Stochastic Trends, Outliers, and State Dependent Effects of Monetary Policy

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June 9, 2019

Background and Motivation

There are three main types of monetary policy asymmetry, related to:

- The size of the shock
- The direction of the shock
- The phase of the business cycle

Background and Motivation

Here we are interested in possible business cycle dependence in the output effects of U.S. monetary policy.

Why is this important?

- Relevant for effective stabilization policy
- Relevant for modeling

Background and Motivation

There are two main theories where business cycle asymmetry shows up.

- Models with downward price rigidities
  - This will manifest itself as a convex aggregate supply curve with asymmetry in output and prices depending on which side of potential output the short-run equilibrium is on.

- Credit channel explanation from Bernanke and Gertler (1995)
  - Firms are more likely to use internal financing during expansions but rely on external financing during recessions when those internal funds dry up.

Both theories predict that monetary policy will have more of an effect on output in recessions than expansions.

Background and Motivation

Are the effects of macroeconomic policy state-dependent with respect to the business cycle?

Older Literature:

Peersman and Smets (2002); Garcia and Schaller (2002); Kaufmann (2002); Weise (1999); Lo and Piger (2005)

Universally find that monetary policy actions taken during recessions have larger output effects than those taken during expansions.

Newer Literature:

Tenreyro and Thwaites (2016) (hereafter T&T) find that the output effects of monetary policy actions taken during expansions are larger.

This result has been influential and has left the literature without a consensus (or a changed consensus!) on this topic.

This Paper

This paper has two goals:

1. Illuminate the reasons for the conflicting results in the literature.
2. Provide some evidence on which conclusion is more credible.

This Paper

Preview of Results

The differences in the business cycle asymmetry literature can be explained by three main differences in specification:

1. Results depend on the measure of output and the frequency of data used.
2. Results depend crucially on whether impulse response functions are estimated using (log) levels vs. first differences of output measures.
3. Results depend on outliers in the monetary policy shock measures.

When all three of these differences are considered simultaneously, I find that monetary policy is more effective in recessions than expansions.

State Dependent IRF Estimation via Local Projections

Levels Specification:

$$y_{t+h} = NBER_t(\beta_h^r \varepsilon_t + \gamma_h^{r'} x_t) + (1 - NBER_t)(\beta_h^e \varepsilon_t + \gamma_h^{e'} x_t) + u_{t+h}$$

Here:

- y_{t+h} is the log level of quarterly real GDP
- $NBER_t$ is a dummy variable indicating NBER recessions
- x_t holds controls (including deterministic terms)
- ε_t is a nonlinear version of the Romer and Romer (2004) monetary policy shock
- β_h^r and β_h^e are the effects on log real GDP of a monetary policy shock taken during a recession or expansion at horizon h
- Sample period is 1969:Q1-2008:Q4
- This specification closely matches that of T&T

State Dependent IRF Estimation via Local Projections

First Difference Specification:

$$\Delta y_{t+h} = NBER_t(\widetilde{\beta}_h^e \varepsilon_t + \widetilde{\gamma}_h^{r'} x_t) + (1 - NBER_t)(\widetilde{\beta}_h^e \varepsilon_t + \widetilde{\gamma}_h^{e'} x_t) + v_{t+h}$$

where: $\beta_h^r = \sum_{i=0}^{h} \widetilde{\beta}_i^r$ and $\beta_h^e = \sum_{i=0}^{h} \widetilde{\beta}_i^e$

Following Stock and Watson (2018), we can accumulate the first difference specification to estimate β_h^r and β_h^e directly:

$$y_{t+h} - y_{t-1} = NBER_t(\beta_h^r \varepsilon_t + \gamma_h^{r'} x_t) + (1 - NBER_t)(\beta_h^e \varepsilon_t + \gamma_h^{e'} x_t) + v'_{t+h}$$

Newey-West Standard Errors

Jorda (2005) shows that the disturbance term in the local projection equation is serially correlated and has a MA component.

I use the Newey-West methodology to calculate asymptotic standard errors.

Romer and Romer (2004) Monetary Policy Shocks

Standard measures of monetary policy (such as the money supply or the Federal Funds rate) have endogenous and anticipatory movements in them that make them sub-optimal to use as measures of monetary policy.

Original Romer and Romer (2004) Equation:

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

Romer and Romer (2004) Monetary Policy Shocks

Given that the premise of this study is to estimate non-linearities in the response of monetary policy, subjecting the reaction function of the Federal Reserve to be linear may add some state dependent measurement error, causing asymmetry to show up where there is none.

Non-linear Romer and Romer (2004) Equation:

$$\Delta ff_m = NBER_m * \beta' X_m + (1 - NBER_m) * \beta' X_m + \varepsilon_{m,nl}$$

Since these shocks are in meeting date space, I aggregate them up to the frequency of data that I am using.

Data

Real GDP, industrial production, personal consumption expenditure, 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.

The data used to generate the Romer and Romer (2004) monetary policy shocks was collected from the Philadelphia Federal Reserve's Greenbook data set.

Sample Period:

- Quarterly: 1969:Q1-2008:Q4
- Monthly: 1969:03-2008:12

I set "H" to be 20 for quarterly and 60 for monthly, so the local projection IRF is calculated using the last 5 years of data.

Asymmetry Test

I am interested in the difference between the expansion and recession responses. To test for this, I estimate the following equations:

Levels Specification:

$$y_{t+h} = \beta_h^r \varepsilon_t + \gamma_h^{r'} x_t + (1 - F_t) * (\theta_h^e \varepsilon_t + \gamma_h^{e'} x_t) + u_t$$

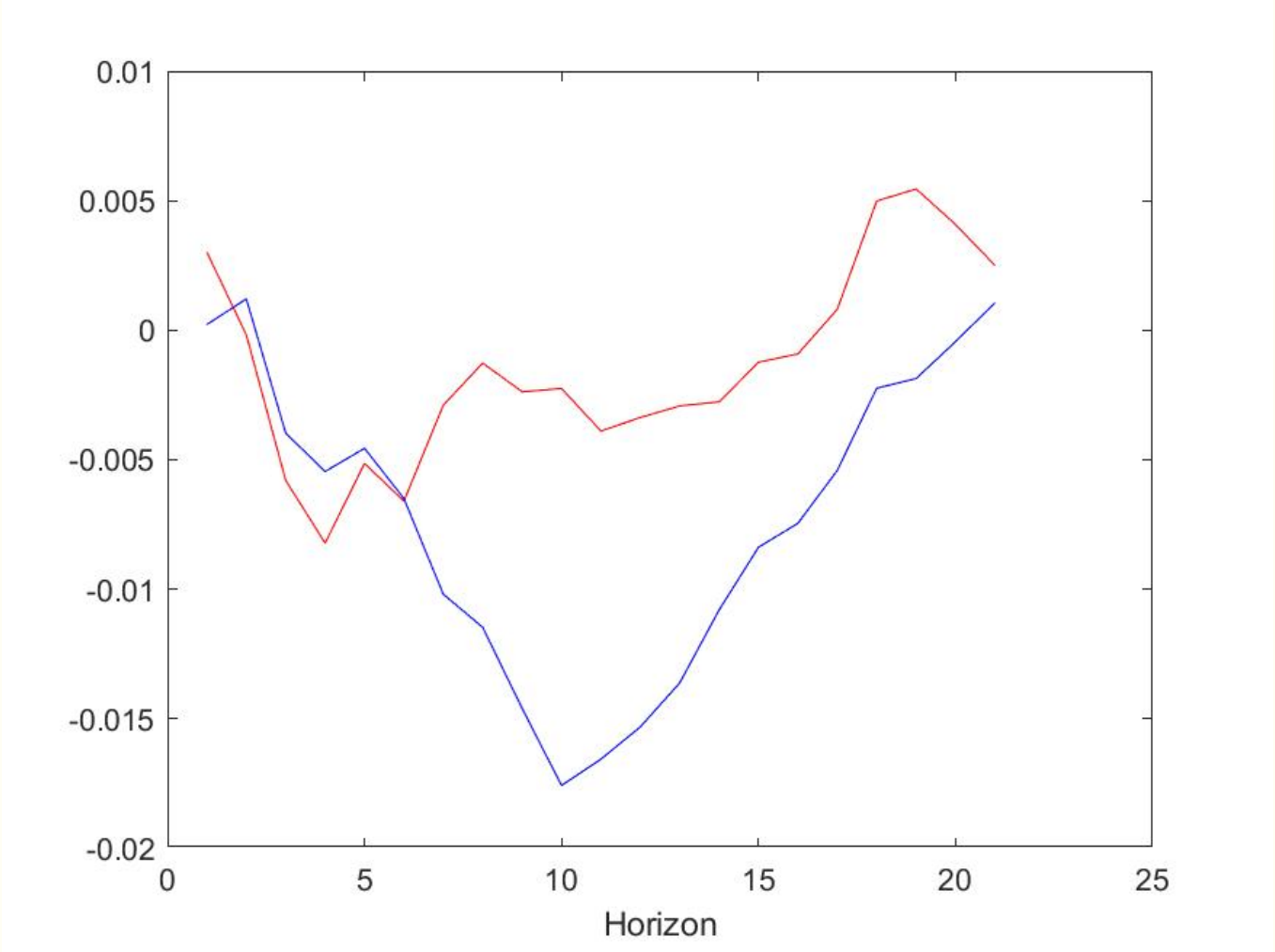
First Difference Specification:

$$y_{t+h} - y_{t-1} = \beta_h^r \varepsilon_t + \gamma_h^{r'} x_t + (1 - F_t)(\theta_h^e \varepsilon_t + \gamma_h^{e'} x_t) + \sum_{i=0}^{h} u_{t+h}^D$$

The coefficient θ_h^e has the interpretation of being the response of output in expansions minus the response of output during recessions. I perform a t-test on this coefficient to determine if asymmetry is present.

Baseline Results

Effect of Monetary Policy Shock on Quarterly Log Real GDP during Expansion (blue) and Recession (red)



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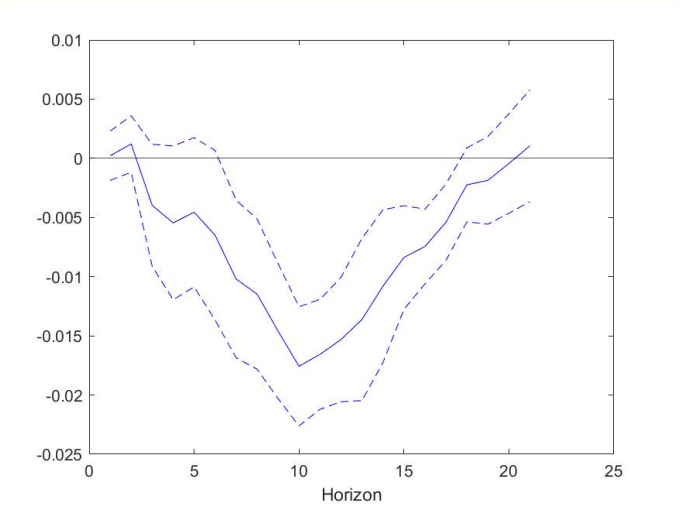
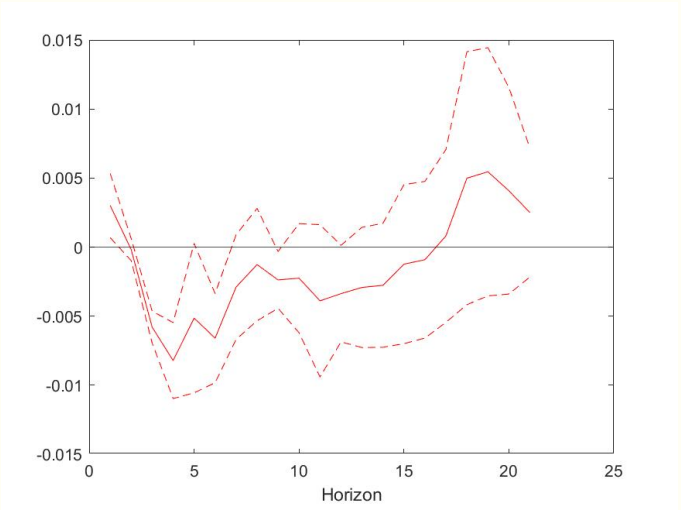
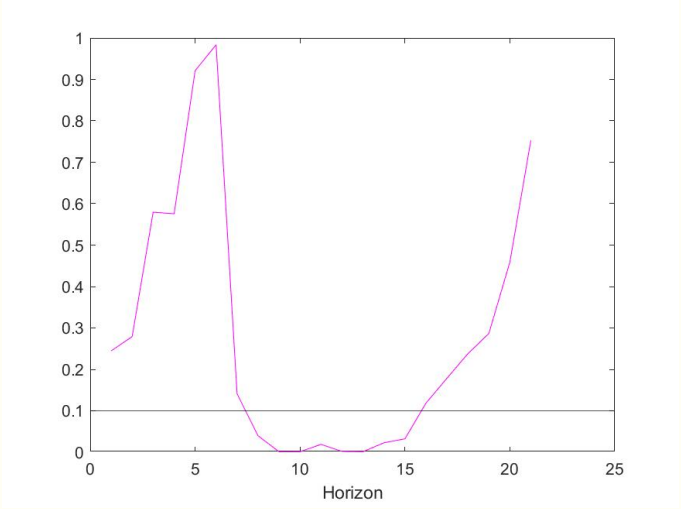






Baseline Results

These results closely match the Tenreyro and Thwaites (2016) results.

Monetary policy is more effective in expansions than recessions.

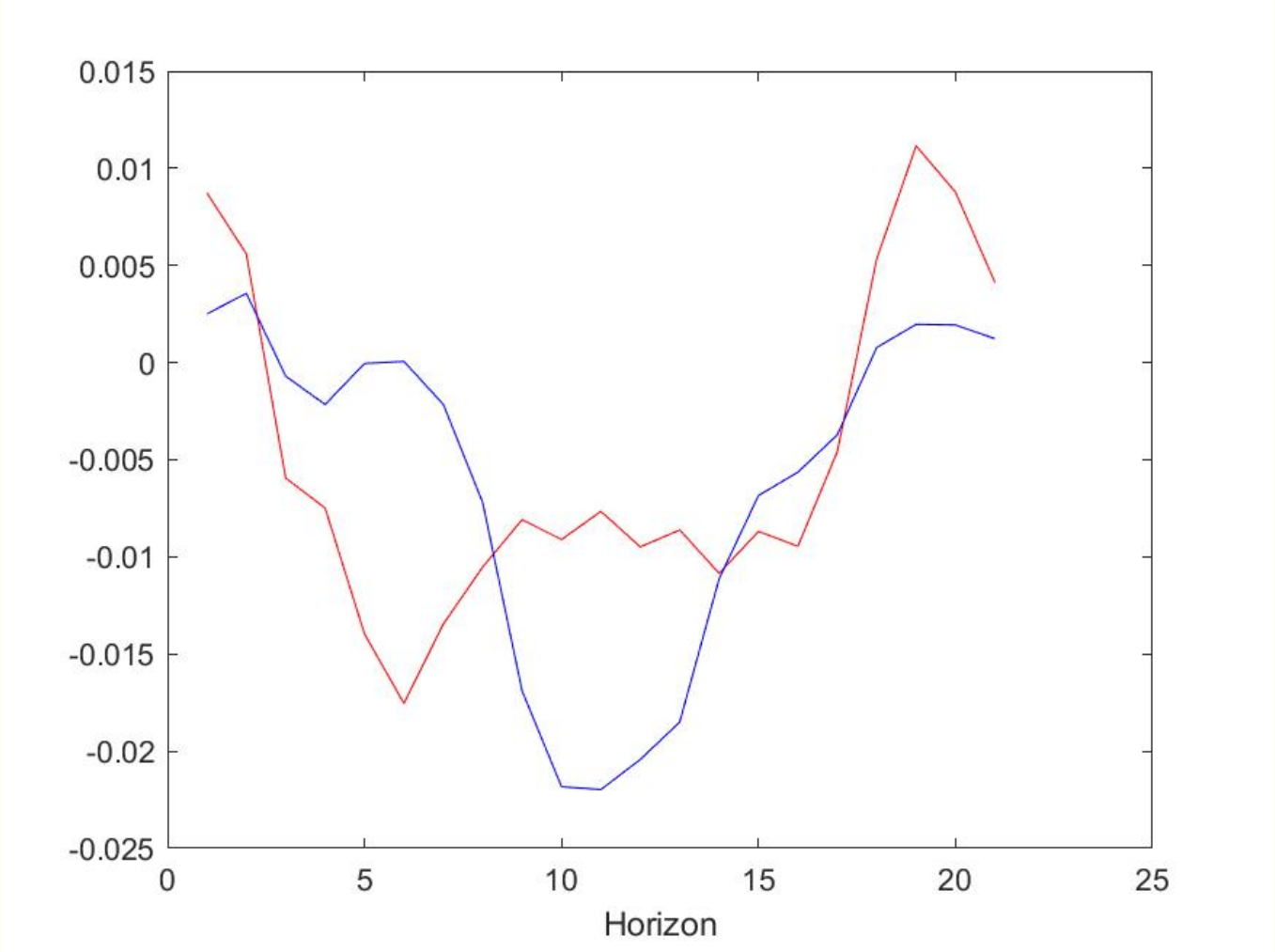
How robust is this result to changing the measure of output or the frequency of data used?

Weise (1999), Peersman and Smets (2002), Garcia and Schaller (2002), and Lo and Piger (2005) all use industrial production (IP) as thier measure of output.

Industrial production is a narrower measure and more sensitive to interest rates than real GDP.

Robustness to Measure of Output and Data Frequency

Effect of Monetary Policy Shock on Quarterly Log IP during Expansion (blue) and Recession (red)



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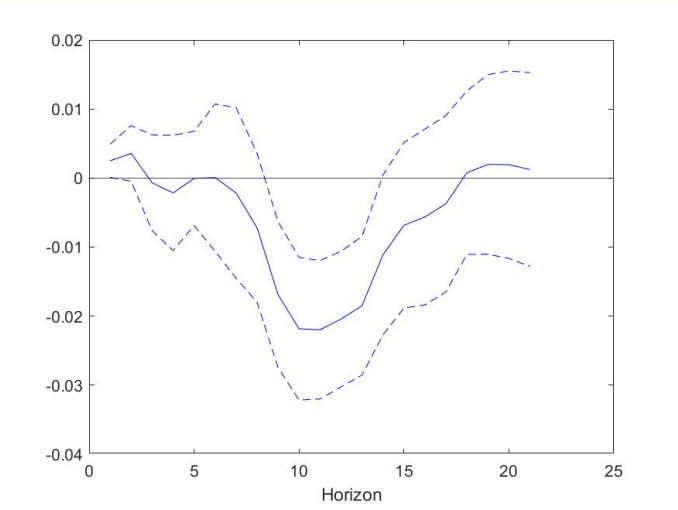
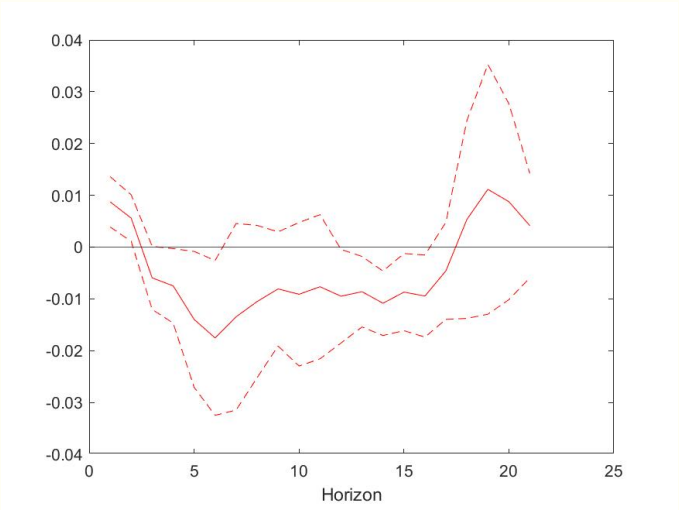
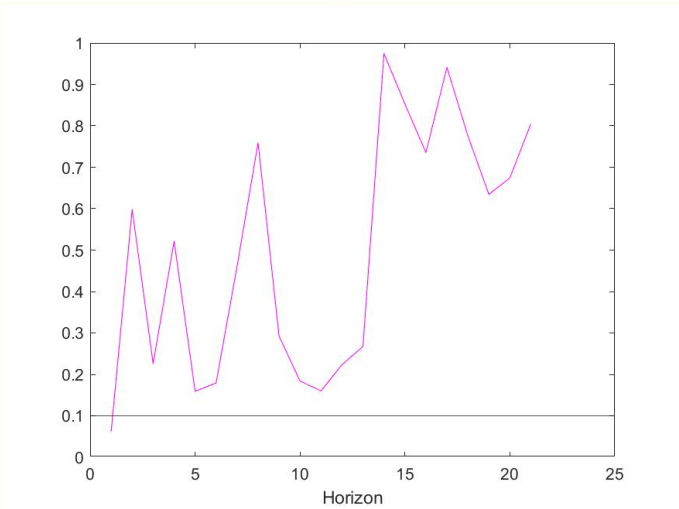






Robustness to Measure of Output and Data Frequency

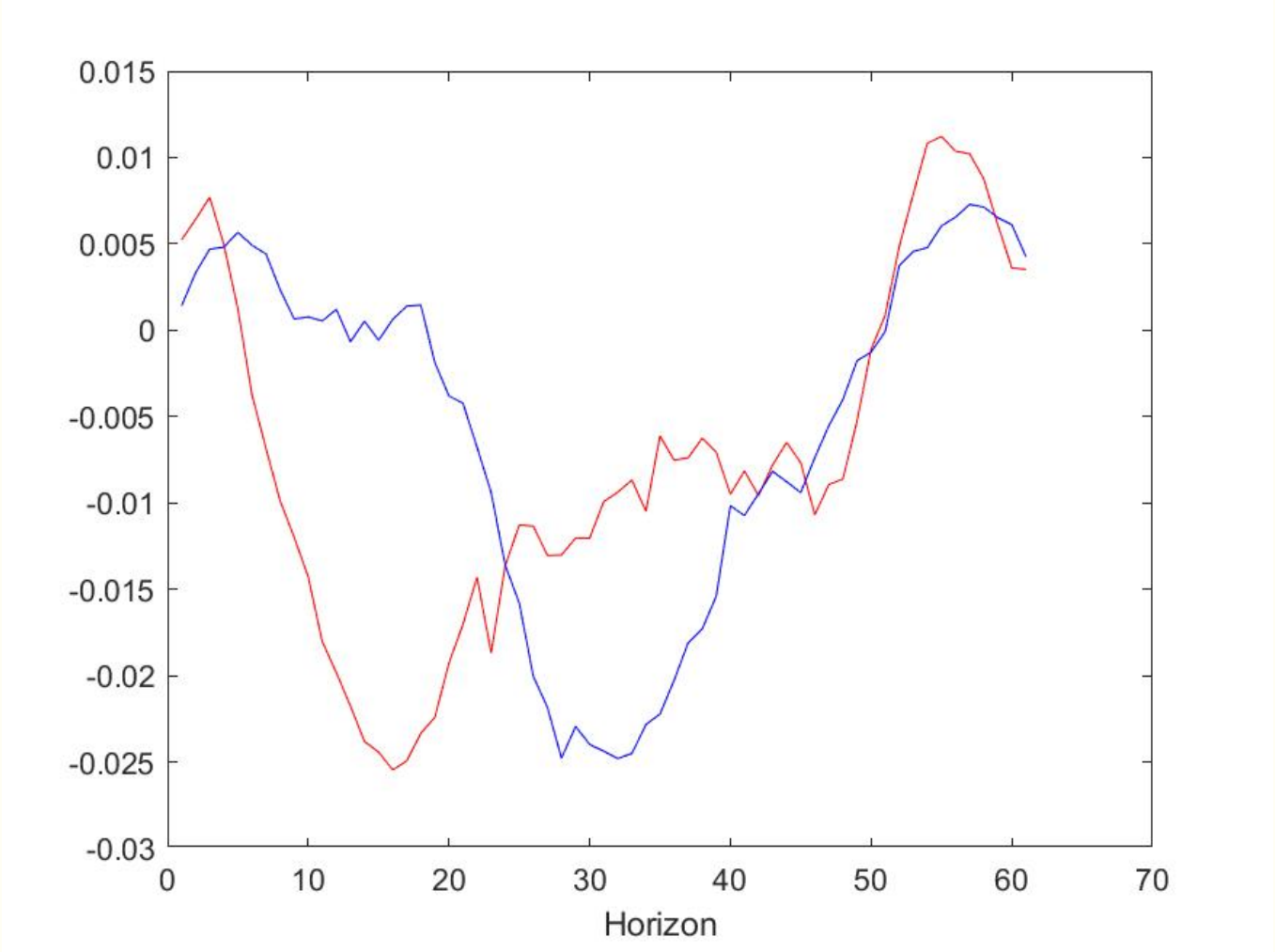
There is weak evidence that monetary policy has more of an effect on IP in expansions than recessions. This is due to the point estimates being larger for expansions but the asymmetry test finding no significance. The recession response did shrink the gap with the expansion response.

The next graph presents the results when I use monthly industrial production as the measure of output.

Given the nature of the NBER majority rule index being used, recessions are more clearly defined in the monthly specification.

Robustness to Measure of Output and Data Frequency

Effect of Monetary Policy Shock on Monthly Log IP during Expansion (blue) and Recession (red)



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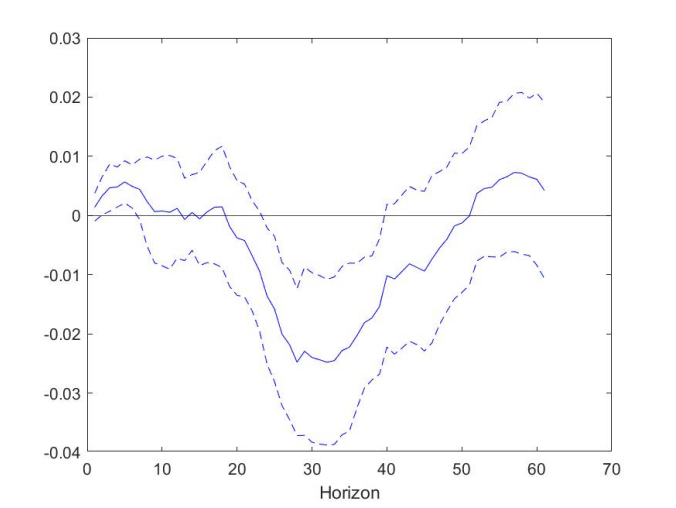
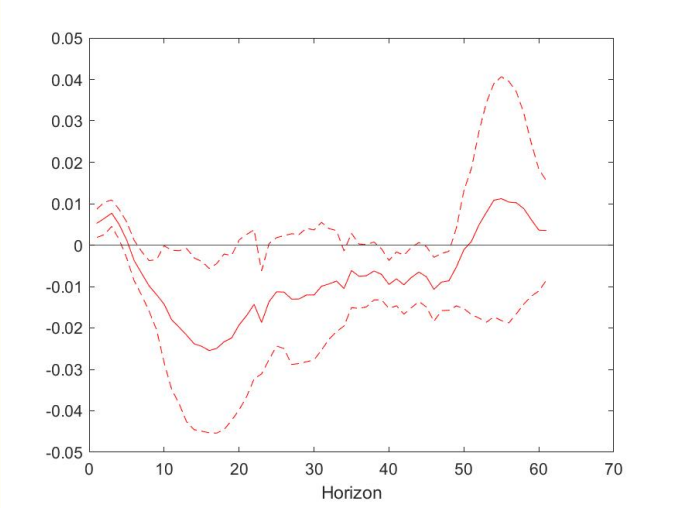
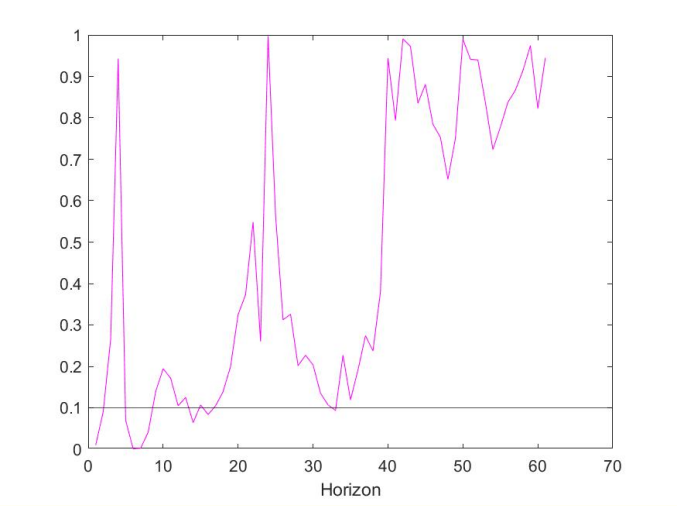






Robustness to Measure of Output and Data Frequency

The recession response is now just as large as the expansion response.

It is now a timing story, there are periods where both camps of the literature are correct.

The frequency of data used has a major impact on the asymmetry results.

Robustness to the Treatment of Stochastic Trends

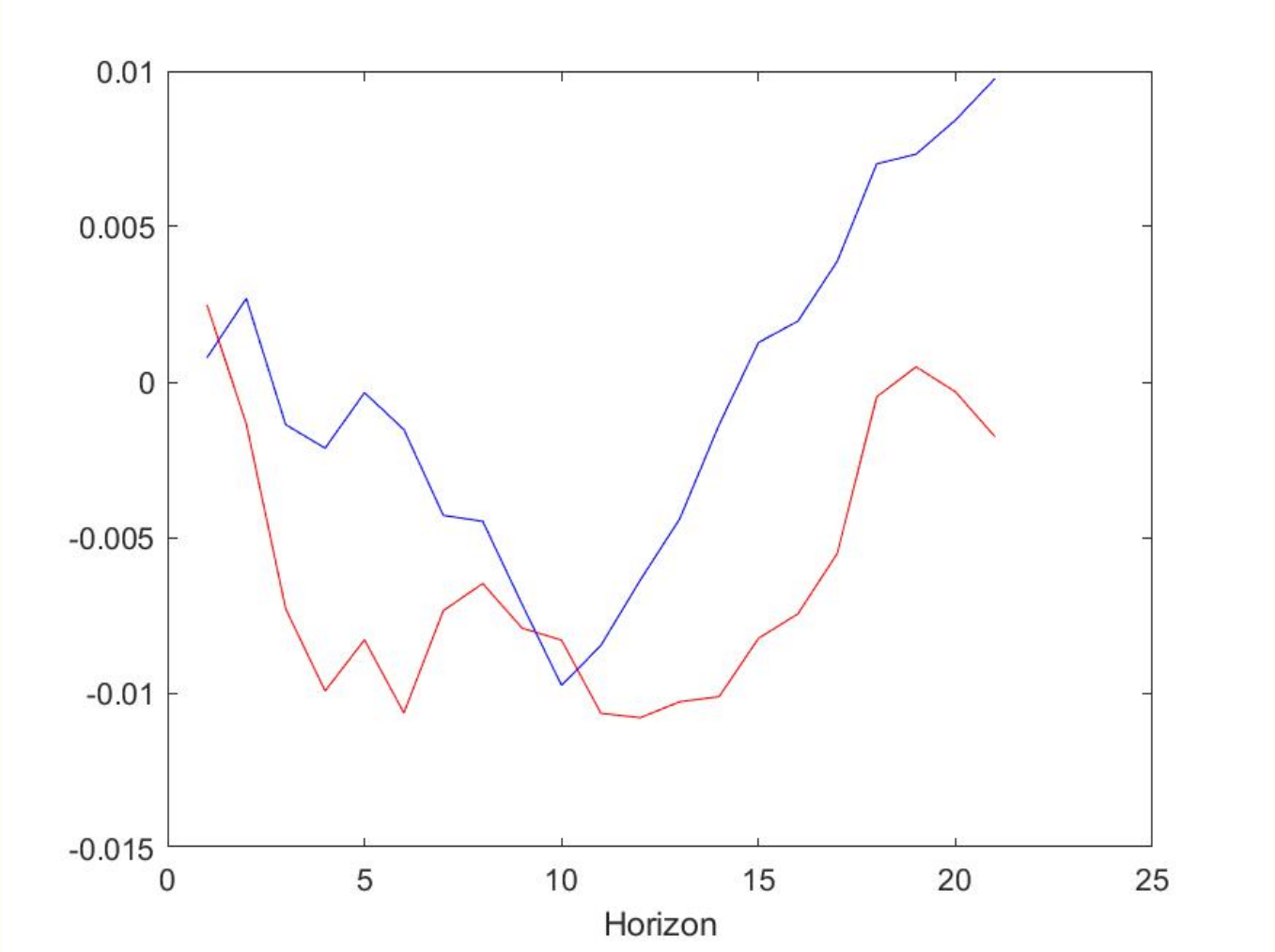
Most early papers in the asymmetry literature assume a unit root in output and specify their empirical models in terms of the growth rates of output measures.

Recent papers, especially those using the local projections framework, run models in levels with a deterministic trend.

The next slides are going to demonstrate that the asymmetry results are not robust to the choice of levels versus growth rates.

Robustness to the Treatment of Stochastic Trends

Effect of Monetary Policy Shock on Quarterly Log Real GDP during Expansion (blue) and Recession (red)



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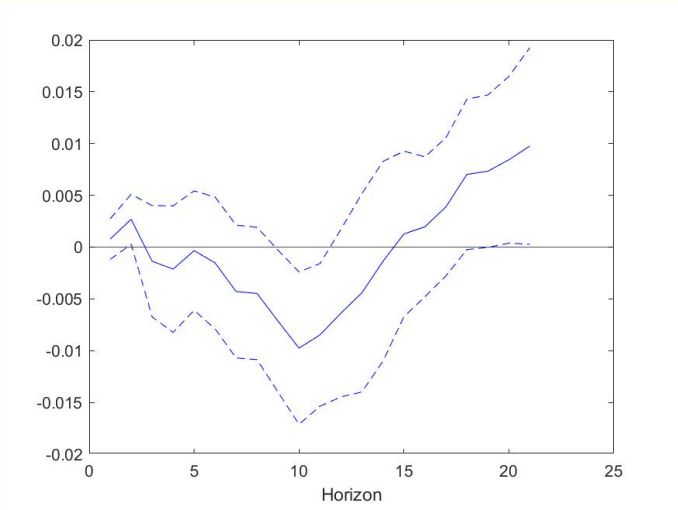

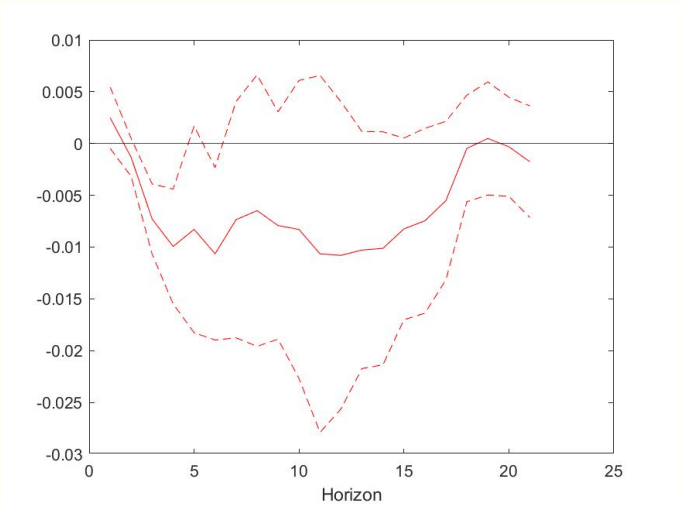

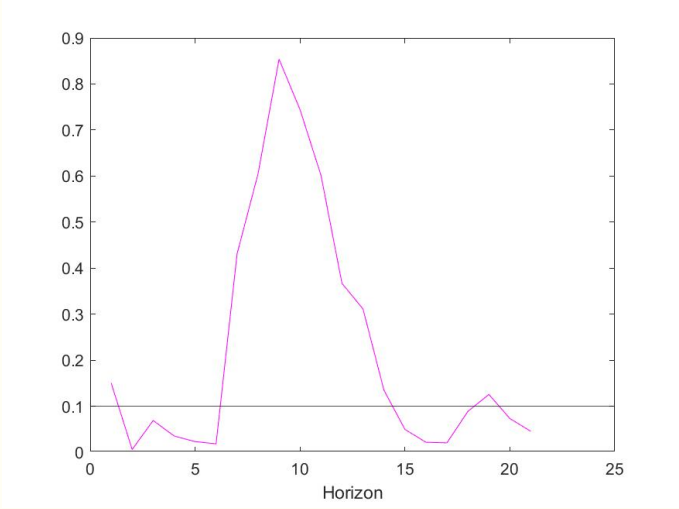

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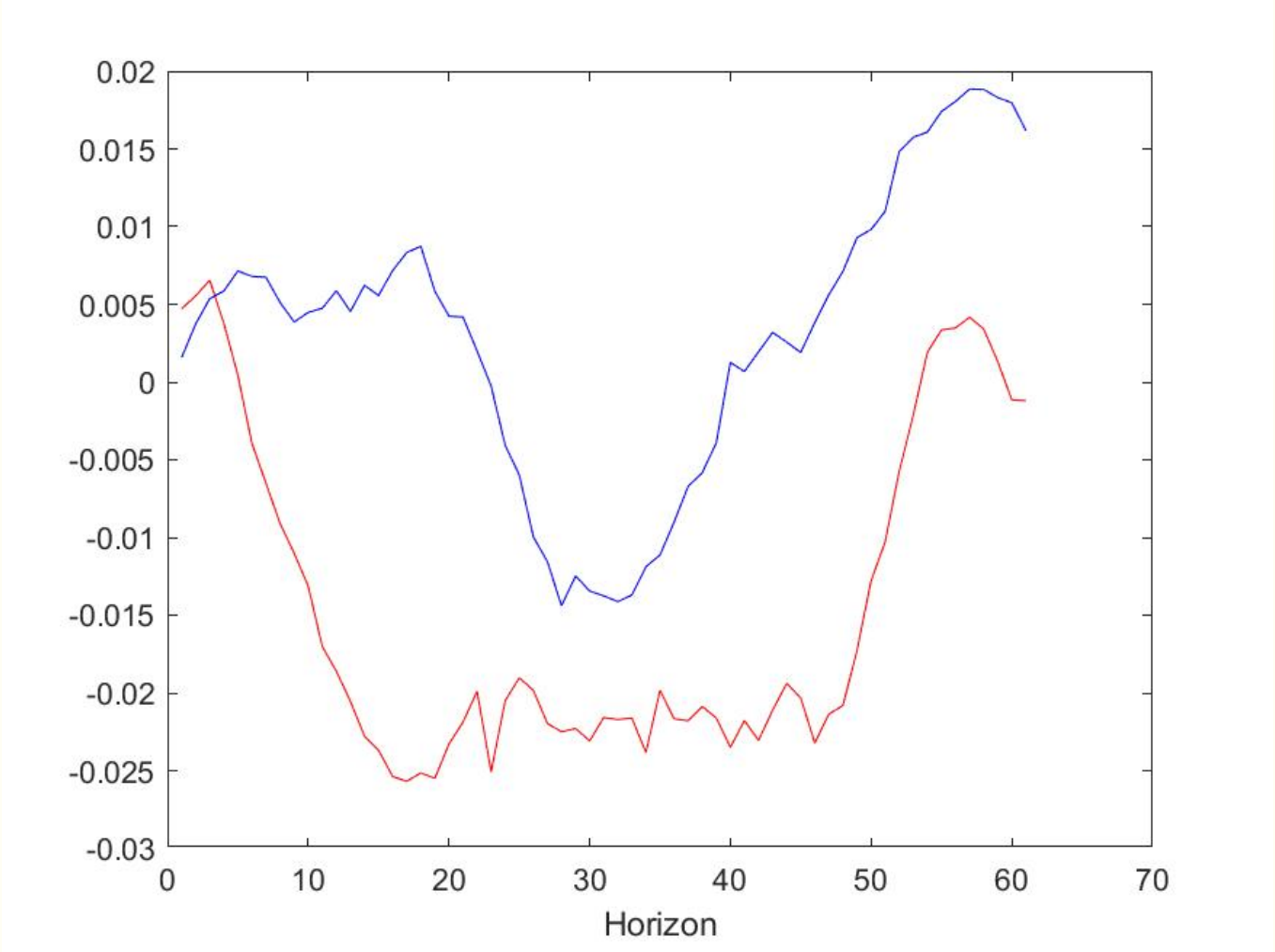
Effect of Monetary Policy Shock on Monthly Log IP during Expansion (blue) and Recession (red)



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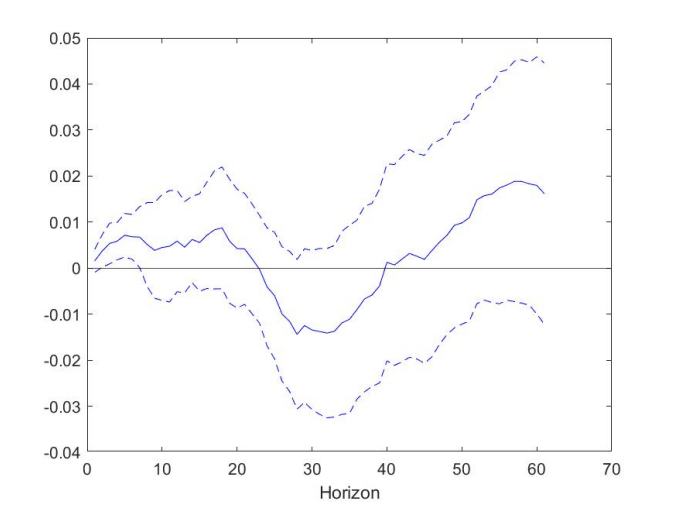
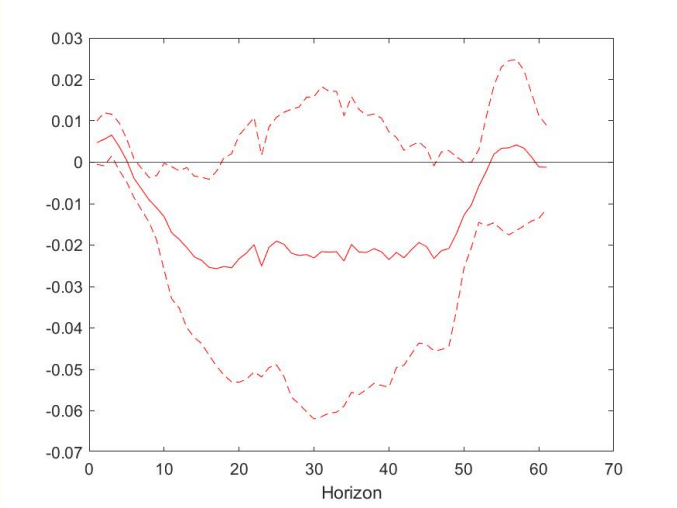
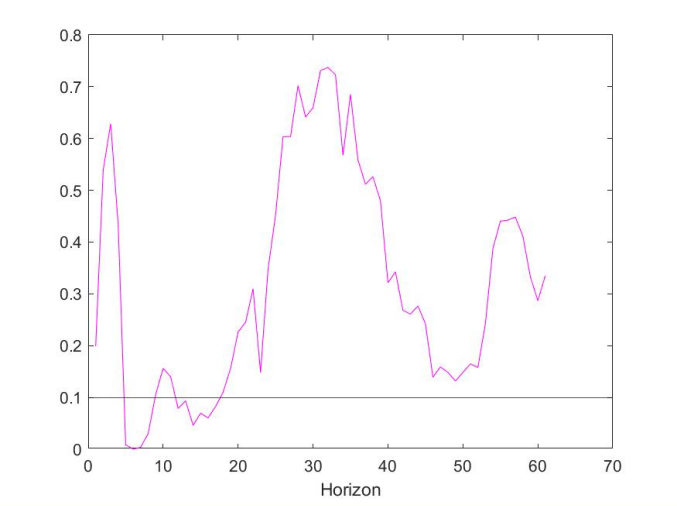






Robustness to the Treatment of Stochastic Trends

There is now evidence that monetary policy is more effective in recessions when output is expressed as growth rates.

Which specification is correct between levels and growth rates?

- Over-differencing if there is no unit root introduces a non-invertable MA component into the regression disturbance (Gospodinov et. al. (2013))

- If there is a unit root, the levels specification will be biased in finite samples (Kilian and Kim (2011)). In addition, typical inference methods are not robust to the presence of a unit root.

Unit root tests show that it is not unreasonable to assume that the growth rate specification is more credible.

Robustness to the Treatment of Stochastic Trends

Unit Root and Stationarity Tests for real GDP:

Time Period	ADF	DF-GLS	Zivot-Andrews	KPSS
1959:Q1-2018:Q3	-2.2335	-0.7539	-4.4729	0.8888*
1959:Q1-2008:Q4	-3.1341	-1.1755	-3.8401	0.3907*

Robustness to Outliers

There are several outliers in the Romer and Romer (2004) monetary policy shock measure.

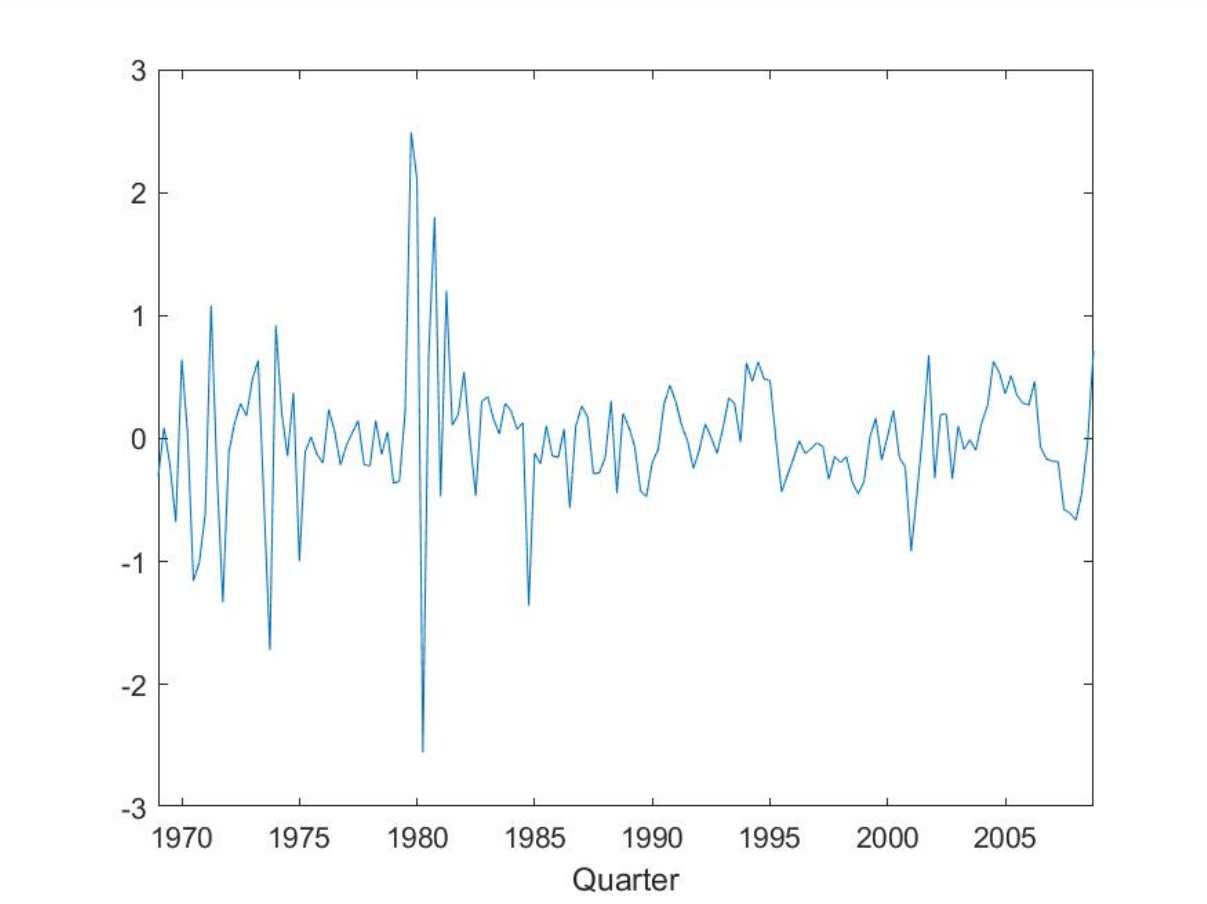
Most of these occur in the early years of the October 1979 - September 1982 Volcker "experiment" with non-borrowed reserves targeting:

Romer and Romer (2004) Shocks

Quarter	**Value**	*NBER*
1980:Q2	-2.6377	1
1979:Q4	2.6151	0
1980:Q1	2.1771	1
1980:Q4	1.9366	0

Robustness to Outliers

Quarterly Romer and Romer (2004) Shocks



Robustness to Outliers

- Romer and Romer (2004) note that their shock series is questionable in the early part of the Volcker experiment.
- These outliers are not contained to Romer and Romer (2004) shocks - a similar pattern of outliers is observed in VAR shocks.
- Earlier papers in the monetary policy asymmetry literature investigated the robustness of results to the exclusion of this period: Morgan (1993), Thoma (1994), Ravn and Sola (2004).
- In the literature measuring the effects of monetary policy shocks more generally, it is common to see robustness checks to the exclusion of this period (Christiano, Eichenbaum and Evans, 1999)

Robustness to Outliers

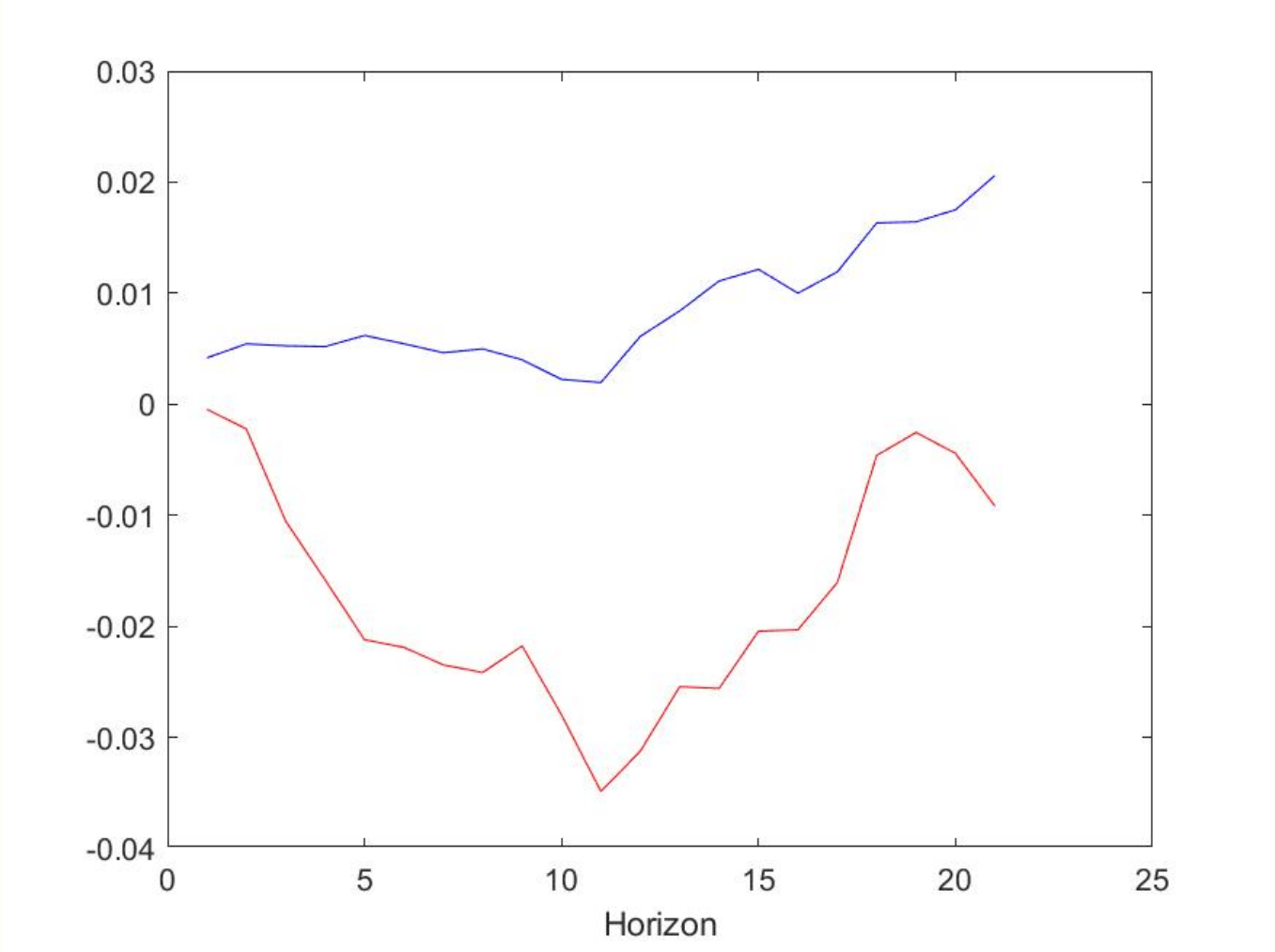
NOTE: Include a slide that shows the level response with the Volcker period dummy (I think that we only need the quarterly GDP one). Think about whether you want to put it before or after this rGDP one since the log first difference is the preferred specification.
NOTE: These figures may not be generated yet

Robustness to Outliers

NOTE: See previous slide

Robustness to Outliers

Effect of Monetary Policy Shock on Quarterly Log Real GDP taken during Expansion (blue) and Recession (red)



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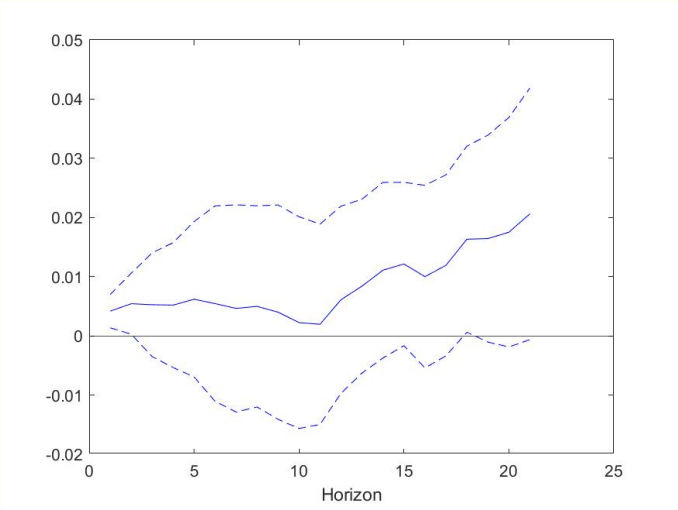
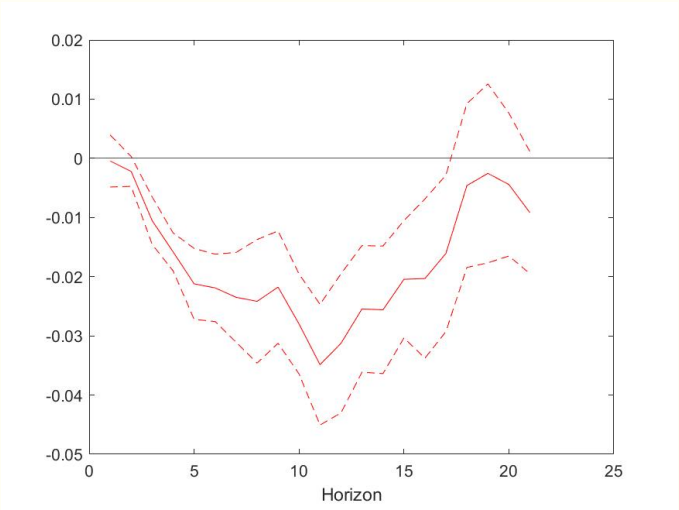
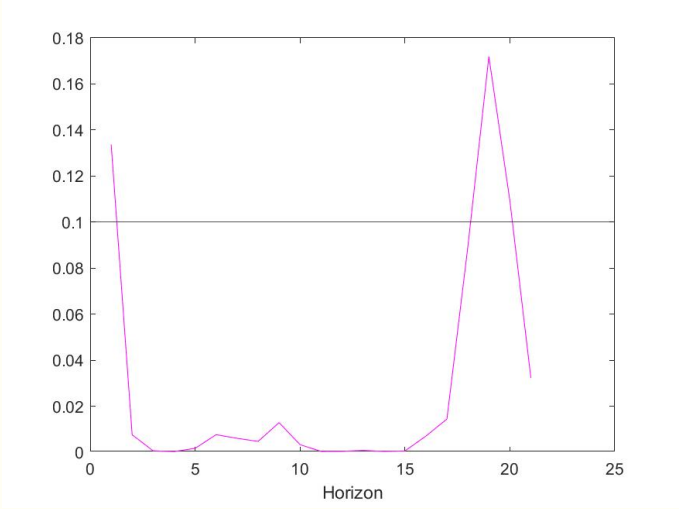
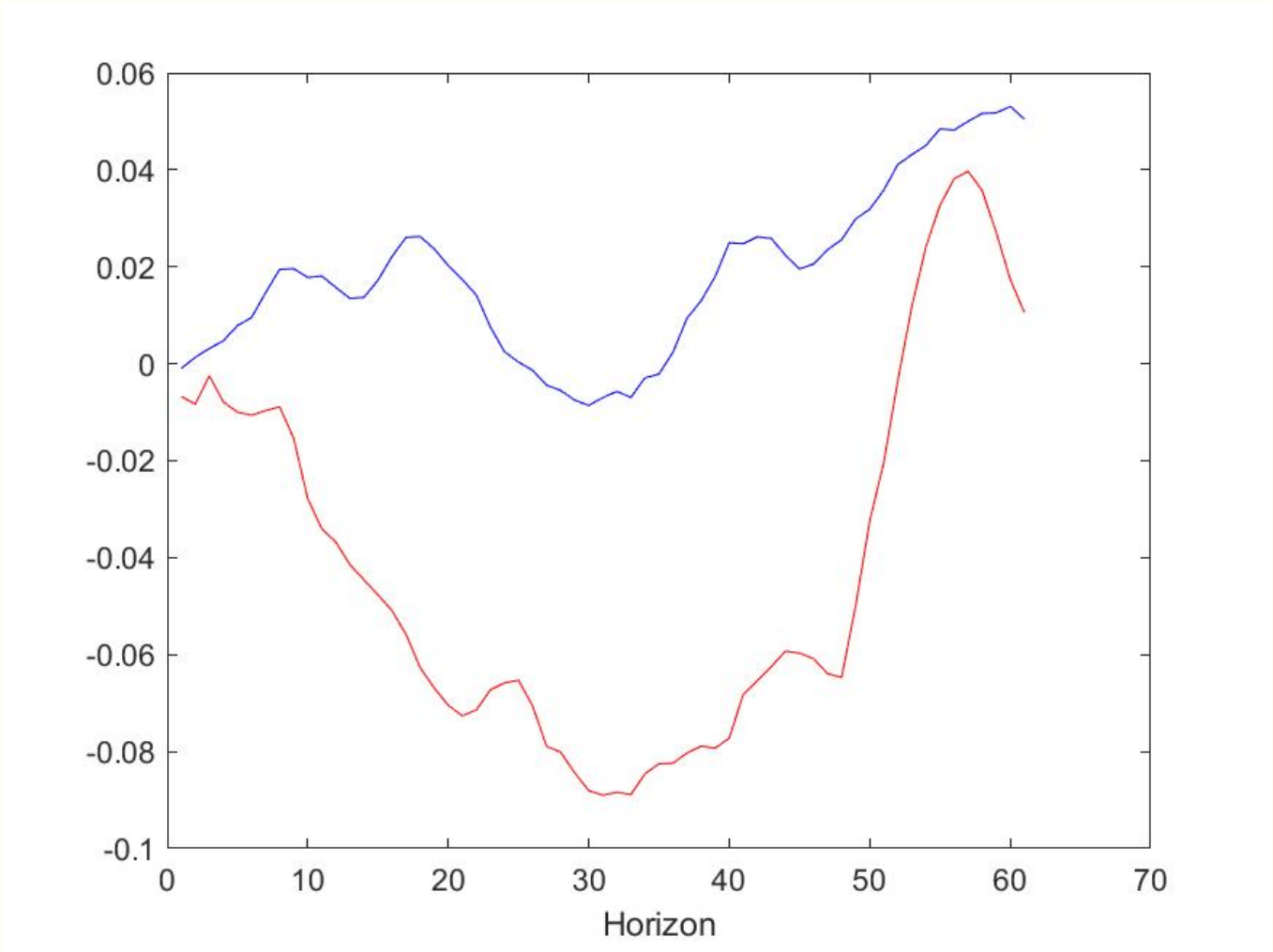






Robustness to Outliers

Effect of Monetary Policy Shock on Monthly Log IP taken during Expansion (blue) and Recession (red)



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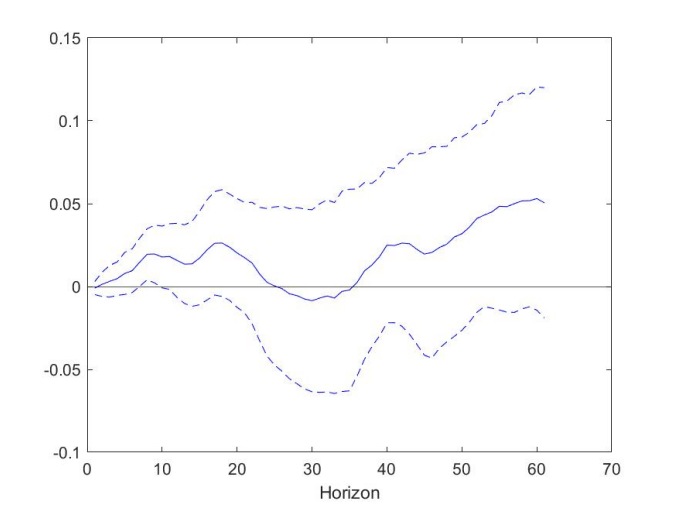

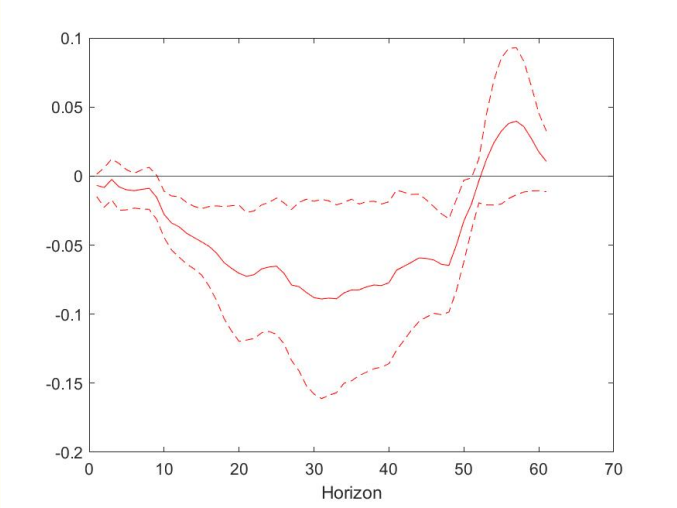

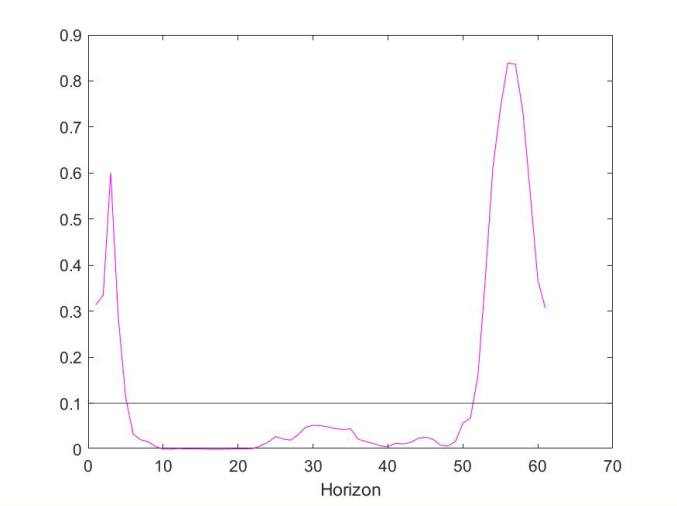

Robustness to Outliers

When the Volcker period is controlled for, there is strong evidence that monetary policy is more effective in recessions than expansions.

This is completely opposite of the baseline case.

The Volcker period results are robust to using VAR shocks in place of the Romer and Romer (2004) shocks and using real Personal Consumption growth as the measure of output.

Conclusion

There are substantial differences in the business cycle asymmetry literature that can be explained by three main differences in specifications:

- Results depend on the measure of output and the frequency of data used.
- Results depend crucially on whether impulse response functions are estimated using (log) levels vs. first differences of output measures.
- Results depend on outliers in the monetary policy shock measures.

When all three of these factors are accounted for, I find that monetary policy is more effective in recessions than expansions.