



# Forecasting FOMC Forecasts

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## **Abstract**

Summarizing Hendry's forty years of work on taming uncertainty is "clear and distinct": Test, test, test. Sure - but test what? Test the maintained assumptions of the disturbances. Test the parameter restrictions of a given model. Test the explanatory power of a model against a rival model. In brief, test everything that is not clear and distinct. We implement Hendry's view to forecast FOMC forecasts. Specifically, monetary policy is forward looking and, in its pursuit of transparency, it communicates its economic projections to the public at large. As a result, there is interest in whether these projections are credible. We argue that central to that credibility is the public's ability to replicate FOMC's projections using publicly available data only. In other words, is it possible to anticipate, reliably and independently, what the FOMC will anticipate for the federal funds rate? To address this question, we assemble FOMC projections from 1992 to 2017; examine their statistical properties; postulate models to predict FOMC projections; estimate the parameters of these models; and generate out-of-sample predictions for inflation, unemployment, and the federal funds rate for 2018. As the reader will soon realize, there is a lot more testing to be done.

# 1 Introduction

Starting in late 2007, U.S. monetary authorities began releasing their *Summary of Economic Projections (SEP)* with the goal of enhancing the public's understanding of their policies:

"The Federal Open Market Committee (FOMC) announced on Wednesday that, as part of its ongoing commitment to improve the *accountability* and public *understanding* of monetary policy making, it will increase the frequency and expand the content of the economic projections that are made by Federal Reserve Board members and Reserve Bank presidents and released to the public."<sup>1</sup> *Emphasis added.*

Importantly, these projections are not mere extrapolations of existing trends but the result of an FOMC directive to participants to craft *appropriate* monetary policies:<sup>2</sup>

"Appropriate monetary policy is defined as the future policy most likely to foster outcomes for economic activity and inflation that best satisfy the participant's interpretation of the Federal Reserve's dual objectives of maximum employment and price stability."<sup>3</sup>

That FOMC participants disagree on the *appropriate* federal funds rate is clear from figure 1:

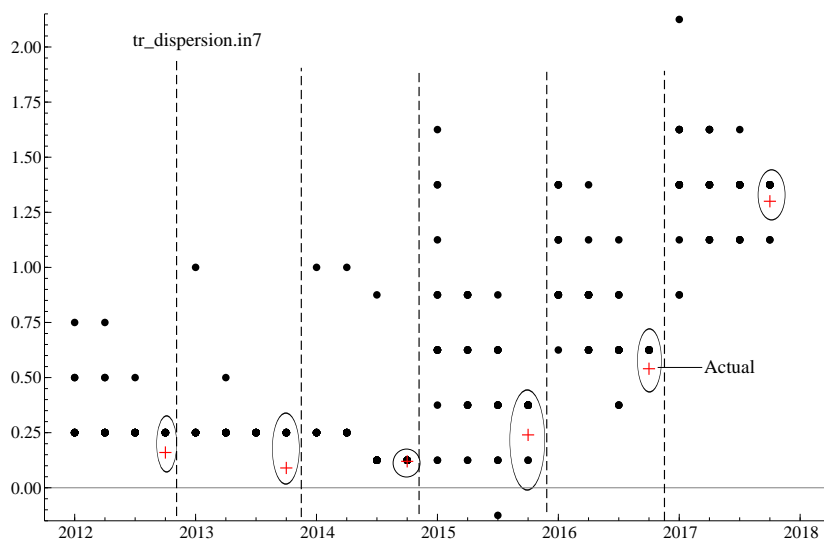


Figure 1: Median of Appropriate Federal Funds Rates for the Current Year

<sup>1</sup>Press Release Nov. 14, 2007 <http://www.federalreserve.gov/newsevents/press/monetary/20071114a.htm>

<sup>2</sup><http://www.federalreserve.gov/monetarypolicy/files/fomcminutes20071031.pdf>.

See also Page 3 of <http://www.federalreserve.gov/mediacenter/files/FOMCpresconf20151216.pdf>

Note that FOMC participants are not picking just any value of the federal funds rate they deem appropriate. Rather, their values vary in steps of 0.125 percentage points; the steps might vary from meeting to meeting. So their interpretation of the appropriate monetary policy is not unconstrained.

<sup>3</sup>See <http://www.federalreserve.gov/monetarypolicy/files/fomcminutes20071031.pdf>.

What is not clear is how these disagreements enhance the FOMC's accountability or the public's understanding of monetary policy: if FOMC participants disagree to this extent about what is appropriate, why would they expect the public to understand their decisions?

We are not the first to note the tension between the intended transparency of the SEP and the dispersion of appropriate policies. Faust (2016) notes that

The SEP, in my view, deserves a special place in the annals of obfuscation in the service of transparency. The SEP is the paradigm case of the second type of communication: it is purely a depiction of the policymakers' different views on the outlook and appropriate policy, with no hints about how any differences may be resolved. (Faust 2016 p. 17)

The question we address here is whether there is a suitable approach to bypass Faust's critique. Developing this approach involves addressing several obstacles. The first one is the FOMC's idiosyncratic data-release protocol. Greatly simplified, the FOMC releases summaries of economic projections in real time but the underlying details are released with a lag of at least five years. To document this idiosyncratic protocol, we offer a brief description of the FOMC with an emphasis on both its structure and its data-release protocol. Our examination yields a data set of FOMC projections from 1992 to 2017 which we use in our modeling work.

The second obstacle is how to model a process that, by design, is secretive. To address this obstacle, we argue that FOMC projections can enhance the public's understanding if they are, at a minimum, replicable by the public. If so, that would mean that both the FOMC and the public share an understanding of both the goals of monetary policy and the functioning of economy. This shared understanding allows the public to anticipate decisions about interest rates and to understand unexpected departures from those anticipations.<sup>4</sup> We illustrate the applicability of our framework by assessing the credibility of Forward Guidance. Specifically, after the federal funds rate reached "zero" in 2009, the FOMC issued a string of increasingly ambiguous FOMC statements about the duration of the exceptionally low interest rates. Then, in December 2012, the FOMC issued a statement that removed the ambiguities. We use SEP data to generate an ex-ante prediction of the *date* when the unemployment rate would cross the announced threshold and find very supportive results.

The third obstacle is how to assess the quality and/or usefulness of our work. Indeed, asking if FOMC projections are replicable amounts to asking whether it is possible to extract a narrative of the FOMC's views of the economy's functioning. But we want a narrative that is consistent with the FOMC record, that can be rejected by the data, that uses publicly available data, that is statistically reliable, and that helps mapping FOMC projections into FOMC interest-rate decisions. Again, we find that such an objective is feasible and useful in understanding policy decisions.

---

<sup>4</sup>Previous work includes Arai (2015), Fendell and Rulke (2012), Nakazono (2013), Rulke and Tillman (2011), and Sheng (2015).

## 2 Obstacle 1: Bypassing Secrecy

### 2.1 A Brief Description of the FOMC

The FOMC consists of 19 participants: 12 Presidents from the Federal Reserve Banks and 7 Governors from the Board of Governors of the Federal Reserve System. For each meeting, FOMC participants (voting and non-voting) submit projections for inflation and unemployment among other variables; only 12 participants vote in a given FOMC meeting.<sup>5</sup>

### 2.2 Frequency of Meetings and Forecast Horizon

- From 1992 to the present, the FOMC has met about eight times per year.
- From 1992 to 2007, projections were released twice per year (February and July) in the *Monetary Policy Report*. February meetings reported projections for current and one-year ahead; July meetings reported projections only for the current year.<sup>6</sup>

Forecast Date	Forecast Horizon			
	1995	1996	1997	1998
February 1995	•	•		
July 1995	•			
February 1996		•	•	
July 1996		•		
February 1997			•	•
July 1997			•	

- Since 2007, projections are released four times per year in the *Summary of Economic Projections*. Projections are for the current and at least two years ahead. During the last two meetings of each year, participants extend their projections by one year:

---

<sup>5</sup>The seven governors of the Federal Reserve Board, the President of the New York Federal Reserve Bank, and four presidents on a rotating basis. See – <http://www.federalreserve.gov/monetarypolicy/files/fomcminutes20071031.pdf>.

<sup>6</sup>They reported one-year ahead every other meeting. See <https://www.federalreserve.gov/boarddocs/hh/2006/february/ReportSection1.htm>  
<https://www.federalreserve.gov/boarddocs/hh/2006/july/ReportSection1.htm>

Forecast Date	Forecast Horizon: SEP					
	2010	2011	2012	2013	2014	2015
2010:Q1	•	•	•			
2010:Q2	•	•	•			
2010:Q3	•	•	•	•		
2010:Q4	•	•	•	•		
2011:Q1		•	•	•		
2011:Q2		•	•	•		
2011:Q3		•	•	•	•	
2011:Q4		•	•	•	•	
2012:Q1			•	•	•	
2012:Q2			•	•	•	
2012:Q3			•	•	•	•
2012:Q4			•	•	•	•

The projections also include a long-run horizon defined as "... each participant's assessment of the rate to which each variable would be expected to converge under appropriate monetary policy and in the absence of further shocks to the economy." <sup>7</sup>

### 2.3 Data-Release Protocol

Details about FOMC projections are released on separate schedules. This difference creates a distinction between real-time and delayed data releases.

- Real-time data: Correspond to the information included in the FOMC release: range and central tendency from FOMC participants for GDP growth, inflation, and unemployment. Further
  - since 2012, FOMC releases include projections for the *appropriate* federal funds rate;
  - since 2015, FOMC releases include the median of forecasts from FOMC participants.
- Delayed data: Correspond to the projections from FOMC participants considered individually. These data are released in two stages:
  - With a five year lag, the FOMC releases the numerical projections of FOMC participants without attribution
  - With a ten-year lag, the FOMC releases the numerical projections of FOMC participants with attribution

<sup>7</sup>See <http://www.federalreserve.gov/monetarypolicy/files/fomcprojtabl20151216.pdf>



A delay of five years in releasing these details contradicts the goal of accountability stated in the SEP. Again, we are not the first to note this contradiction. Thus, following Romer (2010), we report in figures 2 and 3 participant-specific projections of inflation and unemployment from 1992 to 2012 the present along with recent FOMC's SEP.<sup>8</sup> This record shows several features of interest. First, disagreements about the outlook among FOMC members are the norm: the 2008 financial crisis only exacerbated them. In other words, Faust's critique applies to the history of FOMC forecasts, not just to the SEP. Second, FOMC projections are notoriously inaccurate and thus the public cannot rely on the accuracy of these projections as a substitute for understanding monetary policy or its credibility.<sup>9</sup> Third, there is no information about the dispersion of projections after 2012. This absence reflects the FOMC's protocol for data release in which information about participants' projections is released with a delay of at least five years. This protocol contradicts the goal of accountability stated in the SEP. This contradiction violates a central tenet of social relations: Trust but Verify.

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<sup>8</sup>The data assembled by Romer (2010) contains participant-specific projections for 1992 to 2006 with attribution. We replicated his data, added the observations for 2007 with attribution, and extended the data to include FOMC participants through 2012 but without attribution because they are not available. Note that there are no comparable data for the interest rates.

<sup>9</sup>Note, however, that forecast accuracy is not an FOMC mandate. Intuitively, FOMC participants are not impartial observers of their own forecasts but rather must influence the economy so as to meet their dual mandate. As a result, a narrow interpretation of forecast accuracy is not useful if that accuracy means high inflation and high unemployment. Further, forecasts revisions cannot be unambiguously interpreted as reactions to news. As indicated earlier, FOMC participants' projections depend on their assessments of the *appropriate* monetary policy. Thus, even if FOMC participants had and released a shared knowledge of the economy, its usefulness to the public would be transitory because the makeup of the FOMC participants changes over time. New participants would bring their own interpretation of appropriate monetary policy which would translate into different interest-rate projections, even in the absence of economic news.

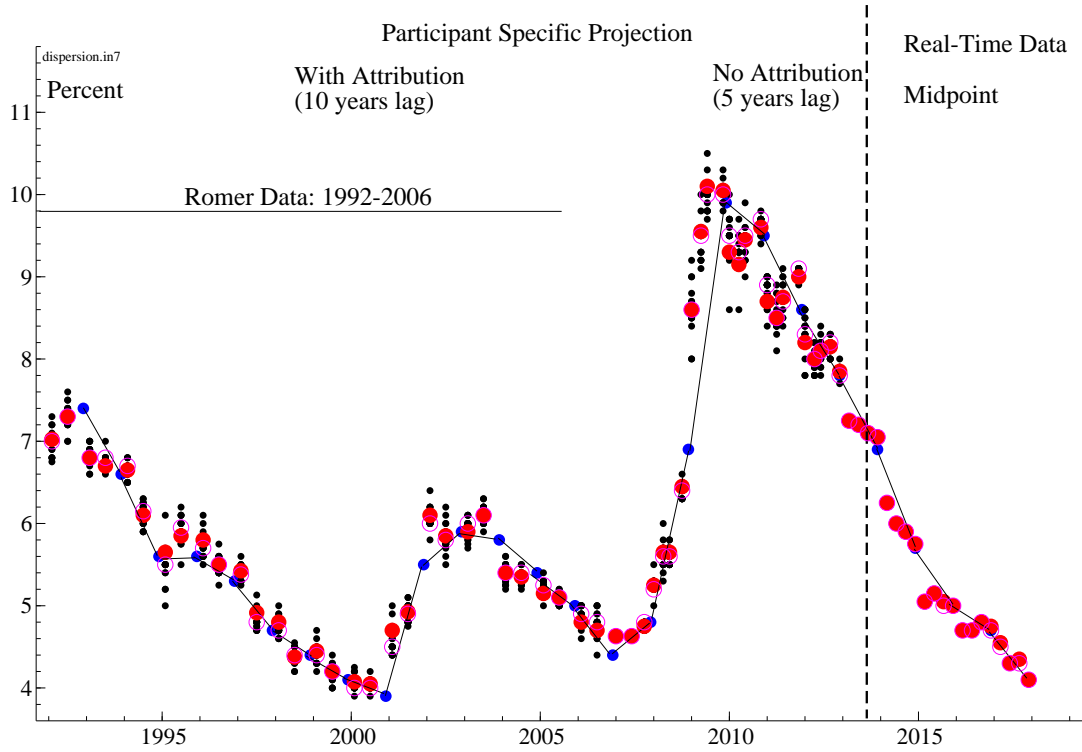


Figure 2: Current-Year Projections for Unemployment

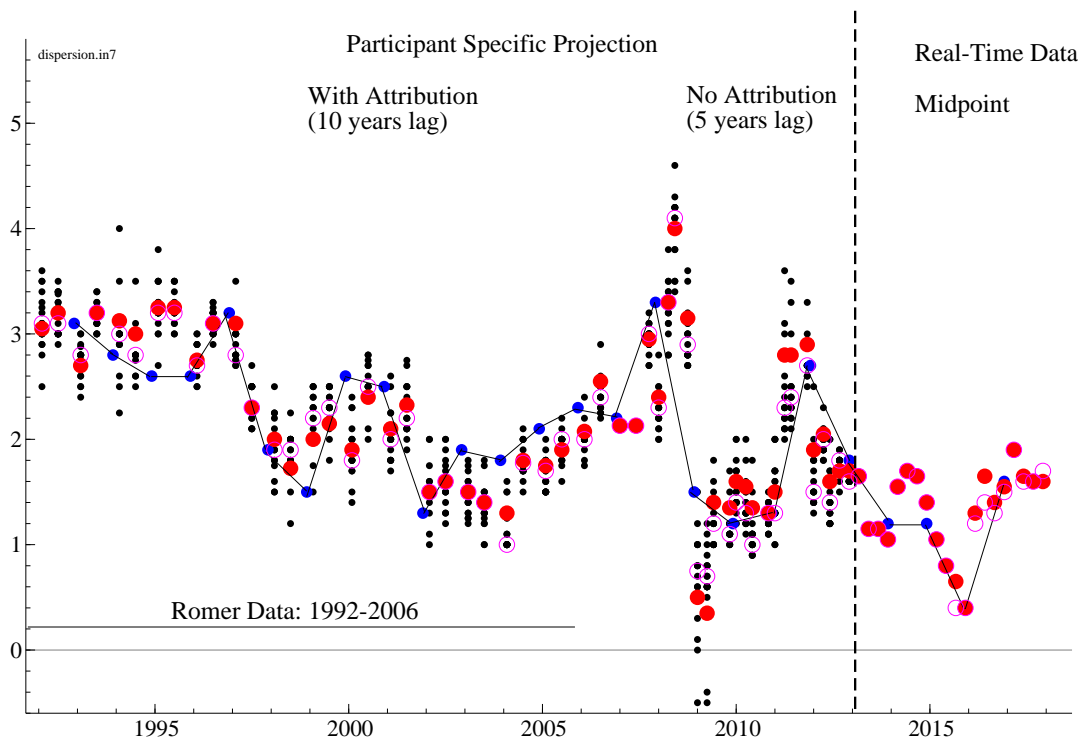


Figure 3: Current-year Projections for Inflation

These observations fit the views Rulke and Tillman (2011) who examine whether FOMC participants exhibit herd behavior. Nevertheless, further work is needed before classifying the FOMC as exhibiting herd behavior. Specifically, drawing inferences about collective behavior based on a small group is tricky: members may become aware of their herding behavior and thus alter it. In addition, herds lack a final known destination whereas FOMC participants generate their forecasts based on policies to attain the FOMC dual's mandate.

The forecasts also exhibit instances of seemingly extreme values. Indeed, forecasts for unemployment in 2010 made during the April 2009 meeting might be construed as extreme. Tillman (2011) and Nakazono (2013) have noted such instances and they attribute them to the differential behavior of FOMC participants who are not voting during the meeting. Indeed, they argue that these participants might submit "extreme" forecasts as a way of registering their disagreements. Again, further work is needed because declaring a forecast as extreme involves two considerations: First one needs a benchmark to judge whether the forecast is extreme. Second, one needs a method to differentiate between mood swings and interpretations of an appropriate policies.<sup>10</sup>

## 2.4 Empirical Analysis

Because the FOMC has not released the data needed to compute the median forecast for 2013-2015, one would have to wait three years to have a complete series of medians for these two variables given the FOMC's release protocol. The alternative of using the available data on mid-points could, potentially, entail a loss of information. For example, if the extreme views do not change over time but the distribution of forecasts for other participants does, then the same range is consistent with different medians. The operational question, then, is whether there is a loss of information when the public relies solely on real-time FOMC projections of the midpoints for unemployment and inflation to anticipate, or understand, FOMC projections for the federal funds rate?

To answer that question, we examine whether movements in the median of FOMC projections for inflation and unemployment projections can be explained by movements of in publicly available data: recorded values of inflation and unemployment available prior to the FOMC meeting; projections from the Survey of Professional Forecasters for inflation and unemployment; and mid-points of the FOMC projections. Finally, we include Greenbook forecasts as an alternative to publicly available data in real time. Although Greenbook forecasts are released with a five-year delay, and thus are not available in real time, they are available through 2012 and thus represent an alternative to publicly available data. Figure 4 represents the timeline of available information for the variables:

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<sup>10</sup>One way to detect extreme values is to see if the distributions of forecasts are asymmetric. Because normal distributions are symmetric, finding evidence of normality would reject the presence of extreme forecasts.

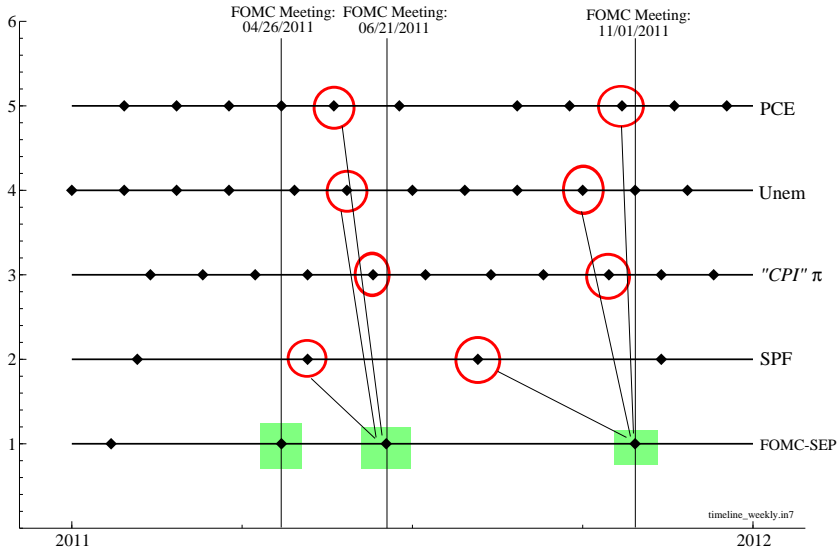


Figure 4: Timeline of Releases of Public Data

Inspection of the data reveals that the median of the forecast distribution for inflation is not, in general, closely related to alternative measures of inflation (figure 5), not even to the Greenbook forecasts. Furthermore, the character of the relation depends on the inflation rate itself: there is a break in the correlation for large values of the inflation rate. The exception is the mid-point of the distribution suggesting that the distribution of projections is fairly symmetrical. For unemployment, movements in the alternative measures are closely related among themselves with unconditional correlations exceeding 0.94 (figure 6). Nevertheless, a closer inspection of the data reveals that the correlation is sensitive to large values of the unemployment rate.

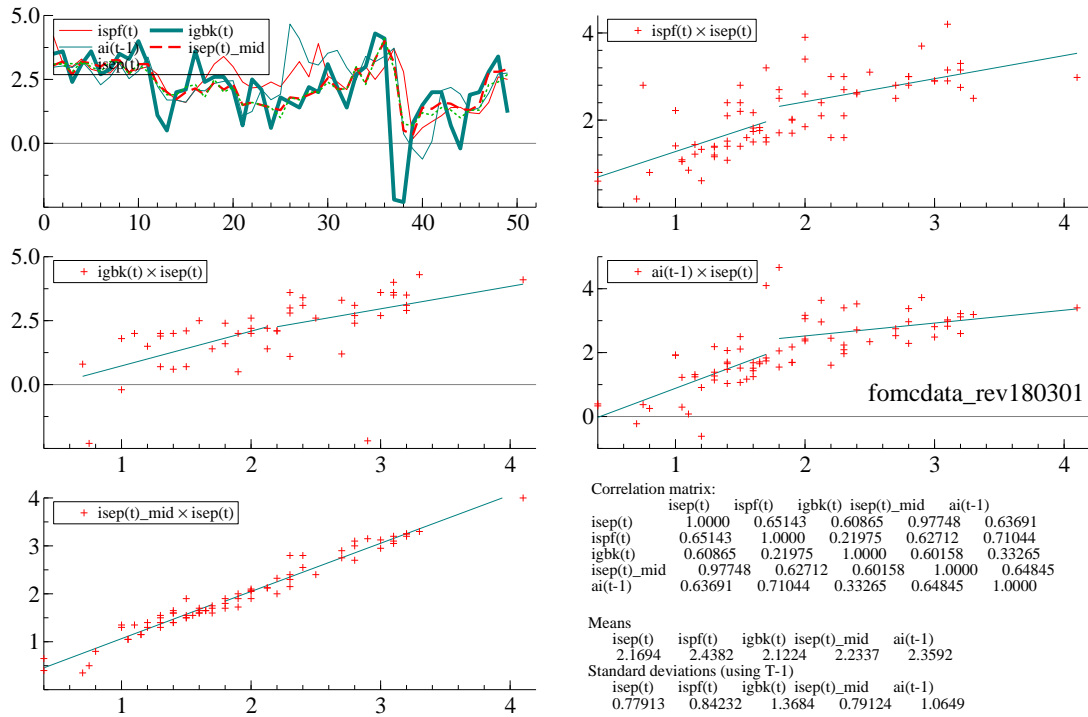


Figure 5: Alternative Measures of Inflation and their Correlations

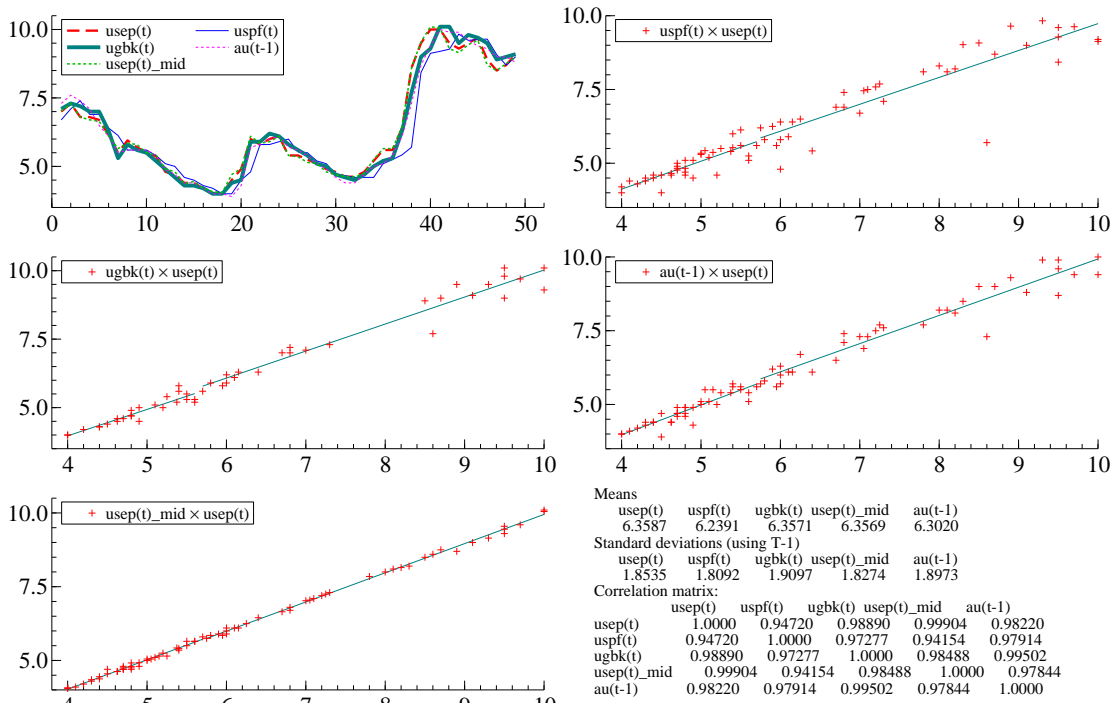


Figure 6: Alternative Measures of Unemployment and their Correlations

## 2.5 The Informational Loss of the FOMC's Data Protocol

We now carry out a formal statistical analysis to assess whether reliance on publicly real-time data carries a loss of information. But a loss of information relative to what? Relative to the Greenbook forecasts which are not available publicly in real time. We quantify that loss using two approaches. The first is a single equation approach to assess whether we can replace the missing medians for 2013-2015 with their mid-points. The second approach relies on a system of equations to assess whether the delay in releasing the Greenbook forecasts carries a deterioration of forecast accuracy.

### 2.5.1 Equivalence Between Median and Midpoints of FOMC Forecast Distributions

We postulate that

$$\pi_t^{med} = \alpha_{11} + \alpha_{12} \cdot \pi_{t-1}^{spf} + \alpha_{13} \cdot \pi_t^{mid} + \alpha_{14} \cdot \pi_t^{gb} + \alpha_{15} \cdot \pi_{t-1}^a + D + e_{\pi t} \quad (1)$$

$$u_t^{med} = \alpha_{21} + \alpha_{22} \cdot u_{t-1}^{spf} + \alpha_{23} \cdot u_t^{mid} + \alpha_{24} \cdot u_t^{gb} + \alpha_{25} \cdot u_{t-1}^a + D + e_{ut} \quad (2)$$

$$\mathbf{e}'_t = (e_{\pi t} \ e_{ut}) \sim IN(\mathbf{0}, \mathbf{\Omega})$$

where

$\pi_t^{med}$  is the current-period projection of the median inflation for the  $t$ th FOMC meeting

$u_t^{med}$  is the current-period projection of the median unemployment for the  $t$ th FOMC meeting

$\pi_{t-1}^{spf}$  SPF inflation forecast made at time  $t - 1$

$u_{t-1}^{spf}$  SPF unemployment forecast made at time  $t - 1$

$\pi_t^{mid}$  is the current-period projection of the mid-point of the range of inflation forecasts for the  $t$ th FOMC meeting

$u_t^{mid}$  is the current-period projection of the mid-point of the range of unemployment forecasts for the  $t$ th FOMC meeting

$\pi_t^{gb}$  is the current-period projection of the Greenbook forecasts for inflation for the  $t$ th FOMC meeting

$u_t^{gb}$  is the current-period projection of the Greenbook forecasts for unemployment for the  $t$ th FOMC meeting

$\pi_{t-1}^a$  actual inflation one month prior to the FOMC meeting ( $t - 1$ )

$u_{t-1}^a$  actual unemployment one month prior to the FOMC meeting ( $t - 1$ )

*D* Two dummy variables: one for Bernanke's tenure as Chair of the FOMC and another for changes in the CPI measure targeted by the FOMC<sup>11</sup>

Assessing whether there is a loss of information involves testing whether  $\alpha_{13} = \alpha_{23} = 1$  and all the other  $\alpha$ 's equal to zero. If so, then the mid-points serve as sufficient statistics for the medians and thus there is no loss of information. If  $\alpha_{14} \neq 0$ ;  $\alpha_{24} \neq 0$ , then Greenbook forecasts are needed to predict the median of the forecast distribution. In this case, one cannot rely solely on publicly available information.

For parameter estimation we apply ordinary least squares to equations (1) and (2) using observations from FOMC meetings held from 1992 January to November 2012 (49 meetings). To avoid the statistical pitfalls associated with the joint nature of model specification and parameter estimation, we use Autometrics, a computer-automated algorithm, developed by Doornik and Hendry (2013).<sup>12</sup> Their algorithm combines least squares with a selection criteria that excludes insignificant coefficients and tests for both parameter constancy and white-noise residuals; the critical values for rejection are not fixed in advance but, rather, are calculated sequentially. Table 1 reports results for equations (1) and (2), labeled the General formulation, and for the simplified formulation, labeled the Specific formulation, using a significance level of five percent.

The results for inflation indicate that  $\pi_t^{mid}$  is a sufficient statistic for  $\pi_t^{med}$ : the intercept is no different from zero, the slope is no different from one, and the other coefficients are zero. Furthermore, the residuals are consistent with maintained assumptions for inference. For unemployment,  $u_t^{mid}$  is also a sufficient statistic  $u_t^{med}$ : the intercept is no different from zero but the slope is statistically different from one. Furthermore, the residuals are consistent with maintained assumptions for inference. Taken together, the results suggest that the mid-points of the distributions are suitable substitutes for the median of the distributions over from 1992 to 2012. Thus we use the real time midpoints over 2013-2015 to replace the missing median values over the same period.

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<sup>11</sup>The Measure of inflation changes over time:CPI from January 1992 to July 1999; PCE from January 2000 and January 2004; Core PCE starting in July 2004.

<sup>12</sup>For a discussion of the issues raised by automated specification, see Hendry and Krolzig (2003), Granger and Hendry (2004), and Phillips (2004).

Table 1: Regression of Median of Forecast Distribution for Inflation:  $\pi_t^{med}$   
 January 1992 to Nov. 2012 49 obs

	General		Specific	
	coeff	std. error	coeff	std. error
$\pi_t^{spf}$	0.094	0.054	-	-
$\pi_t^{gb}$	0.033	0.025	-	-
$\pi_{t-1}^a$	-0.007	0.036	-	-
cpi	-0.108	0.072	-	-
$\pi_t^{mid}$	0.847	0.069	0.985	0.028
Bernanke	-0.066	0.059	-	-
Constant	0.056	0.103	-0.025	0.068
ser	0.161		0.142	
$\overline{R}^2$	0.957		0.966	
$H_o^\dagger$				
Serial Ind.	0.281		0.363	
ARCH	0.853		0.936	
Normality	0.725		0.798	
Hetero	0.005**		0.076	
Hetero-X	0.039*		0.076	
RESET23	0.032*		0.520	

$^\dagger$  significance level needed to reject the null hypothesis



Table 2: Regression of Median of Forecast Distribution: Unemployment  $u_t^{med}$

January 1992 to Nov. 2012 49 obs				
	General		Specific	
	coeff	std err	coeff	std err
$u_t^{gb}$	0.211	0.062	-	-
$u_t^{mid}$	0.824	0.034	1.013	0.006
Bernanke	0.040	0.023	-	-
cpi	0.002	0.024	-	-
$u_{t-1}^a$	-0.022	0.057	-	-
$u_t^{spf}$	-0.013	0.027	-	-
Constant	-0.021	0.047	-0.083	0.043
ser	0.063		0.082	
$\overline{R}^2$	0.99		0.99	
$H_o^\dagger$				
Serial Ind.	0.3891		0.3932	
ARCH	0.7850		0.9054	
Normality	0.6501		0.9521	
Hetero	0.0243*		0.1437	
Hetero-X	0.0096**		0.1437	
RESET23	0.9110		0.1724	

$^\dagger$  significance level needed to reject the null hypothesis

## 2.5.2 Delays in Data Release and Forecast Accuracy

To quantify the loss of information from delaying the release of the Greenbook forecasts, we focus on the forecast accuracy of two models that differ in the use of conditioning variables: publicly available and Greenbook. We also use the two measures of central tendency: median and mid-point. The general formulation is

$$\begin{bmatrix} \pi_{t,t}^m \\ u_{t,t}^m \end{bmatrix} = \begin{bmatrix} c^\pi \\ c^u \end{bmatrix} + \begin{bmatrix} \alpha_{12} & \alpha_{13} \\ \alpha_{22} & \alpha_{23} \end{bmatrix} \begin{bmatrix} \pi_{t-1,t}^m \\ u_{t-1,t}^m \end{bmatrix} + \begin{bmatrix} \alpha_{14} & \cdots & \alpha_{19} \\ \alpha_{24} & \cdots & \alpha_{29} \end{bmatrix} \begin{bmatrix} \pi_{t-1}^{spf} \\ \pi_{t-1}^a \\ u_{t-1}^{spf} \\ u_{t-1}^a \\ \pi_t \\ \pi_t^{gb} \\ u_t^{gb} \end{bmatrix} + \begin{bmatrix} e_t^\pi \\ e_t^u \end{bmatrix}$$

$$\mathbf{e}'_t = (e_t^\pi \ e_t^u); \mathbf{E}(\mathbf{e}_t) = \mathbf{0}; \mathbf{E}(\mathbf{e}_t \cdot \mathbf{e}'_{t-1}) = \mathbf{0}; \mathbf{E}(\mathbf{e}_t \cdot \mathbf{e}'_t) = \mathbf{\Omega}$$

where

$\pi_{t,t}^m$  is the current-period projection of the inflation rate for the  $t$ th FOMC meeting where  $m$  =median or midpoint

$u_{t,t}^m$  is the current-period projection of the unemployment rate for the  $t$ th FOMC meeting where  $m$  =median or midpoint

To quantify the loss of information, we focus on forecast accuracy of using two types of information: Greenbook forecasts only (model M1) and publicly available data only (model M2). For parameter estimation we use ordinary least squares with observations from FOMC meetings held from 1992 January to July 2007. The estimation results are reported in table 3:

Table 3: Modeling FOMC Forecasts - Alternative Information Sources  
1992(2)-2007(7) (32 Obs)

	Inflation				Unemployment				
	Public - M2		GBK M1		Public - M2		GBK - M1		
	Median	Mid-point	Median	Mid-point		Median	Mid-point	Median	Mid-point
$\pi_{t-1,t}$	0.755	0.724	0.553	0.590	$\pi_{t-1,t}$	0.086	0.145	0.111	0.172
	0.121	0.114	0.110	0.092		0.073	0.073	0.052	0.059
$u_{t-1,t}$	-0.349	-0.103	0.162	0.159	$u_{t-1,t}$	0.073	-0.037	-0.110	-0.107
	0.492	0.500	0.176	0.161		0.296	0.322	0.083	0.104
$\pi_{t-1}^{spf}$	0.004	0.132	-	-	$\pi_{t-1}^{spf}$	0.096	0.103	-	-
	0.159	0.148				0.096	0.095		
$u_{t-1}^{spf}$	0.495	0.349	-	-	$u_{t-1}^{spf}$	-0.231	-0.145	-	-
	0.557	0.533				0.335	0.343		
$u_{t-1}^a$	-0.117	-0.198	-	-	$u_{t-1}^a$	0.974	0.957	-	-
	0.238	0.224				0.143	0.144		
$\pi_{t-1}^a$	0.167	0.125	-	-	$\pi_{t-1}^a$	-0.043	-0.097	-	-
	0.095	0.094				0.057	0.061		
$\pi_t^{gb}$	-	-	0.260	0.276	$\pi_t^{gb}$	-	-	-0.001	-0.024
			0.070	0.058				0.033	0.038
$u_t^{gb}$	-	-	-0.130	-0.117	$u_t^{gb}$	-	-	0.968	0.925
			0.162	0.144				0.077	0.093
Cons	-0.059	-0.327	0.200	0.039	Cons	-0.059	-0.327	0.498	0.636
	0.456	0.448	0.336	0.297		0.456	0.448	0.159	0.191
SER.	0.342	0.322	0.296	0.258		0.342	0.322	0.140	0.166

For inflation, the parameter estimates indicate no evidence of an inverse association with unemployment regardless of how it is measured. But measurement matters in terms of fit: reliance on Greenbook forecasts alone yields smaller SERs with virtually no difference between the mid-point and the median. So what matters is the conditioning variable. For unemployment, the parameter estimates indicate no evidence of an inverse association with inflation regardless of how it is measured. But again, measurement matters greatly in terms of fit: formulations using the Greenbook

forecasts have much lower SERs.

Given the parameter estimates, we use s-step forecasts from October 2007 to November 2011. Given these forecasts, we quantify the loss of information as the root mean squared forecast error. Table 4 reports that, regardless of whether one uses the mid-point or the median of the forecasts, the availability of Greenbook forecasts for parameter estimation yields lower RMSFE for inflation and unemployment.

Table 4: Forecasting FOMC Forecasts - Alternative Information Sources

RMSFE-COMPARISON: October 2007-November 2011									
INFLATION					UNEMPLOYMENT				
MEDIAN		MIDPOINT			MEDIAN		MIDPOINT		
M1	M2	M1	M2		M1	M2	M1	M2	
0.596	0.996	0.614	0.771		0.593	0.808	0.718	0.836	
Memo									
Target size					Target size				
1%	0.557	0.728	0.614	1.246	1%	0.609	0.722	0.718	0.796
0.1%	1.086	0.728	0.614	1.246	0.1%	0.561	0.722	0.718	0.796
0.01%	1.086	0.728	1.146	1.246	0.01%	0.561	0.722	0.654	0.796

To assess the sensitivity of the results, we apply Autometrics to the system (i.e., not equation by equation) using three levels of significance. Table 4 shows a deterioration of forecast performance in response to the application of increasingly tighter significance levels.

## 2.6 Credibility of Forward Guidance

Forward Guidance is an FOMC announcement indicating the likely stance of monetary policy in the foreseeable future and how this stance may respond to departures from the FOMC's dual objectives. Forward Guidance was introduced during the 2008 financial crisis to influence long-term interest rates by anchoring expectations of the future federal funds rate. Initial announcements focused on the end date of the period of unusually low interest rates but were not concise. But the FOMC issued in December 2012 a statement that removed the ambiguities:

In particular, the Committee decided to keep the target range for the federal funds rate at 0 to 1/4 percent and currently anticipates that this exceptionally low range for the federal funds rate will be appropriate at least as long as the unemployment rate remains above 6-1/2 percent, inflation between one and two years ahead is projected to be no more than a half percentage point above the Committee's 2 percent longer-run goal, and longer-term inflation expectations continue to be well anchored.

Figure 7 shows that at the time of the announcement, the actual unemployment rate was close to eight percent, which was very close to the *mid-point* of the projections for the current-year unemployment rate. The unemployment rate declined subsequently but the pace of decline was subdued

at best. By April 2014 the unemployment rate was above the 6.5 threshold but the FOMC forecast was below the threshold. By May 2014, the unemployment rate, both actual and FOMC forecasts were below the threshold and the FOMC statements did not refer to the threshold afterwards.

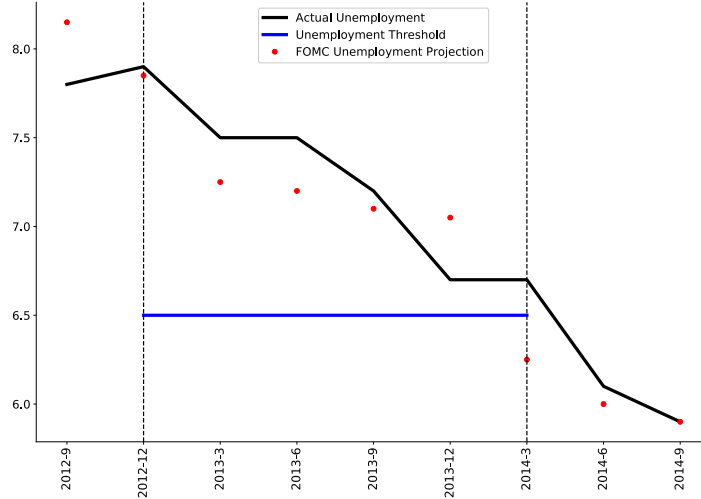


Figure 7: Unemployment Rate: Actual and FOMC Forecast and the 6.5 Threshold

These observations suggest that, ex-post, the FOMC's forward guidance was credible: the federal funds rate was raised in December of 2015 after the unemployment rate fell below the 6.5% threshold. But this type of ex-post verification involves the public waiting for the actual unemployment rate to cross the announced threshold and then verifying the reaction of the FOMC. Waiting to verify means that the public may be late to benefit from this change in policy. Thus a fair question to ask is whether the public, relying only on public available data, can anticipate the date the unemployment rate will reach 6.5 and is that date consistent with what the FOMC anticipates?

To answer these questions, we model the mid-point of FOMC projections from 1992 to 2012, which are available in real time. Specifically, we postulate that

$$\begin{bmatrix} 1 & -\alpha_{11} \\ -\alpha_{21} & 1 \end{bmatrix} \begin{bmatrix} \pi_{t,t}^m \\ u_{t,t}^m \end{bmatrix} = \begin{bmatrix} c^\pi \\ c^u \end{bmatrix} + \begin{bmatrix} \alpha_{12} & \alpha_{13} \\ \alpha_{22} & \alpha_{23} \end{bmatrix} \begin{bmatrix} \pi_{t-1,t}^m \\ u_{t-1,t}^m \end{bmatrix} + \begin{bmatrix} \alpha_{14} & \cdots & \alpha_{17} \\ \alpha_{24} & \cdots & \alpha_{27} \end{bmatrix} \begin{bmatrix} \pi_{t-1}^{spf} \\ \pi_{t-1}^a \\ u_{t-1}^{spf} \\ u_{t-1}^a \end{bmatrix} + \begin{bmatrix} e_t^\pi \\ e_t^u \end{bmatrix}$$

$$\mathbf{e}'_t = (e_t^\pi \ e_t^u); \mathbf{E}(e_t) = \mathbf{0}; \mathbf{E}(e_t \cdot e'_{t-1}) = \mathbf{0}; \mathbf{E}(e_t \cdot e'_t) = \mathbf{\Omega}_t$$

$$\mathbf{\Omega}_t = \mathbf{M} + \mathbf{A} \cdot [e_t \cdot e'_t] + \mathbf{C} \cdot \mathbf{\Omega}_{t-1}$$

where  $\pi_{t,t}^m$  is the mid-point of the current-year projection of inflation for the  $t$ th FOMC meeting and  $u_{t,t}^m$  is the mid-point of the current-year projection of unemployment for the  $t$ th FOMC meeting. Note that we cannot include the interest rate because they began to be released in 2012.

We estimate the parameters with three methods:

- FIML with no-cross persistence ( $\alpha_{13} = \alpha_{23} = 0$ ) and constant variance-covariance for the disturbances ( $\mathbf{A} = \mathbf{C} = \mathbf{0}$ )
- OLS with cross persistence and constant variance-covariance for the disturbances ( $\mathbf{A} = \mathbf{C} = \mathbf{0}$ )
- MGARCH with no-cross persistence ( $\alpha_{13} = \alpha_{23} = 0$ )

Reliance on MGARCH recognizes that the disturbances are influenced by two considerations: mismatch of mid-points among participants and rotation protocol of participants in the FOMC process. A mismatch of mid-points occurs when the participant associated with the mid-point inflation is not the same participant associated with the mid-point unemployment rate. If the mismatch were fixed over time, then the intercept would capture it. But the mismatch is unlikely to be fixed over time because participants change over time or because their projections are reflecting strategic considerations. Rotation of participants is built-in in the FOMC protocol because participants whose tenure expire are replaced by other participants who ma. the FOMC rotation protocol. In other words, in the that

Table 5 shows the estimation results using FOMC meetings from February 1992 to December 2012. The fitted values in figures 8-9 reveal a fairly good level of accuracy.

Table 5: Modeling Mid-points of FOMC Forecast Distributions

Alternative Estimation Methods

Estimation Period: Feb 1992 to Dec. 2012

	FIML		VAR		MGARCH	
	$\pi_t^{mid}$	$u_t^{mid}$	$\pi_t^{mid}$	$u_t^{mid}$	$\pi_t^{mid}$	$u_t^{mid}$
$\pi_{t-1}^{mid}$	0.509		0.561	0.104	0.736	
	0.135		0.137	0.086	0.145	
$u_{t-1}^{mid}$		0.305	0.227	0.106		0.464
		0.209	0.333	0.208		0.133
$\pi_{t-1}^{spf}$	-0.129		-0.028	0.008	0.158	0.026
	0.177		0.185	0.116	0.165	0.099
$\pi_{t-1}^a$	0.366		0.274	-0.207	0.320	-0.155
	0.095		0.105	0.066	0.090	0.074
$u_{t-1}^{spf}$		-0.577	0.235	-0.330	0.154	-0.208
		0.177	0.294	0.183	0.184	0.133
$u_{t-1}^a$		1.185	-0.432	1.122	-0.146	1.102
		0.140	0.215	0.134	0.147	0.128
$\pi_t^{mid}$		-0.147				
		0.087				
$u_t^{mid}$	-0.008					
	0.050					
Cons.	0.566	0.903	0.182	0.923	0.998	1.023
	0.523	0.322	0.533	0.333	0.913	0.406
ser	0.497	0.333	0.484	0.302	0.435	0.252

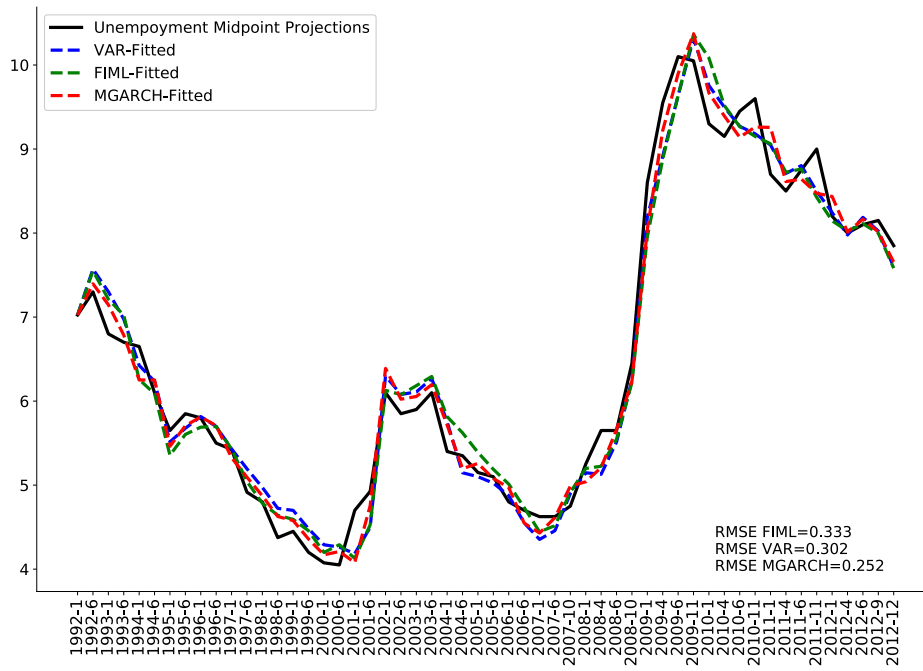


Figure 8: Fitted Values for the FOMC Forecasts of the Unemployment Rate – Alternative Models

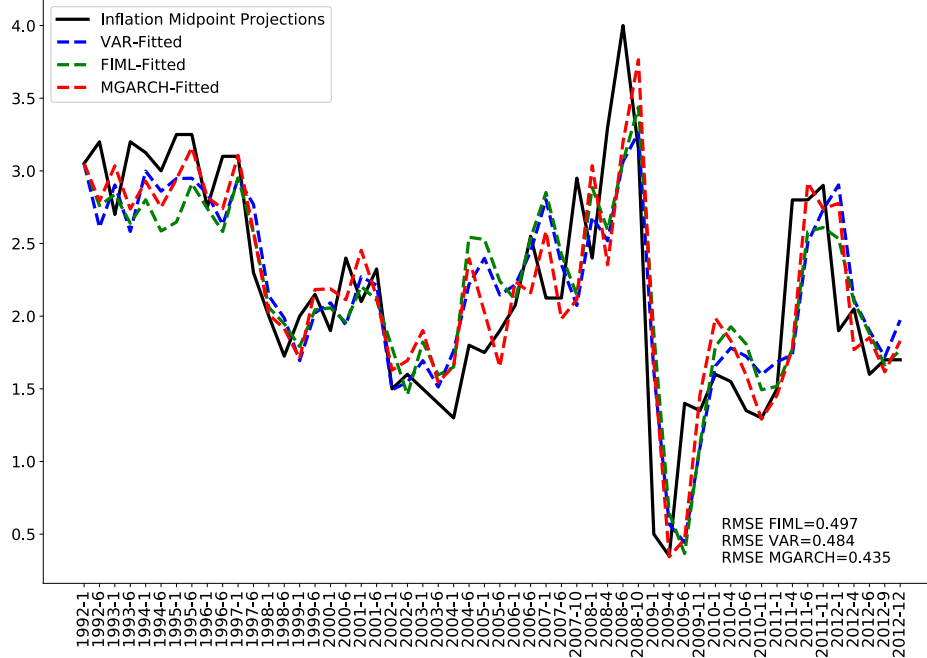


Figure 9: Fitted Values of FOMC Forecasts for Inflation

Given these estimates, we use s-step ahead forecasts of the FOMC projections from April 2013 to April 2014; figures 10-12 show the 95 percent confidence intervals for the unemployment rate.



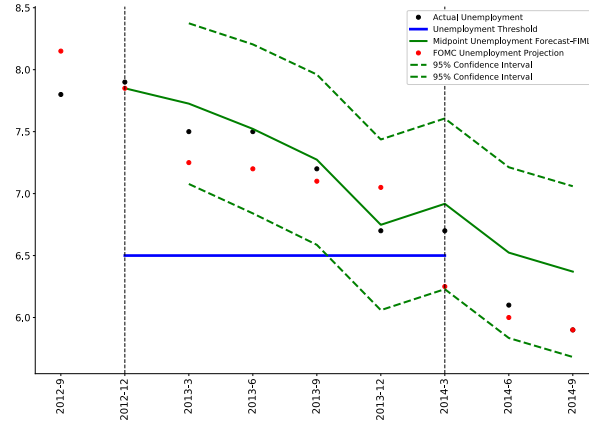


Figure 10: Unemployment Rate: Actual, Predicted and FOMC Forecast - FIML

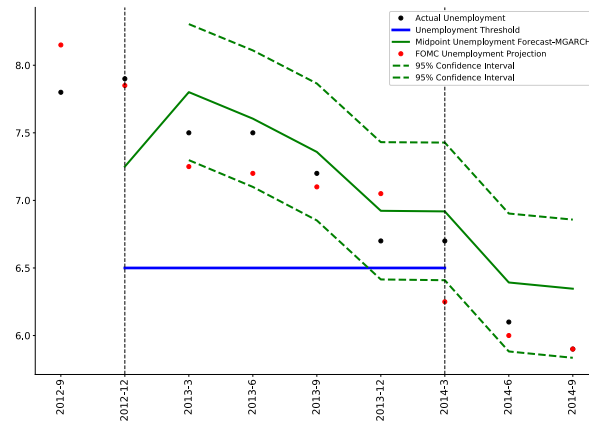


Figure 11: Unemployment Rate: Actual, Predicted and FOMC Forecast - MGARCH

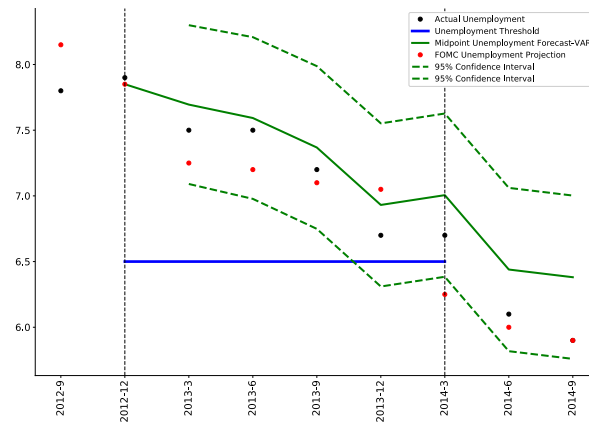


Figure 12: Unemployment Rate: Actual, Predicted and FOMC Forecast - VAR

Regardless of estimation method, the results indicate that, using the SEP forecasts along with publicly available data, the public would have been able to obtain a fairly accurate prediction of the date when the unemployment rate would be below 6.5 percent (April 2014). Furthermore,

all three formulations predict that the FOMC projection for the unemployment rate in April of 2014 was (1) close to the actual and (2) below the 6.5% threshold. Finally, these predictions are made with the SEP data available as of 2012. Thus, despite the limitations of the SEP that Faust correctly notes, the SEP information can be used to bypass Faust’s condemnation of the SEP to the darkest place in the pantheon of failures.

### 3 Obstacle 2: Bypassing the Limitations of the SEP

Critics of the SEP argue that reconciling differences in FOMC’s appropriate policies involves the FOMC making its reaction function available to the public. Faust states

As noted above, the most important function to convey regards the reaction function of the policymakers. But the SEP approach of providing separate variable-by-variable summaries of the 19 forecasts obscures any link between the paths of the of the federal funds rate as depicted in the dot-plot and the forecasts of the other variables. (Faust 2016 p. 18)

Bernanke (2016) reinforces Faust’s observations by noting that,

Wouldn’t it be easier if the FOMC just provided its reaction function, together with collective projections of key macroeconomic variables? In principle, yes; and in fact, in the course of expanding the SEP, the FOMC under my chairmanship experimented with developing a consensus committee forecast, together with alternative scenarios, that could be released to the public. (Bernanke 2016 page 7).

These criticisms are corroborated by the survey results of Wessel and Olson (2016, p. 2):

"Only a third had a very clear or mostly clear grasp on the Fed’s reaction function, the way the Fed anticipates responding to changes in the economic outlook."

The above remarks raise several questions. First, why do Faust, Bernanke, and Wessel and Olson use the singular when referring to the reaction function? Indeed, the FOMC directive associated with the SEP allows for the possibility of 19 reaction functions.<sup>13</sup> Thus, in the absence of compelling evidence or acquiescence to authority, adherence to a single reaction function contradicts

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<sup>13</sup>Heuristically, the *ith* FOMC participant determines the appropriate interest rate that minimizes the welfare loss of deviations of inflation and unemployment from the dual mandate. Subject to the behavior of the economy, the FOMC participant would solve

$$\begin{aligned} & \underset{R_i}{\text{Min}} L_i(\pi_i - \pi^*, u_i - u_i^*); i = 1, \dots, 19 \\ \pi_i &= g_i(R_i, u_i | x, \Theta_i) \\ u_i &= j_i(R_i, \pi_i | x, \Theta_i), \end{aligned}$$

where  $L_i$  is the participant’s welfare loss associated with a deviation from the dual mandate,  $R_i$  is the *ith* FOMC participant’s appropriate federal funds rate; the *ith* FOMC’s participant pojections for inflation is  $\pi_i$  and for unemployment is  $u_i$ ;  $x$  is vector if exogenous variables with publicly available data;  $\Theta_i$  is the vector of coefficients relevant to the *ith* participant;  $\pi^*$  is the FOMC’s target inflation rate (2%);  $u_i^*$  is the *ith*’s participant estimate of the

the FOMC directive embodied in the SEP. Second, even if knowledge of a single reaction function were available, how would it help the public? A reaction function that depends on variables that the public cannot observe directly – the FOMC’s own forecasts – is not a reaction function helpful to the public: We want to anticipate decisions and react to the gap between decisions and expectations. Third, an important obstacle in implementing Bernanke’s "consensus function" is, at the risk of stating the obvious, the lack of consensus among FOMC participants. Figure 13 shows three measures of the dispersion of the appropriate federal funds rate for the current and one-year ahead.

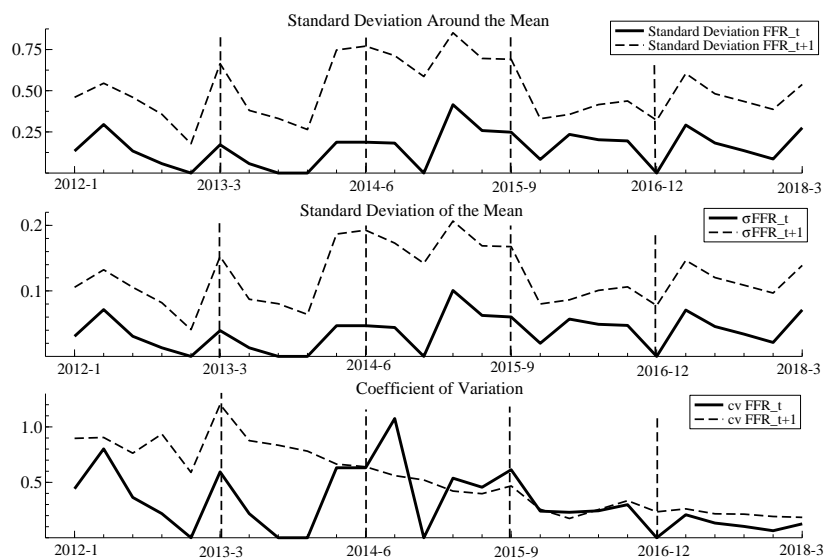


Figure 13: Dispersion of Appropriate Interest Rates

The dispersion of appropriate policies, measured as the coefficient of variation, has declined considerably since 2012 but it is not zero.<sup>14</sup> Importantly, Tillman (2011) and Nakazono (2013) argue that the dispersion of forecasts may be due to FOMC participants who are not voting during the meeting and submit "extreme" forecasts as a way of registering their disagreements.

If taken at face value, these observations suggest that the public’s effort in scrutinizing the SEP is misplaced, that the FOMC’s effort in assembling them is wasteful, and that the FOMC’s communication policy embodies a potential contradiction (diversity of views versus single reaction function). Missing from the discussion so far, however, is the role evidence. What evidence is offered by Faust to conclude that a "depiction of policymakers views with no hint about differences may be resolved" automatically means that the SEP "deserves a special place in the annals of

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natural unemployment rate;  $g_i(\cdot)$ , and  $j_i(\cdot)$  are  $i$ th participant’s specific functional forms. The appropriate policy is  $R_i^* = f_i(\pi^*, u_i^*, x, \Theta_i)$  but note that the existence of the solution is not guaranteed. We interpret Faust as suggesting that the dispersion of  $R_i^*$ s is large enough to undermine the usefulness of a function that combines the 19  $R_i^*$ s into a single  $R^*$ , period after period without a significant loss of information. See additional evidence of the plurality of reaction functions in the May 2018 Papers and Proceedings of the American Economic Association.

<sup>14</sup>Note that for the current year, this coefficient is zero when the appropriate policy equals, ex-post, the actual policy. Measures of uncertainty for unemployment and inflation are not available because the FOMC has not released the data for participants’ forecasts.

obfuscation in the service of transparency."

### 3.1 Taylor Rules as Verification Devices

Lacking a single "official reaction function," one could assess whether FOMC decisions on interest rates are consistent with their SEP's projections using the Taylor rule:<sup>15</sup>

$$R_t = [r + \pi_t + 0.5 \cdot (\pi_t - 2) + 0.5 \cdot (u_t - u_n)] \cdot 0.5 + 0.5 \cdot R_{t-1},$$

where  $R_t$  is the median of the distribution of the FOMC projections for the current-year federal funds rate made at time  $t$ ;  $\pi_t$  and  $u_t$  are the median of the current-year projections for inflation and unemployment made at time  $t$ .<sup>16</sup>

Recognizing the uncertainties associated with  $r$  and  $u_n$  (Bernanke 2016, Powell 2018), we consider three values for  $r$  (0, 1, 2) and two value for  $u_n$  (4, 5). The Taylor rule with  $r = 0$  and  $u_n = 4$  yields remarkably close interest-rate predictions for meetings since 2016 but not before then (figure 8). The results with  $r = 1$  and  $u_n = 4$  yields remarkably close interest-rate predictions for meetings prior to 2016 (figure 2):

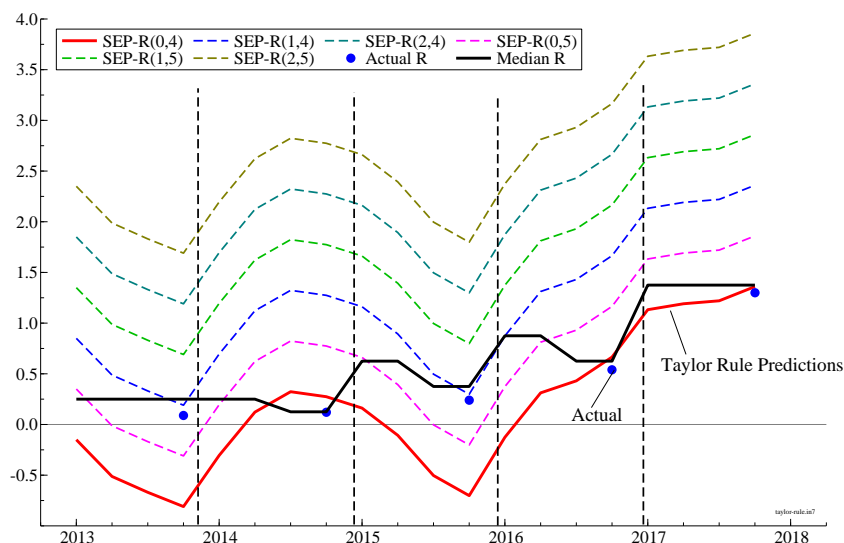


Figure 14: Taylor Rule Predictions - Sensitivity to Values of the Natural Rate

<sup>15</sup>We focus on these two variables because the record of press releases of FOMC decisions and *Bluebooks*, documenting the alternative options over which FOMC members vote, indicates that the outlook for economic activity (*i.e.* unemployment) and inflation are the most important considerations for determining the outlook for interest rates. See page 52 of <https://www.federalreserve.gov/monetarypolicy/files/FOMC20090128bluebook20090122.pdf>

<sup>16</sup>Note that the median of  $R$  need not correspond to a participant with the median of  $\pi$  or  $u$ . Mismatch of medians can be solved if FOMC released the participant specific projections with attribution. So the problem is secrecy and not a technical one. It is one thing not to reveal the reaction function. It is another not to release the data so that the public can craft their own reaction function.

Whether these projections are consistent with the FOMC process is impaired by an identification problem: is the FOMC's behavior inconsistent with its goals or is the FOMC consistent with its goals but the assumed coefficients prevent us from detecting. To study this issue further, we assume that the Taylor rule used here is correct but that the coefficient values are not. Thus, as an alternative, we apply OLS to

$$R_t = \varphi_1 \cdot \pi_t + \varphi_2 \cdot u_t + \varphi_3 \cdot R_{t-1} + \varphi_4 \cdot C_B + \varphi_5 \cdot C_Y + e_t; e_t \sim IN(0, \sigma^2)$$

where

$C_B$  : dummy variable equal to one for Bernanke's tenure as Chair of the FOMC

$C_Y$  : dummy variable equal to one for Yellen's tenure as Chair of the FOMC<sup>17</sup>

For parameter estimation, we use the median of FOMC's participants projections for the federal funds rate for FOMC meetings held from 2012 to December 2017, containing the longest span of FOMC projections for the federal funds rate. For the explanatory variables we use alternative measures: both the mid-points and the medians of the current-year projections for  $\pi$  and  $u$ . This reliance would help the public to rationalize, ex-post, whether interest-rate decisions are consistent with both the SEP projections and the Taylor rule.

The results (table 3 below) offer several findings of interest. First, they suggest that the SEP can provide, as Bernanke (2016) notes, indirect information about the reaction function.<sup>18</sup> Indeed, the parameter estimates suggest that an increase in the FOMC forecast for inflation raises the FOMC forecast for the federal funds rate and that an increase in the FOMC forecast for the unemployment rate lowers the FOMC forecast for the federal funds rate; these results are robust to measurement and consistent with the dual mandate. Second, the coefficient estimates are remarkably close to those of the Taylor rule reported above. Third, the estimates are congruent: residuals are white noise and parameter estimates are constant. Fourth, FOMC-Chair effects are both positive and significant.

Despite their appeal, these results fall short of what is needed for verification. First, the Taylor rule only helps to detect ex-post inconsistencies between the rule and FOMC decisions. Even if we could forecast the explanatory variables of the Taylor rule, we do not know whether the implied interest rate from these forecasts is consistent with the FOMC forecasts. If one wants an ex-ante prediction of the interest rate that can then be compared to the FOMC decisions, then one needs to model these SEP measures; we do that below. Second, arguably the SEP's projections for inflation and unemployment are jointly determined along with the appropriate interest rate. But the Taylor rule takes FOMC projections for inflation and unemployment as given. Third, the FOMC's projection horizon extends the current year: there is thus a potential endogeneity of across

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<sup>17</sup>Chair-specific effects allows for the possibility that the Chair of the FOMC may exert idiosyncratic influence on the target federal funds rate or capture declines in the neutral rate (see Bernanke 2016, Powell 2018)

<sup>18</sup><https://www.brookings.edu/blog/ben-bernanke/2016/11/28/federal-reserve-economic-projections/>

forecast horizons.

Table 6: OLS Parameter Estimates: FOMC Meetings from 2012 to 2017 with SEPs (24 obs)  
Sensitivity to Measures of Inflation and Unemployment (Entries in parentheses are t-statistics)

$$\underline{\underline{R_t = \varphi_1 \cdot \pi_t + \varphi_2 \cdot u_t + \varphi_3 \cdot R_{t-1} + \varphi_4 \cdot C_B + \varphi_5 \cdot C_Y + e_t; e_t \sim IN(0, \sigma^2)}}$$

	Mid	Median	Actual	SPF
$R_{t-1}$	0.50 (3.08)	0.50 (3.20)	0.51 (2.73)	0.44 (2.83)
$C_B$	1.67 (2.47)	1.63 (2.47)	1.63 (2.08)	1.92 (2.90)
$C_Y$	1.35 (2.70)	1.32 (2.71)	1.38 (2.33)	1.56 (3.14)
$\pi_t$	0.25 (2.26)	0.25 (2.37)	0.14 (1.63)	0.26 (2.37)
$u_t$	-0.26 (-2.82)	-0.25 (-2.83)	-0.23 (-2.21)	-0.28 (-3.34)
SER	0.191	0.190	0.206	0.180
Adj.Rsqrd	0.805	0.810	0.772	0.826
Hansen Parameter Instability <sup>†</sup>				
$\sigma^2$	0.224	0.183	0.391	0.187
$R_{t-1}$	0.087	0.069	0.071	0.101
$C_B$	0.161	0.170	0.260	0.119
$C_Y$	0.074	0.076	0.052	0.057
$\pi_t$	0.121	0.129	0.143	0.107
$u_t$	0.119	0.128	0.089	0.091
joint	1.085	1.086	1.063	1.060
Residual Properties <sup>‡</sup>				
H <sub>0</sub> : Serial independence	0.362	0.412	0.026*	0.175
H <sub>0</sub> : Homoskedasticity	0.593	0.590	0.688	0.414
H <sub>0</sub> : Normality	0.546	0.582	0.251	0.573

<sup>†</sup> interpretation <sup>‡</sup>p-values needed to reject the null hypothesis

Addressing these limitations involves tradeoffs among computational feasibility, details about transmission channels, and econometric reliability. To this end, we consider models that differ in design and estimation approaches.

### 3.2 Replication as Verification

We now develop empirical models that explain the median of FOMC projections for inflation, unemployment, and the federal funds rate in terms of publicly available data; we focus on current and one-year ahead projections for FOMC meetings held from 2012 to 2017 (figure 9).<sup>19</sup>

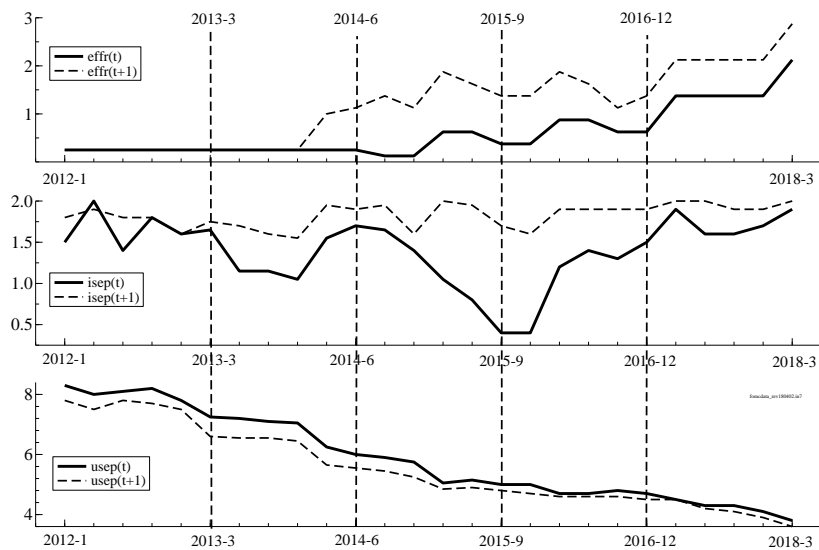


Figure 15: FOMC Forecasts - Current and One-Year Ahead

The data show two properties of interest. First, differences between current and one-year ahead projections have been, *over this period*, one-sided. For example, the median projection for the appropriate federal funds rate for the one-year ahead is effectively equal to the current-year plus a fairly constant "term" premium. For inflation, the one-year ahead projections are well anchored around two percent, even though projections for the current-year departs from their target. For unemployment, the projections reveal sustained optimism that next year will have a lower unemployment rate. Second, the projections reveal an FOMC that expects to meet its dual mandate next year despite evidence to the contrary in the current year.

Though the FOMC provides this information in real time, it is released along with the interest-rate decision. So, if what we want is to anticipate that decision, then we need to forecast the FOMC's own forecasts. Thus we postulate a model that treats FOMC projections as jointly determined. To be sure, we are not arguing that the FOMC participants determine their projections using econometric formulations only. Further, even a casual reading of FOMC transcripts reveals that the FOMC considers many variables in their decision-making process: term structures (foreign and domestic), exchange rates, interest rates (foreign and domestic), among others. Instead, we argue is that these equations are the ones that the public *could* use to replicate FOMC's forecasts.<sup>20</sup>

<sup>19</sup>The FOMC also provides projections for two and three years ahead but modeling those is beyond the scope of this paper.

<sup>20</sup>Nevertheless, the Board of Governors posts the Eviews files needed to run the staff's model FRB/US; see <https://www.federalreserve.gov/econres/us-models-package.htm>.

### 3.3 Formulations

#### 3.3.1 Vector Autoregressive Approach

We begin with a VAR to explain current and one-year ahead projections for inflation, unemployment, and the federal funds rate for a total of six endogenous variables:<sup>21</sup>

$$\begin{bmatrix} \pi_{t,t} \\ u_{t,t} \\ R_{t,t} \\ \pi_{t,t+1} \\ u_{t,t+1} \\ R_{t,t+1} \end{bmatrix} = \begin{bmatrix} a_{11} & \cdots & a_{16} \\ \vdots & \ddots & \vdots \\ a_{61} & \cdots & a_{66} \end{bmatrix} \cdot \begin{bmatrix} \pi_{t-1,t} \\ u_{t-1,t} \\ R_{t-1,t} \\ \pi_{t-1,t+1} \\ u_{t-1,t+1} \\ R_{t-1,t+1} \end{bmatrix} + \begin{bmatrix} b_{11} & \cdots & b_{16} \\ \vdots & \ddots & \vdots \\ b_{61} & \cdots & b_{66} \end{bmatrix} \cdot \begin{bmatrix} \pi_{t-1}^{spf} \\ \pi_{t-1}^a \\ u_{t-1}^{spf} \\ u_{t-1}^a \\ C_{Bt} \\ C_{Yt} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \\ e_{5t} \\ e_{6t} \end{bmatrix},$$

$$\mathbf{e}'_t = (e_{1t} \cdots e_{6t}) \sim IN(0, \mathbf{\Omega}_e)$$

where

$\pi_{t,t}$  and  $\pi_{t,t+1}$  are the inflation projections for the current and one-year ahead, respectively, made during the  $t^{th}$  FOMC meeting

$u_{t,t}$  and  $u_{t,t+1}$  are the unemployment projections for the current and one-year ahead, respectively, made during the  $t^{th}$  FOMC meeting

$R_{t,t}$  and  $R_{t,t+1}$  are the federal funds rate in the current and one-year ahead projections, respectively, made during the  $t^{th}$  FOMC meeting

This formulation

- treats FOMC projections as jointly determined
- includes
- allows Chair-specific effects.

For estimation we use the median of FOMC's participants projections for FOMC meetings held from 2012 to December 2017; we also report results using Autometrics. Based on the estimation results, the models offer a fair replication of the FOMC projections (figures 16 and 17) but note that the fitted values using Autometrics are not as close as those of the VAR. In terms of the adequacy for statistical inference, the residuals do not exhibit serial correlation or departures from

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This posting requires of the public an intimate familiarity with computer software. Even if that familiarity is present, one should not associated the views of the Board with the views of the FOMC as the dispersion of forecasts for the last 15 years demonstrates.

<sup>21</sup>The appendix documents the stationarity tests of these variables.



normality (figures 18 and 19).

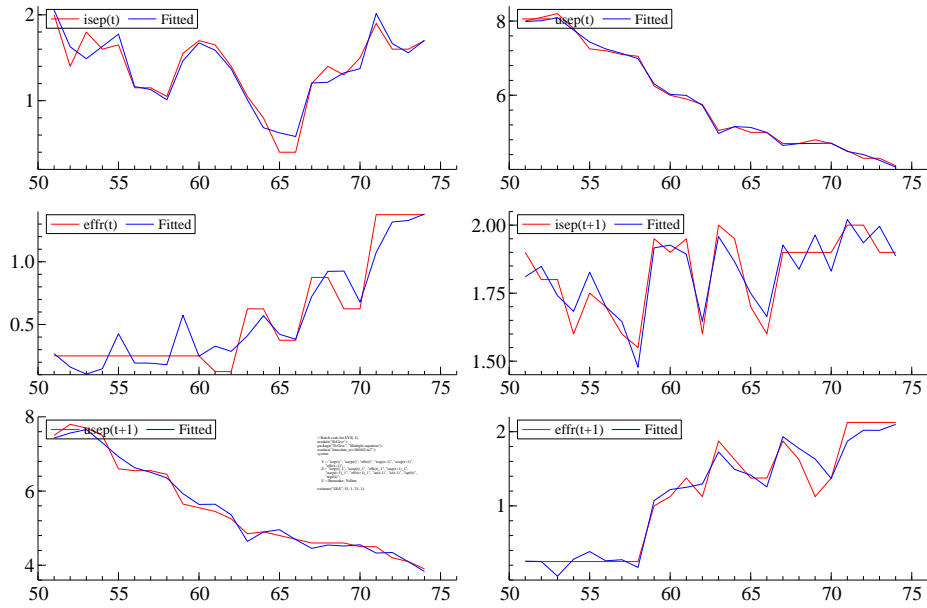


Figure 16: Actual versus Fitted FOMC Forecasts - VAR

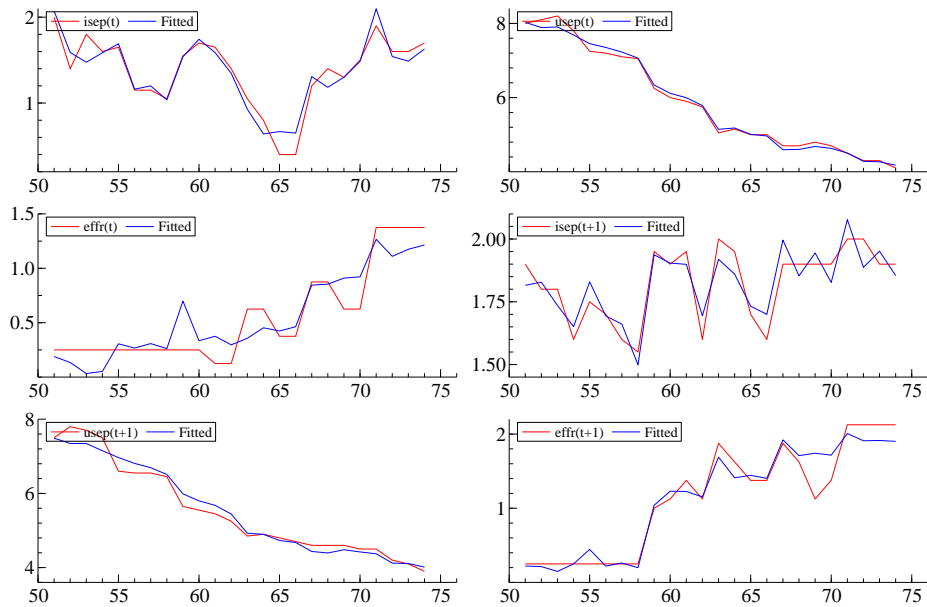


Figure 17: Actual versus Fitted FOMC Forecasts - VAR with a 5% Size

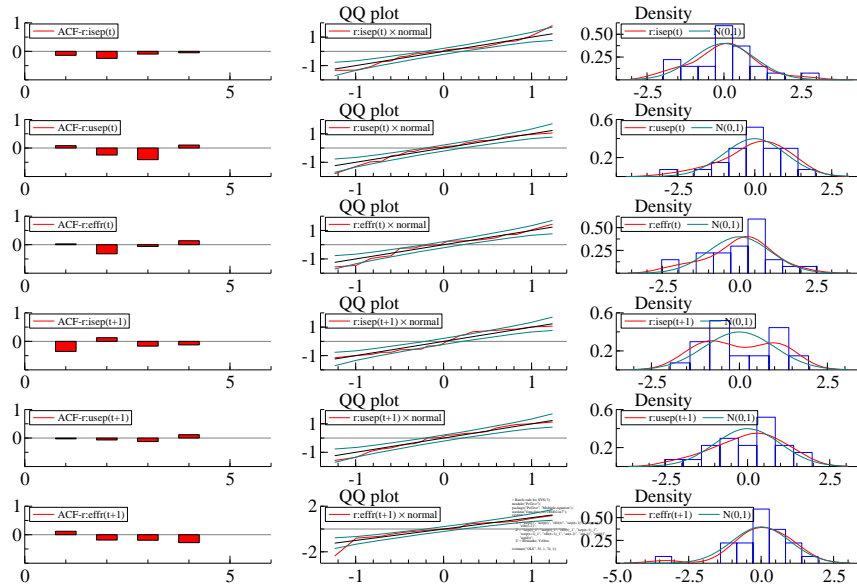


Figure 18: Tests of Serial Independence and Normality of Disturbances for VAR

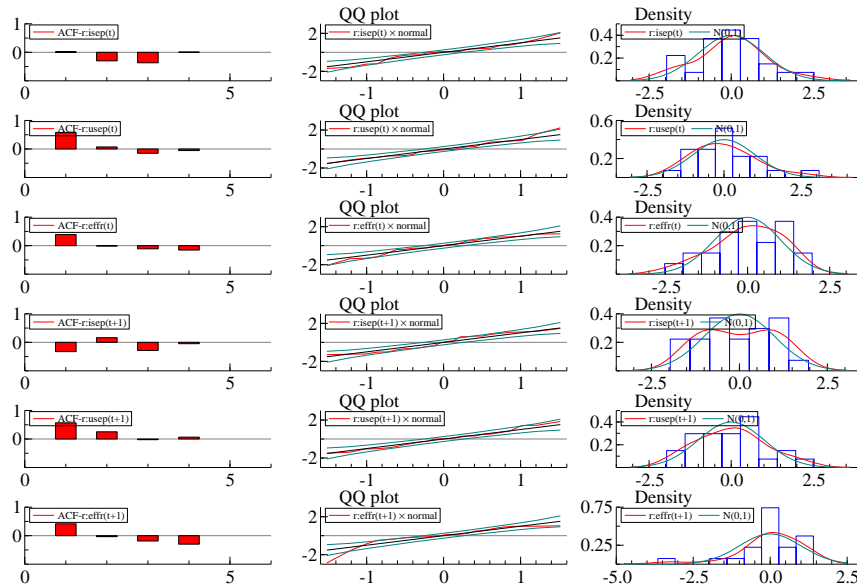


Figure 19: Tests of Serial Independence and Normality of Disturbances for VAR with a 5% Target Size

### 3.3.2 "Incredible Restrictions" Formulation

As an alternative to the VAR, we introduce incredible (but hopefully useful) parameter restrictions. Specifically, we assume a recursive structure in which current-year projections influence the one-

year ahead projections but not the other way around; this assumption is motivated by the profile of the current- and one-year ahead predictions discussed in figure 15 above:

$$\begin{array}{ll}
\text{current year } t & \text{one-year ahead } t + 1 \\
R_t = f_0(\pi_t, u_t | X_t, \Theta) & R_{t+1} = f_1(\pi_{t+1}, u_{t+1}, R_t | X_t, \Theta) \\
\pi_t = g_0(R_t, u_t | X_t, \Theta) & \pi_{t+1} = g_1(R_{t+1}, u_{t+1}, \pi_t | X_t, \Theta) \\
u_t = j_0(R_t, \pi_t | X_t, \Theta) & u_{t+1} = j_1(R_{t+1}, \pi_{t+1}, u_t | X_t, \Theta)
\end{array}$$

where

$\Theta$  : vector of unknown coefficients that need to be estimated

$X$  : vector of exogenous variables with publicly available data in real time and prior to the FOMC meeting; recorded data for inflation and unemployment

Note that FOMC projections for a given horizon are jointly determined. With these considerations in mind, the structure for current-year projections is Thus we postulate a model that treats FOMC projections as jointly determined. Specifically, the model has six endogenous variables that are grouped into a recursive structure in which projections for the current-year determine the one-year ahead projections but not the other way around. For parameter estimation we postulate a model that is linear in the parameters. The structure for the current-year projections is

$$\begin{bmatrix} 1 & -\alpha_{12} & -\alpha_{13} \\ -\alpha_{22} & 1 & -\alpha_{23} \\ -\alpha_{32} & -\alpha_{33} & 1 \end{bmatrix} \begin{bmatrix} \pi_{t,t} \\ u_{t,t} \\ R_{t,t} \end{bmatrix} = \begin{bmatrix} \alpha_{11} & 0 & 0 \\ 0 & \alpha_{21} & 0 \\ 0 & 0 & \alpha_{31} \end{bmatrix} \begin{bmatrix} \pi_{t,t-1} \\ u_{t,t-1} \\ R_{t,t-1} \end{bmatrix} + \begin{bmatrix} \beta_{11} & \beta_{12} & 0 & 0 \\ 0 & 0 & \alpha_{23} & \alpha_{24} \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \pi_{t-1}^{spf} \\ \pi_{t-1}^a \\ u_{t-1}^{spf} \\ u_{t-1}^a \end{bmatrix} \\
+ \begin{bmatrix} \beta_{15} & \beta_{16} \\ \beta_{25} & \beta_{26} \\ \beta_{35} & \beta_{36} \end{bmatrix} \begin{bmatrix} C_B \\ C_Y \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{bmatrix}$$

The structure for one-year ahead projections is

$$\begin{bmatrix} 1 & -\alpha_{45} & -\alpha_{45} \\ -\alpha_{55} & 1 & \alpha_{55} \\ -\alpha_{65} & -\alpha_{66} & 1 \end{bmatrix} \begin{bmatrix} \pi_{t,t+1} \\ u_{t,t+1} \\ R_{t,t+1} \end{bmatrix} = \begin{bmatrix} \alpha_{14} & 0 & 0 & 0 \\ 0 & \alpha_{24} & 0 & 0 \\ 0 & 0 & \alpha_{34} & \alpha_{35} \end{bmatrix} \begin{bmatrix} u_{t,t} \\ \pi_{t,t} \\ R_{t,t} \\ R_{t-1,t+1} \end{bmatrix} \\
+ \begin{bmatrix} \beta_{45} & \beta_{46} \\ \beta_{55} & \beta_{56} \\ \beta_{65} & \beta_{66} \end{bmatrix} \begin{bmatrix} C_B \\ C_Y \end{bmatrix} + \begin{bmatrix} e_{4t} \\ e_{5t} \\ e_{6t} \end{bmatrix}$$

where  $(e_{1t} \cdots e_{6t}) \sim IN(0, \mathbf{\Omega})$ .<sup>22</sup>

This formulation has several features of interest:

- The equation for  $R_{t,t}$  generalizes the conventional Taylor rule by using endogenously determined FOMC projections
- Chair-specific effects are included
- Publicly available information is targeted: inflation data affects directly inflation projections but not unemployment projections and vice versa
- Persistence is present but there is no cross-persistence.

Arguing that these restrictions are ad-hoc is elaborating on the obvious. The relevant question is not whether there are restrictions but whether they are helpful in addressing Faust's critique.

For estimation we apply FIML to data on the median of FOMC's participants projections for FOMC meetings held from 2012 to December 2017; the results are shown in table 7 below. For the current-year predictions, the results suggest that simultaneity is weak at best: increases in  $R_{t,t}$  barely lower  $\pi_{t,t}$  and  $u_{t,t}$  (cols. 1 and 2). In addition, increases in  $\pi_{t,t}$  raise  $R_{t,t}$  whereas increases in  $u_{t,t}$  lower  $R_{t,t}$  (col. 3). The results also indicate that movements in current-year predictions for unemployment are transmitted to one-year ahead predictions for unemployment almost one for one (col. 5). For one-year ahead inflation, the pass-through is considerably smaller and barely significant. The results also indicate that FOMC-Chair effects are both positive and significant for the current-year interest rate (col. 3). These effects are also positive, significant for the one-year ahead inflation rate, and with a value very close to the FOMC target for the inflation rate (col. 4). These FOMC-Chair effects, if taken at face value, suggest that the Bernanke's had a target real rate close to zero whereas Yellen had a negative target real interest rate of about 30 basis points.

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<sup>22</sup>Note that the order conditions for identification are met.

Table 7: FIML Estimation Results of Parameters of Structural Model: 2012 - 2017

Current Year Bloc						One-year Ahead Bloc					
$\pi_{t,t}$		$u_{t,t}$		$R_{t,t}$		$\pi_{t,t+1}$		$u_{t,t+1}$		$R_{t,t+1}$	
(1)		(2)		(3)		(4)		(5)		(6)	
$\pi_{t-1}^a$	0.666	$u_{t-1}^a$	0.394	$R_{t-1,t}$	0.387	$\pi_{t,t}$	0.137	$u_{t,t}$	0.914	$R_{t,t}$	-1.37
	0.185		0.086		0.124		0.067		0.060		0.947
$\pi_{t-1}^{spf}$	0.069	$u_{t-1}^{spf}$	0.795	$\pi_{t,t}$	0.279	$u_{t,t+1}$	-0.059	$\pi_{t,t+1}$	0.364	$\pi_{t,t+1}$	5.484
	0.207		0.100		0.113		0.048		0.597		3.953
$\pi_{t-1,t}$	0.200	$u_{t-1,t}$	-0.398	$u_{t,t}$	-0.315					$u_{t,t+1}$	-0.717
	0.15		0.082		0.085						0.42
$u_{t,t}$	-0.272	$\pi_{t,t}$	0.176							$R_{t-1,t+1}$	0.522
	0.281		0.109								0.241
$R_{t,t}$	-0.361	$R_{t,t}$	-0.223								
	0.518		0.186								
$C_B$	2.164	$C_B$	1.166	$C_B$	2.079	$C_B$	1.942	$C_B$	-0.513	$C_B$	-4.027
	1.965		0.691		0.642		0.345		1.316		6.711
$C_Y$	1.775	$C_Y$	0.784	$C_Y$	1.664	$C_Y$	1.970	$C_Y$	-0.490	$C_Y$	-5.081
	1.553		0.538		0.463		0.240		1.289		6.962

With the exception of one-year ahead projection for inflation, the model offers a fair replication of the FOMC projections (figure 20). In terms of the adequacy for statistical inference, the residuals do not exhibit serial correlation or departures from normality (figure 21)

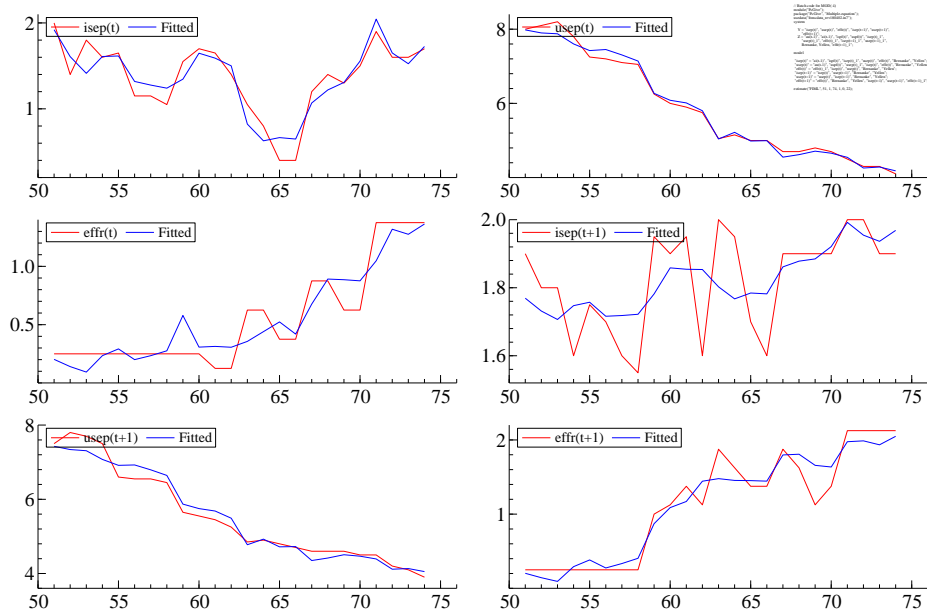


Figure 20: Actual versus Fitted FOMC Forecasts - FIML

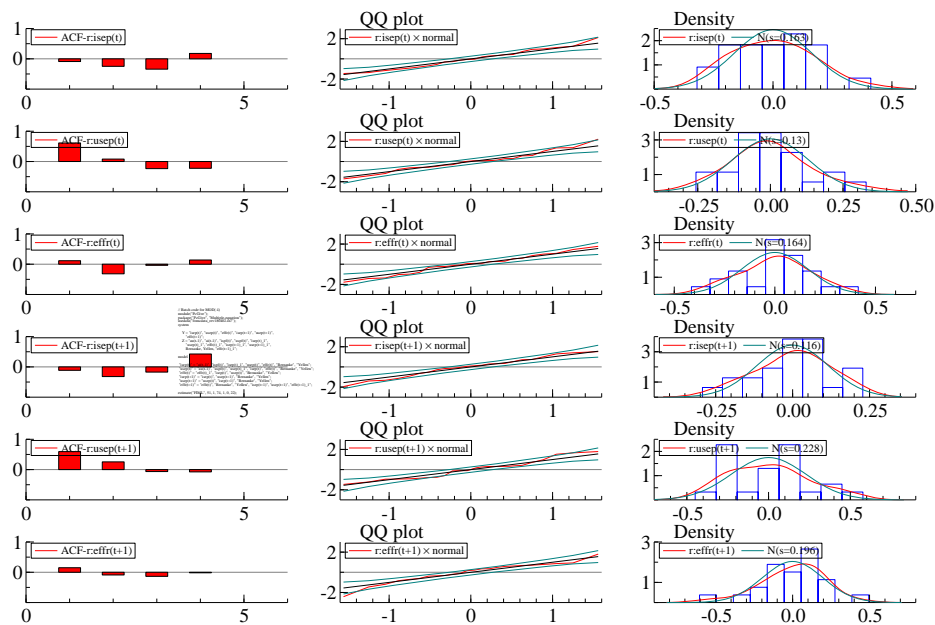


Figure 21: Tests of Serial Independence and Normality of Disturbances for FIML

### 3.3.3 Single Equation: Rules of Thumb Approach

A fair question to ask is whether we need to rely at all on the above models to predict  $R_{t,t}$ . As an alternative, we could just regress  $R_{t,t}$  on the pre-determine variables, and then forecast them to

generate the forecast of  $R_{t,t}$ . Though appealing in principle, this approach removes the links between the modeling of the FOMC projections and the forecast for  $R_{t,t}$ : In other words, one would not know if the forecast for  $R_{t,t}$  is consistent with the forecasts for inflation and unemployment. And the question is whether our modeling of those links above helps anticipating interest-rate decisions. To that end, we consider

$$R_{t,t} = \alpha_1 \cdot u_{t-1}^{spf} + \alpha_2 \cdot u_{t-1}^a + \alpha_3 \cdot \pi_{t-1}^{spf} + \alpha_4 \cdot \pi_{t-1}^a + \alpha_5 \cdot R_{t-1,t} + \alpha_6 \cdot C_B + \alpha_7 \cdot C_Y + e_t; \quad e_t \sim IN(0, \sigma^2).$$

For estimation we apply OLS to data on the median of FOMC’s participants projections for FOMC meetings held from 2012 to December 2017. Again, we also report results using Autometrics; the results are shown in table 8:

Table 8: Single Equation Results for the Federal Funds Rate  $R_{t,t}$

	General		Specific (5%)	
	Coefficient	t-value	Coefficient	t-value
$\pi_{t-1}^a$	0.11	0.66	$0^e$	
$u_{t-1}^{spf}$	-0.75	-1.58	-0.51	-4.43
$u_{t-1}^a$	0.25	0.47	$0^e$	
$\pi_{t-1}^{spf}$	0.18	0.39	0.46	2.37
$C_B$	3.54	3.67	3.43	3.83
$C_Y$	2.92	4.23	2.79	4.48
$R_{t-1,t}$	0.45	2.58	0.44	2.83
ser	0.19		0.18	
$\overline{R}^2$	0.81		0.83	
$H_o^\dagger$				
Serial independence	0.202		0.175	
Homoskedasticity	0.417		0.414	
Normality	0.486		0.573	

$\dagger$ p-values needed to reject the null hypothesis

Reliance on Autometrics removes the actual values for both inflation,  $\pi_{t-1}^a$ , and unemployment,  $u_{t-1}^a$  but it retains the SPF forecasts; both persistence and chair-specific effects are quite significant. In terms of congruency, the residuals’ distributions are consistent with the assumptions needed for statistical inference.

Having implemented the three models, we now ask whether they are equally suitable for addressing Faust’s critique for predicting interest rates. Answering that question involves examining the properties of these models.

## 4 Obstacle 3: Assessing Model Usefulness

### 4.1 Predictability

Figure (22) compares the median projection for the federal funds rate against the models' predictions. Though there are numerical differences in terms of fit, those differences do not appear large enough to justify using one model instead of another.

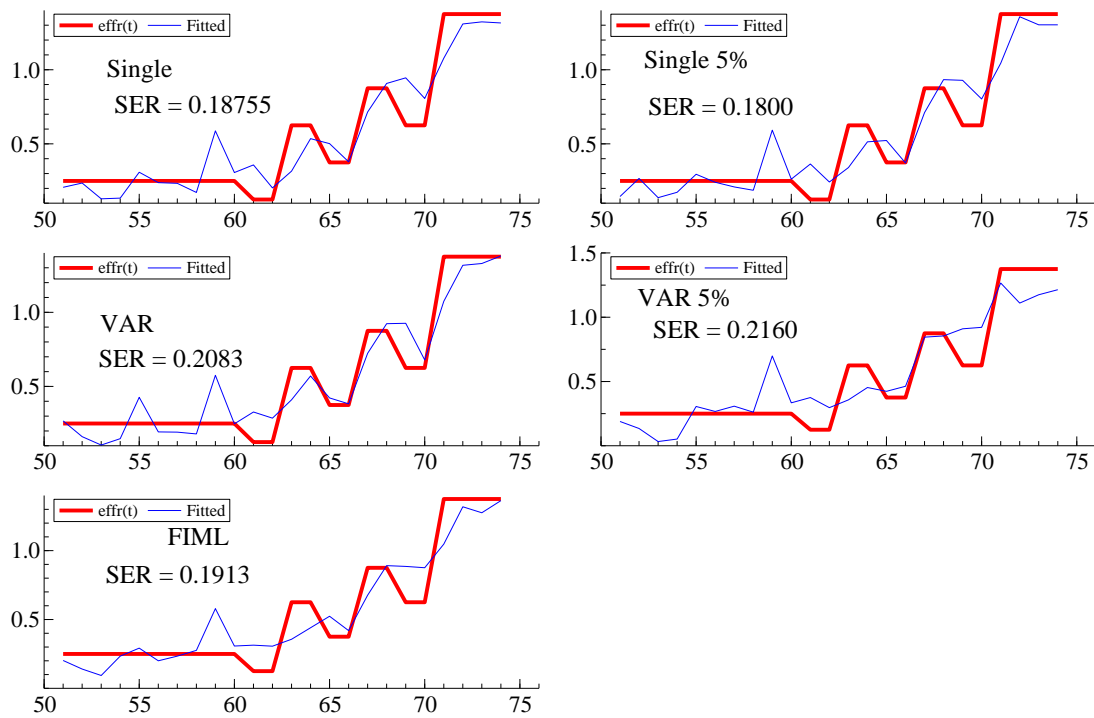


Figure 22: Actual versus Fitted FOMC Forecasts for the Federal Funds Rate - Alternative Models



## 4.2 Reduced Form Coefficients

We now use the long-run, reduced-form coefficients for  $R_{t,t}$  from each model and estimation method.

Table 9: Static Long Run Solutions for the current-year projections for the federal funds rate

<i>Model</i>		$\pi^a$	$\pi^{spf}$	$u^a$	$u^{spf}$	$C_B$	$C_Y$	Properties of Residuals			
								SER	Normality	Indep	Homosk.
single	GUM	0.20	0.18	0.25	-0.75	3.53*	2.92*	0.188	0.486	0.202	0.417
	5%	0 <sup>e</sup>	0.46*	0 <sup>e</sup>	-0.51*	3.44*	2.79*	0.180	0.573	0.175	0.414
VAR	GUM	0.26	0.17	-0.01	-0.50	3.47*	2.81*	0.208	0.494	0.852	0.142
	5%	0.26*	0 <sup>e</sup>	0.10	-0.56*	3.45*	2.84*	0.216	0.397	0.125	0.551
FIML		0.29*	0.03	-0.17*	-0.34*	3.63*	2.99*	0.191	0.956	0.201	0.836

\* means that the associated t-ratio is greater than 2; 0<sup>e</sup> means excluded by the algorithm

The results are sensitive to both model specification and estimation method. Nevertheless, they share three features of interest:

- A combined increase of one percentage point in the actual and SPF inflation rate raises the federal funds rate ranging from 40 to 50 basis points.
- A combined increase of one percentage point in the actual and SPF unemployment rate reduces the federal funds rate from 26 to 50 basis points.
- Chair-specific effects are significant and positive; the value of Yellen's tenure is lower than the one for Bernanke by about 60 basis points.

In the absence of a universally accepted point estimate these results are not helpful in discriminating among models.

## 4.3 Dynamic Stability

We now use impulse responses to examine how much of a revision in FOMC projections for one variable are reflected as revisions in other variables.

**VAR Model** A a one-percentage point transitory upward revision to the current-year inflation rate leads to transitory upward revision in the federal funds rate projection for the current year and a downward revision for the one-year ahead projections for the federal funds rate (figure 23). A one-percentage point upward revision in the current-year projection for unemployment is accompanied by an upward revision in the federal funds rate projection for the current year (figure 24). Thus, though the model is dynamically stable, the associated impulse responses are not consistent with the dual mandate.

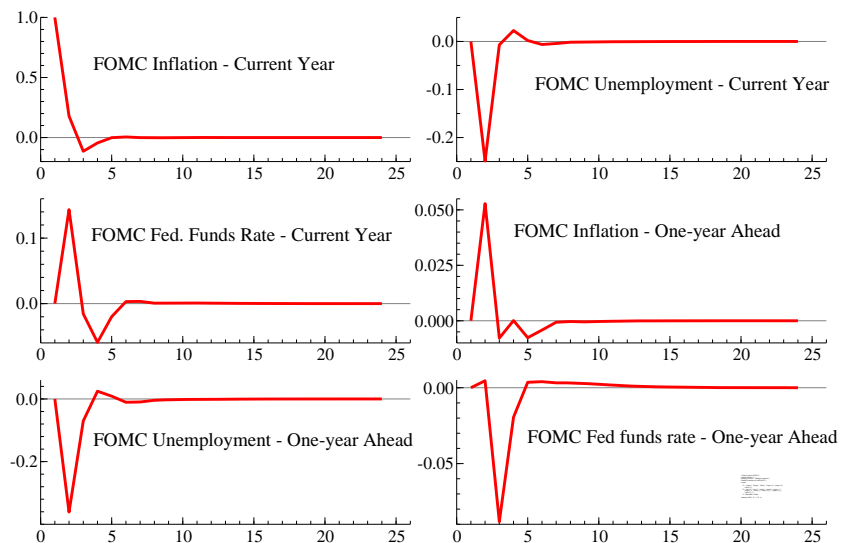


Figure 23: Impulse Responses to a one percent Inflation revision - VAR

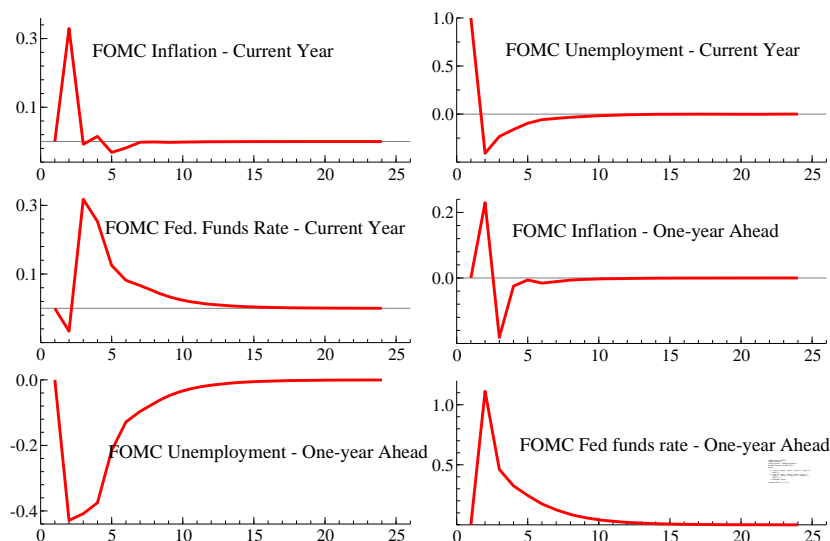


Figure 24: Impulse Responses to a one percent Unemployment revision - VAR

**Autometrics VAR** The results reveal that revisions to the current-year inflation projection do not affect the other variables (figure 25). Further, an upward revision in the current-year unemployment rate prediction leads to a downward revision in the current-year interest rate but an even larger upward revision in the one-year ahead prediction for the interest rate. Thus these results are not consistent with the dual mandate.

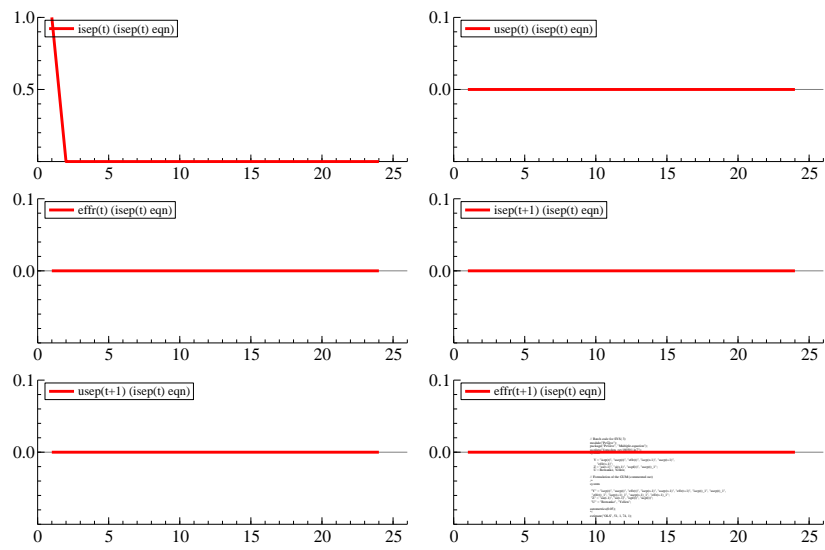


Figure 25: Impulse Responses to a one percent Inflation revision - VAR 5%

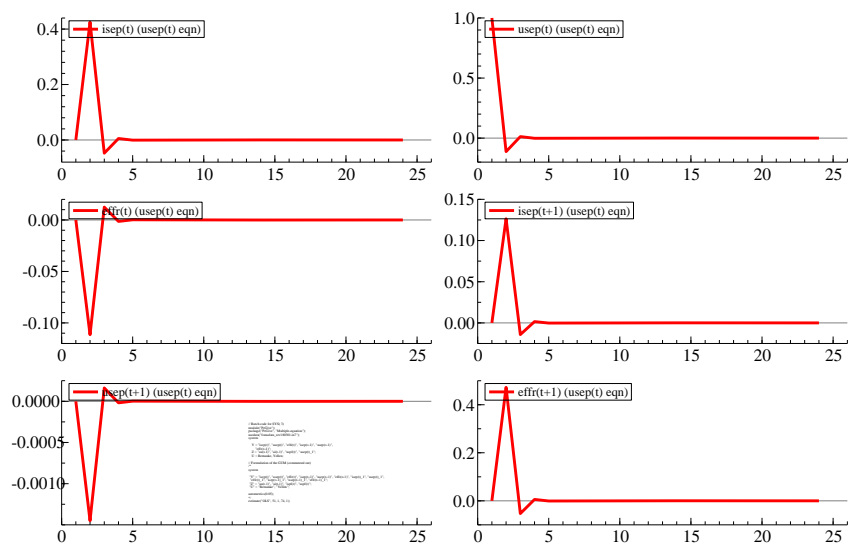


Figure 26: Impulse Responses to a one percent Unemployment revision VAR 5%

**Constrained Model** A one-percentage point upward revision of the forecast inflation rate raises both the current- and one-year ahead interest rate (figure 27). A one-percentage point upward revision in the unemployment projections for the current year lowers the federal funds rate projection for both the current and the one-year ahead projections. Thus, apart from suggesting dynamic stability, this model's results are consistent with the dual mandate.

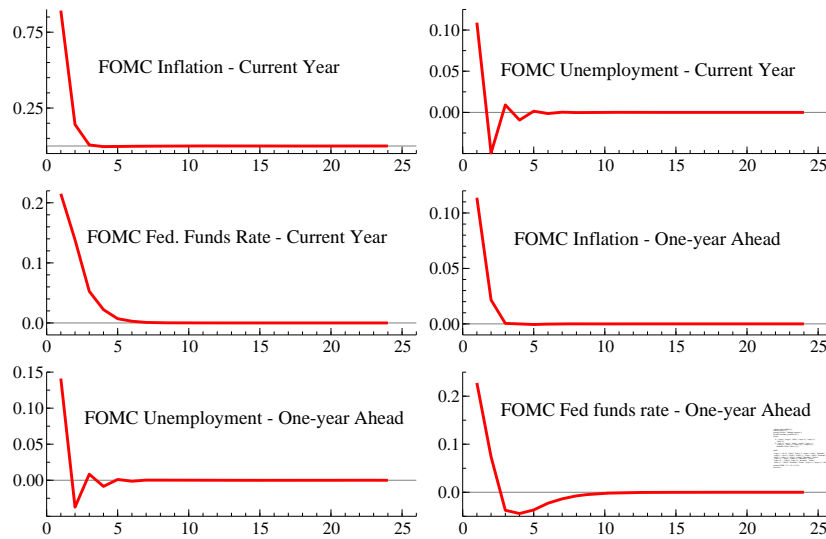


Figure 27: Impulse Responses to a one percent Inflation Revision FIML

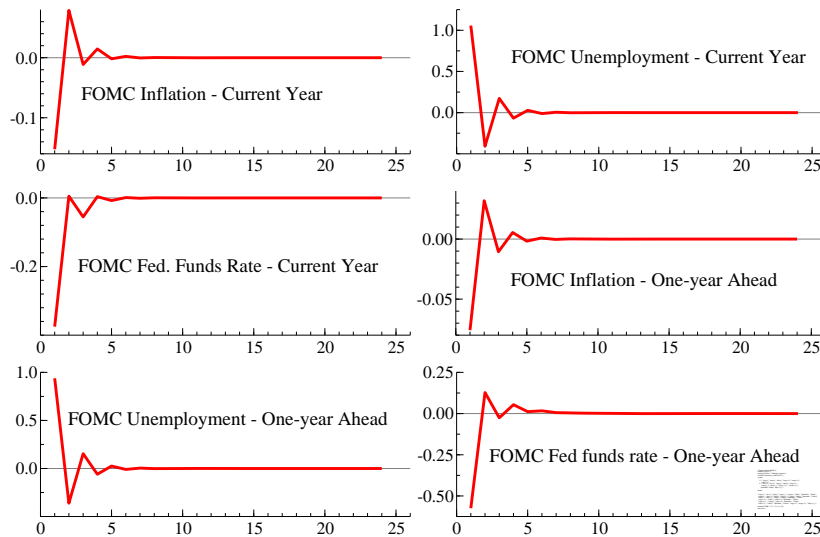


Figure 28: Impulse Responses to a one percent Unemployment revision FIML

#### 4.4 Ex-ante Forecasting Accuracy

We now implement 1-step ahead out-of-sample forecasts of the FOMC forecasts for the March and June 2018 meetings.<sup>23</sup> In doing so, we assume that Chair Powell has the same view of the world as Chair Yellen; we examine this assumption in the next section.

<sup>23</sup>Prior to each of these meetings, we sent our forecasts to Gordon Bodnar, Neil Ericsson, Fred Joutz, and Tara Sinclair.

Table 10: 1-step ahead projections for median from C-VAR

		March and June 2018					
		$\pi_{t,t}$	$\pi_{t,t+1}$	$u_{t,t}$	$u_{t,t+1}$	$R_{t,t}$	$R_{t,t+1}$
March 2018	Model	1.75	1.98	3.91	3.80	1.45	2.24
	<i>SEP</i>	1.8 - 2.1	1.9 - 2.3	3.6 - 4.0	3.3 - 4.2	1.63 - 2.63	1.63 - 3.88
June 2018	Model	1.88	1.99	3.88	3.78	1.80	2.36
	<i>SEP</i>	2.0 - 2.2	1.9 - 2.3	3.5 - 3.8	3.3 - 3.8	1.88 - 2.63	1.88 - 3.63

For both meetings, the model's prediction for  $R_{t,t}$  is a bit below the lower bound of the FOMC's range of appropriate interest rates. Such an underprediction owes to two factors. First, the model shows a slight underprediction for  $\pi_{t,t}$ , which then lowers  $R_{t,t}$  via the interest-rate equation. Second, the forecast assumes that Powell's approach is the same as that of Yellen, which need not be correct. We now re-examine this assumption.

#### 4.5 Autometrics Redux: Occam's Razor

We postulate the following General Unrestricted Model (GUM) and use data including Powell as the Chair of the FOMC:

$$R_{t,t} = \alpha_1 \cdot u_{t-1}^{spf} + \alpha_2 \cdot u_{t-1}^a + \alpha_3 \cdot \pi_{t-1}^{spf} + \alpha_4 \cdot \pi_{t-1}^a + \alpha_5 \cdot R_{t-1,t} + \alpha_{60}(L) \cdot \pi_{t,t} + \alpha_{70}(L) \cdot u_{t,t} \\ + \alpha_8 \cdot C_B + \alpha_9 \cdot C_Y + \alpha_{10} \cdot C_P + \alpha_{11}(L) \cdot \mu_{t,t} + \alpha_{12}(L) \cdot \mu_{t,t+1} + e_t, \quad e_t \sim IN(0, \sigma^2).$$

where  $\alpha(L)$  is a polynomial of degree one in the lag operator,  $C_P$  is the Chair effect for Powell and, to assess the empirical relevance of Faust's critique for forecasting, we include  $\mu_{R_{t-1,t}}$  and  $\mu_{R_{t-1,t+1}}$  which represent the degree of disagreement among FOMC participants of the appropriate interest rate; we measure this disagreement using coefficient of variation of the distribution of FOMC participants' appropriate federal funds rate shown earlier in figure 13.

Note that the equation includes the FOMC's current-year predictions for inflation and unemployment. Thus, if  $\alpha_{60}(L) = \alpha_{70}(L) = 0$ , then information about the FOMC's inflation and unemployment forecasts is not needed for predicting  $R_{t,t}$ . Similarly, if  $\alpha_{11}(L) = \alpha_{12}(L) = 0$ , then the force of Faust's critique for forecasting would be attenuated.

The estimation results reveal several features of interest. First, sole reliance on the GUM suggests that the previous value of the federal funds rate is the most important factor in explaining movements in that interest rate; neither FOMC-Chair effects nor participants' difference, nor economic data (FOMC's or public) are statistically important. Second, the implementation of Autometrics reveals a different characterization: Chair effects and  $u_{t-1}^{spf}$  are important and their long-run values are robust to the choice of target size. Third, FOMC's current-year forecasts of inflation and unemployment are not relevant for forecasting FOMC rate decisions. In other words, one cannot reject the null hypothesis that  $\alpha_{60}(L) = \alpha_{70}(L) = 0$ . Estimates using a 0.01% target size

show that persistence is no longer relevant and information about both inflation and unemployment play statistically important roles. The exclusion of persistence sounds like a limitation until one realizes that persistence is already embodied in the FOMC Chair. But the Chair embodies more than history: It embodies the power to persuade participants around the Chair's view. Yellen's approach is illustrative:

And the question is, are we ever going to converge? I would feel my job is to get everybody to see that off-white is not a bad alternative. (Laughter) As brilliant as your choice was, maybe you could live with off-white, and it's not so bad. And we can converge on that and it's going to function just fine and maybe we can agree. Yellen (2018)<sup>24</sup>

Given this persuasive power, it is not surprising to find that one cannot reject the null hypothesis that  $\alpha_{11}(L) = \alpha_{12}(L) = 0$ .

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<sup>24</sup>See [https://www.brookings.edu/wp-content/uploads/2018/03/es\\_20180227\\_yellen\\_bernanke\\_transcript.pdf](https://www.brookings.edu/wp-content/uploads/2018/03/es_20180227_yellen_bernanke_transcript.pdf)

Table 11: Estimation Results for Single Equation for the Federal Funds Rate – Sensitivity to Target Size

	GUM		0.01		0.0001		0.0001+IIS+SIS	
	Coeff	Std.Err	Coeff	Std.Err	Coeff	Std.Err	Coeff	Std.Err
$R_{t-1,t}$	0.71	0.31	0.56	0.16	–	–	–	–
Yellen	-0.38	1.10	1.54	0.55	2.82	0.37	2.41	0.26
Bernanke	-0.92	1.53	1.87	0.73	3.42	0.55	2.70	0.39
Powell	0.15	1.19	2.26	0.58	3.55	0.36	3.05	0.26
$u_{t-1}^{spf}$	-0.02	0.81	-0.23	0.09	-0.46	0.07	-0.23	0.06
$\pi_{t-1}^{spf}$	0.42	0.50	–	–	–	–	–	–
$\pi_{t-1}^a$	0.09	0.28	–	–	0.25	0.08	–	–
$u_{t-1}^a$	0.84	0.44	–	–	–	–	–	–
$\pi_{t,t}$	-0.17	0.32	–	–	–	–	–	–
$\pi_{t,t-1}$	-0.18	0.28	–	–	–	–	–	–
$u_{t,t}$	-0.62	0.40	–	–	–	–	–	–
$u_{t,t-1}$	-0.04	0.26	–	–	–	–	–	–
$\mu_{t,t}$	-0.55	0.62	–	–	–	–	–	–
$\mu_{t,t+1}$	-0.44	0.61	–	–	–	–	–	–
$\mu_{t-1,t}$	-0.51	0.28	–	–	–	–	–	–
$\mu_{t-1,t+1}$	0.072	0.61	–	–	–	–	–	–
SER	0.18		0.20		0.21		0.14	
Adj.Rsqrd	0.88		0.86		0.85		0.93	
$H_0^\dagger$								
Serial Indep.	0.48		0.17		0.10		0.24	
ARCH	0.73		0.59		0.64		0.46	
Normality	0.45		0.05		0.31		0.75	
Hetero	NA		0.05		0.20		0.13	
Hetero-X	NA		0.04		0.24		0.13	
RESET23	NA		0.03		0.00		0.01	
Parameters	16		5		5		5	

† Significance level needed to reject the null hypothesis

These differences in estimation results are relevant for forecasting. Specifically, as the cost of including irrelevant variables is assumed to be increasingly greater than the cost of excluding relevant variables (declines in target size), we note a reduction in both the level and the change of the forecasts. Second, combining lowest target size with super-saturation miss the level of interest rates but predict the change in the interest-rate announcements while lowering the standard error of the forecast.

Table 12: Forecasts for the Federal Funds Rate – Sensitivity to Target Size

	Formulation				SEP Range
	GUM	0.01	0.0001	0.0001+	
				IIS+SIS	
June 2018	2.47	2.55	2.22	2.13	1.875 - 2.625
September 2018	2.71	2.71	2.34	2.15	2.125 - 2.375
Forecast std. err	0.18	0.20	0.21	0.14	

In other words, disagreements among FOMC participants are not relevant for explaining or predicting the federal funds rate.

## 5 Conclusions

This paper is not about invalidating Faust’s critique: The SEP offers no way to reconcile the dispersion of appropriate interest rate policies. To Faust and Bernanke, the way to reconcile these differences is for the FOMC to provide its reaction function. We argue that providing a reaction function that relies on variables the public does not observe is not helpful. This paper is about the feasibility of bypassing the absence of the FOMC reaction function. The results show that it is possible to replicate accurately the FOMC projections, to obtain results that are consistent with expectations, and to extract simple rules of thumb to predict interest-rate decisions.

There are many objections to our findings. First, FOMC participants’ projections rely on their assessments of the *appropriate* monetary policy. We do not have access to the solutions of participants’ optimization problem, much less the aggregate of such solutions. Second, there is no guarantee that a replicable, but unknown, model even exists. Indeed, our work is subject to the criticism that we are testing a joint hypothesis: that the mapping exists and that our approach offers a characterization of it. Third, from a modeling standpoint, our mapping treats SPF forecasts as given. Fourth, the sample period is brief and the number of observations is small and correspond to an unusual circumstances in U.S. history. Finally, we have not undertaken an exhaustive sensitivity analysis of our econometric results. Thus, taken as whole, these limitations underscore the undeniably tentative character of our results.

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## A Appendix: Time-series Properties

Unit Root Tests: Sensitivity to Test Statistic						
		ADF	DF-GLS	PHILLIPS-PERRON	KPSS	NG-PERRON
	Ho	Unit Root	Unit Root	Unit Root	No Unit Root	Unit Root
$\pi_{t,t}$	1%	Fail to Reject	Fail to Reject	Fail to Reject	Fail to Reject	Fail to Reject
	5%	Fail to Reject	Reject	Fail to Reject	Fail to Reject	Fail to Reject
	10%	Fail to Reject	Reject	Fail to Reject	Fail to Reject	Reject
$\pi_{t,t+1}$	1%	Fail to Reject	Reject	Fail to Reject	Fail to Reject	Fail to Reject
	5%	Fail to Reject	Reject	Fail to Reject	Fail to Reject	Reject
	10%	Fail to Reject	Reject	Fail to Reject	Reject	Reject
$u_{t,t}$	1%	Fail to Reject	Fail to Reject	Reject	Fail to Reject	Fail to Reject
	5%	Reject	Fail to Reject	Reject	Reject	Reject
	10%	Reject	Fail to Reject	Reject	Reject	Reject
$u_{t,t+1}$	1%	Fail to Reject	Fail to Reject	Reject	Fail to Reject	Fail to Reject
	5%	Reject	Fail to Reject	Reject	Reject	Fail to Reject
	10%	Reject	Fail to Reject	Reject	Reject	Fail to Reject
$R_{t,t}$	1%	Fail to Reject	Fail to Reject	Fail to Reject	Fail to Reject	Fail to Reject
	5%	Fail to Reject	Fail to Reject	Fail to Reject	Reject	Reject
	10%	Fail to Reject	Reject	Fail to Reject	Reject	Reject
$R_{t,t+1}$	1%	Fail to Reject	Fail to Reject	Fail to Reject	Fail to Reject	Reject
	5%	Fail to Reject	Fail to Reject	Fail to Reject	Reject	Reject
	10%	Fail to Reject	Fail to Reject	Fail to Reject	Reject	Reject

## **B Appendix: Detailed Data for Explanatory Variables**

### **B.1 Survey of Professional Forecasters:**

- Source: The Federal Reserve Bank of Philadelphia.
- SPF data for unemployment and CPI ranges from August 1981 to November 2017.
- We use the sample February 1992 – November 2017. SPF data is published quarterly: February, May, August, and November.
- From February 1992 to February 2009 (included), SPF unemployment forecast only included nowcasts and one-period-ahead forecasts.
- Starting from May 2009 SPF unemployment forecasts were: nowcast, one-period-ahead, two-periods-ahead, and three-periods-ahead.
- From February 1992 to May 2005 (included) SPF CPI forecasts only included nowcasts and one-period-ahead forecasts.
- Starting from August 2005 SPF CPI forecasts were: nowcast, one-period-ahead, and two-periods-ahead.
- SPF PCE and Core PCE forecasts start in February 2007 and goes until November 2017. Forecasts were: nowcast, one-period-ahead, and two-periods-ahead.

### **B.2 Actual**

- Source: FRED
- We use monthly unemployment, CPI, PCE, and Core PCE data published by the Federal Reserve Bank of St. Louis.
- Monthly unemployment data ranges from January 1948 to December 2017.
- Monthly CPI data is available from January 1947 to December 2017.
- Monthly PCE and Core PCE data is available from January 1959 to November 2017.
- All inflation data is transformed to be percent change from year ago.