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HOW SENSITIVE ARE VAR RESULTS TO CHANGING THE COMPONENTS OF MONEY?

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ABSTRACT

Recent empirical research points to the sensitivity of interest and income elasticities of money demand, as well as the long-run neutrality of money, to the methodology underlying the measurement of monetary aggregates. Barnett, Fisher and Serletis (1992) show that empirical conclusions may differ when money is measured by the flow of monetary services, rather than by summation of the dollar amount of monetary assets. Belongia (1996) suggests that the choice of a money stock measure will affect inferences about the magnitude and the sign of monetary shocks. In this paper, a vector autoregression (VAR) framework is adopted to analyze the dynamic relationship between the variables. Eight definitions of money are used to determine how sensitive some of the VAR results are to changing the components of money. The evidence presented in the paper underscores the importance of the changing components of money in examining the impact of money on economic activity. Further, the evidence shows clearly that the various definitions of money have different, and often, opposing relationships with other macro variables.

Key Words: *Money, Monetary Policy, VAR.*

JEL Classifications: *C20, E52*

I. INTRODUCTION

The monetary aggregates are constructed by summing the dollar values of the stocks of the monetary assets included in each aggregate. Summation implicitly assumes that the assets' owners regard them as perfect substitutes. Yet, according to the micro demand theory, if these assets were in fact perfect substitutes, rational consumers would choose to hold only a single asset, unless all the assets had the same user cost. Thus, measuring a monetary aggregate by summing the dollar values of the included assets is not generally consistent with the economic theory of consumer decision-making.

Many economists concede that the reported simple-sum monetary aggregates are flawed index numbers and that, conceptually, weighted monetary aggregate such as the Divisia series advocated by Barnett (1980) would better represent the trust of monetary policy.[1] Barnett suggests a method of aggregation that is consistent with economic theory. In his model, the consumer's utility function is assumed to have a special form, in which the quantities of monetary assets held during the current decision period are said to be weakly separable from the quantities of other goods and services. Swofford and Whitney (1987) pointed out the importance of weak separability and suggested other definitions besides M1 and M2 based on separability tests. Weak separability implies a two-stage model for consumer behavior. First, the consumer allocates expenditure among the various broad categories of goods. Then, in a second stage, the consumer allocates expenditure among the goods within each broad category based only on the relative prices of the goods in that category.

In the theory of Monetary Aggregation, monetary aggregates are constructed based upon evidence from aggregation and index number theory. Divisia monetary indices called monetary services indices (MSI) by the Federal Reserve Bank of St. Louis because they measure a flow of monetary services (similar to the flow of services generated by a typical durable good, such as a TV over a period). This is the opposite of the simple sum indices, which are related to the stock of money outstanding. The simple sum index can only be consistent with aggregation and index number theory if all asset components are perfect substitutes. Only then is the simple sum index a monetary services index.[2]

Recent empirical research suggests that conclusion regarding issues such as interest and income elasticities of money demand, and the long-run neutrality of money, may be sensitive to the method of measurement of monetary aggregates. For example, Barnett, Fisher and Serletis (1992) show that empirical conclusions may differ when money is measured by the flow of monetary services, rather than by the summation of the dollars amount of monetary assets. Belongia (1996) shows that inferences about money's effects on economic activity can depend heavily on the measure of money chosen. He investigates this issue by replicating five studies that reported the effects of money (as a simple-sum monetary aggregate) on economic activity. He finds that the qualitative inference in the original study is reversed when a simple-sum monetary aggregate is replaced by a Divisia index of the same asset collection. In this paper, I present the empirical results of the VAR using different methods of measurement of monetary assets. The empirical results show that basic inferences about the direction, magnitude, and significance of money on economic activity can depend crucially on the measure of money chosen. The organization of the paper is as follows. Section 2 presents the literature review. Section 3 describes the data. Section 4 introduces the VAR model. Section 5 reports evidence from the VAR model. Section 6 concludes.

II. LITERATURE REVIEW

The relation between output (GDP) and money has been studied for a long time. For example Friedman and Schwarts (1963) provide evidence that shocks in output have a positive impact on nominal money. Sims (1972) wrote a well-known study in this regard. He applies Granger causality analysis to test the direction of causality between money and output. He employs time series regressions including output and money variables. He concludes that causality is unidirectional from money to income. However, in a later article, Sims (1980) restudies the relationship between money and output using a VAR model that includes an interest rate variable in addition to money and output variables. The empirical findings from this study contradict his conclusion from his earlier paper. Specifically, he reports that the innovations to money are far from being the primary determinant of short-run movement of real output. Both output and money respond to shocks in interest rates. This common response to interest rates, he argues, explains the empirical correlation between fluctuations in money and output.

Litterman and Weiss (1985) present a dynamic IS-LM model with rational expectations to study the relationship between money, interest, and output. They argue that economic agents have some information about future real activity, which shows up first in the equilibrium price of financial assets, particularly nominal interest rates. The observed co-movement between money and output is consistent with the Fed reaction function, which attempts to offset the movements in expected inflation rates arising from anticipated output shocks. Applying a VAR method to test the data, they conclude that the real interest rate is an exogenous variable governed only by its own past history. They confirm the results reached by Sims regarding the dominant role of the interest rate. Taylor (1993), Sims (1992), Bernanke and Blinder (1992) also confirm this conclusion. However, Davis and Tanner (1997), reemphasize the role played by the quantity of money as the main factor influencing output fluctuations. The results of a VAR model using yearly data for the 119-year period 1874-1993 show that lagged innovations in money explain output variations at a low level of significance and those interest rate innovations are not significant determinants of output. These results also hold when the model is run using quarterly data.

III. AN OVERVIEW OF THE DATA

Quarterly data on the U.S. economy are used for the sample period 1959.3-2001.1 and are taken from the Federal Reserve Bank of St. Louis Web Site.[3] The variables used in this paper are the federal funds rate (FFR), real output (GDP), consumer price index (CPI) and several definitions of money. The definitions of money used in the analysis are provided in Table I.

Swofford and Whitney (1987) identified a set of monetary assets consistent with weak separability. The most disaggregate and broadest group of monetary assets that meet the necessary conditions for weakly separable utility maximization are currency, demand deposits, other checkable deposits, overnight repurchases, savings deposits in commercial banks, and savings and loans associated with mutual saving banks, and credit unions. Other checkable deposits include super Now accounts. Further, they find that expanding the monetary aggregate function past savings deposits leads to the violation of the necessary condition for weak separability. In this paper, DEF1, DEF2, and DEF3 (see Table I) are composed of this set of monetary assets, so that DEF1, DEF2 and DEF3 meet the necessary condition for weak separability. Swofford and Whitney (1987) argued that a stable monetary aggregate must include only assets that are weakly separable from consumption goods and leisure. Otherwise, the marginal rate of substitution between the monetary assets in the monetary aggregate would be affected by changes in the composition of expenditure on other goods even though total income remained unchanged. If weak separability does not obtain, empirical results with narrow scopes are misspecified.

MI (Divisia index) employs user costs in their calculation, which is the one period holding cost used in Barnett (1980). MI is constructed by calculating expenditure shares for the financial assets to be aggregate using their shares as the index weights. To calculate the numerators for expenditure shares, the dollar deposits in that category multiply the user cost of each asset.

Table I
Definitions of Money

Variable	*Components**
M1	Currency and Traveler's checks Demand deposits held by consumers Demand deposits held by business Other checkable deposits Super Now accounts held at commercial banks Super Now accounts held at thrifts
M2	M1 Overnights RPs Overnight Eurodollars Money market mutual fund shares Money market deposit accounts at commercial banks Money market deposit accounts at thrifts Saving deposits at saving and loans (S&Ls) Saving deposits at mutual saving banks (MSBs) Saving deposits at credit unions Small time deposits and retail RPs at commercial banks Small time deposits at S&Ls, MSBs and retail RPs at thrifts Small time deposits at credit unions
Divisia M1**	Monetary services index (MSIM1). This index is constructed from the components list used for M1, as describe above.
Divisia M2**	Monetary services index (MSIM2). This index is constructed from the components list used for M2, as describe above.
DEF1	Currency Demand deposits Other checkable deposits (OCD)
DEF2	Currency Demand deposits OCD Small saving accounts
DEF3	DEF2 Over night agreements
Divisia DEF3**	Monetary services index (MI). This index is constructed from the component list in DEF3.

* These components are taken from the Federal Reserve Bank of St. Louis Web Site.
** The Divisia index measures changes in aggregate as a geometric weighted average of the change in each component. The weights are the average expenditure share of each component.

Summing over all asset categories in the aggregate yields total expenditures on monetary services and provides the denominator for the share expressions. Barnett (1980) discusses the construction of monetary aggregates in light of index number theory. Barnett demonstrates that a Divisia index number, constructed using only observed prices and quantities, can accurately measure the changes in the unobserved, true monetary aggregate.[4]

Transforming Nonstationary Data

The validity of the VAR approach relies on the presumption that the economic variables under consideration are covariance stationary. Granger causality tests are not applicable if the data are nonstationary. Data are said to be stationary if neither the mean nor the autocovariances (including the variance) of the error terms depend on time. Using a VAR terminology, the effect of a shock to the error terms on the endogenous variables must eventually die out for the data to be stationary. Thus, it may be important to induce stationarity by appropriately transforming any nonstationary series, a process referred to as "trend removal." Differencing the data or including a time trend variable in the model are among the common practices of transforming nonstationary data. Alternative detrending transformations will yield variables with different time series properties and thus generate different variance decomposition results.

There are appropriate tests, such as the Augmented Dickey-Fuller Test (ADF) that can be used to determine whether the data are nonstationary. In this paper, data are used in a growth rate form. Usually, data expressed in this form are expected to be nonstationary. The output of the ADF test consists of the t-statistic on the coefficient of the lagged test variable and critical values for the test of a zero coefficient. After running the ADF test, if the Dickey-Fuller t-statistic is smaller (in absolute value) than the reported critical values, we cannot reject the hypothesis of nonstationarity and the existence of a unit root. We would conclude that our series might not be stationary. We may then wish to test whether the series is I (1) (integrated of order one) or integrated of a higher order. A series is I (1) if its first difference does not contain a unit root.

IV. THE VAR MODEL

The VAR method is used here as the main method to examine relationships between the variables. Employing this method is of special importance for the approach used in this paper. The VAR method allows all variables to be endogenous. This is valuable because allowing all variables to affect, and to be affected, by other variables helps to examine all types of shocks in the economy. The mathematical form of a VAR is

$$y_t = A_1 y_{t-1} + \dots\dots\dots + A_N y_{t-N} + Bx_t + \varepsilon_t \qquad ...(1)$$

Here y_t is a vector of endogenous variables, x_t is a vector of exogenous variables, and B is matrix of coefficients to be estimated, and ε_t is a vector of innovations that are correlated with each other but uncorrelated with their own lagged values and uncorrelated with y_{t-1} and x_t. The best estimator of each equation in a VAR is Ordinary Least Squares (OLS). The assumption here is that the disturbances are not serially correlated and is unrestrictive because any serial correlation could be absorbed by adding more lagged y's.

In this paper, the vector y_t includes the federal funds rate (FFR), the eight definitions of money (see Table I), consumer price index (CPI) and GDP. Impulse response functions (IRF) from the VAR model are utilized to test the directions and the channels of influence between the variables.

The Impulse Response Function (IRF)

The impulse response function (IRF) shows how one variable responds over time to a single innovation in itself or in another variable. Specifically, it traces the effect on current and future values of the endogenous variable of a one standard deviation shock to one of the innovations. Innovations or surprise movements are jointly summarized by the error terms of the VAR model. There is one impulse response function for each innovation and each endogenous variable. Thus, a 4-variable VAR has 16 impulse response functions.

Vector Error Correction Model (VEC)

Cointegration exits when a group of nonstationary variables has a linear combination of them that is stationary. Cointegration means that although many developments can cause permanent changes in the individual elements of the group, there is some long-run equilibrium relation tying the individual components together. If the group is cointegrated, then it is not correct to fit a VAR to the differenced data [Hamilton (1994)]. As argued by Engle and Granger (1987), the VAR estimated with cointegrated data (without including the cointegration term) will be misspecified. However, another representation of VAR, the Vector Error Correction model (VEC), can be used. It is a VAR model for data in difference from augmented by the error correction term. In a VEC model the short-run dynamics of the variables in the group are influenced by the deviation from an equilibrium relationship.

As the VEC specification only applies to cointegrated series, we should run the Johansen cointegration test prior to VEC specification. This test is needed to confirm that the variables are cointegrated and to determine the number of cointegrating equations. Estimation of a VEC model proceeds by first determining one or more cointegrating equations using the Johansen procedure. The first difference of each endogenous variable is then regressed on a one period lag of the cointegrating equation(s) and lagged first differences of all of the endogenous variables in the system. As in the traditional VAR analysis, the Impulse Responses can be used from the VEC model to obtain information concerning the interaction between the variables.

Ordering of Variables

Ordering of variables is usually required when an unrestricted VAR is applied. The conventional orthogonalization procedure involves imposing a particular causal ordering of the variables. This choice is arbitrary and can result in a significant difference for the variance decomposition when there is contemporaneous correlation among the innovations. In order to examine the potential sensitivity of the results to ordering, another variable's ordering is examined. The results of the impulse response functions still hold even when the orderings are changed.[5] However, differences in the variance decomposition do exist. For instance, if money appears before GDP in the ordering of variables, the proportion of the output forecast error variance explained by money innovations would be greater than if the opposite situation occurred. This result is consistent with reported evidence in the literature. It is highly essential for this analysis that the order of the variables does not change the conclusions of the paper. The aim of this paper is to investigate whether the conclusions relating to monetary issues are sensitive to the particular measure of money used. It is worth noting that is that in each set of

VARs tested, the order of the eight definitions of money is kept the same to make the comparison reliable.

V. EMPIRICAL RESULTS

The data in level form are expected to be non-stationary as evident in many studies. To test the series, the unit root test (ADF) is applied to the data in level form. Table II shows the t-statistic for the coefficient of the lagged test variable and critical values for the test of a zero coefficient. The unit root tests show that the hypothesis of unit root cannot be rejected at any level of significance for any of the series in level form. All the series (FRR, M1, M2, DEF1, DEF2, DEF3, MI, MSIM1, MSIM2, CPI, GDP) appear to be non-stationary.[6] As such, the data need to be transformed to render them stationary prior to estimation. However, if the data series are cointegrated, the VAR estimation cannot be applied to the transformed data, and the Vector Error Correction model (VEC) will be used. The Johansen Cointegration test [Johansen (1991)] is applied to group1 (FFR,M1,GDP,CPI), group 2 (FFR,M2,GDP,CPI), group 3 (FFR,DEF1,GDP,CPI), group 4 (FFR,DEF2,GDP,CPI), group 5(FFR,MI,GDP,CPI), group 6 (FFR,MSIM1,GDP,CPI), group 7 (FFR,MSIM2,GDP,CPI), and group 8 (FFR,DEF3,GDP,CPI).[7] The hypothesis of no cointegration is not rejected for groups 1, 3, 4, and 8, while the same conclusion does not hold for groups 2, 5, 6 and 7, which include M2, MI, MSIM1 and MSIM2. The cointegration test indicates that the series with M2 and MI are cointegrated with three possible cointegrated equations, while the series including MSIM1 and MSIM2 are cointegrated with one possible cointegrated equation. Therefore, the VAR model will be estimated for groups (1, 3, 4, and 8) and the VEC model for groups 2, 5, 6 and 7.[8] The lag length in the cointegration test is determined according to the Akaike Information Criterion (AIC). AIC is a guide to the selection of the number of terms in an equation. It is based on the sum of squared residuals but places a penalty on extra coefficients. Under certain conditions, selecting the specification with the lowest value of the AIC can choose the length of a lag distribution. The lags are examined up to ten quarters. The final estimation of the VEC model will be carried out using five lags for (M2, MI, and MSIMI) and six lags for MSIM2.[9]

Table II
Unit Root Test (1959:03-2001:1)

Variables in levels	*ADF Statistics**
GDP	-1.072240
M1	-1.369307
M2	-1.458408
DEF1	-1.377603
DEF2	-0.052274
MSIM1	0.3560770
MSIM2	2.1099300
FFR	-2.500288
DEF3	-1.020194
MI	1.054163

* The critical values are -3.74, -2.88, and 2.57 at 1%, 5% and 10% respectively.

Evidence from the VAR Model

In line with the recent trend in empirical research, this paper applies the VAR approach. A four-variable VAR model is estimated to capture the time series relationships among the federal funds rate (FFR), money (DEF1, M1, DEF2, DEF3), real GDP and consumer price index (CPI). All the variables are in the log of the level form except for FFR. The model is estimated by applying the OLS method to each equation. VEC model is used to capture the relationship among the FFR, Money (M2, MI, MSIM1, MSIM2), GDP and CPI. In order to investigate how sensitive some of the VAR and VEC results are to changing components of money, the analysis proceeds as follows. In the first phase, monetary policy is measured by money. The second phase measures monetary policy by the federal fund rate. The analysis of the two phases is needed to determine the impact of unanticipated changes in monetary policy. The responses of monetary policy indicators to shocks in CPI and GDP are also examined.

Empirical Results Interpreting Shocks to Money as Policy Shocks

In this section, shocks to Money (DEF1, DEF2, M1, M2, DEF3, MSIM1, MSIM2, MI) are interpreted as policy shocks. A four-variable VAR system is estimated as VAR (DEF1, FFR, GDP, CPI). On the basis of AIC criterion, the appropriate lag length is six. From the IRF results (Figure I), one can draw the following observations. First, FFR responds positively to innovations in money (DEF1) [as in Eichenbaum (1992)]. This effect is followed by a decline in output (GDP). This a puzzling result if DEF1 innovations are used to identify money supply shocks, because an expansionary monetary policy is expected to cause an increase in both money (DEF1) and GDP. Second, a positive shock to DEF1 results in an increase in CPI. The estimation results of the models with M1, DEF1, and DEF3 are generally the same (see Figure III).[10]

The second graph in the first column of Figure II (VAR (DEF2, FFR, GDP, CPI)) shows that a positive shock to money (DEF2) has a negative impact on FFR for the first two quarters, after which the impact becomes positive; whereas a positive shock to money (DEF1, M1) has a positive impact on FFR for 16 quarters ahead. Another noteworthy difference between DEF2 and DEF1 and M1 is their impact on GDP. A positive shock to money (DEF2) has no impact on GDP for two quarters, after which the impact becomes positive for several quarters and then starts to phase out. Whereas, a positive shock to money (DEF1, M1) has a positive impact on GDP for the first three quarters, after that the impact becomes negative. More importantly, these results are not puzzling if the change in money (DEF2) is used as proxy for monetary shocks.[11] Another major difference from DEF1 and M1: a positive shock to DEF2 leads to a decrease in CPI for 2 quarters ahead, after which the impact becomes positive, while a positive shock to money (DEF1, M1) leads to a rise in CPI for 16 quarters ahead.

To shed further light on the importance of the changing components of money in examining the impact of money on economic activity, a VEC model is estimated using M2 as a monetary policy indictor. Figure IV depicts the impulse response functions calculated from the VEC model (M2, FFR, GDP, CPI). From this figure, one can draw the following observations. First, in response to a surprise increase in M2, FFR responds with an initial decline and then a protracted rise, while FFR responds positively to a shock to M1 for 16 quarters ahead. Second, a positive shock to M2 has a significant positive impact on GDP. The impact starts immediately, reaches its peak in 8 quarters, and then starts to decline. This shock has a small negative impact on CPI for the first two quarters and then the impact becomes significantly positive.[12]

Figure V shows the impulse responses estimated from the VEC model [MSIM1, FFR, GDP, CPI].[13] The most striking result is that an unexpected rise in money (MSIM1) has a small negative impact on FFR (compared with a positive impact in DEF1, M1 and DEF3 systems). The main conclusion here is that by using the monetary services index (MSIM1) in this model, the negative impact of money on the interest rate is found in this case. Also, this negative impact occurs in the first two quarters with M2, DEF2 and MSIM2 models. Interestingly and in contrast to the other models, MSIM1 has a negligible effect on CPI (see the first graph in the fourth row).

Re-estimating the quarterly VEC system with MSIM2 instead of M2 yields impulse response estimates (Figure VI), whose general qualitative pattern is similar to that of M2. However, in this model, there are some differences. One of the major differences is that money (MSIM2) does not respond to any variable except to itself. A second result from Figure VI is that a positive shock to MSIM2 has a negative impact on FFR for the first two quarters, after which the impact becomes positive. However, the impact is insignificant. The most interesting fact is that a shock to MSIM2 leads to an increase in GDP for 16 quarters ahead. The Output Puzzle is not found in this case.[14] A noteworthy point is that the CPI stays low for 8 quarters, and then starts to rise.

The last VEC model is estimated using MI to identify money shocks. The first graph in the second row of Figure V shows that a money (MI) shock has a significant negative impact on the interest rate (FFR) for 6 quarters ahead, after which the impact becomes positive.[15] The Output Puzzle is found after eight quarters; thus an expansionary monetary policy leads to an increase in MI and a decrease in GDP.

In summary, the IRF results in Figures (I-VII) suggest that basic inferences about money's affects on economic activity may depend crucially on the measure of money chosen. For instance, an increase in the federal funds rate (FFR) and a decline in output (GDP) follow a positive innovation to money (M1, DEF1, DEF3). This result is puzzling if money shocks are considered as a monetary policy instrument. In contrast, an increase in both the federal funds rate and output follow a positive innovation to money (M2, DEF2, MSIM2). No Output Puzzle is found in this case. Interestingly, when the monetary policy is measured by MSIM1, an expansionary monetary policy impacts both FFR and GDP negatively. When MI measures money, a positive shock to money is followed by a decline in FFR and no impact in output (GDP) for 7 quarters ahead; after that, FFR starts to increase and GDP to decline.

Empirical Results Interpreting Funds-Rate Shocks as Policy Shocks

The following analysis uses innovations in the short-term interest rate (FFR) as a measure of monetary policy actions. Bernanke and Blinder (1992) argue that innovation in the federal funds rate is a good measure of changes in monetary policy. The second row of the Figures (I-VII) depicts the response of the monetary policy, as measured by FFR, to shocks in the other variables in the model. It is evident that FFR responds positively to innovations in all the other

Figure I
Impulse Responses from the VAR Model (DEF1, FFR, GDP, CPI)

Impulse responses of the four-variable VAR system are orthogonalized recursively in the order shown in the figure below. The VAR system has six lags and a constant term. The horizontal axes represent the quarters; the vertical axes measure the response of a particular to one standard deviation in each one of the variables in the model. LDEF1 is money, FFR is federal funds rate, LGDP is real gross domestic product, and CPI is consumer price index.

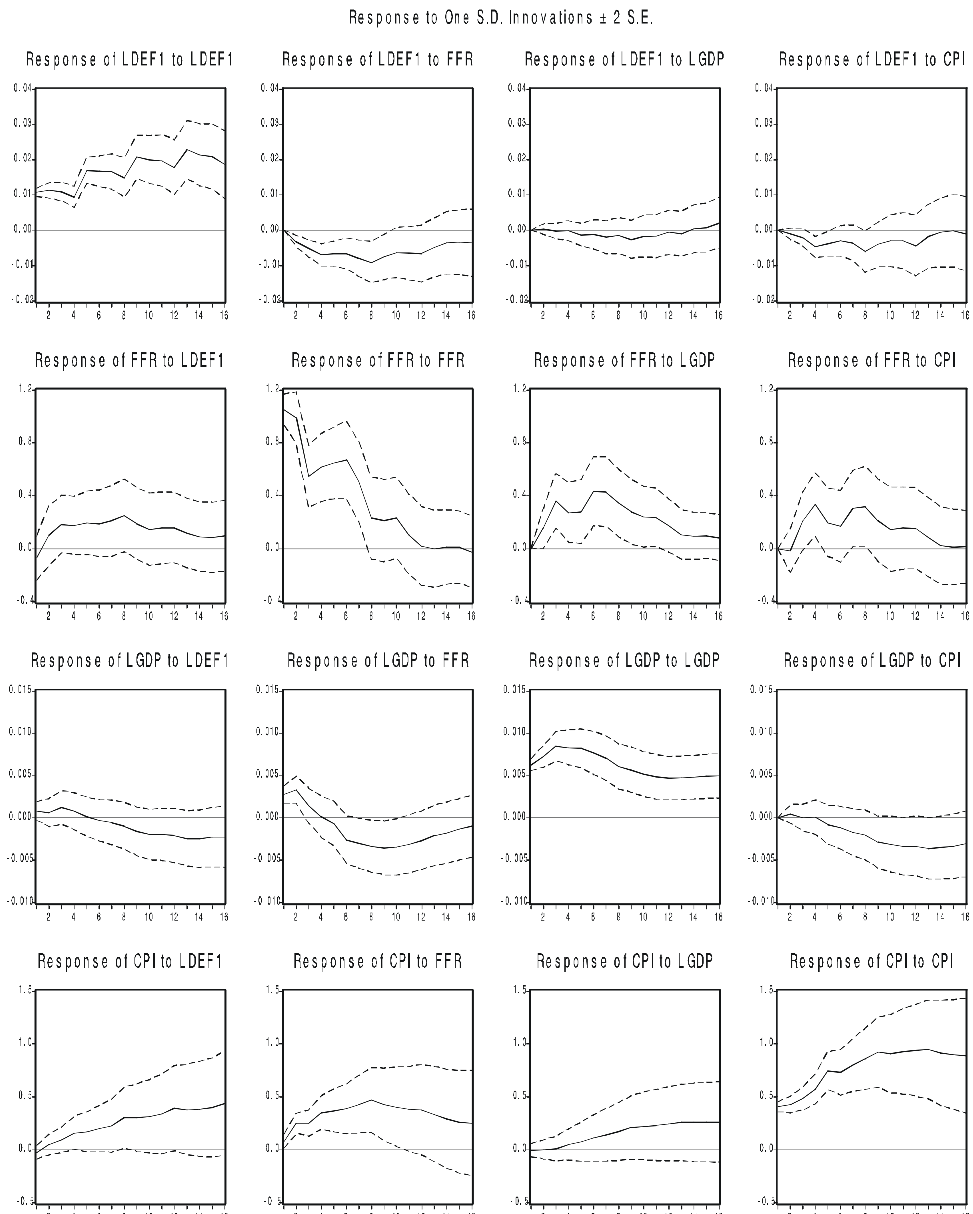


Figure II
Impulse Responses from the VAR Model (DEF2, FFR, GDP, CPI)

Impulse responses of the four-variable VAR system are orthogonalized recursively in the order shown in the figure below. The VAR system has six lags and a constant term. The horizontal axes represent the quarters; the vertical axes measure the response of a particular to one standard deviation in each one of the variables in the model. LDEF2 is money, FFR is federal funds rate, LGDP is real gross domestic product, and CPI is consumer price index.

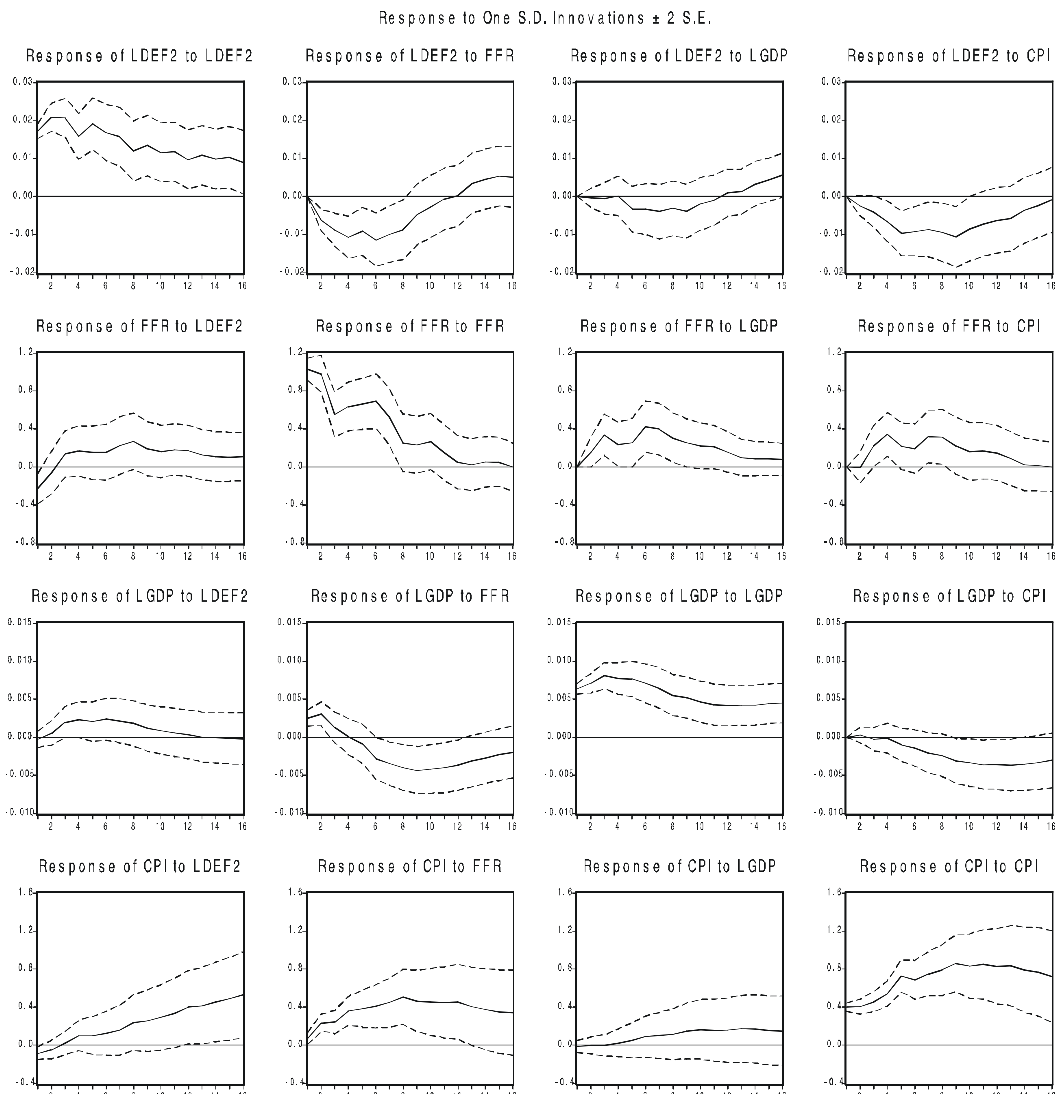


Figure III
Impulse Responses from the VAR Model (M1, FFR, GDP, CPI)

Impulse responses of the four-variable VAR system are orthogonalized recursively in the order shown in the figure below. The VAR system has five lags and a constant term. The horizontal axes represent the quarters; the vertical axes measure the response of a particular to one standard deviation in each one of the variables in the model. LM1 is money, FFR is federal funds rate, LGDP is real gross domestic product, and CPI is consumer price index.

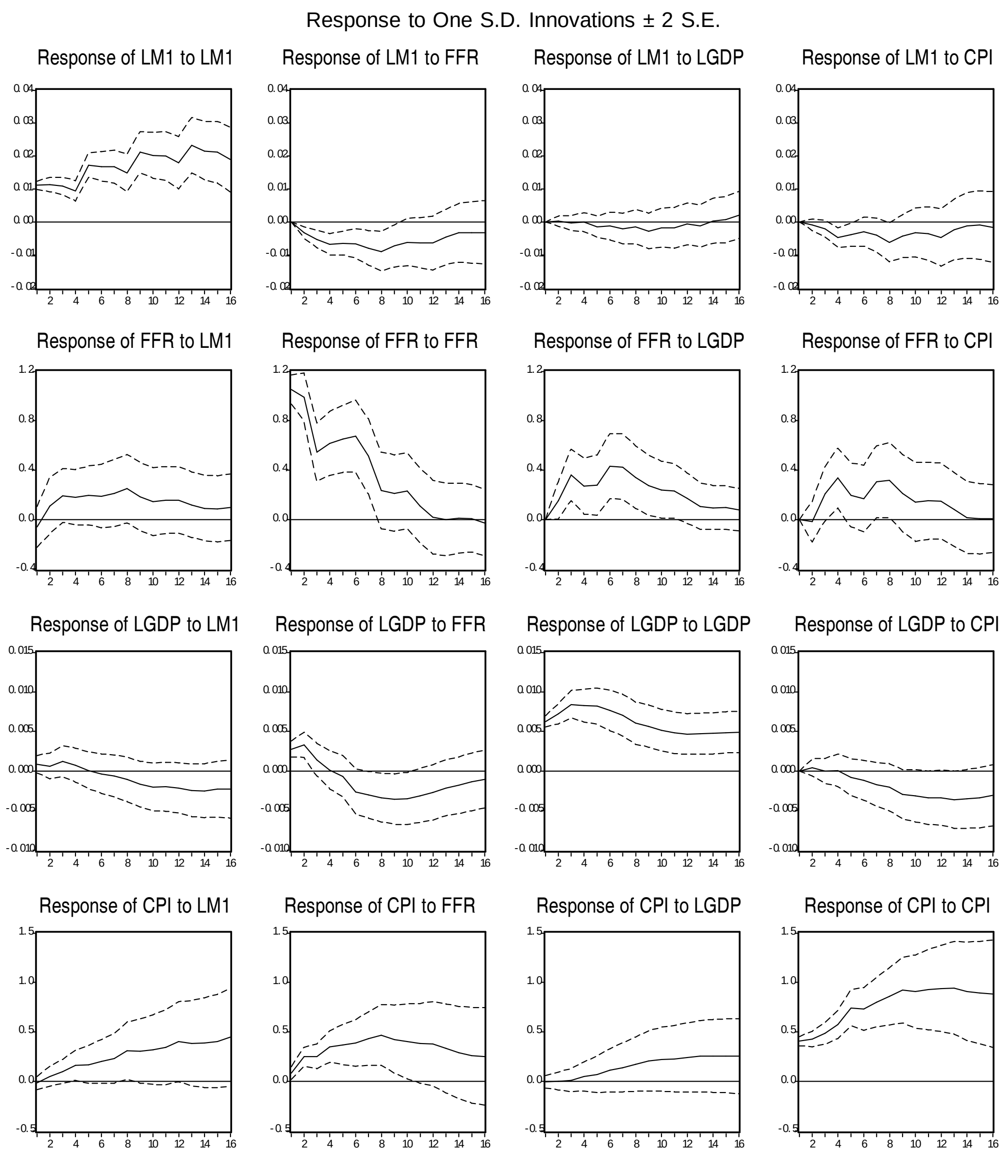


Figure IV
Impulse Responses from the VEC Model (M2, FFR, GDP, CPI)

Impulse responses of the four-variable VEC system are orthogonalized recursively in the order shown in the figure below. The VEC system has five lags and a constant term. The horizontal axes represent the quarters; the vertical axes measure the response of a particular to one standard deviation in each one of the variables in the model. LM2 is money, FFR is federal funds rate, LGDP is real gross domestic product, and CPI is consumer price index.

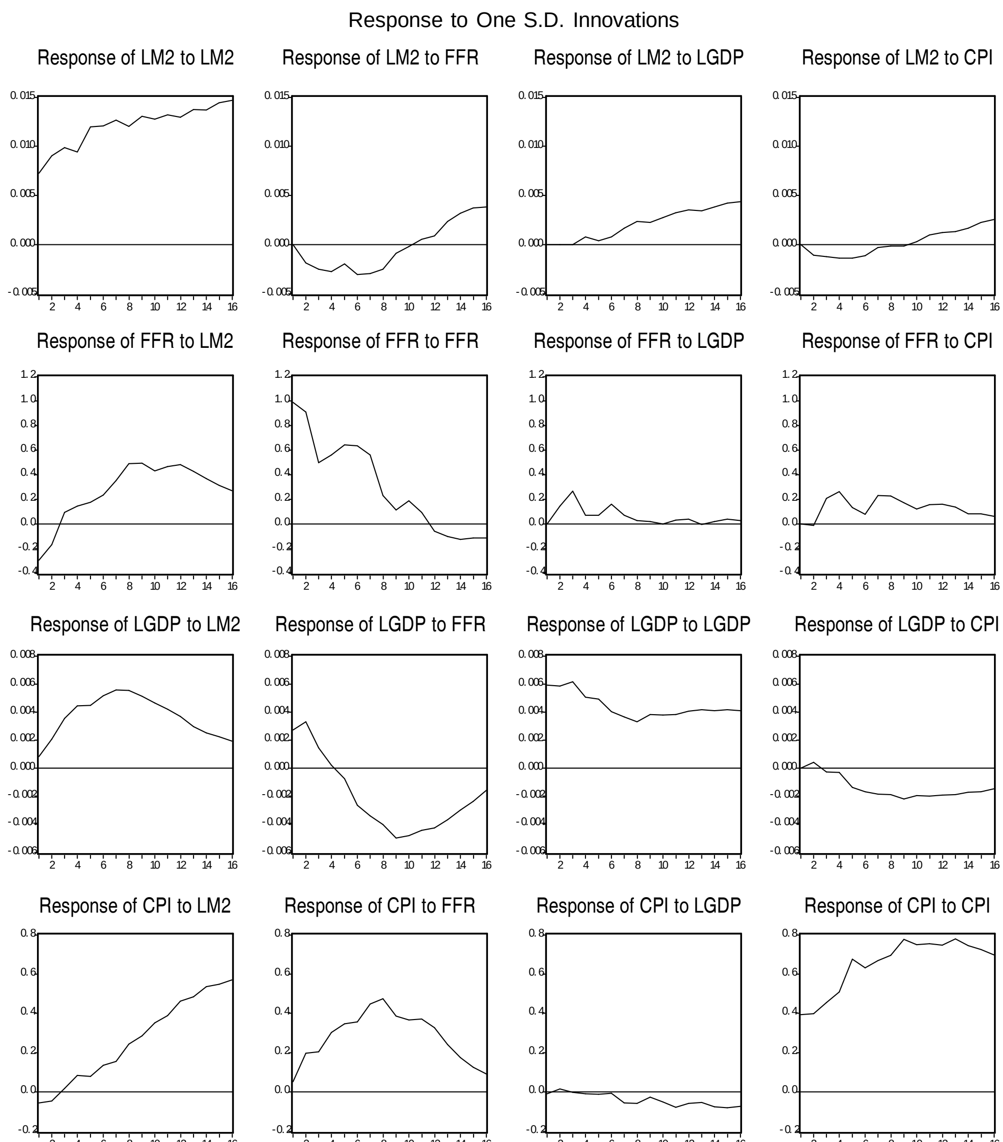


Figure V
Impulse Responses from the VEC Model (MSIM1, FFR, GDP, CPI)

Impulse responses of the four-variable VEC system are orthogonalized recursively in the order shown in the figure below. The VEC system has five lags and a constant term. The horizontal axes represent the quarters; the vertical axes measure the response of a particular to one standard deviation in each one of the variables in the model. MSIM1 is money, FFR is federal funds rate, LGDP is real gross domestic product, and CPI is consumer price index.

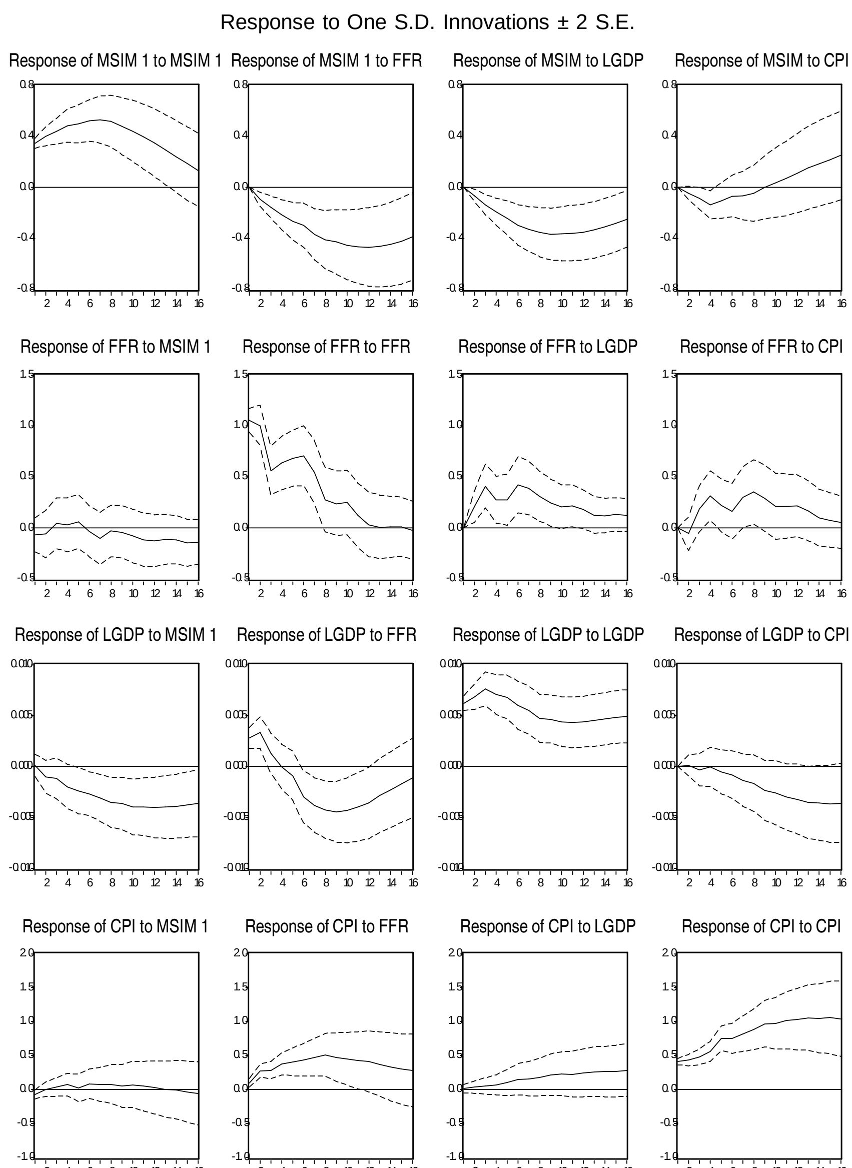


Figure VI
Impulse Responses from the VEC Model (MSIM2, FFR, GDP, CPI)

Impulse responses of the four-variable VEC system are orthogonalized recursively in the order shown in the figure below. The VEC system has six lags and a constant term. The horizontal axes represent the quarters; the vertical axes measure the response of a particular to one standard deviation in each one of the variables in the model. MSIM2 is money, FFR is federal funds rate, LGDP is real gross domestic product, and CPI is consumer price index.

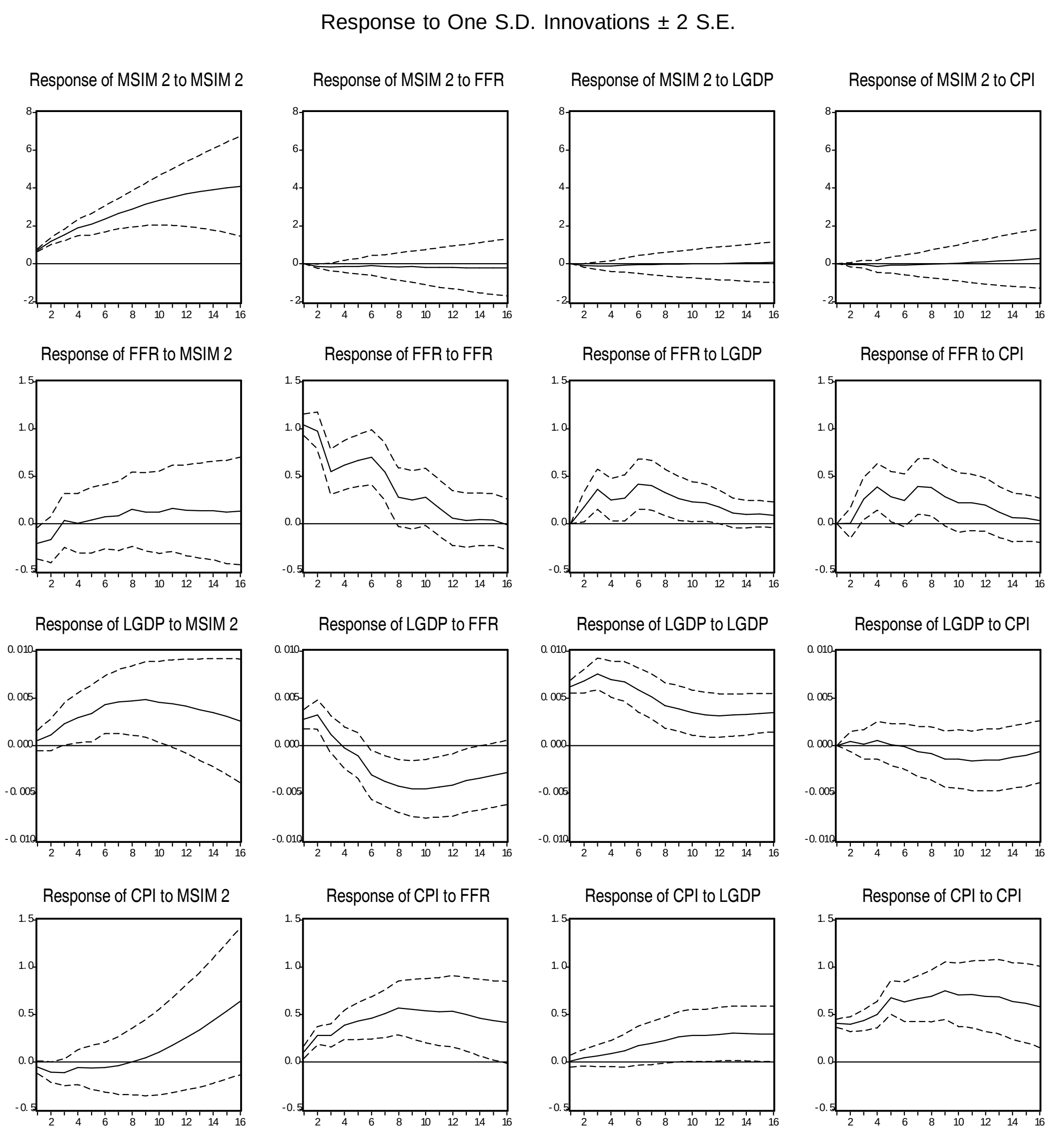
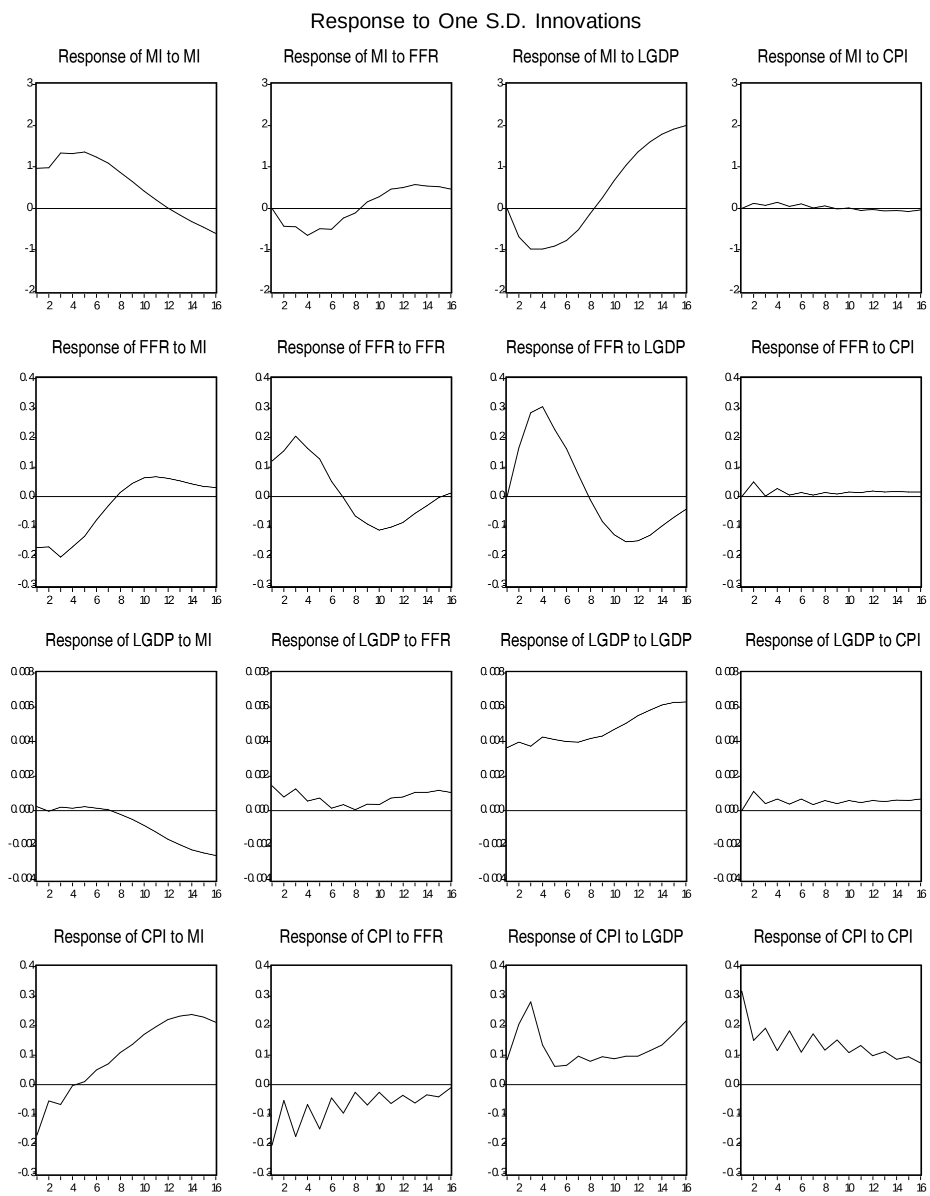


Figure VII
Impulse Responses from the VEC Model (MI, FFR, GDP, CPI)

Impulse responses of the four-variable VEC system are orthogonalized recursively in the order shown in the figure below. The VEC system has five lags and a constant term. The horizontal axes represent the quarters; the vertical axes measure the response of a particular to one standard deviation in each one of the variables in the model. MI is money, FFR is federal funds rate, LGDP is real gross domestic product, and CPI is consumer price index.



variables in the model. This positive response of FFR confirms the view of a reaction role on the part of the Fed. The Fed adopts a "leaning against the wind" policy to stabilize the economy.

The second graph in the first row of Figure I shows that a FFR shock leads to a negative money (DEF1) response up to 16 quarters. The negative impact on money is inconsistent with the view that a rise in the interest rate leads to an increase in deposits or in bank loans, which in turn results in an increase in money supply. Interestingly, the impact of the interest rate on GDP is positive for three quarters ahead and negative afterwards.[16] Output Puzzle is not found for the first three quarters; a positive FFR shock is followed by an increase in GDP. The fourth row of impulse functions (see Figure III) shows that the CPI responds positively to all variables. The highest response is the one to a shock in FFR. Price Puzzle is found in this case. This increase in CPI in response to a positive shock to the interest rate has been labeled the "Price Puzzle". As Christiano, Eichenbaum, and Evans (1994) discuss, this response could occur because the Fed is using some indicators of inflation that are not included in the VAR. Finally, the estimation results of the models with DEF1 and M1 are generally the same.[17]

As for the IRFs from VAR (DEF2, FFR, GDP, CPI), a positive shock to FFR has little negative effect on money (DEF2) for 11 quarters ahead, after that the impact becomes positive (see Figure II). This is a major difference from the DEF1 and M1 VAR models. A positive shock to FFR has a negative impact on DEF1 and M1 for 16 quarters ahead.[18] Furthermore, a positive shock to FFR has a positive impact on GDP for three quarters; after that the impact becomes negative. In general, the response of GDP to a contractionary policy on the part of the Fed is similar for 7 cases (DEF1, DEF2, DEF3, M1, M2, MSIM1, MSIM2). In all of these cases monetary shocks lead to an output response that is usually described as following a hump-shaped pattern.[19] This result, on the other hand, does not hold with using MI. The IFRs calculated from VEC model [Figure VII, (MI, FFR, GDP, CPI)] shows that a positive shock to FFR leads to an increase in GDP. The most striking result is that the response of CPI to an interest-rate innovation is similar for 7 cases (DEF1, DEF2, DEF3, M1, M2, MSIM1, MSIM2). Price Puzzle is found in these cases as a contractionary policy causing an increase in CPI. Interestingly and in contrast to those cases, monetary shocks with MI measure lead to a decrease in CPI (see Figure VII). Also, with MI measure, a shock to FFR has a negative impact on CPI (compared with a positive impact in all other models). This implies that a positive shock to interest rates leads to higher inflation.

Comparing these results with those accruing in M2, MSIM1 and MISIM2 subsequent to the same type of shock, one can draw the following remarks: (i) a shock in FFR causes a significant decline in money (M2, MSIM1); (ii) the shock has a positive impact in GDP for 4 quarters; after that the impact becomes negative. In this case, the Output Puzzle is found for the first 4 quarters; (iii) in the case of MISM2, a shock to FFR has no impact on MSIM2 (Figure VI).

In summary, when innovations in the short-term interest rate (FFR) are considered as a monetary policy tool, a positive shock to the FFR represents a contractionary policy shock. In general, the Output Puzzle is found; a positive FFR shock is followed by a decline in output (GDP). In response to a policy shock, output follows a hump-shaped pattern in which the peak impact occurs several quarters after the initial shock. This hump-shaped pattern is a very common finding (see Sims 1992). The response of consumer price index (CPI) to an interest-rate innovation is similar for seven models (M1, DEF1, DEF2, M2, MI, MSIM1, and MSIM2). In all these cases, monetary shock (innovation in FFR) is followed by a rise in the CPI (Price Puzzle). In contrast, using Divisia DEF3 (MI) as a measure of money, monetary shock is followed by a decline in CPI. Overall, these results reaffirm the central theme of this paper: conclusions about the direction of money growth on economic activity depend on the chosen measure.

VI. CONCLUSIONS

This paper attempts to study how sensitive some of the VAR and VEC results are to changing the components of money. The impulse response functions (IRF) are computed in order to investigate interrelationships within the system. A number of important results in this regard are represented in eight scenarios. Consistent with Belongia (1996), the results suggest that empirical conclusions from the VAR and VEC approaches may differ when money is measured by the flow of monetary services, rather than by summation of the dollar amount of monetary assets. Specifically, the evidence presented in this paper underscores the importance of the changing components of money in examining the impact of money on economic activity. When M2, DEF2 and MSIM2 measure money, it is found that money has a real positive effect on output (GDP), while using the other measures for money show a negative money effect on GDP. Another noteworthy difference between M2 and the other measures is in their responses to GDP. The empirical results show that a positive shock to GDP results in an increase in M2 (money), while this shock has a negative impact on M1, DEF1, DEF2, and MSIM1. The predictions of macroeconomic models regarding the positive impact of output (GDP) on money are supported only by using M2 as a measure for money. Moreover, GDP shocks drive up money (DEF3) for 7 quarters ahead, whereas these shocks push money (MI) in the opposite direction, but with somewhat shorter lags and bigger magnitudes.

Another interesting finding is that MSIM2 does not respond to a shock in any of the variables. Additionally, it appears that a positive innovation to the interest rate (FFR) is followed by a significant decline in money (MSIM1 and DEF3) compared with a small decline in the other measures of money. The response of output (GDP) to an interest-rate shock is similar for seven models (a humped-shaped response), while this response is different with the MI model (GDP responds positively to a shock to FFR).

Notes

1. For surveys of the relevant issues, see Barnett (1982) and Barnett, Fisher, and Serletis (1992).
2. Diewert (1976) shows that the Divisia index is capable of measuring changes in a wide class of utility functions using only observed prices and quantities.
3. The Federal Reserve Bank of St. Louis' World Web serves at www.stls.frb.org.
4. MI is consistent with economic theory.
5. To save space, the results for different ordering are not presented here and will be available upon request.

6. If a variable follows a unit root process, such that the first difference is stationary, the variables is said to be integrated of order one, I(1).
7. The Johansen tests are based on the Likelihood ratio or the so-called trace statistics. Any results that I discussed but do not formally present in the paper are available from the author upon request.
8. The hypothesis of no cointegration is rejected. Therefore, since we have nonstationary individual series and cointegration in the group of series, the VEC model is used in this case.
9. The best model will be estimated according to AIC criterion.
10. To save space, the IRF figure for VAR (DEF3, FFR, GDP, CPI) is not presented here and will be available upon request.
11. In the first three quarter, an expansionary monetary policy leads to an increase in both money (DEF2) and GDP.
12. The results indicate that the longer the time lag the greater the effect of money (M2) on FFR and CPI.
13. VEC model will be estimated including one cointegration equation.
14. An expansionary monetary policy leads to an increase in both money (MSIM2) and output (GDP).
15. On the other hand, money (DEF3) has a positive impact on FFR. However, a positive shock to money (DEF3, MI) has no impact on GDP for the first 6 quarters, after that the impact becomes negative.
16. See the second graph in the third row of Figure I.
17. See Figures I and III.
18. The impacts of a positive shock to FFR on GDP and CPI are similar to those in the system with MSIM2.
19. The negative output effects of a contractionary shock build to a peak after several months and then gradually die.

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