5-8-2020

Evaluating the effectiveness of quantitative easing: An SVAR approach

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Evaluating the Effectiveness of Quantitative Easing: An SVAR Approach

An Honors College Project Presented to

the Faculty of the Undergraduate

College of Business

James Madison University

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April 24, 2020

Accepted by the faculty of the Department of Economics, James Madison University, in partial fulfillment of the requirements for the Honors College

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Acknowledgments

I would like to extend my thanks first and foremost to Dr. Vipul Bhatt. Dr. Bhatt not only was my advisor for this project, but also encouraged me to undertake a project like this in the first place. I can honestly say I would not be pursuing a career in economics if it were not for him. I also would like to thank the other members of my committee on this project, Dr. Kirk Elwood and Dr. Andre Neveu, for providing valuable insight and comments as I worked on this paper. All three of these individuals were always available for questions about my paper or even just to talk about life, for which I will always be grateful.

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Abstract

The 2008 recession affected the American economy more than any recession since the Great Depression. Unlike its response to the Great Depression, the Federal Reserve aimed to stimulate the economy through all means in its power. However, the Federal Reserve's conventional monetary policy tools were not viable options due to the zero lower bound. As a result, the Federal Reserve pursued an unconventional monetary policy tool known as quantitative easing which involved purchases of long-term assets on a scale never before seen in the United States. Since its inception, quantitative easing has faced significant scrutiny over its merit and has been the focus of research that has resulted in conclusions ranging from a complete failure to a resounding success. This paper focuses on quantitative easing's effect on the macroeconomy and finds that although quantitative easing was effective in increasing inflation and lowering rates on long-term Treasuries and mortgages, there was a negative effect on real economic activity, casting doubt on how effective these programs were on stimulating the economy as a whole.

Section 1: Introduction

The 2008 recession caused by the housing bubble burst presented a new challenge to the Federal Reserve: expansionary monetary policy at the zero lower bound (ZLB). The Federal Reserve lowered the federal funds rate (FFR) several times in the years leading up to 2008 in an attempt to stimulate the economy, causing interest rates to approach the ZLB. As a result, the Federal Reserve's traditional monetary policy tool of lowering the short-term interest rate became ineffective, causing a need to find another method to aid the economy's recovery. The Federal Reserve turned to a new and unproven tool called "quantitative easing" (QE). QE involved large-scale purchases of assets with longer maturities, such as mortgage-backed securities (MBS's) and 10-year Treasuries, in an attempt to lower long-term interest rates and stimulate the economy.

There were four waves of QE in the U.S. The first round (QE1) began in November 2008 and lasted until March 2010. During this time the Federal Reserve purchased roughly $1.7 trillion in MBS's and government bonds in an attempt to lower mortgage rates and overall risk. In the words of the Federal Reserve, QE1 aimed to "reduce cost and increase the availability of credit for the purchase of houses, which in turn should support housing markets and foster improved conditions in financial markets more generally." (Federal Reserve Press Release, November 25th, 2008). The second round (QE2) involved the purchasing of $600 billion in long-term Treasuries in an attempt to decrease long-term interest rates. QE3 occurred from November 2010 to June 2011 and took a two-pronged approach:

The Federal Reserve would continue to buy MBS's and long-term Treasuries in the amount of $85 billion per month, while selling short-term Treasuries to finance their purchases. In theory, this would cause short-term rates to increase and long-term rates to fall, thus decreasing the term premium or causing the yield curve to invert or "twist". The last installment of quantitative easing (QE4) occurred from January 2013 to December 2014. The Federal Reserve committed to start buying $85 billion in Treasuries per month, with the expectation of this amount slowly tapering in order to allow Treasury yields and the unemployment rate to slowly adjust to smaller injections of money.

The record amount of purchases by the Federal Reserve generated significant debate over the merit of this program and put monetary policy officials squarely in the global spotlight. Extensive research has been conducted on QE, yet there is by no means a consensus as to the effectiveness of QE. Most research focuses on the impact QE had on the financial sector, while this paper contributes to the more limited literature on evaluating the macroeconomic effectiveness of QE programs in the U.S.

The effectiveness of QE on the U.S. economy will be examined below using a structural vector autoregression (SVAR) model. I will measure QE's effect on long-term rates and see if these effects passed through to increased real economic activity, proxied by real industrial production (Index: 2012=100). Viability of QE as a monetary policy depends on analysis results robustly showing that long-term rates fell, which passed into the macroeconomy in increased production and

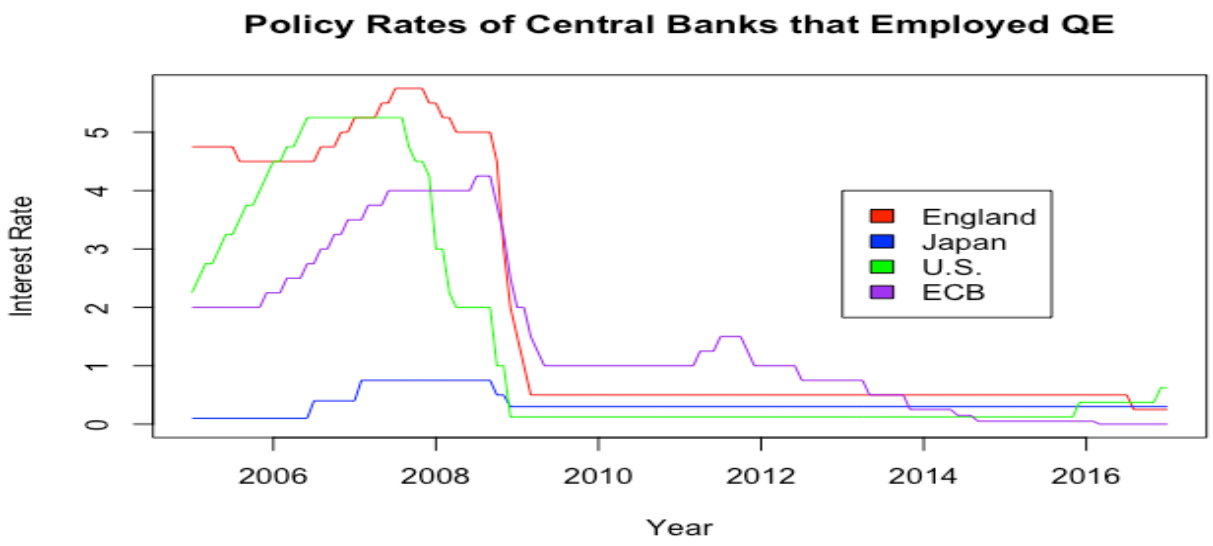
inflation. Therefore, my final analysis will focus mainly on industrial production and inflation when evaluating the effectiveness of quantitative easing. Few studies have used SVAR models in analyzing macroeconomic variables, so this paper will provide insight from a different angle. The results of these models will provide evidence of the effectiveness of quantitative easing and its viability as a monetary policy tool to combat future recessions.

The rest of the paper precedes as follows: *Section 2* provides a brief explanation of the theory/mechanism behind quantitative easing while *Section 3* provides an extensive review of the existing literature on this topic. The overview not only helps identify the best specification for the SVAR model in terms of the functional form and the variables to be included, but also relates what other researchers have concluded about the efficacy of QE. *Section 4* describes the data used in the analysis while *Section 5* provides information on the methodology and models used in the paper. Next, *Section 6* offers analysis and discussion of the main findings of the paper. Lastly, *Section 7* contains concluding remarks.

Section 2: How Does Quantitative Easing Work?

As mentioned earlier, the Federal Reserve and most other central banks faced the ZLB starting around 2009. *Figure 1* shows the policy rates of 4 major banks: the Bank of England (BOE), Federal Reserve Bank of the United States (US), Bank of Japan (BOJ), and European Central Bank (ECB). As a result of the ZLB, these central banks created QE programs to affect the economy through different, less familiar, channels.

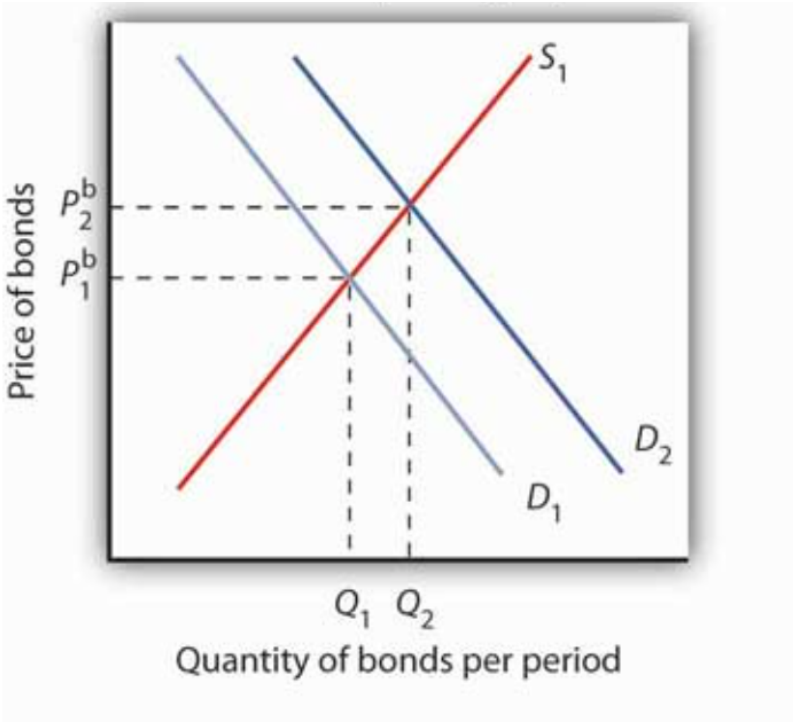
Figure 1



Policy Rates retrieved from data section of Bank for International Settlements (BIS)

There are a number of different theories that describe how quantitative easing should affect an economy — this section focuses on a few of the more common models . First, as Doh (2010) discusses, the Federal Reserve's purchases increased the demand for bonds following the 2008 crisis. As *Figure 2* shows, this causes bond prices to increase, and thus, since prices and interest rates are inversely-related, interest rates to decrease. Since the Federal Reserve mainly purchased longer-term assets in its QE programs, longer-term interest rates should fall. Fawley and Neely (2013) describe how this channel works: When a central bank purchases assets of a certain duration, which are accompanied by a given level of risk, investors demand less compensation via lower interest rates for holding assets of that duration due to the low risk associated with central banks. As a result of lower interest rates, investment should increase and stimulate the economy

Figure 2



through increased aggregate demand. This would lead to higher industrial production and prices — or at least prevention of further deflation. Similarly, Doh (2010) discusses the role the term premium, or spread between short-term and long-term interest rates, has on stimulating the economy in the preferred-habitat model. Since the U.S. was facing the ZLB, a decrease in the term premium through lowering long-term interest rates would help stimulate the economy. The preferred-habitat model relates the size of the decrease of the term premium to the level of risk aversion in the economy — the higher the risk aversion, the larger the decrease in the term premium, and vice versa. Risk aversion in the United States was high following the 2008 crisis, meaning QE should result in a relatively large decrease in the term premium and stimulation of the economy through increased aggregate demand. Schenkelberg and Watzka (2013) discuss another theory that involves

steering inflation expectations, commonly referred to as "signaling", as labeled by Bernanke et al. (2004). This theory asserts that changing expectations about future monetary policy changes inflation expectations. In this scenario, QE should result in an increase in inflation expectations. If these perceptions are permanent, long-term interest rates would fall. As a result, aggregate demand would increase further, causing output and prices to increase more. While these theories use different mechanisms in explaining how QE should work, they all produce the same end result: increased output and prices.

Section 3: Related Literature

Although QE was unfamiliar to most when the Federal reserve employed the tool in response to the Great Recession, it was not the first time such a program had been utilized. Coenen and Wieland (2003) note that "Operation Twist", a predecessor to QE, occurred in 1961 in the U.S., and the BOJ officially started rounds of QE in 2001 that lasted for several years. The United Kingdom also employed QE following the 2008 crisis and the ECB began a program similar to QE in 2015. The QE programs by the Federal Reserve and the Bank of England were most similar as they both relied heavily on bond purchases, while the ECB and BOJ typically lent directly to banks. First, a brief discussion of these other QE programs is necessary to gauge the effectiveness of the tool in different countries, times, and circumstances. Then, the findings related to QE in the United States will be discussed. It is important to discuss the findings of the research conducted in all of

these areas to help frame the findings of this paper and discuss the validity of QE as a monetary policy tool as a whole.

Section 3.1: Operation Twist

Previous research on Operation Twist offers intriguing results as to the effectiveness of this monetary tool. Fawley and Neely (2013) discuss the objective of Operation Twist was to lower long-term rates relative to short-term rates, thus "twisting" the yield curve. To do so, the Federal Reserve sold short-term assets while simultaneously purchasing longer-term assets. However, there is significant disagreement on the effectiveness of this tool. For one, Modigliani and Sutch (1966) found that Operation Twist was, at the very best, of "average success". On the other hand, a study by Swanson (2011) found that Operation Twist in the 1960's resulted in long-term Treasury yields dropping by approximately 15 basis points (BP). Nonetheless, this tool served as the basis for the Operation Twist that the Federal Reserve started beginning on September 21st, 2011, which directly led to QE3, as Fawley and Neely (2013) note.

Section 3.2: Bank of Japan

Studies on the effectiveness of QE by the BOJ suggest a statistically significant, positive impact on the economy, but temporary and smaller in size than one might expect. Ueda (2012) asserts that initial response to QE saw 10-year rates decrease by around 35 BP and the stock market index increase by nearly 20%. However, both of these returned to their original levels just a few months later. Meanwhile, Swanson (2011) concluded that QE did result in a decrease in the rates

on longer-term assets in Japan. Moreover, Bernanke, et al. (2004) found that the BOJ's purchases of Japanese Government Bonds (JGB's) had a statistically significant impact in lowering the rates on these bonds. Similarly, Schenkelberg and Watzka (2013) assert that QE led to a statistically significant decrease in long-term interest rates, which caused a significant, but transitory, increase in output and prices. Their analysis also determined that prices increased by 5 BP and industrial production increased by 0.4% after 20 months, while long-term yields fell by 7 BP. Moreover, they came to this finding without imposing any sign restrictions on long-term yields since there is no definitive proof that QE causes long-term yields to decrease. As a result, long-term yields are able to increase or decrease, allowing for a better indication of the true impact QE has on long-term rates. More on this technique will be discussed later in this paper. However, Ugai (2007) discusses how other studies have found the impact to be insignificant and difficult to distinguish given the zero interest rate policy and other tools the BOJ employed at the time. The lack of a consensus on the effectiveness of the BOJ's QE is a common thread in analysis of most central bank's QE policies.

Section 3.3 European Central Bank

The ECB began its QE program in March 2015 — much later than most other major central banks. The ECB planned on purchasing €60 billion worth of Euro-area government bonds per month with purchases lasting until at least September 2016. This amount increased to €80 billion in March 2016 and finally ended in 2019 after a tapering in the amount of monthly purchases. In an analysis of the QE

program undertaken by the ECB, Peersman (2017) found that there was a statistically significant increase in output and prices one year after the program began. Furthermore, the peak effect of QE was at least 6 months later than the peak effect of conventional monetary policy. Peersman (2017) asserted that the purchases by the ECB had the same effect as a roughly 25 BP decrease in the policy rate or a 10% increase in the monetary base at a given policy rate. The analysis conducted by Gambacorta et al. (2014) of unconventional monetary policy in 8 locations — Canada, the Eurozone, Japan, Norway, Sweden, Switzerland, the U.K., and the U.S. — found there was a significant, but temporary, increase in output and prices in the Eurozone as a result of QE. Gambacorta et al. (2014) also asserted that unconventional monetary policy tends to have a relatively larger impact on output than prices in percent terms (3:1), while conventional monetary policy still has a larger impact on output than prices, but by a smaller margin (1.5:1). All of these findings line up relatively well with the research done on QE by the BOJ: a statistically significant, but temporary, positive effect on the economy. However, the peak effect of QE on output by the BOJ occurred much quicker than the peak effect observed in the Euro area.

Section 3.4: Bank of England

The Bank of England began purchasing long-term assets around the same time the Federal Reserve did, but on a smaller scale. There were 3 major rounds of purchases in the U.K. as Meier (2009) notes. Fawley and Neely (2013) discuss the expansion of the QE program in the U.K.: Starting on March 5th, 2009, the Bank of

England announced it would purchase up to a total of £75 billion in assets, with the majority of these assets being medium to long-term gilts, the U.K. equivalent of U.S. Treasuries. This program was expanded several times through July 5th, 2012, at which point the Bank of England announced it would purchase up to £375 billion in longer-term assets. The Bank of England maintained that the goals of the program were to "boost the money supply through large-scale asset purchases and, in doing so, to bring about a level of nominal demand consistent with meeting the inflation target in the medium term." (Bank of England Press Release, 2012). Previous studies by Kapetanios et al. (2012) and Palley (2011) have found that interbank borrowing rates dropped significantly following the first round of QE, asset and stock prices increased, government and corporate bond prices fell, and economic growth returned two quarters after the first purchases began. Joyce et al. (2012) suggest QE could have had as large of an effect as a 1.25% increase in real GDP and a 125 BP effect on the consumer price index. Further, Meier (2009) found that the announcement of QE in the U.K. was associated with a 35-60 BP decrease in gilt yields, while a study conducted by Joyce (2012) found that gilt yields fell by almost 100 BP and rates on long-term government bonds fell by 40 to 100 BP. Lastly, Reza et al. (2015) claim that gilt yields fell between 45 and 130 BP and GDP increased between 65 BP and 175 BP as a result of these large-scale purchasing programs. The analyses of the Bank of England's QE offer the most definitive results that QE is a viable monetary policy tool.

The research involving the BOJ, ECB, and Bank of England suggest that QE has merit, but size and duration can vary depending on the structure, scope, and timing of the program. However, analysis of QE in the U.S. is still the most important, due to the size of the U.S. economy and scope of the QE programs.

Section 3.5: Federal Reserve

As discussed earlier, the Federal Reserve had several installments of QE and was the most active of all of the central banks in responding to the 2008 crisis. A study by Gagnon et al. (2011) found that the purchases between December 2008 and March 2010 had significant, long-lasting effects on the long-term interest rates of U.S. Treasuries, mortgage-backed securities, and corporate bonds, which is not frequently observed in the research on QE programs by other central banks. Further, the same study concluded that the first two rounds of QE reduced the 10-year premium by 30-100 BP. An article by Krishnamurthy and Vissing-Jorgensen (2011) backed up these claims, but also noted that the effect on riskier corporate bonds (Baa or riskier) was noticeably smaller. Similarly, Nelson (2013) finds that QE1 was associated with a decrease in long-term Treasuries by 90 BP. Additionally, he found that QE1's effect was roughly equivalent to a 400 BP slash of the FFR, while QE2's effect was equal to a 40-120 BP decrease in the FFR. However, these estimates may overstate the effectiveness of QE. A study by Belke (2018) notes that long-term interest rates decreased in most countries worldwide, even though no QE had been undertaken in these countries as of yet. For example, rates in the Euro area decreased well before the ECB began its purchasing program. The same study

suggests there was a global downward trend in long-term interest rates during this time which many papers do not account for in their analyses, resulting in frequent overstating of the impact of QE.

A few findings of the impact on macroeconomic variables include claims by Baumeister and Benati (2011) that the lower long-term rates positively affected output growth and significantly decreased the risk of deflation and "output collapse". Similarly, the study by Liu et al. (2014) used counterfactual analysis and found that unemployment would have been 70 BP higher and inflation would have been 100 BP lower if the Federal Reserve had not conducted QE. A study by Chung et al. (2012) found similar results: These large-scale asset purchases increased real GDP by 3%, increased inflation by 100 BP, lowered the unemployment rate by 150 BP, and decreased the term premium by 70 BP when compared to projected values of these measures had the Federal Reserve not undertaken QE. Lastly, Reza (2015) found the cumulative effect of the QE programs to have lowered the yield on 10-year Treasuries by 65-120 BP, while Dahlhaus et al. (2014) found that QE lowered 10-year Treasuries by 82 BP.

The analyses of QE in the U.S. are by far the most varied and contested. Generally, most studies find QE did lower long-term rates, but results on the impact on real economic activity are less clear. Further, the lag until peak impact is observed and how long the impact of QE lasts are both unclear as well. This paper attempts to add clarity to these issues.

Section 4: Data

The data used in this paper consists of 556 observations of 8 key macroeconomic variables. All observations are monthly and seasonally-adjusted, where applicable, from January 1973 to April 2019. The 8 variables are inflation (INFL), industrial production (IP), unemployment rate (UR), federal-funds rate (FFR), 30-year mortgage rate (M30), 10-year Treasury rate (T10), 1-year Treasury rate (T1), and the trade-weighted exchange rate (ER) (Index: 1997=100). Industrial production is used to measure output instead of GDP so that all variables have a monthly frequency since GDP is only measured at a quarterly frequency and lower. Inflation was calculated using the consumer price index (CPI). All data is available on the Federal Reserve Economic Data (FRED) website run by the Federal Reserve Board of St. Louis. The *Appendix* provides additional information on the exact data used in this paper.

Section 5: Methodology

Section 5.1: *Specification of VAR Model*

To evaluate the effectiveness of QE the following reduced-form VAR model is used:

$$Y_t = c + A(L)Y_{t-1} + u_t$$

where Y_t is a vector of endogenous variables, c is a vector of intercepts, A(L) is a matrix of autoregressive coefficients of lagged Y_t values, and u_t is a vector of residuals. The macroeconomic chosen for the benchmark regression are:

$$Y_t = \{INFL_t, T1_t, T10_t, FFR_t, IP_t, M30_t, ER_t, UR_t, RES_t\}$$

All of these variables achieve stationarity when differenced. 4 lags of each variable are included in this model using the AIC, while the ordering of the SVAR used in this paper is {IP, UR, INFL, ER, M30, T10, T1, FFR, RES}, in order of decreasing endogeneity, although different orderings resulted in similar results, which is discussed later in the paper.

Section 5.2: Sign Restrictions

The main assumptions imposed in this model are threefold: 1) QE increases reserves, which signals the QE shock, 2) there is a non-zero increase in INFL as a result of QE, and 3) there is a subsequent reduction in the FFR as a result of the increase in reserves. These restrictions force the following responses: 1) Reserves increase immediately since that signals the shock, 2) inflation increases following the shock, and 3) the FFR decreases following the shock. These restrictions only limit the direction of the response — there is no effect on the magnitude. These assumptions are widely-accepted theories, as research by Coenen and Wieland (2003) and Peersman (2017) assert that QE leads to an increase in inflation, while the immediate negative impact on the federal funds rate when reserves increase is included as part of a coordinated monetary policy front. Yields, mortgage rates, and industrial production are left unrestricted since these are the main variables of interest that will reveal the impact of QE on the macroeconomy, while the exchange rate and unemployment rate are left unrestricted due to a lack of consensus on how QE affects these variables. *Figure 3* below summarizes the sign restrictions

implemented in the model. Any variables not present in the table are left unrestricted.

Figure 3

Variable	RES	INFL	FFR
Restriction	>0	≥0	<0

Section 6: Results

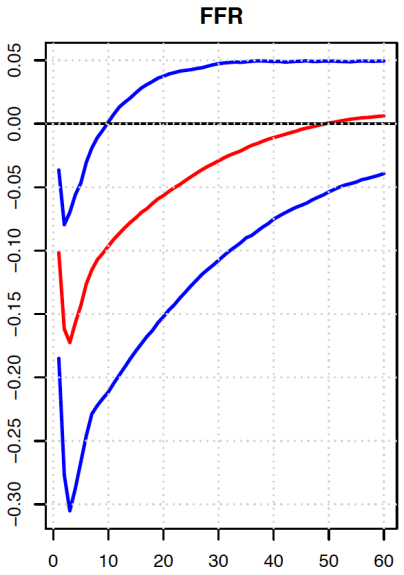
Section 6.1: Impulse Response Functions

Using these restrictions and the VAR model previously specified, *Figure 11* in the appendix shows the impulse response functions for the 9 macroeconomics variables in the model. The red line represents the median impulse response function from a Bayesian vector autoregression with 10000 draws, while the blue lines represent the 16th and 84th percentiles of the posterior distribution of the impulse response functions. As noted above, the impulse is a positive shock to reserves, so all the graphs show the given variables' response to this shock at that point in time, which explains the immediate positive response of reserves and inflation and the negative response of FFR. While the IRFs show how QE affected each of these variables during each month in the 60-month horizon, the cumulative effect of QE on each variable will be the main focus of the results since the overall effect of QE on long-term interest rates, inflation, and industrial production in the years following QE is much more important than the effect QE had on these variables on a month-to-month basis. A discussion of selected IRFs is presented below. The robustness of

these results hold in several different orderings of the VAR model, as the impulse response functions in *Figures 11-14* in the Appendix show.

Section 6.1a: Federal Funds Rate (FFR)

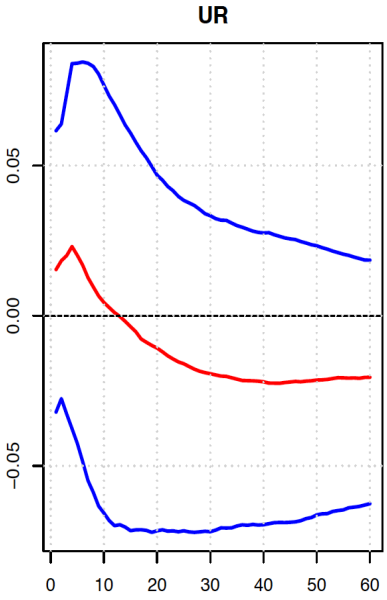
Figure 4



The peak effect on FFR is observed 3-4 months after the initial shock at -18 BP, while the cumulative effect is a decrease of the FFR by 280 BP. The peak and cumulative effect on FFR in this study are both smaller in magnitude in comparison to other studies (*see Nelson (2013)*). However, the effect is still quite large and suggest that QE was effective in lowering the FFR.

Section 6.1b: Unemployment Rate (UR)

Figure 5

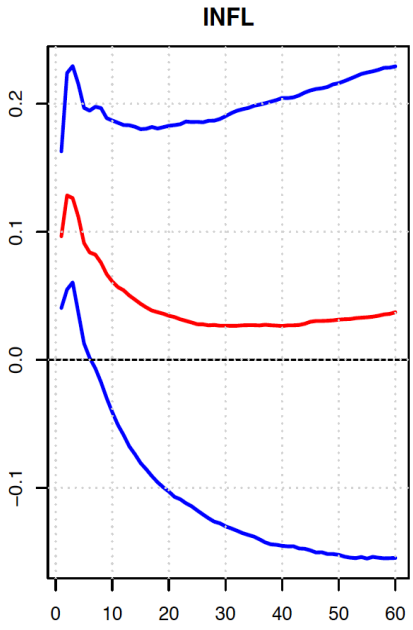


The impact that QE had on the unemployment rate changed signs during the 60-month horizon. Initially, QE caused the unemployment rate to increase, with a peak effect of 2.5 BP 4 months after the shock. However, the desired impact of QE seems to have a significant lag — starting 14 months after the shock, the unemployment rate began to fall and have the effect the Federal Reserve desired. The cumulative effect of QE on the unemployment rate during the 60-month horizon totals a respectable decrease of 79 BP, though this estimate is significantly smaller than the estimate provided by Chung et al. (2012).

Section 6.1c: Inflation (INFL)

Using the sign restrictions listed above, the peak effect of QE on inflation is 12 BP 3-4 months after the shock to reserves. The impact on the inflation nearly disappears (2 BP) 20 months after the initial shock and hovers around this level for the remaining 40 months. The peak response of inflation is similar to the results of previous studies of QE in the U.S., but the cumulative effect on inflation paints a better picture. Over the 60-month horizon, QE resulted in a substantial increase in inflation of 142 BP. This estimate is slightly larger than the estimate provided by Liu et al. (2014), but still suggests that QE was effective in increasing inflation during the recession.

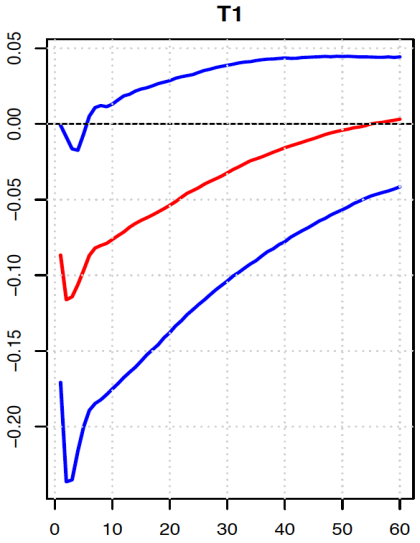
Figure 6



Section 6.1d: 1-Year Treasuries (T1)

QE appears to have had a larger impact on 1-Year Treasuries than any other variable even though the Federal Reserve aimed more to decrease rates on long-term bonds. The peak effect of QE on 1-Year Treasuries decreased rates by 11 BP 2 months after the shock while the cumulative effect of QE on 1-Year Treasuries totaled a decrease of 230.5 BP.

Figure 7



Section 6.1e: 10-Year Treasuries (T10) and 30-Year Mortgages (M30)

As mentioned earlier, QE largely focused on lowering the rates on 10-Year Treasuries and 30-Year mortgages. The response of these rates suggest that these goals of the Federal Reserve's QE programs were successful. The graph below shows both of these rates dropping without sign restrictions in response to the increase in reserves, which has been found nearly universally in other literature on the topic. Rates on 10-Year Treasuries fell by a peak value 5 BP 15 months after the initial shock and the impact remained negative for the duration of the 60-month horizon. The cumulative effect during the 60-month horizon totaled a decrease of 187 BP. This large decrease in the rate on long-term Treasury rates is a clear indication that QE was successful in lowering rates on long-term bonds. However, one goal of the Federal Reserve was to decrease the term premium, which appears to have been unsuccessful due to the larger decrease in rates on 1-Year Treasuries than 10-Year Treasuries.

Figure 8

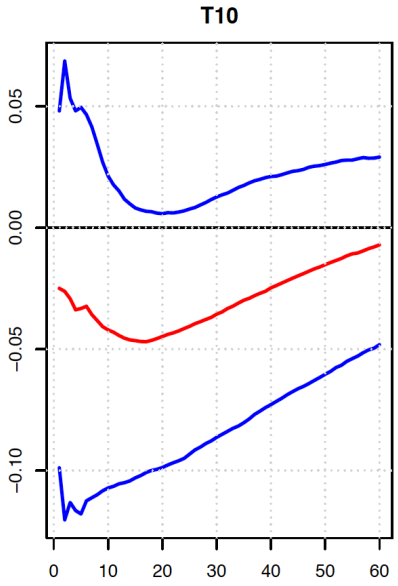
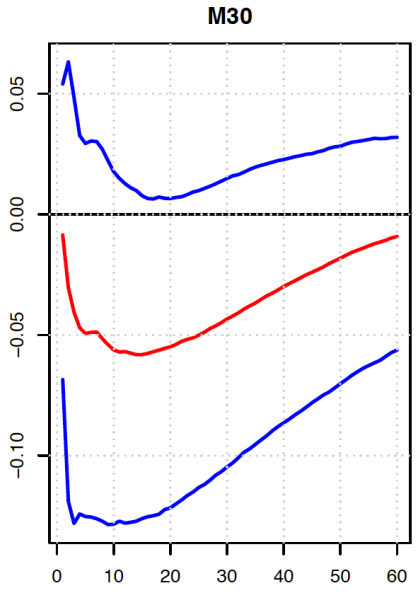


Figure 9

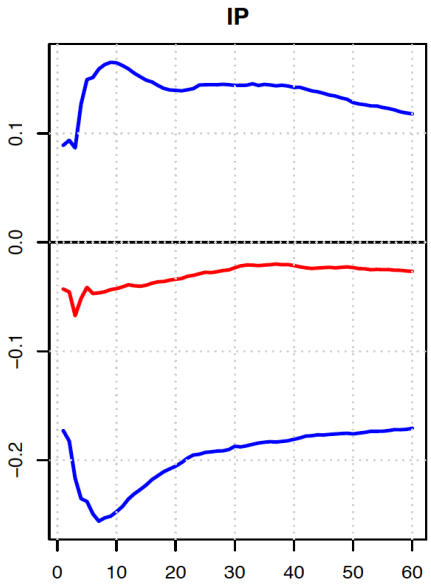


Meanwhile, rates on 30-year mortgages fell by a peak value of 5 BP, which is also in-line with previous studies *(see Krishnamurthy and Vissing-Jorgensen (2011), Dalhaus (2014), Baumeister and Benati (2011),*

Lenza et al. (2010)). The response of this variable to QE did remain negative for the entire duration of the 60-month horizon and had a cumulative effect of lowering rates on 30-year mortgages by 221.5 BP, another clear indication that the Federal Reserve's goal of lowering long-term rates was successful. The cumulative effect on these rates is larger than in most research, but clearly suggests success in lowering long-term rates. However, the effect on real economic activity is still the determining factor of the efficacy of QE in U.S.

Section 6.1f: Industrial Production (IP)

Figure 10



The response of IP to the shock suggests that QE was not successful in increasing real economic activity. Although the effect on IP was small in magnitude, the sign of its response to the increase in reserves is negative the entire 60-month horizon, implying that QE actually decreased real economic activity. In fact, the cumulative effect of QE lowered industrial production by 1.205%. As noted earlier, the impact on industrial production is slight for proponents of QE for most central banks: In Japan, Schenkelberg and Watzka (2013) found a negative effect on industrial production for the first 15 months, which then switched to a small positive effect after 15 months. Meanwhile, Lenza et al. (2010) also found a dip in industrial production in the Euro area for several months following the unconventional monetary policy undertaken there. Proponents of QE explain this

observation through the lagged effect of monetary policy shocks on real economic activity, though the 60-month horizon in the IRF's of this paper provide no evidence that the effect on IP was significantly lagged and any lagged effect longer than 60 months is highly unlikely. While it may appear there is little research to prove that QE has a significant impact on real economic activity, the counterfactual analysis mentioned earlier must be considered. The results of most papers suggest QE had a minimal effect, but when considering the economy was likely still deteriorating, QE may have been more successful than it appears.

Section 7: Conclusion

In line with most previous research on the effectiveness of QE, the results of this research paper cast doubt on the efficacy of such programs on the surface. While it appears that the Federal Reserve was successful in lowering rates on 10-Year Treasuries and 30-Year Mortgages and increasing price levels, these did not result in the increased real economic activity suggested by economic theory. This could indicate that economists need to reconsider the mechanisms through which QE affects the economy, or simply more research is needed to refine our models instead of concluding our current theories are completely insufficient. On the other hand, it is entirely possible that the observed effects of QE on the economy are a result of the economy continuing to decline after QE began, thus implying that quantitative easing cushioned the blow of what could have been a catastrophic recession, as suggested by the counterfactual analysis discussed previously in this paper. Due to the success in lowering long-term rates, increasing inflation, and

robustness of counterfactual analysis, quantitative easing more than likely had a positive impact on real economic activity that was negated by a continued downturn in the economy; however, with so few instances of QE worldwide and a lack of consensus from the research on the topic, its effectiveness is still uncertain. It is further important to note that there was a significant lag in observing the peak effect of QE on most of the macroeconomic variables discussed, which was similarly found in previous research in this area. However, analysis did show that QE did have a long-lasting effect on most variables that totaled significant effects as a result of QE, especially rates on Treasuries, mortgages, and inflation. Further research into developing a tool that affects the economy quicker would likely increase the effectiveness of monetary policy. The next step of research on QE should focus on explaining why the effect of interest rates and inflation did not pass through to an observable increase in real economic activity, while other research in this area could focus on zero restrictions instead of sign restrictions in the VAR model, different orderings of the VAR model to further test the robustness of the results, as well as meta-analysis of all the different research on QE programs worldwide.

Appendix

Text in Parentheses denotes abbreviation used on FRED's database.
https://fred.stlouisfed.org

1. Consumer Price Index (CPIAUCSL)- Consumer Price Index for All Urban Consumers: All Goods. Index: 1982-1984=100; seasonally adjusted.
2. Industrial Production (INDPRO)- Industrial Production Index. Index: 2012; seasonally adjusted.
3. Unemployment Rate (UNRATE)- Civilian Unemployment Rate. Seasonally adjusted.
4. Federal Funds Rate (FEDFUNDS): Effective Federal Funds Rate; Seasonally adjusted.
5. 30-Year Mortgage Rate (MORTGAGE30US): 30-Year Fixed-Rate Mortgage Average in the United States. Weekly observations averaged to obtain a monthly observation.
6. 10-Year Treasury (DGS10)- 10-Year Treasury Constant Maturity Rate. Daily observations averaged to obtain a monthly observation.
7. 1-Year Treasury (DGS1)- 1-Year Treasury Constant Maturity Rate. Daily observations averaged to obtain a monthly observation.
8. Exchange Rate (TWEXBMTH)- Trade-weighted U.S. Dollar Index: Broad Goods. Index: January 1997=100.

Figure 11

Impulse Response Functions for VAR ordering {IP, UR, INFL, ER, M30, T10, T1, FFR, RES}

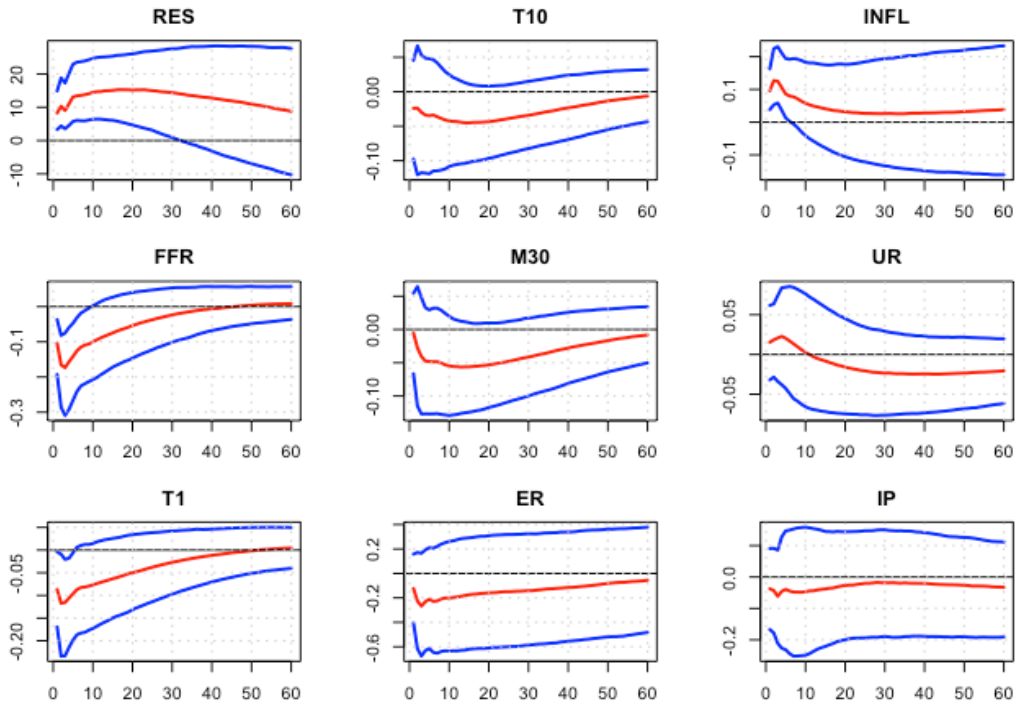


Figure 12

Impulse Response Functions for VAR ordering {RES, T1, T10, M30, FFR, INFL, ER, IP, UR}

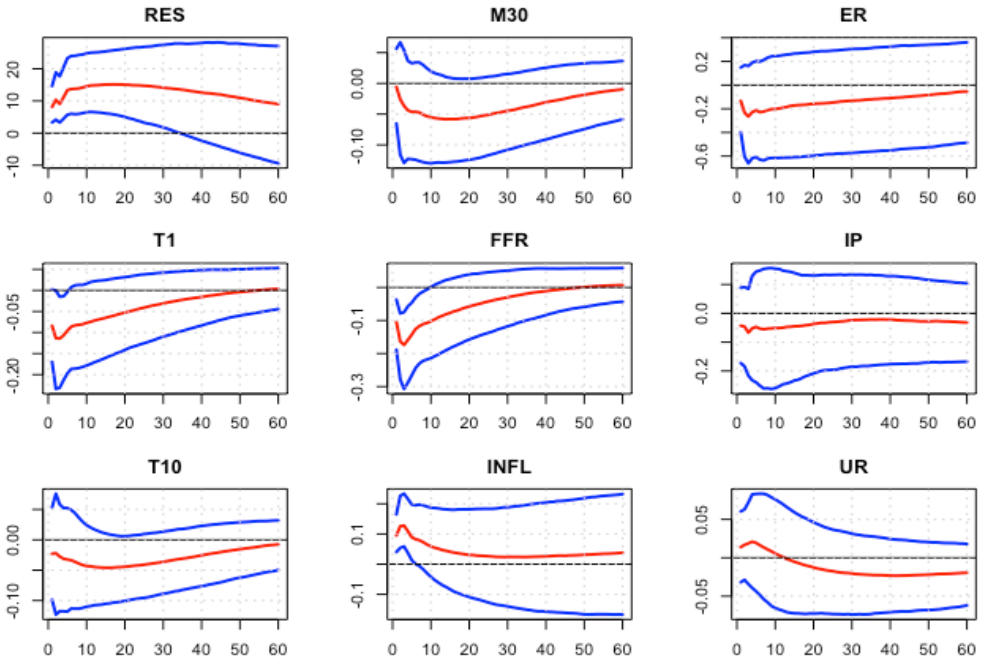


Figure 13

Impulse Response Functions for VAR ordering {RES, FFR, INFL, M30, T10, T1, IP, ER, UR}

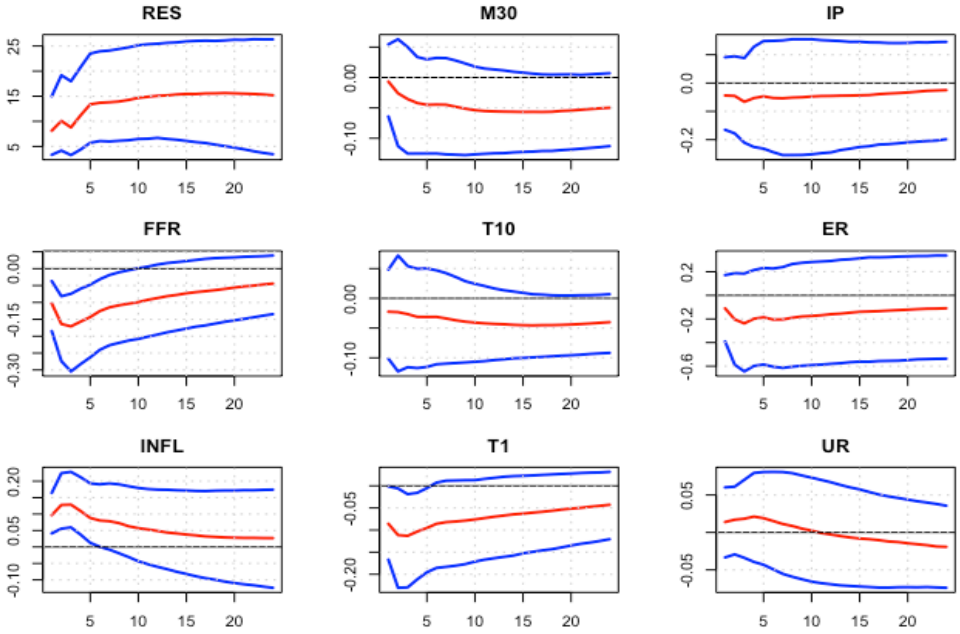
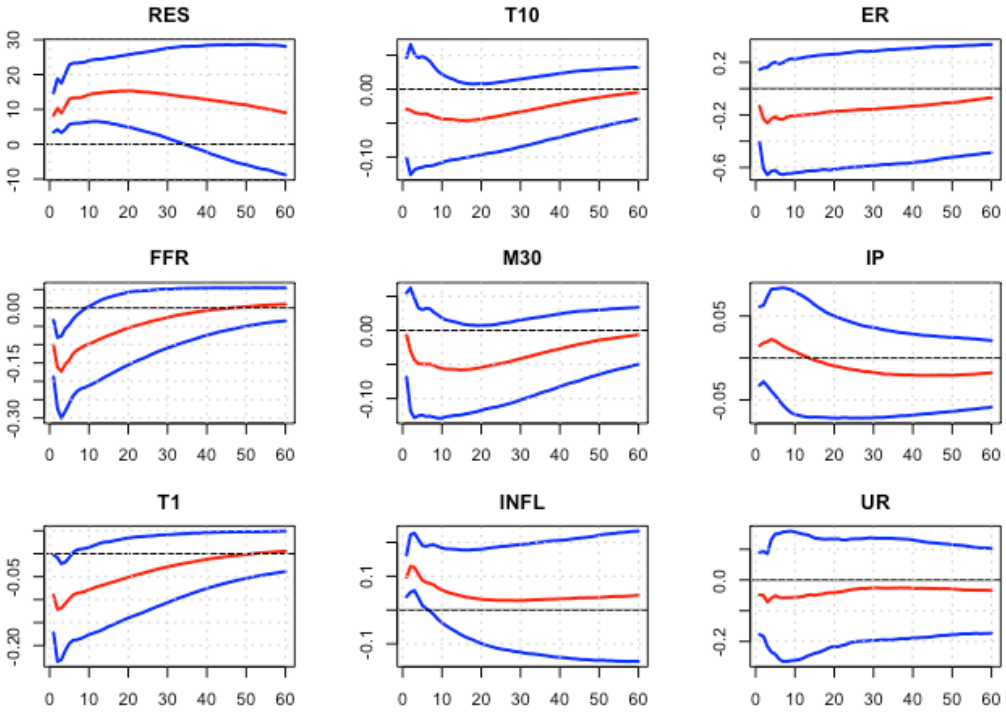


Figure 14

Impulse Response Functions for VAR ordering {RES, FFR, T1, T10, M30, INFL, ER, UR, IP}



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