THE RELATIONSHIP BETWEEN MONETARY AGGREGATES, INFLATION AND OUTPUT IN FIJI

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Abstract

This paper examines the relationship between selected monetary aggregates and inflation and output. Simple correlation coefficients and Granger causality tests under a VAR framework were used to discover the leading or lagging role of the monetary aggregates. In addition, the information provided by the monetary aggregates as predictors of output and inflation was examined. This was assessed by examining their predictive power for subsequent observations on an in-sample basis. Overall, the results indicated a lack of robustness in the relationship between the monetary aggregates and the economic activity variables, as well as in their predictive power.

1.0 Introduction

Since the 1980s, the traditional relationship between money and policy target variables has deteriorated in many developing economies, including Fiji. Consequently, money growth targets began losing their importance and in the last decade, have almost completely lost their central role in the conduct of monetary policy. Today, many central banks are focussed on either implicit or explicit inflation targets.

Until the mid-1990s, the Reserve of Bank of Fiji utilised quantitative controls to influence money and credit growth. The Bank used money and credit aggregates as intermediate targets for monetary policy. However, financial deregulation and innovation since the mid-1980s saw the downgrading of quantitative controls. Although money and credit aggregates retained their role as important information variables, the Bank no longer used them as intermediate targets in the 1990s.

This paper examines the usefulness of monetary aggregates in policymaking for Fiji, specifically, the relationship between monetary aggregates, economic activity and inflation. The correlation between the variables is examined to ascertain the degree to which movements in the monetary aggregates lead or lag movements in inflation and output.[1]

Vector autoregression (VAR) methodology is also used to identify leading and lagging relationships among the variables. Furthermore, this paper examines the predictive power of monetary aggregates on output and inflation. VAR techniques are used to detect the incremental forecasting

[1] The method used in this paper is similar to that of Bullock, Morris & Stevens (1989).

value of the monetary aggregates.[2] VAR methodology is useful since the interrelationships between the monetary aggregates and policy goals can be examined without imposing severe structural restrictions on the system.

The rest of the paper is structured as follows: Section two provides a brief review of the empirical literature. Section three presents the empirical methods and results while the last section concludes the paper.

[2] The method used in this paper is similar to that of Friedman (1996) and Tallman and Chandra (1996).

2.0 Background

2.1 Empirical Literature Survey

The role of monetary aggregates in policy making has elicited immense interest and voluminous empirical literature for more than three decades and across a number of countries. One of the early works by Friedman and Schwartz (1963) proposed that changes in money stock preceded changes in nominal income in the U.S. In Australia, Sheppard (1973), Davis and Lewis (1977) and Boehm (1983) all found evidence of monetary aggregates leading real activity.

Simple regression analysis has been used to determine the relationship between monetary aggregates and policy targets in various studies although their results can be misleading especially since economic time series are usually autocorrelated. This means that lags of one variable would frequently be correlated with the current value of the other so simple regression results would be misleading. In addition, macroeconomic models used to discover policy effectiveness such as that of Sargent and Wallace (1975) contain many ad hoc restrictions imposed to identify the model. The seminal work of Sims (1972; 1980a; 1980b; 1982) introduced the vector autoregressive technique as a more general testing procedure to distinguish more clearly the relationship among variables.

Sims (1980a) raised three basic criticisms against traditional macroeconomic models. Firstly, economic theory was weak in selecting the variables to enter the reduced form model and exclusion restrictions were widely imposed on the models. Secondly, by default, many variables were taken to be exogenous with respect to the system and finally, outcomes of the models were typically amended by users with judgmental ex post decisions. These problems are not found in the VAR methodology. In addition, estimation of unrestricted VAR models is simple since single equation methods like OLS (ordinary least squares estimation) are consistent and under normality of errors, efficient (Canova, 1995).

VAR techniques have been used in a number of studies to determine the information in monetary aggregates. Using U.S. data, Sims (1972) found that money led income in a Granger causality test between two variables (money and output). In a later study, employing a VAR with additional variables (prices and interest rates), Sims (1980b) found that the statistical significance of the effect of money was lower on output when other variables were included. In their study, King and Plosser (1984) demonstrated that narrow money had a weaker effect on real activity. Contrary to the latter findings, Stock and Watson (1989) used a three and four-variable VAR (in differences as well as in levels) and found evidence that a narrow monetary aggregate (M1) was a statistically significant predictor of real output. Extending Stock and Watson's sample period and using a different interest rate measure, Friedman and Kuttner's (1993) in-sample causality tests showed that Stock and Watson's results were not robust to the changes.

Friedman (1996) remarked "[that] whether the central bank makes money growth a target or uses it as an information variable…the whole concept is senseless unless observed fluctuations in money do anticipate movements of prices, or output". Log-levels of U.S. data were used for output, the price level and a monetary aggregate in a three-variable VAR as well as a four-variable VAR that included the interest rate. Friedman (1996) imposed a recursive ordering (money was placed last) in order to generate variance decompositions to examine money growth's contribution in explaining subsequent output and price fluctuations. He found that the predictive role of monetary aggregates (M1 and M2) declined in the 1990s, becoming almost non-existent.

Similarly, Estrella and Mishkin (1996) identified three roles for monetary aggregates: as information variables, as indicators of policy actions and as instruments in a policy rule. Successively stronger and stable relationships between the monetary aggregates and final policy targets are required for these roles. The authors found little evidence for U.S. and Germany data, indicating monetary aggregates (monetary base and M2 in particular) could not be used in a straightforward way for monetary policy purposes.

For the U.K., Astley and Haldane (1997) found that none of the monetary aggregates in the 1990s offered sufficiently robust early-warning signals to justify only looking at money, as would be the case under a strict intermediate monetary-targeting regime. Tallman and Chandra (1996), for Australia, examined two (monetary aggregate and inflation or output), three (plus inflation), four (adding interest rate) and five (including exchange rate) variable VAR systems. The authors found that monetary aggregates contained no significant information for explaining subsequent fluctuations in output growth or inflation. A further study by Tallman and Chandra (1997) found no robust relationship between real output growth and inflation with any of the monetary aggregates examined. Instead, the authors found that monetary aggregates played a corroborative role.

A study by Hayo (1998) on 14 EU countries plus Canada, U.S. and Japan tested a number of hypotheses to determine money-output Granger causality. The results of the study indicated that general hypotheses based upon Granger causality tests were not robust with respect to different monetary variables, time periods or countries. The substantial findings were more or less connected with specific countries, like the reverse causality for Canada and the U.S., the existence of significant two-way causalities in Austria and Spain, and the statistically insignificant effects for Germany. For South Korea, Baek (1993) found that money supply shocks gave stronger and longer run effects to prices whereas real output growth was neutral to money growth. In South Africa, Nell (1999) showed that money was endogenous to consumer price inflation. An important point made in Hayo's (1998) paper is that specific claims, such as that of Davis and Tanner (1997), that money still causes economic activity when appropriately adjusting the time period, should be restricted to the U.S. economy.

In many of these studies, conclusions usually depend on model specification. Questions of econometric practice dominate this issue. Christiano and Ljungquist (1988) show that the results of Granger-causality tests depend on the use of (log-) level variables or growth rates. They argue in favour of using level variables since a simulation study found that the power of the tests on growth variables was low and that there was a danger of making a false inference. On the other hand, Stock and Watson

(1989) contend that by removing the trend from the monetary variable and including the residual in the Granger-causality framework, it was possible to restore the influence of money on output. However, a study by Hafer and Kutan (1997) rejected the trend removal suggested by Stock and Watson (1989). The authors claim that the instability of results in Granger-causality tests depended on whether the variables are trend- or difference stationary. Assuming the variables are trend stationary, money is typically found to Granger-cause output in the U.S. The reverse is true for variables that are differenced.

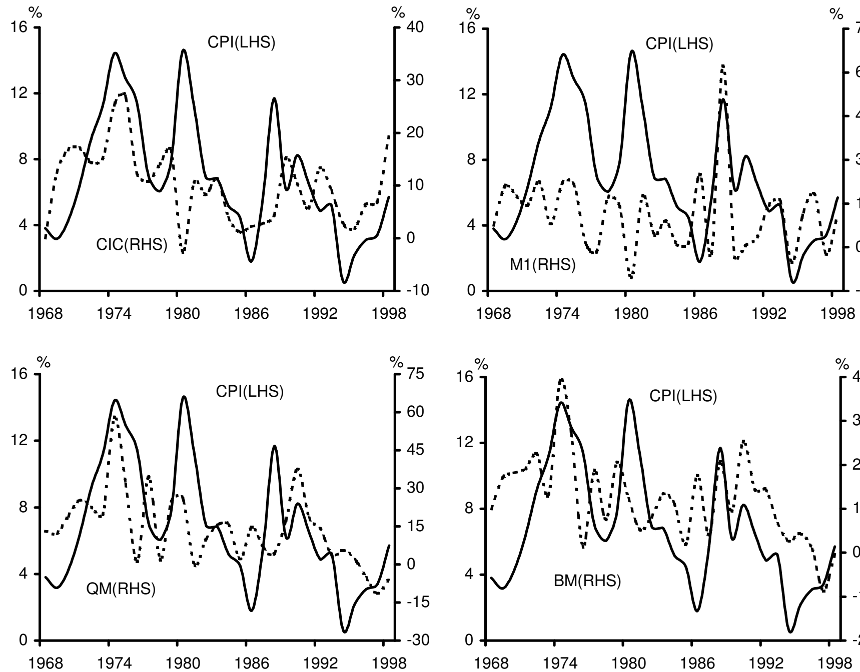
In Fiji, Joynson (1997) examined the money demand function in Fiji to determine if a stable relationship existed between money, income and interest rates. The author used an error-correction model to estimate the money demand relationship in Fiji. The Johansen cointegrating VAR technique was also used for consistency. The results of this study cast doubt on monetary aggregates as intermediate targets of monetary policy. In addition, consistent with many overseas studies, Joynson (1997) found that a change in income is quickly translated into a change in the demand for money. However, a rigorous investigation into the information in monetary aggregates has not been examined. This paper extends the empirical work to examine the leading or lagging relationship that monetary aggregates have with policy targets, and their ability to predict inflation and output.

2.2 Monetary Aggregates and Economic Activity Indicators: A Preliminary Analysis

A graphical representation of the data is examined to provide a reference point for interpreting the relationships among the data that the statistical methods may uncover in the later section. Figures 1 to 4 depict the annual percent changes of the monetary aggregates, output (real and nominal GDP) and inflation. Most of the aggregates appear to display a

FIGURE 1

Comparison of Changes in Monetary Aggregates and Changes in the CPI

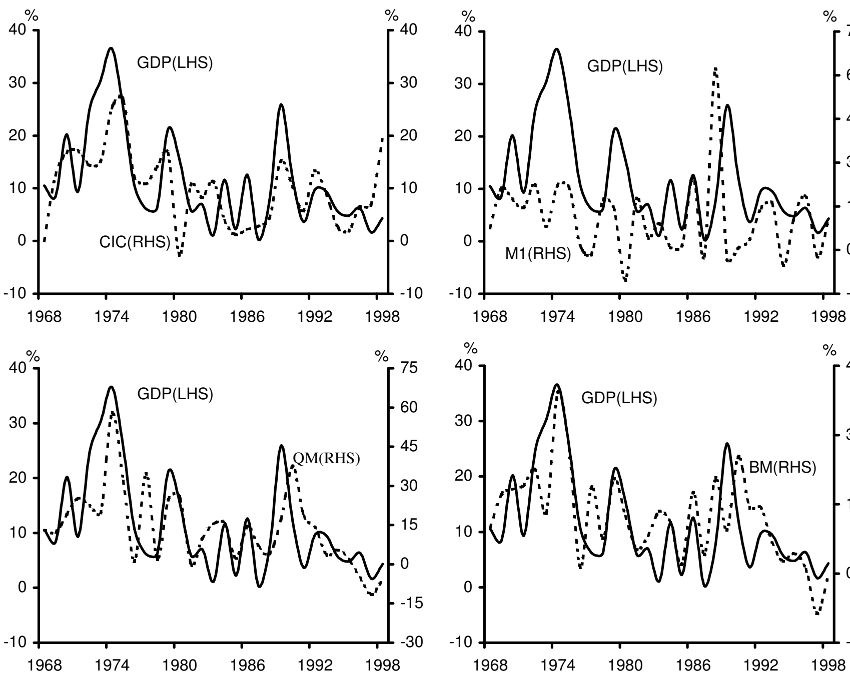


KEY: CIC - Currency in circulation, M1 - Narrow money, QM - Quasi money, BM - Broad money noticeable correlation with inflation. Currency in circulation, quasi money and broad money seem to lead inflation.

In relation to nominal GDP (Figure 2), there appears to be a high correlation with the monetary aggregates. M1, quasi money and broad money movements seem to indicate a leading role with nominal GDP. In Figure 3, M1 and broad money growth appear to track changes in real GDP.

FIGURE 2

Comparison of Changes in Monetary Aggregates and Changes in Nominal GDP

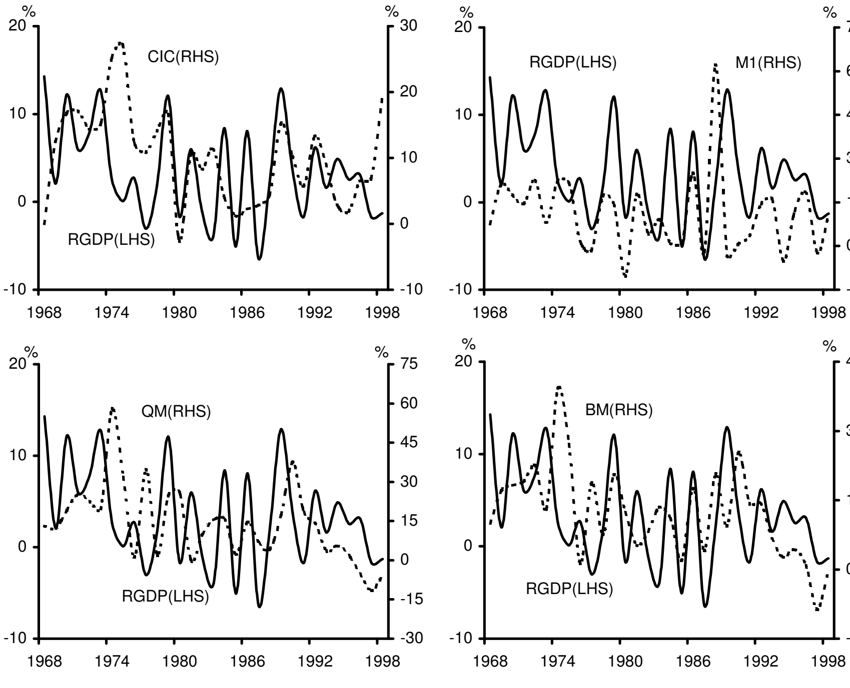


KEY: CIC - Currency in circulation, M1 - Narrow money, QM - Quasi money, BM - Broad money

The sharp spike of M1 in 1988, probably as a result of the 1987 coups, may influence the overall correlation between M1 and the economic activity variables, which may not be representative of the long-term relationship between the variables.

FIGURE 3

Comparison of Changes in Monetary Aggregates and Changes in Real GDP



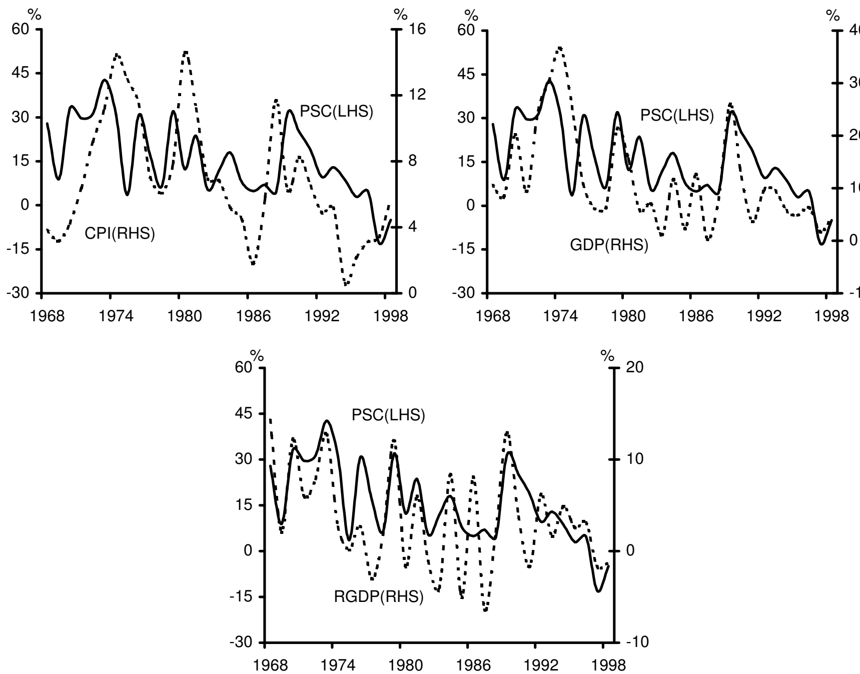
KEY: CIC - Currency in circulation, M1 - Narrow money, QM - Quasi money, BM - Broad money

The graphical relationship between private sector credit and inflation and output (Figure 4) indicates a high correlation with nominal and real GDP. Private sector credit's relationship with inflation growth is less conclusive.

The preliminary graphical interpretation of the variables suggests correlation between the monetary aggregates and inflation and output. Although the graphs indicate some evidence of a leading role for monetary aggregates, empirical methods are needed to substantiate the exact nature of the relationship between the monetary variables and inflation and output. This is covered in the following section.

FIGURE 4

Comparison of Changes in Private Sector Credit and Changes in Inflation and Output



3.0 Empirical Methods

3.1 Data

The variables used were annual data on five monetary and credit aggregates – currency in circulation, M1, quasi money, broad money and private sector credit. The economic activity variables were real and nominal GDP (output) and the CPI (price level).[3] The sample period was from 1966 to 1998.

As discussed in Section two, the problematic issue in time series analysis is whether the given time series is difference stationary or trend stationary. Data are usually detrended under the assumption that the series has a trend and a cyclical component. However, Nelson and Plosser (1982) suggested that many macroeconomic series actually have stochastic, rather than deterministic, trends. In other words, the series may contain a unit root. A testing procedure that distinguishes between deterministic time trends and unit roots in the data is needed.

The time series properties of the data were examined through the Dickey-Fuller (1979) and Phillips-Perron (1988) tests. The Dickey-Fuller test depends on a nuisance parameter so the Phillips-Perron test acts as a complementary test, as it is known to be robust to nuisance parameters. In addition, the Phillips-Perron test is not affected by weak dependence and heterogeneity of the sample data.

[3] See Appendix A for a detailed description.

All variables were tested in natural log form for the presence of unit roots. The results (Table 1) suggest a nonstationary I (1) time series for all the variables except prices. However, since the estimated root for prices is less than unity, the prices series is treated as I (1). Accordingly, each of the series was first differenced. The joint hypothesis of a unit root and no linear trend could not be rejected for each of the variables.

Table 1: *Unit Root Tests*

Variable	Dickey-Fuller Test		Phillips-Perron Test	
	I(1)	I(2)	I(1)	I(2)
Currency in circulation	-1.845	-3.202*	-0.974	-3.586*
M1	-1.510	-4.740**	-1.215	-7.685**
Quasi money	-2.503	-2.094	-2.483	-3.613*
Broad money	-2.786	-1.651	-2.435	-3.912**
Private sector credit	-3.408*	-1.358	-2.925	-3.713**
Prices	-1.822	-2.505	-1.105	-2.723
Nominal GDP	-2.475	-2.486	-2.099	-3.266*
Real GDP	-3.322*	-3.615*	-3.348*	-6.033**

An **(*) indicates rejection of hypothesis of a unit root at the one (five) percent level.

3.2 Correlation Analysis

This section helps to quantify the strength of the relationship between the pairs of variables and provides simple correlation coefficient tests to ascertain whether a particular monetary variable leads or lags an economic activity variable.

3.2.1 Monetary Aggregates and Inflation

Table 2 summarises the results of tests to determine a leading or lagging relationship of the monetary aggregate with inflation. The formula for the correlation coefficient is given in Appendix B, along with notation on how significance levels are calculated.

The first column shows correlation coefficients between current movements in the various monetary aggregates and current movements in inflation. The next column shows the correlation between the current movement in inflation and movements in the monetary aggregates a year ago, and so on.

Table 2: *Correlation Coefficients Between Changes in Monetary Aggregates and Inflation*

Indicator[1]	Lag in Years[2]			
	0	1	2	3
Currency in circulation	0.46**	0.49**	0.42**	0.23
M1	0.18	0.07	0.34	0.09
Quasi money	0.46**	0.49**	0.27	0.15
Broad money	0.49**	0.46**	0.37**	0.15
Private sector credit	0.40**	0.32*	0.21	0.06

1. The estimation period is from 1966-98. All monetary aggregates and inflation are in log-difference form.
2. An **(*) indicates significance at the five or higher (ten) percent level.

The first three correlation coefficients between currency in circulation and inflation are significant. Not only is the current year's currency in circulation correlated with inflation, but currency in circulation two years ago, is correlated with current inflation. Broad money and quasi money also have a significant relationship with inflation. The results suggest a clear leading relationship for these three aggregates. Private sector credit has a less significant coefficient while M1 has no coincident coefficients. No clear lagging role was found for any of the aggregates.

3.2.2 Monetary Aggregates and Nominal GDP

The same methods are used to determine whether monetary aggregates lead or lag nominal GDP. Table 3 presents the correlation coefficients between monetary aggregates and nominal GDP. There is evidence of private sector credit leading nominal GDP two years out. Broad money and currency in circulation also have a significant leading role a year out.

Table 3: *Correlation Coefficients Between Changes in Monetary Aggregates and Nominal GDP*

Indicator[1]	Lag in Years[2]			
	0	1	2	3
Currency in circulation	0.58**	0.42**	0.18	0.18
M1	0.21	-0.16	0.17	-0.12
Quasi money	0.66**	0.29	0.27	0.08
Broad money	0.66**	0.43**	0.27	0.13
Private sector credit	0.64**	0.41**	0.35*	0.26

1. The estimation period is from 1966-98. All monetary aggregates and inflation are in log-difference form.
2. An **(*) indicates significance at the five or higher (ten) percent level.

3.2.3 Monetary Aggregates and Real GDP

Evidence of the correlation coefficients in Table 4 suggests no substantive leading or lagging relationship between the monetary aggregates and real GDP. Private sector credit has a positive correlation with real GDP for current periods but no significant leading role. Broad money appears to have a significant two-year leading relationship with real GDP. It is possible, however, that this is due to a contemporaneous correlation between real GDP and broad money, and between broad money and lagged broad money.

Table 4: *Correlation Coefficients Between Changes in Monetary Aggregates and Real GDP*

Indicator[1]	Lag in Years[2]			
	0	1	2	3
Currency in circulation	-0.10	-0.03	-0.17	-0.28
M1	0.18	0.25	-0.06	0.09
Quasi money	0.19	-0.01	0.22	-0.25
Broad money	0.24	0.23	0.35**	-0.07
Private sector credit	0.60**	-0.04	0.16	0.05

1. The estimation period is from 1966-98. All monetary aggregates and inflation are in log-difference form.
2. An **(*) indicates significance at the five or higher (ten) percent level.

3.2.4 Discussion of Results

The results suggest that monetary aggregates (except M1) primarily have a leading relationship with inflation and nominal GDP. The correlation coefficients between real GDP and the monetary aggregates are less conclusive. Interestingly, the coefficients between M1 show no significant leading or lagging relationship with inflation or nominal GDP.

Nevertheless, these simple correlation coefficients are not enough to measure the relationship between monetary aggregates and the indicators of economic activity. Correlation does not always imply causation. A more rigorous statistical technique is needed and this is addressed in the next section.

3.3 VAR Methodology

Vector autoregressive methodology is used to identify leading or lagging relationships among the data. The models are specified in first difference form due to test statistics that suggest nonstationarity of the data in log-level form. Each VAR is estimated with two lags of each variable in the system. The number of lags was determined by estimating models with three or more lags, then using likelihood ratio tests to compare these with models with two lags. The difference between the log determinants was small enough to conclude that there are no more than two lags of each variable. The structure of the VAR is outlined below:

$$x_t = A(L)x_{t-1} + \varepsilon_t$$

where x_t is a vector of endogenous variables

ε_t is a vector of error terms

A is a series of square matrices representing correlations among endogenous variables

L is a lag operator

Granger causality tests are carried out on the full sample to determine causation between the variables.[4]

[4] C.W.J. Granger (see Granger (1969)) suggested a technique to determine whether X causes Y. See Appendix C for further discussion.

3.3.1 Monetary Aggregates and Inflation

On examination of Table 5, the hypothesis that the coefficients of M1 and currency in circulation are zero is rejected at the five and ten percent significance level, respectively. From the evidence, M1 and currency in circulation have a leading role in relation to inflation. None of the other aggregates portrayed significant results. These results are in contrast to the analysis of the correlation coefficients determined in the previous section where M1 showed no significant relationship with

Table 5: *VAR Tests of Monetary Indicators and Inflation*[1]

Null Hypothesis	F-statistic (ρ -value)
H_1: Inflation $\not\Rightarrow$ Currency in circulation	2.09 (0.14)
H_2: Currency in circulation $\not\Rightarrow$ Inflation	3.04 (0.07)*
H_1: Inflation $\not\Rightarrow$ M1	2.33 (0.12)
H_2: M1 $\not\Rightarrow$ Inflation	3.67 (0.04) **
H_1: Inflation $\not\Rightarrow$ Quasi money	0.87 (0.43)
H_2: Quasi money $\not\Rightarrow$ Inflation	1.62 (0.22)
H_1: Inflation $\not\Rightarrow$ Broad money	0.05 (0.95)
H_2: Broad money $\not\Rightarrow$ Inflation	1.19 (0.32)
H_1: Inflation $\not\Rightarrow$ Private sector credit	0.57 (0.57)
H_2: Private sector credit $\not\Rightarrow$ Inflation	1.10 (0.35)

1. Calculated values for f-tests of the hypothesis that the coefficients on lags of explanatory variables are jointly zero. An **(*) denotes significance at the 5 (10) percent level.

inflation. The results for the correlation analysis and VAR methodology are only consistent in relation to currency in circulation.

3.3.2 Monetary Aggregates and GDP

This section presents some results for the relationship between GDP, as a measure of activity and the various monetary aggregates. Both the relationship between the monetary aggregates and nominal and real GDP are tested.

Table 6: V*AR Tests of Monetary Indicators and Nominal GDP*[1]

Null Hypothesis	F-statistic (ρ -value)
H_1: Nominal GDP $\nRightarrow$ Currency in circulation	1.23 (0.31)
H_2: Currency in circulation $\nRightarrow$ Nominal GDP	1.23 (0.31)
H_1: Nominal GDP $\nRightarrow$ M1	0.63 (0.54)
H_2: M1 $\nRightarrow$ Nominal GDP	3.13 (0.06) *
H_1: Nominal GDP $\nRightarrow$ Quasi money	2.98 (0.07)*
H_2: Quasi money $\nRightarrow$ Nominal GDP	0.74 (0.49)
H_1: Nominal GDP $\nRightarrow$ Broad money	0.46 (0.63)
H_2: Broad money $\nRightarrow$ Nominal GDP	0.98 (0.39)
H_1: Nominal GDP $\nRightarrow$ Private sector credit	0.50 (0.61)
H_2: Private sector credit $\nRightarrow$ Nominal GDP	2.10 (0.14)

1. Calculated values for f-tests of the hypothesis that the coefficients on lags of explanatory variables are jointly zero. An **(*) denotes significance at the 5 (10) percent level.

The results in Table 6 and 7 suggest the following:

- M1 leads nominal GDP;
- Nominal and real GDP lead quasi money;
- Real GDP leads broad money and M1.

Although M1 shows a significant leading relationship with real GDP, real GDP has a stronger leading relationship, comparatively. These results are similar to that of Joynson (1997). Again, these results are not consistent with those in the previous section.

Table 7: V*AR Tests of Monetary Indicators and Real GDP*[1]

Null Hypothesis	F-statistic (ρ -value)
H_1: Real GDP $\not\Rightarrow$ Currency in circulation	1.03 (0.37)
H_2: Currency in circulation $\not\Rightarrow$ Real GDP	0.42 (0.66)
H_1: Real GDP $\not\Rightarrow$ M1	3.96 (0.03)**
H_2: M1 $\not\Rightarrow$ Real GDP	3.01 (0.07) *
H_1: Real GDP $\not\Rightarrow$ Quasi money	2.99 (0.07)*
H_2: Quasi money $\not\Rightarrow$ Real GDP	1.08 (0.35)
H_1: Real GDP $\not\Rightarrow$ Broad money	2.47 (0.10)*
H_2: Broad money $\not\Rightarrow$ Real GDP	0.88 (0.43)
H_1: Real GDP $\not\Rightarrow$ Private sector credit	0.83 (0.45)
H_2: Private sector credit $\not\Rightarrow$ Real GDP	0.29 (0.75)

1. Calculated values for f-tests of the hypothesis that the coefficients on lags of explanatory variables are jointly zero. An **(*) denotes significance at the 5 (10) percent level.

3.3.3 Discussion of Results

Based on these results, there is support for the notion that measures of economic activity lead the monetary aggregates although this is confined to certain aggregates. M1 was the only monetary aggregate showing significant leading relationships with inflation and nominal GDP and a lagging relationship with real GDP. Inconsistency between these results and results of the simple correlation coefficients may be due to contemporaneous correlation between the variables.

Generally, no consistent leading or lagging roles for either economic activity variables or the monetary aggregates could be found using this methodology. The next section will continue VAR methodology to examine the information provided by the monetary aggregates as predictors of output and inflation.

3.4 In-sample Tests

The forecasting content of the monetary aggregates is assessed by examining their predictive power for subsequent observations of output growth and inflation on an in-sample basis. The models are specified in first difference form due to test statistics that suggest nonstationarity of the data in log-level form. Each VAR is estimated with two lags of each variable in the system. The structure of the VAR is the same as the one used in the previous section.

The methodology involves examining f-tests, block exogeneity tests[5] and variance decompositions for each of the systems. The f-tests measure whether the monetary aggregates are significant for predicting output and inflation. F-tests are examined for the two and three-variable systems containing the respective monetary aggregates. The basic two-variable system contains the monetary aggregate and inflation or the output (nominal and real). The three-variable system contains the monetary aggregate, output (real or nominal) and inflation.

For bivariate VARs, the f-test is equivalent to a Granger causality test, similar to the one carried out in the previous section. In the three-variable system, the f-tests are insufficient for determining Granger causality since it tests only the direct effect of the monetary aggregate in single equations of inflation and output. Therefore, for the three-variable system we test whether the system is block exogenous to the movements in monetary aggregates. This test is useful to determine whether the relevant monetary aggregate is important to the whole system.

Variance decomposition is used to complement the block exogeneity and f-tests by examining a system's quantitative importance in predicting output and inflation. It usually involves orthogonalisation of errors due to correlation of errors. This means that there is a common component that cannot be identified with any specific variable. To tackle this problem the errors are orthogonalised by a Cholesky decomposition. This is an arbitrary method where all of the effect of any common component is attributed to the variable that comes first in the VAR system.

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[5] Refer to Appendix C for discussion.

Therefore, the results of the variance decomposition are dependent on the ordering of equations. Thus, two specifications are observed where the initial ordering places the monetary aggregate first and the second specification places the monetary aggregate last.

3.4.1 In-sample Results

From the data sample, the shortest sample period is taken (1966 to 1976), and the f-test is calculated. The procedure then adds one more observation and generates the f-tests and ρ-value, repeating this process until the end of the sample (1998).

The results are shown in Figures 5, 6 and 7. The graphs summarise the results from the tests of the joint significance of two lags of the relevant monetary aggregate in the output (real and nominal) and inflation equations.

The f-tests are done for the two and three-variable systems. For each aggregate, there are two lines that reflect the ρ-values from the f-test of the exclusion restriction in the separate systems. When the line crosses at the 5 (grey line) and 10 (black line) percent level, it implies a rejection of the restriction at these significance levels.

The f-test results for the inflation equations indicate that quasi money, broad money and private sector credit are not significant for predicting inflation. In contrast, M1 and currency in circulation appears significant in the two-variable system since the late eighties.

FIGURE 5

F-tests of Aggregates in Predicting Inflation

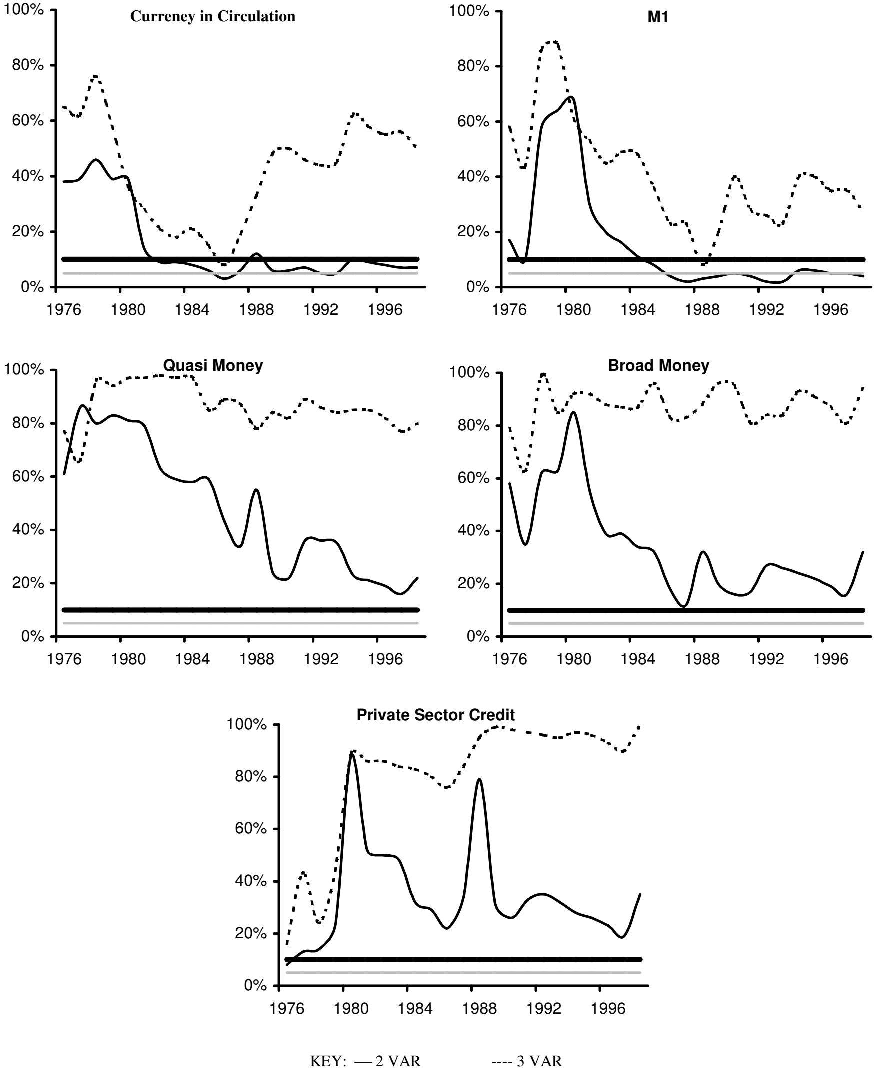
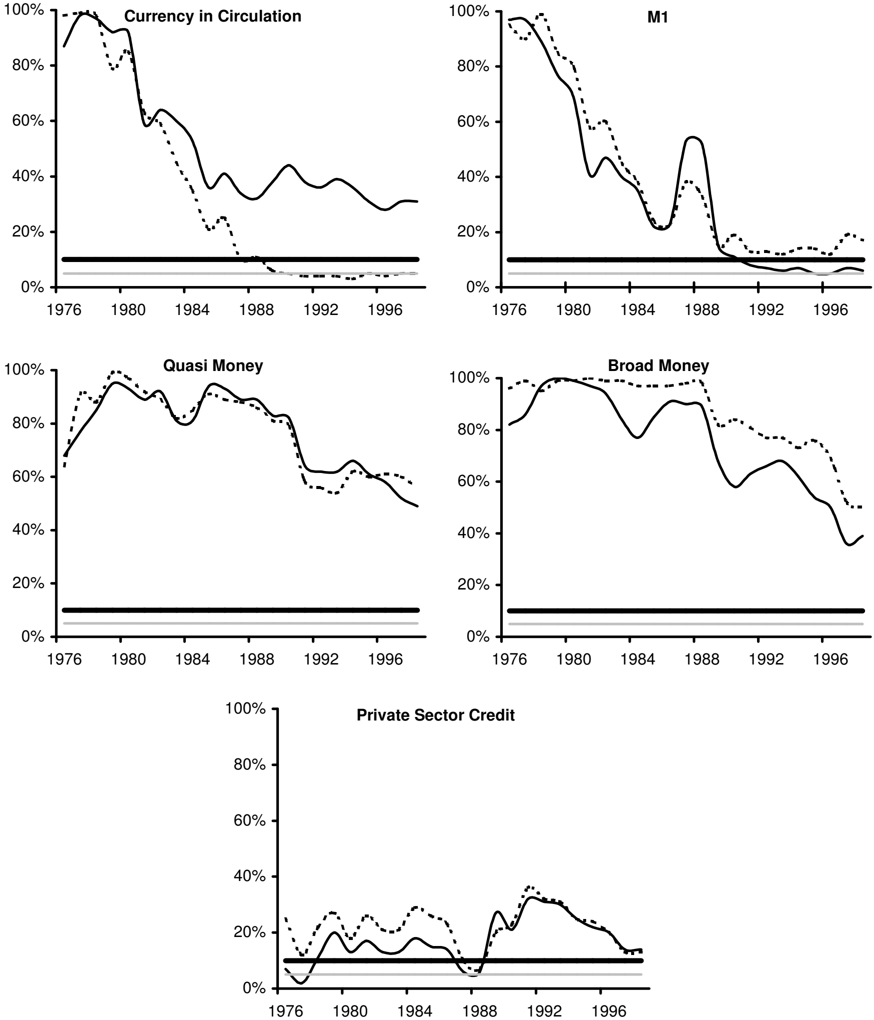


FIGURE 6

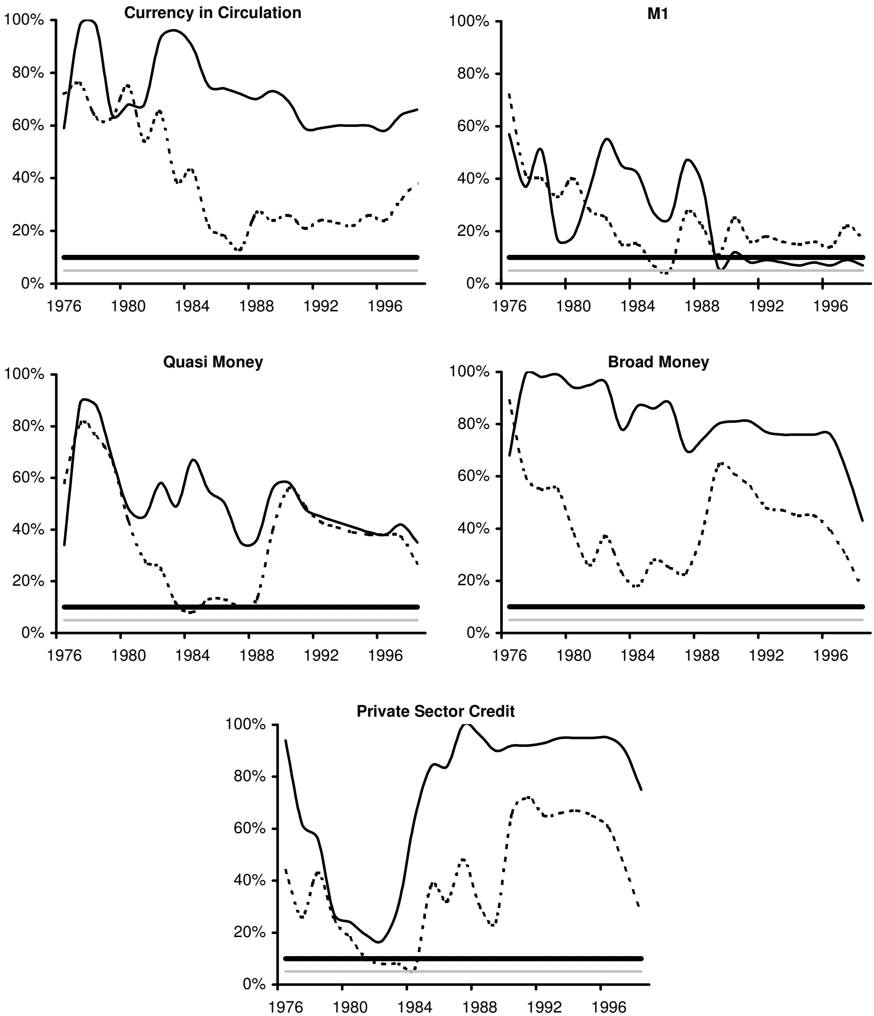
F-tests of Aggregates in Predicting Nominal GDP



KEY: — 2 VAR ---- 3 VAR

FIGURE 7

F-tests of Aggregates in Predicting Real GDP



KEY: — 2 VAR ---- 3 VAR

F-tests of quasi money, broad money and private sector credit in predicting nominal GDP are insignificant. On the other hand, currency in circulation appear significant for the three-variable system while M1 is significant for the two-variable system in the later part of the sample.

For the real GDP equations, the f-tests indicate M1 was significant from the late eighties. Generally, the other aggregates appear to be insignificant in predicting real GDP.

Similar methods are used for the block exogeneity tests and the ρ-value charts are presented in Appendix D. Two three-variable systems are tested; one with inflation, the monetary aggregate and nominal GDP and for the other, real GDP is added instead of nominal GDP.

The results suggest that quasi money, broad money and private sector credit are not statistically significant for the three-variable system (with nominal GDP). M1 and currency in circulation appear to be significant to this system but only for a brief period. There appears to be no consistently significant aggregate for the system that includes nominal GDP. The results for the alternative system with real GDP suggest similar results. The difference lies in the longer period of significance of M1 and currency in circulation to the systems.

Nevertheless, these block exogeneity tests are not conclusive evidence that monetary aggregates are unimportant for output and inflation since it overlooks the possibility of important contemporaneous correlations among the data. An important tool of VAR methodology, variance decomposition, is used to explore this issue further.

The results for the two specifications are shown in Tables 8 and 9. Table 8 shows results from the three-variable system – the monetary aggregate, inflation and nominal GDP. Real GDP instead of nominal GDP is included in the system examined in Table 9. The tables reveal that there is no aggregate that explains an important proportion of the forecast variance of either output (real and nominal) or inflation in both the specifications. For example, in Table 9, over the 2-year horizon, broad money explains about 81 percent of fluctuations of inflation using the first ordering. However, in the other specification where broad money is placed last, the explanatory power of broad money innovation substantially diminishes. It can be seen from the tables that whenever the results are significant, there is a lack of robustness.

3.4.2 Discussion of Results

In support of the findings in Section 3.3, the in-sample results imply that the information content in monetary aggregates is negligible. There are isolated instances where certain monetary aggregates contain information for the prediction of inflation and output. However, there is no single monetary aggregate that holds significant explanatory power for the prediction of inflation and output.

Table 8: *Variance Decomposition Results*

Aggregate in System	Variance of :	Forecast Horizon	Percent of Forecast Innovations Explained by Innovations in the Monetary Aggregate[1]	
			Ordering M, CPI, GDP[2]	Ordering CPI, GDP, M[2]
Currency in circulation	Inflation	2	8.40	4.10
		3	21.92	13.64
	Nominal GDP	2	31.25	19.41
		3	35.15	22.45
M1	Inflation	2	13.97	0.27
		3	30.30	5.66
	Nominal GDP	2	39.88	8.28
		3	40.29	8.11
Quasi money	Inflation	2	14.58	0.27
		3	15.80	0.59
	Nominal GDP	2	33.49	0.07
		3	39.68	3.40
Broad money	Inflation	2	16.08	0.02
		3	25.44	1.08
	Nominal GDP	2	41.27	2.25
		3	47.37	6.70
Private sector credit	Inflation	2	5.12	0.01
		3	10.38	0.80
	Nominal GDP	2	26.83	4.34
		3	41.65	19.33

1. Each variance decomposition represent the percent of forecast variance explained by the innovation associated with the monetary variable.
2. M = monetary aggregate

Table 9: *Variance Decomposition Results*

Aggregate in system	Variance of :	Forecast Horizon	Percent of Forecast Innovations Explained by Innovations in the Monetary Aggregate[1]	
			Ordering M, CPI, RGDP[2]	Ordering CPI, RGDP, M[2]
Currency in circulation	Inflation	2	9.08	7.77
		3	22.22	19.36
	Real GDP	2	9.62	7.94
		3	9.57	7.70
M1	Inflation	2	16.28	0.09
		3	31.82	7.45
	Real GDP	2	15.30	0.05
		3	15.05	0.05
Quasi money	Inflation	2	17.10	2.80
		3	18.84	2.56
	Real GDP	2	16.30	0.03
		3	24.65	9.90
Broad money	Inflation	2	80.91	1.09
		3	80.71	5.35
	Real GDP	2	67.89	3.71
		3	66.88	11.18
Private sector credit	Inflation	2	5.71	0.00
		3	13.19	1.21
	Real GDP	2	47.32	3.47
		3	47.41	7.48

1. Each variance decomposition represent the percent of forecast variance explained by the innovation associated with the monetary variable.
2. M = monetary aggregate

4.0 Conclusions

Although the simple correlation coefficients revealed that monetary aggregates have a leading relationship with inflation and nominal GDP, the results are not robust when applying a more rigorous statistical technique, vector autoregression. Contrary to the correlation coefficient results, Granger causality tests using the VAR methodology reveal that M1 has a more significant leading relationship with inflation and nominal GDP, while real GDP was shown as leading M1. The other aggregates provided less conclusive results. This inconsistency may be because the VAR Granger causality tests were harder to pass and as a result of contemporaneous correlation.

The forecasting content of the monetary aggregates was also tested by examining their forecasting power for subsequent observations of output growth and inflation on an in-sample basis. The methodology involved applying rigorous tests on the monetary aggregates forecasting ability. There are isolated instances where certain monetary aggregates contained information for the prediction of inflation and output. However, variance decomposition results provided evidence that no robust relationship was found between the monetary aggregates and the economic activity variables.[6]

[6] There are some difficulties in drawing strong conclusions from VAR models in this study as the results are model-dependent and the techniques rely on the inclusion of all relevant variables in the model. This paper only focuses on the two- and three- variable systems. In addition, the paper fails to confirm the forecasting power of the monetary aggregates by performing out-of-sample forecasting tests. Further research is necessary to explore these issues.

Overall, the results imply a lack of robustness in the relationship between monetary aggregates and output and inflation.

Appendix A Data Sources and Construction

Series	Construction and Sources
Currency in circulation	Holdings of notes and coins with non-bank public. IMF *International Financial Statistics Yearbook* (1998).
M1	The sum of currency in circulation plus demand deposits held with commercial banks by the rest of the domestic economy other than the central government. IMF *International Financial Statistics Yearbook* (1998).
Quasi money	Liabilities of the monetary system (i.e. the central bank and the commercial banks); time deposits with central bank plus savings and time deposits with commercial banks. IMF *International Financial Statistics Yearbook* (1998).
Broad money	M1 plus quasi money. IMF *International Financial Statistics Yearbook* (1998).
Private sector credit	Lending by commercial banks to domestic sector excluding credit to government and official entities. IMF *International Financial Statistics Yearbook* (1998).
Consumer prices	Consumer price index (Base 1990=100) IMF *International Financial Statistics Yearbook* (1998). Bureau of Statistics, *Current Economic Statistics*, various issues. Reserve Bank of Fiji, *Quarterly Review* (1999).

Series	Construction and Sources
Nominal GDP	Gross domestic product at current prices. IMF *International Financial Statistics Yearbook* (1998). Bureau of Statistics, *Current Economic Statistics*, various issues. Reserve Bank of Fiji, *Quarterly Review* (1999).
Real GDP	Gross domestic product at constant factor cost. IMF *International Financial Statistics Yearbook* (1998). Bureau of Statistics, *Current Economic Statistics*, various issues. Reserve Bank of Fiji, *Quarterly Review* (1999).

Appendix B Correlation Coefficients[7]

The correlation between two variables, x and y, is calculated as:

$$\rho_{xy} = \frac{\Sigma(x-\bar{x})(y-\bar{y})}{\sqrt{\{\Sigma(x-\bar{x})^2(\Sigma(y-\bar{y})^2\}}}$$

where $\bar{x}$ and $\bar{y}$ are the sample means of x and y.

The significance probability of the sample correlation coefficient is calculated by treating

$$\sqrt{(n-2)}\frac{\rho}{\sqrt{(1-\rho^2)}}$$

as coming from a t-distribution with n-2 degrees of freedom, where n is the sample size.

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[7] The source of the following is cited in Bullock, Morris & Stevens (1989).

Appendix C Granger Causality and Block Exogeneity Tests[8]

1. Granger Causality

If { x_t } does not improve the forecasting performance of { y_t }, then { x_t } does not Granger-cause { y_t }. The practical way to determine Granger causality is to consider whether the lags of one variable enter into the equation for another variable. In terms of a two-variable VAR

$$x_t = a_{10} + a_{11}x_{t-1} + a_{12}y_{t-1} + \varepsilon_{1t}$$
$$y_t = a_{20} + a_{21}x_{t-1} + a_{22}y_{t-1} + \varepsilon_{2t}$$

{ x_t } does not Granger-cause { y_t } if $a_{21} = 0$. More generally, let y_t be given by:

$$y_t = a_{20} + a_{21}(1)x_{t-1} + a_{21}(2)x_{t-2} + a_{21}(3)x_{t-3} + ... + a_{22}(1)y_{t-1} + a_{22}(2)y_{t-2} ... + \varepsilon_{yt}$$

To determine if { x_t } Granger-causes { y_t }, a standard f-test is used to test the restriction:

$$a_{21}(1) = a_{21}(2) = a_{21}(3) = ... = 0$$

[8] The source of the following is from Enders (1996).

2. Block Exogeneity Test

Granger causality is different from a test for exogeneity. A necessary condition for the exogeneity of y_t is that current and past values of x_t do not affect y_t. Therefore, y_t may not be exogenous to x_t even though x_t does not Granger-cause y_t. If $\phi_{21}(0)$ is not zero, pure shocks to y_t (i.e., ε_{yt}) affect the value of y_t even though the { x_t } sequence does not Granger-cause the { y_t } sequence.

The block exogeneity test is useful for detecting whether to incorporate a variable into a VAR. This multivariate generalisation of the Granger causality test should actually be called a "block causality" test. The issue is to determine whether lags of one variable, w_t, Granger-causes any other of the variables in the system. In the three-variable case with w_t, x_t and y_t, the test is whether lags of w_t Granger-cause either x_t or y_t. Essentially, the block exogeneity restricts all lags of w_t in the x_t and y_t equations to be equal to zero. This cross-equation restriction is properly tested using the likelihood ratio test given by

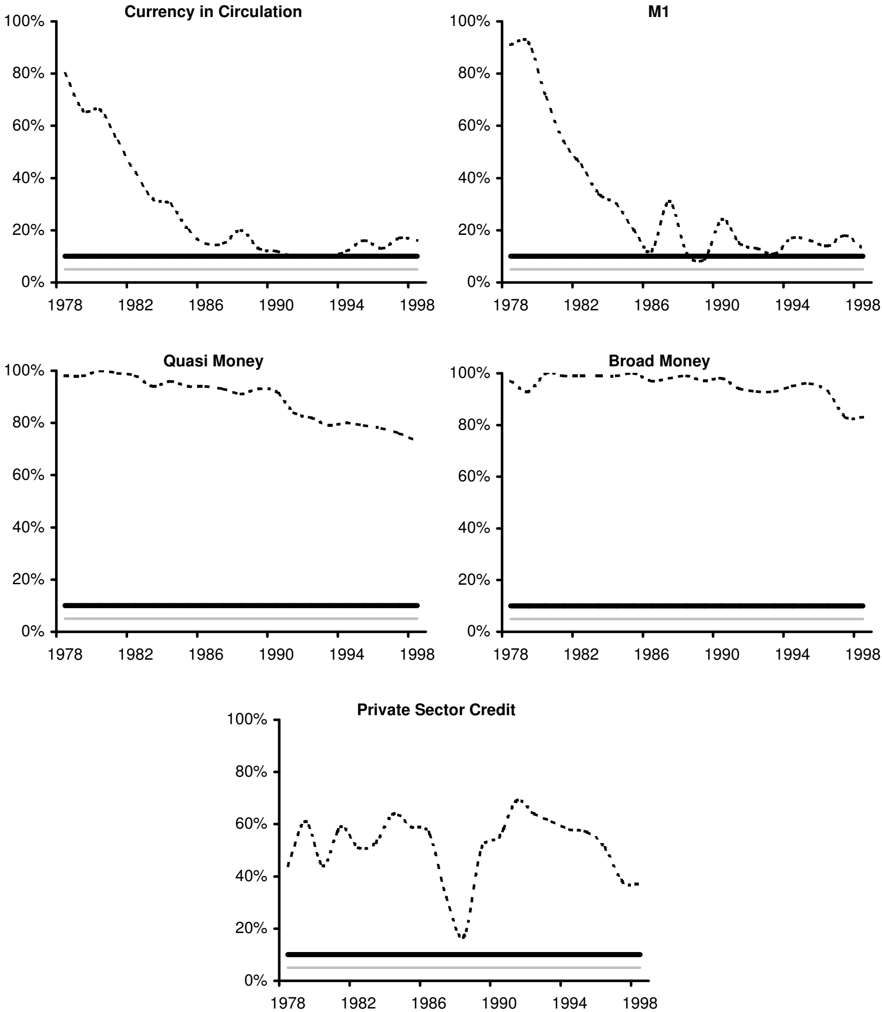
$$(T-c)(\log\left|\sum_r\right| - \log\left|\sum_u\right|)$$

where $\sum_u$ and $\sum_r$ are the variance/covariance matrices of the unrestricted and restricted systems, respectively.

The x_t and y_t equations using lagged values of { x_t }, { y_t }, and { w_t } are estimated and $\sum_u$ is calculated. The equations are then re-estimated excluding the lagged values of { w_t } and $\sum_r$ is calculated. The likelihood ratio statistic mentioned above is then formed. This statistic has a chi-square distribution with degrees of freedom equal to $2p$ (since p lagged values of { w_t } are excluded from each equation). Here $c = 3p + 1$ since the unrestricted x_t and y_t equations contain p lags of { x_t }, { y_t }, and { w_t } plus a constant.

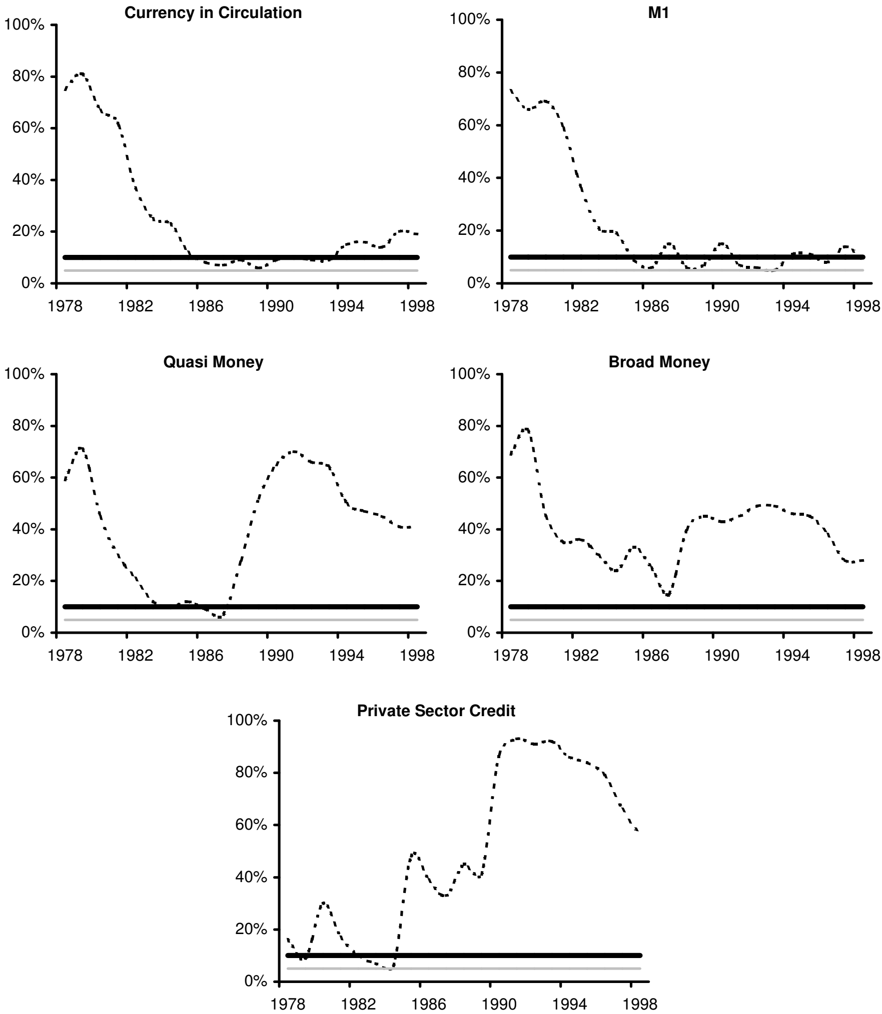
Appendix D Block Exogeneity Test Results

Block Exogeneity Tests for the Aggregates (with Nominal GDP)



KEY: ---- 3 VAR

Block Exogeneity Tests for the Aggregates (with Real GDP)



KEY: ---- 3 VAR

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