Forecast Error Monetary Policy Shocks

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Abstract

Much research on the impact of monetary policy on the broader economy has focused on identifying exogenous monetary policy shocks. Different approaches to addressing the inherent endogeneity of monetary policy have resulted in widely different estimates of the impact of Federal Reserve actions on the U.S. economy. This paper presents a new way of constructing monetary policy shocks by interpreting the Federal Reserve’s own forecast errors as policy shocks. Making use of a forward looking Taylor rule, we first construct a measure of the impact on the federal funds rate of the Fed’s errors in forecasting GDP and inflation. We then follow Romer and Romer (2004) and investigate the effect of the shock on output and price movements. On the one hand, we would hope that forecast errors would not have a large impact on the economy, particularly given their size and prevalence as documented in the forecast evaluation literature. On the other hand, we argue that the policy forecast error should be a high quality measure of a monetary policy shock given the effort the Fed puts towards producing forecasts that do not have an endogenous error component. Our results suggest that the impact of our shock on the macroeconomy is quite small which lead us to conclude that monetary policy shocks of this type have little effect on the U.S. economy.

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I. Introduction

This paper presents a method for measuring monetary policy shocks based on the forecast errors of the Federal Reserve. We begin by assuming the Federal Reserve sets its federal funds interest rate target according to a forward-looking Taylor Rule. The shock is then found to be a weighted sum of inflation and output growth forecast errors, following the approach of Sinclair et al. (2012). The Fed puts significant resources into producing accurate forecasts and is generally judged the best forecaster for the U.S. economy, particularly for output and inflation, which are the two series used in the Taylor Rule. This suggests that the forecast errors of the Fed should be exogenous. If the Fed does follow a forward-looking Taylor Rule, as much research suggests they do, then we can interpret the impact of the Fed’s forecast errors on the federal funds rate that the Fed targets as an exogenous shock which can then be used in the traditional ways to evaluate the impact of a monetary policy shock on the economy.

Previous work on measuring monetary policy shocks has attempted to separate the actual policy change from the policy change that was expected based on an information set dated prior to the policy change. These previous works capture unexpected monetary policy. We take the view that the Federal Reserve attempts to minimize monetary policy surprises. Therefore, the unexpected component of monetary policy is likely to be small. Our shock thus captures a

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2 See, for example, Romer and Romer (2000), Gamber and Smith (2009), and El-Shagi et al. (2014).
3 One potential criticism of our assumption that the forecast errors are exogenous to other events in the economy is the research that suggests that forecast errors are worse around turning points (e.g. Sinclair et al., 2010). We plan to address this in future work.
4 This is especially true since the Fed moved toward greater policy transparency after 1994. Using federal funds futures data, Lang, et al. (2003) found that prior to 1993, 60 percent of federal funds rate changes were surprises. After 1994 that percent fell to 24 percent.
different dimension of surprise. If policy is based on forecasts, forecast errors will cause actual policy to deviate from intended.

We examine the role of our monetary policy shock using the same regression methodology as Romer and Romer (2004, henceforth R&R). We compare the effect of our policy shock on output and prices against a variety of other popular monetary policy shock measures, such as the R&R narrative shock, standard VAR monetary policy shock, and a hybrid R&R VAR shock. Our results are consistent with the literature in that we find the R&R shock tends to produce the largest impact on output and prices (regardless of the measure of output and price variables), while our measure of policy shock produces the most moderate impact, with the VAR shocks in between.

Section 2 presents a brief review of the relevant literature. Section 3 presents our methodology for constructing the shock as well as comparison across shocks. Section 4 describes the data, Section 5 details our empirical results and Section 6 presents various robustness checks of our analysis. Section 6 presents our conclusions and the implications of our results.

II. A Brief Review of Alternative Monetary Policy Shock Measures

The standard method for constructing monetary policy shocks is as follows:

\[ r_t = r^t_{it-i} + shock_t, \]  

\[ \text{Eq. 1} \]

\[ ^5 \text{Using the terminology coined by Coibion (2012).} \]
where \( r_t \) is the policy instrument, \( r_{t-1} = E[r_t | \Omega_{t-1}] \) is the expectation of the policy instrument based on information set \( \Omega_{t-1} \). The difference between the expectation and the actual values of the instrument, \( shock \), measures the unanticipated movement in policy.

In the VAR approach to measuring monetary policy shocks \( \Omega_{t-1} \) contains the past values of policy as well as past values of the other variables in the VAR. In Romer and Romer (2004) and Thapar (2008), \( \Omega_{t-1} \) contains the Federal Reserve’s Greenbook forecasts.

The measure of monetary policy shocks described by equation (1) is clearly sensitive to the researcher’s choice of information set. There are two dimensions to this choice: a cross-sectional dimension and a time-series dimension. The cross-sectional dimension is the choice about what variables to include in the information set. The evolution of the VAR literature on measuring monetary policy shocks illustrates this choice. Sims (1992) identified a price puzzle where the price level increases in response to a monetary tightening. He reasoned that the Fed likely conditions its policy on indicators of future inflation. In a VAR that does not include these indicators, the price level is actually responding to a combination of the inflation that is in the pipeline and the monetary tightening. Therefore, omitting indicators of future inflation will lead to an increase in the price level in response to a monetary tightening. Sims resolved this issue by adding commodity prices to \( \Omega_{t-1} \).

It is obviously not possible for a VAR to include all of the varied and detailed information that the Federal Reserve incorporates into their monetary policy decisions.\(^6\) The validity of the VAR methodology rests on whether the small number of variables included in the VAR is a reasonable approximation to that varied and detailed information.

\(^6\) Though scholars have tried, either with larger scale monetary VARs identified with sign restrictions (for example, Faust and Rogers, 2001), or using the FAVAR approach as in Bernanke, Boivin, and Eliasz (2005).
Romer and Romer (2004) and Thapar (2008) take the view that variables included in \( \Omega_{t-1} \) by VAR researchers do not closely approximate the information set used by the Federal Reserve. They therefore replace VAR generated forecasts with the Fed’s own Greenbook forecasts which presumably include varied and detailed information about the economy.

The second dimension to the choice of what to include in the information set is the temporal dimension. If a researcher is using quarterly data (Thapar, 2008, for example) and information that might influence the Fed’s policy choice becomes available at a higher frequency, the measured shock will be mis-identified because it will actually include systematic changes in the Fed’s policy instrument.

Kuttner (2001), Poole and Rasche (2003), Lang et al. (2003), Swanson (2006), and Barakchian and Crowe (2013) attempt to measure monetary policy shocks using high-frequency data on federal funds futures in order to minimize the misspecification described above. These authors define monetary policy surprises as the difference between the federal funds rate expected by the futures market and the actual realized federal funds rate target. These measures show a large decline in the proportion of federal funds interest rate targets that is due to monetary surprises after 1994.

Overall in this literature there remains substantial debate as to the best way to identify a monetary policy shock as well as the size of the impact of the resulting shocks. The main question is whether the identified shocks are truly exogenous, or if they are impacted in some way by anticipatory movements or other factors such that they do not accurately measure the impact of monetary policy on the economy. This leads us to produce a new measure of monetary policy shocks which should provide new insight on these issues.
III. Construction of the New Monetary Policy Shock

We assume that the Fed implicitly follows a forward-looking Taylor rule (Clarida, et al., 2000) as the monetary policy rule. By “forward looking” we mean that the Fed sets the federal funds interest rate target based on forecasts of output growth and inflation. Our measure of monetary policy shocks is derived from the Taylor Rule as a weighted average of the forecast errors for inflation and output growth.

According to the forward-looking Taylor rule, the Fed, sets a target federal funds rate, $i^f_t$, based on equation (2) below, where the superscript “$f$” denotes that the target is based on forecasted variables. The Fed’s interest rate target ($i^f_t$) is written as:

$$i^f_t = r^* + \pi^f_{t+h} + 0.5(\pi^f_{t+h} - \pi^*) + 0.5(y^f_{t+h} - y^*), \tag{2}$$

where $r^*$ is the equilibrium real interest rate, $\pi^*$ is the Fed’s implicit inflation rate target, and $y^*$ is the potential output growth rate. The Fed forecasts both inflation, $\pi^f_{t+h}$, and output growth, $y^f_{t+h}$, $h$ periods ahead.

The actual outcome in period $t+h$, however, likely differs from the Fed’s forecasts. Therefore, if the members of the FOMC had known the actual values for $\pi^f_{t+h}$ and $y^f_{t+h}$ (i.e., if they had perfect forecasts or perfect foresight), they would have chosen a (potentially different)
federal funds rate. Consequently, their interest rate target under perfect foresight \( (i^T_{t+h}) \) would have been:

\[
i^T_{t+h} = r^* + \pi_{t+h} + 0.5(\pi_{t+h} - \pi^*) + 0.5(y_{t+h} - y^*),
\]

(3)

where \( \pi_{t+h} \) and \( y_{t+h} \) represent the actual realizations of inflation and real output growth \( h \) periods ahead. The difference between \( i^T_{t+h} \) and \( i^F_{t+h} \) measures the difference in the Fed funds rate that occurs because of inaccurate forecasts of output growth and inflation and thus represents the monetary policy shock:

\[
\text{shock}_t = i^T_{t+h} - i^F_{t+h} = 1.5(\pi_{t+h} - \pi^f_{t+h}) + 0.5(y_{t+h} - y^f_{t+h}).
\]

(4)

The differences, \( (\pi_{t+h} - \pi^f_{t+h}) \) and \( (y_{t+h} - y^f_{t+h}) \), are the Fed’s forecast errors for the inflation rate and real output growth respectively. In equation (4) we define the shock as perfect foresight minus forecast, following the traditional forecast evaluation literature. In our analysis below, however, we then take the inverse of the shock to be consistent with the traditional definition for a monetary policy shock. Throughout the results section we will be focusing on a contractionary monetary policy shock.

IV. Data

The forecasts used to construct our monetary policy shock are from the Federal Reserve’s Greenbooks from the middle of each quarter from 1965Q4 through 2008Q4 (the Greenbook forecasts are only available after a five year delay) available from the Federal Reserve Bank of Philadelphia. The projections used in this analysis are the growth rate of real output (GNP from 1965 to 1991 and GDP from 1992 on)\(^9\) and the inflation rate (based on the implicit price deflator

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\(^9\) The last forecast in the fourth quarter of 1991 was the first forecast of GDP.
through the first quarter of 1996, then the chain-weighted PCE price index from 1996Q2 on).
Our main results are based on the 4 quarter-ahead forecasts of real output growth and inflation.
The actual figures were the data published approximately 90 days after the end of the quarter to
which they refer. Use of the real time data avoids definitional and classification changes.

The output data we focus on for measuring the impact of our policy shock on the
macroeconomy are real GDP (seasonally adjusted) from the Bureau of Economic Analysis and
Industrial Production (seasonally adjusted, average of monthly data) from the Federal Reserve.
For inflation we use the GDP Deflator (seasonally adjusted, 2009 = 100) and the Personal
Consumption Expenditures chained type price index (seasonally adjusted, 2009 = 100), both
from the Bureau of Economic Analysis.

V. Results

a. Comparison of the Monetary Policy Shocks

We use the regression framework in R&R to analyze the effect of our monetary policy
shock on output and prices. The basic specification is set up as follows:

\[ x_t = a_0 + \sum_{i=1}^{L_x} b_i x_{t-i} + \sum_{j=1}^{L_S} c_j S_{t-j} + e_t \] (5)

where \( x \) indicate the macroeconomic variable under investigation (growth rate of output
or price measures) and \( S \) indicates the monetary policy shock series used to capture the direct
impact of shocks on the macroeconomic variable. Lagged values in both the macroeconomic
variable and shock series are allowed for to accommodate the dynamic movements of the
variable and possible delayed effect of shocks, where \( L_x \) is the maximum number of lags
included of the dependent variable and \( L_S \) is the maximum number of lags included of the shock.
For both output and inflation we use a maximum of eight quarters of lags of the dependent
variable. For output we use twelve quarters of lags of the shock, whereas for inflation we allow for a longer set of lags for the shock extending it to 16 quarters. This is similar to R&R who argue that “there appear to be longer lags in the impact of policy on prices” (page 1073).

To summarize the results, we examine the impulse response of the macroeconomic variable to a one-time realization of the monetary policy shock series of 100 basis points. The impulse responses are cumulated to show the effect of the shock on the levels of the macroeconomic variables rather than their growth rates. The output measure we focus on is GDP and the price measure is the GDP deflator. Alternative measures are considered in the robustness section. All of our analysis is done at the quarterly frequency.

We also consider a range of alternative measures of monetary policy shock to compare against our benchmark monetary policy shock measure. Similar to Coibion (2012), we look at:

- R&R narrative monetary policy shock\(^{10}\)
- Monetary policy shock extracted from a standard 3 variable (output, price, fed funds rate) VAR identified using short-run Cholesky decomposition. This is a variation of the VAR examined by Christiano et al. (2006), and also used by Romer and Romer (2008), and more recently by Barakchian and Crowe (2013).
- Hybrid monetary policy shock extracted from the same standard 3 variable VAR as specified above but with the cumulated R&R shock replacing the fed funds rate.

In addition, we compare our results against a naïve specification of equation (5) with the change in the actual fed funds rate as the shock series.

\(^{10}\) We use the expanded R&R shock constructed by Barakchian and Crowe (2013) in order to allow for as long of a sample period as possible for comparison purposes. The monthly shock series is summed to produce its quarterly equivalent.
It is important to first examine the scale and historical pattern seen in our shock as compared to the others in the literature. This is shown in Figures 1 through 4. All the shocks are normalized following the standard in the literature where a positive shock is capturing a contractionary movement in policy.

The first noticeable difference between the policy forecasting shock and the others is that it has a much larger magnitude. The only one that comes close is the early part of the sample of the naïve change in federal funds rate. Forecast errors are frequent and large as compared to other shocks that have been previously used to identify exogenous changes in monetary policy.

The other interesting pattern obvious in these comparisons is at the end of the sample: the other shocks all suggest that there were expansionary shocks in 2007 and 2008 (the beginning of the Great Recession), but our shock suggests that as the Fed was overestimating output and inflation in this period it resulted in a large contractionary shock.

b. The Impact of Policy Shocks on Output

For our single equation regression analysis, the sample period used goes from 1972Q1 to 2008Q2. Following R&R we impose 2 years of lags for the output measure and 3 years of lags for the shock series. Figure 5 shows the impulse response of GDP to a 100 basis point innovation in the monetary policy shock series. The impulse response functions (IRFs) are surrounded by 1-standard error bands. To put this result in context, Figure 6 plots the IRF of our shock along with the IRFs of the other main shocks used in the literature. Overall we can see

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11 One reason our shock is so large is because we did not allow for smoothing in the Taylor rule. As discussed in Sinclair et al. (2012), smoothing monotonically decreases the magnitude of the shock. Thus our results provide an upper bound for the size of the shock. Given that our results suggest that the impact of even the large shock is small, we report only this upper bound.

12 Error bands constructed using Monte Carlo methods where we repeatedly draw coefficients from a multivariate normal distribution with mean and variance-covariance matrix given by the point estimates and variance-covariance matrix of the regression coefficients. The standard errors are the standard deviations over each forecast horizon across the different 1000 draws that we conduct.
that the estimated impact of our shock is quite muted as compared to the other shocks used in the literature. This however, might be due to using 100 basis points in all cases. Given that our shock is much larger than the others, perhaps a one standard deviation comparison would show a larger impact. This we explore in Figure 7. Even in this case the impact of our shock looks quite small.

c. The Impact of Policy Shocks on Prices

Figure 8 illustrates the impulse responses of prices as measured by the GNP/GDP deflator price index to a 100 basis point increase in the monetary policy shock variable. The estimation of equation (5) here includes 2 years of lags for the price variable and 4 years of lags for the shock series. This follows R&R who argued that the impact of monetary policy on price is longer lasting. Similar to what we presented for output, we include in Figures 9 and 10 the IRFs for the other commonly used monetary policy shocks both on a common 100 basis point scale (Figure 9) and on a 1 standard deviation scale (Figure 10). From both of these it is clear that our shock has a similar impact to the others at the low end of the estimates, with the R&R narrative shock having a much larger impact than the others.

VI. Robustness Checks

a. Alternative Measures of Output and Inflation

For a first set of robustness checks we explored other measures of output and inflation. For output we used Industrial Production. The results are presented in Figures 11 through 13. For inflation we used the PCE price index. These results are presented in Figures 14 through 16. Our results for IP are very similar to the results reported for GDP. For inflation, however, there are some notable differences between the deflator results and the PCE results. In particular, for PCE we find an economically small, but statistically significant positive response to our shock.
whereas all other shocks show a negative response. Due to the small economic size of the impact, combined with the fact that the other shocks, notably R&R, also move up, we continue to interpret these results as consistent with our finding that the overall impact is small (and in this case of the opposite sign).

b. Limiting the Sample Size

We also considered a shorter sample period from 1990Q4 to 2008Q2. A number of researchers have argued that monetary policy might be different in this sample. For example, Barakchian and Crowe (2013) argue that monetary policy has become more forward looking during this period. Coibion (2012) argues that the Volcker period drives the strong results for Romer & Romer shock. In this analysis we took the shocks constructed for the full sample and only restricted the sample for estimating equation (5). We leave for further research constructing the shocks for the shorter sample as well as changing the weights in the Taylor rule for the later sample as suggested by Clarida et al. (2000). Figures 17-19 present the results for GDP and Figures 20-22 present the results for inflation. Although the results for some of the other shocks are affected by the change in sample size, our results are remarkably consistent and remain economically small.

c. The Role of Forecast Horizon

There has been much debate in the Taylor rule literature about the length of the forecasting horizon that the Fed uses in the Taylor rule. To obtain a proper estimate of the policy shock, it is important to use the appropriate forecast horizon used by the Fed.\textsuperscript{13} We considered

\textsuperscript{13} For example, Sinclair et al. (2012) focus on short horizons to avoid being affected by the Fed’s future path for monetary policy. If that is not actually the horizon used by the Fed in the Taylor rule, however, then it would be an inappropriate measure for the policy shock.
different alternative horizons, including the current quarter forecast which is presented in Figure 23 for GDP. This graph shows a very different impact for GDP than our previous results – for horizons 12+ quarters out we find a statistically significant positive output response to what we would think would be a contractionary shock. We interpret this to suggest that the Fed is indeed using a forward looking Taylor rule.

VII. Conclusions and Implications of Results

This paper constructs a measure of unintended monetary policy based on forecast errors in the Taylor rule. Monetary policy shocks are defined as the difference between the target federal funds rate that would have been set using the Taylor rule with perfect foresight and the federal funds rate target that would have been set using the Taylor rule based on forecasted output growth and inflation.

Our results suggest that the shock has the expected direction of impact on real output and prices, but that the impact is much smaller than that identified from other monetary policy shock measures. Given that the forecast errors are supposed to be orthogonal to all known variables in the economy in order for the Fed to be producing rational forecasts, it seems that our forecast error measure should be a high quality measure of exogenous variation in monetary policy. Thus our results suggest either that monetary policy has little effect on the economy or that the effects of intentional monetary policy may be different than the effects of monetary policy mistakes, at least ones that come in the form of forecast errors.
References


Figure 1: Policy Forecasting Shock vs Fed Funds Rate

Figure 2: Policy Forecasting Shock vs Romer & Romer

Figure 3: Policy Forecasting Shock vs VAR Shock
Figure 4: Policy Forecasting Shock vs Hybrid VAR Shock

Figure 5: Impact of policy Forecasting Shock on GDP
Figure 8: Impact of Policy Forecasting Shock on Deflator

Figure 9: Impact of All Policy Shocks on Deflator (100 basis pt)
Figure 10: Impact of All Policy Shocks on Deflator (1 SD)

Figure 11: Impact of policy Forecasting Shock on IP
Figure 12: Impact of All Policy Shocks on IP (100 basis pt)

Figure 13: Impact of All Policy Shocks on IP (1 SD)
Figure 16: Impact of All Policy Shocks on PCE (1 SD)

Figure 17: Impact of Policy Forecasting Shock on GDP, 1988Q4 to 2008Q2
Figure 18: Impact of All Policy Shocks on GDP (100 basis pt), 1988Q4 to 2008Q2

Change in actual fed funds rate
Romer & Romer Narrative Shock
Policy Forecasting Shock
Barakchian & Crowe Shock

Figure 19: Impact of All Policy Shocks on GDP (1 SD), 1988Q4 to 2008Q2

Change in actual fed funds rate
Romer & Romer Narrative Shock
Policy Forecasting Shock
Barakchian & Crowe Shock
Figure 20: Impact of Policy Forecasting Shock on Deflator, 1988Q4 to 2008Q2

Figure 21: Impact of All Policy Shocks on Deflator (100 basis pt), 1988Q4 to 2008Q2
Figure 22: Impact of All Policy Shocks on Deflator (1 SD)

Figure 23: Impact of Policy Forecasting Shock (with nowcast) on GDP