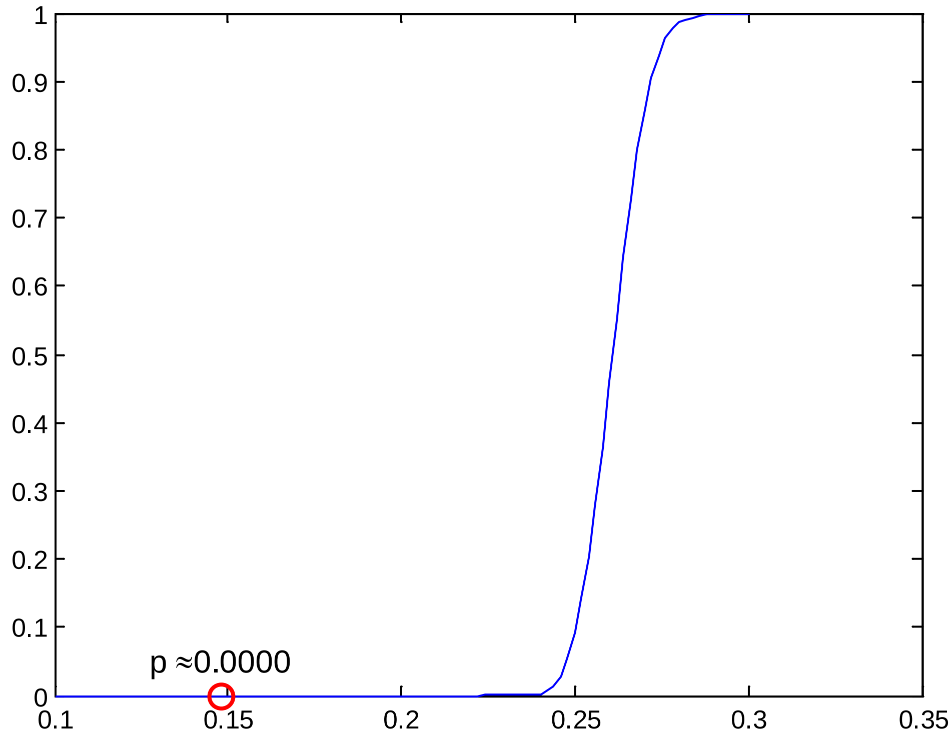
(in percent of total votes)



Note: "Total votes" includes all voting members present at the FOMC meeting (final votes) and all voting- and non-voting members attending (policy go-around).

Source: Board of Governors.

FIGURE 3: Bootstrapped disagreement distribution (under H_0)



Note: Above the cumulative distribution function is shown. The red circle marks the actual disagreement. The null hypothesis H_0 is "*no chairman-effect*"

TABLE 1: FOMC reaction functions with final votes: equation (3c)

Coefficients / FOMC member	α	β	γ	ρ	Memo: σ	Adj. R^2	Obs.
Federal Reserve Districts							
Boston	-7.01 (69.38)	0.90 (5.362)	-7.97 (39.05)	0.99 (0.05)	-0.11	0.97	34
New York	3.04 (0.65)	2.03 (0.80)	-2.68 (0.52)	0.94 (0.02)	-0.76	0.98	105
Philadelphia	3.59 (0.64)	0.70 (0.65)	--2.09 (0.30)	0.91 (0.03)	-0.33	0.99	47
Cleveland	4.40 (0.41)	0.56 (0.40)	-1.64 (0.30)	0.83 (0.05)	-0.34	0.95	51
Richmond	4.14 (0.78)	0.81 (0.86)	-2.35 (0.68)	0.86 (0.05)	-0.34	0.96	44
Atlanta	3.54 (0.71)	1.38 (0.38)	-2.58 (0.61)	0.87 (0.04)	-0.53	0.96	45
Chicago	4.73 (1.44)	-1.48 (1.79)	-3.22 (1.21)	0.95 (0.02)	0.46	0.98	59
St. Louis	9.00 (17.42)	2.41 (6.40)	0.10 (8.13)	1.01 (0.05)	23.13	0.97	37
Minneapolis	3.50 (1.25)	0.85 (1.34)	-3.11 (1.30)	0.96 (0.03)	-0.27	0.98	45
Kansas City	5.94 (0.97)	0.62 (0.79)	-0.57 (1.27)	1.07 (0.05)	-1.08	0.96	37
Dallas	2.52 (0.73)	1.56 (0.79)	-2.39 (0.45)	0.93 (0.03)	-0.65	0.99	48
San Francisco	3.43 (0.83)	1.66 (1.02)	-2.83 (0.79)	0.88 (0.05)	-0.58	0.97	42
Board of Governors							
Kelley	3.10 (0.46)	1.79 (0.55)	-2.73 (0.39)	0.92 (0.02)	-0.66	0.98	105
Lindsey	5.28 (1.03)	-0.07 (1.01)	-3.52 (0.67)	0.91 (0.02)	-0.02	0.97	57
Phillips	4.10 (0.31)	0.78 (0.36)	-2.99 (0.49)	0.88 (0.03)	-0.26	0.97	72

Note: Standard errors in brackets.

TABLE 2: FOMC reaction functions with second round preferences: equation (3c)

Coefficients FOMC member	α	β	γ	ρ	Memo: σ	Adj. R^2	Obs.
			Federal Reserve Districts				
Boston	3.76 (0.77)	2.36 (1.12)	-3.76 (0.94)	0.95 (0.02)	-0.63	0.97	105
New York	2.72 (0.79)	2.45 (0.96)	-2.92 (0.60)	0.94 (0.02)	-0.84	0.97	105
Philadelphia	3.09 (0.54)	1.80 (0.58)	-2.49 (0.41)	0.91 (0.02)	-0.72	0.97	105
Cleveland	4.15 (0.55)	0.89 (0.61)	-2.04 (0.33)	0.91 (0.03)	-0.44	0.97	103
Richmond	3.52 (0.65)	2.43 (0.88)	-3.34 (0.71)	0.91 (0.02)	-0.73	0.96	105
Atlanta	3.31 (0.50)	1.45 (0.54)	-2.75 (0.48)	0.91 (0.02)	-0.53	0.97	105
Chicago	2.60 (0.85)	2.09 (0.91)	-3.23 (0.71)	0.93 (0.02)	-0.65	0.97	105
St. Louis	1.26 (3.96)	8.43 (8.93)	-8.02 (7.17)	0.98 (0.02)	-1.05	0.96	105
Minneapolis	2.30 (0.93)	3.56 (1.40)	-3.68 (0.99)	0.94 (0.02)	-0.97	0.97	105
Kansas City	2.85 (0.89)	2.71 (1.09)	-3.69 (1.03)	0.95 (0.02)	-0.74	0.97	105
Dallas	2.51 (0.69)	2.35 (0.79)	-2.54 (0.43)	0.92 (0.02)	-0.93	0.97	105
San Francisco	1.09 (2.13)	5.26 (3.08)	-5.07 (2.29)	0.95 (0.03)	-1.04	0.96	105
			Board of Governors				
Kelley	2.93 (0.52)	2.07 (0.61)	-2.95 (0.43)	0.91 (0.02)	-0.70	0.98	105
Lindsey	6.69 (1.15)	-0.73 (1.04)	-4.04 (0.80)	0.90 (0.02)	0.18	0.97	57
Phillips	3.82 (0.35)	1.40 (0.44)	-3.38 (0.59)	0.87 (0.04)	-0.41	0.97	77

Note: Standard errors in brackets.

TABLE 3: Individual interest rate reaction functions with second round preferences: equation (4c)

Coefficients / FOMC member	α	β	γ	ρ	Θ	Memo: σ	Adj. R^2	Obs.
Federal Reserve Districts								
Boston	4.78 (0.45)	2.75 (1.29)	-3.66 (1.03)	0.95 (0.02)	0.32 (0.15)	-0.75	0.98	104
New York	4.10 (0.30)	2.06 (0.79)	-2.85 (0.54)	0.93 (0.02)	1.08 (0.05)	-0.72	0.98	104
Philadelphia	4.07 (0.35)	2.23 (0.87)	-2.76 (0.63)	0.94 (0.02)	0.98 (0.16)	-0.81	0.98	104
Cleveland	4.24 (0.26)	1.29 (0.58)	-2.14 (0.33)	0.91 (0.03)	0.88 (0.19)	-0.60	0.97	102
Richmond	4.23 (0.43)	2.26 (0.97)	-3.12 (0.74)	0.93 (0.02)	0.64 (0.12)	-0.73	0.97	104
Atlanta	4.01 (0.27)	1.38 (0.49)	-2.74 (0.45)	0.90 (0.03)	-0.01 (0.17)	-0.50	0.97	104
Chicago	4.10 (0.35)	2.04 (0.92)	-2.72 (0.62)	0.94 (0.02)	0.82 (0.25)	-0.75	0.97	104
St. Louis	3.52 (0.71)	3.95 (2.01)	-4.25 (1.46)	0.96 (0.02)	0.82 (0.11)	-0.93	0.97	104
Minneapolis	3.93 (0.35)	2.99 (1.18)	-3.37 (0.84)	0.94 (0.02)	0.51 (0.24)	-0.89	0.98	104
Kansas City	4.16 (0.45)	2.62 (1.04)	-3.64 (0.98)	0.95 (0.02)	0.08 (0.11)	-0.72	0.97	104
Dallas	3.69 (0.44)	3.04 (1.31)	-3.09 (0.82)	0.95 (0.02)	0.77 (0.15)	-0.98	0.98	104
San Francisco	3.98 (0.37)	2.55 (1.24)	-3.25 (0.92)	0.93 (0.03)	0.77 (0.15)	-0.79	0.97	104
Board of Governors								
Kelley	4.00 (0.22)	1.85 (0.54)	-2.88 (0.41)	0.91 (0.02)	0.82 (0.17)	-0.64	0.98	104
Lindsey	6.40 (0.66)	-1.05 (1.01)	-4.00 (0.77)	0.90 (0.02)	0.23 (0.29)	0.26	0.97	56
Phillips	4.59 (0.17)	1.33 (0.40)	-3.06 (0.50)	0.87 (0.04)	0.36 (0.33)	-0.37	0.97	76

Note: Standard errors in brackets.

Table 4: Results of the bootstrap

Bootstrap type	**Reaction function**	**True dissent (1)**	**Mean dissent under H_0 (2)**	**σ of dissent under H_0**	**p-value of one sided test**
Baseline	Smoothing (3)	0.117	0.264 [0.254]	0.006 [0.006]	~0 [~0]
Baseline	Inertia	0.117	0.258 [0.248]	0.007 [0.007]	~0 [~0]
Zero residuals	Smoothing (3)	0.117	0.187 [0.172]	0.004 [0.004]	~0 [~0]
Zero residuals	Inertia	0.117	0.196 [0.178]	0.00 [0.006]	~0 [~0]
Unobserved factor	Smoothing (3)	0.117	0.262 [0.252]	0.016 [0.016]	~0 [~0]
Unobserved factor	Inertia	0.117	0.255 [0.244]	0.015 [0.015]	~0 [~0]
Random residuals	Smoothing (3)	0.117	0.266 [0.256]	0.006 [0.006]	~0 [~0]
Random residuals	Inertia	0.117	0.255 [0.245]	0.007 [0.007]	~0 [~0]
Random reaction function	Smoothing (3)	0.117	0.130 [0.123]	0.010 [0.008]	0.16 [0.32]
Random reaction function	Inertia	0.117	0.128 [0.127]	0.011 [0.010]	0.16 [0.18]
Random forecasts	Smoothing (3)	0.117	0.138 [0.134]	0.012 [0.010]	0.06 [0.08]
Random forecasts	Inertia	0.117	0.156 [0.152]	0.011 [0.011]	0.01 [~0.001]

Notes: The results without rounding to the next feasible interest rate step are reported in parenthesis.

(1) Computed as standard deviation of the difference of individual interest rate preferences from the policy go-around and the final policy rate after the meeting. (2) The null hypothesis H_0 is "*no chairman-effect*" simulated with the bootstrap referred to in the "*Bootstrap type*" column. (3) "*Smoothing*" refers to the reaction functions with interest rate smoothing only, "*Inertia*" refers to the reaction functions with both interest rate smoothing and inertia of preferences.