Accommodative Monetary Policy Shocks Do Not Stimulate Output

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Abstract:

This paper investigates whether the response of U.S. output to a monetary policy shock is symmetric over three dimensions: the direction of the shock, the size of the shock, and what phase the business cycle is in when the shock takes place. Theory suggests that looking at individual asymmetries may not tell the whole story and that interactions among the asymmetries may be important. My results show that business cycle and directional asymmetry are important while the size of the shock is less so. In addition, the directional asymmetry results are being driven by monetary policy stimulus in recession having little effect on output. Models that do not incorporate directional asymmetry are likely to miss this result. This calls into question the ability of traditional monetary policy to combat recessions.

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1 Introduction

There is a large literature focusing on whether the effects of monetary policy shocks are asymmetric across multiple dimensions. The literature has focused mainly on three dimensions: asymmetry related to the direction of the shock, the size of the shocks, and asymmetry related to the phase of the business cycle. The asymmetry literature began with Cover (1992) who was interested in studying directional asymmetry. Since then, a large literature has explored all three types of asymmetry with varying results. This paper will contribute to the asymmetry literature by studying all three manifestations of asymmetry simultaneously. While this literature has focused on many countries including the United States, I study the asymmetric effects of monetary policy using U.S. data.

Most papers study one particular type of asymmetry at a time as in Cover (1992), Morgan (1993), Thoma (1994), Kandil (1995), Karras (1996), Peersman and Smets (2002), Garcia and Schaller (2002), Kaufmann (2002), Tenreyro and Thwaites (2016), and Angrist et al. (2018). A small group of papers attempt to study multiple manifestations of asymmetry simultaneously, including Weise (1999), Ravn and Sola (2004), and Lo and Piger (2005). It is important to consider the asymmetry types simultaneously since inherent in any model with only one type of asymmetry is an assumption that the results are not being driven by the other two types of asymmetry. By including all three types of asymmetry, this assumption can be dropped.

Most papers in the business cycle asymmetry literature, such as Thoma (1994), Weise (1999), Peersman and Smets (2002), Kaufmann (2002), Garcia and Schaller (2002), and Lo and Piger (2005) find that monetary policy has a larger impact on output during recessions than expansions. However, more recent evidence from Tenreyro and Thwaites (2016) finds that the output effects of monetary policy shocks are much larger in expansions than recessions. In the directional asymmetry literature, most of the early papers found that contractionary monetary policy shocks had more of an effect on output than accommodative monetary policy. Cover (1992) found that negative money supply shocks have a negative effect on output while positive money supply shocks have little effect on output. Kandil (1995) and Karras (1996) agree with the result that negative money supply shocks have larger effects on output than positive money supply shocks. Morgan (1993) used the federal funds rate as his policy measure and found that contractionary monetary policy reduces output while accommodative policy has insignificant effects.

Weise (1999), Ravn and Sola (2004), and Lo and Piger (2005) all find little evidence of directional asymmetry in their models that simultaneously estimated multiple asymmetries. There is much less evidence regarding size asymmetry than exists for the other two types of asymmetry. Evidence for this type of asymmetry comes from Weise (1999) and Ravn and Sola (2004). Weise (1999) found that large shocks had disproportionately larger effect than small shocks while Ravn and Sola (2004) found that large shocks were neutral and small shocks had real effects on output. Lo and Piger (2005) also studied size asymmetry but found no evidence for this type of asymmetry.

The theme that exists between each of the asymmetry types is that there is no consensus about the direction of the asymmetry or which types of asymmetry are important. Reaching a consensus in this literature is important given the importance of monetary policy to control inflation during expansions and boost output during recessions. If traditional monetary policy is not very effective at impacting output during recessions then fiscal policy and non-traditional monetary policy might have more of a place moving forward. Knowing about size asymmetry is important as well. If small shocks are found to have disproportionately larger effects on output than larger shocks then central bankers can respond to recessions by taking smaller policy actions rather than resorting to large scale changes.

My analysis will focus on investigating multiple manifestations of asymmetry in the same model. This paper will use a similar methodology as Tenreyro and Thwaites (2016) by using the local projection framework developed in Jordá (2005), but will study multiple manifestations of asymmetry at the same time and the possible interactions between them. The few papers that look at multiple types of asymmetry do not consider the interactions between them, making this a novel contribution to the literature. In addition to this contribution, the use of local projections will provide me with a simple framework to investigate multiple types of asymmetry. The existing literature has made use of non-linear VAR models when studying the asymmetric effects of monetary policy. In VAR models, restrictive assumptions must be made about the short-run dynamics of the model in order to extrapolate forward and calculate the impulse responses. This becomes even more complicated when a non-linear VAR or a VAR model with regime switching is used since the state over the horizon must be considered when interpreting the impulse responses. Local projection models bypass this problem by directly calculating the impulse responses over the horizon based on the state of the model at time t. This will make the impulse responses generated from this model easier to interpret than impulse responses from a VAR model.

My analysis finds that business cycle asymmetry and directional asymmetry are important for explaining changes in output while size asymmetry is less so. The interaction between business cycle and directional asymmetry is also found to be an important factor for explaining output. Monetary policy shocks are found to affect output more in recessions than expansions. Contractionary monetary policy shocks are found to affect output in both recessions and expansions while accommodative monetary policy shocks have little effect on output in recessions and a negative effect on output during expansions. This result shows the value added of including multiple types of asymmetry in the same model. A model containing only business cycle asymmetry might incorrectly conclude that accommodative monetary policy is effective during recessions while the business cycle results are being driven by policy contractions.

The rest of the analysis proceeds as follows: Section 2 lays out the existing literature and my contribution to this literature. Section 3 lays out the model to be estimated. Section 4 lays out the results of the analysis. Section 5 concludes.

2 Literature Review and Motivation

There is a sizable literature investigating whether monetary policy shocks have asymmetric effects on output or prices depending on the phase of the business cycle, the size of the policy shock, or the direction of the shock. Most papers in this literature focus on a single type of asymmetry. In this paper I will focus on asymmetric effects of monetary policy shocks on measures of output, and will consider all three types of asymmetry simultaneously. The remainder of this literature review will summarize the existing literature on all three types of asymmetry.

There are three main theoretical arguments that can be used to explain the asymmetric effects of monetary policy on output. The first theoretical model that features monetary policy asymmetry are rigid price models. Prices in these models are more rigid in the downward direction and this manifests itself as a convex short-run aggregate supply curve. This can be used to explain all three types of asymmetry with respect to output. Directional asymmetry is present since accommodative monetary policy will have more of an effect on output than contractionary monetary policy through its effects on the aggregate demand curve. Business cycle asymmetry is present since a recession means that the intersection between the aggregate demand curve and short-run aggregate supply happens to the left of potential GDP on the flat portion of the short-run aggregate supply curve. At this point, a shock in either direction will affect output more than a shock during an expansion, where the intersection of aggregate demand and the short-run aggregate supply curve is on the vertical portion of the short-run supply curve. Size asymmetry will also show up depending on where the short-run equilibrium occurs on the short-run supply curve. For example, on the flat portion of the curve, small monetary policy shocks will disproportionately affect output more than large shocks.

The second theoretical argument is the credit channel theory laid out in Bernanke and Gertler (1995). This channel works through the balance sheet channel of firms and the decision by these firms to use external finance through banks and other financial institutions.

During business cycle expansions, firms have a surplus of internal funds that can be used so they will be less likely to use external finance to fund their operations. During business cycle recessions, the internal sources of funds dry up, meaning firms will more heavily rely on external financing. Since monetary policy affects the macroeconomy through financial institutions and external finance, monetary policy actions will have more of an effect on output during recessions when external finance is being more widely used.

The third theoretical argument can be used to explain size asymmetry. Menu cost models are models where firms face costs, known as menu costs, to adjust their prices. If the prices of a firms inputs only change by a small amount then the increase in profits from adjusting prices may be smaller than the cost associated with changing prices, so the firm will decide to not change its prices. Only when this price change gets large enough will firms undergo price changes. In this case, only small shocks will have real effects on output since firms will adjust their prices proportionally to the shock when the shock is large.

The empirical monetary policy asymmetry literature began with Cover (1992), who studied asymmetry between accommodative and contractionary monetary policy. Money supply shocks were used as the measure of monetary policy. This paper employed a two-step procedure to estimate monetary policy shocks. The first step involved specifying the money supply process and obtaining the residuals from the regression of that process. The second step involved using these residuals as the monetary policy shock series upon which output, measured as real gross national product, could be regressed. By regressing output growth on positive and negative money supply shocks, he found that contractionary monetary policy shocks had no effect on output but accommodative monetary policy shocks decreased output.

There have been a few other papers that studied directional asymmetry. Kandil (1995) and Karras (1996) found similar results to Cover (1992) while also employing a similar method. Kandil (1995) used real industrial production and the consumer price index from nineteen industrialized countries and found that prices and wages tend to respond more to contractionary monetary policy than to accommodative monetary policy. Karras (1996) used real GDP in a panel of 38 different countries and found evidence supporting international asymmetry between accommodative and contractionary monetary policy. A more recent paper, Angrist et al. (2018), used propensity score matching on the policy variable and found that contractionary monetary policy had an effect on yield curves and macroeconomic variables, industrial production and consumer price index among them, but monetary accommodation had less profound effects.

Regime switching frameworks are popular tools used to study the other two types of asymmetry. One can allow the states of the model to be recessions or expansions in the case of business cycle asymmetry or large and small shock regimes by tying the switching to the variance or size of the shocks. Peersman and Smets (2002) allow for regime switching between high and low growth rate periods. They measure monetary policy as a shock to the short-term interest rate from a simple VAR model, finding that monetary policy in the Euro-area had significantly larger effects on output, measured as industrial production, in recessions than expansions. Garcia and Schaller (2002) model regime switching as the economy switching from expansion and recession states. They use movements in the Federal Funds rate and innovations from a VAR as their monetary policy measures and find that US monetary policy has larger effects on output, measured using industrial production, during recessions than expansions. Kaufmann (2002) allows for switching between above average and below average growth periods. Kaufmann uses the first difference of the Austrian 3-month interest rate as the policy variable and using Bayesian methods, finds a significant negative effect of monetary policy on real GDP during below average growth periods and insignificant effects during normal and above average growth periods.

Tenreyro and Thwaites (2016) used the smooth-transition technique, developed in Granger and Teräsvirta (1993), to study business cycle asymmetry. Tenreyro and Thwaites (2016) innovated in two dimensions over the existing literature. First, they made use of the Romer and Romer monetary policy shocks from Romer and Romer (2004). Second, they employed local projections, developed in Jordá (2005), to generate impulse responses. Following these two methodologies they found that the response of output and prices to monetary policy shocks were more powerful in expansions than recessions. In this paper, I will use methodology similar to The Tenreyro and Thwaites (2016), specifically the combination of Romer and Romer (2004) monetary policy shocks and local projection methods.

An analysis of the theories behind the asymmetric effects of monetary policy on output suggest that a model containing a single type of asymmetry may not be enough to explain the movements in output. All three types of asymmetry can be partially explained by the convex aggregate supply curve theory, suggesting that there may be some interactions between the different types of asymmetry. In fact, the Aggregate Demand-Aggregate Supply model supports the idea that there may be interactions between the three types of asymmetry if the short-run aggregate supply curve is convex. If the short-run equilibrium takes place below potential GDP as it does during a recession, then small shocks will disproportionately affect output more than larger shocks and accommodative monetary policy will affect output more than contractionary monetary policy. Both of these asymmetries interact with business cycle asymmetry since these effects on output will be larger than they would be in a business cycle expansion. There have been a few papers that explored multiple manifestations of asymmetry within the same model, namely Weise (1999), Ravn and Sola (2004), and Lo and Piger (2005).

Weise (1999) considers all three types of asymmetry at once. Money based indicators of monetary policy are used, which come from ordering money last in a VAR model. The innovation of this paper was to show that these asymmetries could be modeled by applying a smooth-transition technique, developed in Anderson and Teräsvirta (1992), to a VAR model. Asymmetry is determined through the use of impulse response functions, calculated using forecasts generated by drawing shocks from the residuals of the model. By repeating this numerous times and averaging over initial values, you can get impulse responses for different subsamples of the data, such as low output growth versus high output growth periods. Weise did not find evidence of asymmetry regarding the direction of the shock but did regarding the phase of the business cycle and the size of the shock. Shocks during low growth periods were found to have larger effects on industrial production than shocks during high growth periods and large shocks were found to have disproportionately larger effect than smaller shocks. The size of shocks were measured based on their standard deviation, with the large versus small shock comparison based on a two versus a one-standard error shock. The size of shock asymmetry was particularly pronounced in negative, low growth rate periods suggesting that there are interactions between the types of asymmetry.

Ravn and Sola (2004) used unanticipated money supply shocks as their measure of monetary policy while revisiting the Cover (1992) (the seminal asymmetry paper) two equation model. They tie the regime switching to the mean and variance of the monetary policy shock, allowing them to study large versus small shocks in addition to the direction of the shock. They distinguish between four different types of shocks: large positive, large negative, small positive, and small negative. Large versus small shocks are defined by multiplying the residuals (unexpected money supply shocks) at time t by the probability of being in a small shock or large shock state at time t-1. Using US data, they find that large shocks are neutral while smaller shocks have real effects on real GNP and less support of directional asymmetry.

Lo and Piger (2005) use a regime switching framework to study all three types of asymmetry simultaneously as well as some interactions between the types of asymmetry. They use a time-varying transition probability model that allowed the switching process to be a function of the sign and size of the shock, as well as the phase of the business cycle. The shocks were identified from a monetary VAR model. Using US data, they found that policy actions taken during a recession had larger effects on industrial production than actions taken during expansions, but less evidence of the other two types of asymmetry.

To summarize the previous three papers, Weise (1999), Ravn and Sola (2004), and Lo and Piger (2005) use non-linear VARs or regime switching frameworks to generate impulse response functions. Their frameworks make it difficult to directly incorporate multiple types of asymmetry in a straightforward way and lead to impulse response functions with complicated interpretations. In this paper, I make use of the local projection methodology to generate impulse response functions. This will allow me to easily incorporate all three types of asymmetry into one model and directly calculate the impulse responses for each of these different states of asymmetry. In addition, my local projection model will allow me to easily incorporate interaction terms between the types of asymmetry, something these papers did not have in their models.

The use of local projections in the asymmetry literature was popularized by Tenreyro and Thwaites (2016). They used this model to study business cycle asymmetry and found that the response of GDP and prices to monetary policy shocks were more powerful in expansions than recessions. Developed by Jordá (2005), local projection models directly calculate the impulse response functions over increasing horizons without having to rely on extrapolation of short-run dynamics as in a VAR model. Local projections offer a few other advantages over VAR models. One, they are simple to estimate and draw inference from since they rely on running OLS over increasing time horizons. Two, local projections are more robust to misspecification of the data generating process than VAR models. Finally, local projections can more easily accommodate non-linear specifications in multivariate contexts.

The asymmetry literature generally measures monetary policy by using residuals from a simple monetary VAR or by using the Romer and Romer residuals, as discussed in Section 3.2. In both cases, there are outliers in the measured shocks that happen during the 1979-1982 time period, corresponding to the Volcker chairmanship at the Federal Reserve. There have been some papers in the asymmetry literature that have highlighted the importance of the Paul Volcker chairmanship period, which lasted from 1979-1987. Prior to and during his chairmanship was a period characterized by high inflation rates, making the Feds primary goal during this time to reign in inflation. Volcker also oversaw the transition of the Fed from targeting the money supply to the Federal Funds rate as its primary policy tool. This paper finds that the results of asymmetry vary depending on how the residuals in this period are treated, much like other papers in this literature.

Morgan (1993) showed that changes in the Federal funds rate showed some asymmetry in output when looked at over the full sample 1963:2-1992:3, finding that increases in the funds rate had more of an effect than a decrease. There is less evidence for this result when the period 1979:4-1982:4 was excluded from the sample, the period when the Fed deemphasized the Federal funds rate. Thoma (1994) studied asymmetry and instability in the money-income causality. He used a rolling regression approach to show that the p-value of the money-income causality test is highly correlated with the level of real economic activity. There were two periods in his sample that this relationship was the strongest, 1969-1973 and 1978-1982. Ravn and Sola (2004) were also concerned about this period, their regime switching model allowing them to control for the Volcker period since the change in policy that happened then produced some large negative outliers that needed to be controlled for. Specifically they found that a large outlier in the money supply equation appeared in the first quarter of 1983. They found that the results of Cover (1992) were not robust to this outlier. Even Romer and Romer (2004) find outliers during this time period and find that there are many problems with measuring shocks during this time. The baseline specification in this paper follows Romer and Romer (2004) by generating residuals from an estimation of the Feds reaction function. Analyzing the data for this period, one will find that the residuals generated will typically be the largest during the 1979-1982 period, suggesting that some of the varying results observed in the asymmetry literature might be driven by how papers dealt with this time period. Given the effect that this period can have on the results of monetary policy asymmetry, my baseline model will include a dummy variable for the Volcker period.

3 Empirical Strategy

In this section, I lay out the econometric method used in the paper. This section begins with a discussion of the local projection methodology for computing impulse responses and how inference is conducted in this framework. Second, the Romer and Romer (2004) monetary policy shock measure is discussed. Finally, a brief description of the data used for this paper is discussed.

3.1 Local Projection Model

I follow Tenreyro and Thwaites (2016) in the use of the local projection model, developed in Jordá (2005), for estimating impulse responses. The local projection approach has a few advantages over a VAR model. First, it is simple to estimate and draw inference from, requiring only running OLS over increasing time horizons. Second, this model is robust to misspecification of the data generating process. Finally, it can more easily accommodate non-linear specifications in multivariate contexts. Tenreyro and Thwaites (2016) used their local projection model to study the asymmetric effects of monetary policy on output and prices in regards to business cycle asymmetry. I modify their approach to include all three types of asymmetry in one model, estimating equations of this form:

$$y_{t+h} = c + \gamma^{'} x_t + \beta_h \varepsilon_t + \beta_h^{rec} \varepsilon_t rec_t + \beta_h^{small} \varepsilon_t small_t + \beta_h^{neg} \varepsilon_t neg_t + u_t \qquad (1)$$

where y_{t+h} is output measured in log levels at time horizon h, ε_t is the monetary policy shock, x_t is a control vector, rec_t is a dummy variable that is one if the shock ε_t takes place in a quarter t that is in a recession and zero otherwise, $small_t$ is a dummy variable that is one if the shock ε_t is small (defined below) in quarter t and zero otherwise, and neg_t is a dummy variable that is one if the shock ε_t is negative (accommodative monetary policy) in quarter t and zero otherwise.

Equation 1 is estimated using log levels of the output variable. I will instead work with first differences of the logged output variable, given the strong evidence of a stochastic trend in the log level of measures of output in the United States. To accomplish this, consider first the local projection of the first difference of the log level of output on the monetary policy shock:

$$\Delta y_{t+h} = c + \gamma^{'} x_t + \beta_{h,D}\varepsilon_t + \beta_{h,D}^{rec}\varepsilon_t rec_t + \beta_{h,D}^{small}\varepsilon_t small_t + \beta_{h,D}^{neg}\varepsilon_t neg_t + u_{t+h}^{D}$$

where $\beta_{h,D}$, $\beta_{h,D}^{rec}$, $\beta_{h,D}^{small}$, and $\beta_{h,D}^{neg}$ are the responses of the growth rate of output to a monetary policy shock under the different types of asymmetry. Note that the sum of growth rate responses gives the level responses. We can estimate this level response directly in the growth rate specification using the transformation suggested in Stock and Watson (2018). Summing the growth rates over h gives:

$$\sum_{i=0}^{h} \Delta y_{t+i} = \sum_{i=0}^{h} (c + \gamma^{'} x_t + \beta_{i,D}\varepsilon_t + \beta_{i,D}^{rec}\varepsilon_t rec_t + \beta_{i,D}^{small}\varepsilon_t small_t + \beta_{i,D}^{neg}\varepsilon_t neg_t) + \sum_{i=0}^{h} u_{t+i}^{D}$$

This can be simplified:

$$\sum_{i=0}^{h} \Delta y_{t+i} = c + \gamma^{'} x_t + \beta_{h}\varepsilon_t + \beta_{h}^{rec}\varepsilon_t rec_t + \beta_{h}^{small}\varepsilon_t small_t + \beta_{h}^{neg}\varepsilon_t neg_t + \sum_{i=0}^{h} u_{t+i}^{D}$$

where $\beta_{h,D}$, $\beta_{h,D}^{rec}$, $\beta_{h,D}^{small}$, and $\beta_{h,D}^{neg}$ are the responses of the log level of output to a monetary policy shock under the different types of asymmetry. These log level responses are equal to the sum of the growth rate responses up to horizon h. The terms inside the summation $\sum_{i=0}^{h} \Delta y_{t+h}$ cancel out, until this equation is left:

$$y_{t+h} - y_{t-1} = c + \gamma^{'} x_t + \beta_{h}\varepsilon_t + \beta_{h}^{rec}\varepsilon_t rec_t + \beta_{h}^{small}\varepsilon_t small_t + \beta_{h}^{neg}\varepsilon_t neg_t + \sum_{i=0}^{h} u_{t+i}^{D} \qquad (2)$$

The impulse response for the logged first difference of output for the different types of asymmetry are $\beta_{h,D}$, $\beta_{h,D}^{rec}$, $\beta_{h,D}^{small}$, and $\beta_{h,D}^{neg}$. The standard errors are calculated from the estimation of equation 2. This specification will be helpful because it will allow for all impulse responses to be reported in log level form rather than in logged first difference form, making it easier to draw conclusions.

Following Tenreyro and Thwaites (2016), the control vector will contain one lag each of output and the Federal funds rate. Impulse responses will be calculated out to twenty quarters, $H = 20$. The shocks developed in Romer and Romer (2004) will be used as the measure of the monetary policy shock (see Section 3.2) and real GDP will be used as the measure of output to construct the dependent variable.

The dummy variable rec_t is defined as one if the Romer and Romer (2004) shock takes place in a quarter t that is in a recession and zero otherwise. The NBER indicator is a monthly variable published by the National Bureau of Economic Research indicating if the U.S. economy is in a recession or expansion. To convert this measure to a quarterly measure I count a quarter as in a recession when one of the months in the quarter are counted as a recession by the monthly NBER indicator. The dummy variable $small_t$ is defined as one if the Romer and Romer (2004) shock is small in quarter t and zero otherwise. I follow Lo and Piger (2005) and define a small shock as any shock within one standard deviation of its historical mean and large shocks are anything larger than one standard deviation of its historical mean[1]. The dummy variable neg_t is defined as one if the Romer and Romer (2004) shock is negative in quarter t and zero if the Romer and Romer (2004) shock is positive. Negative shocks represent accommodative monetary policy while positive shocks represent contractionary monetary policy. When it comes to the shock measures in this paper, it is important to note that they represent different things. The business cycle shock measure represents the Fed responding to some outside variable, whether the economy is currently in a recession or expansion. The other two measures, size and directional shocks, represents

[1]The Romer and Romer residuals will be the main shock measure used. Since they are constructed as residuals from a regression they are mean zero by construction.

how the Fed responds with monetary policy. That is, when the Fed conducts monetary policy, it must decide to raise or lower the policy variable and by how much.

There are a few tests that can be run using Equation 2. One, we can test the null hypothesis that the effects of a monetary policy shock do not depend on whether the economy is in an expansion or recession by testing if $\beta_h^{rec} = 0$. Two, we can test the null hypothesis that the effects of a monetary policy shock do not depend on whether the shock is small or large by testing if $\beta_h^{small} = 0$. Third, we can test the null hypothesis that the effects of a monetary policy shock do not depend on whether the shock is positive or negative by testing if $\beta_h^{neg} = 0$.

There are several implicit assumptions that were made in Equation 2. One, the differential effects of a monetary policy shock that are due to the shock occurring when the economy is in an expansion or recession do not depend on whether the shock is a large versus small shock or whether the shock is a positive versus negative shock. Two, the differential effects of a monetary policy shock that are due to the shock being a small versus large shock do not depend on whether the shock is positive versus negative or whether the economy is in a recession or expansion. Three, the differential effects of a monetary policy shock that are due to the shock being a positive versus negative shock do not depend on whether the shock is large versus small or whether the economy is in a recession or expansion. My baseline model drops these assumptions by introducing three new interaction variables into Equation 2:

- $rec_t * small_t * \varepsilon_t$
- $rec_t * neg_t * \varepsilon_t$
- $neg_t * small_t * \varepsilon_t$

$$y_{t+h} - y_{t-1} = \alpha_h + \gamma_h^{'} x_t + \beta_h \varepsilon_t + \beta_h^{rec} rec_t \varepsilon_t + \beta_h^{small} small_t \varepsilon_t + \beta_h^{neg} neg_t \varepsilon_t$$
$$+ \beta_h^{recsmall} rec_t small_t \varepsilon_t + \beta_h^{recneg} rec_t neg_t \varepsilon_t + \beta_h^{negsmall} neg_t small_t \varepsilon_t + \sum_{i=0}^{h} u_{t+i}^{D} \quad (3)$$

I employ the Newey-West methodology to calculate asymptotic standard errors. As Jordá (2005) shows, the disturbance term in the local projection equation is serially correlated and has a moving average (MA) process. I use these standard errors to calculate 95% confidence intervals around the impulse response of output in recessions and expansions from Equations 2 and 3 depending on the specification of output. The maximum autocorrelation lag is set to be H+1 following Jordá (2005).

3.2 Romer and Romer (2004) Monetary Policy Shocks

I make use of the monetary policy shocks developed in Romer and Romer (2004). One must be mindful of the endogenous or anticipatory movements that plague monetary policy measures such as the money supply or the Federal funds rate. Romer and Romer (2004) developed a two-step process to derive a measure of monetary policy that is free from these problems. First, the intended Federal Funds rate for a given Federal Open Market Committee (FOMC) meeting is found by reading the narrative record of each FOMC meeting. Second, the intended funds rate series is regressed around the forecast dates of the Fed's Greenbook forecasts. The Greenbook forecast is produced prior to each FOMC meeting by the research staff of the Board of Governors. The forecasts contain projections of many macroeconomic variables of output, prices, employment, and investment. By regressing the intended funds rate on these forecasts, the residuals from this regression are now free of anticipatory movements. These residuals are the series of interest. The Romer and Romer (2004) regression is written as follows:

$$\Delta ff_m = \alpha + \beta ffb_m + \sum_{i=-1}^{2} \gamma_i \widetilde{\Delta y}_{m,i} + \sum_{i=-1}^{2} \lambda_i (\widetilde{\Delta y}_{m,i} - \widetilde{\Delta y}_{m-1,i}) + \sum_{i=-1}^{2} \phi_i \widetilde{\pi}_{m,i} + \sum_{i=-1}^{2} \theta_i (\widetilde{\pi}_{m,i} - \widetilde{\pi}_{m-1,i}) + \rho \widetilde{u}_{m,0} + \varepsilon_m$$

where Δff_m is the change in the intended funds rate around FOMC meeting m, ffb_m is the level of the intended funds rate before any changes were made at the associated FOMC meeting, $\widetilde{\Delta y}$ is the forecast of real output growth, $\widetilde{\pi}$ is the forecast of inflation, and $\widetilde{u}$ is the forecast of the unemployment rate. The series ε_m is the monetary policy shock series that will be used in this paper in meeting date space. I follow Tenreyro and Thwaites (2016) by summing the shocks that take place within a particular quarter to obtain a quarterly Romer and Romer (2004) shock measure.

3.3 Volcker Period Outliers

The Volcker period of the Federal Reserve was a period of change in the conduct of monetary policy. There was an emphasis placed on reducing the high inflation rates that persisted during the 1970s and the Fed also switched to targeting non-borrowed reserves rather than interest rates from 1979-1982. Many asymmetry papers have used measures of interest rates or money supply as their measure of monetary policy in the past. The Volcker period makes it unclear which one measure is the correct one to use given that the target switched during this time period. I use Romer and Romer (2004) monetary policy shocks to measure monetary policy which allows us to circumvent this measurement problem during the Volcker period. Romer and Romer (2004) note that even when the FOMC was not explicitly targeting the Federal Funds rate, they were concerned about this key interest rate and the implications that policy actions would have on the funds rate. Because of this, it is natural to construct a shock series using the intended Federal Funds rate for the duration of the sample period.

There are still some potential problems with using the Romer and Romer (2004) monetary policy shock series. Romer and Romer (2004) found large outliers in their monetary policy shock measure during this Volcker period of 1979-1982. Coibion (2012) found that when the rapid decrease in the federal funds rate in mid-1980 and the subsequent rise in late 1980 are dropped from the sample then the estimated effects that the Romer and Romer (2004) shocks have is significantly reduced. In addition to these papers, there have been numerous papers that have explored the robustness of asymmetry to this period. Morgan (1993) found that the asymmetric effects of changes in the federal funds rate on output disappeared when 1979:Q4-1982:Q4 is excluded from the sample. Thoma (1994) found that the money-income relationship was strongest over the periods of 1969-1973 and 1978-1982. Ravn and Sola (2004) found that the asymmetry results found in Cover (1992) were not robust to a large outlier found in 1983:Q1.

The result from past research suggests that the Volcker period should be accounted for in the data. I accomplish this by adding dummy variables into Equation 2 and Equation 3 for the quarters 1979:Q4-1982:Q4. Given that the existing literature has found sensitivity of results to the inclusion of the Volcker period, my baseline specification will contain these Volcker period dummy variables.[2]

3.4 Data

The data used in this study was taken from a variety of sources. Real GDP and federal funds rate data was taken from the St. Louis Federal Reserve's FRED database. The NBER indicator data was taken from the National Bureau of Economic Research recession indicators. Finally, the data used to generate the Romer and Romer (2004) monetary policy shocks was collected from the Philadelphia Federal Reserve's Greenbook data set. The main sample period for the quarterly frequency runs from 1969:Q1-2008:Q4. Since H=20, the

[2]However, my primary conclusions are robust to the exclusion of the Volcker period dummies.

last 20 quarters of this sample are reserved for the calculation of impulse responses by local projections. The sample period cuts off prior to the onset of the Great Recession, since the interest rate was near the zero lower bound for most of the duration and aftermath of the recession.

4 Results

This section contains the results of the analysis. Section 4.1 begins with the baseline results of the interaction model in Equation 3. Section 4.2 contains the results of the non-interaction model in Equation 2. Finally, since directional asymmetry has some interesting results, it is important to check if those results persist in the absence of the other asymmetry types. Section 4.3 contains the impulse responses from a model containing only directional asymmetry.

4.1 Baseline Interaction Model Results

Using Equation 3, I used a t-test to determine if there were asymmetric effects of monetary policy on output across the business cycle, the size of the shock, the direction of the shock, and any interactions between these asymmetries. The test was conducted over the sample period from 1969:Q1-2008:Q4. The sample ends right before the onset of the Great Recession when the federal funds rate was dropped to the zero lower bound and had no variation until 2015. Following Section 3.3, dummy variables for the Volcker period of 1979:Q4-1982:Q4 are added into the model. Newey-West standard errors were used in the calculation of the test statistics. The t-test is calculated over the length of the horizon H for each type of asymmetry.

Figure 1 contains the results of the t-test for the different types of asymmetry and interactions. In this Figure, the red line is the test statistic for business cycle asymmetry, the blue line is for size asymmetry, the green line is for directional asymmetry, the yellow line is for the interaction between business cycle and size asymmetry, the cyan line is for the interaction between business cycle and directional asymmetry, and the magenta line is for the interaction between directional and size asymmetry. The test statistics are reported in absolute value and the horizontal line shows the 10% significance level for a two-sided test.

In the interaction model test contained in Figure 1, business cycle asymmetry and the interaction between business cycle and directional asymmetry are the only asymmetries that are strongly significant for more than one period. These two asymmetry types are significant for the first eight periods of the horizon. Other asymmetry types are also significant in this model but they are weakly significant. For this reason, when displaying impulse response functions below I will use a model that drops size asymmetry and its interactions. This will considerably simplify the presentation of impulse response functions.

The t-tests tell us which types of asymmetry exist but do not give us information regarding the nature of the asymmetry. This is explored by generating the impulse response functions of output to a monetary policy shock. Figure 2 contains the impulse responses of output to a monetary shock when local projections is run on Equation 2. Figure 2a contains the response of output to a contractionary shock during a recession. Figure 2b contains the response of output to an accommodative shock during a recession. Figure 2c contains the response of output to a contractionary shock during an expansion. Figure 2d contains the response of output to an accommodative shock during an expansion.

Looking at Figure 2, the results of the t-test become clear. Business cycle asymmetry can be observed by comparing Panel (a) to Panel (c) and comparing Panel (b) to Panel (d), particularly in horizons up to ten. In panel (a) there is a significant peak response of output to a contractionary shock in a recession of -0.0726 at horizon 5 while in Panel (c) the response of output to a contractionary shock in an expansion is -0.0227 at horizon 14. In the latter case, the peak response happens much later in the horizon and is not significant at any point along the horizon. In Panel (b), there is a significant peak response of output to an accommodative shock in a recession of -0.0232 at horizon 4. There is also a positive response of output to an accommodative shock during a recession of 0.0228 at horizons 11 and 13, although this is not significant. Comparing this to Panel (d), the peak response of output to an accommodative shock in an expansion is -0.0251 at horizon 15 and the response is significant at this horizon. It is important to note that these accommodative shocks have the incorrect sign (find a better location for this). All this gives evidence that the response of output to either a contractionary or accommodative shock is larger during recessions, particularly within the first ten horizons from the time of the shock.

Directional asymmetry can be observed by comparing Panel (a) to Panel (b) and comparing Panel (c) to Panel (d). In the absence of directional asymmetry, these impulse responses should be mirror images of each other across zero. This is not the case in either recessions or expansions. The peak response of output to a contractionary shock during a recession is much larger and happens earlier in the horizon than the peak response of output to an accommodative shock in a recession. The response of output to a contractionary shocks is significantly less than zero from horizons 1-8 and the response of output to an accommodative shock is significantly less than zero from horizons 1-6 and horizons 19-21. Looking at shocks during expansions, the response of output to contractionary and expansionary shocks are not mirror images of each other. There is no significant difference from zero for the response of output to a contractionary shock during an expansion and the response of output to an accommodative shock is significantly less than zero only from horizons 14-15. The overall conclusion for directional asymmetry is that it is more prevalent during recessions and during the first 10 horizons, which is why the interaction between business cycle and directional asymmetry was significant in Figure 1.

Figure 2 reveals a striking result regarding the response of real GDP to accommodative shocks. The sign on the response of output is counter-intuitive to what theory says that it should be. This is true in both expansions and recessions. In recessions, there is a significant negative response of output to an accommodative shock during the first 6 horizons and during the last 3 horizons. While the response of output does have the correct sign during the middle portion of the horizon, this is not significant at any point. During expansions, the response to output is negative and significant from horizons 14-15, and it is negative and insignificant at every other horizon. If one had estimated an asymmetry model that did not included directional asymmetry, they would not find this result.

The results from the interaction model with Volcker period dummies give three main results. One, monetary policy has more of an effect on output during recessions than expansions. Two, directional asymmetry exists strongly during recessions and weakly during expansions, reinforcing the significance of the interaction term between business cycle and directional asymmetry in Figure 1. Three, accommodative monetary policy is having a negative effect on output or at best no effect on output at all. This is true during expansions and recessions, but it is especially troublesome during the latter case. This leaves the door open for more non-traditional monetary policy or fiscal policy working in conjunction with monetary policy moving forward.

4.2 Non-Interaction Model Results

In this Section, I perform the t-test for asymmetry using the non-interaction model from Equation 2. Figure 3 contains the results of the t-test for the different types of asymmetric effects of monetary policy. The red line is the test statistic for business cycle asymmetry, the green line is the test statistic for directional asymmetry, and the blue line is the test statistic for size asymmetry. The test statistics are reported in absolute value and the horizontal line shows the 10% significance level for a two-sided test.

This t-test picks up business cycle asymmetry the strongest. Business cycle asymmetry is important during the earliest horizons and again later in the horizon. Size asymmetry is briefly significant during the early stages of the horizon and directional asymmetry is not significant at any point along the horizon. The results of Figure 3 show the value added of the interaction model of Section 4.1. In both cases, business cycle asymmetry matters. However, directional asymmetry is also important but only manifests itself inside of recessions. This second point is impossible to pick up without the interaction terms. The impulse responses of the non-interaction model are not presented but are qualitatively similar to the impulse responses in Section 4.1.

4.3 Business Cycle Asymmetry Results

The results thus far have shown that business cycle asymmetry, directional asymmetry, and the interaction between the two are most important for explaining output. In this section, I demonstrate the value added of a model containing multiple types of asymmetry. Models containing only business cycle asymmetry miss the important result that monetary policy shocks do not affect output. I run the following local projection regression that contains only business cycle asymmetry.

$$y_{t+h} - y_{t-1} = c + \gamma^{'} x_t + \beta_h \varepsilon_t + \beta_h^{rec} \varepsilon_t rec_t + \sum_{i=0}^{h} u_{t+i}^{D} \tag{4}$$

Figure 4a contains the results of the response of output to a shock that takes place during a recession and Figure 4b contains the results of the response of output to a shock that takes place during an expansion. The Volcker period has been dummied out in this specification. This Figure shows that in a model containing only business cycle asymmetry, one would conclude that accommodative monetary policy increases output during recessions. In Figure 4, the impulse response is based off of a one standard deviation increase in the monetary shock measure. Theory tells us that an increase in interest rates will decrease output, which is exactly what the impulse response is showing. If we want to see how output is affected by a decrease in the monetary shock measure, the response in Figure 4a needs to be multiplied by -1. This response is positive and significant in the medium run.

The conclusion from Figure 4a is that accommodative monetary policy increases output during recessions. This is in contrast with the conclusion from Section 4.1 where we found that a monetary shock during recessions either has no effect on output or decreases output.

Models that only contain business cycle asymmetry incorrectly conclude that accommodative monetary policy shocks increase output during recessions.

5 Conclusion

There is substantial evidence in the literature that the effects of monetary policy shocks on output might be asymmetric in three dimensions: shocks in different phases of the business cycle, shocks that differ in size, and shocks that differ in direction. In this paper, I explore the three types of asymmetry and potential interactions simultaneously using a local projection model. My results indicate that business cycle asymmetry, directional asymmetry, and the interaction between them are important for explaining how output reacts to a monetary policy shock. The results suggest that monetary policy shocks affect output more in recessions than expansions. In addition, no matter the phase of the business cycle, accommodative shocks appear to have little to no impact on output, with some impulse responses suggesting that accommodative shocks cause output to fall. These results suggest that models that only have one type of asymmetry in them are too simple to explain movements in output. This was demonstrated in Section 4.3, where a model containing only business cycle asymmetry found that monetary policy shocks during recessions do increase output.

The fact that accommodative monetary policy shocks have no significant effects on output is concerning for those in favor of using monetary policy to combat recessions. If these results are believed, then there is a larger need to resort to non-traditional accommodative monetary policy or accommodative fiscal policy working in conjunction with monetary policy to successfully combat recessions. One of the lessons that can be taken away from the Great Recession is that lowering the interest rates may not be enough to combat a recession, especially when the zero lower bound is reached. The results of this paper show that conventional monetary policy itself may not be enough even when the economy is not facing the zero lower bound.

There are a two issues with this result about accommodative monetary policy shocks having no significant effects on output. One, this result could be caused by poorly identified shocks. Romer and Romer (2004) believed that their shocks were not trustworthy during the Volcker period due to changing monetary policy at the time. This paper did address this by dummying out that period, alleviating the effect that the large outliers from that period had on the impulse responses. Equations that used dummy variables during the Volcker period did produce impulse responses that were more consistent with theory. The second issue is the distinction between what a monetary policy shock is and how the Fed conducts monetary policy. In the asymmetry literature, shocks that are generated from a VAR or Romer and Romer shocks are used in empirical models, which gives a policy measure that is orthogonal to output. In reality, the Fed does not conduct monetary policy in terms of "shocks", rather gathering all information about economic conditions before determining how to set the federal funds rate. While the result that accommodative recession shocks do not have a significant effect on output is alarming, the actual policy actions taken by the Fed might have significant effects on output.

References

Anderson, H. and T. Teräsvirta (1992). Characterizing Nonlinearities in Business Cycles Using Smooth Transition Autoregressive Models. *Journal of Applied Econometrics 7*(S), S119–136.

Angrist, J., O. Jordá, and G. Kuersteiner (2018). Semiparametric Estimates of Monetary Policy Effects: String Theory Revisited. *Journal of Business and Economic Statistics 36*(3), 371–387.

Bernanke, B. and M. Gertler (1995). Inside the Black Box: The Credit Channel of Monetary Policy Transmission. *Journal of Economic Perspectives 9*(4), 27–48.

Coibion, O. (2012). Are the Effects of Monetary Policy Shocks Big or Small? *American Economic Journal: Macroeconomics 4*(2), 1–32.

Cover, J. (1992). Asymmetric Effects of Positive and Negative Money-Supply Shocks. *The Quarterly Journal of Economics 107*(4), 1261–1282.

Garcia, R. and H. Schaller (2002). Are the Effects of Monetary Policy Asymmetric? *Economic Inquiry 40*(1), 102–119.

Granger, C. and T. Teräsvirta (1993). *Modelling Non-Linear Economic Relationships*. Oxford: Oxford University Press.

Jordá, O. (2005). Estimation and Inference of Impulse Responses by Local Projections. *American Economic Review 95*(1), 161–182.

Kandil, M. (1995). Asymmetric Nominal Flexibility and Economic Fluctuations. *Southern Economic Journal 61*(3), 674–695.

Karras, G. (1996). Why are the Effects of Money-Supply Shocks Asymmetric? Convex Aggregate Supply or "Pushing on a String"? *Journal of Macroeconomics 18*(4), 605–619.

Kaufmann, S. (2002). Is There an Asymmetric Effect of Monetary Policy Over Time? A Bayesian Analysis Using Austrian Data. *Empirical Economics 27*(2), 277–297.

Lo, M. C. and J. Piger (2005). Is the Response of Output to Monetary Policy Asymmetric? Evidence from a Regime-Switching Coefficients Model. *Journal of Money, Credit and Banking 37*(5), 865–887.

Morgan, D. P. (1993). Asymmetric Effects of Monetary Policy. *Federal Reserve Bank of Kansas City Economic Review 78*(2), 21–33.

Peersman, G. and F. Smets (2002). *Monetary Transmissions in Diverse Economies*. Cambridge, UK: Cambridge University Press.

Ravn, M. and M. Sola (2004). A Reconsideration of the Empirical Evidence on the Asymmetric Effects of Money-Supply shocks: Positive vs. Negative or Big vs. Small? *Quarterly Review Federal Reserve Bank of St. Louis September/October*, 41–60.

Romer, C. D. and D. H. Romer (2004). A New Measure of Monetary Shocks: Derivation and Implications. *American Economic Review 94*(4), 1055–1084.

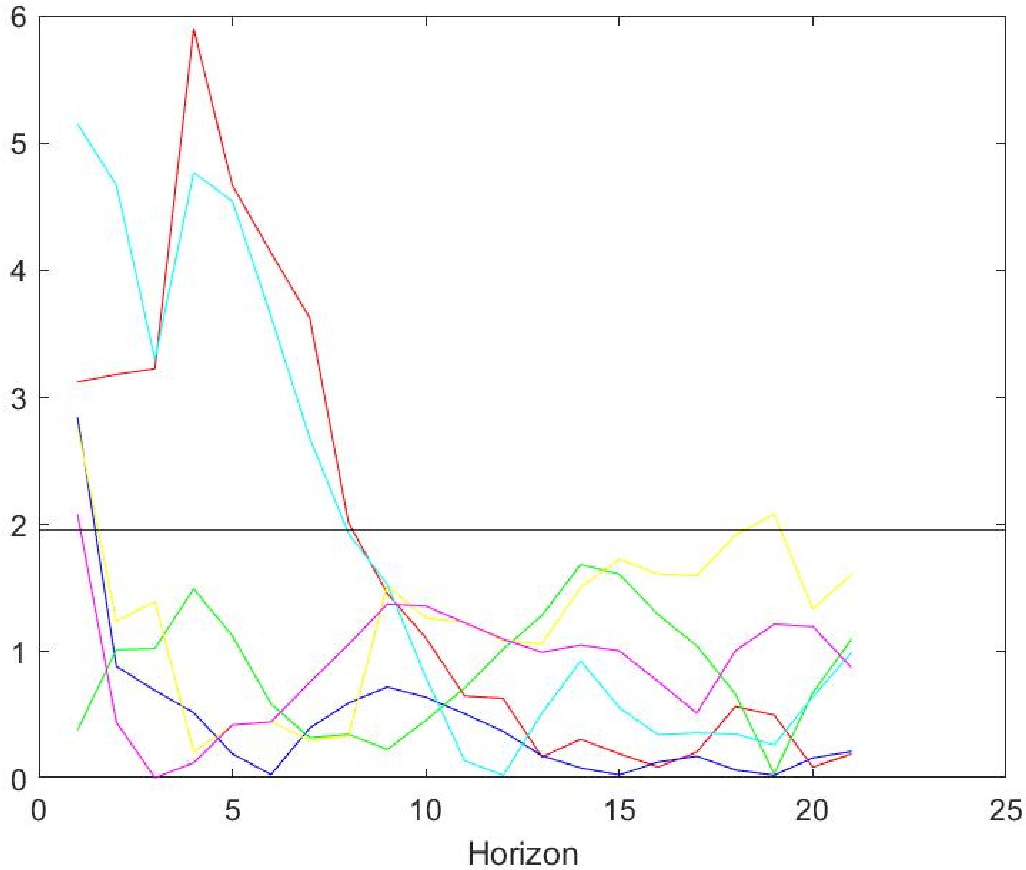
Stock, J. H. and M. W. Watson (2018). Identification and Estimation of Dynamic Causal Effects in Macroeconomics Using External Instruments. *Economic Journal 128*(610), 917–948.

Tenreyro, S. and G. Thwaites (2016). Pushing on a String: U. S. Monetary Policy Is Less Powerful in Recessions. *American Economic Journal: Macroeconomics 8*(4), 43–74.

Thoma, M. A. (1994). Subsample Instability and Asymmetries in Money-Income Causality. *Journal of Econometrics 64*(1-2), 279–306.

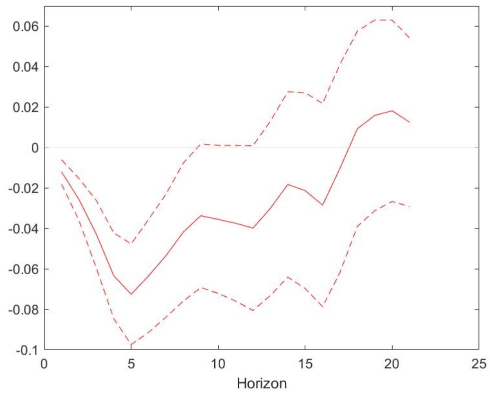
Weise, C. (1999). The Asymmetric Effects of Monetary Policy: A Nonlinear Vector Autoregression Approach. *Journal of Money, Credit and Banking 31*(1), 85–108.

Figure 1
Test Statistics for the Types of Asymmetry
Baseline Model

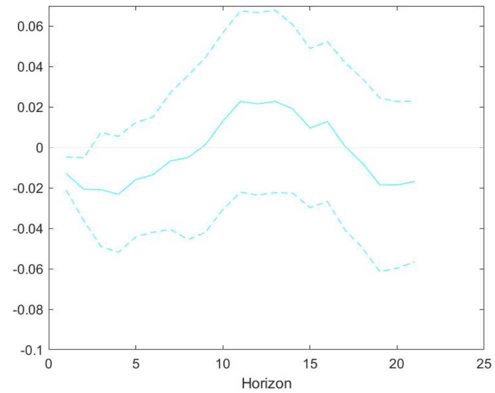


Notes: This Figure displays the t-statistics in absolute value for the different types of asymmetries and interactions when local projections are run on Equation 3. The sample size is 1969:Q1-2008:Q4. The colors are as follows: rec = red, small = blue, neg = green, recsmall = yellow, recneg = cyan, negsmall = magenta. The horizontal bar represent the 5% significance level for a two sided test. Romer and Romer linear shocks are used in this equation.

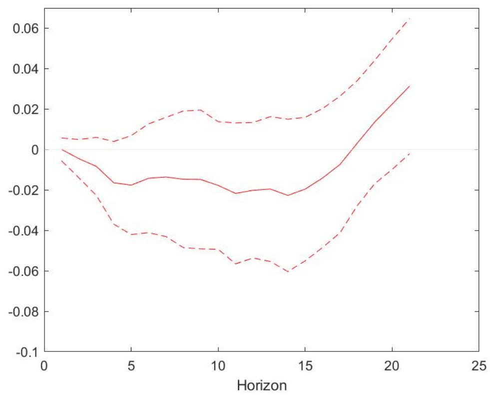
Figure 2
Impulse Response of Output to a Monetary Policy Shock
Baseline Model with Volcker Dummy



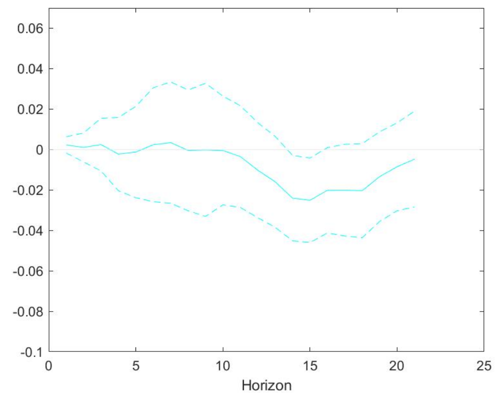
(a) Contractionary Recession Shock



(b) Accommodative Recession Shock



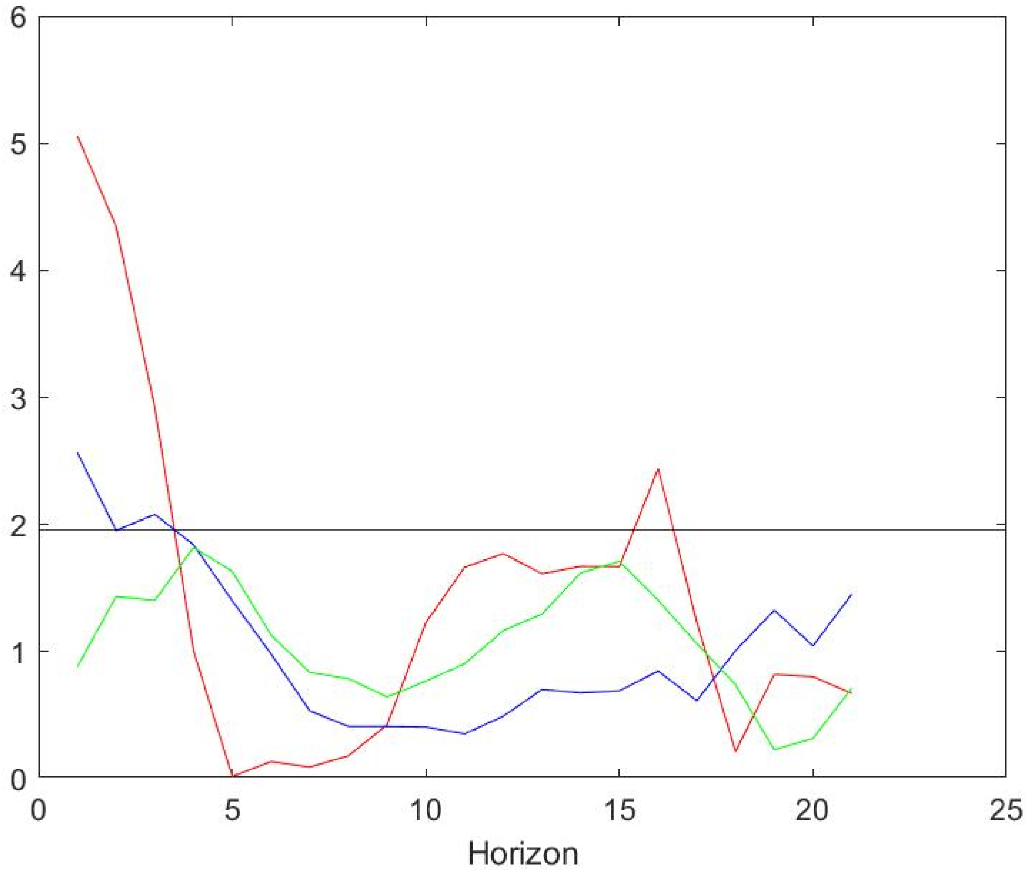
(c) Contractionary Expansion Shock



(d) Accommodative Expansion Shock

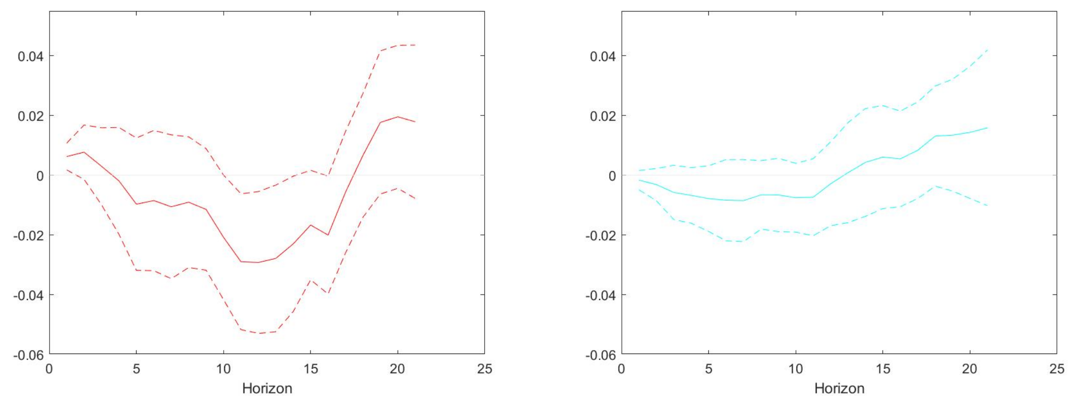
Notes: This Figure displays the impulse responses of output to a monetary policy shock when local projections are run on Equation 2, size asymmetry is dropped from the model, and the Volcker period of 1979:Q4-1982:Q4 is dummied out. Positive (contractionary) shocks will be in red and negative (accommodative) shocks will be in cyan for this Figure. Panel (a) shows the response of output to a contractionary shock in a recession. Panel (b) shows the response of output to an accommodative shock in a recession. Panel (c) shows the response of output to a contractionary shock in an expansion. Panel (d) shows the response of output to an accommodative shock in an expansion. The sample size is 1969:Q1-2008:Q4. Romer and Romer linear shocks are used in this equation.

Figure 3
Test Statistics for the Types of Asymmetry
Non-Interaction Model



Notes: This Figure displays the t-statistics in absolute value for the different types of asymmetries when local projections are run on Equation 2. The sample size is 1969:Q1-2008:Q4. The colors are as follows: rec = red, small = blue, neg = green. The horizontal bars represent the 5% significance level for a two sided test. Romer and Romer linear shocks are used in this equation.

Figure 4
Impulse Response of Output to a Monetary Policy Shock
Business Cycle Asymmetry Model



(a) Recession Shock **(b) Expansion Shock**

Notes: This Figure displays the impulse responses of output to a monetary policy shock during a recession (red) and a monetary policy shock during an expansion (cyan) when local projections are run on Equation 4 and the Volcker period of 1979:Q4-1982:Q4 is dummied out. The sample size is 1969:Q1-2008:Q4. Romer and Romer linear shocks are used in this equation.