AN EMPIRICAL ANALYSIS OF OUTPUT, INTEREST AND MONEY: THE CASE OF JORDAN

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ABSTRACT

This paper investigates the dynamic interactions among money, interest rates, and output (GDP). The Generalized Impulse Response Functions and the Generalized Forecast Error Variance Decomposition are computed in order to investigate interrelationships within the system. The results reveal that a shock to the interest rate has a negative impact on money (M2).

The negative impact on M2 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. The impact of the interest rate on GDP is positive. The positive effect of the interest rate on GDP is in contradiction with a theoretical relationship where interest rates have a negative impact on output.

INTRODUCTION

In general, there are two empirical facts about the relationship between money and economic activity upon which most macroeconomists agree. The first is the co-movement of money and output in economic time series. The second is that money changes precede changes in output. However, these facts tell nothing about the origin of changes or the direction of influence. "The monetary changes might be produced by independently originating changes in output (endogenous money); the changes in output might be produced by independently originated changes in money (exogenous money); the two might be mutually interacting (two-way influence), each having some elements of independence; or both might be reacting to a common change in a third set of influences" [Friedman and Schwartz (1963a), p. 686].

This issue of the direction of influence between money and economic activity has attracted a great deal of attention among macroeconomists and has been one of the most controversial issues in the macroeconomic literature. Theoretical disagreement among different schools of thought has led economists of these schools to use different approaches and statistical techniques to examine this issue empirically. The empirical findings have been dependent, to a large extent, on techniques used, data form, and models' specifications. Hence, no widely held consensus has been reached.

Despite the importance of previous studies, until now the majority of research considers developed countries economies without going further in testing this relation in less developed countries. Considering this mater, the relationship between money and economic activity in developing countries still needs lengthy analysis and more researcher attention. So, the importance of this study stems from its being an empirical try in this direction. The purpose of this paper is to investigate empirically the relationship between money and output in Jordan. A Generalized Vector Auto Regression (GVAR) technique is used here as the main method of analysing the short-term relationships between the variables. This paper also departs from most previous work specifically by dealing with the problem of cointegration in the data series. The presence of nonstationarity and cointegration found in the data requires the use of the Error Correction (EC) model to estimate the dynamic short-run relationships between the variables. In the EC model, the short-run dynamics of the variables are influenced by the deviation from an equilibrium relationship between the groups of variables.

The paper proceeds along the following lines. Section 2 presents the literature review. Section 3 discusses the data and the methodology. Section 4 reports the empirical results, and Section 5 provides conclusions

LITERATURE REVIEW

Sims (1972) applies Granger causality analysis to test the direction of causality between money and output. Using time series regressions including income and money variables, his main empirical finding is that causality is unidirectional from money to income. However, in a later article, Sims (1980) re-examines the monetarist proposition using a VAR model that includes an interest rate variable in addition to money and income variables. The evidence from this model contradicts his conclusion from his previous work. He shows that the shocks to the money supply 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 a 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. This conclusion is also confirmed by Tylor (1993), Sims (1992), and Bernake and Blinder (1992). 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 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 rates innovations are not significant determinants of output. These results also hold when they run the model using quarterly data.

According to the traditional monetary transmission mechanism with interest rate channels, an expansionary monetary policy leads to a fall in interest rates, which in turn lowers the cost of capital, causing a rise in investment and output [Mishkin (1996]. When assessing the final impact of money on economic activity, most of the recent studies use aggregate measures of output, such as GDP or the index of industrial production, to measure economic activity. A lag in the effect of money and interest rates on such aggregates has been found by many studies. For example, Gordon and Leeper (1994) find a delay of six months before output (measured by the industrial production) responds significantly to monetary policy shocks. Also, interest rates have a puzzling procyclical behavior with output [see Christiano (1991), Blanchard and Fisher (1989) and Fiorito and Kollintzas (1994)]. Such findings might be due to the absence of important variables in the analysis. The positive co-movement of interest rates and output during business cycles challenges the transmission mechanism by which interest rates has a negative effect on investment. Proponents of the Real Business Cycle model, therefore, explain investment fluctuations as being due to productivity shocks.

Other studies focus on the federal funds rate as a measure of the stance of monetary policy [see for example Bernanke and Mihov (1998) and (1995) and Bagliano and Favero (1998)]. In these studies the authors are trying to separate exogenous policy actions from endogenous money responses to developments in the economy. A number of these studies have found evidence consistent with the liquidity effect of money

METHODOLOGY

This study adopts an unrestricted vector autoregression (UVAR) framework to analyse the dynamic relationship between the variables. The UVAR does not impose arbitrary restrictions of the effects of the endogenous variables. It was common in earlier VAR-type analyses to rely on a Choleski factorization. Unfortunately, the Choleski factorization is known to be sensitive to the ordering of variables when the residual covariance matrix is non diagonal. This paper employs generalized forecast error variance decomposition (GFEVD) developed in Koop, Pesaran and Lee (1996) and Pesaran and Shin (1998) to deal with this problem. Unlike the orthogonalized forecast error variance decomposition, the generalized approach is invariant to the ordering of the variables in the UVAR model. The generalized forecast error variance decomposition (GFEVD) from the UVAR model is computed in order to investigate interrelationships within the system. The empirical work undertaken in this study is based on estimating the UVAR on eight definitions of money.

The UVAR approach, introduced by Sims (1980), suggests a standard tool to analyse time series relationships among macroeconomic variables. A VAR is a system in which every equation has the same right hand variables, and those variables include lagged values of all of the endogenous variables. VARs are well suited to forecasting variables where each variable helps forecast other variables.

The mathematical form of a UVAR is

$$y_t = m + A_1 y_{t-1} + ... + A_N y_{t-N} + \varepsilon_t \quad (1)$$

Here is a vector of endogenous variables; m is a vector of constant, N is the vector autoregressive order, are matrices of lag coefficients of up to some lag length N, and is a vector of innovations. The components of vector are each white noise process with zero mean, constant variance, and are individually serially uncorrelated. However, the components of vector could be contemporaneously correlated.

In this paper, the vector includes Money supply (M2), 3 month certificate deposit rate (CDs) and Gross Domestic Product (GDP). All the variables are in the log of the level form except for CDs.

UVARs have proven successful for forecasting systems of interrelated time series variables. Vector autoregression is also frequently used, although with considerable controversy, for analysing the dynamic impact of different types of random disturbances on systems of variables. However, the estimated coefficients of a UVAR themselves are difficult to interpret. We will look at the generalized forecast error variance decomposition (GFEVD) of the system to draw conclusions about a UVAR.

Unit Root Tests

The first step in our statistical analysis is to analyse the stationarity properties of the macro time series considered in this study. Applying the unit root test will do this. Unit root tests are important in examining the stationarity of a time series, which is a matter of concern in three important areas. First, a crucial question in the ARIMA modeling of a single time series is the number of times the series needs to be first differenced before an ARMA model is fit. Each unit root requires a first differencing operation. Second, stationarity of regressors is assumed in the derivation of standard inference procedures for regression models. Nonstationary regressors invalidate many standard results and require special treatment. Third, in cointegration analysis, an important question is whether the disturbance term in the cointegrating vector has a unit root.

The Augmented Dickey-Fuller Test (ADF) is applied in this paper. The ADF test consists in running a regression of the first difference of the series against the series lagged once, lagged difference terms, and optionally, a constant and a time trend. With two lagged difference terms, the regression is

$$\Delta y_t = \beta_1 y_{t-1} + \beta_2 \Delta y_{t-1} + \beta_3 \Delta y_{t-2} + \beta_4 + \beta_5 t \quad (2)$$

There are three choices in running the ADF test regression. One is whether to include a constant term in the regression. Another is whether to include a linear time trend. The third is how many lagged differences are to be included in the regression. In each case the test for a unit root is a test on the coefficient of   in the regression. If the coefficient is significantly different from zero then the hypothesis that y contains a unit root is rejected and the hypothesis is accepted that y is stationary rather than integrated.

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. A large negative t-statistic rejects the hypothesis of a unit root and suggests that the series is stationary. Under the null hypothesis of a unit root, the reported t-statistic does not have the standard t distribution. We must refer to the critical values presented in the test output. The reported critical values are chosen on the basis of the number of observations and the estimation option.

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. The empirical evidence from a VAR model is very sensitive to the choice of lag length in the equations of the model. Alternative choices will give different innovations series and thus will likely make a difference in the variance decomposition results. The appropriate lag length could be tested using the likelihood ratio test, the Akaike Information Criterion or the Schwarz Criterion. In this study, the lag length will be specified based on these criteria and the results obtained in each case will be compared. Changing the lag length will also test the robustness of the empirical results.

Variables in the System and the Data

The VAR data came from the monthly and yearly statistical bulletins of the Central Bank of Jordan. This study use quarterly data for the period 1964.9-2008.4. The use of this temporal aggregation of three-month interval is justified by the fact that monthly data may be too frequent to reflect the natural interval in the relationship between money and output and may contain significant measurement error resulting in a high proportion of noise that may destroy the original picture of the relationship, Spencer, 1989.

Jordan's monetary policy regime is characterized as a fixed exchange rate regime with a system of publicly targeting M2 growth that is consistent with maintaining the exchange rate. Moreover, the use of certificate of deposits interest rate (CD) as well as interest rates on government debt as instruments. Therefore, the following are the potential variables of interest for the study. All of them are in log linear form. Variables are the GDP, M2 and CDs. GDP is Gross Domestic Product, M2 is Money Supply, CDs is 3 Month CD rate.

EMPIRICAL RESULTS

Before estimating final models, a few issues need to be addressed regarding the application of the VAR method. The first step is testing the stationarity of each series. If data series are nonstationary, cointegration tests will be applied to each system of variables to be used for estimation. If the data are not cointegrated, the growth rate form of the data will be used in the VAR estimation. If cointegration exists, the Error Correction model will be applied. Given the sensitivity of the VAR results to the lag length, for each model the lag length will be determined before final estimation according to three criteria. These are the Likelihood Ratio (LR), the Akaike Information Criterion (AIC), and the Schwarz Criterion (SC). Finally, the results should be robust to the ordering of the variables to be considered conclusive.

Unit Root Tests

The above mentioned hypotheses and the propositions of the different macroeconomic models will be tested using the results from the VAR models. The analysis includes the aggregate variables: real GDP, the money supply (M2), and the interest rate (CD). These three variables are the main focus of most theoretical and empirical work on the money-output relationship. The data in level form are expected to be nonstationary as has been found by many studies. To test the series, the unit root test [see Dickey and Fuller (1981)] is applied to the data in level form. The Augmented Dickey-Fuller Test (ADF) is applied here by regressing the difference of a variable on its level lagged once, and on a given number of lagged difference terms.

Table 1
Unit Root Tests

Variables Level	In ADF statistics
GDP	1.28
M2	1.8
CDs	-1.65

The critical values are –3.47, -2.88, and –2.57at 1%, 5% and 10% respectively.

Table 1 shows the t-statistic on the coefficient of the lagged test variable and critical values for the test of a zero coefficient. As can be seen from the statistics presented in the table, the unit root test shows 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 appear to be non-stationary.[1] As such, the data do not 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 Error Correction model will be used. The Johansen Cointegration test [Johansen (1991)] is applied here to the group of the three variables, GDP, M2 and CDs.

Lag Length

To determine the best lag length, the three criteria mentioned earlier are applied to the results from running the EC model using different lags. The Log Likelihood Ratio (LR) is given by the following equation.

$$LR = (T-K)\,(\log |\Sigma (p_i)| - \log |\Sigma (p_j)|) \sim \chi^2 (n^2 (p_j - p_i)) \quad (3)$$

Where Σ is the covariance matrix, T is the number of observations, K is the number of parameters in each equation, n is the number of equations, and p is the number of lags, given that $p_j > p_i$. The other two criteria, the AIC and the SC, try to minimize a function that depends on two elements: the determinant of the covariance matrix of residuals and a penalty for including a large number of parameters in the model. In other words, we have that Akaike (p)= T Log($|\Sigma (p)|$ + 2pn, where Σ is the covariance matrix, p is the number of lags , n is the number of equations and T is the number of observations. Similarly, Schwarz (p) = T Log ($|\Sigma (p)|$ + (pn^2) Log T. The best model is the one that minimizes these two functions.

The lags are examined up to 12 quarters. There is no significant increase in the explanatory power by adding more lags than 5 quarts. This is confirmed by the SC statistics: the minimum value is reached at the 5^{th} lag. So the final estimation of this model will be carried out using five lags for each variable.

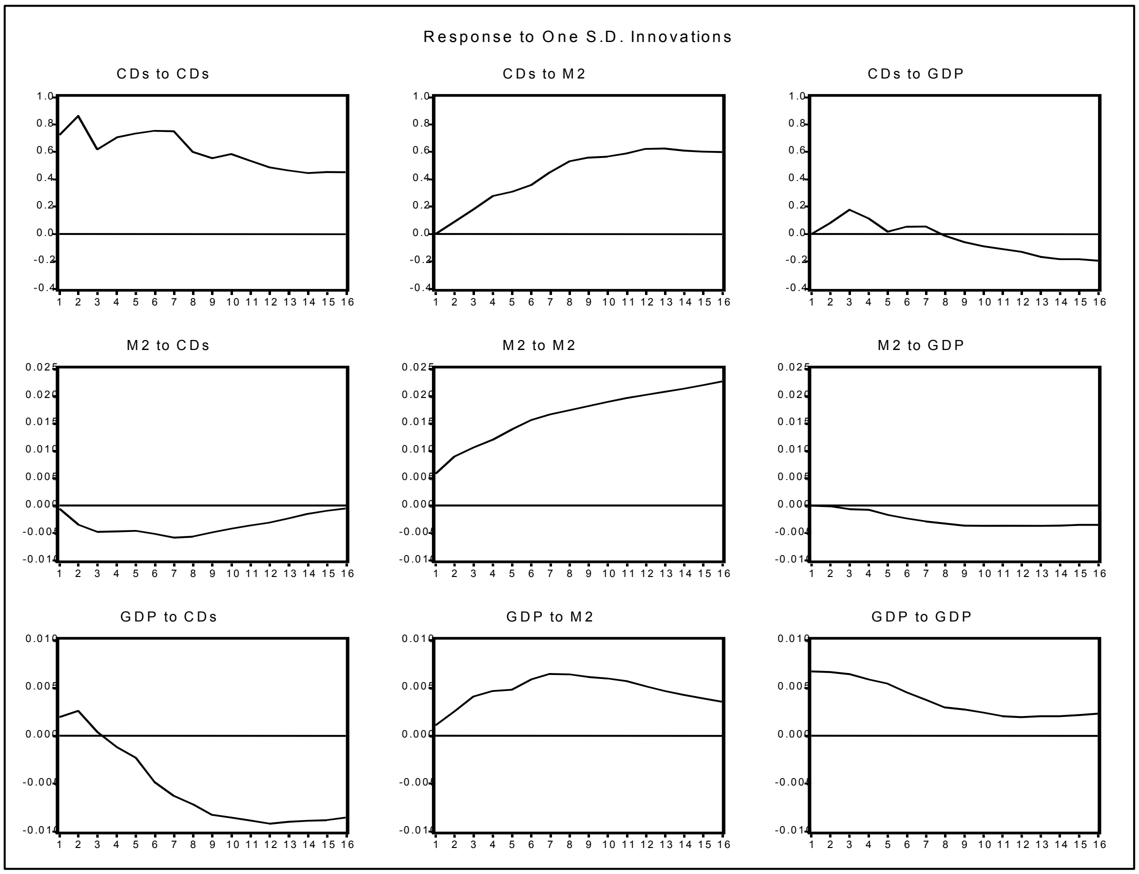
In analysing the results from the EC model, the focus will be placed on the two tools mentioned earlier, the Forecast Error Variance Decomposition (FEVD) and the Impulse Response Function (IRF). Impulse Response Functions show how one variable responds over time to a single innovation in itself or in another variable. Innovations in the variables are represented by shocks to the error terms in the equations.

The Generalized Impulse Response Function (GIRF)

The GIRFs (shown in Figure 1) provide details on the dynamic relationships among the variables. The signs of the relationships and the time factor are provided here. A shock to the interest rate has a negative impact on money up to 17 quarts ahead; after that the impact becomes positive. The negative impact on M2 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. The impact of the interest rate on GDP is positive for the first 3 quarts and then negative afterwards. The positive effect of the interest rate on GDP is in contradiction with a theoretical relationship where interest rates have a negative impact on output.

FIGURE 1: GENERALIZED IMPULSE RESPONSES FROM THE EC MODEL

The horizontal axes represent the quarters, the vertical axes measure the response of a particular variable to one standard deviation innovation in each one of the variables in the model. CDs is the three-month CD Rate, M2 is the Money Supply M2 and GDP is real Gross Domestic Product.



The Generalized Forecast Error Variance Decomposition (GFEVD)

The FEVDs for the three aggregate variables are presented in Tables 2, 3, and 4. What we are doing here is decomposing the forecast error of the endogenous variable Y over different time horizons into components attributable to unexpected innovations (or shocks) in variable X, where X can be any variable in the system. First, let us examine the variability of each variable explained by its own innovations. M2 accounts for most of its variation (above 92%). CDs account for about two-thirds of its variation in each ordering, while real GDP accounts for less than one-fifth of its own variation. This indicates that M2 is strongly exogenous in this model, while GDP is strongly endogenous.

TABLE 2 GENERALIZED VARIANCE DECOMPOSITION FROM EC MODEL			
Variance Decomposition of M2:	Explained By:		
Period	M2	CDs	GDP
1	100.0	0.00	0.00
5	92.84	6.52	0.64
10	93.23	4.37	2.40
16	95.18	2.17	2.64
Variance Decomposition of CDs :	Explained By:		
Period	M2	CDs	GDP
1	1.01	96.57	0.00
5	3.9	94.34	1.75
10	16.55	82.35	1.1
16	28.88	68.81	2.31
Variance Decomposition of GDP:	Explained By:		
Period	M2	CDs	GDP
1	1.51	0.00	90.37
5	24.91	5.89	69.20
10	38.85	29.17	19.61
CDs is the three-month CD Rate, M2 is the Money Supply M2 and GDP is real Gross Domestic Product			

When we look at the effect of innovations in one variable on the others, CDs explains most of the GDP variation, ranging from 46% to 61%. M2 innovations explain a high proportion of the variation in CDs and GDP while CDs and GDP have small contributions in accounting for M2 variation. Further, the effect of M2 on GDP is more immediate than on CDs. While both M2 and CDs affect GDP, the results indicate that M2 affects GDP at a shorter horizon than CDs. Therefore, the above pattern of interaction between the variables suggests that the direction of influence runs from money to interest rates and from interest rates to real GDP. However, as we noticed in the impulse function analysis, the signs of the relationships are not consistent with prediction of macroeconomic theories.

In general, the previous analysis suggests that there are time lags in the dynamic relationships among the variables. These delays might be due to the fact that other important variables are absent in the analysis. Further, two of the widely accepted propositions in macroeconomics, the negative effect of money on interest rates and the negative effect of interest rates on output, are not supported by the analysis of the variables used here.

TABLE 3
GENERALIZED VARIANCE DECOMPOSITION FROM EC MODEL

Variance Decomposition of CDs :	Explained By:		
Period	CDs	M2	GDP
1	100.0	0.00	0.00
5	91.06	7.18	1.75
10	76.05	22.85	1.10
16	61.34	36.35	2.31
Variance Decomposition of M2 :	Explained By:		
Period	CDs	M2	GDP
1	1.01	98.99	0.00
5	12.11	87.25	0.64
10	9.13	88.47	2.40
16	4.80	92.55	2.64
Variance Decomposition of GDP:	Explained By:		
Period	CDs	M2	GDP
1	7.35	2.27	90.37
5	6.15	24.65	69.20
10	34.87	33.15	31.98
16	53.01	27.38	19.61

CDs is the three-month CD Rate, M2 is the Money Supply M2 and GDP is real Gross Domestic Product

TABLE 4
GENERALIZED VARIANCE DECOMPOSITION FROM EC MODEL

Variance Decomposition of GDP :	Explained By:		
Period	GDP	CDs	M2
1	100.0	0.00	0.00
5	76.42	9.27	14.31
10	31.02	43.94	25.04
16	17.26	61.28	21.47
Variance Decomposition of CDs :	Explained By:		
Period	GDP	CDs	M2
1	7.35	92.65	0.00
5	15.64	78.11	6.25
10	12.15	65.67	22.18
16	8.01	54.75	37.24
Variance Decomposition of M2:	Explained By:		
Period	GDP	CDs	M2
1	1.51	1.93	96.56
5	0.21	12.64	87.15
10	0.78	8.61	90.60
16	0.47	4.47	95.06

CDs is the three-month CD Rate, M2 is the Money Supply M2 and GDP is real Gross Domestic Product

CONCLUSION

As the evidence (using data from Jordan) presented in this paper show, aggregate money, as measured by M2, has a positive relationship with interest rates. But broad measures of money contain an endogenous component that hides the effect of the exogenous shocks of money. It is monetary change that results from an exogenous policy shock that is expected to have a negative effect on interest rates. In other worlds, the monetary changes induce variations in the interest rate, which in turn affects output, is an indication of the impact of exogenous monetary changes on economic activity.

ENDNOTES

1 If a variable follows a unit root process, such that the first difference is stationary, the variable is said to be integrated of order one, I(1).

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