A New Measure of Monetary Policy Shocks

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Abstract

This paper constructs a new measure of monetary policy shocks that is orthogonal to fundamentals by combining the high-frequency approach of Gürkaynak et al. (2005) and Romer & Romer (2004)'s narrative approach. The empirical features of the new measure are: (i) contractionary monetary policy surprises revise the private sectors' unemployment rate expectation upward and inflation expectation downward; (ii) the hypothesis that the new measure is white noise cannot be rejected at both the daily and the monthly frequency; (iii) the new measure has insignificant effects on the long-term real rates; (iv) the new measure co-moves negatively with the current stock prices and the stock price futures.

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Evaluating the effects of monetary policy is important for both policy makers and researchers. This is not an easy task for three reasons. First, most movements in monetary policy instruments are the result of the systematic component of a policy rule. For example, the central bank may lower the federal funds target when inflation is below the target level or when GDP growth is too slow and below potential. The second challenge is that monetary policy announcements may not only affect the current policy instrument but also shape the market's expectation about the future interest rate path. Third, the private sector might update its beliefs about economic fundamentals after the central bank adjusts its monetary policy instruments or even through central bank's inaction. To estimate the causal effects of monetary policy on financial and macroeconomic variables, we need to overcome these three challenges and identify the nonsystematic movements in monetary policy instruments.

In this paper, I provide a new method of constructing a measure for monetary policy shocks that is orthogonal to fundamentals. Figure 1 plots the monthly new measure. In response to the first challenge, the endogeneity concern, I use the high-frequency identification approach pioneered by Kuttner (2001) to exploit the fact that a disproportionate amount of monetary news is revealed around the window when the Federal Open Market Committee (FOMC) announcements occur. To address the second challenge, the monetary policy path, I follow Gürkaynak et al. (2005) and use surprises for futures contracts settled in subsequent months along with the surprise for the current month as instruments for innovations in expected future short rates as well as for the current rate. The third challenge, the information effect, is eliminated or at least heavily mitigated, by regressing various futures data onto the Greenbook forecasts of output growth and inflation, in the spirit of Romer & Romer (2004), and then taking principal components of the regression residuals.

To measure the success of the newly constructed monetary policy surprise measure, I revisit Campbell et al. (2012), Nakamura & Steinsson (2018) and Cieslak & Schrimpf (2018), the three leading studies that explore the non-neutrality of central bank's communication. If the FOMC announcement has strong information effects, the contractionary monetary policy shocks will lead to increased optimism about economic fundamentals and raise private investors' expectations about inflation and output growth. Campbell et al. (2012) and Nakamura & Steinsson (2018) provide convincing evidence to support the information effect using private macroeconomic forecasts. Cieslak & Schrimpf (2018) confirm this view by documenting the positive comovement between S&P 500 futures and Treasury yields. I conduct the same analysis as the above studies with the new monetary policy surprise. I find the contractionary monetary policy shocks lower private investors' expectations about inflation and output growth and the positive comovement between S&P 500 futures and Treasury yields is highly mitigated.

After successfully identifying the exogenous component of monetary policy shocks, I apply the new measure to the same vector autoregression (VAR) analysis in Romer & Romer (2004). Using the previous measures, contractionary monetary policy shocks appear to be expansionary. With the new measure, this issue is highly mitigated.

This paper contributes towards two main strands of literature.

First, this paper adds to the literature that studies the effects of monetary policy identification. This includes the VAR studies such as Christiano et al. (1999) and also in the work of Romer & Romer (2004). Recent studies provide lots of evidence that monetary policy news is multi-dimensional. For example, Gürkaynak et al. (2005) construct a "current federal funds rate target" factor and a "future path of policy" factor. Campbell et al. (2012) distinguish between Delphic and Odyssean forward guidance. The Delphic forward guidance publicly states a forecast of macroeconomic performance and likely or intended monetary policy actions based on the policymaker's potentially superior information. Odyssean forward guidance publicly commits the policymaker. As summarized in Hamilton (2018), the rational response of a private actor to revelation of the Fed's economic assessment is to revise his or her own assessment. Campbell et al. (2012) find that over 1990 to 2007, when the Fed announced an interest rate that was higher than the market anticipated, it was associated with a move to lower forecasts of unemployment and higher forecasts of inflation in the Blue Chip consensus forecast, exactly opposite to what is predicted by the Odyssean (the Fed is going to be more contractionary than anticipated) and exactly what is predicted by the Delphic (the economy is in better shape than people thought). Nakamura & Steinsson (2018) confirm this finding in a careful analysis of high-frequency data through 2014.

To disentangle the two components, I provide a method that combines the high-frequency approach of Gürkaynak et al. (2005) and Romer & Romer (2004)'s narrative approach. It is easy to implement and survives the prevailing tests in the literature. Campbell et al. (2012) solve the problem by estimating a monetary policy rule with forward guidance shocks. Nakamura & Steinsson (2018) model Fed's information as beliefs about the path of the "natural rate of interest" and estimate the structural model using real interest rate data.

My paper also contributes to the literature regarding the assessment of the effects of the unconventional monetary policies and especially to those using event studies to investigate the impact on various interest rates (e.g. Gagnon et al. 2011, Krishnamurthy et al. 2011). Different from previous literature, by decomposing the unexpected change into the information component and the non-information component, I find the non-information monetary policy doesn't have significant effects on the long-term interest rates, supporting the neutrality of central bank's communication.

The remainder of the paper proceeds as follows. I begin by reviewing the current issue in the monetary policy identification in Section 1. In section 2, I describe the procedure of constructing the new measure of monetary policy shocks. Section 3 describes the effects of monetary policy using the new measure. Section 4 applies the new measure to previous studies. Section 5 concludes. Appendix provides further details of the data source and discussions of the event dates.

1 Existing approaches and the problem

A number of studies have proposed alternative methods to measure monetary policy surprise.

Surprise in the federal funds rate target (MP1). The high-frequency identification approach was pioneered by Kuttner (2001). The identifying assumptions made in his paper are that first, no other shocks affect the expectation for federal funds rate around the window of FOMC announcement; second, the surprise in the target rate can be measured by the 1-day change in the spot-month federal funds future rate (FF1), scaled up to reflect the number of days affected by the change. The monetary policy surprise constructed in this way is called MP1 in the literature.

Swanson & Williams (2014) provide evidence that the zero lower bound was not a constraint on the Federal Reserve's ability to manipulate the two-year Treasury yield. Therefore, I rescale the monetary policy shock such that its effect on the two-year nominal Treasury yield is equal to 100 basis points during the period of 1990:3m-2012:12m. The first row of Table 1 shows the summary statistics. The mean of MP1 is nonzero, and most of the surprises are negative.

To convert the shock series into monthly frequency, I assign each shock to the month in which the corresponding FOMC announcements are made. If there are two meetings in a month, I sum the shocks. Second, if there are no meetings in a month, I record the shock as zero for that month.

A good feature of monetary policy shocks is to capture only unanticipated movements in interest rates. The first row of Table 2 shows the p-value for the hypothesis that the monetary policy shock series is white noise. However, the hypothesis is rejected at the monthly frequency.

To study the information effect, I follow Campbell et al. (2012) and estimate the responses of revisions of inflation and unemployment rate forecasts to monetary policy accommodation. The regression equation is

$$\triangle y_{t+1}^{h} = \beta_h \text{MPS}_t + \varepsilon_{t+1} \tag{1}$$

where $\triangle y_{t+1}^{h}$ is the revision of h-quarter-ahead Blue Chip consensus forecast of inflation and unemployment rate at the beginning of month $t+1$, and $h = 0, 1, 2, 3, 4$. MPS_t is the monetary policy surprise in month t. In the case of Kuttner (2001), it is represented by the MP1_t.

Column 1 of Table 3 presents the regression result.[1] The coefficients with 90% confidence intervals are plotted in Figure 3. In theory, a true contractionary monetary policy shock should increase unemployment rate expectation and decrease the inflation expectation. However, the estimation results show the opposite direction. The interpretation is that part of what happens is the Fed raises the interest rate because it sees fundamentals as stronger, and the private forecasts

[1] Blue Chip Economic Indicator survey is conducted between the 2nd and the 7th day of each month. The monetary surprise data I use for this regression is restricted to include only the announcements made after the first week of the calendar month.

respond to the signal by being more optimistic about the the fundamentals.

Cieslak & Schrimpf (2018) look at the problem from the perspective of the comovement of S&P 500 and bond yield. Again, a true contractionary monetary policy shock should raise interest rates and depress output, both of which should lower stock prices. However, as Table 4 shows, when the MP1 is positive, the numbers of days that stock price increased (29) is more than that of decreasing (24). When the MP1 is negative, the numbers of days that stock price increased (47) become bigger than that of decreasing (31) by only a small amount. I conduct the same analysis using 1-month and 2-month S&P 500 E mini futures data and find the similar results.

To look at the effects on nominal and real interest rates of different maturities, I estimate

$$\triangle i_d = \alpha + \beta \text{MPS}_d + \varepsilon_d \tag{2}$$

where $\triangle i_d$ is the change in an outcome variable of interest (e.g., the yield on a five year zero-coupon Treasury bond) at day d, MPS_d is the measure of the monetary policy news in the FOMC announcement at day d.

The regression coefficients are reported in the upper left panel of Table 5. The first column is for the nominal bond yield, second column for the real bond yield measured using Treasury Inflation Protected Securities (TIPS) rate, and the third column is the breakeven inflation rate. The sample period for the real rates and the breakeven rates is from 2004:1m to 2012:12m[2]. Following Nakamura & Steinsson (2018), I drop the observations from July 2008 through June 2009. The $MP1$ doesn't have significant effects on neither the 10-year nominal nor real interest rates.

3-month ahead Federal funds futures (FF4). Gertler & Karadi (2015) use the three month ahead funds rate future (FF4) surprise to identify monetary policy shock. I rescale the monetary policy shock such that its effect on the two-year nominal Treasury yield is equal to 100 basis points. I plot the 12-month backward-rolling window cumulative change in the first row second column of Figure 2. First, we learn that the change in FF4, △FF4, is more likely to be negative around the NEBR recession periods. Second, after 2008, the △FF4 didn't vary considerably, which will make it vulnerable to be used as an instrument.

Column 2 of Table 3 presents the regression result of equation 1 with the monetary policy surprise MPS measured by the daily change in FF4. The coefficients from the regression equation 1 are reported in the second column of Table 3. The coefficients with 90% confidence intervals are plotted in Figure 4. Still, the contractionary monetary policy looks like expansionary one.

Instrument set of futures (FF1, FF2, ED2, ED3, ED4). Gürkaynak et al. (2005) argue that monetary policy news is multi-dimensional. I examine the surprises in the current month's fed funds futures (FF1), in the three month ahead monthly fed funds futures (FF4), and in the six

[2] Swanson (2015) suggests using post-2004 periods due to the low liquidity of TIPS in its first few years.

month, nine month and year ahead futures on three month Eurodollar deposits (ED2, ED3, ED4) on the days of FOMC announcement. I take the first principal component of the unanticipated daily change in the above five interest rates. I then rescale the monetary policy shock such that its effect on the two-year nominal Treasury yield is equal to 100 basis points. Column 3 of Table 3 presents the regression result of equation 1. The coefficients with 90% confidence intervals are plotted in Figure 5. The coefficients appears to be the opposite of what they should be.

The Romer-Romer shock. The seminal empirical paper on Fed information is Romer & Romer (2004). They construct their monetary policy shocks by combining the narrative approach with the Greenbook forecasts.[3] First, they derive the intended federal funds rate changes during FOMC meetings using narrative methods. Second, in order to separate the endogenous response of policy to information about the economy from the exogenous policy deviation, they regress the intended funds rate change on the current rate and on the Greenbook forecasts of output growth and inflation over the next two quarters. The specific equation they estimate in the second step is as follows.[4]

$$\begin{aligned}\triangle fft_m &= \alpha fftb_m + \sum_{j=-1}^{2} \beta_j^{\triangle INFL} \triangle INFL_{m,q+j}^{GB} + \sum_{j=-1}^{2} \beta_j^{\triangle RealGDP} \triangle RealGDP_{m,q+j}^{GB} \\ &+ \sum_{j=-1}^{2} \beta_j^{INFL} INFL_{m,q+j}^{GB} + \sum_{j=-1}^{2} \beta_j^{RealGDP} RealGDP_{m,q+j}^{GB} + \beta^{UNEMP} UNEMP_{m,q} \\ &+ constant + \varepsilon_m\end{aligned}$$

where $\triangle fft_m$ denotes the change of federal funds target that on the FOMC meeting m, and $fftb_m$ is the level of the federal funds rate before any changes associated with the meeting, which is included to capture any tendency toward mean reversion in FOMC behavior. Let q be the quarter where the meeting m takes place. $INFL_{m,q+j}^{GB}$ denotes Greenbook forecasts for inflation for quarter $q+j$ made at meeting m, j=-1,0,1, 2. $RealGDP_{m,q+j}^{GB}$ denotes Greenbook forecasts for unemployment rate for quarter $q+j$ made at meeting m. $\triangle INFL_{m,q+j}^{GB}$ and $\triangle RealGDP_{m,q+j}^{GB}$ is the revised forecast for inflation and real GDP growth rate between two consecutive meetings. In computing the forecast innovations, the forecast horizons for meetings m and $m-1$ are adjusted so that the forecasts refer to the same quarter.

To convert the shock series into monthly frequency, Romer & Romer (2004) use the following procedure. First, they assign each shock to the month in which the corresponding FOMC meeting occurred. If there are two meetings in a month, they sum the shocks. Second, if there are no

[3]Wieland & Yang (2016) extend their shock series to the end of 2007.

[4]This is the same equation as the equation 1 in Romer & Romer (2004).

meetings in a month, they record the shock as zero for that month.

Let's first take a look at the the responses of Blue Chip expectation revision for inflation and unemployment rate to Romer-Romer shock. Column 4 of Table 3 shows the estimated coefficients as in regression equation 1, and Figure 6 plots the 90% confidence interval. Contractionary monetary policy seems to increase the inflation expectation, which is not true according to theory.

The Romer-Romer meeting dates are very different from Gürkaynak et al. (2005), especially for the pre-1994 period. As stated in Gürkaynak et al. (2005), the FOMC did not explicitly announce changes in its target for the federal funds rate, but such changes were implicitly communicated to financial markets through the size and type of open market operation. Therefore, they define a monetary policy announcement date to be the one of the next open market operation following the FOMC decision. For this reason, the regression results of equation 2 and the stock price movements are not shown in Tables 4 and 5.

The "informationally-robust" shock. Miranda-Agrippino & Ricco (2018) regress the monthly surprise in FF4 onto the Greenbook forecasts and uses the residual as proxy for the monetary policy shock. It is called "informationally-robust" shock. In addition to using △FF4, their approach differs from Romer & Romer (2004) in the following perspectives.

First, they group the daily monetary policy surprises occurred in the same month together before the estimation procedure. Therefore, the observations used for the regression are at monthly frequency instead of at meeting frequency. Second, in the regression, they include the months when there are no FOMC meetings and run a Romer-Romer regression with these no-meeting months as observations. Thus the constructed shock series are nonzero for any given month, while Romer and Romer assign zero for those no meeting months. Finally, the previous price level of the federal funds futures is not included to capture any tendency toward mean reversion in FOMC behavior. The regression they estimate is as follows.[5]

$$\begin{aligned}\triangle FF4_t = &\sum_{j=1}^{p} \triangle FF4_{t-j} + \sum_{j=-1}^{2} \beta_j^{\triangle INFL} \triangle INFL_{t,q+j}^{GB} + \sum_{j=-1}^{2} \beta_j^{\triangle RealGDP} \triangle RealGDP_{t,q+j}^{GB} \\ &+ \sum_{j=-1}^{3} \beta_j^{INFL} INFL_{t,q+j}^{GB} + \sum_{j=-1}^{3} \beta_j^{RealGDP} RealGDP_{t,q+j}^{GB} + \beta^{UNEMP} UNEMP_{t,q}^{GB} \\ &+ constant + \varepsilon_t\end{aligned}$$

Column 5 of Table 3 presents the responses of Blue chip expectation revision for unemployment rate and inflation to contractionary monetary policy measured by the "informationally-robust"

[5]This is the same equation as the equation 1 in Miranda-Agrippino & Ricco (2018).

shock. Figure 7 plots the coefficients with 90% confidence interval. Almost all the coefficients are insignificant from zero, and a couple of the unemployment rate revision responses go into the opposite direction.

In previous regressions with other shock measures, because of the Blue Chip Economic Indicator survey period, I first drop the FOMC announcements made in the first week and then group the announcement days into monthly observations. However, the "informationally-robust" shock, by construction, is monthly and available form the author's website from 1991:2m-2010:1m. I reestimate the equation 1 with observations in 1991:2m-2010:1m period and restricted to the months where all the FOMC announcements are made after the first week. The results are similar to Figure 7. Later on, when I present the regression results using the new measure in section 3.1, the results barely change if I use the same subsample.

Furthermore, for no-meeting months, both Campbell et al. (2012) and Nakamura & Steinsson (2018) assign zero to them and conduct their Blue Chip data analysis without those months. Since the "informationally-robust" shock is nonzero for all the months, I reestimate the equation 1 using observations, i) occurred in 1991:2m-2010:1m, ii) restricted to the months where all the FOMC announcements are made after the first week, iii) including the no-meetings months. The results are similar to Figure 7. The results in Section 3.1 barely change if estimated using the same subsample.

In summary, all the measures of monetary policy shocks mentioned above still seem to have an important signaling component. They tend on average to be pro-cyclical, as if the fed was lowering rates during recessions for some reason other than a response to perceived economic conditions.

2 Construction of the new measure

The changes of interest rates of various maturities around the FOMC announcement window respond to a varieties of information about current and future policy. There are two components. One is Delphic, which relates to the FOMC's macroeconomic forecast and likely or intended monetary policy actions based on the policymaker's potentially superior information about future macroeconomic fundamentals and its own policy goals. Another one is Odyssean, which is the policymaker's commitment to the current and future monetary policy. I obtain the Odyssean component from the residuals of a regression of each surprise on the policymaker's potentially superior information. These residuals captures the Odyssean component up to different horizons based on the expiration horizon of the initial interest rate futures. I summarize the information by taking the first principal component of the residuals.

In the rest of this section, I lay out the procedure to construct the new instrument for monetary policy shocks in detail. I proceed in the following five steps.

Step 1, following Kuttner (2001) and Gürkaynak et al. (2005), I build daily market surprises in the instrument set: the current month's fed funds target rate (MP1), the three month ahead monthly fed funds futures (FF4), and the six month, nine month and year ahead futures on three month Eurodollar deposits (ED2, ED3, ED4).

Different from Kuttner (2001), when the FOMC meeting occurs on a day when there are 7 days or less remaining in a month, I instead use the change in the price of next month's fed funds futures contract. This avoids multiplying the change by a very large factor. Let FF1 be the interest rate of the current month fed funds futures and FF2 be the interest rate of the next month fed funds futures. The announcement is made on day d, which is the t^{th} of the month, and the calendar month has T days in total. The surprise in the federal funds rate target MP1 is defined as

$$MP1_d = \begin{cases} FF2_d - FF1_{d-1} & \text{if} \quad \mathrm{t = 1} \\ (FF1_d - FF1_{d-1})\frac{T}{T-t} & \text{if} \quad \mathrm{1 < t < T - 7} \\ FF2_d - FF2_{d-1} & \text{if} \quad \mathrm{t >= t - 7} \end{cases}$$

Step 2, I regress these daily surprises, MP1, $\triangle FF4$, $\triangle ED2$, $\triangle ED3$, and $\triangle ED4$ onto (i) the level of the futures's interest rate one day before to capture mean reversion in FOMC behavior, (ii) their lags in previous meetings, to control for the autocorrelation, (iii) Greenbook forecasts and forecast revisions for real output growth, inflation and the unemployment rate, as in Romer & Romer (2004), to control for the central bank's private information. Specifically, I recover a daily instrument for monetary policy shocks using the residuals of the following regression:

$$\begin{aligned} MPS_d = \beta_0 \text{MPS\_level}_{d-1} + \beta_i MPS_{d-} + \sum_{j=-1}^{s} \beta_j^{\triangle INFL} \triangle INFL_{d,q+j}^{GB} + \sum_{j=-1}^{s} \beta_j^{\triangle RealGDP} \triangle RealGDP_{d,q+j}^{GB} \\ + \sum_{j=-1}^{s} \beta_j^{INFL} INFL_{d,q+j}^{GB} + \sum_{j=-1}^{s} \beta_j^{RealGDP} RealGDP_{d,q+j}^{GB} + \sum_{j=-1}^{s} \beta_j^{UNEMP} UNEMP_{d,q+j}^{GB} \\ + constant + \varepsilon_d \end{aligned} \quad (3)$$

where MPS_t denotes the market-based monetary policy surprise that on the FOMC announcements day d. Let q be the quarter where the announcement takes place. I run 5 regressions separately using MP1, and the daily change of FF4, ED2, ED3, ED4 as dependent variables and obtain the five residual series.

Step 3, I normalize the residuals of each regression to have zero mean and unit variance, similar to the normalization procedure in Gürkaynak et al. (2005). I take the principal components of these residuals and use the first principal component to represent the new monetary policy shock.

Step 4, for convenience, I rescale the monetary policy shock such that the effect on the two-year nominal Treasury yield is equal to 100 basis points.

Step 5, to convert the shock series into monthly frequency, I assign each shock to the month in which the corresponding FOMC announcement occurred. If there are two announcement days in a month, I sum the shocks. If there are no meetings in a month, I record the shock as zero for that month.

In Figure 1, I plot the new instrument over time. The summary statistics are shown at the bottom row in the Table 1. As explained in Nakamura & Steinsson (2018), the high-frequency identification approach is powerful to address the endogeneity concern at the cost of reduced statistical power. The estimated monetary shocks are quite small, with the standard deviation about 5 basis points both in their paper and in this paper.

I compare the new measure with the first principal component measure in Figure 8. Both of the monetary policy surprises are measured in percentage points. The regression line has a slope near 1, the correlation between the two measures is 0.87, reported in Table 2.

A closer look will show the difference between the two measures. As shown in Table 2, the hypothesis that the newly constructed shock is white noise cannot be rejected. This holds for the shock series both in the daily and the monthly frequency. It rejects the hypothesis the first principal component shock is white noise if we look at the daily frequency.

3 Effects of the monetary policy surprise

In this section, I use the new measure to estimate the effects of the monetary policy on the macroeconomic forecasts and on the financial market.

3.1 Response of private sector forecast

Column 6 of Table 3 shows the estimated private forecast responses to the new measure. Figure 9 plots the regression coefficients β_h, where $h = 0, 1, 2, 3, 4$, with 90% confidence interval. Following a contractionary monetary policy news shock, the current and expected unemployment rate tend to increase, and the current and expected inflation rate tend to fall. Thus, the contractionary monetary policy shock behaves like contractionary.

3.2 Comovement of stock price and monetary policy surprise

As shown in Table 4, this is the first time that when the monetary policy shock is positive, the numbers of days that stock price decreased (54) is more than that of increasing (52). When the monetary policy shock is negative, the numbers of days that stock price increased (66) become bigger than that of decreasing (30) by a huge amount. This is also true if I use the 1-month and 2-month S&P 500 E mini futures instead of S&P 500 index.

3.3 Response of interest rates and inflation

The effects on various interests rates are shown in the upper right panel of Table 5. The new measure has similar effects as the first principal component measure on the nominal interest rates. However, the new measure doesn't have significant effects on the 10-year real rate, consistent with the prediction of theory that the effect of monetary policy shocks on real interest rates is zero in the long run.

4 Application

In this section, I apply the new measure of monetary policy to the VAR specification by Romer & Romer (2004). It is a monthly VAR with the log of industrial production, the unemployment rate, the log of the CPI, the log of a commodity price index in the first block, and the federal funds rate is replaced by the monetary policy measure. Following Coibion (2012), I use the cumulative Romer and Romer shock. The identification assumption is recursive.

Figure 10 plots the impulse responses. The estimates imply that a shock that raises the funds rate is expansionary: industrial production rises after 1 year or so, the unemployment rate falls for around 10 months, and the points estimates are statistically different from zero.

I substitute the cumulative Romer and Romer shock with the new measure cumulated in the same way. Figure 11 shows the impulse responses to the monetary policy. Although there's slightly significant increase of industrial production in the first few months, the unemployment rate doesn't goes into the other direction significantly.

5 Conclusion

This paper constructs a new measure of monetary policy shock. Through various analysis, this new measure is shown to be orthogonal to fundamentals.

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Table 1: Summary statistics of the new and old measures of monetary policy surprise

Monetary Policy Shock	mean	standard deviation	25^{th} percentile	median	75^{th} percentile
MP1	-0.0155	0.073	-0.006	0.000	0.000
$\triangle FF4$	-0.0136	0.065	-0.010	0.000	0.000
First Principal Component	-0.0000	0.049	-0.003	0.000	0.016
Romer-Romer	0.0122	0.142	0.000	0.000	0.030
Information-robust	-0.0000	0.056	-0.013	0.004	0.024
new measure	0.0000	0.039	-0.011	0.000	0.012

NOTES: The monetary policy surprises are measured in basis points. They are rescaled such that the effect on the two-year Treasury yield is 100 basis points. The sample period is 1990:3m-2012:12m.

Table 2: White Noise Test p-value and Correlation with New Measure

	p-value at Monthly frequency	p-value at Daily frequency	Correlation
MP1	0	0.22	0.65
$\triangle FF4$	0	0.06	0.80
First PC	0.25	0.02	0.87
Romer-Romer	0.01	-	0.15
Information-robust	0.98	-	0.68
New Measure	0.89	0.34	1

NOTES: The monetary policy surprises are measured in basis points. They are rescaled such that the effect on the two-year Treasury yield is 100 basis points. The sample period is 1990:3m-2012:12m.

Table 3: Regressions Estimating Private Forecast Responses to Various Measures of Contractionary Monetary Policy Shocks

Forecast	MP1	FF4	First PC	Romer-Romer	Information Robust	New Measure
Unemployment rate						
Current quarter	**-0.25**	**-0.20**	**-0.27****	0.07	**-0.03**	**-0.04**
	(0.18)	(0.14)	(0.12)	(0.07)	(0.12)	(0.14)
Next quarter	**-0.25**	**-0.23**	**-0.20**	0.01	0.03	0.14
	(0.23)	(0.21)	(0.18)	(0.05)	(0.20)	(0.20)
2 quarters hence	**-0.50***	**-0.52***	**-0.36***	0.00	**-0.08**	0.10
	(0.30)	(0.26)	(0.21)	(0.05)	(0.25)	(0.22)
3 quarters hence	**-0.47**	**-0.44**	**-0.28**	**-0.03**	**-0.02**	0.32
	(0.31)	(0.30)	(0.23)	(0.04)	(0.27)	(0.22)
4 quarters hence	**-0.05**	**-0.25**	**-0.07**	**-0.00**	0.09	0.40*
	(0.30)	(0.34)	(0.25)	(0.04)	(0.29)	(0.22)
Inflation						
Current quarter	**0.27**	**0.32**	**0.37**	**0.02**	-0.04	-0.20
	(0.47)	(0.38)	(0.31)	(0.04)	(0.25)	(0.33)
Next quarter	**0.41**	**0.37**	**0.19**	**0.02**	-0.11	-0.14
	(0.36)	(0.26)	(0.23)	(0.06)	(0.17)	(0.26)
2 quarters hence	-0.01	-0.04	-0.13	**0.05**	-0.21*	-0.45**
	(0.20)	(0.15)	(0.14)	(0.06)	(0.13)	(0.19)
3 quarters hence	**0.13**	**0.19**	**0.03**	**0.06**	-0.09	-0.30*
	(0.26)	(0.18)	(0.13)	(0.05)	(0.12)	(0.17)
4 quarters hence	-0.12	-0.02	-0.16	**0.02**	-0.13	-0.37**
	(0.21)	(0.15)	(0.13)	(0.06)	(0.10)	(0.15)

NOTES: Each row in each panel reports the coefficients β_h in regression equation 1. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Bold indicates coefficients that are of the opposite sign predicted for a monetary policy contraction. Red indicates expected sign and statistically significantly different from zero.

Table 4: Covmovement of S&P 500 with Monetary Policy Shocks

	+ MP1	− MP1	+ △FF4	− △FF4
S&P 500 ↑	29	47	33	55
S&P 500 ↓	24	31	32	36
	+ First PC	− First PC	+ New Measure	− New Measure
S&P 500 ↑	64	54	52	66
S&P 500 ↓	53	31	54	30

NOTES: This table counts the days by the directions of the stock price movement and the sign of the monetary policy surprise for all the event days.

Table 5: Responses of interest rate and inflation to the monetary policy shock

	MP1			△FF4		
	Nominal	Real	Inflation	Nominal	Real	Inflation
1Y Treasury yield	1.13***			1.04***		
	(0.17)			(0.11)		
2Y Treasury yield	0.97***	1.61***	0.28	1.00***	1.06***	0.01
	(0.22)	(0.31)	(0.48)	(0.12)	(0.17)	(0.25)
5Y Treasury yield	0.59**	0.79**	0.28	0.73***	0.66***	0.04
	(0.25)	(0.31)	(0.59)	(0.14)	(0.17)	(0.23)
10Y Treasury yield	**0.27**	0.03	0.12	0.43***	**0.26***	0.01
	(0.21)	(0.25)	(0.52)	(0.11)	(0.14)	(0.19)
Observations	196	66	66	196	66	66

	First PC			New Measure		
	Nominal	Real	Inflation	Nominal	Real	Inflation
1Y Treasury yield	0.98***			0.98***		
	(0.08)			(0.11)		
2Y Treasury yield	1.00***	0.91***	0.09	0.99***	0.67***	0.02
	(0.09)	(0.18)	(0.14)	(0.11)	(0.20)	(0.15)
5Y Treasury yield	0.82***	0.76***	0.01	0.81***	0.53***	-0.09
	(0.09)	(0.20)	(0.15)	(0.11)	(0.20)	(0.15)
10Y Treasury yield	0.54***	**0.43****	-0.06	0.52***	0.27	-0.15
	(0.09)	(0.18)	(0.14)	(0.10)	(0.17)	(0.13)
Observations	196	66	66	195	66	66

NOTES: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Figure 1: Monthly Cumulative New Measure

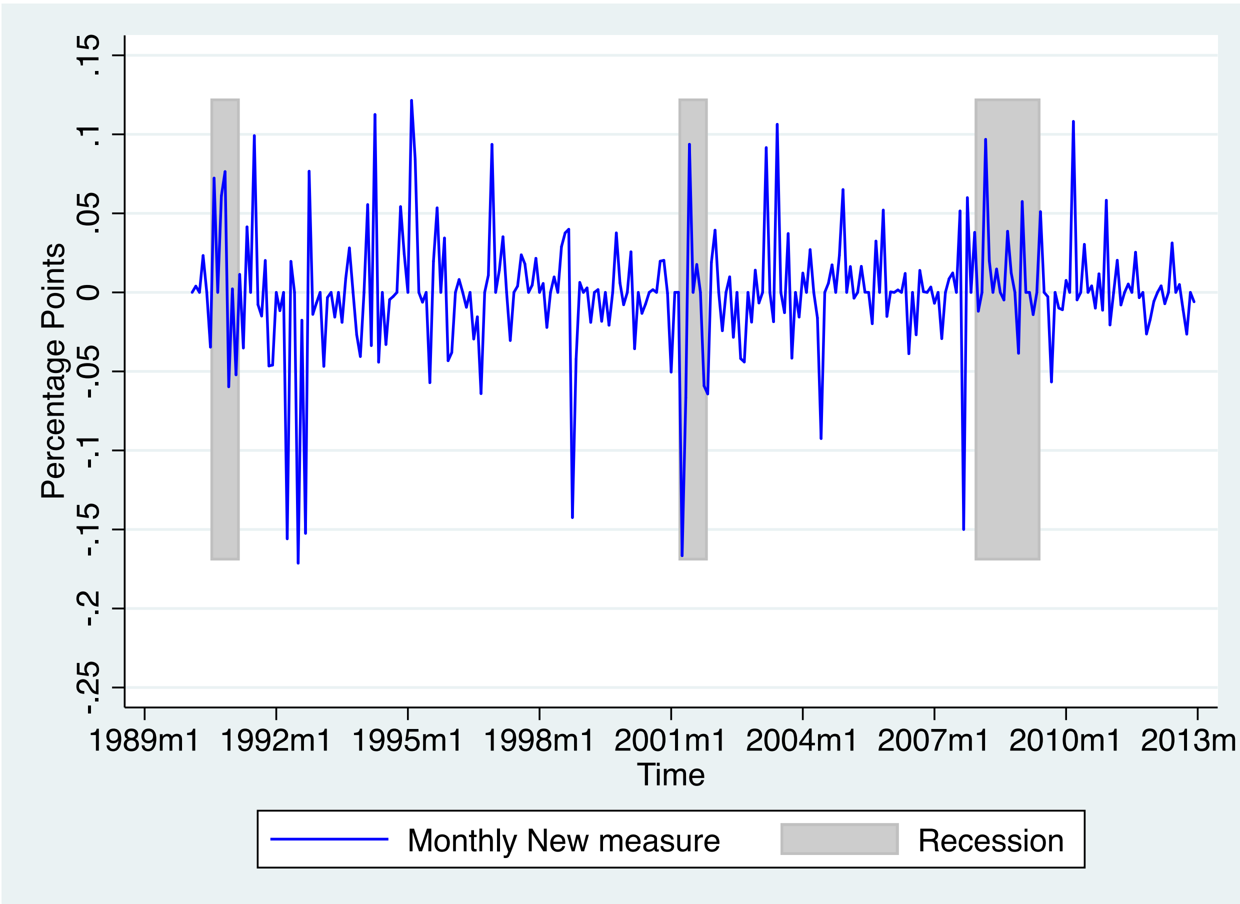


Figure 2: 12-month Backward Rolling Window of Cumulative Monetary Surprises

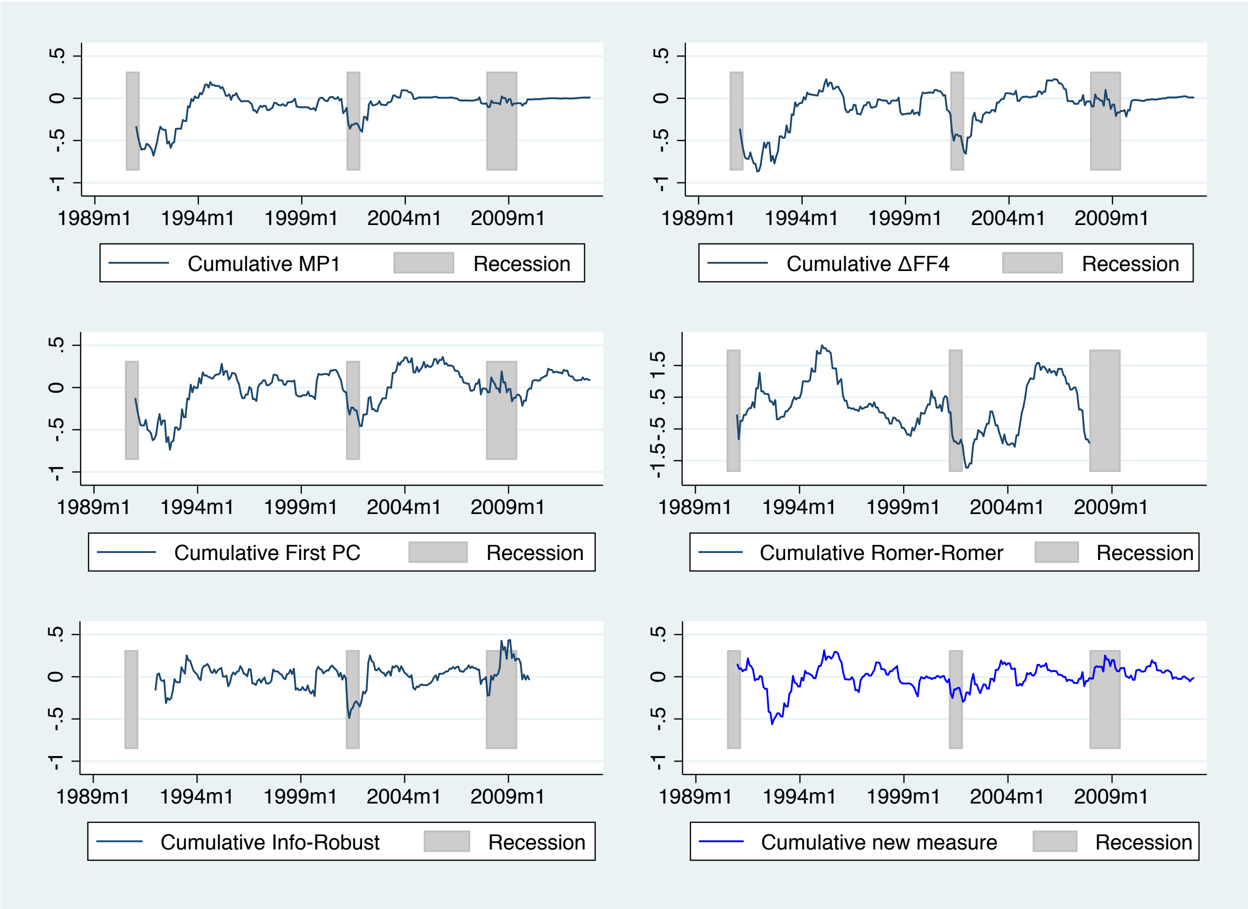


Figure 3: Private Forecast Revisions to Contractionary **MP1**.

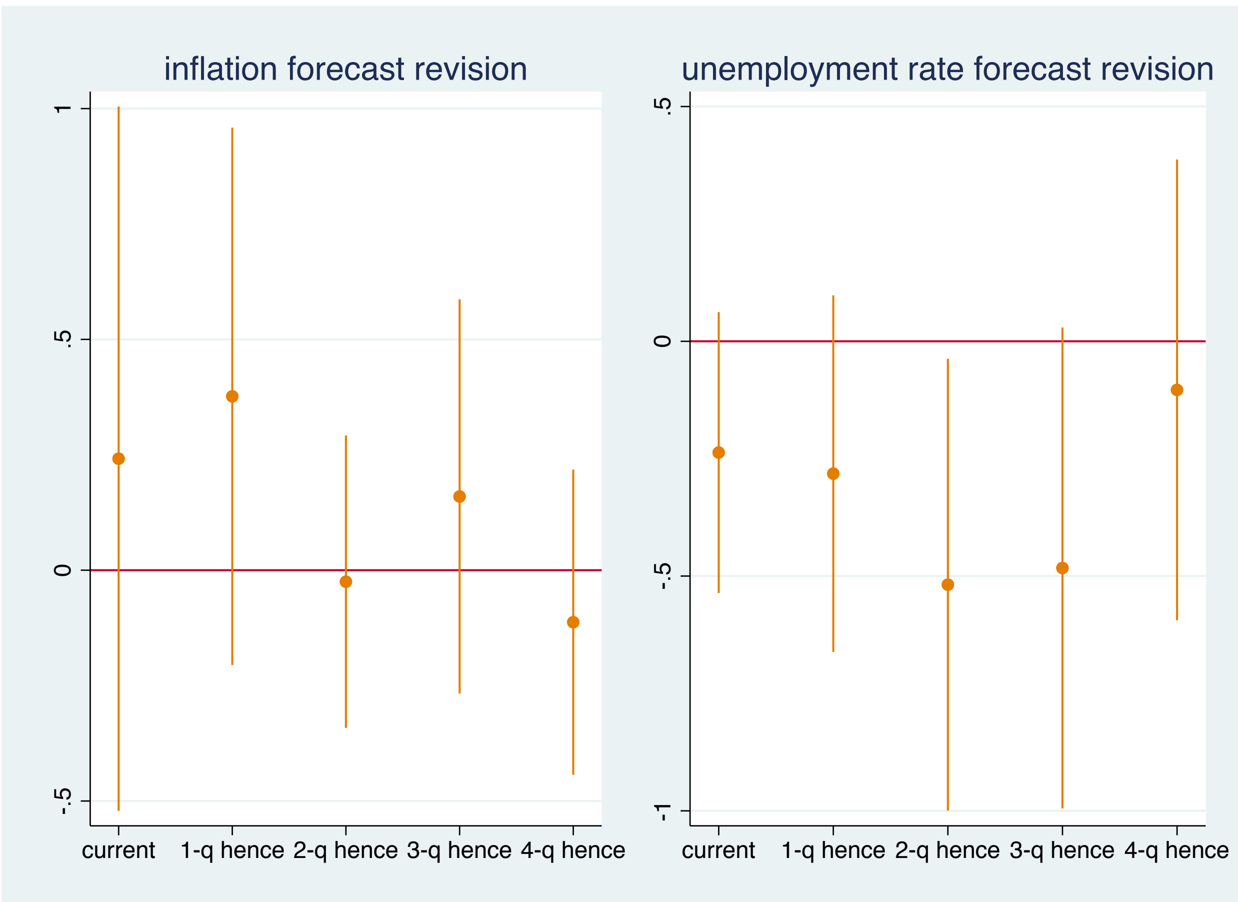


Figure 4: Private Forecast Revisions to Contractionary $\triangle$**FF4**.

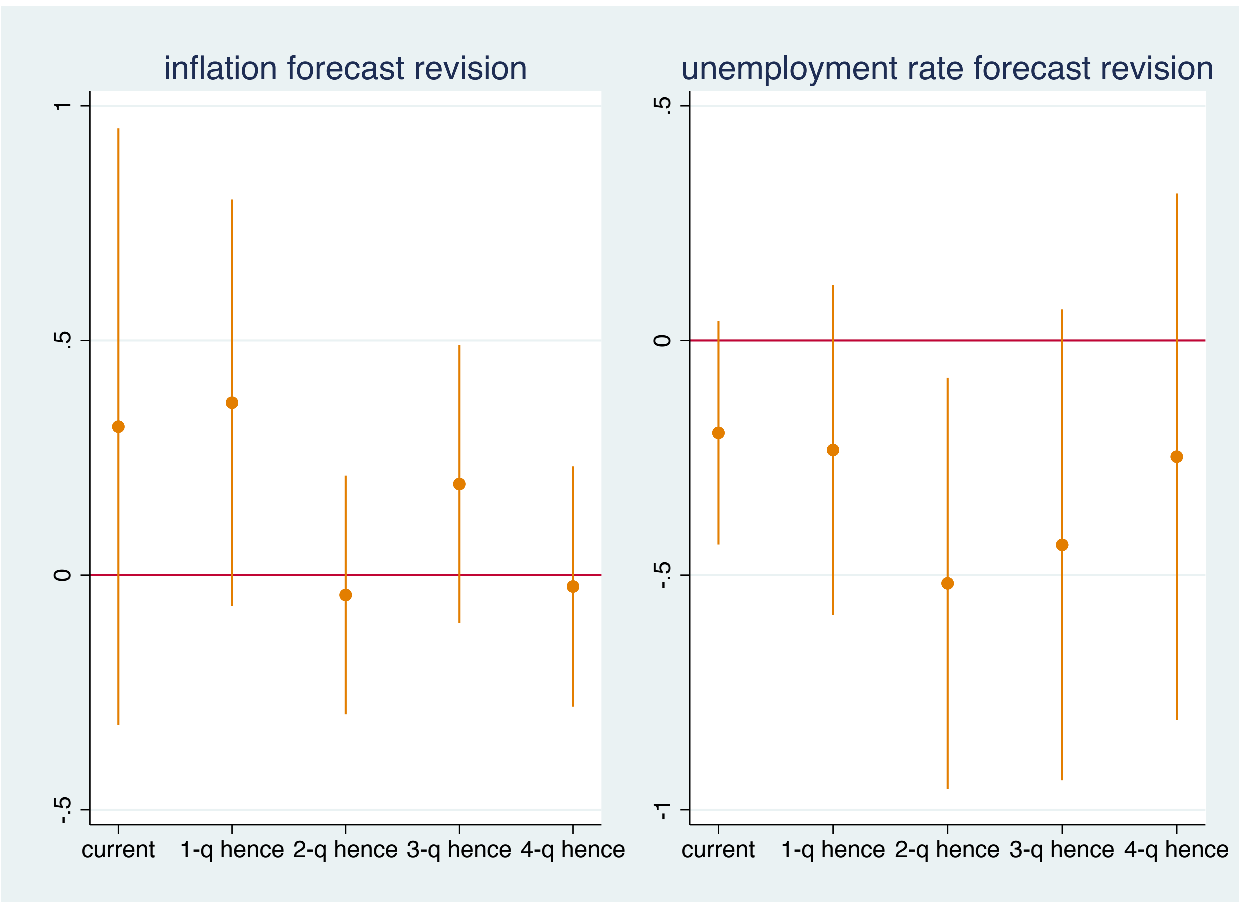


Figure 5: Private Forecast Revisions to Contractionary **First Principal Component**.

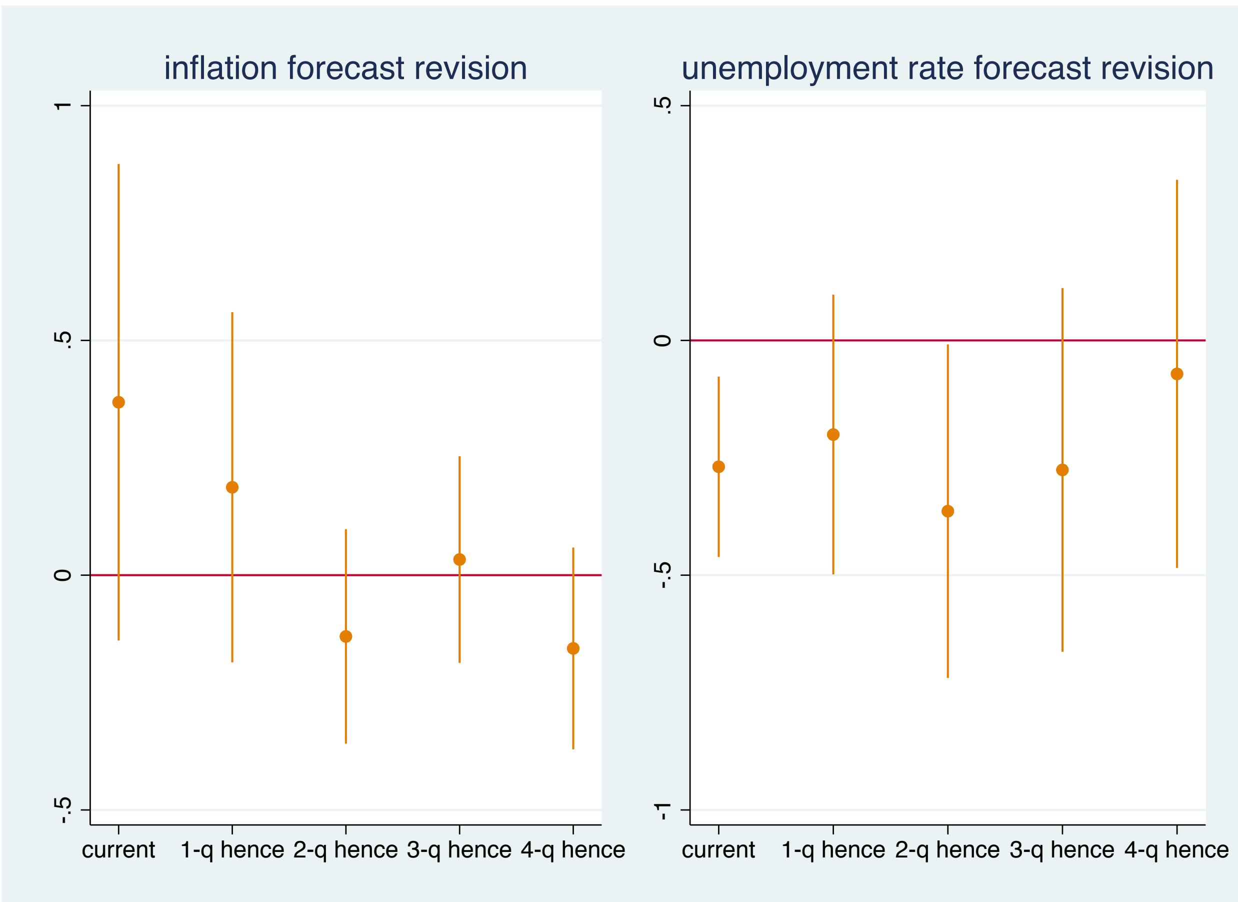


Figure 6: Private Forecast Revisions to Contractionary **Romer-Romer** Policy Surprise.

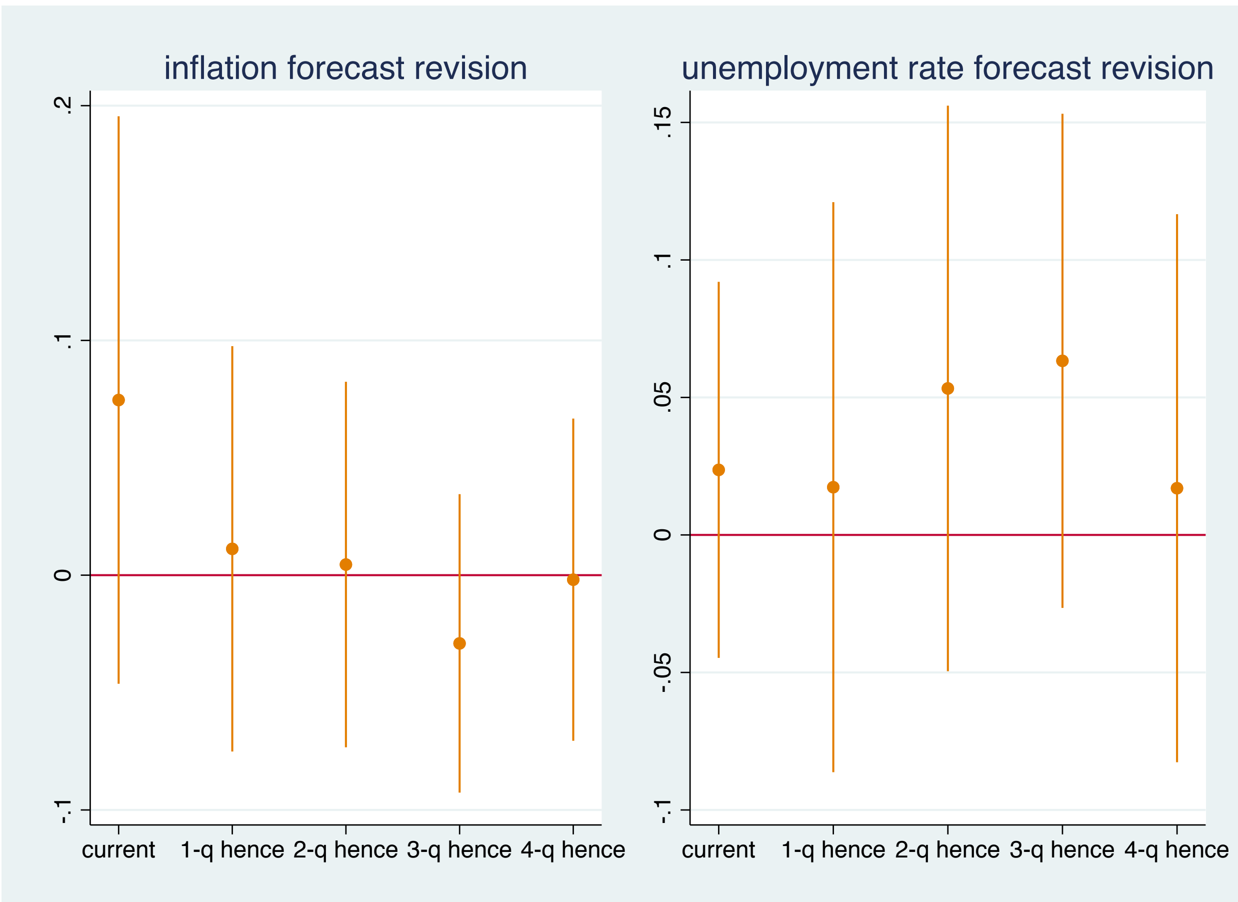


Figure 7: Private Forecast Revisions to Contractionary **"Informationally-Robust"** Shock.

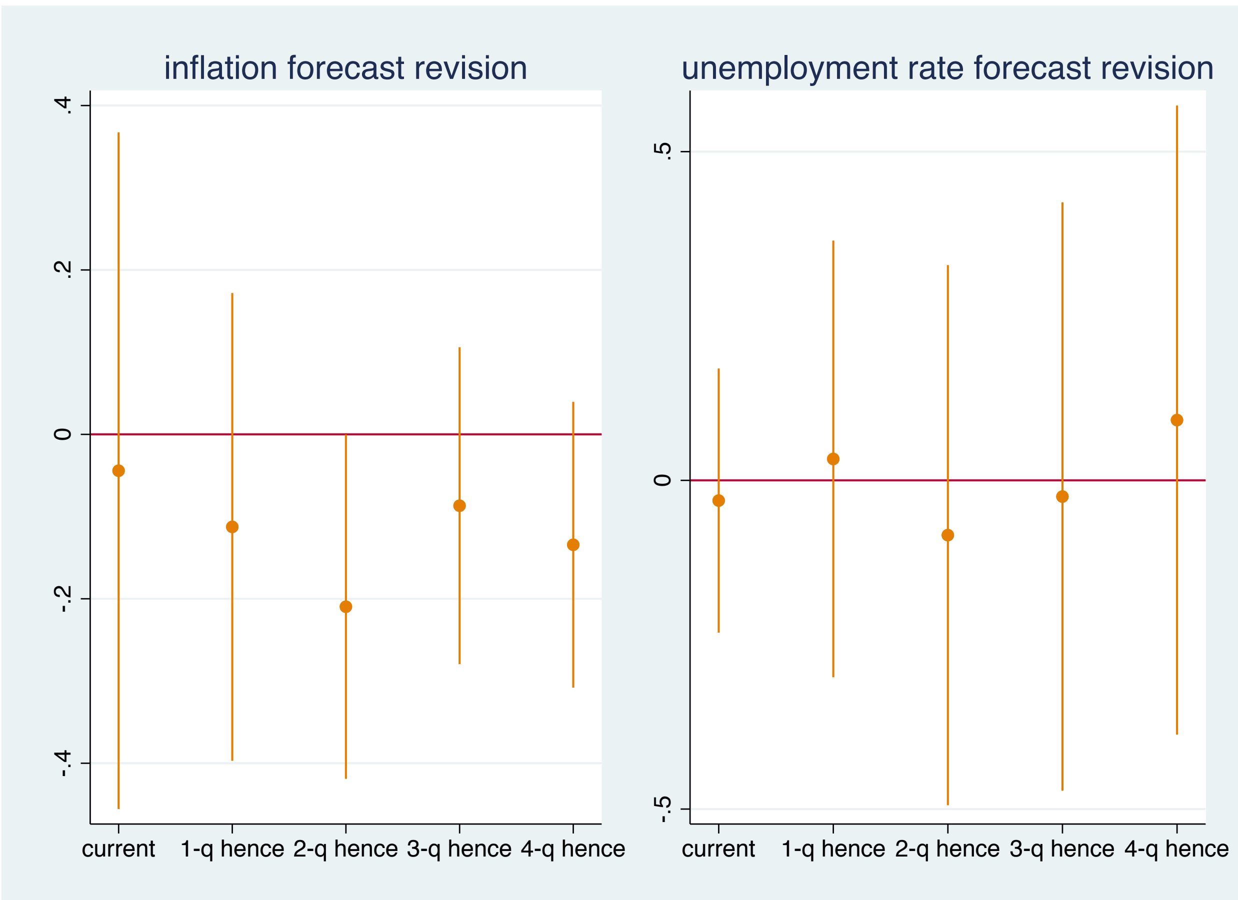


Figure 8: Comparison of the New Measure With the First PC

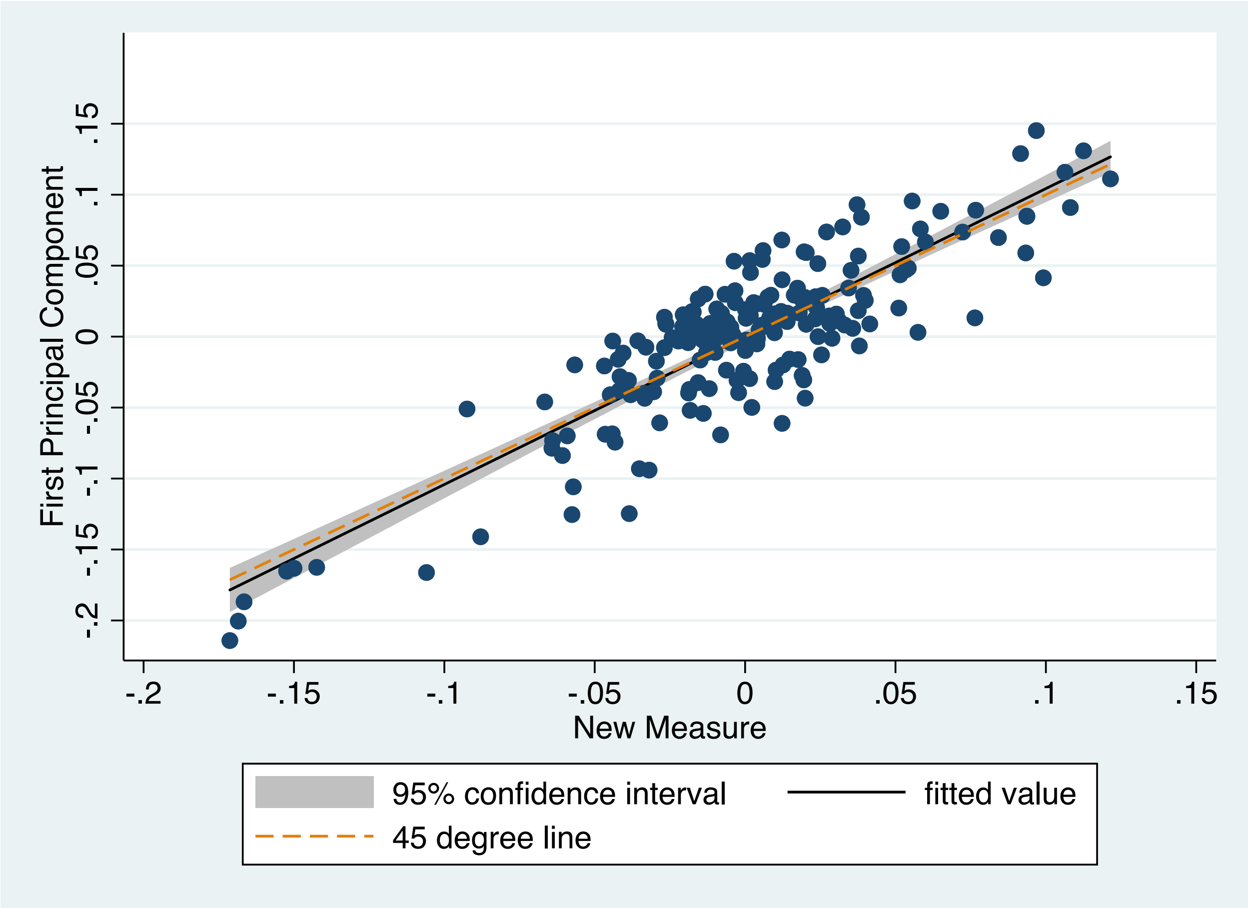


Figure 9: Private Forecast Revisions to the Contractionary **New Measure**.

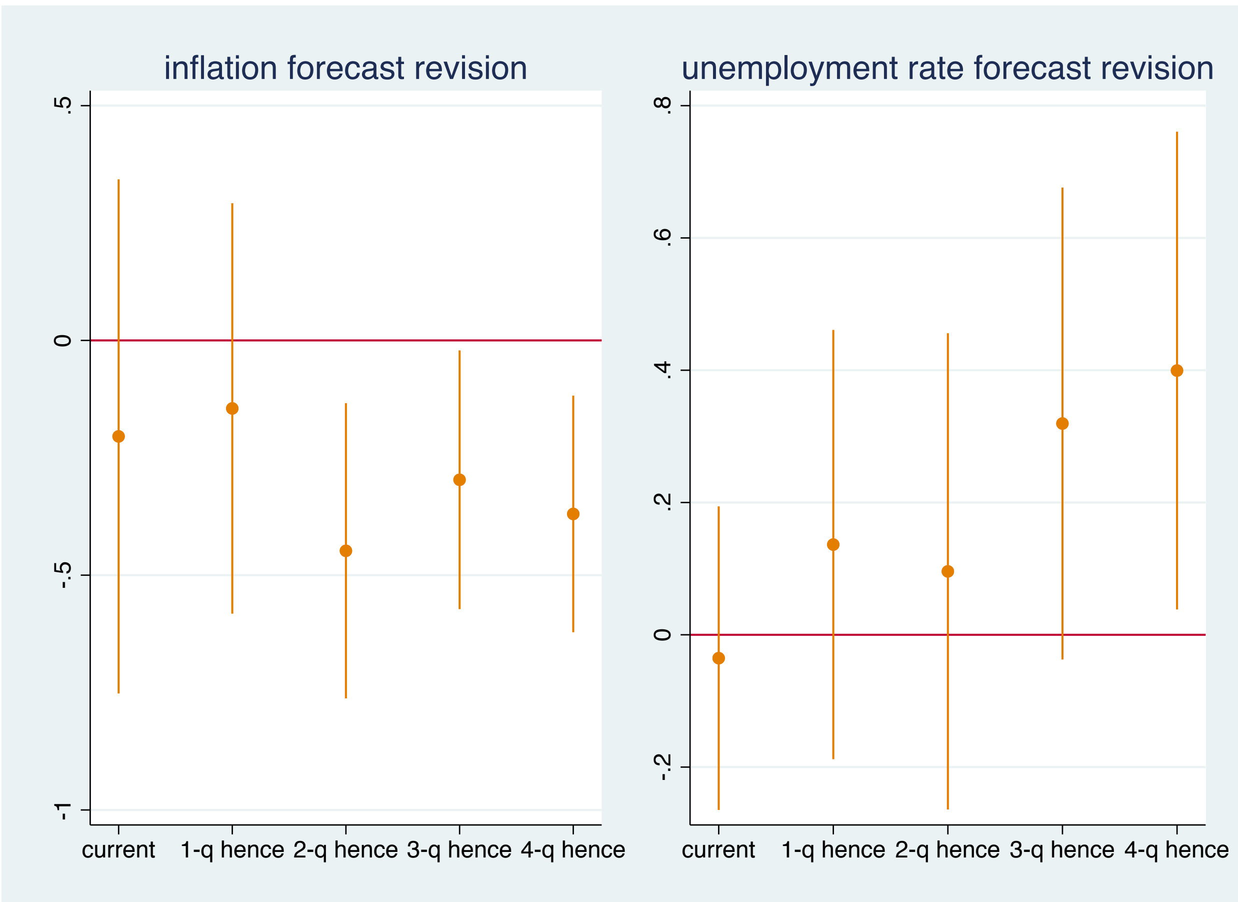
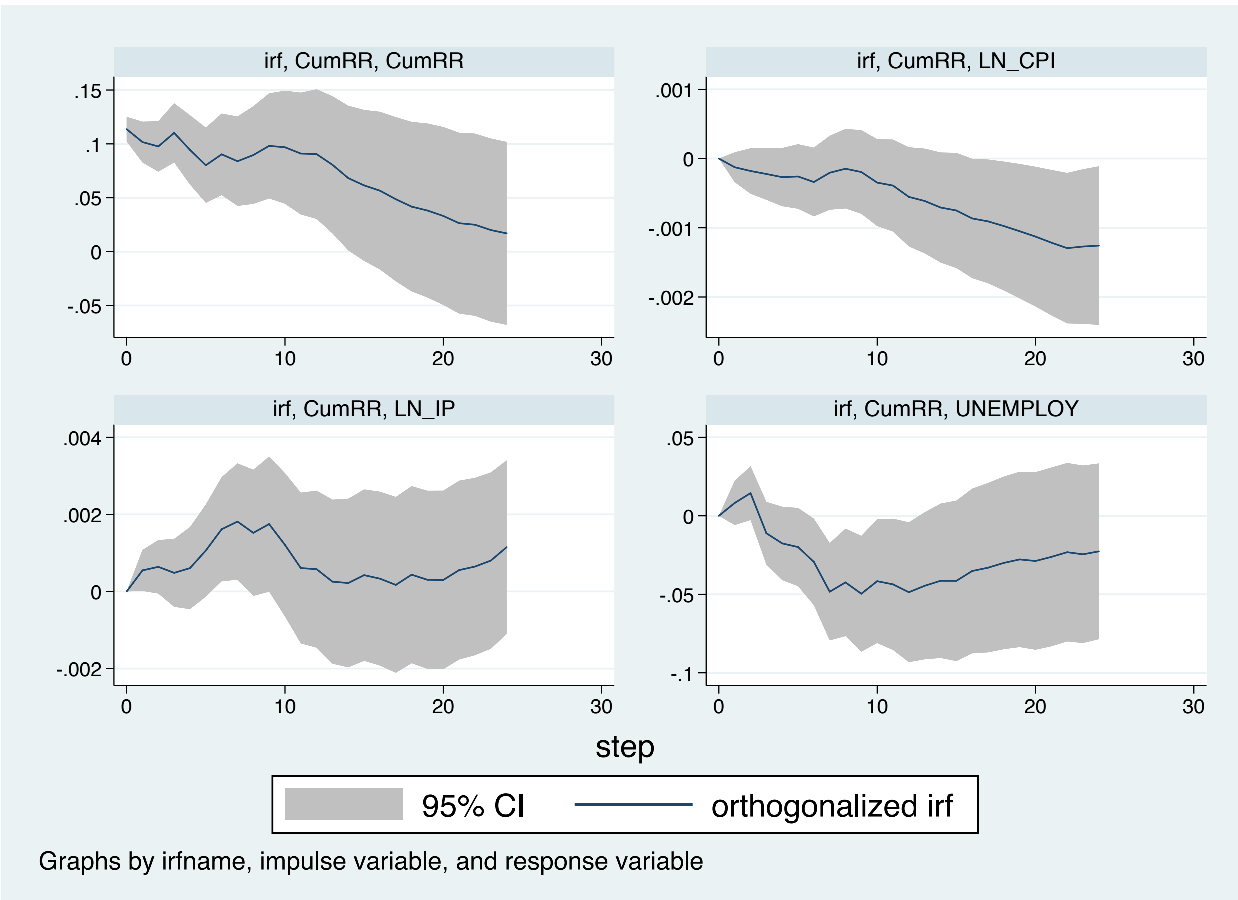
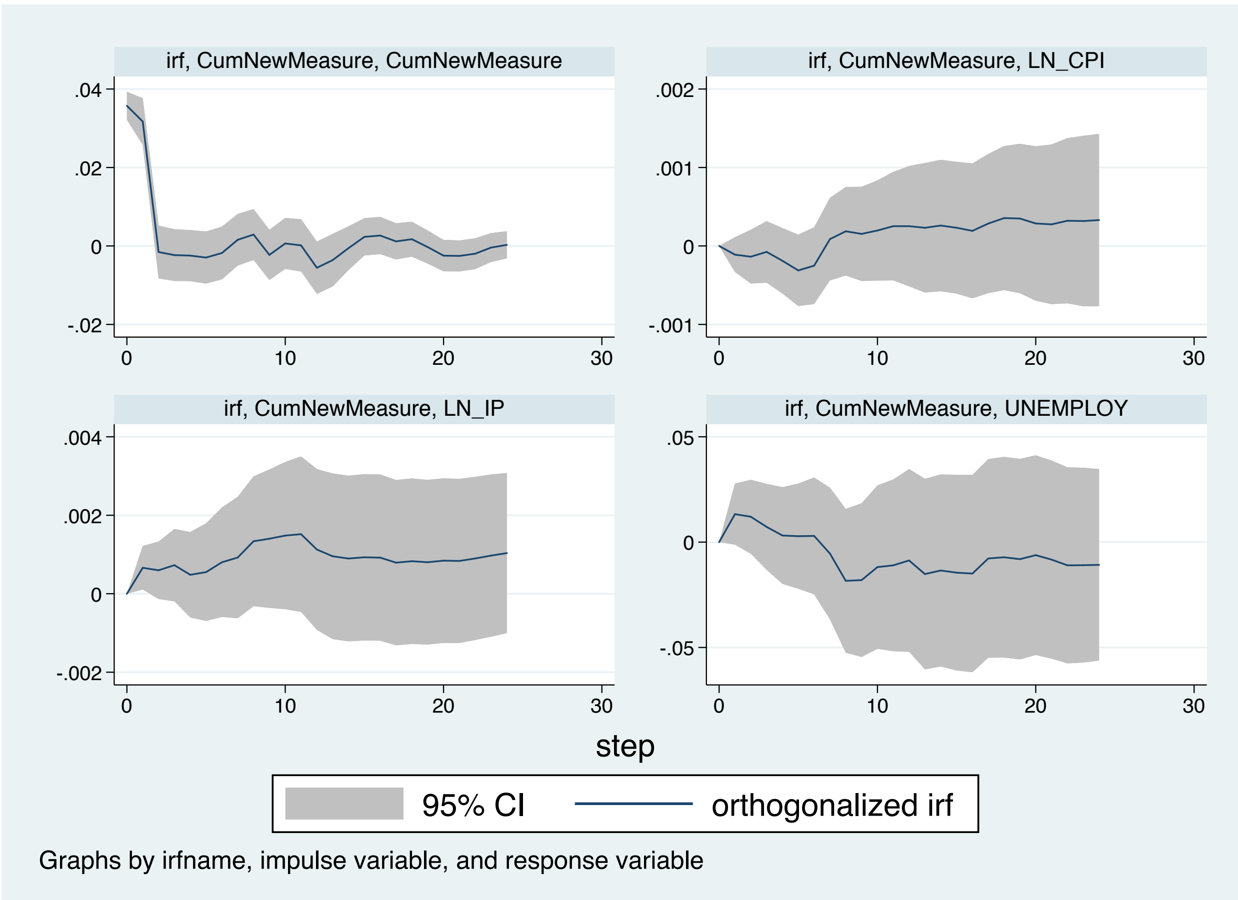


Figure 10: Impulse Responses Using Cumulative **Romer-Romer** Shock



NOTES: The upper right corner is the log of CPI, the lower left is log of industrial production and the lower right is unemployment rate.

Figure 11: Impulse Responses Using Cumulative **New Measure**



NOTES: The upper right corner is the log of CPI, the lower left is log of industrial production and the lower right is unemployment rate.

Appendix

A. Data

To construct the new measure of monetary shocks, I use the daily change in federal funds futures and eurodollar futures at different horizons. These data are obtained from Bloomberg.

I use the Greenbook 1-quarter backcast, nowcast, and up to 5-quarter forecasts of real GDP growth, nominal GDP growth, unemployment rate, and GDP deflator. The Greenbook data are hosted and maintained on the Philadelphia Fed website[6], https://www.philadelphiafed.org/research-and-data/real-time-center/greenbook-data/philadelphia-data-set. The original Greenbook can also be accessed in The Board of Governors's website https://www.federalreserve.gov/monetarypolicy/fomc_historical_year.htm

I obtain the FOMC meeting dates between February 1990 and December 2004 from the appendix to Gürkaynak et al. (2005), available at https://www.ijcb.org/journal/ijcb05q2a2x.pdf. As stated in their paper, prior to 1994, the FOMC did not explicitly announce changes in its target for the federal funds rate, but such changes were implicitly communicated to financial markets through the size and type of open market operation. Therefore, they define a monetary policy announcement date to be the one of the next open market operation following the FOMC decision. I obtain the the remaining FOMC meetings from the Federal Reserve Board website at http://www.federalreserve.gov/monetarypolicy/fomccalendars.htm. I cross-referenced these dates and times with data used in Nakamura & Steinsson (2018)[7].

To measure expectations of macroeconomic variables, I use data on expectations of GDP deflator and unemployment rate from the Blue Chip Economic Indicators. For each variable, I use the mean forecast, i.e. consensus forecast. Blue Chip carries out a survey from more than 50 leading business economists during the first few days of every month soliciting forecasts of these variables for at least the next 3 quarters and up to the next 8 quarters. The survey is conducted over two days, generally beginning on the first working day of each month and finishing within the first week of each month.

The daily zero-coupon nominal Treasury yields are obtained from Gürkaynak et al. (2007) dataset. The daily inflation-indexed Treasuries (TIPS) yield data is obtained from the updated Gürkaynak et al. (2010) online dataset.

To measure the comovement of stock price and Treasury yields, I have daily Treasury bond futures with maturities of 2, 5, 10 and 30 years as well as 3-month Eurodollar futures and S&P 500 E-mini futures data from Bloomberg.

To compare with other measure of monetary policy surprises, I obtain the updated Romer and

[6] This data set will be updated annually, usually in April.

[7] Data is available at https://eml.berkeley.edu/~enakamura/papers/realratesreplication.zip.

Romer shock series in Wieland & Yang (2016) at Wieland's website [8]. These are monthly data. To match the survey period of Blue chip data, I re-construct the monthly shock series in the Blue Chip regression in Section 1. I obtain the information robust measure constructed by Miranda-Agrippino & Ricco (2018) on Miranda-Agrippino's website http://silviamirandaagrippino.com/research/.

B. Surprise in federal funds target

Federal funds futures have a payout that is based on the average effective federal funds rate that prevails over the calendar month specified in the contract. Thus, immediately before an FOMC meeting, at time $t - \triangle t$, the implied rate from the current-month federal funds future contract, $FF1$, is largely a weighted average of the federal funds rate that has prevailed so far in the month, i_0, and the rate that is expected to prevail for the reminder of the month, i_1

$$FF1_{t-\triangle t} = \frac{d1}{D1}\rho_0 + \frac{D1 - d1}{D1} E_{t-\triangle t}(r_1) + \rho 1_{t-\triangle t} \tag{4}$$

where $d1$ denotes the day of the FOMC meeting, $D1$ is the number of days in the month, and ρ_1 denotes any term or risk premium that may be present in the contract. Then, by leading this equation to time t (one day after the policy announcement) and differencing, the surprise component of the change in the federal funds rate target, which we call MP_1, is given by

$$MP1_t = (FF1_t - FF1_{t-\triangle t}) \frac{D1}{D1 - d1} \tag{5}$$

Under the assumption that the change in the risk premium ρ in this narrow window of time is small in comparison to the change in expectations itself, Kuttner (2001) interpret (5) as the surprise change in monetary policy expectations.

[8] https://sites.google.com/site/johannesfwieland/Monetary_shocks.zip?attredirects=0