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

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Abstract

The aim of this paper is to examine whether Chairman Greenspan influenced the Reserve Bank Presidents. This question is interesting, because it has been argued that their preferences would be more persistent compared to those of the Governors. We estimate individual Taylor-type reaction functions for the Federal Reserve Districts using their voiced interest rate preferences during the policy go-around as well as real-time economic information on the inflation and unemployment gap. A bootstrap analysis exploits information contained in these reaction functions and constructs counterfactual distributions of disagreement among the Federal Reserve Districts, assuming the absence of factors that could have enforced consensus. We compare these simulated distributions with the observed disagreement during the committee deliberations and find empirical evidence in favour of coordination. This detected coordination helped to bring the preferences of the Federal Reserve Districts more in line with Chairman Greenspan's views.

JEL Codes: C15, C53, D72, E58

Keywords: Federal Reserve Districts, Greenspan era, real-time data, individual reaction functions, bootstrap.

Non-technical summary

The "*Greenspan Fed*", the Federal Reserve of the United States under Chairman Alan Greenspan, took a large number of its interest rate decisions in a consensual manner. Why was that the case? On the one hand, it could have been due to the fact that all members of the Federal Open Market Committee (FOMC) fully shared the central bank's mandate and had similar views about future risks to price stability. On the other hand, it could have been due to the Chairman's influence on the preferences of these other members, prior to their decision-making. In addition, other reasons could possibly also serve as an answer. However, despite this apparent dichotomy, the existing literature on monetary policy committees does not provide a clear answer to the question either.

The Greenspan era is of particular interest with regard to monetary policy decision-making since many sources confirm Greenspan's outstanding leadership in the FOMC. Meyer (2004), for example, provides anecdotal evidence that Chairman Greenspan systematically influenced the preferences of the other members of the Board of Governors prior to FOMC meetings. Was the high degree of consensus in FOMC voting really the result of the Chairman's outstanding leadership skills, or was it due to other factors, such as the reduction of business cycle volatility during the Great Moderation and increased transparency in monetary policy decision-making? Therefore, the aim of this paper is to examine whether Chairman Greenspan influenced the Reserve Bank Presidents. This question is interesting because it has been argued that their preferences would be more persistent than those of the Governors.

Over the past fifty years, the FOMC voting records clearly show that disagreement on monetary policy decisions varied across chairmen. When Chairman Greenspan took over in 1987, he initially faced stronger disagreement than his predecessor Volcker. Throughout the Greenspan era, the Federal Reserve Bank Presidents were indeed active dissenters and deviated from the Chairman's interest rate preference in both directions. Over time, however, he succeeded in bringing down this disagreement so that from 1997 onwards the FOMC took monetary policy decisions in a highly consensual manner. This drive towards consensus under Greenspan's tenure can further be highlighted by the fact that, during the second half of the Greenspan era, the FOMC usually took decisions by unanimity and never reported more than two dissenting votes. From 1999 onwards they even avoided going on record with their dissent, instead voicing their disagreement only during the internal policy go-around.

The paper estimates reaction functions based on Greenbook staff forecasts (1989 to 2006) and on

individual members' forecasts (1992 until the end of 2000). Although Chairman Greenspan was in office from 11 August 1987 to 31 January 2006, the present analysis focuses on the sample ranging from the first meeting in 1989 to the first meeting in 2006. Greenbook forecasts for inflation, GDP and unemployment and data on individual interest rate preferences from the FOMC's policy go-around are available for this sample period (see Meade, 2005). In addition, individual forecasts of FOMC members (see Romer, 2010) are currently available for the subsample ranging from 1992 to the end of 2002.

Using information from FOMC transcripts, we thus examine whether chairman Greenspan might have influenced the interest rate preferences of the Reserve Bank Presidents. The approach of this paper contains the estimation of individual Taylor-type reaction functions for the Federal Reserve Districts. Those reaction functions are based on the voiced interest rate preferences from the policy go-around, as well as real-time economic information on the inflation and unemployment gap. We then propose a bootstrap analysis as a kind of "litmus" test for the presence of a consensus-enhancing factor in the Committee. This analysis exploits information contained in these reaction functions and constructs notional distributions of disagreement among the Federal Reserve Districts, assuming the absence of factors that could have enforced consensus. Finally, by comparing these simulated distributions with the observed disagreement during the Committee deliberations, the paper finds empirical evidence in favour of coordination among Committee members.

Consequently, the present empirical analysis provides new evidence suggesting that chairman Greenspan might have systematically influenced the Fed Reserve Presidents in their voting behaviour towards a consensus. The detected coordination helped to bring the preferences of the Federal Reserve Districts more in line with Chairman Greenspan's views. It should be noted, however, that in the case of the FOMC several explanations are conceivable for this coordination behaviour. While this is most likely due to a dominant chairman, other factors, such as the Committee's consensus tradition and the presence of joint paradigms on monetary policy, may be difficult to disentangle from the Greenspan's influence. Other explanations, such as informal rules and the existence of a bias statement, have been discussed in the literature. Nevertheless, these tools were all introduced or refined under Chairman Greenspan. Since they might thus reflect his efforts to generate greater homogeneity in voting across FOMC members, those communication tools should not to be considered separately when discussing explanations for the detected coordination behaviour.

1. INTRODUCTION

The "*Greenspan Fed*", the Federal Reserve of the United States under Chairman Alan Greenspan, took a large number of its interest rate decisions in a consensual manner. Why was that the case? On the one hand, it could have been due to the fact that all members of the Federal Open Market Committee (FOMC) fully shared the central bank's mandate and had similar views about future risks to price stability. On the other hand, it could have been due to the Chairman's influence on the preferences of these other members, prior to their decision-making. In addition, other reasons could possibly also serve as an answer. However, despite this apparent dichotomy, the existing literature on monetary policy committees does not provide a clear answer to the question either. In addition, the available theoretical models make bold assumptions which would hardly pass a reality-test. Moreover, only few authors have empirically examined the role of the chairman of a monetary policy committee (see Blinder, 2004; Gerlach-Kristen, 2008; Riboni and Ruge-Murcia, 2008 and 2011; Apel, Claussen, Gerlach-Kristen, Lennartsdotter and Røisland, 2013). Blinder (2007) argues that the chairman's role in a monetary policy committee may be linked to its decision-making system. He mentions the Federal Open Market Committee (FOMC) under Chairman Greenspan as an example of an autocratically-collegial committee. In such a committee the chairman dictates the "*consensus*", whereas in a genuinely-collegial committee all members are assigned equal weight. Furthermore, Bolton, Brunnermeier and Veldkamp (2013) show that "*resoluteness*" allows leaders in any large organisation to overcome a time-consistency problem – an issue that arises in uncertain situations, whenever leaders learn about the best course of action only over time.

In this context, the Greenspan era is of particular interest, because many sources confirm Greenspan's outstanding leadership in the FOMC. Fair's (2007) empirical comparison of five chairmen (Martin, Miller, Burns, Volcker, Greenspan) concludes that Greenspan showed the best performance among them. In addition, former Governor Meyer (2004, p. 50) writes: "*the Chairman's disproportionate influence on FOMC decisions, his efforts to build consensus around his policy recommendations before FOMC meetings, and the strong tendency for Committee members to support the majority view – all these were secrets of the temple that I learned at my first FOMC meeting.*" He provides further anecdotal evidence for Greenspan's modified approach to influencing the preferences of other members of the Board of Governors prior to FOMC meetings. "*The Chairman abandoned the*

private talks before the FOMC meetings and instead used the Monday Board meeting (the day before the FOMC meeting) to share with us his views on the outlook and indicate where he was leaning with respect to policy." (Meyer, 2004, p. 51)

Was the high degree of consensus in FOMC voting really the result of the chairman's outstanding leadership skills, or was it due to other factors, such as the reduction of business cycle volatility during the Great Moderation and increased transparency in monetary policy decision-making? Therefore, the aim of this paper is to examine whether Chairman Greenspan influenced the Reserve Bank Presidents. This question is interesting, because it has been argued that preferences of Reserve Bank Presidents are more persistent than those of the Governors (Meade, 2005). In addition, "*while the Reserve Bank Presidents are not part of the pre-meeting discussions at the Board, they have their own devices for influencing the policy discussions in between the meetings. They do this specifically through requests to change the discount rate.*" (Meyer, 2004, p. 51)

In order to investigate this issue, we estimate individual Taylor-type reaction functions for the Federal Reserve Districts using their voiced interest rate preferences during the policy go-around as well as real-time economic information on the inflation and unemployment gap. A bootstrap analysis exploits information contained in these reaction functions and constructs counterfactual distributions of disagreement among the Federal Reserve Districts, assuming the absence of factors that could have enforced consensus. We compare these simulated distributions with the observed disagreement during the committee deliberations and find empirical evidence in favour of coordination. This detected coordination helped to bring the preferences of the Federal Reserve Districts more in line with Chairman Greenspan's views.

The paper is organized as follows. Section 2 reviews the literature on chairman dominance in the FOMC. Section 3 addresses data issues. Section 4 provides empirical results of Taylor-type rules for all Federal Reserve Bank Districts. Section 5 presents a novel bootstrap analysis to measure consensus-building in the FOMC and Section 6 concludes.

2. CHAIRMAN DOMINANCE IN THE FOMC

Several authors (Kettl, 1986; Chappell, McGregor, and Vermilyea, 2004 and 2005; Meade, 2005; Blinder, 2007) document the prominent role of the chairman of the FOMC. Some even describe him as

holding a disproportionate influence over FOMC decisions (Kettl, 1986; Meyer, 2004; Kohn, 2008). However, does the chairman really dominate the FOMC's deliberations on the feds fund rate?

In fact, the chairman's 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. Furthermore, the leadership role is also a reflection of the internal monetary policy decision process. In that sense, Kettl (1986, p. 14-15) suggests that the formal powers of the FOMC chairman include several legal and extra-legal privileges: those of a spokesperson and a point man, as well as a manager, agenda-setter, and coalition-builder. Kohn (2008) additionally 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 thus a critical factor in accomplishing the goals of the Federal Reserve.

In addition, over the past fifty years, the FOMC voting records clearly show that disagreement on monetary policy decisions varied across chairmen. Figure 1 (see Appendix) illustrates that under chairmen Burns and Miller disagreement was substantial. Chairman Volcker's strive for price stability in the 1980s, on the contrary, was widely shared by FOMC members. When Chairman Greenspan took over in 1987, he initially faced stronger disagreement than his predecessor. Over time, however, he succeeded in bringing down this disagreement so that from 1997 onwards, the FOMC took monetary policy decisions in a highly consensual manner (see, for example, Meade, 2005; Jung, 2013). The drive towards consensus under Chairman Greenspan's tenure can be further highlighted by the fact, that during the second half of the Greenspan era, the FOMC usually took decisions by unanimity and never reported more than two dissenting votes. More recently, under Chairman Bernanke, disagreement in the FOMC appears to have somewhat increased again. This, however, might in fact be due to the high uncertainties faced by policy-makers regarding ways to appropriately address the consequences of the financial crisis.

Only few authors point out (see Meade, 2005; Banternghansa and McCracken, 2009) that, during the Greenspan era, there was in fact substantial and possibly more hidden disagreement among members, particularly on how to respond to inflation forecasts. Information on individual interest rate preferences of FOMC members, which is extracted from the FOMC transcripts, confirms that as of

Greenspan's third term in 1996, disagreement was only voiced in the policy go-around, rarely in the final votes (see Figure 2). In line with Meyer's (2004) notion of the Chairman's influence at the level of the Board of Governors, members of this Board dissented infrequently prior to Greenspan's third term. For example, in the early Greenspan years, Governor Seger was well known for her dissent in favour of easier monetary policy. Moreover, throughout the Greenspan era, the Federal Reserve Bank Presidents were active dissenters and deviated from the Chairman's interest rate preference in both directions. From 1999 onwards, however, they avoided going on record with their dissent, voicing their disagreement only during the internal policy go-around (see Figure 3).

What caused this increasingly consensual voting during the Greenspan era? On the one hand, the reduction of business cycle volatility during the Great Moderation and the increased transparency monetary policy decision-making could provide answers to this question. On the other hand, the reign of a dominant chairman might also explain why all members of the FOMC voted in this increasingly consensual manner. Blinder (2007) argues that in the history of the Federal Reserve, Alan Greenspan's leadership stands out. Moreover, Meyer (2004) provides an insider's view which reveals that prior to an interest rate decision Greenspan was stronger than other FOMC chairmen in his consensus-building efforts. First, he would visit other Board members in bilateral consultations in advance of FOMC meetings, signalling his views on the outlook and implied policy response. Furthermore, during the FOMC meetings, he would signal his interest rate preference first, before other FOMC members could disclose theirs (in contrast, most other chairmen revealed their preferences at the end of the discussion). Most importantly, at the end of each FOMC meeting, his interest rate proposal would always be adopted.

Clearly, the Fed's decision-making process is characterised by captainship. Meyer (2004) suggests that, during voting, the FOMC chairman would traditionally be on the winning side, that is, the side of the majority, and that if this was not the case, he even might be expected to resign. In fact, in the post-Bretton-Woods era, most chairmen of the FOMC were outstanding leaders, although to varying degrees (see Kettl, 1986; Romer and Romer, 2004; Chappell, McGregor and Vermilyea, 2005). Chappell, et al. (2005), for example, find that Chairman Burns influenced other FOMC members' interest rate preferences in a non-dictatorial manner. They also explain that, during the Greenspan era, the Chairman's preferences were greatly matched by the majority of members, whereas this was not

true during the Volcker era.

However, a number of other factors related to the monetary policy process may also have contributed to more consensual voting of FOMC members over the last two decades. In that sense, Goodfriend (2007) suggests that a "*new consensus*" on US monetary policy emerged. Chappell, et al. (2007) emphasise that other elements of the Fed's communications, such as the existence of a bias statement, contributed to more consensual voting in the 1990s. In addition, Gerlach-Kristen and Meade (2010) find that the existence of informal rules limit dissent in the FOMC (they characterise the voting process as "*a game of musical chairs*"), and that dissent become rarer the longer a chairman stays in office. Since the beginning of the financial crisis in 2007, however, more members have dissented, reflecting increased uncertainty and more disperse views among policy-makers regarding the best possible monetary policy response to shocks.

Finally, economic theory also shaped Fed policy-makers' views on the economy. Romer and Romer (2004) find that Fed chairmen had different beliefs on how the economy works. In the 1960s and 1970s the Phillips-curve was a popular paradigm, and most policy-makers took until the 1980s to subscribe to the primacy of a price stability goal within the Fed's dual mandate. Before 1979, however, inflationary go-stop monetary policies dominated the picture. Moreover, Meade and Sheets (2006) observe strong disagreement among FOMC policy-makers during the late 1970s and early 1980s. The committee was divided concerning the question of how aggressively monetary policy should be tightened in order to bring high inflation down to more moderate levels, particularly in view of strong divergences in regional unemployment rates. In the 1990s, Meade and Thornton (2012) observe a decreasing relevance of the Phillips-curve as a guide for US monetary policy. The agreement among most members regarding a quantitative benchmark (the so called "*comfort zone*", see Bernanke, 2002) and, more recently, a numerical long-term inflation goal have eventually helped to clarify the Fed's focus on price stability within the dual mandate (see FOMC, 2012). Nevertheless, with the beginning of the financial crisis in 2007 another paradigm shift occurred. The FOMC thus emphasised aspects of financial stability and introduced massive non-standard monetary policy measures, including quantitative easing, thereby addressing deflationary risks (see Blinder, 2010).

3. DATA ISSUES

Chairman Greenspan was in office from 11 August 1987 to 31 January 2006. The present analysis focuses on the sample ranging from the first meeting in 1989 to the first meeting in 2006. Greenbook forecasts for inflation, GDP and unemployment and data on individual interest rate preferences from the FOMC's policy go-around are available for this sample period (see Meade, 2005). In addition, individual forecasts of FOMC members (see Romer, 2010) are currently available for the subsample ranging from 1992 to the end of 2002. While the Federal Reserve has published the widest possible range of data across central banks, some data limitations remain for the scope of the present analysis. Those limitations mainly refer to lags in the publication of FOMC transcripts, the confidentiality of individual policy-makers' data sets, and to data revisions. Since data revisions can be substantial in the US, we use real-time data which capture genuine data uncertainties faced by policy-makers at the time of the meeting (see Table in A.1 of the appendix for a summary of the data and sources).[2]

Section 3.1 explains why we use both Greenbook forecasts and individual forecasts by FOMC members. Section 3.2 explains how we code interest rate preferences based on transcripts. Finally, Section 3.3 provides information on the macroeconomic indicators that we use to estimate individual reaction functions and bootstraps.

3.1 Forecasts

Unlike many other monetary policy committees, the FOMC does not attempt to arrive at a common forecast. In addition, the dispersion of individual forecasts illustrates the range of views of its members (see Kohn, 2008). This point is important, because even in the absence of dissents, members would express their alternative views in the individual forecasts. Since individual FOMC policy-makers often appear to distance themselves from the staff's Greenbook forecast for inflation and output, policy-makers´ individual economic forecasts contain additional information about their individual views not contained in the Greenbook forecast. However, when it comes to forecasting, these forecasts do not contain useful information relative to the staff's Greenbook forecasts (see Romer and Romer, 2008).

[2] When modelling the behaviour of policy-makers' reaction functions, real-time data should be used. Real-time data proxies the information set available to policy-makers at the time of the decision, whereas the use of final data would mislead the analysis of preference parameters. This is due to the implicit assumption that policy-

We use two alternative sources of inflation (CPI) and unemployment forecasts.[3] On the one hand, we use Greenbook staff forecasts, available for each meeting and at different horizons (we refer to the 4-quarter-ahead forecast). Since these forecasts are staff forecasts, they do not contain information about the views of the members. On the other hand, we use policy-makers' individual forecasts which are published twice a year (first published in Romer, 2010). These forecasts are only available for a limited sample of 1992 to 2002 and have the disadvantage that they need to be transformed into the appropriate meeting frequency for the present empirical analysis.

A growing number of recent studies (see Banternghansa and McCracken, 2009; Tillmann, 2010 and 2011; and Tillmann and Rülke, 2011) have used individual forecasts by FOMC participants as forward looking measures for inflation and the real economic stance.[4] Individual forecasts of inflation and unemployment are the final, not initial, forecasts released by the Federal Reserve for each Monetary Policy Report. The data, published with a lag of around ten years, is available from the website of the Federal Reserve of Philadelphia. We use the individual forecasts for the sub-sample ranging from 1992 to the end of 2000. This sub-sample excludes Greenspan's last years as chairman of the Fed (that is, most of his fourth and the fifth term), during which the Fed had to respond to the collapse of the dot-com bubble and the consequences of a terrorist attack on 11 September 2001. Individual forecast data are for the voting and non-voting members, except the chairman, and for the biannual frequency only; that is, for the Monetary Policy Reports in February and July each year (for a detailed description of the data set see Romer, 2010). 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. 3-quarter-ahead), whereas the July reports include forecasts for the current year (1-quarter ahead) and for the following year (5-quarter-ahead).

In order to derive individual forecasts for each meeting with a constant horizon, we apply an interpolation procedure. Our transformation of biannual forecasts of inflation and unemployment into

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makers make their decisions under perfect foresight, which, in fact, they did not.

[3] Note that until the end of 1999, the FOMC's economic projections for inflation were based on the CPI index. From February 2000 onwards, the Fed gave more prominence to inflation as measured by the PCE index. During 2002 and 2003, PCE inflation was slightly below CPI inflation; otherwise, however, the data were similar. Since this change implies only small changes in the inflation process during our sample, we can ignore the switch of the FOMC to the new index and use CPI forecasts throughout this paper.

[4] Although ideally individual forecast data should constitute of independent observations, the latter may in fact not be fully independent. Since FOMC members meet on a regular basis, interactions from previous meetings may have a bearing on the latest meeting.

meeting frequency makes use of the dynamics implied by the corresponding Greenbook forecasts for each meeting (for details see annex A.2).[5] While this may be perceived as a strong assumption, an alternative interpolation procedure, assuming that policy-makers did not change their individual forecasts during those meetings for which no published forecast is available, led to deterioration in the results of the reaction functions. Nevertheless, such transformations have the potential drawback that they might affect the results of the econometric tests. We apply a Kalman filter which provides optimal interpolations if the underlying process is correct. An alternative way to handle this issue would be to apply mixed frequency (MIDAS) regressions (see Andreou, Ghysels and Kourtellos, 2010). However, in the present case there is little difference between approximations based on MIDAS and those based on a state space model with a Kalman filter (see Bai, Ghysels and Wright, 2013).

Finally, researchers have discovered that members' individual forecasts have some conceptual shortcomings for empirical work. They may, for example, be subject to strategic forecasting of FOMC members (see McCracken, 2010; Ellison and Sargent, 2012). Tillmann (2011) finds this point to be possibly relevant for non-voting members of the FOMC, although not for its voting members. According to his study, non-voters systematically over-predict (under-predict) inflation relative to the consensus forecast when favouring tighter (looser) policy. Hence, whenever strategic motives are present, individual forecasts may not be unbiased indications of the "true" preferences of an individual member. A recent paper by Pierdzioch, Ruelke and Tillmann (2013) examines the sources of a forecast bias in the FOMC members' forecasts and finds that the bias is rather persistent, yet unrelated to policy-makers' preferences.

3.2 Interest rate preferences

During the Greenspan era, the discussion on interest rates at FOMC meetings consisted of two rounds (Meade, 2005) which both voting and non-voting FOMC members participated in. The first round served the exchange of views on the economic situation and allowed members to position themselves. The second round was devoted to the discussion of policy options. This was not only an occasion for staff to present policy options, but also for Chairman Greenspan to provide his views and

[5] This transformation assumes that the dynamic of the Greenbook forecasts is close to the dynamics of the FOMC members' forecasts. It is a simplification since it only captures the influence of new incoming information on the forecasts (common factor), but not the judgemental component of FOMC members' forecasts (member specific

policy recommendations. At the end of the second round, Greenspan made final proposals before a formal vote was taken, with the chairman casting his vote before the other members.

Information about FOMC members' interest rate preferences can be obtained from three principal sources: the FOMC minutes, the FOMC transcripts and the records of communication of FOMC participants. The voting records report individual preferences of voting members at the end of the meeting (final vote), and the transcript gives insight regarding the voting behaviour of all FOMC participants during the internal policy go-around. Both voting record from FOMC minutes and FOMC meeting transcripts report the preferences in the form of agreement or dissent from the decision. Based on the final feds fund rate, this information can be transformed into an interest rate level assuming that dissents are voiced in multiples of ±25 basis points.

Several authors (Meade, 2005, and McCracken, 2010) suggest including policy-makers' interest rate preferences revealed in the policy go-around when analysing preference heterogeneity in the FOMC. In contrast to the voting records which only include the voting members, these data include all FOMC participants. Moreover, after the policy go-around members may revise their initial preferences in light of the discussion. Data from the policy go-around are thus closer to the initial preferences at a specific meeting. However, these individual preferences may also be influenced by some form of consensus-building prior to the meetings, or by the fact that FOMC members meet repeatedly in the same composition.[6] This point applies specifically to the preferences of the members of the Board of Governors during the Greenspan era.

While we use information on individual preferences from the FOMC transcripts, we caution that our analysis does not exploit anecdotal information based on communication by individual FOMC members which could in turn reveal whether they were influenced by Chairman Greenspan prior to the policy rate decision. Typically, such information is scant and not fully systematic as it relates to specific episodes. In addition, communication by FOMC members prior to FOMC meetings found in speeches and interviews may contain clues about their preferences. For example, Hayo and Neuenkirch (2013) construct an index from speeches by FOMC participants. They suggest this index would be particularly

component).

[6] 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. However, they also affirm that 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, not at the end.

helpful when assessing disagreements in the FOMC across regions since speeches by non-voting presidents reflect regional economic development to a greater extent than those by voting presidents. While speeches are informative about policy-makers' views on monetary policy, they are not the best measure of individual preferences. First, it requires a certain interpretation by the researcher to transform the textual information into a preference. Second, the views expressed in speeches might have a strategic intent which would be difficult to capture by this transformation, whereas the content of the speech might depend on where the speech is given (Hayo and Neuenkirch, 2013). Third, individual members might, in fact, not disclose their policy assessment before each FOMC meeting. Alan Greenspan famously stated: "*Since becoming a central banker, I have learned to mumble with great incoherence. If I seem unduly clear to you, you must have misunderstood what I said.*" (Alan Greenspan, as quoted in the Wall Street Journal, September 22, 1987)

In our empirical analysis, we use two measures for the policy-makers' interest rate preferences: (a) following the mainstream of the literature, 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) following Meade (2005), the interest rate preferences in levels constructed from the FOMC internal policy go-around (second-round preferences), which are recorded in the FOMC transcripts. The data set from Meade (2005) covers the period 1989 to 1997. This database excludes the early-Greenspan years 1987 and 1988 since the FOMC meeting structure at that time differed from later years and transcripts reveal some confusion between the borrowed reserves target and the interest rate objective. In order to make estimations for our long sample, we follow Meade's (2005) approach by coding the data and extending only the individual interest rate preferences of all (voting and non-voting) FOMC participants. This allows us to cover all meetings until January 2006.

The FOMC transcripts contain information on whether a FOMC participant expressed agreement, argued for a higher federal funds rate or argued for a lower federal funds rate relative to Greenspan's proposal. We code a basis-point variable indicating the size of the interest rate move advocated (in basis points) relative to Greenspan's proposal for the funds rate and transform it into an interest rate level. For example, if a FOMC participant preferred an increase of 50 basis points in the funds rate while Greenspan proposed an increase (reduction) of 25 basis points, this variable would be set equal to +25 (-25). Moreover, if a Reserve Bank President was absent, a deputy from the same District voted in his

place. For the purpose of this analysis, we assume that a FOMC participant did not disagree with Chairman Greenspan if the policy-maker's view is not reported as clear dissent in the transcript. While this assumption might impose more agreement relative to what actually happened, there were only few occasions for which this point was relevant.

Furthermore, in the present study, we are not exploiting information from the relative position of members concerning Greenspan's proposal on the policy bias. From 1983 the FOMC occasionally adopted a policy bias after the FOMC meeting. From 1994 this became regular practice until it was stopped at the beginning of 2000 (see Chappell, McGregor and Vermilyea, 2007). Thereby, the committee as well as individual members could signal whether they were leaning towards higher or lower interest rates based on conditions prevailing at the meeting. The policy bias arguably helped Greenspan in reducing the number of dissenting votes. By offering potential dissenters to go on record with their bias instead of with a dissenting vote, this communication tool facilitated consensus-building on the fed funds rate in line with the Chairman's views.

3.3 Macroeconomic indicators

We compute forward-looking measures of the inflation gap as the difference of the individual inflation forecast (4-quarter-ahead) and a notional numerical inflation goal which is assumed to be the same for each member. This is a proxy used by other researchers (see Taylor, 1993), and it does not suggest that FOMC members individually or collectively have shared this value for policy purposes. We also compute forward-looking measures for the unemployment gap for each member as the difference of the individual unemployment forecast (4-quarter-ahead) and an aggregate measure of the non-accelerating inflation rate of unemployment (NAIRU). Our proxy of the unemployment gap assumes that members share the aggregate (time-varying) measure of Greenbook estimates of the NAIRU as benchmark. This is, however, not necessarily true. Meade and Thornton (2012) have shown that FOMC members differ in their individual NAIRU forecasts. In addition, real-time individual NAIRU estimates by members are not available. Furthermore, the NAIRU in the US was on a downward trend in the 1990s before stabilising for some time at around 5% (see Figure 4) and FOMC policy-makers were aware of the decline from about 6 % to 5 %. Moreover, policy-makers also faced elevated uncertainty about the productivity effects of the new economy, as documented in the FOMC

transcripts. Therefore, while our unemployment gap measure only captures the diversity contained in individual unemployment forecasts for the US as a whole, the reaction parameter to the unemployment gap captures any measurable differences across members in response to labour market shocks.

In the reaction functions, we replace the output gap, which is traditionally used when estimating Taylor-type rules (see Taylor, 1993; Orphanides, 2003 and 2007), with an unemployment gap (similar to Blinder and Reis, 2005; Orphanides and Wieland, 2008). This is not strictly necessary but 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, FOMC members placed considerable weight on the unemployment variable in order to to achieve their dual mandate. Studies by Meade and Sheets (2005) suggest that differences in regional unemployment were particularly important in order to understand disagreement in the FOMC. Moreover, anecdotal evidence from the FOMC transcripts shows that policy-makers generally shifted their focus from output growth to unemployment indicators following the Volcker era. The third advantage of using an unemployment gap concerns the fact that an unemployment variable as a proxy for the level of economic activity is not affected by the extraordinary output gap uncertainty. In contrast, this uncertainty renders the output gap to be a critical choice for a driving force of policy making in the Taylor rule (see Orphanides, 2003). Nevertheless, the NAIRU could also be sensitive to uncertainties related to its estimation, to the presence of non-linearities of the unemployment term, and to structural changes of the NAIRU (see Meyer, Swanson and Wieland, 2001).

4. TAYLOR-TYPE RULES FOR THE FEDERAL RESERVE DISTRICTS

In this section, we present the results of estimated reaction functions for the Federal Reserve Districts in the form of individual Taylor-type rules with interest rate smoothing. In order to check whether a Fed Reserve President might have systematically disagreed with the Chairman during his tenure we estimate a separate reaction function for Greenspan. Relative to other conceivable approaches, this framework has the advantage that it allows for a structural interpretation of the estimated parameters. The reaction functions link the individual interest rate preference to several factors on which participants from different Districts may disagree when deciding about the appropriate interest rate. These factors are the natural interest rate, the expected inflation gap and the expected

unemployment rate in relation to the NAIRU (or an output gap).

Using (aggregate) empirical reaction functions, several authors have suggested that the Fed's monetary policy response can be described by a Taylor rule at least since 1979. In their empirical analysis Blinder and Reis (2005, p. 5) point out that Chairman Greenspan took the Fed's dual mandate seriously and that "*monetary policy decisions of the Greenspan era are well described by a Taylor rule*". Moreover, Judd and Rudebusch (1998, p. 3) find that a Taylor-rule framework "*is a useful way to summarize key elements of monetary policy*" in the US during the Burns, Volcker, and Greenspan periods.

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 several models in their assessment of inflationary risks. The reaction functions in the present study are therefore used as benchmarks, and it is not assumed that policy-makers would de facto follow a simple rule. Moreover, we assume that policy-makers base their interest rate decisions on the published individual forecasts. Some evidence suggests that these individual forecasts might indeed be better approximations of individual assessments than the Greenbook forecast. However, as explained in section 3, these individual forecasts could be biased in the presence of strategic motives. Therefore, as a check for robustness, we report empirical results with the Greenbook staff forecasts as well.

Previous studies (see Besley, Meads, Surico, 2008; Jung, 2013; Fendel and Rülke, 2012) have reported pooled empirical reaction functions based on real-time data using unbalanced panels. The present approach is different. Using individual reaction functions in the present analysis is preferable since our bootstrap approach (see Section 5) requires that we capture the major potential sources of disagreement at the level of the individual participant. We include the preferences of participants from all Federal Reserve Bank Districts for which sufficiently long series can be generated. In this respect, we ignore possible preference changes owing to new appointments of Reserve Bank Presidents. Since in view of new appointments the number of observations for most members would be too small to generate statistically meaningful individual reaction functions, we only include Chairman Greenspan but not the Governors in the present exercise (for the reaction functions of some members of the Board see El-Shagi and Jung, 2012). For the Chairman, the Romer dataset does not report individual forecasts.

We assume that his response can be measured using Greenbook staff forecasts. Moreover, Federal Reserve Bank Presidents are often found to behave differently from members of the Board of Governors as they care more about economic developments in their region; specifically the inflationary consequences of the regional unemployment situation (see Meade and Sheets, 2005). This allows us to capture those participants who accounted for the biggest share of dissenting in the FOMC throughout the Greenspan era (see Figure 3).[7]

Another 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. Greenbook forecasts were based on the technical assumption of "*appropriate monetary policy*", and not on an own interest rate path, which could constitute an endogeneity problem. Anecdotal evidence suggests that although, the FOMC often used the constant interest rate subject to judgemental adjustment (see Bullard, 2009) in the period considered, individual members were free to condition their forecasts on any interest rate path they deemed appropriate. Individual forecasts by policy-makers were conditional on each member's own judgement of the "*appropriate policy*" path over the forecast horizon. Therefore, it is not clear what this would imply for the interest rate assumption, particularly since this assumption was never reported. As is evident from the recently released fed funds projections (since January 2012), FOMC members may disagree on the interest rate assumption (particularly on the timing regarding the exit of near zero interest rates). There is, however, no information available that would allow us to account for any of these differences among FOMC members in the sample used.

When estimating individual reaction functions, we use the frequency of the FOMC meetings (8 regular meetings per year) and the second-round preferences of the participants from the Federal Reserve Districts. Using the final votes for this estimation does not yield a sufficient number of observations. This is due to the rotation system of the FOMC, which only gives the Fed New York President a permanent voting right. Voting records provide only data on interest rate preferences for

[7] Unemployment trends in the Federal Reserve Districts were quite heterogeneous. It could be the case that some regional Fed Presidents systematically include a regional variable in their individual reaction function and that such a reaction function would be relevant when explaining the response of these Fed Districts to incoming data. A regional variable, such as regional unemployment, would increase the heterogeneity across Districts. Jung and Latsos (2013) and Chappell, et al. (2008) find that regional influence was present during the Greenspan era, but its impact on interest rates was small. Therefore, in this paper, we do not include separate regional variables in the above regressions as is, for example, done in Meade and Sheets (2005).

those members who actually vote, while FOMC transcripts may also provide indications of the preferences of the non-voting members (though not always consistently). This is confirmed by the comparison of results of the individual reaction functions with those of final votes and with second-round preferences. In this context, we make two observations. First, the statistical quality of the estimates with final votes is inferior to those with second-round preferences. Second, a direct comparison between the parameters is not possible since several parameter estimates of the specification with final votes are insignificant.

We follow Orphanides (2001) who defends the use of OLS estimates for real-time data. 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 autocorrelation and heteroscedasticity and calculate HAC standard errors for the single regressions. Like Besley, Meads and Surico (2008) we use a version of the Taylor-type rule with the lagged policy rate. The reaction functions for the Chairman and the Districts take the following form:[8]

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

where i_n is the interest rate preference of the policy-maker in district n at time t, i is the (nominal) fed funds rate in levels, π_n is the individual inflation forecast of the policy-maker in district n at horizon h, π^* is a notional inflation target set to 2%, and x_n is the forward looking indicator of the real economic stance. The dependent variables in the respective Taylor rules are the individual interest rates in levels. They are continuous variables, just like the set of explanatory variables, even though the FOMC normally changed its federal funds rate in steps of a multiple of 25 basis points. In line with Orphanides and Wieland (2008), we use an (individual) forward-looking unemployment gap which is the difference between the (individual) unemployment forecast and the (staff) estimate of the NAIRU: $(u_{n,t+h} - u_t^*)$.While the notional value for the inflation target of 2% is in line with recent clarifications on the price stability goal by the FOMC (2012), there is ample evidence that FOMC members in fact strongly disagreed on the optimal inflation level. Before a long-run inflation goal was set, the so-called

[8] Results for the other specifications mentioned are available from the authors upon request. We also estimated the unrestricted versions, as suggested in Jung (2013) and Besley et al. (2008), but discuss in the following only the

"comfort zone" (that is, a range of 1% to 2% inflation) represented the range of collective views of most FOMC participants regarding levels of inflation consistent with the Federal Reserve's dual mandate. Individual inflation gaps seem to ignore this point. Consequently our approach captures any differences across members in the underlying inflation target in the estimate of the constant, that is, the natural rate of interest, and in the reaction parameter to the inflation gap.

Table 1 shows the characteristics of the reaction functions for Greenspan and for each Federal Reserve District. Overall, it appears that individual regressions which use the second-round preferences have good statistical properties (high explanatory power, first order autocorrelation is mostly absent). Our estimates for Chairman Greenspan show that he followed the Taylor principle ($\beta>1$) and, at the same time, cared about US unemployment. This result is robust to the sample and consistent with Blinder and Reis (2005) who suggest 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. In addition, the estimates of ρ confirm that the Greenspan Fed smoothed interest rates. In fact, 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 generally been made in steps of 25 or 50, seldom 75 or more basis points; that is, these changes are small relative to the interest rate level (note that in exceptional circumstances, such as the financial crisis of 2007, the FOMC has changed rates by more than 75 basis points).

Furthermore, differences in the constant α across Districts and relative to the Chairman may give indications on preference heterogeneity. The estimates of α can be interpreted as the natural rate of interest. When abstracting from different notions about the price stability goal over the medium term and applying the long-run inflation target of 2% for the FOMC as a whole, we obtain (implied) estimates of the natural (real) rate of interest r^*.[9] In line with other studies, our estimates suggest that there is some disagreement about the natural rate of interest. As indicated by the estimated values of α, participants from most Districts would see the natural (real) rate in a range between 1% and 2% (see

restricted versions, because the values of the parameter are better interpretable.

[9] Since 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 in fact did during the 1990s. Therefore, our estimates of α may underestimate the true heterogeneity.

Table 1, long sample). The range is in line with Laubach and Williams (2003) who provide an estimate of about 1% to 5% for the aggregate natural real rate of a forty-year sample. Two points are noteworthy, however. First, while we observe small differences in the estimated parameter α across members, these differences do not imply that participants from Fed Districts had values that were significantly different from the Chairman (which can be found by applying a Wald-test, for example). Second, these differences were more nuanced in the first half of the Greenspan era, as the comparison between the short and the long sample suggests.

Interest rate smoothing is an important factor for all members, as demonstrated by the high and significant values of ρ. Members could have a different notion about the goal of monetary policy, and such disagreement could become apparent in the smoothing parameter. We find that differences in the smoothing parameters across Districts are small. Hence, participants from Federal Reserve Districts appear to have had similar preferences concerning interest rate smoothing. Given that individual smoothing parameters were fairly similar to Chairman Greenspan's parameter, observed disagreement among FOMC participants might still be attributable to their different preferences regarding responses to incoming data. For example, during the 1990s, FOMC members considerably disagreed on how to respond to the NAIRU (see Meade and Thornton, 2012). In this context, we report the sacrifice ratio σ (ratio of beta over gamma) for each District. This measure better captures the trade-off between unemployment and inflation and illustrates that most participants from the Federal Reserve Districts have assessed this trade-off somewhat differently from the Chairman. It turns out that, in contrast to the Chairman, several Districts preferred monetary policy to make a larger contribution to the labour market, in particular during the first sample (while in few cases the opposite was also the case).

Moreover, for the Greenspan era (long sample), we find that all participants react to the inflation gap and the unemployment gap in a manner consistent with Greenspan's response. Differences in slope parameters across FOMC participants are small and do not indicate systematic differences in responses to shocks. Estimated parameters for the forecasted inflation gap and the forecasted unemployment variable are significant and have the correct sign. Similar to Chairman Greenspan's reaction function, those functions for the Fed Presidents suggest they took inflationary risks seriously. This is evident from the estimated ß coefficients, which exceed unity in a statistically significant manner for the long sample (see Table 1, upper part), and show that the Presidents all followed the Taylor principle (ß > 1).

For the first half of the Greenspan era (short sample), however, the dispersion among Districts is by far greater. The estimates show that the Taylor principle could be violated for the reaction functions of some Districts. Although, regarding the response to inflationary shocks, the Taylor principle may still hold, this is not fully ensured because of the higher standard error. On the one hand, such changes in the reaction pattern could be due to structural changes in the relationship; for example, a shift in the paradigm. On the other hand, however, this result could simply be attributable to the reduced number of observations, which increases the uncertainty bands around the parameter estimates.

Finally, it has been argued that FOMC participants may show heterogeneity in the persistence of their dissent (see McCracken, 2010). For example, participants who dissent frequently may have a lower smoothing parameter than other members who vote in a more consensual manner. The existing literature estimates monetary policy reaction functions of committee members either with a lagged interest preference (inertia) or with the lagged policy rate which would account for an interest rate smoothing motive. This difference between the two measures might matter for the explanation of individual interest rates, in particular when policy-makers disagree at several consecutive meetings instead of only one meeting. Therefore, in order to account for this behaviour, which at times might indeed be relevant for some FOMC members, a variant of the Taylor rule can be estimated. This variant includes both the lagged interest rate (interest rate smoothing motive) and the difference between the lagged interest rate preference of a member (inertia) and the lagged fed funds rate:

$$i_{n,t} = (1-\rho_n)(\alpha_n + \beta_n(\pi_{n,t+h} - \pi^*) + \gamma_n x_{n,t+h}) + \rho_n i_{t-1} + \theta_n(i_{n,t-1} - i_{t-1}) + \upsilon_{n,t} \qquad (2)$$

with the notations as above. Equation (2) allows us to separately test for the inertia of preferences and the presence of a smoothing motive. Since both interest rates are highly collinear, it turns out that including the two terms in the reaction function does not improve the results. In addition, El-Shagi and Jung (2012) find that the persistence parameter Θ is insignificant for most FOMC participants. This parameter indicates how quickly individual members adjust to situations when their individual preference differs from the committee's consensus. The following hence focuses on specification (1).

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

In this section, we propose a bootstrap analysis as a kind of "litmus" test for the presence of a consensus-enhancing factor (that is, a dominant chairman) in the FOMC during the Greenspan era. We strive to prove that the observable dissent from the second-round preferences is inconsistent with a preference generating mechanism where consensus-building does not play a strong role.[10] At the same time, we caution that the present bootstrap analysis can only detect whether or not coordination has taken place during the Committee meetings. We cannot capture any consensus-building activities prior to it, such as informal consultations among FOMC members. While other socio-psychological phenomena might also have contributed to a reduction in dissenting by Reserve Bank Presidents during the meeting, these factors might be captured by the bootstrap.

One such factor that may always be present in the deliberations of monetary policy committees is groupthink (see Sibert, 2006; Bénabou, 2013). Therefore, both a dominant chairman and groupthink would be detected as having contributed to consensual voting on policy decisions. Janis (1972) defines groupthink as "*the psychological drive for consensus at any cost that suppresses disagreement and prevents the appraisal of alternatives in cohesive decision-making groups.*" What would happen if Reserve Bank Presidents were influenced by groupthink? They would in fact distance themselves from the estimated reaction functions or they would report individual forecasts, which are inconsistent with their voiced preference. Moreover, if they individually followed different interpretations of the dual mandate, this would also be the case.

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 under Chairman Bernanke. A further specific characteristic of groupthink is that the group might fail to consider viable alternatives and thereby increase the likelihood of making a serious policy error. This, however, is even more difficult to proof. During the Greenspan era, which was marked by the fulfilment of the Fed's dual mandate, policy-makers do indeed not appear to have made any major policy errors. At the same time, however, the subprime crisis in the US was followed by the worst financial global crisis since the Great

[10] In principle, this exercise could also be conducted for the final votes, although it would be less meaningful. The use of final votes deteriorates the significance of the parameters from the individual reaction functions of the Districts so that the question arises whether the residuals in these functions are white noise. Second, preferences extracted from final votes are distorted by informal rules aiming to signal a consensus of the Committee to the public. These preferences hence may not allow us to detect chairman influence.

Depression. This seems to indicate that US monetary policy during the late Greenspan years was too loose. Since the FOMC had voted in a consensual manner in these years and there are lags in the transmission of monetary policy, its decision to make use of the so-called "Greenspan put" may indeed have reflected some form of groupthink.

In the following, Section 5.1 explains why the bootstrap analysis is helpful to detect coordination in the FOMC, while Section 5.2 presents a counterfactual disagreement distribution among FOMC participants from the baseline bootstrap. Section 5.3 provides checks for robustness of the results and Section 5.4 applies limited randomisation in order to analyse possible sources for dissent among members.

5.1 Rationale for the bootstrap analysis

The bootstrap is a method for estimating the distribution of a statistic by resampling a dataset (see Horowitz, 2001). The general idea of our bootstrap is to simulate the distribution of a test statistics (a set of interest rate preferences) under the null hypothesis of "*no chairman-effect*" (that is, the absence of a consensus-building factor). By comparing this outcome with the actually observed test statistics, we test whether or not it is likely that the distribution has changed. If the original dataset is representative of the individual interest rate preferences, the resampled values, assuming no consensus enhancing factor, should not be (statistically) different from the original preference distribution. When resampling the preferences, the bootstrap exercise repeats the simulation for a large number of counterfactual committees (or, more precisely, of counterfactual Districts of the Regional Bank Presidents and excluding the Chairman). The result is a dissent distribution which is implicit in the members simulated interest rate preferences. If the dissent in the data is below the first percentile of the simulated distribution, we interpret the outcome of our test as indicating a "*chairman-effect*".

Since a chairman can reduce the extent of dissent in the FOMC, the test statistics for our comparison are represented by the extent to which Fed Bank Presidents disagree with Greenspan about the preferred federal funds rate during the meeting. Therefore, we define "*disagreement*" as the standard deviation of the difference of individual interest rate preferences from the policy go-around and the fed funds rate reported as outcome of the meeting (in levels). Since Chairman Greenspan always succeeded in having his interest rate preference voted for at the end of a meeting, this measure is

a proxy for disagreement relative to the Chairman during the policy go-around. For actual (simulated) disagreement the measure is similar and refers to the observed (simulated) individual interest preferences during the policy go-around.

In the bootstrap analysis we combine forecasts of FOMC participants with randomly selected estimated reaction functions and randomly selected residuals in several ways. In the baseline bootstrap, randomly selected residuals from the estimated reaction functions are added to the results obtained from the recombination of preferences and expectations (that is, the forecasts). In the robustness checks of the bootstrap we relax this assumption and also allow for different treatment of the residuals. Nevertheless, in all specifications in this section we consider the sets of forecasts issued by an individual member as well as the reactions functions to represent inseparable entities. Thereby, we ensure that forecasts and preferences of each member of the counterfactual committee remain consistent.

To see why the bootstrap helps to detect the presence of coordination, imagine two possible situations. First, in the absence of a chairman who aims to generate homogeneity in policy preferences across members, individual interest rate preferences should mirror members' forecasts. Provided the forecasts are not influenced by strategic motives, the coefficients of the estimated reaction functions would be unbiased and efficient estimates of their individual coefficients. In this case, the forecasts would neither correlate with the coefficients nor with unbiased estimates of those coefficients. Rearranging the reaction function between Reserve Bank Presidents using the bootstrap would hence not affect the statistical properties of the preference distributions (and their cross-member standard deviation which is measuring disagreement). Simulated and actual interest rate distributions should not be statistically different. Second, in the presence of a (consensus-seeking) chairman who imposes his interest rate preference on the Reserve Bank Presidents at the policy meeting, the latter would voice interest rate preferences which compromise between their true preferences and the preference of the chairman. They might even voice preferences identical to those of the chairman. In this case, the estimated coefficients in the reaction functions would not be the true reaction parameters of the Federal Reserve Districts. Consequently, the residuals obtained from the reaction function estimates would be non-zero and would contain information about compromising (for a similar argument see Chappell, McGregor and Vermilyea, 2012). By rearranging the reaction functions and randomly assigning the

residuals using the bootstrap, we construct a counterfactual distribution of interest rate preferences. This distribution contains the random but not the systematic component caused by the compromising behaviour.[11] Simulated and actual interest rate distributions should hence be statistically different in this case.

We emphasise three caveats in the context of bootstrap analysis. First, no single variable exists that is an unbiased indicator of the presence of leadership. Second, this analysis relies on the existence of meaningful individual interest rate functions of FOMC participants and, as the literature suggests, a Taylor rule as a valid benchmark for the Greenspan era. Third, the comparison of interest rate preference distributions might in principle also capture an omitted variable or other coordination efforts between FOMC participants, such as learning behaviour, groupthink or informal rules, which are unrelated to the chairman's influence. We thus provide robustness checks for this last point.

5.2 A counterfactual disagreement distribution form the baseline bootstrap

The baseline bootstrap aims to provide a counterfactual disagreement distribution of interest rate preferences among FOMC participants, which can be compared with actual disagreement during the meeting. We compute the counterfactual disagreement distribution under the null hypothesis "*no chairman-effect*" by simulating the reaction functions for both samples, that is 70 meetings (short sample) and 137 meetings (long sample). In order to simulate the interest rate preferences of one counterfactual committee we draw 12 expectation time series (with replacement), one for each of the 12 Federal Reserve Districts. In addition, in order 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. Moreover, 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 district *a* in bootstrap simulation number *b* is generated following the equation:

$$i_{a,b,t} = x_{l,t}\hat{\psi}_n + \hat{\varepsilon}_{m,s}\,, \tag{3}$$

[11] Note that we do not need to assume fully idiosyncratic residuals as in our baseline bootstrap. The reproduction of the cross-member correlation and dynamics of residuals that might be caused by an omitted variable in the

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 district *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 subscripts, *l*, *m* and *n,* consist of random integers between 1 and 12.

Following Davidson and MacKinnon (2000), we first run all simulations with the number of bootstraps *B* determined endogenously. This 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 and under the condition that the number of bootstraps is finite. 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 (that is, not bootstrapped) p value of the test statistic estimated from the data, α is the significance level that is used for the test of the null, and β is an arbitrarily chosen parameter determining the precision of the bootstrap. We set β to 0.001 and α to 0.01. 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* which allow exact testing at a 1% significance level, that is, $\alpha(B+1)$ has to be integer (see Dufour and Kiviet, 1998). The highest number of bootstraps necessary and 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 2 reports the simulated dissent (standard deviation of preferences) from the baseline bootstrap with and without rounding.[12] The simulated dissent in the bootstrapped distribution under the null hypothesis of "*no chairman-effect*" (see column 3) is significantly in excess of what has been observed (column 2 – Observed Dissent) in both the short and long sample. This means that a force must exist which reduces dissent among Districts relative to the counterfactual that Districts fully base their interest rate preferences on their individual reaction functions. A comparison of the results with and without rounding shows that its impact is so small that it does not change the results.

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reaction function can both be captured by our bootstrap simulations. We check for it in the robustness tests.

[12] Policy changes in the FOMC are usually made in multiples of 25 basis points, that is, in discrete steps. Instead of applying some form of discrete modelling technique (see Lapp, Pearce and Laksanasut, 2003; Hayo and Neuenkirch, 2010), we round the level of the (simulated) interest rate preferences to the next feasible federal funds target rate step in all simulations presented in this paper (that is, multiple steps of 25 basis points). The rationale for it is provided by the fact that rounding is implicit in the way interest rate preferences are expressed

5.3 Checks for robustness

Our results could be sensitive to an unobserved variable not included in the reaction functions. For example, Blinder (2009) argues that the Greenspan Fed suffered from groupthink. While groupthink is difficult to detect, its impact would materialise in the form of an unobserved variable. Moreover, disagreement about the right policy indicators could be another reason for an omitted variable. For example, Reserve Bank Presidents appear to have systematically responded to regional unemployment variables which are not included in the reaction function. The possible presence of an omitted variable would imply that the residuals from individual reaction functions partly reflect other information. This would, in turn, systematically affect interest rate decisions in a way not solely related to compromising behaviour.

In the baseline bootstrap we interpret the residuals as part of the actual interest rate preference, although this might not necessarily be true. If the residuals reflect an omitted variable in the reaction function, our treatment of residuals in the baseline bootstrap might invalidate the results. We thus examine this possibility and provide checks for robustness of the results using two alternative assumptions on the treatment of the residuals (zero residuals and unobserved factor).

First, we run a simulation where no residuals are added to the reaction functions ("*zero residuals*"). This assumption means that, when forming their interest rate preference, Districts would stick to their individual Taylor-type reaction functions and would use their forecasts and reaction parameters. We adjust equation (3) to:

$$i_{a,b,t} = x_{l,t}\hat{\psi}_n \,. \tag{4}$$

Since this simulation excludes the possibility that residuals could originate from another (unobserved) source of heterogeneity in the preferences, it imposes increased homogeneity under the null.

Second, we examine the case of the presence of at least one common unobserved decision factor ("*unobserved factor*"). The presence of such a common factor could be due to an omitted variable in the reaction function (for example, a policy indicator). It may also be caused by the ad hoc emergence of a factor that is considered to be important at specific meetings (for example, groupthink). Such a common factor would induce positive correlation of residuals across individuals in the reaction functions. Our

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and voted for at FOMC meetings.

analysis captures those common factors, which might reduce disagreement among the FOMC Districts, since they could wrongly be measured as an indication of chairman influence.

In order to account for this issue, we use a moving blocks bootstrap (see Künsch, 1989; Fitzenberger, 1997). By drawing all residuals used to simulate a specific period in a single bootstrap sample from the same observation period, we ensure that the residuals used for resampling match the cross-member correlation found in the original sample. Rather than randomly selecting the residuals used to independently create a bootstrap sample, we take sequences (blocks) of residuals and use them in the same order for resampling. We use a block length of 8 (number of meetings per year). It 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 across members, the residuals used to resample the behaviour of a single District 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 thus adjust equation (3) to:

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

where t is the number of the meeting:

$m(b,t) = m(b,t-1)$, if $t \notin \{1, 9, 17, 25, \ldots, N\}$ and

$s(b,t) = s(b,t-1)+1$, if $t \notin \{1, 9, 17, 25, \ldots, N\}$,

with N = 65 (short sample) and N = 129 (long sample).

Our main result appears to be robust to the presence of a common factor that is relevant at the meeting, and not included in our reaction function, and simultaneously affects all policy-makers towards the Committee consensus. Table 2 presents the results of the two checks for robustness. In all bootstraps the simulated dissent (column 3) is significantly in excess of what was observed at the time (column 2 – Observed Dissent). Hence, the additional bootstraps also detect coordination between the internal FOMC discussion and the release of the decision. This detected coordination helped to bring policy-makers' preferences more in line with the consensus view. Column 3 (Simulated Dissent) shows that under the null hypothesis of "*no chairman-effect*" the bootstrap with zero residuals (unobserved factor) has a lower (same) simulated dissent than the baseline bootstrap.

5.4 Limited randomisation

In order to better understand the driving factors underlying dissent among the Federal Reserve Districts in our simulations, we run three additional bootstraps with limited randomisation. In these additional bootstraps, we only randomise one of the three aspects explaining the interest rate preference of the Districts. These aspects are the residuals, the reaction function and the set of forecasts. The equations defining our data generating processes are given by:

$$i_{a,b,t} = x_{l,t}\hat{\psi}_l + \hat{\varepsilon}_{m,t} \quad \text{(residuals are randomised)} \tag{6}$$

$$i_{a,b,t} = x_{l,t}\hat{\psi}_n + \hat{\varepsilon}_{l,t} \quad \text{(reaction function is randomised), and} \tag{7}$$

$$i_{a,b,t} = x_{l,t}\hat{\psi}_n + \hat{\varepsilon}_{n,t} \quad \text{(forecasts are randomised)} \tag{8}$$

While limited randomisation may give insights into the sources of disagreement with the Chairman, we emphasise that distributions obtained from these simulations do not capture our initial null hypothesis of "*no-chairman effect*". Hence, in these counterfactual comparisons the one-sided p-test has a different interpretation than before. The null hypothesis is now that the observed dissent in the FOMC deliberations is consistent with the bootstrapped distribution.

Overall, it turns out that information contained in the forecasts is a potentially important driving factor of disagreement. Table 2 (column 3 – Simulated Dissent) shows that simulations with "*random residuals*" based on equation (6) produce substantially less simulated dissent than "*random forecasts*" based on equation (8). Simulated dissent based on "*random reaction functions*" (equation 7) is comparable to simulated dissent based on "*random residuals*". At the same time, the standard deviations of the dissent distributions (column 4) from equations (6) to (8) are fairly similar.

Moreover, the additional results (see Table 2, column 2 – Observed Dissent – and 3 – Simulated Dissent) suggest that individual forecasts as well as Greenbook staff forecasts (in conjunction with the individual reaction parameters) contain valuable information about preference heterogeneity across Federal Reserve Districts. In the first robustness test, we only resample residuals and maintain the original combination of forecasts and reaction functions. The simulations produce a distribution of dissent that is not significantly different from what we observe in the data. In the second robustness test, we resample the reaction functions and obtain results that depend on the sample. While for the long

sample there is no statistical difference between actual and simulated dissent, for the short sample both distributions are found to be different. Hence, for the short sample the reaction function could also be a driving factor of disagreement, although this result is not robust. Finally, in the last robustness test, we resample the forecasts. As shown in Table 2, the simulated dissent (for random forecasts) is significantly greater than what was actually observed.

6. CONCLUSIONS

How can consensus-building efforts of the FOMC chairman be measured using empirical methods? Given the confidentiality of the committee's deliberations, outsiders cannot directly observe these possible efforts. As a first insider to reveal relevant information regarding these efforts, Meyer (2004) confirmed that Chairman Greenspan systematically influenced the preferences of the other members of the Board of Governors prior to FOMC meetings. Although media reports regularly cover the outcome of FOMC meetings, they are mostly silent or only speculate about the course of events during these meetings. In this respect, Chairman Bernanke's agenda for more transparency has allowed for greater insight into the internal decision-making process. For example, the systematic publication of additional information on diversity among FOMC members, which is an element of the Fed's enhanced communication strategy (adopted on 14 November 2007), might enhance the real-time understanding of the distribution of members' views and the extent of the chairman's influence on them.

This paper uses information from FOMC transcripts and examines whether Chairman Greenspan might have influenced the interest rate preferences of the Reserve Bank Presidents. The present empirical analysis provides new evidence, suggesting that Chairman Greenspan might have systematically influenced the Fed Reserve Presidents in their voting behaviour towards a consensus. The approach of this paper is to estimate individual Taylor-type reaction functions for the Federal Reserve Districts based on their voiced interest rate preferences from the policy go-around as well as real-time economic information on the inflation and unemployment gap. We estimate reaction functions based on Greenbook staff forecasts (1989 to 2006) and on individual members' forecasts (1992 until the end of 2000). We propose a bootstrap analysis as a kind of "litmus" test for the presence of a consensus-enhancing factor in the FOMC. This analysis exploits information contained in these reaction functions and constructs notional distributions of disagreement among the Federal Reserve

Districts, assuming the absence of factors that could have enforced consensus. We compare these simulated distributions with the observed disagreement during the committee deliberations. Thereby, we find empirical evidence in favour of coordination at the meeting which helped to bring the preferences of the Federal Reserve Districts more in line with Chairman Greenspan's views.

Finally, we note that in the case of the FOMC several explanations are conceivable for the detected coordination behaviour. While this behaviour is most likely due to a dominant chairman, other factors, such as the FOMC's consensus tradition and the presence of joint paradigms on monetary policy, may be difficult to disentangle from the chairman's influence using the approach of this paper. Other explanations, such as informal rules and the existence of a bias statement, have been discussed in the literature. However, these tools were introduced or refined under Chairman Greenspan and thus might reflect his effort as chairman to generate greater homogeneity across FOMC members in a more structured manner. Therefore, a further research question emerging from our empirical analysis is whether chairman influence is relevant for other chairmen or other monetary policy committees with a federal setting.

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APPENDIX

A.1 Data and sources

Indicators	**Sources**
Policy rate - Fed funds target rate	Federal Reserve website, Board of Governors
FOMC policy-makers' interest rate preferences	Database by Meade (2005) and updates based on FOMC transcript Voting records extracted from FOMC minutes, Board of Governors
Greenbook staff forecasts : - inflation (CPI) - unemployment	ALFRED database Federal Reserve of St. Louis
Individual forecasts of FOMC policy-makers: - inflation (CPI) - unemployment	Database by Romer (2010) or real-time database of Federal Reserve of Philadelphia
Other variables: - NAIRU	All from real-time database of Federal Reserve of Philadelphia

A.2 Interpolation procedure

We apply a two-step procedure in order to derive forecasts for each meeting with a constant horizon. It calculates individual forecasts at meeting frequency with consistent 3-quarter-ahead forecast horizons. In a first step we generate constant-horizon forecasts basically following Orphanides and Wieland (2008). 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 can exploit the fact that in July two forecasts are reported with a horizon of 1-quarter and 5-quarter-ahead. 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 for the meeting frequency. The procedure interpolates the (biannual) individual 3-quarter-ahead forecasts using the pattern from available Greenbook forecasts with identical horizon. We use a state space model interpolating the dynamics of the individual, biannual forecasts with the dynamics of Greenbook forecasts for each meeting. This model comprises the signal equation (see Mönch and Uhlig, 2005):

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

and two state equations:

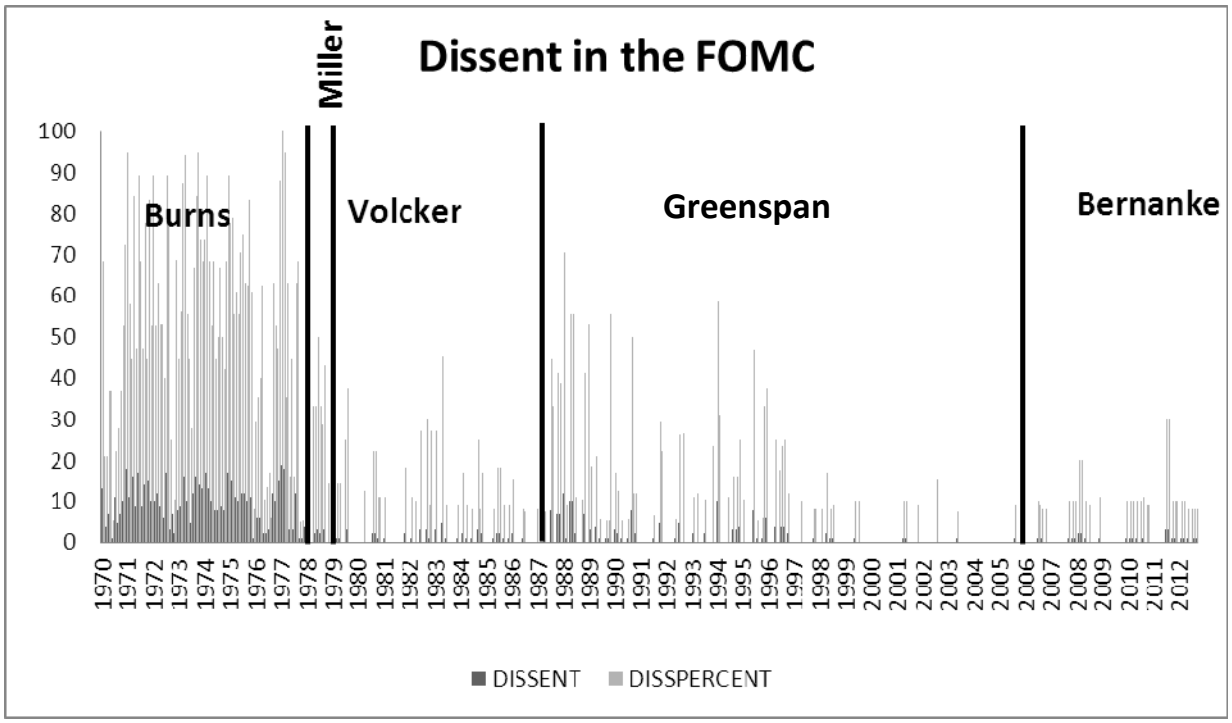
$$\begin{aligned} \overline{x}_{t,i} &= \beta_0 \overline{x}_{t-1,i} + \beta_1 \hat{x}_t^{staff} + \nu_{t,i} \\ \nu_{t,i} &= \nu_{t-1,i} + u_{t,i} \end{aligned} \tag{2}$$

where $\hat{x}_{t,i}$ is the unemployment or inflation forecast of member *i* at time *t*, $\overline{x}_{t,i}$ is the corresponding latent variable (which 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. 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 for which a forecast is available, the signal equation does not include an error term. The system is estimated using a Kalman filter (with ML estimation), and Kalman updates are only performed when a signal is available.

FIGURES AND TABLES

FIGURE 1: Dissent in the FOMC under five chairmen

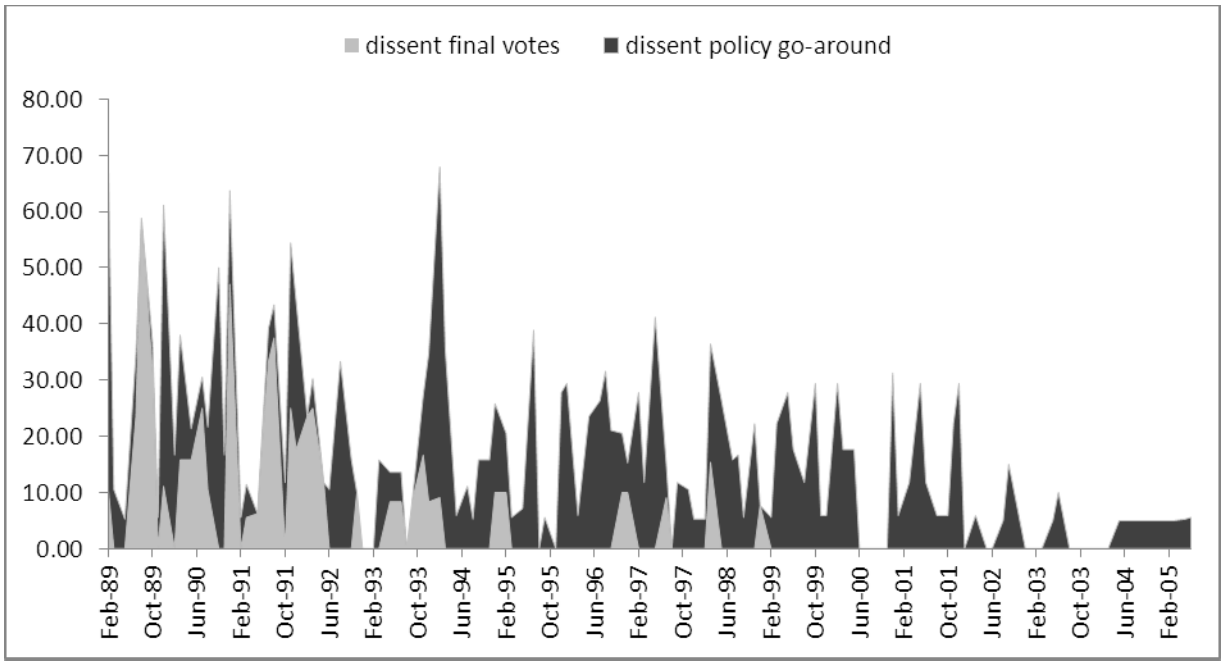
(Total number of dissents; per cent of total votes)



Note: "Dissent" and "Disspercent" include all voting members present at the FOMC meeting. The number of voting members has varied over time. Source: Board of Governors.

FIGURE 2: Dissenting votes by FOMC members: policy go-around versus final votes

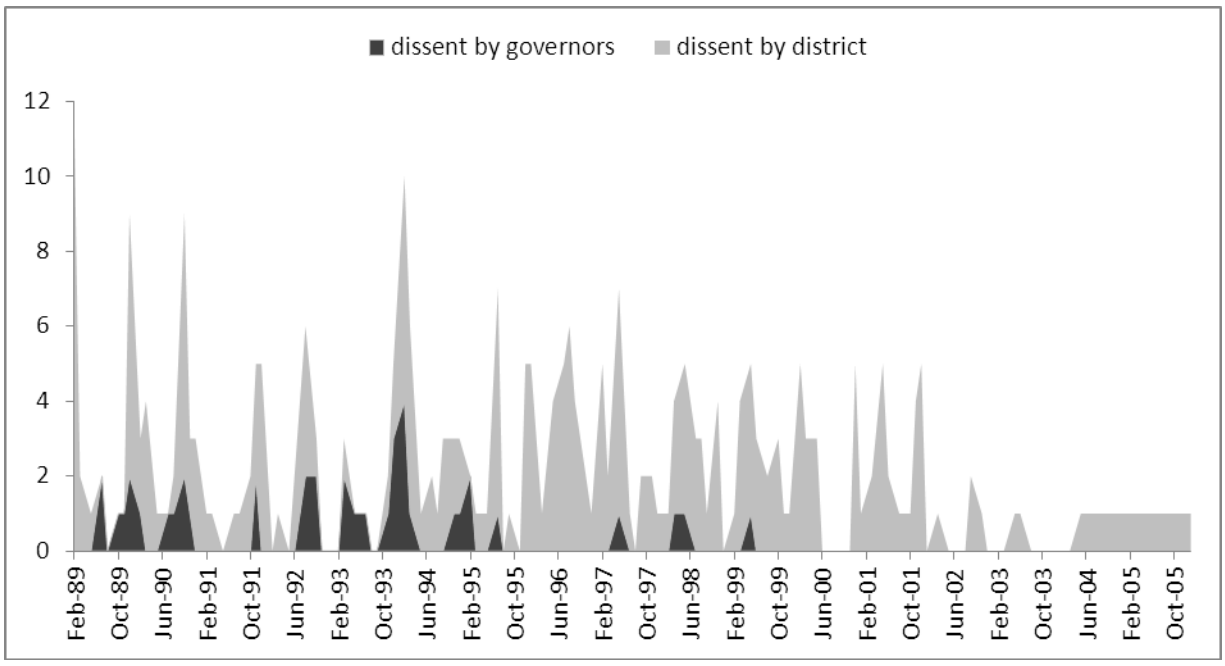
(Per cent of total votes)



Note: "Dissent final votes" includes all voting members present at the FOMC meeting and "dissent policy go-around" includes all voting- and non-voting members attending. Source: Board of Governors.

FIGURE 3: Dissenting votes in the FOMC in the policy go-around: Governors versus Federal Reserve Bank Presidents

(Number of votes)

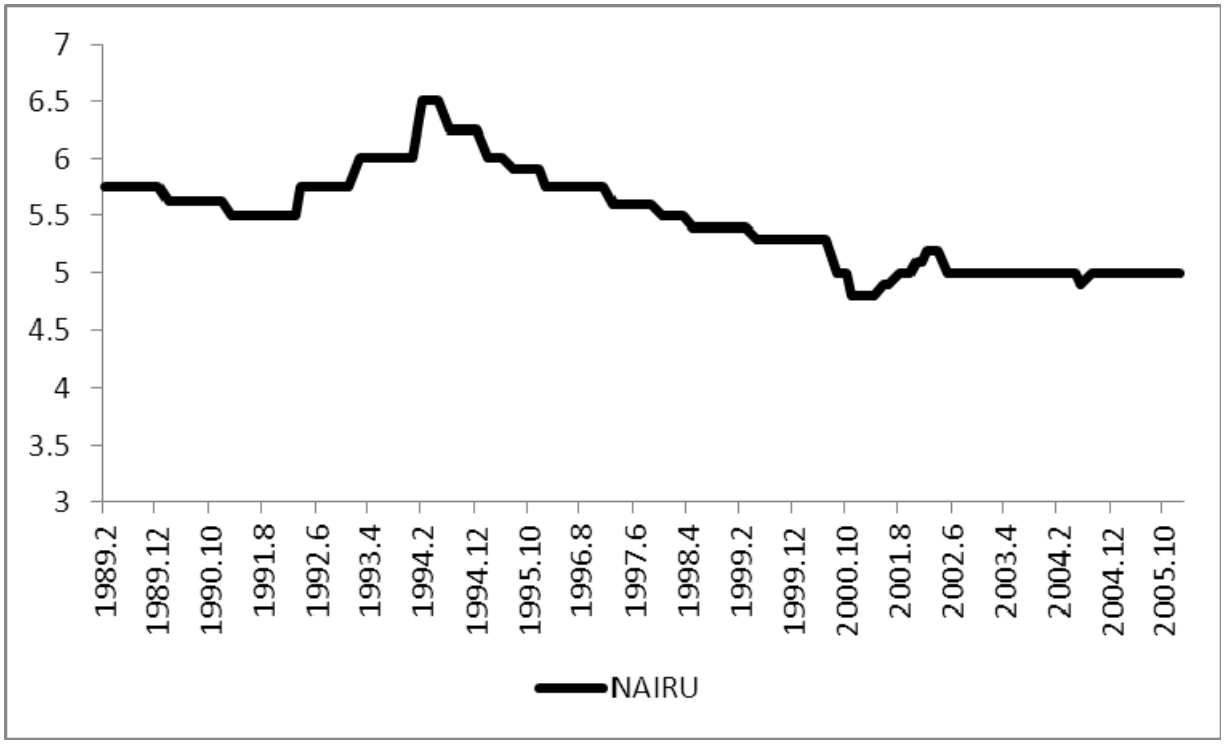


Note: Dissent by District also includes non-voting members present at the FOMC meeting.

Source: Board of Governors.

FIGURE 4: Real-time data for the NAIRU from the Greenbook

(Annual percentage changes)



Source: Real-time database Federal Reserve of Philadelphia.

TABLE 1: Reaction functions of Federal Reserve Districts (Equation 1)

Coefficients Districts	α	β	γ	ρ	Memo: σ	Adj. R^2	DW	Obs.
Sample 1989 to 2006								
Alan Greenspan	3.55 (0.16)	1.68 (0.14)	-2.10 (0.22)	0.86 (0.02)	-0.80	0.99	1.44	136
Boston	3.81 (0.17)	1.70 (0.15)	-2.44 (0.26)	0.85 (0.02)	-0.70	0.99	1.50	136
New York	3.55 (0.16)	1.69 (0.15)	-2.11 (0.22)	0.85 (0.02)	-0.80	0.99	1.39	136
Philadelphia	3.58 (0.15)	1.65 (0.14)	-2.13 (0.21)	0.86 (0.02)	-0.77	0.99	1.28	136
Cleveland	3.69 (0.20)	1.87 (0.17)	-2.26 (0.29)	0.87 (0.02)	-0.83	0.99	1.51	136
Richmond	3.75 (0.12)	1.74 (0.11)	-2.16 (0.17)	0.70 (0.02)	-0.80	0.98	0.82	136
Atlanta	3.65 (0.16)	1.59 (0.14)	-2.25 (0.23)	0.85 (0.02)	-0.71	0.99	1.53	136
Chicago	3.55 (0.17)	1.62 (0.15)	-2.30 (0.25)	0.86 (0.02)	-0.70	0.99	1.36	136
St. Louis	3.87 (0.14)	1.79 (0.12)	-2.16 (0.18)	0.82 (0.02)	-0.83	0.99	1.42	136
Minneapolis	3.68 (0.15)	1.71 (0.13)	-2.13 (0.21)	0.85 (0.02)	-0.81	0.99	1.42	136
Kansas City	3.68 (0.16)	1.69 (0.14)	-2.16 (0.22)	0.85 (0.02)	-0.78	0.99	1.66	136
Dallas	3.43 (0.15)	1.78 (0.14)	-1.96 (0.20)	0.84 (0.02)	-0.91	0.99	1.33	136
San Francisco	3.62 (0.15)	1.85 (0.13)	-2.15 (0.21)	0.84 (0.02)	-0.86	0.99	1.40	136
Sample 1992 to 2000								
Alan Greenspan	3.07 (0.59)	1.63 (0.57)	-2.14 (0.37)	0.87 (0.03)	-0.76	0.97	1.84	70
Boston	3.64 (0.64)	1.61 (0.68)	-2.61 (0.54)	0.89 (0.03)	-0.62	0.98	1.48	70
New York	3.21 (0.66)	1.61 (0.67)	-2.34 (0.41)	0.87 (0.03)	-0.69	0.97	1.94	70
Philadelphia	3.45 (0.66)	1.62 (0.80)	-2.47 (0.67)	0.91 (0.03)	-0.66	0.97	1.42	70
Cleveland	3.88 (0.43)	1.49 (0.68)	-1.86 (0.29)	0.85 (0.04)	-0.80	0.97	1.99	70
Richmond	3.49 (0.43)	1.57 (0.45)	-2.37 (0.32)	0.83 (0.03)	-0.66	0.97	1.74	70
Atlanta	3.53 (0.45)	0.92 (0.40)	-2.43 (0.41)	0.85 (0.03)	-0.38	0.97	1.68	70
Chicago	2.62 (0.86)	2.09 (0.90)	-2.69 (0.59)	0.88 (0.03)	-0.78	0.97	1.99	70
St. Louis[)]	2.60 (1.00)	2.28 (1.02)	-3.59 (1.14)	0.92 (0.03)	-0.64	0.97	1.28	70
Minneapolis	2.58 (0.73)	2.21 (0.73)	-2.67 (0.51)	0.88 (0.03)	-0.83	0.97	1.89	70
Kansas City	3.12 (0.72)	1.77 (0.73)	-3.21 (0.79)	0.90 (0.03)	-0.55	0.97	1.64	70
Dallas	3.65 (0.38)	1.09 (0.37)	-2.46 (0.49)	0.88 (0.03)	-0.44	0.97	1.96	70
San Francisco	2.89 (0.72)	2.56 (0.95)	-3.21 (0.77)	0.88 (0.04)	-0.80	0.96	1.65	70

Note: HAC standard errors in brackets.

TABLE 2: Results of the bootstrap analysis

Bootstrap type	Observed dissent	Simulated dissent	Simulated dissent – standard deviation	p-value of one sided test
Baseline bootstrap and checks for robustness (1)				
Sample 1989 to 2006				
Baseline	0.128	0.315 [0.308]	0.006 [0.006]	~0 [~0]
Zero residuals	0.128	0.227 [0.207]	0.001 [0.001]	~0 [~0]
Unobserved factor	0.128	0.310 [0.303]	0.022 [0.022]	~0 [~0]
Sample 1992 to 2000				
Baseline	0.112	0.272 [0.263]	0.007 [0.007]	~0 [~0]
Zero residuals	0.112	0.196 [0.185]	0.006 [0.005]	~0 [~0]
Unobserved factor	0.112	0.270 [0.261]	0.019 [0.019]	~0 [~0]
Limited randomisation (2)				
Sample 1989 to 2006				
Random residuals	0.128	0.127 [0.126]	0.021 [0.021]	0.54 [0.57]
Random reaction function	0.128	0.127 [0.127]	0.021 [0.021]	0.53 [0.55]
Random forecasts	0.128	0.314 [0.308]	0.006 [0.006]	~0 [~0]
Sample 1992 to 2000				
Random residuals	0.112	0.133 [0.133]	0.013 [0.012]	0.06 [0.04]
Random reaction function	0.112	0.142 [0.138]	0.011 [0.010]	~0 [~0]
Random forecasts	0.112	0.264 [0.265]	0.006 [0.006]	~0 [~0]

Notes: All bootstraps are based on the conventional reaction function with interest rate smoothing (equation 1). The results without rounding to the next feasible interest rate step are reported in parenthesis. The dissent measures are computed as standard deviation of the difference of individual interest rate preferences during the policy go-around from the final fed funds rate after the meeting. The values reported refer to average dissent by member and for each meeting. (1) The null hypothesis H_0 is "*no chairman-effect*". (2) The null hypothesis H_0 is that the observed dissent is drawn from the bootstrapped distribution. It does not reflect our null hypothesis of "*no chairman-effect*".