# Monetary Policy, Fiscal Policy, and the Great Recession

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## Abstract

The aim of this paper is to examine if government policies helped the economy and the people adversely affected by the Great Recession of 2008. This is assessed by examining the relative impacts of monetary and fiscal policies on unemployment during the Great Recession (2008 – 2009) within vector autoregression models. Using federal budget deficits and surpluses as a proxy for fiscal policy and money supply and interest rates to capture the effects of monetary policy, the paper finds that the three variables account for 24.57%, 27.21% and 24.78%, of the variance of unemployment respectively. Estimation of the same model over the pre-Recession periods (2001:10 – 2007:09) finds the three variables explaining 9.53%, 43.16% and 13.74% respectively of the variance of unemployment. This finding is broadly consistent with Christopher Sims' (2013) assertion that monetary and fiscal policies are intertwined during and after the Great Recession.

# Monetary Policy, Fiscal Policy, and the Great Recession

## Introduction

The Great Recession of 2008 chalked another dark period in the economic history of the United States, second only to the Great Depression of the 1930's. It all stemmed from a burst of the housing bubble that spearheaded a near collapse of the banking sector globally. The hardest hit were large U.S. banks, including Lehman Brothers, Bear Sterns and AIG were heavily invested in low grade mortgage backed securities (MBS). Giant mortgage institutions Fannie Mae and Freddie Mac also reached near collapse and survived only because of their being U.S. government sponsored organizations. The auto industry, especially General Motors and Chrysler were on the brink of bankruptcy.

The Great Recession began in December of 2007 and ended in June of 2009 according to the National Bureau of Economic Research (NBER). The period saw massive business failures and near failures across the board, including commercial banks and the auto industry. Daily news of housing and business foreclosures, looming bankruptcy, and layoffs resulted in the official unemployment rate reaching as high as 10.0% in October 2009, while the unofficial rate was estimated to be roaming well above that rate. The severity of the recession caused layoffs not only in all sectors of the private economy but also in state and local governments. The economic gloom was not confined to the U.S. only, as all other industrialized nations were drawn into it. Fortunately, the looming economic depression was averted by having it settle down to what we now call the Great Recession. Economists and economy watchers --

especially those who believe in aggregate demand policies argue that a well-coordinated monetary and fiscal stimuli may have averted the economy from plunging into the second Economic Depression.

In the middle of the last quarter of 2007 and the beginning of 2008 key economic indicators were alerting about a looming risk of a recession. The subprime mortgage crisis had resulted in a widespread credit crunch by late 2007. Many prominent economists have observed that the economy may already be in a recession. Stocks have plummeted and big banks Citigroup and Merrill Lynch reported huge quarterly losses resulting from bad mortgage investments.

In his testimony to the Congress, Federal Reserve Chairman Ben Bernanke emphasized for prompt policy responses to stimulate the economy through targeted government spending and tax incentives (Kopecki, 2008). During his Thursday (January 17, 2008) hearing, Bernanke argued for a fiscal stimulus package of up to $150 billion.

Harvard economist and former Treasury Secretary Larry Summers told lawmakers that Congress should consider a stimulus package of up to $150 billion. He pleaded for an immediate fiscal policy action through a combination of tax cuts and increased spending on unemployment benefits and other programs. (La Monica, 2008).

Congress was persuaded for an immediate stimulus package and wasted little time to pass such legislations to speed up businesses and consumers spending during 2008. The action by the Congress has proved to be an effective timely policy response. “The researchers found that the stimulus checks increased spending for the typical family by 3.5% when the rebate arrived, boosting overall nondurable consumption by 2.4% in the second quarter of 2008”. (Broda, 2008).

The Economic Stimulus Act of 2008, was put in place by the outgoing Bush administration. The program injected $152 billion into the US economy in February of 2008. It consisted of two main parts: providing rebates to individual households to boost consumption and tax relief to small businesses to provide liquidity and stimulate investment. Another panic driven fiscal policy response enacted was the Troubled Asset Relief Program (TARP) which added around $475 billion dollars to stimulate the economy. There were many sectors that were resuscitated by this program, including the banking sector, automotive sector, and households. The TARP also saved some banks that got enmeshed into trouble by investing in the MBS market.

The next fiscal stabilization was President Obama's American Recovery and Reinvestment Act of 2009 (ARRA). This Act appropriated an additional stimulus package of $787 billion, which was dispensed in three ways: $288 billion for tax cuts and benefits to individuals and firms; $275 billion in contracts, grants and loans; and $224 billion in entitlements. It may be noted that the Obama White House also enacted the longest-lasting emergency unemployment compensation program in history and supplemented the Temporary Assistance to Needy Families (TANF) program until the end of 2010.

The monetary response of the Federal Reserve was to keep the bench mark Federal Funds rate (RFF) close to zero. The Fed promptly invoked its role as the lender of last resort by providing commercial banks' easy access to discount window borrowing while concurrently engaging in aggressive pumping of liquidity into the banking sector through its open market operations. Realizing that these traditional expansionary

approaches were too little and too slow, the Fed resorted to aggressive non-traditional measures such as Forward Guidance and Quantitative Easing.[1]

The paper proceeds as follows: Section 2 presents a brief literature review. Section 3 discusses past controversies about money- income relationship. Section 4 presents the empirical methodology and variables used in the analysis. Section 5 discusses empirical results and their interpretations. The paper ends with a brief summary and conclusion.

## Literature Review

Blinder and Zandi (2010) examined the macroeconomic effects of the federal government's total policy responses within Moody's Analytics model. The model's simulated results showed without the government's aggressive policy responses, "GDP in 2010 would be about 11.5% lower, payroll employment would be less by some 8.5 million jobs, and the nation would now be experiencing deflation." In contrast, Cogan et al (2010) have found that large stimulus package of 2009 did not do much to stimulate consumption or government purchases to spur real GDP growth. Mian and Sufi (2012) found a small temporary effect of the 2009 cash for clunkers on consumption which diminished quickly. Taylor (2014) argues that the two payroll tax holiday of 2011 and 2012 did boost the economy but it was also short-lived like the Cash for Clunkers program.

Baumeister and Benati (2010) examined the macroeconomic impact of a compression in the long-term bond yield spread over the Great Recession period of 2008-2009 period. Their analyses of the U.S., Euro area, Japan and U.K. data revealed that a compression in the long-term yield spread exerted a powerful effect of increasing

both output growth and inflation. In a simulation based study using historical relationships between interest rates and components of GDP, Chung et. al (2011) have estimated that the Fed's large scale asset purchases through QEs may have supported 3 million jobs. Taylor (2014) has provided a critique of the Fed's QE policies. He argues, "Growth has been less with quantitative easing than the Fed originally forecast." His criticism is primarily about the slow recovery of the economy from historical perspectives. The average growth rate in the current recovery is approximately 2% as opposed to 6% over a comparable period of past recessions (see Bordo and Haubrich, 2012). Reinhart and Rogoff (2009) have examined financial crises in many countries over many years. They argue that the slow recovery was due to the degree of severity of the financial crisis that triggered the Great Recession (See also Bordo and Haubrich (2012), Papell and Prodan (2012)).

Until October 2014, the Fed had steered through three rounds of QE. From the implementation of QE1 that began in November 2008, the Fed's balance sheet holdings of assets grew from the pre-recession level of about 700 billion to $2.1 trillion by June 2010. By the end of 2012 the Fed set a new goal of holding securities to the tune of $2.054 trillion. However, the Fed continued with QE policy (QE2 and QE3) until October 2014 with the accumulation of $4.5 trillion in assets. This massive amount of reserves kept both short and long term interest rates at their historic lows, thereby slowing down housing foreclosures, lowering businesses and consumers' interest accrued debt burden, and, in turn, increasing business and consumers confidence and spending. The channel of operations may be explained as follows:

As the Fed buys Treasuries and MBS from commercial banks and other financial institutions, their reserves increase, lowering the RFF, which, in turn, lowers all other interest rates through the term and risk structure. Lower long-term interest rates facilitates business investments in capital goods and stimulates purchase of new homes and consumer durables by households. Lower interest rates on bonds tend to increase the demand for other types of assets such as stocks. Higher equity prices raise the net worth of firms and lowers borrowing constraints, thus allowing business expansion through investment in capital goods. Higher equity prices also enhances households' wealth which in turn boosts consumption spending in general. Certainly, the QE policies worked effectively to produce the desired outcomes. The unemployment rate climbed from pre-recession levels of 5% in 2008 to 10% by late 2009, then steadily kept declining to 5.6% by December 2014. Real gross domestic product began contracting in the third quarter of 2008 and did not return to growth until the third quarter of 2009. As consumer and business confidence started growing the stock market started picking up steam which caused the Dow Jones Industrial Average to steadily increase from a low of 6547 on March 8, 2009 to over 18,000 now. These intended outcomes of the Fed's aggressive expansionary activisms were not seen by many legislators, academics, and financial market watchers at the time. They cautioned about high inflation and plummeting value of the dollar.[2]

**Money – Income Relationship**

Estimation of the effectiveness of monetary policy on economic activity often brings some skepticisms because of the controversies about money – income causality over post World War II periods. In their seminal paper using a reduced form single

equation model (widely known as the St. Louis Equation), Andersen and Jordan (1968) showed that over the period 1952 – 1968, the effect of monetary policy on output is larger, faster, and more predictable compared to fiscal policy. Using a three variable model (M1, Industrial production, IP and whole sellers price Index, WPI) over the period 1947-1969, Nobel Laureate economist Christopher Sim's (1972) has found that Money Granger Causes industrial production (implying that past money growth can be used to predict output). However, by expanding the three variable model to include a short-term interest, Sims' ($1980_b$) overturned his 1972 money- income causal relationship and concluded that it is not the changes in money growth but rather changes in interest rates that affects output. In a rejoinder to Sims' conclusion, McCallum (1983) argued that in order to assess the effects of money on output, one should consider the combined effects of money and interest rates since money innovations (changes in money supply) appear as interest rate innovations (changes in interest rates), which in turn affects output. During this period numerous researchers have studied the money income relationship within a VAR framework with mixed results. Many previous studies investigated money-income relationship without including a fiscal variable in their analysis. Using the VAR methodology, Abdullah and Rangazas (1988) have shown that monetary variables are important predictors of real output. Their analysis further indicates that omitted variables and lag misspecification may be the reasons why previous studies based on VAR models failed to find a money income relationship.[3] In a recent paper Sims' (2013) argued, "Recent expansions of central bank balance sheets and of the level of rich-country sovereign debt, as well as the evolving political economy

of the European Monetary Union, have made it clear that fiscal policy and monetary policy are intertwined."

Sims' study was primarily devoted to price level determination. He argues that the recent aggressive activisms in monetary and fiscal policy, which made the U.S. and other advanced economies high debt economies, have made these policies intertwined. We argue that to influence price level determination, the policies must also influence the level of output and employment. This paper therefore sets forth the following objectives:

- Re-examine the money – income relationship over Sims's estimation period (1960:01 – 1978:12), the immediate pre-Recession period (1983:1 – 2006:10) and the Great Recession period (2008:01 – 2014:11) using the same specification as Sims'. No fiscal variable was included in these estimations.
- Estimate the relative impacts of monetary and fiscal policies on unemployment over equal duration samples of the pre-Recession (2001:10 - 2007:09) and the post-Recession (2007:11– 2014:11) period. Any significant difference in the estimated results between these two periods would reveal if the aggressive monetary and fiscal expansion during the Great Recession worked to achieve the intended policy goals.

## Empirical Methodology

### Vector Autoregression

Vector autoregression (VAR), developed by Christopher Sims ($1980_a$), is now a widely used econometric technique for analyzing time series. It is essentially a system of reduced form dynamic linear equations in which each variable is expressed as a function of serially uncorrelated errors and an equal number of lags of all variables in

the system. The following is an example of a VAR system of equations consisting of three variables, x,y, and z:

$$x_t = C_1 + \alpha_{11} x_{t-1} + \beta_{11} y_{t-1} + \gamma_{11} z_{t-1} + e_{tx}$$

$$y_t = C_2 + \alpha_{21} x_{t-1} + \beta_{21} y_{t-1} + \gamma_{21} z_{t-1} + e_{ty}$$

$$z_t = C_3 + \alpha_{31} x_{t-1} + \beta_{31} y_{t-1} + \gamma_{31} z_{t-1} + e_{tz}$$

Where $x_t$, $y_t$, and $z_t$ are variables lagged one period; $\alpha$, $\beta$, and $\gamma$ are regression parameters, and $e_t$'s are the error terms.

This VAR system of equations can be expressed in stacked form, in which $X_t$ represents the vector of variables,

$$X_t = C + \phi(L) X_t + \varepsilon_t \quad (1)$$

where C is the vector of constant term, $X_t$ is a stationary stochastic process, L is the lag operator such that $LX_t = X_{t-1}$ , $\phi(L)$ represents the polynomial of autoregressive parameters, and $\varepsilon_t$ consists of innovations (error terms). For the equation system (1) to exist, the roots of $\det(I - \phi(z)) = 0$ have a modulus greater than 1 so as to ensure that $(I - \phi(z))$ is invertible.

The primary appeal of the VAR approach is that the model is free from a priori structural restrictions (signs and size of estimated parameters) of any particular model builder, yet under certain conditions it provides a reduced form framework within which economically meaningful hypotheses can be tested (Sims,$1980_a$). The VAR specification assumes that the contemporaneous correlations of errors ($e_t$'s) across equations are non-zero. Since there are no contemporaneous explanatory variables in the model, these error terms (also called innovations) serve as a potential source of new information about the movements in a variable during the current period.

The error terms account for the fact that the sum of the explanatory variables does not explain the dependent variable exactly at each observation over the sample period being analyzed. There always remains some discrepancy or errors to be accounted for. Since the explanatory variables include lagged observations and no current observations, the error term captures the movements in the explanatory variables in the current period and thus adds new information to explain the movements of the dependent variable. That is why in the VAR literature, the error term in the equation for a given dependent variable is called an innovation for that variable in the current period. A time series of such innovations is associated with each variable in the VAR system.

**Innovations Accounting**

Individual coefficients estimated in a VAR are not very meaningful because of the problem of severe multicollinearity among the lag variables. Therefore, it has become a standard practice to use Sims' innovation accounting and impulse response functions (IRFs) to draw meaningful economic implications from the VAR analysis. The pros and cons of this technique are discussed in Abdullah (1994) and Cooley and Leroy (1985).

The innovations accounting involves a decomposition of forecast error variance (FEV) of the variables included in the model. It presents a summary of this information by listing the fraction of the overall forecast error variance accounted for by each types of innovations. This variance allocation, or variance accounting can be done for the forecast error of each variable for any forecast horizon. One can thus analyze the way in which the variances of each variable's innovations influence the movements in each of the variables in the system. In principle, the variance decomposition contains

important information by showing which variables have a relatively sizable independent influence on other variables in the system.

While the FEV gives a qualitative measure of the importance of a variable in determining the movements of another variable, it does not provide the directions of change. That piece of important information is provided by IRFs. An impulse response function describes the effect of an innovation in a given variable on the movement of the level of the same or another variable in the system. For example, the impulse response function of unemployment with respect to money describes how the level of unemployment changes over time in response to a shock to money.

**Variables and Model Specifications**

The variables included in our models are monthly money supply (M1, M2), interest rates on short-term (3-month) and long term (10-year) Treasuries, a proxy for fiscal policy (federal budget deficits and surplus, BDS), the unemployment rate (UR, civilian and 16 years and over), the producers price index, (PPI) and industrial production, (IP).[4]

To specify a VAR model, it is necessary that the variables are stationary. Using an Augmented Dickey Fuller unit root test we found that all variables mentioned above are stationary in log first differences with the exception of BDS which is stationary in first difference form. Since the variables are all stationary in log first difference, a linear combination of them will be stationary in log level form (Enders, 2015).[5] This affirms the absence of any co-integrating relationship among the variables included in the model.

We therefore estimated our models with variables in log level form, except BDS which is used in first difference form (CBDS). Accordingly, we specified and estimated five VAR(k) models as follows:

(1) 1960:01 – 1978:12: VAR (RTB3, M1, PPI, IP)

(2) 2007:11 – 2014:11: VAR (CBDS, RTB3, M1, UR)

(3) 2001:10 – 2007:09: VAR (CBDS, RTB3, M1, UR)

(4) 2007:11 – 2014:11: VAR (RTB3, M1, PPI, IP)

The optimal lag length k in the VAR model is determined by examining the minimum value of the Akaike Information Criterion (AIC). We estimated this criterion for 6, 9 and 12 lags and found the minimum value of AIC at 12 lags.[6] It may be noted that lags longer than 12 could not be tested because of data limitations over the period of the Great Recession. The same reason applies as to why the VAR model could not be expanded to include more than four variables at a time. The 12 lags and the variables in log level form are consistent with Sims ($1980_b$) VAR specification and hence the results are comparable to those of Sims.

## Estimated Results and Interpretations

As discussed above, we use Sims' innovations accounting technique to assess the effects of monetary and fiscal policies on unemployment. It is customary in interpreting VAR analyses that we quote the FEV at time horizon when the system attains a stable equilibrium. Based on our estimates of FEV for 36 periods, we find that the model attains this equilibrium around 24 month.

The VDC in Table 1 shows money and interest rate account for 3.2% and 31.72% respectively of the FEV of output (industrial production) at 24 months horizon.

As expected these FEVs are starkly consistent with Sims' (1980$_b$) study in which he found money and interest rate explaining 4% and 30% of the FEV of industrial production respectively.

In October 1979 the Fed switched from interest rate targeting to non-borrowed reserves (NBR) targeting - a major policy regime shift. Thereafter in October 1982 the Fed conducted another policy shift from NBR to borrowed reserves as its operating target and instead of M1 targeted the M2 and M3 money supply as intermediate targets for monetary policy. Although the change from NBR to borrowed reserves was not deemed as dramatic as the change from interest rates to NBR, we re-estimated Sims' model over the 1983:01 – 2007:09 using both M1 and M2 to check if the non-causal money income relationship still holds. The estimated FEV decompositions (available upon request) did not overturn the conclusions of Table 1. We may therefore conclude that changes in the money supply did not have much predictive content in explaining output variance over the 1960:01 – 2007:09 period.

As we discussed above, during the Great Recession the Fed expanded the monetary base like no other time of economic downturn in the past. The U.S. Treasury also infused fiscal stimuli aggressively, hoping to reverse or minimize the adverse effects of the recession on output and employment. Accordingly, we estimated VAR(12) models over the period of the Great Recession that included CBDS, logRTB3, logM1, and logUR. The actual estimation was done over 2009:01 – 2014:11 period. The data from 2007:11 - 2008:12 were reserved for differencing and lag specifications. The estimated FEVs are presented in Table 2.

In order to compare if the impacts of the recession years' aggressive monetary and fiscal activisms were any different from those of the pre-recession year's normal policy operations we re-estimated the same VAR(12) model over the 2001:10 – 2007:09. The length of this estimation period is chosen to make the results between the two periods comparable. The estimated FEVs are presented in Table 3. The FEV of unemployment explained by CBDS, logRTB3 and logM1 are 9.54%, 43.16% and 13.74% respectively (while money and interest rates jointly explained 56.8%). Obviously, both CBDS (9.54%) and money (13.74%) had minor influences on unemployment variance while interest rate showed the most influence on unemployment during the pre-recession period, which is consistent with Sims' ($1980_b$) conclusion.

However, as shown in Table 2 the importance of these variables in explaining the variance of unemployment have improved considerably during the Great Recession. The policy variables, CBDS, logRTB3 and logM1 account for 24.57%, 27.21%, and 24.78% respectively of the variance of unemployment (money and interest jointly explain 52%). One may conclude that over the period of the Great Recession both fiscal policy and monetary policy have significant influence on unemployment. To reaffirm if this inference holds, we estimated the VAR(12) model with Sims' variables. The results presented in Table 4 show that logRTB3, logM1 account for 25.32% and 21.57% (and jointly 47%) of the variance of industrial production. These findings suggest that the effects of monetary policy on output and unemployment during the Great Recession were significantly much larger than those of the pre-Recession years.[7, 8]

The impulse response functions (IRFs) are presented in Fig. 1. They are generated by inducing a one S.D. deviation positive shock to one policy variable at a time in a bivariate setup (example, (logM1, logUR) and so on). This approach is taken because of very high contemporaneous correlations among the innovations of money, interest rates and unemployment (See Table 5). In this bivariate set up, as explained in Abdullah (1994) and Cooley and Leroy (1985), we can trace the dynamics of the response of unemployment independent of the contemporaneous effects of other innovations on unemployment dynamics. The IRFs (solid line, bounded by 2.0 S.E. confidence interval) in Fig. 1a show that an increase in CBDS causes a fall in logUR; Fig.1b shows that an increase in logRTB3 causes logUR to increase, and Fig.1c shows that an increase in logM1 tends to lower logUR.

## Summary and Conclusion

This paper estimated several vector autoregression models. First we estimated models and affirmed Sims' 1980 conclusion that changes in the money supply did not have much independent impacts on output (or unemployment) over the period 1959:01 – 2007:10. We then estimated the same model over 2009:01 – 2014:11 and found that both M1 money supply and short term interest rates account for 21.57% and 25.43% (and jointly 47%) of the FEV of industrial production. This finding is in contrast to pre-recession years of the money income relationship.

Our analyses then focused on our primary goal -- estimating the relative impacts of monetary and fiscal stimuli on unemployment over the period of the Great Recession. This involved estimating models with a fiscal variable over the pre-Recession (2001:10 - 2007:09) and the post-Recession (2008:01 – 2014:11) periods. Any significant

difference in the estimated impacts of monetary and fiscal policies between the two periods would reveal if the aggressive monetary and fiscal stimuli during the Great Recession worked to achieve the intended policy goals. Our estimated forecast error variances show that the fiscal deficits accounted for 24.57% of the variance of unemployment while changes in interest rates and the money supply explained 27.1% and 24.78% respectively. Money and interest rates jointly accounted for 47% of the variance of unemployment.

We also estimated a model with M2 and long-term interest rates in place of M1 and short-term interest rates. The variance of unemployment explained by both M2 and the long-term interest rates worsened somewhat. The estimated results imply that changes in M1 money and short term interest rates and not the non-M1 component of M2 provided the main thrust on the economy during the Great Recession. This may imply that during an economic crisis of the scale of the Great Recession as opposed to normal economic conditions, stakeholders (the public, banks and businesses) prefer to hold relatively more liquid assets. This inference may also be derived by computing the growth monetary aggregates as follows:

Between 2008:01 and 2014:11, the monetary base (high powered money), grew by a staggering 352%. This was ten times higher than the growth rate over the previous seven years (2001:01-2007:12). This dramatic growth in the high powered money translated into M1 and M2 growth of 107% and 55% respectively between 2008:01 and 2014:11, compared to the previous seven years (M1: 25.4% . M2: 50.3%).

The slower growth of M2 and the higher growth of M1 during the recession is explained by the fact that during the Great Recession, people liquidated a considerable

amount of non-M1 components of M2 into M1, driven by recession influenced liquidity constraints and also possibly by fear of uncertainty about the severities of the recession and its duration. The evidence of this is found when we looked into the growth of non-M1 components of M2, which fell by 14.7%, from 57.4% to 42.7% between the two comparable periods of seven years (post-recession and pre-recession periods). The unprecedented growth of MB is obviously the outcome of the three Quantitative Easing operations of the Fed to keep the federal funds rate near zero.

Our finding in this paper agrees with the prevailing notion that the Fed may have saved the economy from plummeting into a second Great Depression and that fiscal stimulus added the additional thrust. The recovery of the economy gives confidence to the monetary policy authority and to the believer in Fed independence that expansionary monetary policy, however non-traditional it may be, and the Fed working as lender of last resort in times of serious economic downturn, can revert the economy from recession to a normal growth path.

Finally, the ultimate purpose to undertake such a study as this paper is not simply develop economic models to conduct hypothesis testing rather to understand how targeted monetary and fiscal policies can be used to ameliorate economic miseries of the citizens in times of financial crisis and economic downturns. One may not forget that economics is all about people and their economic welfare. In order to convince policy makers to devise appropriate policies during any economic crisis economists are expected to provide empirical evidence to back up their policy recommendations. Acting on such policy recommendations the Congress enacted legislations for stimulus package to avert the Great Recession from sliding into an economic depression.

Subsequent data showed that the stimulus spending and tax rebates helped consumer spending and slowed down job losses. Although the recession officially ended in June 2009, the adverse fallout still continued through anemic growth and slow labor participation. The monetary and fiscal stimuli also continued although at a more restrained level.

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## Appendix

Estimating the FEV requires the use of a moving average representation (MAR) of the VAR(k) model, where k is the optimal order of autoregression determined by statistical techniques. The VAR system (1) can be expressed in MAR form as follows:

$$X_t = C_t + \Theta(L)\,\varepsilon_t$$

$$(\varepsilon_t) = 0 \text{ and } E(\varepsilon\,\varepsilon') = W \text{ for } |k| = 0$$

$$= 0 \text{ for } |k| \neq 0$$

Where $C_t$ is constant term of $X_t$ and the moving average coefficients $\Theta(L)$ at lag $0$ is the identity matrix. As one can see, the MAR representation in (2) expresses current values of the dependent variables in terms of current and lagged values of the innovations in all variables of the system. The vector of innovations'$\varepsilon_t$' is the forecast error of the autoregression based on information available at time t – 1, given that the roots of $\Theta(z)$ lie outside the unit circle.

Although by construction the innovations in any series are serially uncorrelated, they may be correlated contemporaneously. To assess the cumulative response of an element of $X_t$ to an innovation, it is necessary that the components of $\varepsilon_t$ be orthogonal. The effect of the orthogonalization is to assign the contemporaneous correlation of the innovations among the variables. Standard practice is to choose some particular ordering of the variables, motivated by economic theory, prior to orthogonalization. The most widely used orthogonalization procedure is the *Choleski factorization*. This procedure eliminates any contemporaneous correlation between a given innovation series and all those series which precede it in the chosen ordering. Thus, the ordering of variables is crucial in interpreting the results of the decomposed FEVs (see Abdullah

(1994), Cooley and Leroy (1985)). However, if the contemporaneous correlations are very small, then the ordering of the variables is inconsequential.

**Tables**

Table 1: Variance Decomposition of Log of Industrial Production
Sample Period: 1960:01-1978:12

| Proportion explained by | 1-month | 6-month | 12-month | 15-month | 18-month | 21-month | 24-month |
|---|---|---|---|---|---|---|---|
| LOGRTB3 | 0.11 | 0.30 | 6.03 | 15.41 | 24.46 | 29.43 | 31.72 |
| LOGM1 | 0.17 | 1.51 | 5.19 | 3.91 | 2.96 | 2.90 | 3.20 |
| LOGPPI | 2.32 | 9.41 | 24.69 | 31.87 | 35.15 | 37.39 | 39.69 |
| LOGIP | 97.40 | 88.77 | 64.10 | 48.80 | 37.42 | 30.28 | 25.40 |

Note: The variables are defined as follows: LOGRTB3 = log first difference of 3-month Treasury bill rate, LOGM1 = log first difference of M1 money stock, LOGPPI = log first difference of the Producer's Price Index, LOGIP = log first difference of Industrial Production. Standard error of FEV decompositions based on Monte Carlo simulations described in RATS manual are available upon request.

Table 2: Variance Decomposition of Log of Unemployment Rate
Sample Period: 2009:01-2014:11

| Proportion explained by | 1-month | 6-month | 12-month | 15-month | 18-month | 21-month | 24-month |
|---|---|---|---|---|---|---|---|
| CBDS | 0.04 | 16.23 | 31.47 | 31.75 | 29.49 | 26.33 | 24.57 |
| LOGRTB3 | 1.86 | 21.30 | 33.28 | 33.28 | 30.51 | 29.15 | 27.21 |
| LOGM1 | 3.51 | 6.68 | 4.06 | 6.13 | 10.68 | 18.80 | 24.78 |
| LOGUR | 94.59 | 55.78 | 31.75 | 28.84 | 29.32 | 25.72 | 23.44 |

Notes to table 1 apply. CBDS = first difference of budget deficits and surpluses, LOGUR = log first difference of the unemployment rate (16 years of age and older).

Table 3: Variance Decomposition of Log of Unemployment Rate
Sample Period: 2001:10-2007:09

| Proportion explained by | 1-month | 6-month | 12-month | 15-month | 18-month | 21-month | 24-month |
|---|---|---|---|---|---|---|---|
| CBDS | 0.05 | 4.58 | 6.48 | 6.38 | 6.80 | 8.44 | 9.54 |
| LOGRTB3 | 7.48 | 43.61 | 48.48 | 46.27 | 46.12 | 44.37 | 43.16 |
| LOGM1 | 0.52 | 11.32 | 10.91 | 13.70 | 13.85 | 13.58 | 13.74 |
| LOGUR | 91.95 | 40.49 | 34.13 | 33.65 | 33.22 | 33.61 | 33.56 |

Notes to tables 1 and 2 apply.

Table 4: Variance Decomposition of Log of Industrial Production
Sample Period: 2009:01-2014:11

| Proportion explained by | 1-month | 6-month | 12-month | 15-month | 18-month | 21-month | 24-month |
|---|---|---|---|---|---|---|---|
| LOGTB3 | 4.05 | 27.50 | 29.66 | 28.51 | 26.98 | 25.91 | 25.32 |
| LOGM1 | 9.09 | 23.28 | 24.80 | 21.88 | 20.16 | 21.31 | 21.57 |
| LOGPPI | 26.08 | 15.48 | 12.42 | 18.21 | 21.93 | 21.68 | 22.37 |
| LOGIP | 60.79 | 33.73 | 33.12 | 31.39 | 30.94 | 31.10 | 30.74 |

Notes to tables 1 and 2 apply.

Table 5. Contemporaneous correlations of innovations

| | CBDS | LOGTB3 | LOGM1 | LOGUR |
|---|---|---|---|---|
| CBDS | 1.00 | | | |
| LOGTB3 | -0.015 | 1.00 | | |
| LOGM1 | 0.029 | -0.906 | 1.00 | |
| LOGUR | 0.006 | -0.859 | 0.697 | 1.00 |

## Figures

Fig. 1 Impulse Response Functions

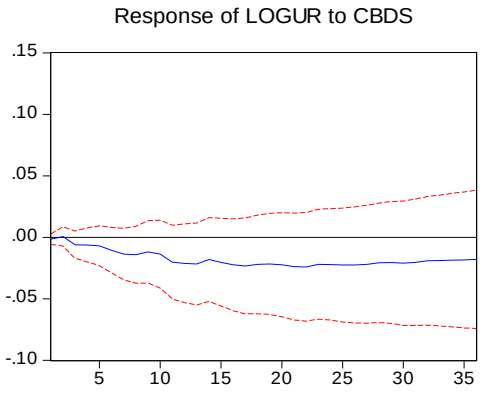


Figure-a

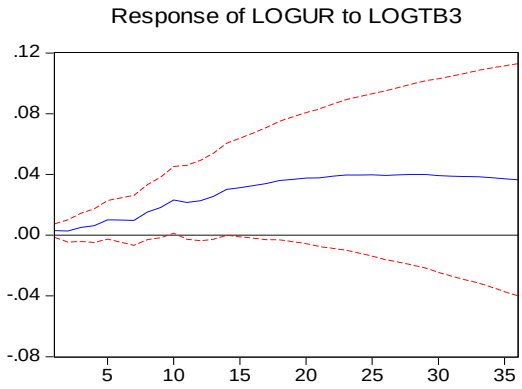


Figure-b

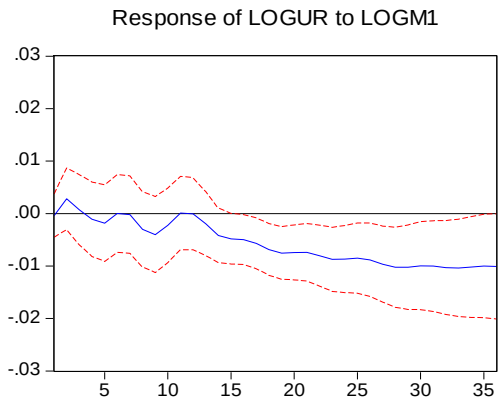


Figure-c

## Endnotes

* The authors would like to thank Professors David Crary, Christopher Elias, and James Saunoris for their helpful comments. The usual caveat applies for responsibility.

1. Quantitative easing (QE) was first used by the Bank of Japan to combat domestic deflation in the early 2000s. Similar policies have been used by the U.S., the UK, and the Eurozone during the Great Recession. Adoption of the QE by these economies was facilitated by having their risk-free short-term nominal interest rates were either at or close to zero. In the U.S. this interest rate is the federal funds rate.

2. In an open letter to former Federal Reserve Chairman Ben Bernanke in 2010, a group of prominent academics and hedge fund managers urged the central bank to stop its bond purchases known as quantitative easing, warning it risked "currency debasement and inflation," (The Wall Street Journal (2014)).

3. Rangazas and Abdullah (1988) have shown that monetary growth, independent of the level of government purchases, can lower the unemployment rate in the

short-run. By decomposing the lags lengths of the variables due to “systemic” dynamics (deterministic lags of the reduced form arising from the lag structure of the economy) and “error” dynamics (error lags arising from the stochastic component of the reduced form) they showed that the channel of monetary influence is through the rate of growth of real money balances.

4. All data for this study was obtained from the St. Louis Federal Reserve’s economic research database (FRED) except government budget deficits and surpluses, which were obtained from the US Department of the Treasury’s Bureau of the Fiscal Service.

5. The Augmented Dickey-Fuller (ADF) test statistics are estimated using the following regression:

$$\Delta \boldsymbol{y_t} = \alpha + (\boldsymbol{\rho} - \boldsymbol{1})\boldsymbol{y_{t-1}} + \sum_{\boldsymbol{i=1}}^{\boldsymbol{6}} \boldsymbol{\beta_i} \Delta \boldsymbol{y_{t-i}} + \boldsymbol{\gamma_t} + \boldsymbol{\varepsilon_t}$$

Where $y_t$ is the pertinent variable, $\varepsilon$ the random disturbance term, and a common lag of six period is used to make the error term serially uncorrelated. The null hypothesis $\rho - 1 = 0$ is tested using the t-statistic. If $\rho - 1 = 0$, $y_t$ has a unit root. The estimated values of the ADF test statistics are not presented but are available on request.

6. Estimated Akaike AIC and Schwartz SC and other related statistics are available upon request.

7. The estimated FEV of the model with M2 and RTB10 are available upon request.

8. When the positions of TB3 and M1 are interchanged in the ordering we find no noticeable difference in explaining the FEV of UR by each. This assures that both money and interest rates explain the FEV of UR independent of each other, having little to no contribution from their conditional correlations.