Asymmetries in Monetary Policy Uncertainty: New Evidence from Financial Forecasts*

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PRELIMINARY

Abstract

We propose indices to measure the monetary policy uncertainty in the US. The indices are based on the accuracy of expectations about the policy relevant interest rate movements. We use survey-based and market-based forecasts of the federal funds rate to measure expectations about current and future (conventional) monetary policy decisions. Our results show that periods of interest rate tightening and easing are distinctly associated with downside and upside uncertainty, respectively. We subsequently analyze the effects of uncertainty conditional on the economy being in a monetary tightening or easing regime. Though in both cases uncertainty is recessionary, the effects are stronger in an easing regime relative to a tightening one. Further, when controlling for fundamental macroeconomic uncertainty, the macroeconomic effects of monetary policy uncertainty get dampened, yet still being significant in an easing regime.

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"Central Banking [has been] traditionally surrounded by a peculiar mystique... The mystique thrives on a pervasive impression that Central Banking is an esoteric art. Access to this art and its proper execution is confined to the initiated elite. The esoteric nature of the art is moreover revealed by an inherent impossibility to articulate its insights in explicit and intelligible words and sentences." Karl Brunner, 1981[1]

1 Introduction

Monetary policy currently markedly differs in its conduct relative to the quote above. Nowadays, monetary policy is more transparent in its implementation as central banks across the globe came to recognize the potentially valuable role that transparency can play in stabilizing the economy. For example, in the US, the Federal Reserve started releasing a statement describing policy actions in regards to the federal funds rate (FFR) after the FOMC meetings since 1994, which was followed by a number of changes in the communication strategy in the subsequent years. A notable example of it is forward guidance: an explicit communication from the Federal Reserve about the likely future course of monetary policy, which has been in use since 2004 and has been one of the important tools of the unconventional monetary policy in the post-financial crisis zero lower bound (ZLB) period of policymaking.[2]

Being more transparent about how monetary policy will evolve (as a function of economic conditions) can help the public to form more accurate expectations about the current and future path of interest rates. They can make more informed investment and spending decisions. Clear and consistent central bank communication may improve the predictability of monetary policy and, thus, prove valuable for the effective conduct of monetary policy. (See, e.g., Woodford, 2005, Blinder et al., 2008, Geraats, 2002.) On the contrary, lack of clear or effective communication may create uncertainty about the course of monetary policy among the public.

A few interesting questions arise: How does uncertainty about monetary policy decisions evolve over time? What are the dynamics of monetary policy uncertainty? Has the change in the Federal Reserve communication changed this uncertainty dynamics? Does

[1]This quote is taken from Blinder (2002).

[2]See Blinder et al. (2008) for a the discussion of central bank communication over time.

monetary policy uncertainty have an effect on the macroeconomy? This paper addresses these questions by constructing a monetary policy uncertainty index for the US. We start from the premise that whether monetary policy is more or less uncertain depends on the predictability of the policy rate. In that sense, our index is based on the accuracy of expectations about the current and future path of monetary policy. We use survey-based and market-based forecasts of the fed funds rate to measure expectations about future monetary policy decisions.

Our paper contributes to several streams of literature. First, given that we base our index on the predictability of the policy rate, we rely on the literature assessing the market's and agent's ability to forecast central bank's policy decisions. This sizable body of literature focuses mainly on event studies demonstrating that news about monetary policy such as FOMC statements, speeches, or reports affect financial markets and, thus, interest rate expectations. See, e.g., Kuttner (2001), Gürkaynak et al. (2005), Connolly and Kohler (2004), and Ehrmann and Fratzscher (2007). Moreover, it has been established that interest-rate predictability has improved with increasing central bank transparency and improvements in communication strategies (e.g., Poole and Rasche, 2003, Swanson, 2006).

Second, by assessing the macroeconomic effects of the monetary policy uncertainty, our paper further complements the theoretical literature discussing the potential benefits of transparency and communication. Findings generally highlight the value of effective communication in the conduct of monetary policy (see, for example, Orphanides and Williams, 2004, Eusepi and Preston (2010), and Eusepi and Preston, forthcoming).

Finally, a large empirical literature focuses on measuring macroeconomic uncertainty and its effects on the economy, see for instance Bloom (2009), Scotti (2016), Jurado et al. (2015), Rossi and Sekhposyan (2015) and Rossi and Sekhposyan (2016). There is also a nascent and much narrower literature concerned with measuring monetary policy uncertainty directly. Some recent contributions on this are Baker et al. (2016), Creal and Wu (2016), Fontaine (2016), Husted et al. (2016), Istrefi and Mouabbi (2017) and Sinha (2015). Monetary policy uncertainty is peculiar in some sense, since, relative to other sources of uncertainty, the central bank could be one of the main sources behind it. Moreover, understanding the dynamics of monetary policy uncertainty conditional on central banks' monetary policy stance could help us evaluate the effectiveness of the policy.

Our paper differs from the literature aimed at understanding monetary policy uncertainty along several dimensions. First, our measure of monetary policy uncertainty is based on the concept of interest-rate predictability in contrast to news-based measures or forecasters' disagreement. Thus, similar to Jurado et al. (2015), we think of monetary policy being more uncertain when there is less predictability. Second, given that interest-rate predictability depends on macroeconomic conditions, we assess the importance of uncertainty about macroeconomic conditions for our monetary policy uncertainty index. As such, we can decompose the sources of monetary policy uncertainty into two components: a component associated with the systematic monetary policy and a component associated with discretionary monetary policy actions. As interest rate expectations are essential for our uncertainty dynamics, we also provide a detailed analysis of policy-rate expectations dynamics and their relation to the monetary policy cycle. Lastly, we identify strong asymmetries in our measure of monetary policy uncertainty and discuss their distinct economic implications.

More specifically, to measure monetary policy uncertainty we use federal funds rate forecasts. In our benchmark specification we rely on federal funds rate forecast errors implied by the Blue Chip Financial Forecasts (BCFF) survey as a basis for our uncertainty index. As robustness, we also consider forecast revisions in federal funds futures around FOMC announcements dates – the so-called "surprise" (Kuttner, 2001). In the course of constructing the uncertainty indexes we provide interesting and novel facts about the dynamics of the forecasts errors from the BCFF and the market-based surprises. We show that the distribution of the forecast errors (surprises) changes with monetary policy interventions. Notably, while the variance is rather stable over monetary policy cycles, the mean and skewness markedly differ depending whether monetary policy is expansionary (easing cycle) or contractionary (tightening cycle).

The behavior of the forecast errors motivates our choice for the uncertainty index. In particular, we introduce the Rossi and Sekhposyan (2015) uncertainty index since this index employs the information in the whole forecast error distribution as opposed to only the first and second moments. In addition to describing the monetary policy uncertainty in terms of probabilistic statements, this measure gives an opportunity to distinguish between upside and downside uncertainty: uncertainty associated with higher than expected positive versus negative outcomes, respectively.

In particular, we find that monetary policy tightening is associated with downside uncertainty, while expansionary policy is associated with upside uncertainty. This suggests that conventional monetary policy is generally implemented more aggressively than anticipated from historical episodes, resulting in uncertainty surrounding the effective policy rate. Interestingly, we find the opposite to be true for the months prior to the lift-off of the federal funds rate in December 2015. Agents expected the Federal Reserve to increase the benchmark interest rate earlier. In general, the Federal Funds Rate expectations are relatively better anchored in tightening relative to easing. Further, we assess the macroeconomic implications of monetary policy uncertainty by analyzing its effects conditional on being in a monetary tightening or easing cycle. Though in both cases the uncertainty has recessionary effects, the effects are stronger in easing relative to tightening. Finally, after purging our measure for macroeconomic uncertainty, asymmetric effects remain. However, "pure" monetary policy uncertainty only induces recessionary effects during easing episodes while the macroeconomic response during tightening episodes becomes insignificant. This suggest that macroeconomic uncertainty is the main driver of monetary policy uncertainty in times of tightening, while uncertainty about discretionary monetary policy appears to have an important role when monetary policy is expansionary.

The paper proceeds as follows. In Section 2, we describe the data and discuss the dynamics of federal funds rate forecasts and their relation to monetary policy. In Section 3, we, first, lay out the construction of the uncertainty index and present the uncertainty indexes for the federal funds rate. We then compare our monetary policy uncertainty index to other measures of monetary policy uncertainty and purge it from the uncertainty stemming from macroeconomic fundamentals. Section 4 discusses the macroeconomic impact of monetary policy uncertainty, and Section 5 concludes.

2 Federal Funds Rate Forecasts and Monetary Policy

For our benchmark specification we employ survey-based expectations of the FFR taken from the Blue Chip Financial Forecasts (BCFF). This survey works well for our purposes since it provides with forecasts of the whole yield curve.[3] Below we discuss the data and forecast properties.

2.1 Data

Since 1982, the BCFF survey is conducted monthly, covering approximately fifty analysts ranging from broker-dealers to economic consulting firms. The BCFF is published on the first day of each month and presents forecasts from a survey conducted during two consecutive business days one to two weeks earlier. The precise dates of the survey vary and are not generally noted in the publication. Since April of 1983, each month the BCFF provides the forecasts of the average interest rate over a particular quarter, beginning with the current quarter and up to four or five quarters into the future.[4] For example, in January, the forecast of the current quarter captures the average expected realization over January, February and March, and the one-quarter-ahead forecast is given by the average expected realization over April, May, and June.

Therefore, the monthly BCFF forecasts are fixed-event forecasts of interest rates over the quarter, implying that their forecast horizon changes with each month in the quarter. We construct fixed-horizon forecasts by weighting the two given fixed-event forecasts following Chun (2011) (or see Dovern et al. (2012) for an application to the survey data of GDP and prices). In order to obtain, for instance, a six-month-ahead (fixed horizon) we look at one-quarter- and four-quarter-ahead (fixed event) forecasts. In the first month of the quarter, the six-month-ahead forecast is simply the forecast of the one-quarter-ahead forecast. In the second month of the quarter, the six-month-ahead forecast is obtained by taking the average of the one-quarter- and two-quarter-ahead forecasts with weights equal to 2/3 and 1/3, respectively. The six-month ahead forecast for the final month of the quarter is the weighted average of the one-quarter and two-quarter ahead forecast with weights equal to 1/3 and 2/3. Nine-month-ahead forecasts are calculated as the weighted average of the two-quarter and three-quarter-ahead forecasts given by the survey with weights similar to the ones discussed above. We obtain forecast errors by subtracting the consensus forecasts (mean across the 50 analysts) from the realizations which are available from the Federal

[3] For instance, the US Survey of Professional Forecasters (SPF) contains only forecasts for the 3-month treasury bill and 10-year treasury bond rates, starting from 1984:Q3 and 1992:Q1, respectively.

[4] Before 1983, forecasts only exist for the current and then every other quarter.

Reserve Board's H.15 website. In addition, we also use the top-10-average and bottom-10-average forecasts to obtain a measure of disagreement, an alternative measure of uncertainty, as Andrade et al., 2016.

2.2 Key Features of Federal Funds Rate Forecasts

Figure 1 plots the forecast errors for the federal funds rate obtained from the BCFF over time. Forecasts errors are shown for several forecast horizons, i.e., 3-month-, 6-month-, 9-month- and 12-month-ahead. A few characteristics stand out. First, forecast errors across different horizons co-move strongly and move in cycles. However, errors are small during the ZLB period. Second, swings are generally larger at longer forecast horizons which is also apparent from the increasing standard deviation with longer horizons (see also in Table 1).

Furthermore, by looking at figure 1, it is apparent that forecast errors in the federal funds rate are tightly linked to the federal funds target rate. Errors are generally negative when the target rate is decreasing, i.e., during easing cycles, and positive when the target rate is increasing, i.e., during tightening cycles. Thus, the Fed policy rate is commonly lower than expected during easing cycles and higher than expected in periods of tightening. Interestingly, there seems to be one exception to this relationship related to the lift-off of policy rates following the ZLB. Starting in early 2015 forecast errors of the federal funds rate were negative. Analysts' expected consistently a higher policy rate implying that they expected the Fed to increase rates sooner. Interestingly, though the magnitude of positive forecast errors seem to be decreasing over time, the magnitude of the negative forecast errors seem to be stable over time.

Table 1 reports the sample moments of the BCFF forecast errors across easing and tightening sub-samples. We identify easing cycles by looking at periods with negative monthly changes in the FFR target rate and tightening cycles by looking at periods with positive monthly changes in the FFR target rate. As the visual inspection suggested, the sample mean of forecast errors and surprises in easing cycles is negative while the one in tightening cycle is positive. Moreover, the forecast errors as well as the surprises are in absolute value less in tightening relative to the easing. This may suggest some asymmetric monetary policy behavior by the Federal Reserve. Analyst are surprised by the Fed since the policy rate generally changed more than expected in both easing and tightening cycles. However, during times of tightening analysts underestimate the rate changes by less indicating that the Fed might be behaving more cautiously in those periods. This is in line with the view that the Fed generally eases in reaction to unexpected events and tightens according to a better-communicated path.

Figure 2 provides the conditional distribution of the forecast errors where observations at time t are associated with easing (tightening) whenever there is a negative (positive) change in the federal funds target rate in period $(t-1)$. As the figure shows, the distribution of the errors in tightening are sharper, while the ones in easing are more spread out. As the forecast horizon increases, the distributions become further apart. The left tail of the forecast errors in the tightening will disappear if the figure was drawn using the sample from mid-1990s onwards, i.e. since the Federal Reserve started to announce their decisions instead of waiting for the market participants to learn about their decisions by observing the rate change implemented by the trading desk.

3 Measuring Monetary Policy Uncertainty

In this section, we first lay down the framework in which we construct our measure of monetary policy uncertainty. Second, we present the uncertainty index obtained from the FFR survey-based forecast errors. Third, we compare the index to the news-based measure of monetary policy uncertainty of Baker et al. (2016) and forecasters' disagreement. Finally, we purge our index for uncertainty about macroeconomic conditions.

3.1 The Uncertainty Index

We construct the monetary policy uncertainty index in the framework of Rossi and Sekhposyan (2015). As mentioned before, we think about monetary policy being more uncertain when there is less predictability. In particular, the uncertainty index is based on the conditional distribution of the forecast errors and captures the ex-ante probability that one would assign to the forecast error, given the historical distribution of the forecast errors. The further away from the (theoretical) mean, i.e., 0.5, the higher the uncertainty. Moreover, we can distinguish between upside and downside uncertainty, i.e., identify situations where a forecast error is above or below the mean of the distribution.

More formally, let the forecast error at time $t+h$ be denoted by $e_{t+h} = y_{t+h} - E_t(y_{t+h})$, i.e., this is the forecast error associated with the h-step-ahead forecast formed with all the available information at time t, and t refers to the forecast origin date. Let $f(e)$ denote the probability density function (PDF) of the forecast errors, e_{t+h}. Given e_{t+h} and $f(e)$, the index at time $t+h$ is defined as $U_{t+h} = \int_{-\infty}^{e_{t+h}} f(e)\,de$. In order to capture upside and downside uncertainty and have them directly comparable to each other in magnitudes, we consider the index $U^{+}_{t+h} = \frac{1}{2} + \max\left\{U_{t+h} - \frac{1}{2}, 0\right\}$ for upside uncertainty and $U^{-}_{t+h} = \frac{1}{2} + \max\left\{\frac{1}{2} - U_{t+h}, 0\right\}$ for downside uncertainty. $U^{*}_{t+h} = \frac{1}{2} + \left|U_{t+h} - \frac{1}{2}\right|$, on the other hand, would be the measure of overall uncertainty. Note that, by construction, the overall measure of uncertainty, as well as the upside and downside ones fluctuate between 0.5 and 1.

We provide an illustrative example below. Consider Figure 3. Figure 3 has 3 panels. The first one shows the probability density of the forecast errors associated with the 6-month-ahead federal funds rate forecasts. Let us consider two distinct episodes. The first one is in February of 2007, when Chairman Bernanke assumed the governorship of the Federal Reserve, while the second episode pertains to August of 2008, i.e., a month before Lehman declared bankruptcy. As it can be seen, the forecast error associated with the Chairman Bernanke's assumption of governorship is positive. On the other hand, the forecast errors associated with August of 2008 are negative and much more unlikely ex-ante than those associated with February of 2007. Panel B shows the CDF corresponding to the PDF, i.e. U_{t+h}. Panel C shows the resulting upside and downside uncertainty indices: there is high positive uncertainty associated with 2008:8, while the uncertainty associated with 2007:2 is a downside one and lower. In constructing the figure and throughout the paper we follow the notion that interest rates above expectations constitute to downside uncertainty, since higher interest rates are typically deterrents for growth. On the other hand, forecast errors below expectations are linked to upside uncertainty, since they typically stimulate economic activity.

It is also worth to note that though the illustrative example depicts the unconditional distribution of forecast errors given the full sample of data, in the construction of the actual monetary policy uncertainty index we consider the distribution in real time, i.e. at each t point in time the distribution is constructed using $t-h$ period forecasts and time

t realizations. The initial distribution is constructed using 15% of the sample data. The distribution is further updated based on an expanding window scheme, i.e. incorporating additional observations as they become available through time. As such, the distribution shifts over time. For instance, as the forecast errors decline over time, the distribution becomes more concentrated. Thus, a smaller forecast error (in absolute value) could be associated with the same level of uncertainty towards the end of the sample as a larger error (in absolute value) earlier in the sample.

3.2 Monetary Policy Uncertainty

As the previous discussion suggests, forecast errors of interest rates and monetary policy seem to be strongly related. To formalize the idea of uncertainty surrounding monetary policy, we introduce the distribution-based measure of uncertainty described in the former subsection and apply it to forecast errors for the Fed's policy interest rate, i.e. federal funds rate. To keep the discussion focused, we discuss the uncertainty measure obtained from the 6-month-ahead forecast errors. The results for other forecast horizons is delegated to the appendix (see Figures 16-18) [5].

Figure 4 plots the real-time uncertainty index obtained from FFR forecast errors. We use five years of monthly data (from 1983:4 till 1988:4) to approximate the conditional distribution of forecast errors in the beginning of the sample period. We further update the distribution with monthly observations as they become available. Blue (light-colored) bars indicate periods of upside uncertainty and red (dark-colored) bars indicate periods of downside uncertainty. Since our measure is based on the forecast error distribution, the findings related to the forecast errors directly translate into the characteristics of the uncertainty index.

More specifically, upside and downside uncertainty are strongly clustered. Tightening cycles are associated with downside uncertainty (i.e., interest rates are higher than expected) and easing cycles with upside uncertainty (i.e., interest rates are lower than expected). As before, one possible explanation is that the Fed generally did rate cuts or hikes more aggressively than anticipated. There is no historic evidence for uncertainty related to the Fed intervening less aggressively than anticipated. However, there is one exception: while

[5] This choice is supported by the finance literature using the BCFF focusing generally on 6-month ahead forecasts (see Chun, 2011 and Kim and Orphanides, 2012)

uncertainty is generally low over the ZLB period, upside uncertainty started to increase in late 2014, immediately after the Fed ended purchases in October 2014. This particular episode of upside uncertainty at the end of our sample seems to be related to the uncertainty surrounding the lift-off of the federal funds rate. Agents overestimated the policy rate consistently over that particular period implying that they expected the Fed to increase rates sooner.

3.3 The Role of Macroeconomic Uncertainty

3.3.1 Purging for Macroeconomic Uncertainty

So far, our measure of monetary policy uncertainty is based on forecast errors of the federal funds rate. Thus, we assume that monetary policy is more or less uncertain given how predictable the policy rate is. However, it is possible that the uncertainty associated with the interest rate forecasts is due to the uncertainty about the macroeconomy. For instance, it is reasonable to think that uncertainty about inflation and real economic activity is higher in recessions. This could be reflected in interest rate uncertainty, yet it is capturing macroeconomic uncertainty instead of monetary policy uncertainty. Hence, given our current measure of monetary policy uncertainty it is unclear of whether the unpredictability in the federal funds rate is due to uncertainty about future economic conditions. If uncertainty stems from uncertainty about underlying economic conditions, this cannot be related to uncertainty surrounding the conduct of monetary policy (such as communication).

To address this issue, we purge the monetary policy index for uncertainty in macroeconomic conditions, that is, GDP and price uncertainty. In the BCFF, survey participants also provide their forecasts for the underlying macroeconomic conditions. Therefore, we use the same framework to construct GDP uncertainty and price uncertainty based on the 6-month-ahead GDP and price level forecast errors, respectively. Assume, for example, that there was an unexpected event influencing GDP, this will be reflected in an unusually high GDP forecast error and, thus, a high level of GDP uncertainty.

Figures 5 and 6 show the uncertainty index obtained for 6-month-ahead BCFF forecast errors of GDP and the CPI, respectively. As expected neither GDP or price uncertainty distinctively relate to the monetary policy cycle. GDP and price uncertainty is generally high during recessions. In contrast to our monetary policy uncertainty index, which, by construction, attains low values during the ZLB period, macroeconomic uncertainty is relatively volatile and can reach high values over that period.

The purged monetary policy index is obtained as a residual from regression the monetary policy uncertainty on output growth and inflation uncertainties. It would be possible to construct monetary policy uncertainty index after purging the interest rate forecast error from the errors associated with output growth and inflation. This is the strategy we follow in the next section. Here, it is assumed the higher moment dynamics between inflation, output growth and interest rates is distinctly different from the first moment dynamics. Figure 7 plots the purged and the original monetary policy uncertainty indices. The purged index exhibits similar dynamics and correlates with the original measure at 0.73. Episodes of high uncertainty such as the early and late 2000s easing cycles that are concurrent with recessions remain high when controlling for macroeconomic uncertainty.

3.3.2 Purging Forecast Errors

As noted previously, an alternative approach one can take is to purge the federal funds rate forecast errors from the forecast errors associated with output growth and inflation before obtaining the uncertainty measure. Thus, we regress the six-month-ahead interest rate forecast errors on output growth and inflation forecasts. We obtain the residual and construct the uncertainty index discussed before based on the residual.[6] Figure 8 shows the results for the forecast errors, while figure 9 shows the forecast-error-based uncertainty index. As we can see, though the uncertainty index is more noisy (it is based on a regression residual), the relationship with the federal funds target rate preserves: monetary policy tightenings are associated with downside uncertainty, while easings with upside uncertainty. Upside uncertainty is typically higher in magnitude relative to downside one, reflecting the notion that tightenings are better communicated to the market relative to the easings.

3.3.3 Robustness: Market-based Surprises

In addition to survey forecasts, we also use market-based forecasts of the federal funds rate. The Fed funds futures contract price represents the market opinion of the average daily fed funds effective rate as calculated and reported by the Federal Reserve Bank of New York

[6]It should be noted that neither approach used for purging takes into account the parameter estimation error in the construction of the uncertainty index.

for a given calendar month. It is designed to capture the market's need for an instrument that reflects Federal Reserve monetary policy. Fed funds futures and options have long been regarded as an effective means of tracking market expectations of monetary action by the FOMC. Futures for the Fed funds rate started trading in the late 80s (December 88) but only up to a six-month-ahead horizon. Meaningful trading volumes of up to 24-month ahead begin only in 2004 (up to 36-month ahead in 2011). We use one- to six-month-ahead Fed funds futures as an alternative measure for expectations of future monetary policy. One disadvantage of working with market-based expectations measures such as futures contain a risk premium (that is increasing with horizon). (See, e.g., Kuttner, 2001 and **?** for a more general discussion). We follow Kuttner (2001), and use the difference between the future price before and after FOMC announcements dates to purge for risk premia. [7]

As described earlier, we use the surprises, that is, daily changes in the futures' price around FOMC announcements. Figure 10 plots the Federal funds future surprise at the 6-month-ahead horizon.[8] Since the surprises are defined in a one-day window, their magnitude is naturally smaller than the magnitude of the survey-based forecast errors. Nevertheless, a similar pattern as before occurs; there are generally more negative surprises during easing episodes and more positive surprises during tightening. As expected, surprises are small during the ZLB period. Moreover, similar to the survey-based forecast errors, the lift-off period seems to exhibit mainly negative surprises; an exception to the behaviour observed before the ZLB. Table 1 suggests that higher moments of the market-based surprises vary across the monetary policy cycle. While the standard deviation seems to be somewhat stable across the monetary policy cycle for the forecast errors, it is larger during easing cycles in the case of surprises.

Figure 11 plots the real-time uncertainty index obtained from Fed futures surprises at the 6-month horizon. Note that the surprises are at the FOMC announcement frequency. Therefore, we calculate the uncertainty index at FOMC announcement frequency. With futures starting in 1988:12, we use FOMC announcements observations occurring between 1988:12 and 1993:4 to approximate the conditional distribution of surprises in the beginning

[7]The data on Federal funds futures are obtained from Bloomberg, while the FOMC announcements dates are obtained from the Federal Reserve's website, see `https://www.federalreserve.gov/monetarypolicy/fomc_historical_year.htm`.

[8]Since FOMC meeting are not on a monthly basis, to plot a monthly series we assume that the daily change in the FFR is zero in months with no meeting (see Romer and Romer, 2004 among others)

of the sample period. To plot the index at monthly frequency, we assume that uncertainty is zero in months with no meeting. Using the market-measure of Fed funds rate expectations, a similar pattern for the monetary policy uncertainty index arises, although less pronounced. In particular, we can observe blue (light) bars mainly during episodes if easing and red (dark) bars during episodes of tightening. Note however, that the clustering is less clear than is the case for the uncertainty index based on the BCFF survey. While the easing cycles of the early and late 2000s are mainly associated with upside uncertainty and the tightening cycle of the mid 2000s can be mostly related to downside uncertainty, the clustering along the monetary policy cycle is less clear throughout the 90s. As is the case with the survey-based uncertainty index, market-based uncertainty is low during the ZLB and starts to rise again in late 2014. Similarly, the period surrounding the lift-off of the Fed funds rate is mostly associated with upside uncertainty implying that the policy rate was lower than expected.

The relation between the monetary policy cycle and Fed funds rate expectations, that is, easing (tightening) can be associated with upside (downside) uncertainty seems robust to the measure of expectations (either survey- or market-based). Note also, that the the uncertainty index based on the BCFF survey is an ex-post measure of uncertainty since it is based on forecast errors. Thus, we compare expectations at any time with the ex-post realized policy rate. However, the uncertainty index based on the market-based surprise is not relying on any ex-post realization since we consider the one-day-window forecast revision (surprise) occurring around FOMC announcements. Hence, one considers the shift in expectations of the policy rate attributable to the FOMC announcement.

3.4 Comparison to Alternative Uncertainty Indices

In Figure 12, we compare our uncertainty indexes for the federal funds rate with the news-based measure of monetary policy uncertainty (MPU) by Baker et al. (2016) (BBD hereafter) and a measure of disagreement across analyst forecasts as in Andrade et al. (2016).

The left panel of Figure 12 displays our measure of uncertainty in the FFR (survey-based) and compares it to the BBD MPU. Both series are positively correlated with a coefficient of 0.12 over the whole sample. The MPU exhibits spikes during the Fed easing cycles in the early 1990s and 2000s as well as the one following the financial crisis of 2007. In contrast to our measure of uncertainty, during Fed tightening episodes, the BBD MPU is generally not elevated. A possible link to the monetary policy stance is not as apparent when looking at the behavior of the BBD MPU than it is when looking at the FFR uncertainty index. Also, by construction the MPU fluctuates around the ZLB period while the FFR uncertainty index does not. Interestingly, our index captures the heightened uncertainty surrounding the lift-off of the FFR while the BBD MPU remains at historically low levels.

Further, the lower left graph plots our FFR uncertainty index against disagreement in the BCFF FFR forecasts. Both uncertainty measures are positively correlated with a coefficient of 0.35. Disagreement is high at the beginning of our sample and decreases continuously strongly reflecting the dynamics of the FFR. For example, when the level of FFR is high, disagreement is high, too. Therefore, disagreement may not provide a sensible measure of monetary policy uncertainty.

4 Macroeconomic Effects of Monetary Policy Uncertainty

To assess how uncertainty surrounding monetary policy affects macroeconomic dynamics, we estimate a vector autoregression containing key macroeconomic variables and the monetary policy uncertainty index (both the original and purged versions). We, then, study the dynamic responses to innovations of monetary policy uncertainty. The VAR is in the following variables:

$$y_t = \left[log(S\&P500)_t,\ U_t^*,\ \Delta^2(log(Wages)_t),\ Hours_t,\ log(Employment)_t,\ log(IndProd)_t\right]'$$

Structural errors are obtained from the reduced form variance-covariance matrix based on a Choleski decomposition assuming recursive ordering similar to Bloom (2009). [9] Please note that though the uncertainty index was depicted and discussed as of the forecast origin date earlier, in the VAR it enters with a lag, which mitigates the endogeneity concerns.

As discussed in the former sections, our uncertainty index for the federal funds rate exhibits substantially different dynamics across the monetary policy cycle. These asymmetries could indicate non-linear dynamics in the responses of macroeconomic variables. Therefore, we estimate the VAR model conditional on the monetary policy cycle. To do so, we simply split our sample according to easing and tightening sub-samples. Observation at time t fall into the tightening (easing) sample whenever the change in the federal funds rate

[9] Bloom (2009) includes prices and the federal funds rate.

is positive (negative) at time $t-1$.[10] As standard in the literature we identify the structural innovations of uncertainty using a Cholesky scheme for each sub-sample (see, e.g., Bloom, 2009 and Jurado et al., 2015).

Figure 13 shows the impulse responses to a one-unit monetary policy uncertainty shock using the original index during easing and tightening periods. Indeed, there seem to be differences in the impulse responses of macroeconomic variables and stock prices. In particular, industrial production and employment respond more to an uncertainty shock in periods of easing than they do in periods of tightening. This is in line with our earlier finding concerning the behavior of the skewness of the FFR forecast error distribution. Agents seem to be more surprised by Fed policy actions during easing cycles than they are during tightening. Therefore, the macroeconomic impact of an increase in uncertainty is more pronounced during easing cycles.

We now estimate the sub-sample VARs containing the monetary policy uncertainty index that is purged for macroeconomic uncertainty. Figure 15 present the corresponding impulse responses. In the case of the purged monetary policy uncertainty shock, the responses of stock prices, employment and industrial production are close to zero and insignificant in the tightening sub-sample. Stock prices, hours, employment and industrial production decrease following a monetary policy uncertainty shock when controlling for macroeconomic uncertainty, although the negative responses are less pronounced. This suggest the following: First, negative effects of monetary policy uncertainty during tightening originate entirely from macroeconomic uncertainty. Hinting at potential information frictions between the agents and the central bank concerning macroeconomic conditions. Second, during easing episodes some negative macroeconomic effects may be linked to Fed's conduct of monetary policy (such as communication) given that macroeconomic uncertainty is not the only source of recessionary macroeconomic effects. Figure **??** shows that the results are overall robust to using measures uncertainty measures associated with forecast errors at three-, six- and nine-month-ahead horizons.

[10] We use changes in the effective federal funds rate here in order to have sufficiently large sub-sample sizes. Note that this choice, if anything, makes it harder to identify asymmetric effects.

5 Conclusion

This paper measures monetary policy uncertainty and its impact on the macroeconomy. We start from the premise that monetary policy is more uncertain whenever there is less predictability in the federal funds rate and obtain our measure of monetary policy uncertainty from the Blue Chip Financial Forecasts for the federal funds rate and Federal funds futures.

In the course of constructing the uncertainty index we provide interesting and novel facts about the dynamics of the survey-based forecasts errors from the BCFF and the market-based forecast revisions (surprises) around FOMC announcement dates. We show that the distribution of the forecast errors and surprises changes with monetary policy interventions. With the exception of the ZLB, agents seem to always under-respond with better-anchored policy-rate expectations during tightening episodes. Further, our results show that monetary policy tightening and easing periods are distinctly associated with downside and upside uncertainty, respectively.

We subsequently analyze the effects of uncertainty conditional on being in a monetary tightening or easing cycle. Though in both cases the uncertainty has recessionary effects, the effects are stronger in easing relative to tightening. This is due to the fact that the expectations are relatively better anchored in tightening relative to easing. Finally, purging monetary policy uncertainty for uncertainty surrounding macroeconomic conditions such as output and prices, we show that asymmetries remain across the monetary policy cycle. Moreover, recessionary effects of monetary policy uncertainty during tightening originate entirely from macroeconomic uncertainty, while they do not during easing episodes.

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Tables and Figures

Table 1: ***Sample Moments of BCFF Forecast Errors of the Federal Funds Rate conditional on the Monetary Policy Cycle***

	Easing				Tightening			
	3-month	**6-month**	**9-month**	**12-month**	**3-month**	**6-month**	**9-month**	**12-month**
Nr.	62	62	62	62	60	60	60	60
Mean	-0.41	-0.64	-0.93	-1.22	0.14	0.16	0.19	0.22
Median	-0.26	-0.51	-0.93	-1.56	0.23	0.33	0.43	0.50
Std.	0.58	0.87	1.20	1.45	0.57	0.88	1.16	1.42
Skewness	-1.73	-0.31	-0.01	0.50	-1.56	-2.08	-1.38	-1.06

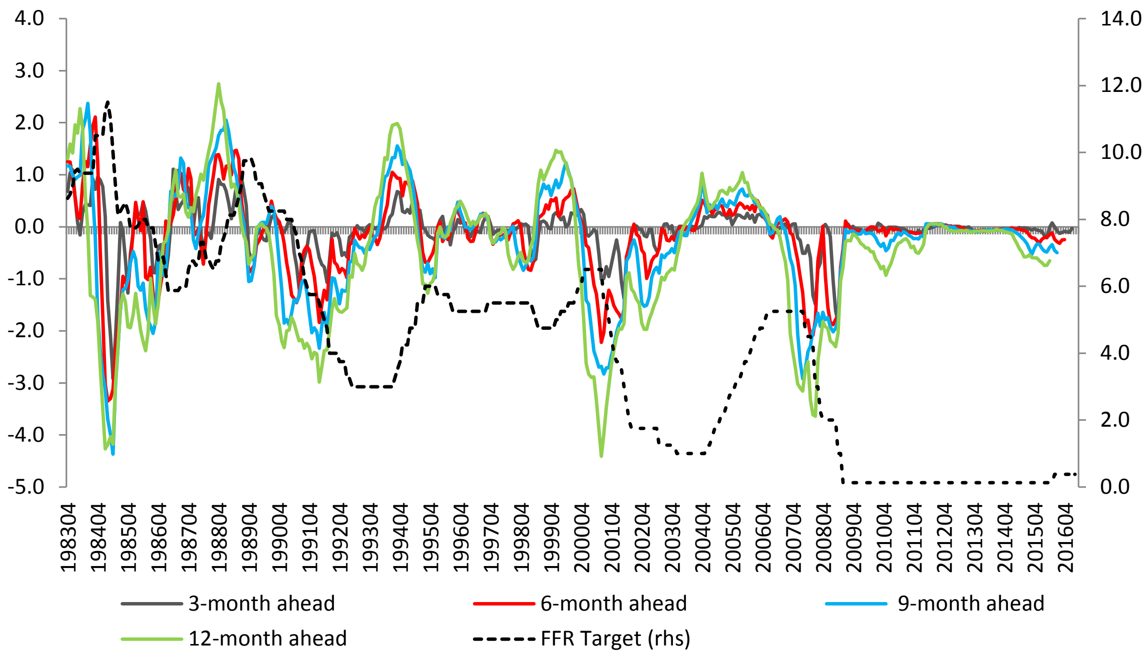
Note: Descriptive statistics for the federal funds rate forecasts at the 3-month, 6-month, 9-month, and 12-month ahead horizons. Observations at time t are associated with the easing (tightening) sub-sample whenever there was a negative (positive) change in the Federal funds target rate in the previous period $t-1$.

Table 2: ***Sample Moments of Taylor-rule Residuals and Surprises conditional on the Monetary Policy Cycle.***

	Easing		Tightening	
	Residuals	**Surprise**	**Residuals**	**Surprise**
Nr.	54	47	48	36
Mean	-0.41	-0.06	0.38	0.02
Median	-0.24	-0.05	0.31	0.02
Std.	0.68	0.12	0.48	0.07
Skewness	-0.12	-0.45	0.25	-0.28

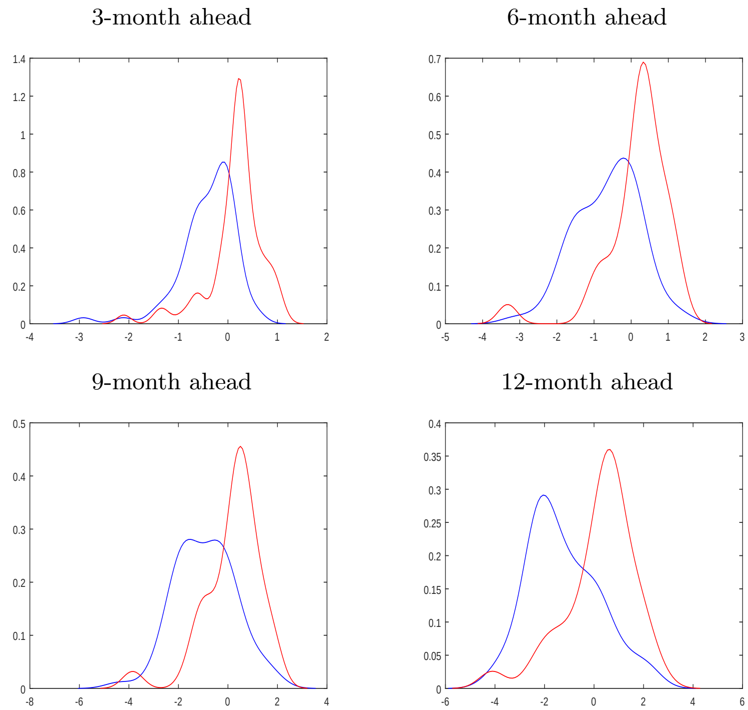
Note: Taylor-rule residuals are the residuals obtained from a regression of Federal funds forecast errors (6-month ahead) on GDP forecast errors (6-month ahead) and price forecast errors (6-month ahead). Surprises are the daily changes in Federal funds futures at the 6-month ahead horizon around FOMC announcements dates.

Figure 1: *Survey-based FFR Forecast Errors*



Note: This Figure plots forecast errors based on the BCFF at the 3-month, 6-month-, 9-month-, and 12-month-ahead horizons (left axis) and federal funds target rate (right axis).

Figure 2: ***Conditional Empirical Distributions of BCFF Forecast Errors of the Federal Funds Rate***



Notes: The blue (red) line shows the empirical distribution of Federal funds rate forecast errors at the 6-month-, 9-month-, and 12-month-ahead horizons for easing and (tightening) sub-samples. Observations at time t are associated with the easing (tightening) sub-sample whenever there was a negative (positive) change in the Federal funds target rate in the previous period $t-1$.

Figure 3: ***Illustrative Example for the Uncertainty Series***

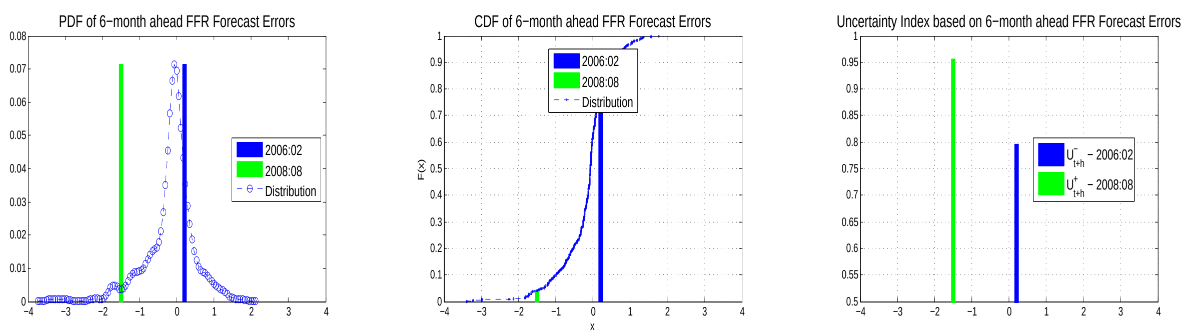
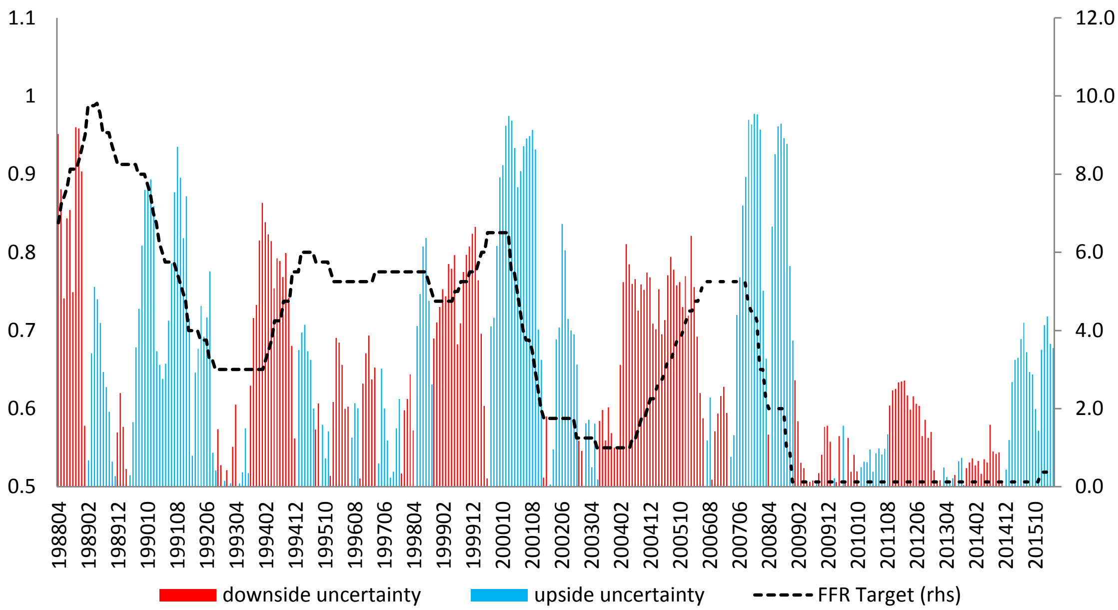
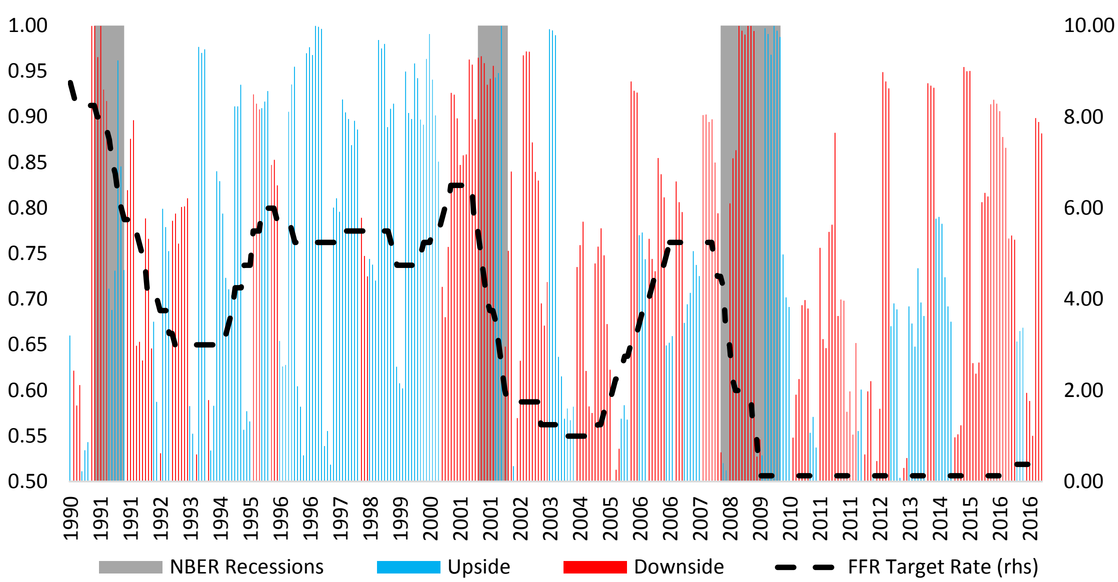


Figure 4: ***Monetary Policy Uncertainty Index***



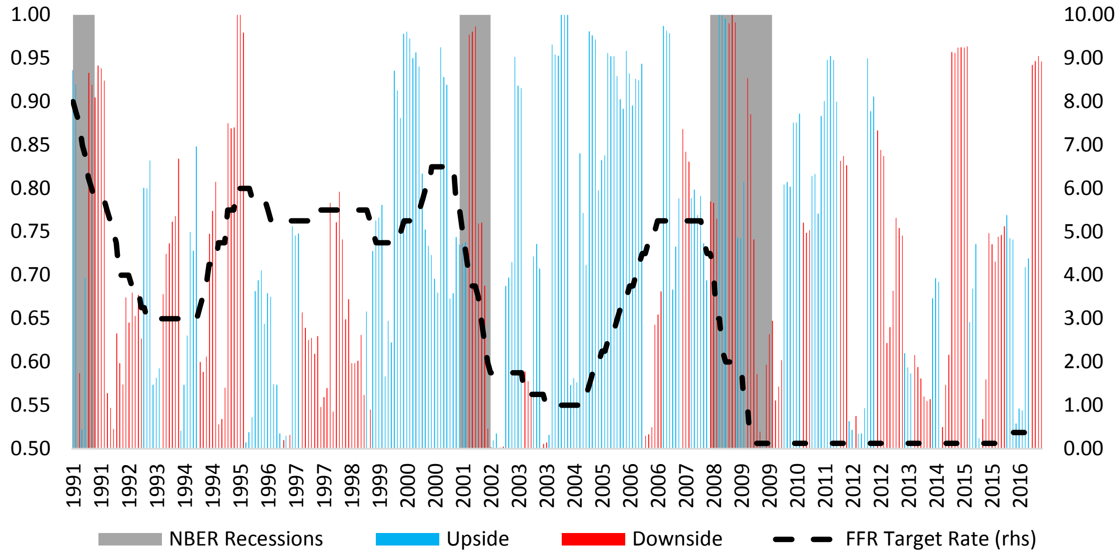
Note: This Figure plots upside and downside uncertainty obtained from the 6-month-ahead Federal funds rate forecast errors from the BCFF survey.

Figure 5: ***GDP Uncertainty Index***



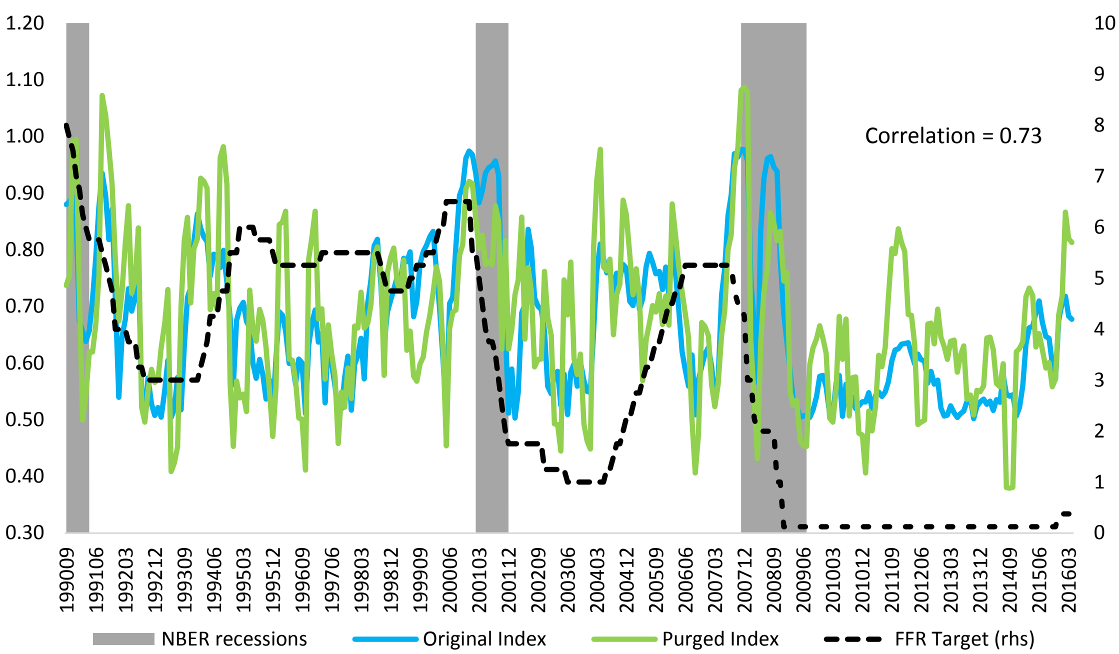
Note: This Figure plots upside and downside uncertainty obtained from the 6-month-ahead BCFF GDP forecast errors.

Figure 6: *Price Uncertainty Index*



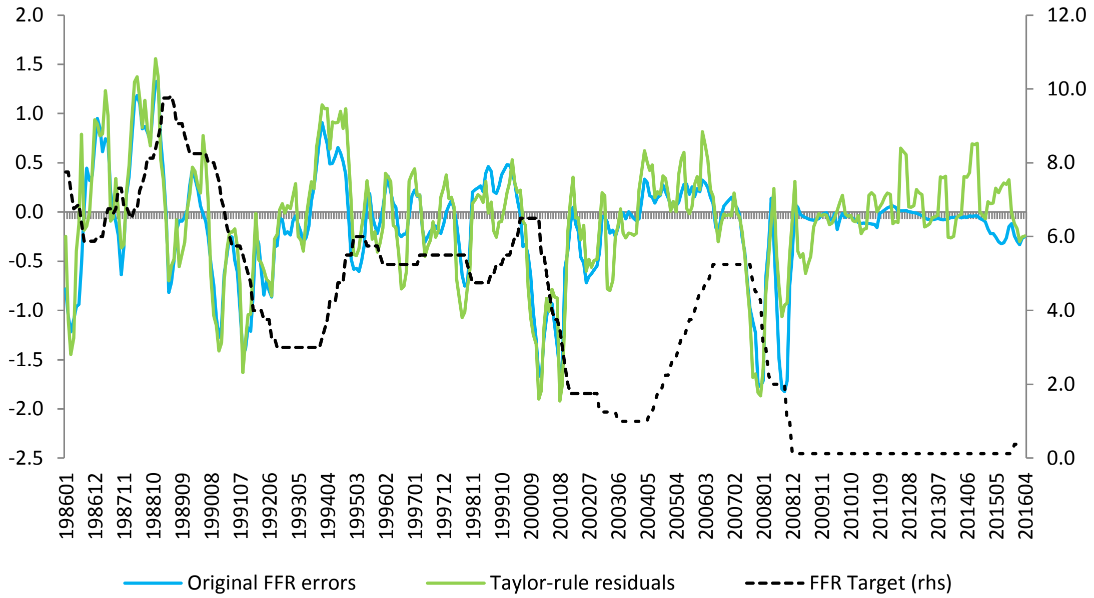
Note: This Figure plots upside and downside uncertainty obtained from the 6-month-ahead BCFF GDP Deflator forecast errors.

Figure 7: *Monetary Policy Uncertainty Index Purged for Macroeconomic Uncertainty*



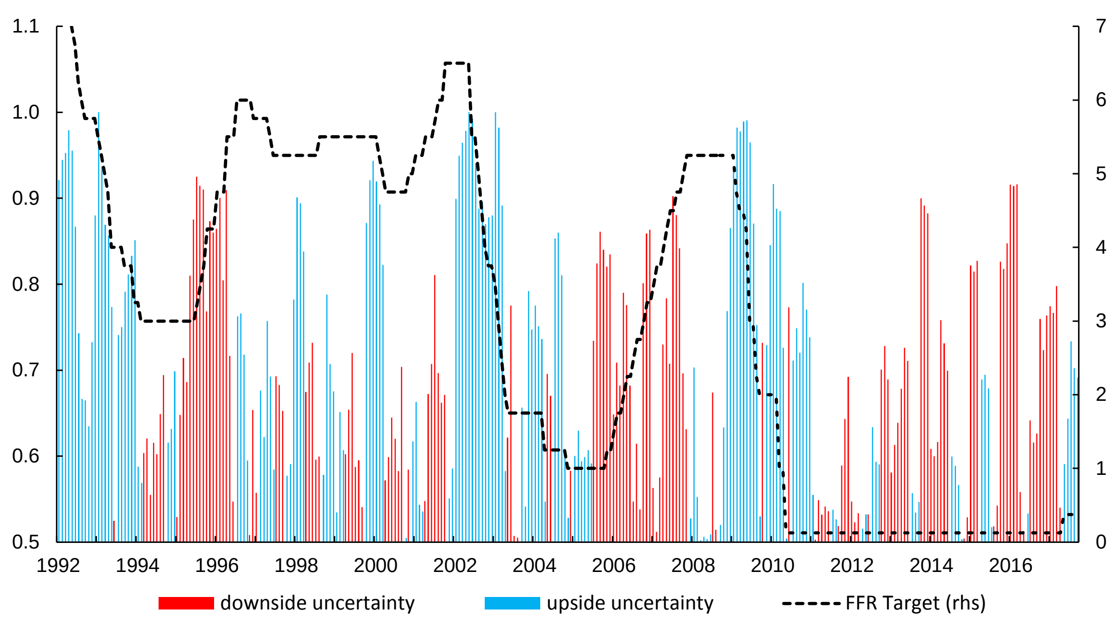
Note: This Figure plots the purged uncertainty index: the normalized residuals of a regression of the federal funds rate uncertainty index obtained from the 6-month-ahead BCFF forecast errors on the Uncertainty indexes obtained from the 6-month-ahead BCFF forecasts errors of GDP and prices, respectively.

Figure 8: ***Taylor-rule Residuals: Purged Federal Funds Rate Forecast Errors***



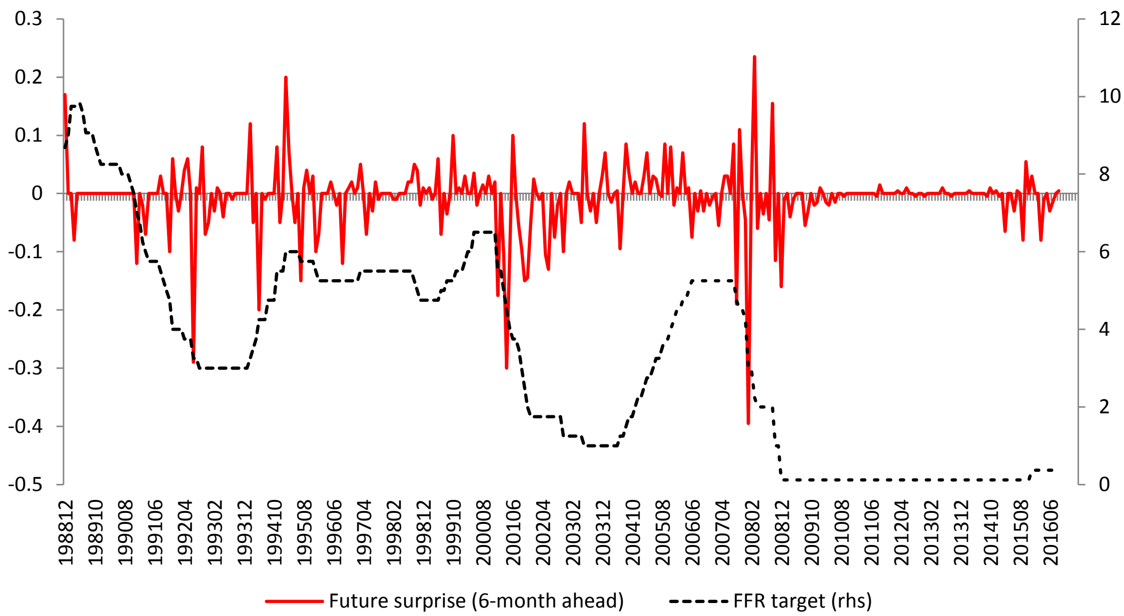
Note: This figure plots the Taylor-rule residuals obtained from a regression of Federal funds forecast errors (6-month ahead) on GDP forecast errors (6-month ahead) and price forecast errors (6-month ahead).

Figure 9: ***Monetary Policy Uncertainty based on Taylor-rule Residuals***



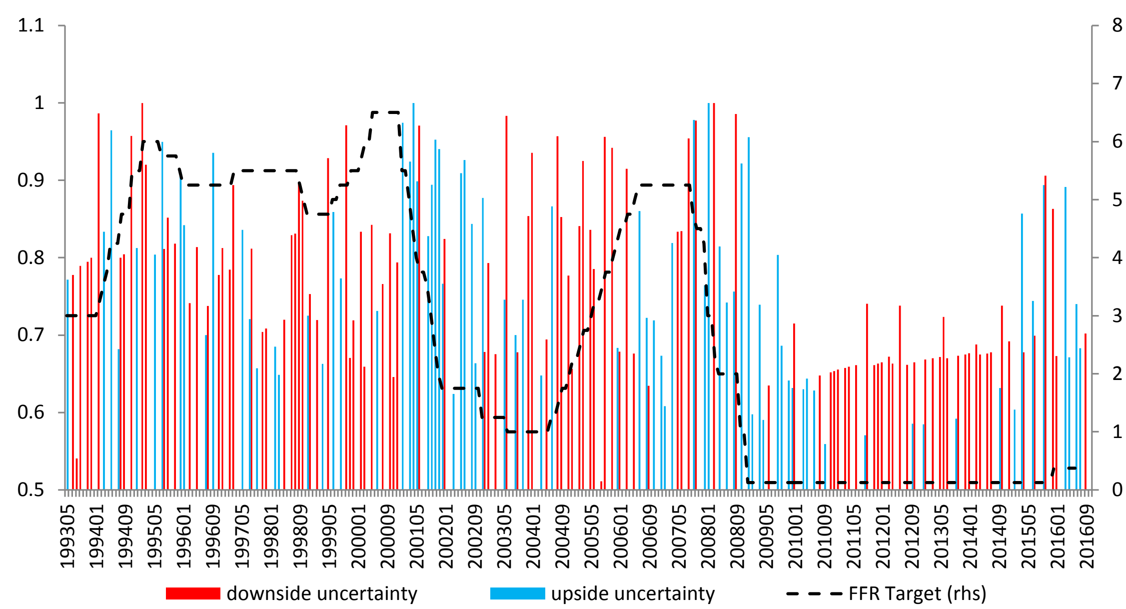
Note: This figure plots the uncertainty index obtained from the Taylor-rule residuals.

Figure 10: *Federal Funds Future Surprises*



Note: This Figure plots the FFR future surprises at the 6-month horizon (daily changes of 6-month future prices around FOMC announcement dates).

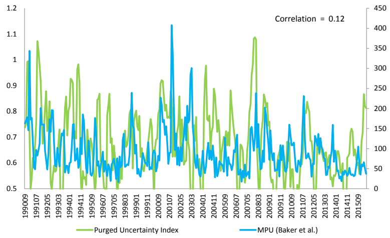
Figure 11: *Market-based Monetary Policy Uncertainty Index*



Note: This Figure plots upside and downside uncertainty obtained from the 6-month-ahead Federal funds future surprises (daily changes of 6-month future prices around FOMC announcement dates).

Figure 12: ***Comparison with Alternative Uncertainty Indices***

FFR Uncertainty and MPU



FFR Uncertainty and Disagreement

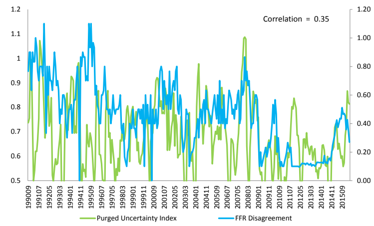
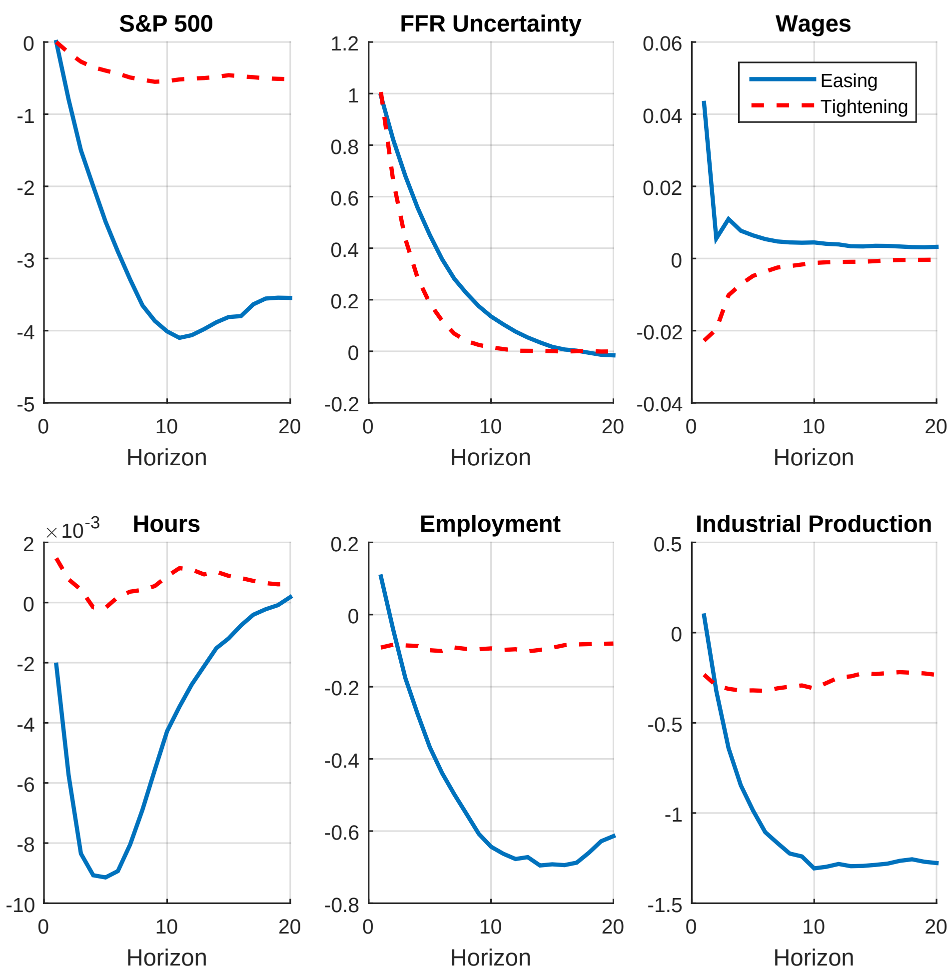
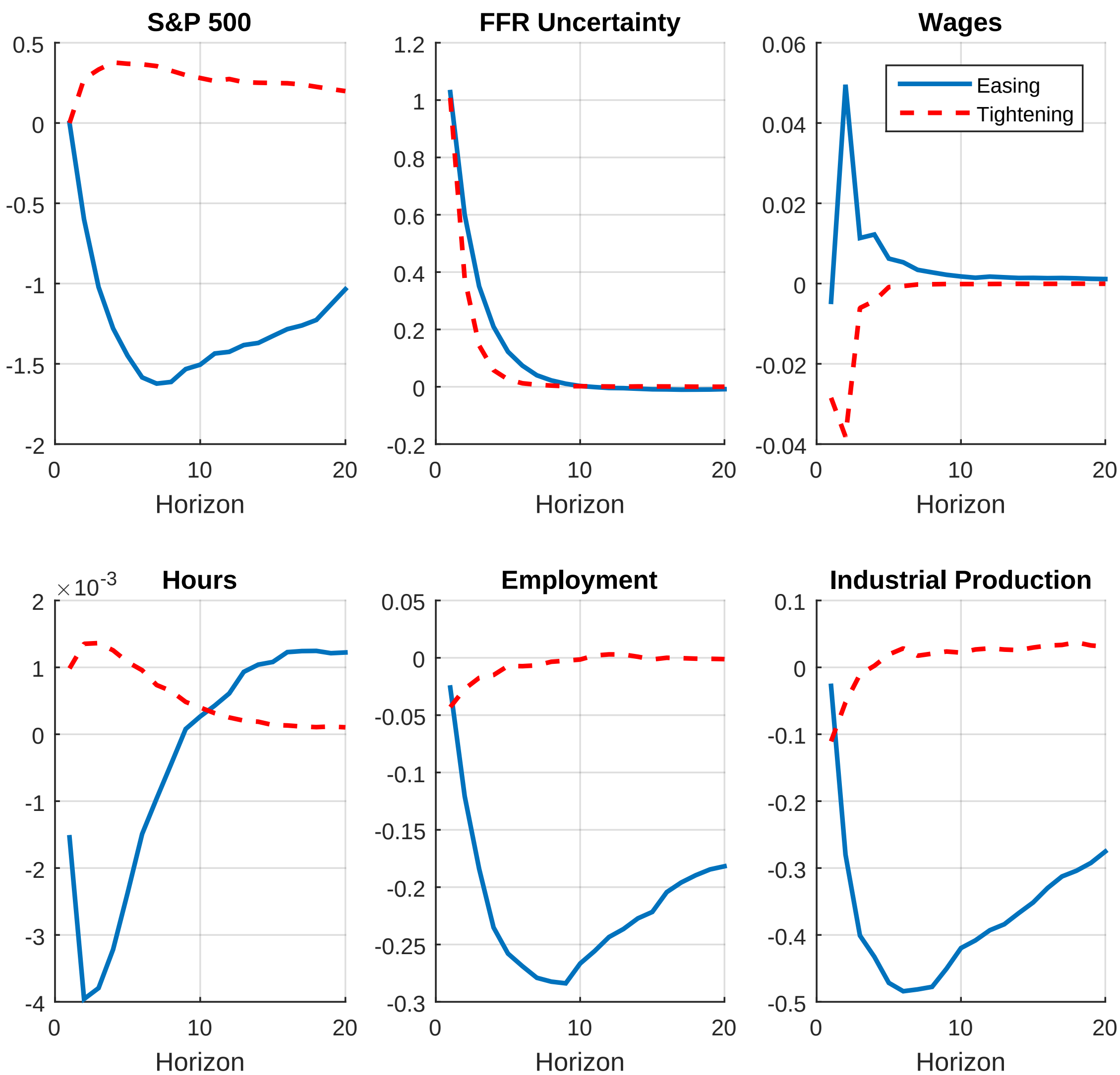


Figure 13: ***Impulse Responses Functions Conditional on the Monetary Policy Cycle: Original Index***



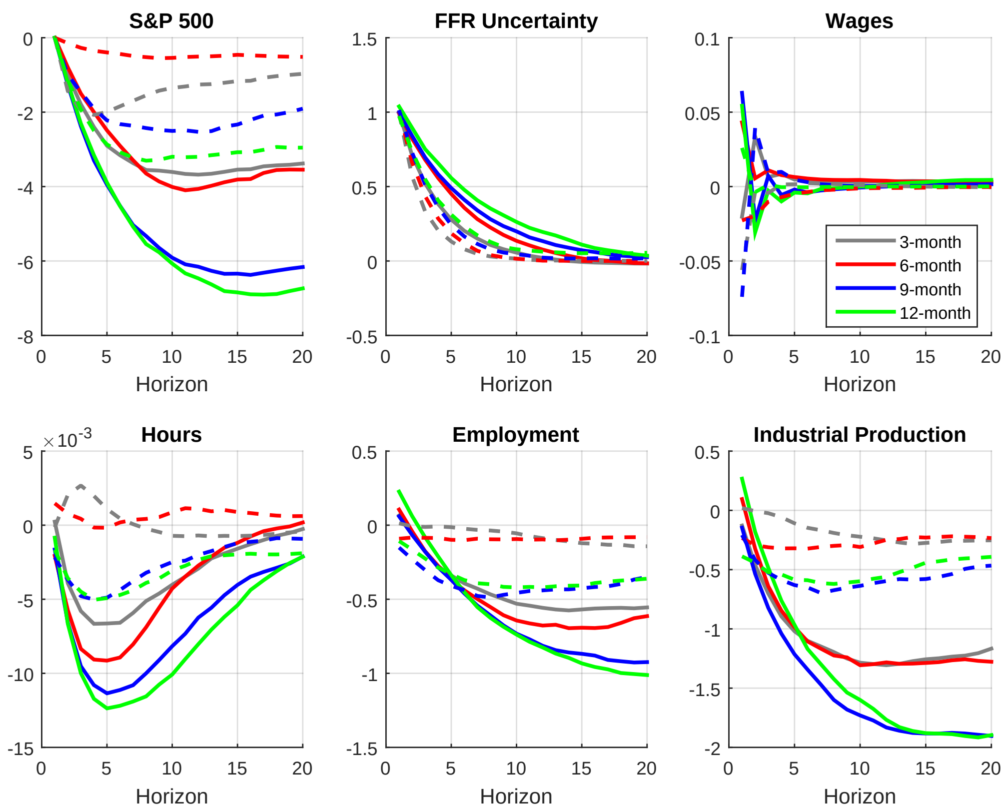
Note: This Figure plots the impulse responses of the S&P 500, FFR uncertainty, wages, hours, employment and industrial production to a one-unit FFR uncertainty shock. Red (blue) lines are the point estimates obtained from the tightening (easing) sub-sample.

Figure 14: ***Impulse Response Functions Conditional on Monetary Policy Cycle: Purged Index***



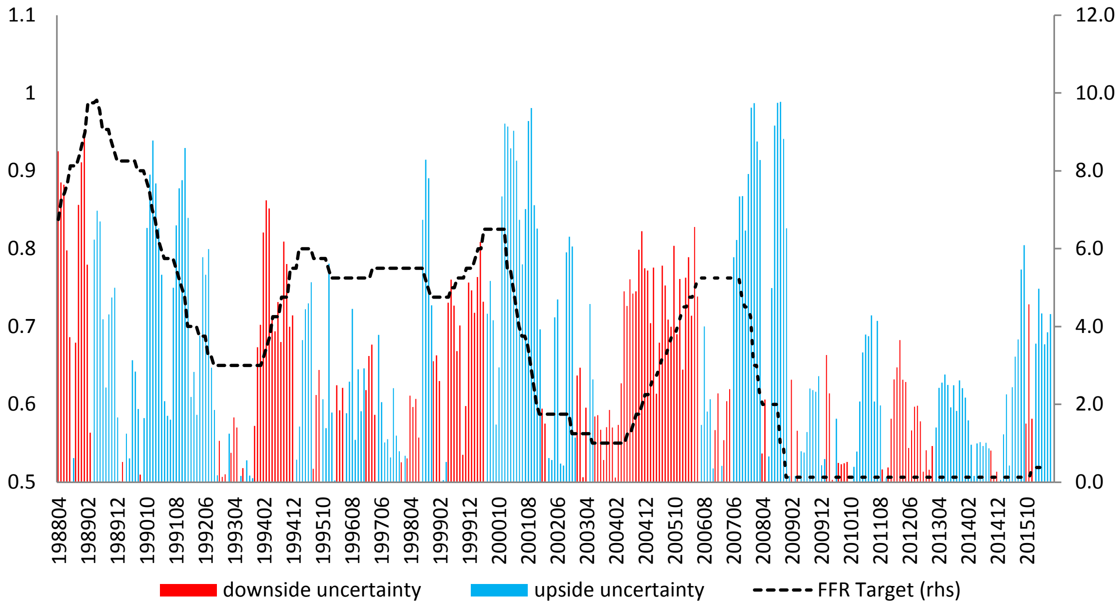
Note: This Figure plots the impulse responses of the S&P 500, FFR uncertainty, wages, hours, employment and industrial production to a one-unit FFR uncertainty shock. Red (blue) lines are the point estimates obtained from the tightening (easing) sub-sample.

Figure 15: ***Impulse Response Functions Conditional on Monetary Policy Cycle: Alternative Horizons***



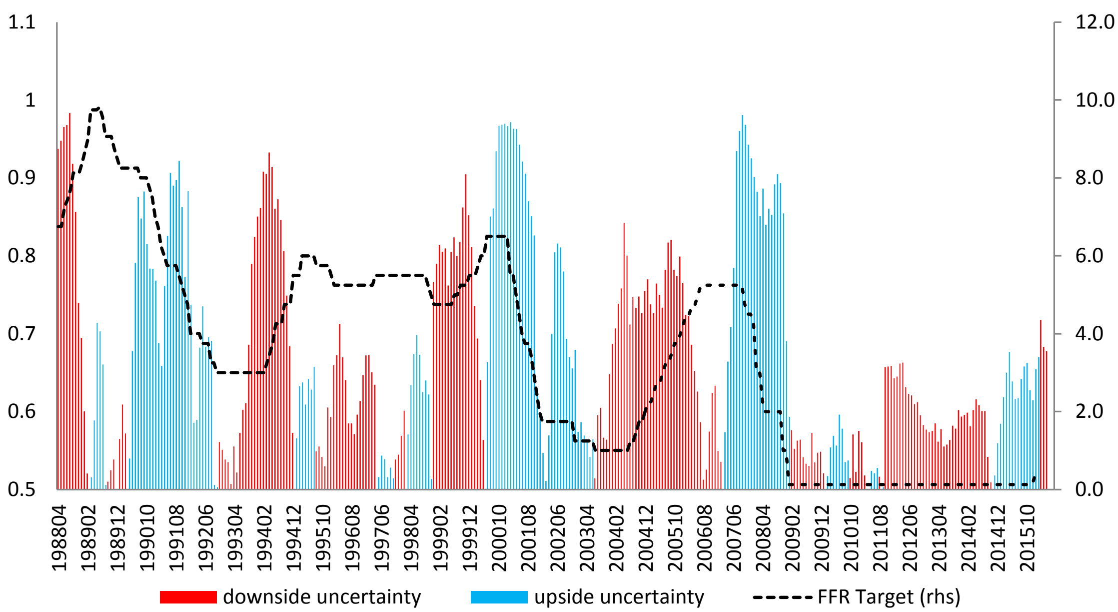
Note: This Figure plots the impulse responses of the S&P 500, FFR uncertainty, wages, hours, employment and industrial production to a one-unit FFR uncertainty shock. Dashed (solid) lines are the point estimates obtained from the tightening (easing) sub-sample.

Figure 16: ***Monetary Policy Uncertainty Index (based on 3-month-ahead expectations)***



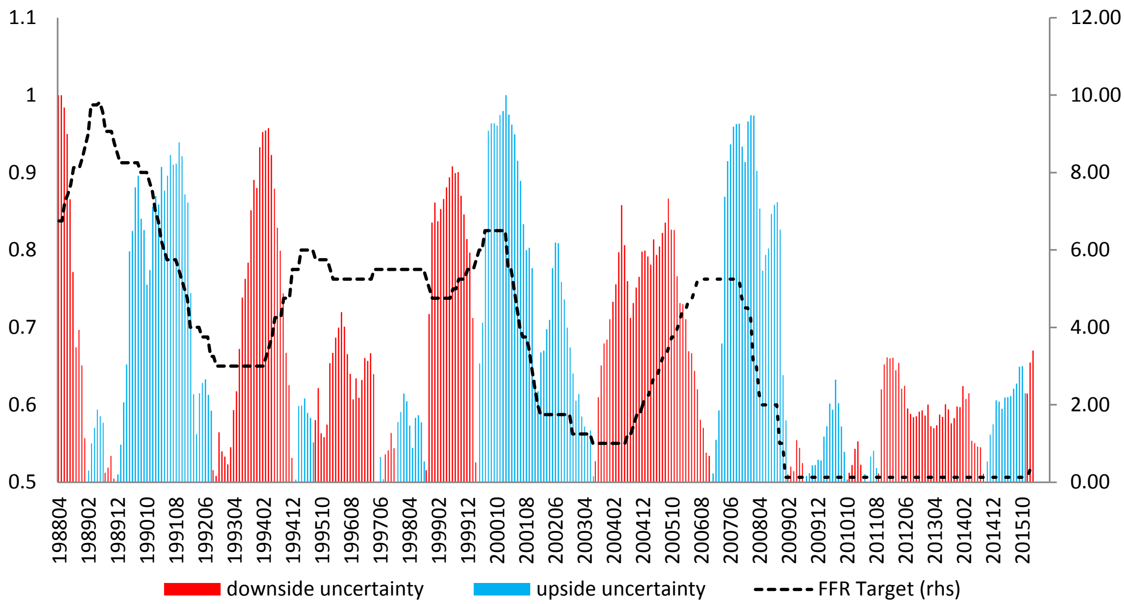
Note: This Figure plots upside and downside uncertainty obtained from the 3-month-ahead Federal funds rate forecast errors from the BCFF survey.

Figure 17: ***Monetary Policy Uncertainty Index (based on 9-month-ahead expectations)***



Note: This Figure plots upside and downside uncertainty obtained from the 9-month-ahead Federal funds rate forecast errors from the BCFF survey.

Figure 18: ***Monetary Policy Uncertainty Index (based on 12-month-ahead expectations)***



Note: This Figure plots upside and downside uncertainty obtained from the 12-month-ahead Federal funds rate forecast errors from the BCFF survey.