Using forecasts to uncover the loss function of FOMC members

Christian Pierdzioch[*], Jan-Christoph Rülke[†] and Peter Tillmann[‡]

January 22, 2013

Abstract

We revisit the sources of the bias in Federal Reserve forecasts and assess whether a precautionary motive can explain the forecast bias. In contrast to the existing literature, we use forecasts submitted by individual FOMC members to uncover members' implicit loss function. Our key finding is that the loss function of FOMC members is asymmetric: FOMC members incur a higher loss when they underpredict (overpredict) inflation and unemployment (real GDP) as compared to an overprediction (underprediction) of similar size. Our findings add to the recent controversy on the relative quality of FOMC forecasts compared to staff forecasts. Together with Capistrán's (2008) finding of similar asymmetries in Federal Reserve staff forecasts our results suggest that differences in predictive ability do not stem from differences in preferences. This is underlined by our second result: forecasts remain biased even after accepting an asymmetric loss function.

JEL classification: E58; E37; E27

Keywords: Federal Open Market Committee; forecasting; asymmetric loss function; monetary policy

[*]Helmut-Schmidt-University, Department of Economics, Holstenhofweg 85, P.O.B. 700822, D-22008 Hamburg, Email: c.pierdzioch@hsuhh.de

[†]Corresponding author: WHU - Otto Beisheim School of Management, Department of Economics, Burgplatz 2, D-56179 Vallendar, Email: jan-c.ruelke@whu.edu

[‡]Justus-Liebig-University Giessen, Department of Economics, Licher Str. 66, D-35394 Giessen, E-mail: peter.tillmann@wirtschaft.uni-giessen.de

We are grateful to Maik Wolters, and participants of the 17^{th} Spring Meeting of Young Economists and the Scottish Economic Society Conference 2012 for helpful comments and suggestions.

1 Introduction

One of the key stylized facts in monetary economics is that monetary policy affects macroeconomic variables with a sizable time lag. It is therefore important for monetary policymakers to gauge the most likely path of nominal and real variables. At most central banks, the staff prepares a wide range of forecasts prior to policy decisions. In the case of the Federal Reserve, these staff forecasts are collected in the Greenbook made available to each member of the Federal Open Market Committee (FOMC). However, a peculiar characteristic of the policymaking process in the US is that FOMC members themselves regularly formulate forecasts. Interest rate decisions, thus, are guided by economic projections from at least two different sources.

While the interest rate setting behavior of the FOMC received enormous attention in the literature, knowledge about the FOMC's forecasting behavior is limited. This is an important deficit since Orphanides and Wieland (2008) and Wieland and Wolters (2011) show that the FOMC's own projections are more important for explaining interest rate decisions than observed macroeconomic outcomes. Until recently, an analysis of FOMC forecasts was difficult because individual forecasts are not publicly available. Instead, the Fed publishes only the range of forecasts, not the individual forecasts. A fascinating new data set put together by Romer (2010), however, contains individual forecasts for the period 1992 to 2000.

We use this data set to study the sources of forecast errors and assess whether a precautionary motive can explain the forecast bias. FOMC forecasts are found to be biased, i.e., forecast errors are correlated with information available at the time of forecasting. This does not necessarily imply a departure from rationality. Instead, biased forecasts could be consistent with rationality to the extent that forecasters minimize a non-standard loss function. We thus use the Romer (2010) data set to uncover the loss function of individual FOMC members using the approach developed by Elliott et al. (2005).[1] This approach backs out the parameters of a forecaster's loss function based on historical forecast errors. Our key finding is that the loss function of FOMC members is asymmetric: FOMC members seem to incur a higher loss when they underpredict inflation and unemployment compared to an

[1] Pierdzioch et al. (2012) apply this methodology to evaluate forecasts published by the Bank of Canada.

overprediction of similar size. For real growth, FOMC members seem to incur a higher loss when the forecast exceeds actual growth than when it undershoots the realized growth rate. This result also holds in small samples and for subgroups of members, i.e., voting members or Federal Reserve governors. Moreover, assuming an asymmetric loss function, we can reject the hypothesis of rational forecasts in most cases.

The empirical investigation is similar to Capistrán's (2008) study. The crucial difference, however, is that he uncovers the loss function of the Federal Reserve staff based on inflation forecasts from the Greenbook. He finds that since the Volcker disinflation an underprediction of inflation was approximately four times as costly as an overprediction. We, in contrast, are able to use forecasts submitted by individual FOMC members. An important advantage is that this data set allows us to examine differences in the shape of the loss function between different subgroups of members, i.e. voting and nonvoting members.

Our findings add to the recent controversy on the relative quality of FOMC forecasts compared to staff forecasts. Romer and Romer (2008) show that FOMC forecasts add little information above and beyond Greenbook forecasts. Ellison and Sargent (2012) assume that the FOMC's forecasts describe worst-case scenarios used to make monetary policy robust with respect to misspecifications of the staff's model. Based on this assumption and a simple model, they replicate the findings of Romer and Romer (2008). Together with Capistrán's (2008) results, our findings suggest a different interpretation. If both the staff and the members of the FOMC share a similar shaped loss function, differences in predictive ability must result from a different source.

One important difference with respect to Capistrán's study remains. Once the asymmetric nature of the loss function is accepted, staff forecasts are found to be rational. In our case, however, an asymmetric loss function does not reconcile forecasting performance with rationality, even if we allow for a general loss function as in Patton and Timmermann (2007a, 2007b). This finding, in turn, implies that the bias of FOMC forecasts must stem from another factor yet to be explained. Interestingly, however, forecast rationality under an asymmetric loss function is rejected less frequently in the group of governors and voting FOMC members compared to the sample comprising all FOMC members. This is consistent with evidence on strategic behavior of nonvoting members recently provided by Rülke and Tillmann (2011) and Tillmann (2011).

Our contribution also adds to three other strands of the literature. First, our findings are relevant for recent attempts to study monetary policy preferences based on individual voting information from monetary policy committees.[2] Belden (1989), Havrilesky and Gildea (1991), Chappell et al. (2005), Meade (2005), Gerlach-Kristen (2008, 2009), Riboni and Ruge-Murcia (2008) and Besley et al. (2008) use data on the voting behavior of members of either the FOMC or the Bank of England's Monetary Policy Committee to uncover policy preferences. Ruge-Marcia (2003) analyzes whether central banker's preferences are asymmetric around an inflation target and reports asymmetric preference parameters for Canada, Sweden and the United Kingdom. Here we complement this line of research by providing evidence on the shape of the loss function governing FOMC members' economic projections.

Second, researchers try to infer the degree of asymmetry of the central banks' objective function from estimated interest rate rules. Surico (2007) estimates a reaction function for the Fed derived from Nobay and Peel's (2003) potentially asymmetric linex-loss function. He finds that before 1979 the Fed weighted positive and negative deviations of the inflation rate from the target differently. After 1979, however, preferences appear symmetric. Rather than specifying a particular loss function, Kilian and Manganelli (2008) present and estimate a risk management model of the Fed weighing upside and downside risks to policy objectives.

Third, we shed light on the sources of forecast bias in Federal Reserve forecasts. Studies by Gavin (2003), Gavin and Mandal (2003), and Gavin and Pande (2008) examine the accuracy of the FOMC's published forecast range. Instead, we are able to examine the rationality of individual forecasts based on a flexible functional form of the forecasters' loss function.

The remainder of the paper is organized as follows. Section two introduces the data set. Section three presents the methodology used to uncover the functional form of the FOMC's loss function. The results and an extensive set of robustness tests are discussed in section four. Some tentative conclusions are drawn in section five.

[2] A survey of recent studies on policymaking in monetary policy committees is provided by Blinder (2009).

2 The data set

We use the data set compiled and disseminated by Romer (2010). The data set contains individual forecasts for real growth, nominal growth, inflation, and the unemployment rate for the period 1992–2000. During these years, the Fed published the monetary policy report to congress following its February and July meetings, respectively.[3] As part of the preparation of this report, every FOMC member submits his or her own forecasts, after intensive briefing by the Board staff. The published report only contains the range of forecasts but does not report member-specific forecasts. Romer (2010), however, managed to obtain those individual forecasts from the Federal Reserve and put together a fascinating data set. Due to the ten-year publication lag, the data set ends in 2000. The data set contains forecasts from board members as well as the twelve voting and nonvoting regional Federal Reserve Bank presidents. It does not, however, contain forecasts from the chairman.

In the July report, the FOMC prepares forecasts of the inflation rate, the annual growth rate of real and nominal GDP, and the unemployment rate in the fourth quarter of the current and the next calendar year. These forecasts are referred to as two-quarters-ahead and six-quarters-ahead forecasts, respectively. The February report contains forecasts of the same variables for the fourth quarter of the current calendar year. These forecasts are referred to as four-quarters-ahead forecasts.

We contrast the forecasts with real-time data on actual realizations. For the nominal and real growth rate, we use estimates which are released three months after the end of the quarter. Although these numbers are slightly revised, they correspond to what the FOMC and the staff were trying to forecast. For the other variables, we use the first release as the revisions in the inflation rate and the unemployment rate are very limited.[4] All forecasts are supposed to be conditional on every member's own judgement of the "appropriate policy" path over the forecast horizon. In total, we have available 457 forecasts for each macroeconomic variable.

A potential drawback in any empirical analysis of the individual FOMC

[3] In 2007, the frequency of forecasts was increased and the coverage was broadened.

[4] As a robustness test, we also use revised data from the OECD's database. The results, which are available upon request, are similar to our baseline results.

forecasts is that the sample period covers the "New Economy" period of (unexpected) high growth rates in the mid-1990's. Hence, the data encompass an expansion phase in which the Federal Reserve and other forecasters gradually learned that the underlying mean of output growth rates was higher than expected. In order to examine the time-series dimension and the cross-sectional dimension of the data, Figure 1 plots the forecasts for the three different time horizons (two-, four-, and six-quarters-ahead forecasts as triangles, dots and squares, respectively), and the realized values (solid line).

Insert Figure 1 about here.

The vertical distance between the forecasts and the solid line can be interpreted as the forecast error. Two observations stand out. First, cross-sectional heterogeneity of forecasts is a characteristic feature of the data. For instance, in February 1994 the real growth (inflation) forecasts vary across FOMC members between 2.5 (2.25) and 3.8 (4) percent. Second, there appears to be a sufficient degree of variation over time to justify our approach based on the historical series of forecast errors. In fact, there are many periods of under- and overprediction of all four variables.[5]

Table 1 summarizes the results of a Wilcoxon test under the null hypothesis that the distribution of forecast errors is symmetric around zero. For most specifications, the null hypothesis can be rejected, and an asymmetric distribution seems to fit the forecast errors better. Evidence of asymmetry is less pronounced for forecast errors of the nominal growth rate of output, and for errors made by Federal Reserve governors.

Insert Table 1 about here.

3 Modeling an asymmetric loss function

A traditional Mincer-Zarnowitz test of forecast unbiasedness is a joint test of the symmetry of the loss function and the efficient use of information. The finding of biased forecasts could, in principle, result from a violation

[5]This data set has been used by Rülke and Tillmann (2011) and Tillmann (2011) to examine the degree of strategic behavior of FOMC members in the forecasting process. An in-depth analysis of other aspects of the forecasting behavior of FOMC members based on individual forecast data is provided by Banterghansa and McCracken (2009).

of either the assumption of symmetry or informational efficiency. In our empirical study, we employ the approach developed by Elliott et al. (2005) to study the shape of the FOMC members' loss function. The idea is to search for the shape of the loss function of a forecaster that would be most consistent with the forecaster's past forecast errors.[6]

The approach rests on the assumption that the loss function, $\mathcal{L}$, of a forecaster can be described in terms of the following general functional form:

$$\mathcal{L} = [\alpha + (1 - 2\alpha)I(s_{t+h} - f_{t+h} < 0)]|s_{t+h} - f_{t+h}|^p, \tag{1}$$

where f_{t+h} reflects the forecast submitted by an individual FOMC member in period t for a variable to be realized h periods in the future. This realization is denoted by s_{t+h}. Thus, the forecast error is $s_{t+h} - f_{t+h}$. The expression $I(s_{t+h} - f_{t+h} < 0)$ reflects an indicator function. The parameter p governs the general functional form of the loss function, where a lin-lin loss function obtains for $p = 1$, and a quad-quad loss function results if one sets $p = 2$. The parameter $\alpha \in (0, 1)$ governs the degree of asymmetry of the loss function and is our primary parameter of interest. A symmetric loss function results in the case of $\alpha = 0.5$. For $\alpha > 0.5$ underpredicting a variable causes a higher loss than overpredicting. For $\alpha < 0.5$, in turn, overpredicting is more costly than underpredicting. For $\alpha = 0.5$ and $p = 2$, the loss a forecaster incurs increases in the squared forecast error. For $\alpha = 0.5$ and $p = 1$, the loss increases in the absolute forecast error.

Elliott et al. (2005) show that, for a given parameter p, the asymmetry parameter, α, can be consistently estimated by means of a Generalized Method of Moments (GMM) approach, which gives the following estimator:

$$\hat{\alpha} = \frac{\gamma_1' \hat{S}^{-1} \gamma_2}{\gamma_1' \hat{S}^{-1} \gamma_1}, \tag{2}$$

where we define

$$\gamma_1 = \frac{1}{T} \sum_{t=\tau}^{T+\tau-h} v_t |s_{t+h} - f_{t+h}|^{p-1} \tag{3}$$

[6] The approach of Elliott et al. (2005) is further generalized in Patton and Timmermann (2007b).

and

$$\gamma_2 = \frac{1}{T} \sum_{t=\tau}^{T+\tau-h} v_t I(s_{t+h} - f_{t+h} < 0)|s_{t+h} - f_{t+h}|^{p-1}, \tag{4}$$

and the vector of instruments, v_t, is used to estimate a weighting matrix given by

$$\hat{S} = \frac{1}{T} \sum_{t=\tau}^{T+\tau-h} v_t v_t' (I(s_{t+h} - f_{t+h} < 0) - \hat{\alpha})^2 |s_{t+h} - f_{t+h}|^{2p-2}. \tag{5}$$

The number of forecasts, starting in period $\tau + h$, is given by T. We consider as instruments a constant (Model 1) and a constant and the lagged realized value (Model 2). With the weighting matrix depending on $\hat{\alpha}$, estimation is done iteratively.

Testing whether $\hat{\alpha}$ differs from α_0 is done by using the z-test $\sqrt{T}(\hat{\alpha} - \alpha_0) \rightarrow \mathcal{N}(0, (\hat{h}'\hat{S}^{-1}\hat{h})^{-1})$, where $\hat{h} = \frac{1}{T}\sum_{t=\tau}^{T+\tau-h} v_t |s_{t+h} - f_{t+h}|^{p-1}$. Elliott et al. (2005) further prove that testing for rationality of forecasts, conditional on a loss function of the lin-lin or quad-quad type, can be achieved by computing

$$J(\hat{\alpha}) = \frac{1}{T}\left(x_t' \hat{S}^{-1} x_t\right) \sim \chi^2_{d-1}, \tag{6}$$

where $x_t = \sum_{t=\tau}^{T+\tau-h} v_t [I(s_{t+h} - f_{t+h} < 0) - \hat{\alpha}]|s_{t+h} - f_{t+h}|^{p-1}$ and $d > 1$ denotes the number of instruments. For a symmetric loss function, we have $J(0.5) \sim \chi^2_d$. The statistic $J(0.5)$ answers the question of whether forecasters under the maintained assumption of a symmetric loss function form rational forecasts. For a lin-lin or quad-quad loss function, the test, $J(\hat{\alpha})$, answers the question of whether forecasters form rational forecasts, given an asymmetric loss function.

4 Uncovering the loss function as implied by FOMC forecasts

In this section we present our main results and several robustness tests and, based on the recent literature on FOMC forecasting, put them into perspective.

4.1 Empirical results

Table 2 summarizes the estimates of the asymmetry parameter for a lin-lin loss function and for a quad-quad loss function, based on the full sample of data.[7] The general picture emerging is that there are indeed deviations from a symmetric loss function. However, there are also important differences across the forecast variables. Our key finding is that FOMC members appear to perceive a higher loss when underestimating the inflation rate and the unemployment rate. For both variables, $\hat{\alpha}$ is significantly larger than 0.5. Thus, an FOMC member forecasting the inflation rate to be too low relative to the eventual realization experiences a larger loss relative to a fellow member forecasting the inflation rate to be too high. For real growth, the opposite is true (see also Patton and Timmermann 2007b). In these cases, overpredicting is more costly than underpredicting. A symmetric loss function fits forecasts well if the estimated asymmetry parameter, $\hat{\alpha}$, is not significantly different from 0.5, which tends to be the case for forecasts for the nominal growth rate (h = 2 and 6). One reason why FOMC members tend to have a symmetric loss function with regard to the nominal growth rate might be that the Federal Reserve has targeted nominal income during our sample period (Kiley, 2003). Hence, the symmetry of the loss function indicates that the Federal Reserve weights over- and underprojections of forecasts of the nominal growth rate equally and is interested in minimizing the absolute or squared forecast error.

As mentioned in Section three, a traditional Mincer-Zarnowitz test is a joint test of the symmetry of the (quadratic) loss function and the informational efficiency of the forecasting process. Setting a forecast such that an asymmetric loss function is minimized implies that, when a Mincer-Zarnovitz regression is being estimated, the forecast is biased. In order to study forecast rationality conditional on the loss function given in Equation (1), Table 3 reports the J-test results of forecast rationality. The results for the lin-lin (quad-quad) loss function imply that under a symmetric loss function only in 2 (0) out of 12 cases rationality cannot be rejected at a one per cent significance level. Compared to that under a flexible loss function, forecast rationality cannot be rejected in 4 (2) cases. Hence, under a flexible loss function FOMC forecasts tend to be slightly more rational.

[7] We coded up all estimations and simulations using the free software R Release 2.15.0 (R Development Core Team 2012).

A key characteristic of the policymaking process in the United States is that the voting right on the FOMC rotates across the regional Federal Reserve Bank presidents, while the Federal Reserve Governors are always allowed to vote.[8] All members, however, submit forecasts. Table 4 reports the results for voters only, which leaves 299 observations for each macroeconomic variable. Our general result remains unchanged, i.e. for the inflation rate and the unemployment rate FOMC members perceive a higher loss when underpredicting the inflation rate compared to an overprediction. For real growth forecasts FOMC members incur a higher loss when overpredicting real economic activity. Interestingly, the results in Table 5 indicate that the hypothesis of forecast rationality can be rejected in fewer cases as compared to the full sample. Under a flexible loss function, forecast rationality cannot be rejected in 8 (7) out of 12 cases at a one percent significance level. Hence, forecast rationality under an asymmetric loss seems to be somewhat stronger in the group of voters compared to the full sample.

As a robustness test, we use only the 133 forecasts submitted by the Federal Reserve governors based at the Fed Board. Tables 6 and 7 report again strong evidence of an asymmetric loss function, except for nominal growth forecasts. Governors' forecasts of the inflation rate and the unemployment rate appear rational under an asymmetric loss function. The rationality condition under an asymmetric loss can be rejected in the case of the real growth rate and, in the case of a quad-quad loss function, also for the nominal growth rate. The general picture that emerges, however, is that evidence of rationality is somewhat stronger under an asymmetric loss for governors than for all members, especially as far as forecasts of the inflation rate and the unemployment rate (quad-quad loss function) are concerned.

Because the numbers of observations for the voting members is relatively small, we also study the forecasts of the nonvoters.[9] The results corroborate the results shown in Tables 3, 5, and 7. Evidence of rationality of forecasts is weaker for nonvoters than for governors with respect to forecasts of the inflation rate and the unemployment rate. Forecasts of nonvoters, thus, appear to be a source of deviations from forecast rationality detected for

[8] The president of the New York Fed does not participate in the rotation scheme. From the remaining eleven regional Federal Reserve Banks, four presidents are entitled to vote in a given year.

[9] To economize on journal space, results for nonvoters are not reported but available upon request from the authors.

forecasts of the inflation rate and the unemployment rate reported in Table 3.

Insert Tables 2–7 about here.

Figure 2 plots the implications of our empirical findings for the shape of the FOMC's loss function, where we assume for illustrative purposes that the loss function is of the lin-lin form and the forecast horizon is $h = 4$ (four-quarters-ahead, Model 1). The solid dark line represents the results for all members, the solid grey line the results for voting members, and the dashed line the results for governors. The figure shows that, as far as inflation and unemployment figures are concerned, the loss of an underprediction is larger than an overprediction of similar size. Put differently, the FOMC members incur the same loss when overpredicting the unemployment rate by 4 percentage points or underpredicting by less than 2 percentage points. For real growth forecasts, in contrast, the FOMC members experience the same loss of an underprediction of the growth rate by 4 percentage points and an overprediction of less than 2 percentage points. For nominal growth forecasts, the loss function also appears asymmetric in Figure 2, but as witnessed by Tables 2, 4, and 6 this asymmetry only obtains for $h = 4$.

Insert Figure 2 about here.

4.2 Interpretation

Our results suggest that FOMC members entertain an asymmetric loss function. Furthermore, this non-standard loss function does not fully explain the bias in FOMC forecasts. We also find that the prevalence of the forecast bias turns out to be somewhat different across voting and non-voting members. These findings can be interpreted in several dimensions:

First, our findings are similar to results Capistrán's (2008) derived from Greenbook forecasts. Since his study is limited to the forecasts for inflation, we can compare estimates for inflation projections only. Interestingly, his estimate of the asymmetry parameter is very close to ours.[10] This suggests

[10] In fact, Capistrán's (2008) estimates of the asymmetry with respect to inflation are slightly higher than ours. His point estimates of α range between 0.8 and 0.9. It should be noted, however, that the loss function studied by Capistrán (2008) depends on the wedge between the actual inflation rate and the inflation target, whereas our loss function depends on the forecast error.

that the Federal Reserve staff and the members of the FOMC share a similarly shaped loss function. This is remarkable since the study by Romer and Romer (2008) sparked a debate about the relative quality of FOMC forecasts. Romer and Romer (2008) find that FOMC forecasts do not contain information that is not already incorporated in staff forecasts. To defend the role of the FOMC, Ellison and Sargent (2012) address this striking result in a model in which the FOMC's projections represent worst case scenarios against which optimal monetary policy should be robust. In conjunction with Capistrán's results, our estimates reveal that loss functions implicit in either staff or FOMC forecasts are similarly shaped. While we cannot rule out the Ellison-Sargent explanation, our results suggest that the staff as well as the FOMC seek to avoid an underprediction of inflation.

Second, an important difference with respect to staff forecasts remains. Even under an asymmetric loss function, FOMC forecasts remain biased, where violations of forecast rationality are weaker in the cases of forecasts of the inflation rate and the unemployment rate for governors and voters as compared to the the sample of all members. An asymmetric loss function, in contrast, reconciles the staff's forecast performance with rationality. This suggests that considerations other than asymmetries might still play a role in the forecasting process. In fact, one could think of several reasons for why forecasters' loss functions deviate from the standard functional form that we studied in this paper. Patton and Timmermann (2007b), who study output forecasts derived from the Greenbook, suggest that the loss function may not only depend on forecast errors, but also on realized values.[11] Another reason is that strategic interactions among forecasters give rise to a loss function that is more complex than a lin-lin or a quad-quad loss function. Members might use their forecast to influence monetary policy decisions according to their preferences. Previous research based on the same data set is consistent with that view. Tillmann (2011) finds that hawkish nonvoters overpredict inflation while dovish nonvoters systematically underpredict inflation. In a similar vein, McCracken (2010) argues that hawkish members have an incentive to forecast high inflation in order to support the need for tighter monetary policy. Rülke and Tillmann (2011) provide evidence consistent

[11] We obtain, however, similar results when we analyze the quantile-based test advanced by Patton and Timmermann (2007b), which also can be used when the loss function depends on actual values. Results are not reported, but are available from the authors upon request.

with the view that nonvoting members 'anti-herd', i.e., they intentionally scatter their inflation forecast away from the forecast consensus.[12] The results of this paper corroborate that notion insofar as forecast rationality under the stipulated asymmetric loss function is more pronounced (as far as the inflation rate and the unemployment rate are studied) for governors and in the group of voting FOMC members compared to the sample comprising all FOMC members.

4.3 Simulation experiment

In order to assess the robustness of our results, and to account for a potential small sample problem, we set up the following simulation experiment: We randomly draw 100 times out of the 457 FOMC forecasts a sample with $n = 50$ observations, where we make sure that the forecast horizon is the same for all observations. We then compute for every random sample the asymmetry parameter. Figure 3 shows the resulting 100 estimates of the asymmetry parameter, where every dot represents one estimate of the asymmetry parameter and the forecast horizon is $h = 2$ in Panel A and $h = 4$ in Panel B. The estimates for the real/nominal growth rate (inflation rate/unemployment rate) are displayed on the vertical/horizontal axis. The information conveyed by the scatter diagram corroborates the information conveyed by Table 2 and Figure 2.

Insert Figure 3 about here.

Estimates of the asymmetry parameter for the real growth rate forecasts are smaller than 0.5. Estimates for the nominal growth rate forecasts are also smaller than 0.5, but the estimated asymmetry parameter and the dispersion of the estimates are larger than in the case of the real growth rate forecasts. A symmetric loss function, thus, fits better the nominal growth rates forecasts than the real growth rate forecasts. As for the umemployment rate, the simulation results confirm that the estimated asymmetry parameter tends to be larger than 0.5. For the inflation rate, the estimated asymmetry parameter also is larger than 0.5 in the majority of cases, where the evidence of $\hat{\alpha} > 0.5$ is somewhat stronger in the case of $h = 2$. In sum,

[12] For theoretical models of 'herding' and 'anti-herding', see Bikhchandani et al. (1992) and Laster et al. (1999). In the former case, forecasters follow the consensus forecast. In the latter case, they form extreme forecasts to impact the policy process.

Figure 3 supports our finding that FOMC members seem to have a more or less symmetric loss function with regard to nominal growth rate forecasts, while they seem to incur a comparatively high loss when they underpredict (overpredict) the unemployment rate and the inflation rate (the real growth rate).

Insert Figure 4 about here.

Figure 4 shows the p-values of the corresponding rationality tests. In line with the results summarized in Table 3, the tests strongly reject rationality in the case of real growth rate forecasts, irrespective of the assumed shape of the loss function. For the nominal growth rate forecasts, both a symmetric and an asymmetric loss function yield evidence of rational forecasts in the case of $h = 2$. Evidence of rationality is much weaker in the case of $h = 4$, where an asymmetric loss function performs somewhat better than a symmetric loss function. Simulation results for the inflation rate show that an asymmetric loss function performs better than a symmetric loss function with respect to the rationality of forecasts in some simulations for $h = 2$, but the picture is less clear for $h = 4$. On balance, however, evidence of rationality of forecasts is not strong as most dots can be found in the lower left-hand corner of the figure. Finally, simulation results for the unemployment rate forecasts are also in line with the results shown in Table 3. Evidence of rational forecasts is somewhat stronger under an asymmetric than under a symmetric loss functions ($h = 2$), but the majority of simulation runs yield significant J-tests.

In sum, the results of the simulation experiment help to build confidence in our results. Results for the estimated asymmetry parameter, $\hat{\alpha}$, and the J-tests derived from the simulated small samples of data are in line with the results derived from the actual data.

4.4 Recursive Estimates

The sample period covers the 1990s, over which the U.S. economy grew strongly without accompanying inflationary pressure. Observers at that time frequently argued that the underlying output-inflation trade-off underwent a structural break.[13] If there was indeed a structural break that went

[13]The FOMC deliberations reflected this debate. Meade and Thornton (2012) document that FOMC members increasingly referred to concepts such as "potential output",

unnoticed by forecasters, the resulting forecast errors would by systematically biased and, hence, the hypothesis underlying the test for rationality would be violated.

Insert Figures 5 and 6 about here.

If rejection of forecast rationality merely reflects forecaster learning in the case of a structural break, it should not be possible to reject forecast rationality before a potential structural break. After a structural break, in contrast, p-values of the $J-$tests should indicate significance of the test results. To evaluate the potential caveat that a structural break in the data generating process distorts the results of our rationality tests, we estimate the model for an initial sample period covering data up to 1995 and then sequentially add an additional year of observations in every recursion. The recursive estimates are based on a lin-lin loss function (for all members) and yield series of estimated asymmetry-parameters, $\hat{\alpha}$, as well as p-values for the J-test. These series are depicted in Figure 5 for two forecasts horizons. For inflation and real GDP forecasts, the estimated degree of asymmetry remains remarkably stable over the sample period. Although forecasts for unemployment exhibit some degree of variation in the estimated $\hat{\alpha}$ ($H = 4$), this variation never invalidates our basic conclusion. In fact, the series of estimated coefficients never crosses the 0.5 line from above. The symmetry underlying nominal GDP forecasts changes sign, but this does not come as a surprise as these forecasts reflect the joint properties of the real growth and inflation forecasts, making these forecasts prone to statistical artifacts. The same is true for the recursively estimated J-tests, whose p-values are shown in Figure 6. With the exception of the nominal growth forecasts ($h = 2$), all p-values remain fairly stable even during the second half of the 1990s.

In sum, the recursive estimates corroborate the robustness of our earlier findings. None of our core results is affected by structural breaks in the data series. In fact, the results are consistent with the view that the FOMC forecasters were aware of the breaks in mean inflation and unemployment in real time.[14]

"Phillips curve" and "NAIRU" towards the second half of the 1990s.

[14] This is also consistent with the results in Tillmann (2010), who uses the Romer-data to show that the Phillips curve trade-off reflected in individual FOMC forecasts changed in the mid-1990s.

5 Concluding remarks

We have recovered the loss function of FOMC members as implied by individual forecasts for key macroeconomic variables. The results clearly suggest that the loss function is asymmetric. Apparently, FOMC members experience a higher loss when overpredicting real economic activity compared to an underprediction. In contrast, FOMC members perceive a higher loss when underestimating the inflation rate and the unemployment rate while forecasts of the nominal growth rate are more in line with a symmetric loss function. We also reported evidence that forecast rationality under an asymmetric loss can be rejected in most cases, where we find interesting differences in this respect between governors and voting members and non-voting members.

However, rejecting forecast rationality does not necessarily imply that forecasters in fact form irrational forecasts. The results in this paper suggest that conditional on a specific functional form of the forecasters' loss function, which features asymmetries, the forecasts remain biased. This leaves two possibilities. One is that forecasters indeed deliver forecasts that are not consistent with forecast rationality. Another possibility, though, is that forecasters' loss function is more general than assumed under the null hypothesis of the J-test used in this study. Further work is needed to broaden the class of admissible loss functions, probably taking strategic motives of FOMC members into account.

Another implication that needs to be addressed is the impact of an asymmetric loss function of FOMC forecasters on monetary policy decisions. If members fear underpredicting inflation they might follow a precautionary motive when adjusting interest rates. Recently, Branch (2011) links biased forecasts based on an asymmetric loss function to a nowcast-based policy rule. This is certainly a promising field for future empirical research.

References

Banternghansa, S., McCracken, M. W., 2009. Forecast disagreement among FOMC members. Working Paper 2009-059A, Federal Reserve Bank of St. Louis.

Belden, S., 1989. Policy preferences of FOMC members as revealed by dissenting votes. Journal of Money, Credit and Banking 21, 432-441.

Besley, T., Meade, N., Surico, P., 2008. Insiders versus outsiders in monetary policymaking. American Economic Review: Papers and Proceedings 98, 218-223.

Bikhchandani, S., Hirshleifer, D., Welch, I., 1992. A theory of fads, fashion, custom and cultural change as informational cascades. Journal of Political Economy 100, 992-1026.

Blinder, A. S., 2009. Making monetary policy by committee. International Finance 12, 171-194.

Branch, W. A., 2011. Nowcasting and the Taylor rule. unpublished, University of California, Irvine.

Capistrán, C., 2008. Bias in Federal Reserve inflation forecasts: is the Federal Reserve irrational or just cautious? Journal of Monetary Economics 55, 1415-1427.

Chappell, H. W., McGregor, R. R., Vermilyea, T. A., 2005. Committee decisions in monetary policy: evidence from historical records of the Federal Open Market Committee. MIT Press, Cambridge.

Elliott, G., Komunjer, I., Timmermann, A., 2005. Estimation and testing of forecast rationality under flexible loss. Review of Economic Studies 72, 1107-1125.

Ellison, M., Sargent, T. J., 2012. A defence of the FOMC. International Economic Review 53, 1047-1065.

Gavin, W. T., 2003. FOMC forecasts: is all the information in the central tendency? Federal Reserve Bank of St. Louis Review, May/June 2003, 27-46.

Gavin, W. T., Mandal, R. J., 2003. Evaluating FOMC forecasts. International Journal of Forecasting 19, 655-667.

Gavin, W. T., Pande, G., 2008. FOMC consensus forecasts. Federal Reserve Bank of St. Louis Review, May/June 2008, 149-163.

Gerlach-Kristen, P., 2008. The role of the chairman in setting monetary policy: individualistic vs. autocratically collegial MPCs. International Journal of Central Banking 4, 119-143.

Gerlach-Kristen, P., 2009. Outsiders at the Bank of England's MPC. Journal of Money, Credit and Banking 41, 1099-1115.

Havrilesky, T., Gildea, J. A., 1991. The policy preferences of FOMC members as revealed by dissenting votes - A comment. Journal of Money, Credit and Banking 23, 130-138.

Kiley, M., 2003. Why Is Inflation Low When Productivity Growth Is High? Economic Inquiry 41, 392-406.

Kilian, L., Manganelli, S., 2008. The central banker as a risk manager: estimating the Federal Reserve's preferences under Greenspan. Journal of Money, Credit and Banking 40, 1103-1129.

Laster, D., Bennett, P., Geoum, I. S., 1999. Rational bias in macroeconomic forecasts. The Quarterly Journal of Economics 114, 293-318.

McCracken, M. W., 2010. Using FOMC forecasts to forecast the economy. Economic Synopses, No. 5, Federal Reserve Bank of St. Louis.

Meade, E. E., 2005. The FOMC: preferences, voting, and consensus. Federal Reserve Bank of St. Louis Review 87, 93-101.

Meade, E. E., Thornton, D. L., 2012. The Phillips curve and US monetary policy: what the FOMC transcripts tell us. Oxford Economic Papers 64, 197-216.

Nobay, A. R., Peel, D. A., 2003. Optimal discretionary monetary policy in a model of asymmetric central bank preferences. The Economic Journal 113, 657-665.

Orphanides, A., Wieland, V., 2008. Economic projections and rules of thumb for monetary policy. Federal Reserve Bank of St. Louis Review, 307-324.

Patton, A. J., Timmermann, A., 2007a. Properties of optimal forecasts under asymmetric loss and nonlinearity. Journal of Econometrics 140, 884-918.

Patton, A. J., Timmermann, A., 2007b. Testing forecast optimality under unknown loss. Journal of the American Statistical Association 102, 1172-1184.

Pierdzioch, C., Rülke, J.-C., Stadtmann, G., 2012. On the loss function of the Bank of Canada: a note. Economics Letters 115, 155-159.

R Development Core Team, 2012. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna. Internet address: http://www.R-project.org.

Riboni, A., Ruge-Murcia, F. J., 2008. Preference heterogeneity in monetary policy committees. International Journal of Central Banking 4, 213-233.

Romer, D. H., 2010. A new data set on monetary policy: the economic forecasts of individual members of the FOMC. Journal of Money, Credit and Banking 42, 951-957.

Romer, C. D., Romer, D. H., 2008. The FOMC versus the staff: where can monetary policymakers add value? American Economic Review: Papers and Proceedings 98, 230-235.

Ruge-Murcia, F. J., 2003. Inflation Targeting under Asymmetric Preferences. Journal of Money, Credit and Banking 35, 763-785.

Rülke, J. C., Tillmann, P., 2011. Do FOMC members herd? Economics Letters 113, 176-179.

Surico, P., 2007. The Fed's monetary policy rule and U.S. inflation: the case of asymmetric preferences. Journal of Economic Dynamics and Control 31, 305-324.

Tillmann, P., 2010. The Fed's perceived Phillips curve: evidence from individual FOMC forecasts. Journal of Macroeconomics 32, 1008-1013.

Tillmann, P., 2011. Strategic forecasting on the FOMC. European Journal of Political Economy 27, 547-553.

Wieland, V., Wolters, M. H., 2011. Forecasting and policy making, in preparation for Elliott, G., Timmermann, A. (Eds.). Handbook of Economic Forecasting, Volume 2, Elsevier.

Table 1: Wilcoxon test (p-values)

variable	h	all members	voting members	governors
real	2	0.000	0.000	0.000
growth	4	0.000	0.000	0.000
rate	6	0.021	0.021	0.011
nominal	2	0.110	0.535	0.296
growth	4	0.000	0.002	0.011
rate	6	0.302	0.671	0.286
inflation	2	0.000	0.000	0.001
rate	4	0.004	0.056	0.204
	6	0.000	0.000	0.005
unemploy-	2	0.000	0.000	0.000
ment	4	0.000	0.000	0.000
rate	6	0.000	0.000	0.000

Notes: The table reports the p-values of the Wilcoxon test under the null hypothesis that the distribution of forecast errors are symmetric around zero.

Table 2: Estimating the asymmetry parameter (all members)

Panel A: lin-lin loss function

variable	h	$\hat{\alpha}_{model1}$	std. error	z-test	$\hat{\alpha}_{model2}$	std. error	z-test
real	2	0.230	0.034	-7.90	0.029	0.014	-34.47
growth	4	0.255	0.035	-6.96	0.106	0.025	-15.79
rate	6	0.230	0.034	-7.90	0.162	0.030	-11.31
nominal	2	0.434	0.040	-1.64	0.433	0.040	-1.68
growth	4	0.301	0.037	-5.38	0.249	0.035	-7.19
rate	6	0.434	0.040	-1.64	0.431	0.040	-1.71
inflation	2	0.730	0.036	6.40	0.782	0.033	8.44
rate	4	0.556	0.040	1.38	0.565	0.040	1.62
	6	0.697	0.037	5.30	0.723	0.036	6.16
unemploy-	2	0.592	0.040	2.31	0.594	0.040	2.37
ment	4	0.634	0.039	3.44	0.702	0.037	5.47
rate	6	0.790	0.033	8.75	0.790	0.033	8.76

Panel B: quad-quad loss function

variable	h	$\hat{\alpha}_{model1}$	std. error	z-test	$\hat{\alpha}_{model2}$	std. error	z-test
real	2	0.200	0.035	-8.46	0.020	0.010	-48.99
growth	4	0.168	0.031	-10.56	0.022	0.011	-43.98
rate	6	0.326	0.048	-3.63	0.325	0.048	-3.66
nominal	2	0.402	0.052	-1.89	0.383	0.051	-2.28
growth	4	0.294	0.047	-4.36	0.061	0.016	-26.82
rate	6	0.511	0.051	0.22	0.423	0.052	-1.49
inflation	2	0.859	0.030	11.85	0.960	0.012	36.99
rate	4	0.666	0.044	3.74	0.712	0.042	5.05
	6	0.754	0.041	6.25	0.761	0.040	6.46
unemploy-	2	0.827	0.033	9.98	0.884	0.025	15.07
ment	4	0.833	0.030	11.05	0.947	0.015	30.85
rate	6	0.733	0.049	4.76	0.903	0.024	16.80

Notes: The instruments used are a constant (Model 1) and a constant and the lagged actual value (Model 2).

Table 3: Testing for forecast rationality (all members)

Panel A: lin-lin loss function

variable	h	J(0.5)	p-value	J($\hat{\alpha}$)	p-value
real	2	75.57	0.000	32.46	0.000
growth	4	58.41	0.000	28.87	0.000
rate	6	48.93	0.000	15.36	0.000
nominal	2	4.75	0.093	1.87	0.172
growth	4	37.96	0.000	15.81	0.000
rate	6	6.08	0.048	3.18	0.074
inflation	2	53.15	0.000	14.04	0.000
rate	4	13.47	0.001	10.89	0.001
	6	33.46	0.000	8.86	0.003
unemploy-	2	7.37	0.000	1.93	0.165
ment	4	43.67	0.000	25.81	0.000
rate	6	50.96	0.000	0.01	0.915

Panel B: quad-quad loss function

variable	h	J(0.5)	p-value	J($\hat{\alpha}$)	p-value
real	2	85.28	0.000	23.03	0.000
growth	4	65.90	0.000	22.54	0.000
rate	6	15.28	0.000	2.18	0.140
nominal	2	16.98	0.000	14.23	0.000
growth	4	59.32	0.000	19.99	0.000
rate	6	29.89	0.000	28.86	0.000
inflation	2	72.50	0.000	12.66	0.000
rate	4	21.61	0.000	12.62	0.000
	6	30.05	0.000	2.16	0.141
unemploy-	2	52.36	0.000	9.40	0.002
ment	4	76.76	0.000	20.84	0.000
rate	6	56.39	0.000	11.58	0.000

Notes: $J(0.5)$ denotes the J-test for a symmetric loss function. $J(\hat{\alpha})$ denotes the J-test for a lin-lin and quad-quad loss function, respectively. The instruments used are a constant and the lagged actual value.

Table 4: Estimating the asymmetry parameter (voting members)

Panel A: lin-lin loss function

variable	h	$\hat{\alpha}_{model1}$	std. error	z-test	$\hat{\alpha}_{model2}$	std. error	z-test
real	2	0.245	0.059	-4.31	0.035	0.025	-18.54
growth	4	0.289	0.063	-3.37	0.164	0.051	-6.53
rate	6	0.245	0.059	-4.31	0.186	0.053	-5.86
nominal	2	0.453	0.068	-0.69	0.452	0.068	-0.70
growth	4	0.269	0.062	-3.75	0.257	0.061	-4.02
rate	6	0.415	0.068	-1.25	0.405	0.067	-1.41
inflation	2	0.830	0.052	6.40	0.897	0.042	9.52
rate	4	0.596	0.068	1.41	0.634	0.067	2.00
	6	0.755	0.059	4.31	0.803	0.055	5.54
unemploy-	2	0.585	0.068	1.25	0.585	0.068	1.26
ment	4	0.654	0.065	2.33	0.758	0.059	4.35
rate	6	0.830	0.052	6.40	0.833	0.051	6.49

Panel B: quad-quad loss function

variable	h	$\hat{\alpha}_{model1}$	std. error	z-test	$\hat{\alpha}_{model2}$	std. error	z-test
real	2	0.210	0.060	-4.86	0.022	0.013	-35.59
growth	4	0.148	0.046	-7.58	0.027	0.017	-27.67
rate	6	0.337	0.080	-2.04	0.332	0.080	-2.09
nominal	2	0.463	0.083	-0.45	0.397	0.079	-1.31
growth	4	0.262	0.077	-3.07	0.052	0.025	-17.81
rate	6	0.541	0.086	0.47	0.479	0.088	-0.24
inflation	2	0.894	0.049	8.08	0.975	0.015	31.37
rate	4	0.689	0.076	2.50	0.764	0.066	4.01
	6	0.776	0.066	4.20	0.788	0.065	4.44
unemploy-	2	0.805	0.057	5.35	0.833	0.051	6.57
ment	4	0.849	0.048	7.23	0.962	0.024	19.11
rate	6	0.726	0.083	2.73	0.915	0.041	10.18

Notes: The instruments used are a constant (Model 1) and a constant and the lagged actual value (Model 2).

Table 5: Testing for forecast rationality (voting members)

Panel A: lin-lin loss function

variable	h	J(0.5)	p-value	J($\hat{\alpha}$)	p-value
real	2	25.78	0.000	12.00	0.000
growth	4	16.47	0.000	9.61	0.002
rate	6	15.39	0.000	4.97	0.026
nominal	2	1.09	0.580	0.56	0.455
growth	4	12.47	0.002	1.36	0.243
rate	6	4.51	0.105	2.79	0.095
inflation	2	30.30	0.000	7.28	0.007
rate	4	10.24	0.006	4.20	0.040
	6	18.53	0.000	4.20	0.040
unemploy-	2	1.62	0.443	0.09	0.766
ment	4	19.40	0.000	10.52	0.001
rate	6	23.34	0.000	0.20	0.656

Panel B: quad-quad loss function

variable	h	J(0.5)	p-value	J($\hat{\alpha}$)	p-value
real	2	30.47	0.000	8.70	0.003
growth	4	24.00	0.000	7.87	0.005
rate	6	5.03	0.081	0.80	0.370
nominal	2	7.00	0.030	4.83	0.028
growth	4	21.27	0.000	6.31	0.012
rate	6	11.14	0.004	11.01	0.001
inflation	2	29.64	0.000	2.85	0.091
rate	4	9.32	0.009	4.42	0.036
	6	13.77	0.001	1.31	0.252
unemploy-	2	14.73	0.000	1.588	0.208
ment	4	28.01	0.000	7.903	0.005
rate	6	21.48	0.000	4.705	0.030

Notes: $J(0.5)$ denotes the J-test for a symmetric loss function. $J(\hat{\alpha})$ denotes the J-test for a lin-lin and quad-quad loss function, respectively. The instruments used are a constant and the lagged actual value.

Table 6: Estimating the asymmetry parameter (Federal Reserve governors)

Panel A: lin-lin loss function

variable	h	$\hat{\alpha}_{model1}$	std. error	z-test	$\hat{\alpha}_{model2}$	std. error	z-test
real	2	0.227	0.063	-4.32	0.041	0.030	-15.44
growth	4	0.267	0.066	-3.54	0.147	0.053	-6.70
rate	6	0.205	0.061	-4.86	0.090	0.043	-9.49
nominal	2	0.424	0.050	-1.53	0.422	0.050	-1.57
growth	4	0.317	0.046	-3.96	0.222	0.041	-6.72
rate	6	0.444	0.050	-1.11	0.443	0.050	-1.14
inflation	2	0.636	0.073	1.88	0.651	0.072	2.10
rate	4	0.578	0.074	1.06	0.584	0.073	1.14
	6	0.659	0.071	2.23	0.680	0.070	2.55
unemploy-	2	0.659	0.071	2.23	0.682	0.070	2.60
ment	4	0.622	0.072	1.69	0.7762	0.063	4.14
rate	6	0.818	0.058	5.47	0.821	0.057	5.55

Panel B: quad-quad loss function

variable	h	$\hat{\alpha}_{model1}$	std. error	z-test	$\hat{\alpha}_{model2}$	std. error	z-test
real	2	0.191	0.066	-4.69	0.028	0.017	-28.37
growth	4	0.184	0.060	-5.24	0.042	0.028	-16.56
rate	6	0.294	0.086	-2.39	0.280	0.086	-2.57
nominal	2	0.405	0.090	-1.06	0.209	0.068	-4.30
growth	4	0.291	0.085	-2.45	0.055	0.026	-16.95
rate	6	0.468	0.096	-0.34	0.313	0.094	-1.98
inflation	2	0.793	0.069	4.24	0.910	0.037	10.97
rate	4	0.633	0.082	1.62	0.647	0.082	1.81
	6	0.747	0.080	3.08	0.748	0.080	3.09
unemploy-	2	0.844	0.054	6.34	0.965	0.022	21.03
ment	4	0.798	0.062	4.76	0.969	0.017	28.07
rate	6	0.788	0.078	3.67	0.897	0.043	9.20

Notes: The instruments used are a constant (Model 1) and a constant and the lagged actual value (Model 2).

Table 7: Testing for forecast rationality (Federal Reserve governors)

Panel A: lin-lin loss function

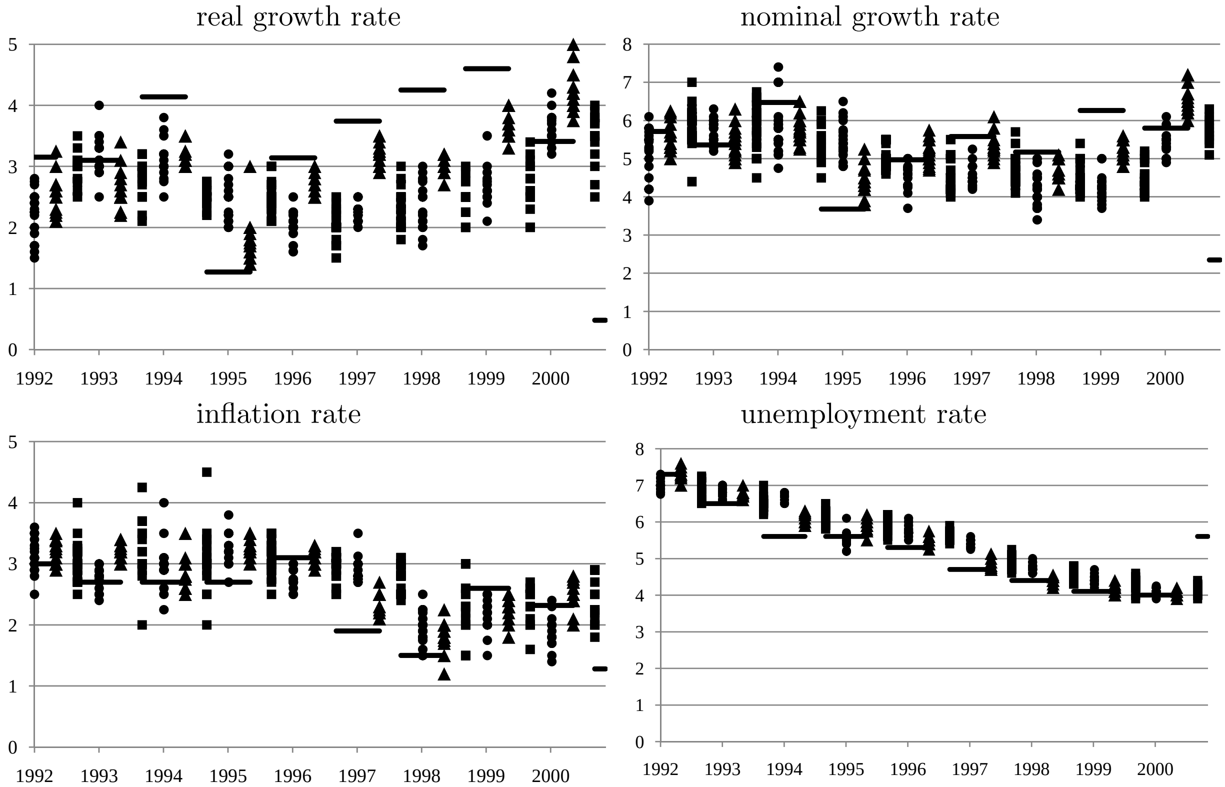
variable	h	J(0.5)	p-value	J($\hat{\alpha}$)	p-value
real	2	21.52	0.000	8.93	0.003
growth	4	15.08	0.001	7.64	0.006
rate	6	17.33	0.000	6.14	0.013
nominal	2	3.77	0.152	0.81	0.369
growth	4	27.16	0.000	8.01	0.005
rate	6	2.29	0.318	1.27	0.259
inflation	2	5.74	0.057	2.07	0.145
rate	4	2.76	0.252	1.57	0.211
	6	7.35	0.025	2.50	0.113
unemploy-	2	7.71	0.002	2.82	0.093
ment	4	18.83	0.000	12.03	0.001
rate	6	18.04	0.000	0.18	0.674

Panel B: quad-quad loss function

variable	h	J(0.5)	p-value	J($\hat{\alpha}$)	p-value
real	2	24.83	0.000	5.49	0.019
growth	4	17.57	0.000	6.48	0.011
rate	6	7.01	0.030	1.94	0.164
nominal	2	12.88	0.002	8.27	0.004
growth	4	17.10	0.000	6.24	0.012
rate	6	10.21	0.006	8.64	0.003
inflation	2	16.93	0.000	3.85	0.050
rate	4	4.54	0.104	2.90	0.088
	6	7.46	0.024	0.50	0.479
unemploy-	2	20.15	0.000	6.22	0.013
ment	4	24.39	0.000	8.17	0.004
rate	6	16.57	0.000	2.28	0.131

Notes: $J(0.5)$ denotes the J-test for a symmetric loss function. $J(\hat{\alpha})$ denotes the J-test for a lin-lin and quad-quad loss function, respectively. The instruments used are a constant and the lagged actual value.

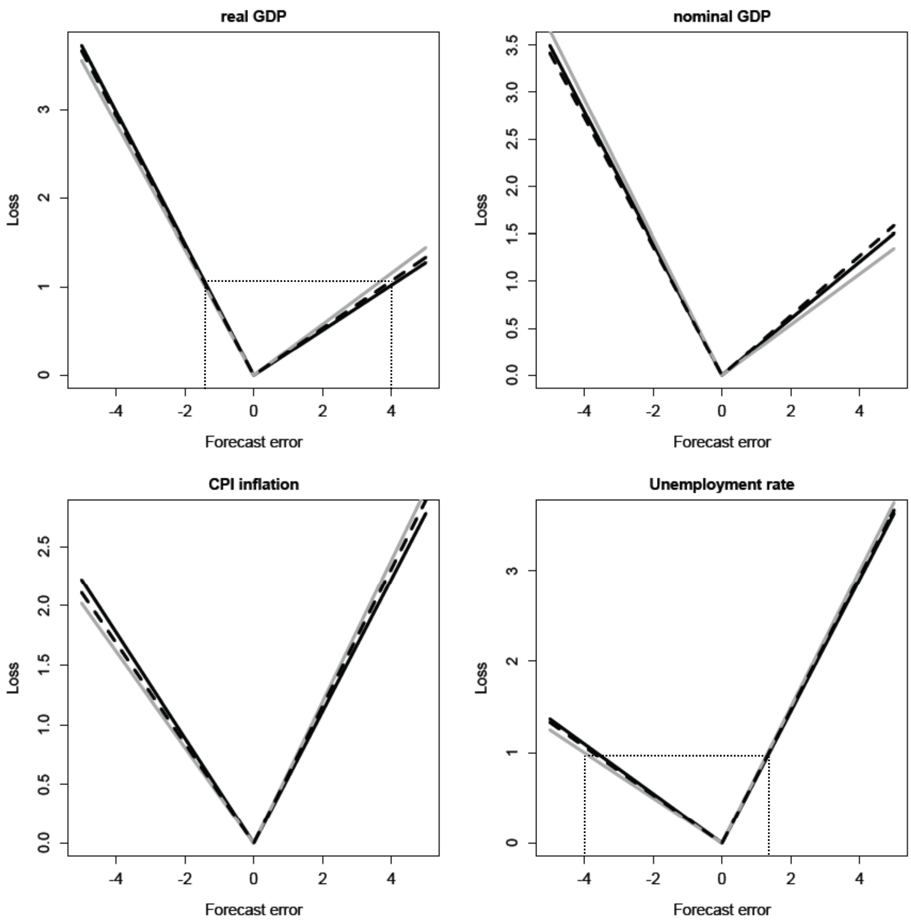
Figure 1: Individual FOMC forecasts



▲ 2Q forecasts; ● 4Q forecasts ■ 6Q forecasts; — realized value

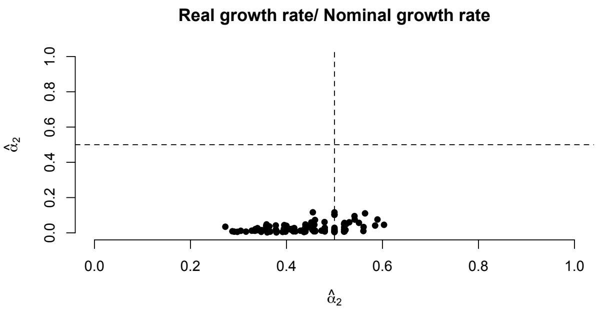
Notes: The figure shows the forecasts of the FOMC and the realized value for the two-, four-, and six-quarters-ahead forecast as triangles, dots, and squares, respectively.

Figure 2: FOMC loss function

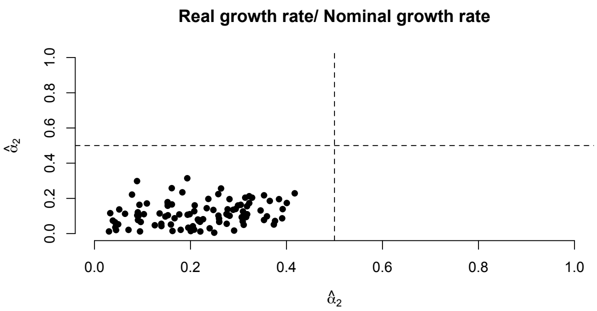


Notes: The loss function as implied by FOMC forecasts (lin-lin form, $h = 4$). The shape of the loss function is governed by the estimated asymmetry parameter, $\hat{\alpha}$, under Model 1. Solid dark line = all FOMC members. Solid grey line = voting members. Dashed line = governors.

Figure 3: Simulation results: asymmetry parameter
Panel A: Forecast horizon $h = 2$



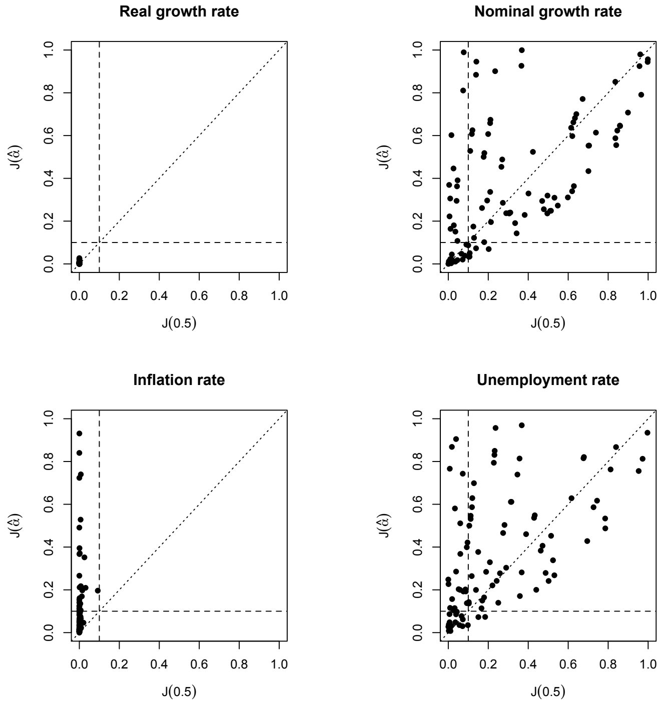
Panel B: Forecast horizon $h = 4$



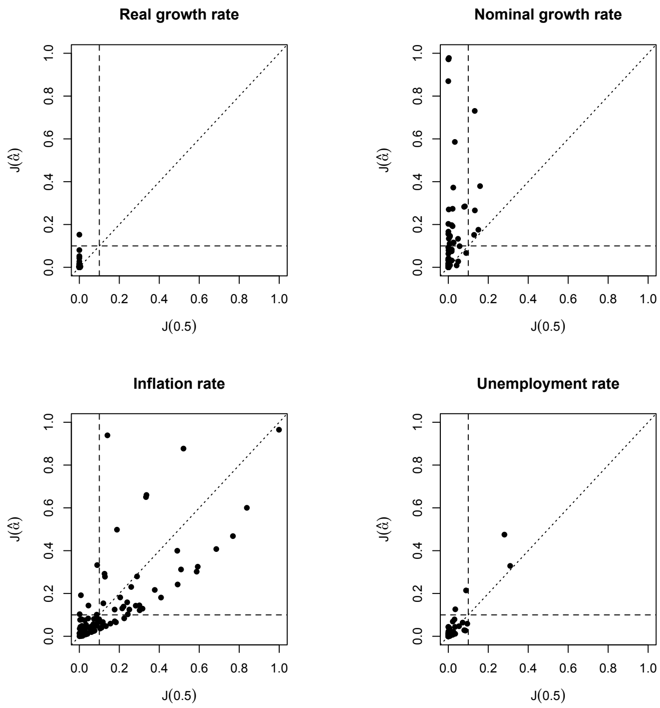
Notes: Figure 3 plots the asymmetry parameter, $\hat{\alpha}$ (Model 2) estimated on simulated data. Every dot represents the results of one out of 100 simulation, where every simulation features $n = 50$ random observations drawn from the FOMC forecasts. The forecast horizon is $h = 2$ in Panel A and $h = 4$ in Panel B. The loss function is of the lin-lin form. The estimates for the real/nominal growth rate (inflation rate/unemployment rate) are displayed on the vertical/horizontal axis. The dashed horizontal and vertical lines represent the cases of a symmetric loss function ($\alpha = 0.5$).

Figure 4: Simulation results: rationality tests

Panel A: Forecast horizon $h = 2$

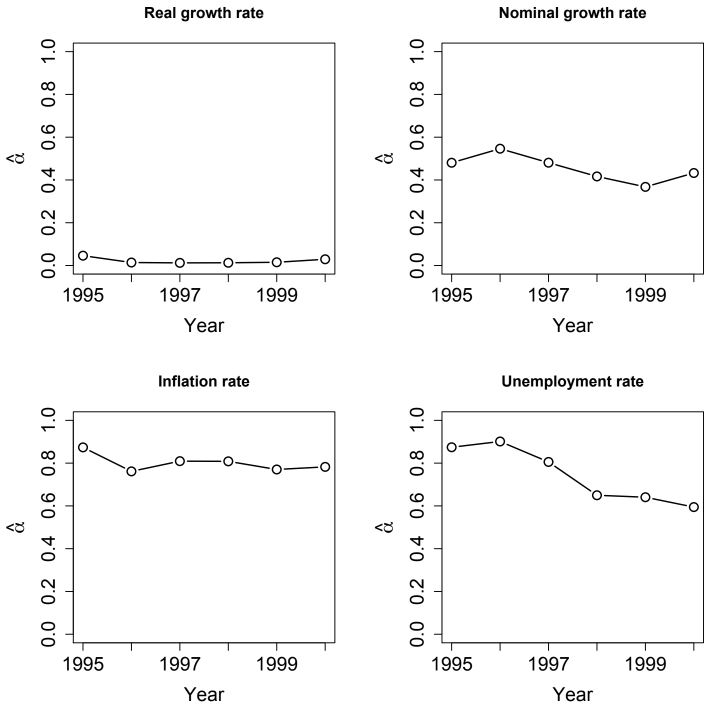


Panel B: Forecast horizon $h = 4$

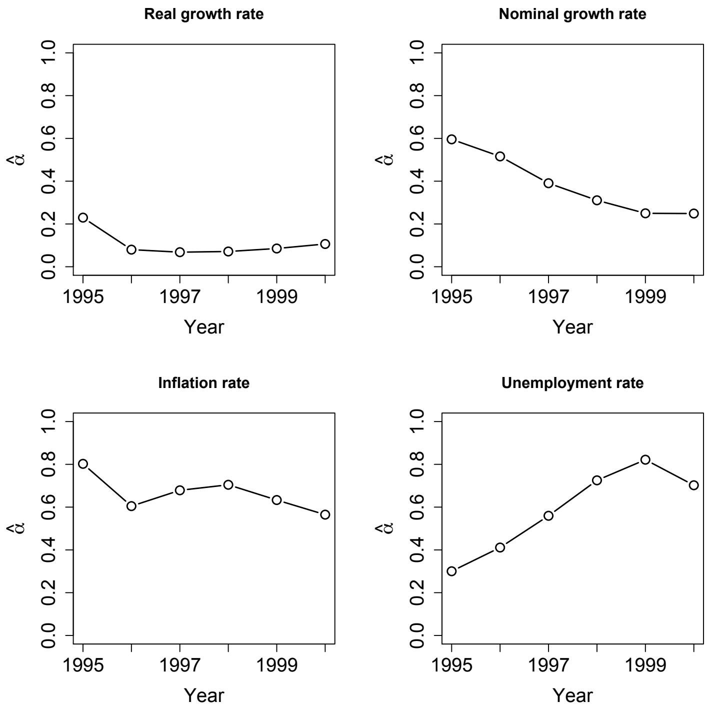


Notes: Figure 4 plots the p-values of the J-tests under an assumed symmetric, $J(0.5)$, and an estimated asymmetric, $J(\hat{\alpha})$, loss function. Every dot represents the results of one out of 100 simulation, where every simulation features $n = 50$ random observations drawn from the FOMC forecasts. The forecast horizon is $h = 2$ in Panel A and $h = 4$ in Panel B. The loss function is of the lin-lin form. The dashed horizontal and vertical lines represent the 10% significance lines. The dashed lines with slope equal to unity help to compare the relative magnitude of the p-values.

Figure 5: Recursive estimates: asymmetry parameter)
Panel A: Forecast horizon h = 2



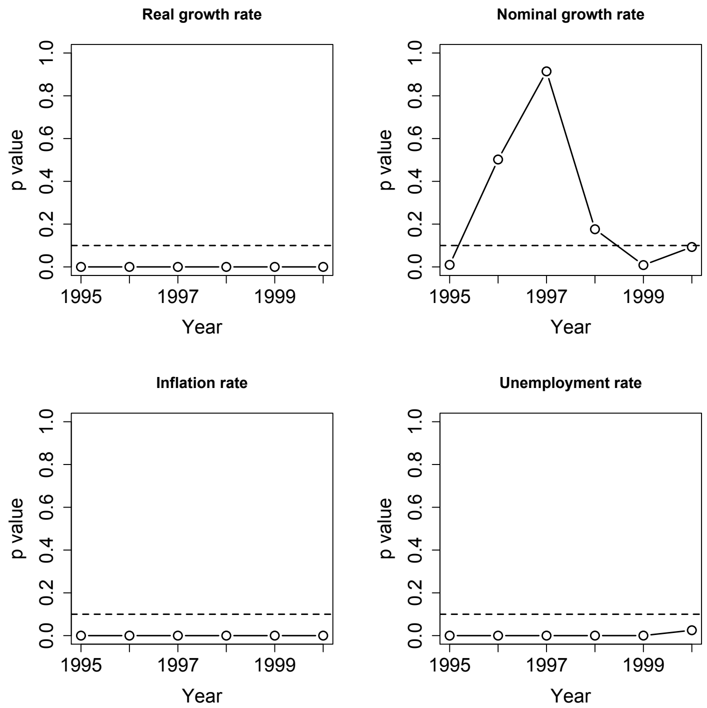
Panel B: Forecast horizon h = 4



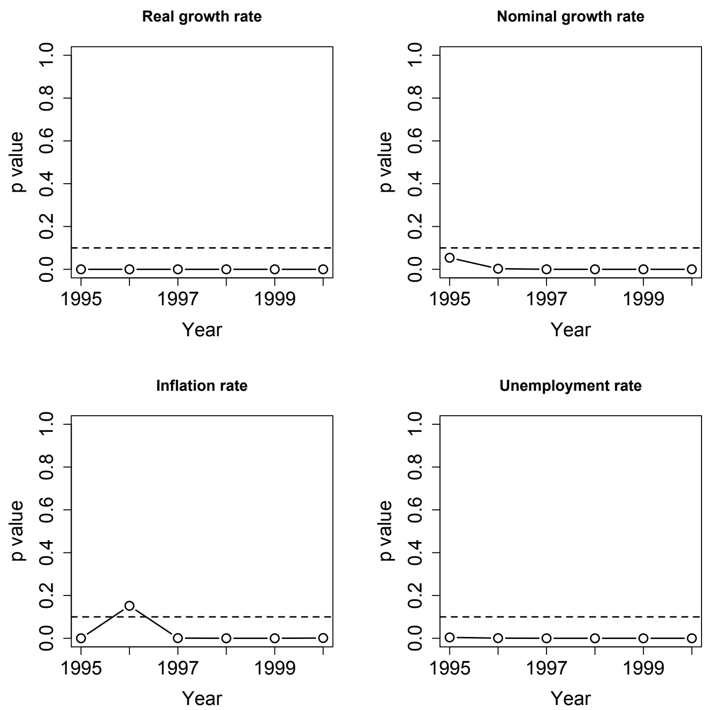
Notes: Figure 5 plots the recursively estimated asymmetry parameter, $\hat{\alpha}$. Every dot represents one estimate based on Model 2. The recursive estimation starts in 1995, and one year of data is added in every recursion. Estimates are based on a lin-lin loss function (all members).

Figure 6: Recursive estimates: rationality tests

Panel A: Forecast horizon $h = 2$



Panel B: Forecast horizon $h = 4$



Notes: Figure 5 plots the recursively computed $J(\hat{\alpha})$ tests. Every dot represents the p-value for Model 2. The recursive estimation starts in 1995, and one year of data is added in every recursion. Estimates are based on a lin-lin loss function (all members).