Estimating the Monetary Policy Reaction Function for Sierra Leone: An Econometric Approach

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Abstract
The objective of the paper is to empirically analyse a Taylor-type monetary policy reaction function for Sierra Leone using the vector autoregressive (VAR). The VAR system included four macroeconomic endogenous variables namely output measured by real GDP, inflation, exchange rate and monetary base. The monetary base instead of the interest rate is employed as the monetary policy instrument given the unique transmission mechanism of monetary policy while the exchange rate is also included. The investigative procedure in this consists of four main steps. First, instead of arbitrarily choosing the lag lengths, the final prediction error (FPE) criterion is employed to select the optimum lag for each variable in the system; Second, to determine whether the monetary base would respond to a shock to one of the endogenous variables, impulse response functions are estimated; Third, the variance decomposition of monetary base is estimated to determine the drivers of variations in the monetary base; and finally, to test the robustness of the findings, the Cholesky ordering is changed. The paper finds that the monetary base responds negatively to a shock to the output gap as well as exchange rate, and positively to the lagged money base, consistent with the theoretical predictions. These findings suggest that the Bank of Sierra Leone would tighten monetary policy (reduce monetary base) if the output gap widens and/or when the Leone depreciates. In addition, the empirical results show that we can rank the relative influence on the monetary base as follows: the lagged money base, output gap, exchange rate and inflation gap. Critically, the finding that the output gap is more influential in explaining the variance in reserve money than the exchange rate and the inflation gap suggests that BSL stresses output stabilization (pursuing full employment) more than exchange rate or price stability in the conduct of monetary policy.

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Key Words: Impulse Response Function, Monetary Policy, Reaction Function, Taylor-Rule, Variance Decomposition, Vector auto-regression

INTRODUCTION

In his seminal work, Taylor (1993) formulated a policy rule by which the Federal Reserve adjusts the monetary policy rate in response to lagged inflation and the real GDP gap, and showed that this rule accurately describes the performance of monetary policy from 1987 – 1992. Since then, a number of studies have been undertaken using this policy rule (known as the Taylor Rule) to examine the behaviour of central banks particularly in developed economies (see Clarida et al. (1998) (2000), Chadha et al. (2004), Fendel and Frenkel (2006), etc). Economist and policymakers have thus been confronted with a challenge of designing policy rules that central banks could follow. Such a policy rule would indicate how the monetary authorities would react to developments in the

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domestic economy. Some economists believe that inflation targeting is the ideal rule setting behaviour for responding to domestic shocks. Others believe that inflation targeting is incorporated in the Taylor rule whereby monetary instruments are adjusted in response to output and inflation shocks. The framework which describes how the central bank adjusts its policy instruments in response to economic developments (for example, shocks in inflation and output) is known as the monetary policy reaction function. The Taylor rule is a special monetary policy reaction function that characterizes the response of interest rate to inflation and real output gap (Ullrich, 2003).

The Banking Act of 1970 which was later amended in 2000 specifies maintaining low inflation as the primary objective of the Bank of Sierra Leone (BSL) while exchange rate stability, balance of payments equilibrium, desired foreign exchange reserve and economic growth are secondary objectives. Although these objectives have not changed since enactment of the Banking Acts, the conduct of monetary policy in Sierra Leone has undergone significant changes reflecting the liberalisation of the financial sector in the 1990s, from system of “direct control” to a system “indirect control”. Unfortunately, the analysis of the conduct of monetary policy in Sierra Leone has received little attention despite the growing body of literature. This paper therefore attempts to estimate a monetary policy reaction function for Sierra Leone, a typical small developing economy. A Taylor-type reaction function is estimated for the Bank of Sierra Leone (BSL). While this type of analysis has flourished lately for advanced economies (e.g Taylor, 1999; Hsing and Lee, 2004), relatively little work has been undertaken for developing economies.

Specifically, the paper aims to identify how monetary policy responds to hypothetical policy information variables particularly in terms of a shock in the output gap, inflation gap and the exchange rate. First, the monetary base instead of the interest rate is employed as the monetary policy instrument$, given the unique transmission mechanism of monetary policy in developing economies (see Montiel, 1991). In Sierra Leone, financial regulation via interest rate ceilings as well as BSL directives to banks to lend to priority sectors of the economy characterized much of the period under study until the liberalisation in mid-1990s. Second, a VAR model is employed in order to account for possible simultaneous relationships among the variables and to avoid the simultaneity bias problem. The impulse response function and variance decomposition of the monetary base are estimated to determine whether the monetary base would respond to a shock to one of the endogenous variables and the explanatory power of each of the endogenous variables on the variance of the monetary base. The exercise is undertaken using annual data from 1970 – 2010.

$\text{Sector 4.1 provides the justification for using the money base instead of the interest rate as a policy instrument.}$
An estimation of a monetary policy reaction function for Sierra Leone is relevant for evaluating the performance of monetary policy and the relationship between monetary policy and macroeconomic variables. In addition, since the BSL does not explicitly follow formal rules, the study will help to determine the extent to which monetary authorities have reacted in a rule-like fashion. Furthermore, given the dearth in this type analysis for developing countries, the study hopes to provide meaningful insights on the evidence from developing countries. In particular, the study is different from the majority of other works in that the monetary base instead of interest rate is used as the monetary policy instrument to account for the unique transmission mechanism in a developing country like Sierra Leone (see Montiel, 1991).

The rest of the paper consists of five sections; Section 2 provides an overview of monetary policy in Sierra Leone including the economy, Section 3 describes the theoretical and empirical literature, Section 4 outlines the methodology where the monetary base reaction function for Sierra Leone, econometric approach as well as the data type and sources are discussed. Section 5 analyses the empirical results. Section 6 summarizes the main findings and draws some policy implications.

**MONETARY POLICY IN SIERRA LEONE**

**BACKGROUND TO THE SIERRA LEONEAN ECONOMY**

The economic situation in Sierra Leone witnessed many dramatic changes during the period under study (1970-2010), from a period of relative stability in 1970s to severe stagnation and recession in the 1980s and 1990s. Average growth in real GDP between 1980 and 1990 was 0.6 percent and -3.3 percent between 1990 and 1996 (Worldbank, 1998). Also, inflation accelerated reaching its peak of 178.0 percent in 1987. The eruption of the civil war in 1990 was responsible for the malignant macroeconomic conditions in the 1990s. However, with the end of the civil war in 2001, the macroeconomic situation radically improved on the backdrop of macroeconomic and structural reforms initiated by the Government. The economy sustained a robust real growth (6.6 percent) during 2001–2006. Inflation declined significantly and remained low in 2001 and 2002, albeit increasing to 7.6 percent and 14.2 percent in 2003 and 2004, respectively (see IMF, 2006).

The onset of the global financial crisis in 2008 through 2009 hampered the pace of economic recovery with real GDP growth declining to 4.8 and 4.0 percent in 2008 and 2009 respectively. Inflationary pressures eased as inflation declined in 2008 and 2009, 13.2 and 12.2 percent respectively. The exchange rate (Le/$) also depreciated rapidly in 2008 and 2009, about 22 percent on average. Although there was a rebound in real growth in 2010 with an estimated real GDP growth of 5.0 percent, inflationary pressures increased with inflation increasing to 17.8 percent in 2010. Increase in the international prices of petrol and foodstuffs as well as the introduction of a goods and services tax in
2010 accounted for souring of inflationary pressures. The exchange rate though relatively stable in 2010 depreciated by 7.7 percent. Figure 1 depicts the recent trends in real growth, inflation and exchange rate.

**Figure 1: Recent Development in Real Growth, Inflation and Exchange Rate (%)**

Another important development was the deregulation of the financial system and liberalisation of the exchange rate regime under the International Monetary Fund (IMF)'s Economic Stabilisation Programme and WorldBank Structural Adjustment Programme (SAP) in the 1990s. As a result, the financial sector, especially the banking system experienced substantial growth in services and products. However, despite the transition to flexible exchange rate regime where the exchange rate is determined by market forces, the monetary authorities intervene from time to time in order to prevent excessive depreciation of the Leone. Foreign exchange auctions are normally held on weekly basis by the Central Bank to that effect.

On the fiscal side, overall expenditures were consistent with price stability, while overall external balance remained top priority reflecting the history of persistent deficits and the economic difficulties in the 1980s and 1990s. In order words, the current fiscal policy framework seeks to enhance revenue collection, improve expenditure management and control systems, and phase out Central Bank financing of the budget deficit. With the maintenance of strict fiscal discipline, the country consequently benefited from debt relief through the Highly Indebted Poor Countries Initiative (HIPC). This created an environment where financial market activities thrived, while the BSL increased the size
of the foreign exchange auction following a deepening of the foreign exchange market. Also, the investment climate became increasingly attractive while the efficacy of money market operations of the BSL improved with the rationalisation of fiscal policy.

**CONDUCT OF MONETARY POLICY IN SIERRA LEONE**

Prior to 1990, monetary policy in Sierra Leone was conducted under a system of direct controls with not only ceilings imposed on interest rates but several other restrictions on financial market activities. Typically, the system of direct monetary management required commercial banks to maintain an explicit credit ceiling in order to make sure that an explicit money supply target was achieved. However, with the deregulation of the financial system following the SAP to address the country’s economic challenges, the BSL shifted away from the system of direct monetary controls, discovered to be financially repressive, to a system of indirect monetary management.

The indirect monetary management framework allows the BSL to have three basic targets of monetary policy; the final target, intermediate target and the operating target. The targets of monetary policy are based on the ‘quantity theory of money’ given the BSL’s view that inflation is a monetary phenomenon. As a result the final target is set in terms of inflation rates while the growth in money supply (M2) is the intermediate target and is derived from the quantity theory equation. The schematic illustration of the monetary policy framework is shown below.

**Policy Instrument → Operational Target → Intermediate Target → Ultimate Target**

(OMO) \rightarrow (Reserve Money) \rightarrow (Money Supply) \rightarrow (Inflation)

The BSL uses open market operations (OMO) to achieve an operational target that is closely related to the intermediate target. The attainment of this operational target leads to attainment of the intermediate target. Reserve money or high-powered money and net domestic assets are considered as the main operating targets. The process by which reserve money influences the intermediate target is represented by the following equation:

\[
M_2 = m(R_m)
\]  

\[16\] The quantity theory of money relates quantity money and the velocity of money to the level of nominal output by the following relationship: \[MV = PY\]

Where \(M\) is money supply, \(V\) is velocity of money, \(P\) is price level and \(Y\) is output. Money demand is posited to be a function of the value of output. Thus any money supply in excess of money demand will cause prices to increase.

\[17\] \(M_2\) is defined as the sum of currency in circulation, demand deposits, time savings and foreign currency deposits.
Where;

\( M_2 \) is money supply; \( R_m \) is reserve money; and \( m \) is the money multiplier.

Assuming that \( m \) can be projected fairly accurately, then the \( M_2 \) target can be achieved by targeting the corresponding \( R_m \) level. The reserve money level is influenced through OMO. It is apparent that BSL can only achieve its ultimate objective of price stability by controlling the supply of reserves thus preventing excess liquidity and maintaining the desired level of money supply in the system. Therefore, to meet its monetary policy objectives the Bank will depend on the liquidity forecasts, to determine if there is a liquidity shortage in which case the Bank’s policy would be expansionary by retirement of existing securities. For example, government cash flows have a large impact on the liquidity supply and may lead to excess liquidity in the system with inflationary consequences, which may not be in line with current monetary policy. In such situations the BSL may decide to sell securities (government paper) in order to sterilise the excess liquidity.

A further interesting aspect of monetary policy in Sierra Leone is how the foreign exchange rate market has been organised. There has been a multiple exchange rate regime for a long time and the current system comprises the official, banking system, and parallel exchange rate markets. Although the parallel market operations are rampant, they are still classed as illegal. The foreign exchange market plays a crucial role in complementing the monetary policy operations of the BSL. The BSL hold weekly auctions where foreign currency is sold to commercial banks and importers in order to supplement the supply of foreign exchange. Exchange rates are determined in the interbank market although BSL determines the exchange rate to be used for official transaction as well as the rate for customs valuation purposes. It is important to note that prior to adoption of the flexible exchange rate regime in 1990, Sierra Leone experimented with various types of exchange rate systems ranging from fixed exchange rate regime (1964 – 1982), to a dual exchange rate regime (1982 – 1983), to a dollar Peg (1983 – 1986) and to dirty float (1986 – 1990). However, even under the current flexible exchange rate regime (‘managed float’) where the exchange rate is determined by market forces, the BSL intervenes regularly via the weekly auctions to prevent excessive depreciation of the Leone.

**MONETARY DEVELOPMENTS**

Analysis of monetary variables revealed that the path of monetary policy has been expansionary for most of the period under study. Both broad money supply (M2) and narrow money (M1) expanded in the 1970s, recording annual average growth rates of 17.1 percent and 20.6 percent, respectively. There was no slowdown in the growth of money supply in the 1980s when annual average growth rates of M1 and M2 were 35.4 percent and 49.5 percent, respectively. The growth in money supply in the 1970s and 1980s was consistent with the prevalence of high inflation and persistent fiscal deficits.
during this period. The expansion in money supply was thus an indication of fiscal accommodation by the money authorities. Increases in net domestic asset following the sharp rise in credit to government (net claims on government) propelled money supply during this period.

Figure 2: Recent Trends in Monetary Variables (Growth Rates of M1 and M2), 2000 - 2010

While the growth of narrow money (M1) continued to accelerate in the 1990s at an annual average rate of 49.3 percent, the growth of M2, though still high, fell to 35.9 percent from 49.5 percent in the 1980s. Macroeconomic and financial reforms initiated in the 1990s were derailed by the advent of the civil war in 1991 hence the growth of money could not be contained as government credit expanded in the face of increasing expenditure to prosecute the war. However, the growth rate of M1 and M2 slowed to 27.2 percent and 27.5 percent, respectively, between 2000 and 2010. In addition, the adoption of prudent macroeconomic and financial policies at the end of the civil war in 2001 placed the country on the path to economic recovery.

LITERATURE REVIEW

The literature on how monetary authorities react to macroeconomic developments and the impact of their behaviour on the wider economy though very extensive, was initially motivated by Friedman and Schwartz’s (1963) and the introduction of Real Business Cycle models. Although, several studies have tried to describe the way monetary policy is set by central banks, the most prominent of them is the seminal work by Taylor (1993). Taylor (1993) described a very specific and simple rule for monetary policy with following equation:
\[ r_t = r + \pi_t + \beta_1(\pi_t - \pi^*) + \beta_2y_t, \quad \beta_1, \beta_2 > 0, \]  

(2)

Where;

\( r_t \) denotes the nominal interest rate, \( r \) the equilibrium real rate of interest, \( \pi_t \) the inflation rate, \( \pi^* \) the target inflation and \( y_t \) denotes the deviation of the actual output from its potential level. \( \beta_1 \) and \( \beta_2 \) are reaction coefficients that determine how strongly the monetary authority stresses inflation stabilization and output stabilization.

Taylor (1993) used a linear trend of the real GDP to measure potential Output and assumed \( \pi^* \) to be 2 percent to show that this rule can perfectly stimulate short-term nominal interest of the United States (US) when \( \beta_1 = 0.5, r = 2 \) and \( \beta_2 = 0.5 \). The policy rule in equation (2) has the feature that the central bank policy rate rises if inflation increases above the target or if real GDP rises above potential GDP and the central bank policy rate decreases if inflation is below the target or if real GDP decreases below potential GDP (Kozicki, 1999). Most subsequent research is related to this seminal article by Taylor where the interest rate is specified as a variable that is linearly related to a set of macroeconomic variables, namely inflation and output gaps. A survey of several major research related to the monetary policy reaction function and the Taylor rule have therefore been summarized.

Clarida, Gali and Gertler (1998) estimated the reaction functions for the (U.S., Japan, and Germany) and (U.K., France, and Italy) countries and found that central banks in U.S., Japan, and Germany pursued inflation targeting implicitly, were forward-looking, and reacted to the expected inflation instead of the past inflation. However, their results showed that central banks in the U.K., France, and Italy relied too much on the German monetary policy and kept interest rates higher than the domestic economic conditions required. Finally, they suggested that targeting inflation may be better than fixing the exchange rate.

In reviewing and investigating previous works, Judd and Rudebusch (1998) maintained that the Taylor rule is a valuable guide to characterize major relationships among variables when conducting monetary policy. They showed that the Taylor rule over-predicts the Federal Funds Rate (FFR) during the Burns period, under-predicts most of FFR throughout the Volcker era, and predicts FFR quite well during some of the Greenspan term.

Romer (2001) analyzed several issues relating to the application of the Taylor rule. He argued that the values for the coefficients of the output gap and the inflation gap would change the effectiveness of monetary policy indicating that larger values of the coefficients would cause the actual inflation rate and output to decline more than expected. He also argued that it would be more appropriate to use the lagged values for
the output gap and the inflation gap due to a lag in information. He maintained that the exchange rate and the lagged federal funds rate should be included to incorporate the open economy and the partial adjustment process. Finally, he stressed that potential GDP may be measured differently, causing the output gap to vary.

Bernanke, et al. (1999) investigated inflation targeting for seven countries and found that inflation targeting had achieved the objectives of clearly stating the monetary policy goal and establishing the credibility of central banks. However, they did not find the evidence that inflation targeting has influenced inflation expectations. Gerlach and Smets (2000) examined whether monetary policy would respond to a shock to the exchange rate for Australia, Canada, and New Zealand. They found that while Australia’s central bank does not respond to a shock to exchange rates, central banks in Canada and New Zealand respond significantly to a shock to the exchange rate.

Applying the VAR model, Assane and Malamud (2000) examined the relationship between monetary policy and exchange rates and showed that after the federal funds rate rises, the U.S. dollar appreciates and that a weak dollar causes the Fed to raise the federal funds rate. Galbraith, et al. (2007) used a VAR model of the American economy from 1984 to 2003 to show that, contrary to official claims, the Federal Reserve does not target inflation or react to “inflation signals.” Rather, the Federal Reserve reacts to the very “real” signal sent by unemployment; in a way that suggests that a baseless fear of full employment is a principal force behind monetary policy.

Hsing (2004) used a VAR model to estimate the Bank of Canada’s reaction function and found that the extended Taylor rule including the exchange rate applies to Canada because one of the objectives of the Bank of Canada is to maintain currency stability in order to promote international trade. Furthermore, using the impulse-response function and variance decomposition for the call rate, he showed that the Bank of Canada would raise the call rate in response to a depreciation of the Canadian dollar and that more variation in the call rate can be attributable to a shock to the output gap. Hsing and Lee (2004) also used a similar approach to estimate the monetary policy reaction function for the Bank of Korea and found that the call rate reacts positively to a shock to the inflation gap, the output gap, the exchange rate gap, the stock price gap, and the lagged call rate during some of the quarters. They also showed that the inflation gap and the exchange rate gap are more influential in the short run in explaining the variance in the call rate whereas the output gap and the stock market gap are more important in the long run.

Sutherland (2010) estimated monetary policy reaction functions for European Union countries and found that differences exists across countries as to whether monetary policy reacts solely to expected inflation or also takes into account expected output developments. In particular, the results showed that a range of other factors, such as monetary policy in large economies, can also influence monetary policy reactions in
smaller ones. On the other hand, the results also showed that monetary policy has reacted less to contemporaneous measures of the output gap, while asset price developments do not generally appear to have influenced monetary policy decisions.

Sánchez-Fung (2002) used the money base as a policy instrument to estimate Dominican Republic’s monetary policy reaction and found that the Central Bank has been biased towards targeting the gap between the parallel and official exchange rates, apparently doing so in a more systematic fashion after the mid 1980s. Kaytanci (2008) estimated Turkey’s monetary policy reaction function based on an extended Taylor rule and applied the vector error-correction model over the period 2002:01 - 2007:12. He found that the overnight rate responds positively to shock to the output gap, the inflation gap, or the lagged overnight rate during all of the period but, the overnight rate responds negatively to shock to the exchange rate throughout the study period. Thus, he maintained that the Central Bank of Turkey would raise the overnight rate if output gap widens, or inflation gap rises.

Inoue and Hamori (2009) estimated a Taylor-type monetary policy reaction function for India by employing dynamic ordinary least squares (OLS). The results showed that the output gap and the exchange rate were statistically significant with their correct signs but the same was not true for the inflation gap. They concluded that inflation has not played a crucial role in the conduct of India’s monetary policy and thus inappropriate for the country to adopt inflation targeting. Iklaga (2009) estimated a Taylor-type monetary policy reaction function of the Central Bank of Nigeria. The results showed inflationary pressures played a significant role in the decisions taken by the Bank during the period of study. In addition, the results uncover the role of output in determining the assessment of the Bank on the future path of interest rates.

**METHODOLOGY**

**MODEL SPECIFICATION**

The simple Taylor rule in general form can be written as

\[ i = f((y-y^*), (\pi-\pi')) \]  

where,

\( i \) : short-term interest rate

\( (y-y^*) \): output gap
(\(\pi - \pi^*\)): inflation gap

\(y\): actual output

\(y^*\): potential output

\(\pi\): actual inflation rate

\(\pi^*\): target inflation rate

Because optimal policy rules are sometimes based on complex models, the Taylor rule has the greatest advantage of simplicity and applicability albeit this is also its weakness. However, it should be realised that an attempt to estimate a monetary policy reaction function for a developing country like Sierra Leone, particular emphasis should be given to its specification. An almost-certain (primary) demand management instrument to be used by monetary authorities in a developing country is the monetary base, or reserve money (high-powered money). For instance McCallum's (1988) popular nominal feedback rule considers the monetary base as the policy instrument while Sánchez-Fung (2002) used the money base as a policy instrument when estimating Dominican Republic’s monetary policy reaction function. Monetary policy instruments (for example interest rates) frequently employed in developed countries (Bernanke and Blinder, 1992) are less likely to be implemented, given the unique transmission mechanism of monetary policy in developing economies (see Montiel, 1991). Most developing countries had some form of financial repression where interest rates ceilings were imposed until the early 1990s. Indeed, as pointed out in Section 2.2, monetary base or reserve money is the operational target in the BSL monetary policy framework. Furthermore, since financial regulation characterized much of the period under study, the money base could be the most suitable policy instrument. The money base was therefore chosen as the policy instrument.

With regard to the targets of monetary policy, the Taylor rule with the standard variables in the literature (inflation and output gaps) is extended to include the exchange rate. The original Taylor rule was developed for a closed economy, where central banks can concentrate on the interest rate alone and hence does not include exchange rate. However, in reality open-economy issues such as the behavior of exchange rates are central to monetary policy. In small developing open economies like Sierra Leone, inflation targets and Taylor rules are suboptimal unless they are modified.

Since the Sierra Leone has had a multiple exchange rate regime for long time, some sort of exchange rate indicator could likely be an implicit target of the central bank. The official exchange market has been utilized, historically, for different reasons, for example,
foreign exchange rationing, not only in the Sierra Leone but in many developing countries as well. At the moment, foreign exchange is utilized for servicing of foreign debt and the purchase of petroleum products and foodstuffs. Consequently, any depreciation could trigger an immediate increase in (at least) the prices of the debt service, petroleum products and foodstuffs. Variations in such prices could result in varied effects on the macroeconomy.

Given the foregoing, our empirical model is therefore specified as follows:

$$R_m = f ((y-y^\ast), (\pi-\pi^\ast), E, R_m)$$  \hspace{1cm} (4)

where

$E$ : the exchange rate in terms of the Leones per U.S. dollar

Replacing short-term interest rate with the monetary base/reserve money ($R_m$), equation (4) can be estimated by the following VAR (Vector Auto Regression) model,

$$X_t = \beta_t X_{t-1} + ... + \beta_t + \varepsilon_t$$  \hspace{1cm} (5)

where,

$X_t$ : vector of the endogenous variables [$R_m, (y-y^\ast), (\pi-\pi^\ast), E$]

$\beta$ : parameter matrix

$\varepsilon_t$ : white noise error term.

Equation (4) is the hypothetical monetary policy rule for Sierra Leone. First, the monetary base ‘$R_m$’ replaces the short term interest rate ‘$i$’ as the instrument of monetary policy. Second, the exchange rate is included since the depreciation of Leone causes import prices to rise, and given that the Sierra Leone economy is dependent on imports of raw materials, exchange rate channel plays significant role in determining inflation (See Pongsaparn, 2002).

**ECONOMETRIC APPROACH**

This study employs the vector autoregressive (VAR) approach developed by Sims (1980). The VAR system in this study comprises four macroeconomic endogenous variables namely output measured by real GDP, inflation, exchange rate and money base (see
Section 4.4 for definitions of variables). The conventional structural modelling procedure or simultaneous equations technique has been criticized as overly restrictive, and the selection of endogenous and exogenous variables is far too arbitrary and judgmental. The VAR model on the contrary allows all the variables in the system to be endogenous where each can be written as linear function of its own lagged values and the lagged values of all other variables. In addition, the VAR model takes in consideration possible simultaneous relationships among the variables in order to avoid the simultaneity bias problem.

The investigative procedure in this consists of four main steps. First, instead of arbitrarily choosing the lag lengths, the final prediction error (FPE) criterion as defined by Akaike and Schwanz (1969) is employed to select the optimum lag for each variable in the system; Second, to determine whether the money base would respond to a shock to one of the endogenous variables, impulse response functions are estimated; Third, the variance decomposition of money base is estimated to determine the explanatory power of each of the endogenous variable on the variance of money base; and finally, to test the robustness of the findings, the Cholesky ordering is changed.

**THEORETICAL PREDICTION OF RELATIONSHIPS**

The Taylor rule indicates that the interest rate would respond positively to a shock to output gap \((Y - Y^*)\) and inflation gap \((\pi - \pi^*)\). However, since the reserve money \((R_m)\) (an aggregate and not a rate) is the monetary policy instrument in our model, we expect \(R_m\) to respond negatively to a shock to \((Y - Y^*)\) and \((\pi - \pi^*)\). For the output gap \((y - y^*)\) a negative response should be expected because its estimates provide a key benchmark against which to assess inflationary or disinflationary pressures and the cyclical position of the economy. When the actual output is greater than the potential output, this implies that an economy is faced with excess demand. This situation is often seen as a source of inflationary pressures and calls for appropriate policy responses that involve reducing aggregate demand such as reduced government spending or in this case the tightening of monetary policy (a reduction in \(R_m\)).

In similar vein, a negative response is expected for the inflation gap \((\pi - \pi^*)\) since its estimates indicate the reaction of the monetary authorities to inflationary developments. Monetary policy tightens (reduction in the growth of \(R_m\)) whenever actual inflation is larger than expected inflation and vice versa. Finally, according to the extended Taylor rule, we also anticipate that the response of \(R_m\) to \(E\) would be negative. For instance, when the Leone becomes weaker or the exchange rate rises/depreciates, BSL would attempt to stabilize the weak Leone by tightening monetary policy (reducing \(R_m\)) so that the demand for Leone would increase (Hsing, 2004). The opposite holds when the Leone becomes stronger or the exchange rate falls/appreciates.
It is important to note that some of these variables may have simultaneous relationships. We expect that \( R_m \) would respond to \((Y - Y^*)\), \((\pi - \pi^*)\) or \(E\). On the other hand, after the BSL eases monetary policy via an expansion in reserve money, consumption and investment spending would rise, thus shifting the aggregate demand curve to the right and causing the equilibrium GDP to rise. A higher GDP would cause \((Y - Y^*)\) to increase. In the short run, as output rises, unemployment rates drop and inflation rates increases, causing inflation gap to widen. Hence the application of the VAR model which allows all the right-hand side variables to be identical and lagged is appropriate as there is no simultaneity problem and the OLS estimates are as good as the GLS estimates.

**DATA TYPE AND SOURCES**

The econometric model outlined in section 4.1 (the extended Taylor Rule) is estimated using annual data for the period 1970-2010. The reserve money \((R_m)\) is defined as reserve money \((R)\) normalized by nominal GDP. The inflation gap \((\pi - \pi^*)\) is expressed as a deviation of actual inflation, \(\pi\) (defined as the annual change in the log of Sierra Leone’s consumer price index) from its potential value, \(\pi^*\) and the output gap, \((y - y^*)\) is expressed as a deviation of actual output, \(y\) (defined as the log of real GDP) from its potential value, \(y^*\). The estimation of trend inflation and potential real GDP are achieved by passing \(\pi\) and \(y\) through the Hodrick-Prescott filter (HPF) (see Hodrick and Prescott, 1997). The HPF’s recommended smoothness parameter of 100 for annual data was used. The exchange rate ‘E’ represents the nominal exchange rate. The data sources are Bank of Sierra Leone and the IMF’s International Financial Statistics.

**EMPIRICAL ANALYSIS AND RESULTS**

A lag selection test with a maximum of four (4) lags was undertaken in order to determine the order of the VAR. The Schwarz and Hannan-Quinn (HQ) information criteria were minimized to obtain a lag length of one (1). The Akaike on the other hand supported a lag length of 4. Thus, a VAR (1,1) model was estimated based on evidence from the Schwarz and Hannan-Quinn (HQ) information criteria. Due to the lags, the actual observation for the VAR estimation ranges from 1972 – 2010. The results of the lag selection test are shown in Appendix 1.

Next, we estimate the unrestricted VAR model of equation (4) to graph the impulse response functions. Figure 2 presents the impulse response function of the reserve money \((R_m)\) to a one standard deviation shock output gap \((y - y^*)\), inflation gap \((\pi - \pi^*)\), exchange rate \((E)\) and the lagged reserve money. As shown in figure 2, reserve money responds negatively to a shock in output gap and positively to a shock in the lagged reserve money. The standard error bounds indicate that both responses (to a shock in output gap and lagged reserve money) are significant. On the other hand, the response of reserve money to a shock in the inflation gap is insignificant over ten years. The response of reserve money to a shock in the exchange rate was negative though not significant.
after the first two years. Appendix 2 presents the impulse response function in numerical values.

The negative response of reserve money to a shock in output gap was consistent with our theoretical prediction where deviations from actual output can result in inflationary or disinflationary pressures depending on the cyclical position of the economy. This implies that inflationary pressures in Sierra Leone will escalate if the country is faced with excess aggregate demand as a result of actual output being greater than potential output. Under such circumstances the BSL will seek to contain/reduce inflationary pressures by reducing aggregate demand through the contraction of monetary policy (lowering reserve money). The reverse will hold if potential output is greater than actual. These findings buttress the view that shocks in the output gap could help to explain the direction of monetary policy. The finding is similar to Hsing (2004) that showed that the direction of monetary policy in Canada can be attributable to a shock in the output gap in addition to the exchange rate. Kaytanci (2008) also found similar result for Turkey but with a shock in the inflation gap also explaining the direction of monetary policy. Furthermore, Iklaga (2009) showed that output play a role in determining the further path of monetary policy (interest rates) in Nigeria.

Figure 2. Impulse Response Function of Reserve Money

Response to Cholesky One S.D. Innovations ± 2 S.E.

Cholesky Ordering: \( (y - y^*) \), \( (\pi - \pi^*) \), \( E \), \( R_m \)
In addition, a negative response of reserve money to a shock in the exchange rate was also consistent with our theoretical prediction. This indicates that depreciation of the Leone would trigger a tightening of monetary policy through a reduction in reserve money, and vice versa. The result is similar to several findings in the literature (for example, Hsing (2004), Hsing and Lee (2004), Kaytanci (2008) and Sanchez-Fung (2002), among others) wherein the developments in the exchange rate could help to explain the path of monetary policy. Furthermore, the positive response reserve money to a one standard deviation shock in the lagged reserve money implies that past trends in reserve money may help explain its current and future direction.

On the other hand, the finding that a shock in the inflation gap does not trigger a response in reserve money is not only contrary to our theoretical prediction but also to a large number of empirical findings in the literature (for example, Kaytanci (2008), Hsing and Lee (2004), Iklaga (2009) etc). In particular, this finding implies that inflation has not played a role in the conduct of monetary policy in Sierra Leone during the period under study. Inoue and Hamori (2009) found similar results for India and concluded that inflation targeting was not appropriate for the country. Galbraith, et al. (2007) got similar results for the U.S wherein the monetary policy does not react to inflation but to ‘real’ signals from unemployment.

Finally, the variance decomposition of reserve money ($R_m$) is reported in Appendix 3A. The results show that the lagged reserve money is the most influential variable as it can explain up to 76.38% of the variation in reserve money. The output gap, exchange rate and inflation gap explain up to 22.58%, 13.96%, and 3.06% of the variation in reserve money, respectively. The results suggest that following the lagged reserve money, output gap and exchange rate are the second and third most influential variables, respectively. The inflation gap is the least influential and this not was surprising given that the response of reserve money to a shock in the inflation gap was not significant. Hsing (2004) also found similar results for Canada where the output gap and the exchange rate where more influential in explaining the path of monetary policy than inflation. However, Iklaga (2009) showed that inflation played a more significant role than output in explaining monetary developments in Nigeria.

To test the robustness of the above findings, the Cholesky ordering is changed (see Appendix 3B and 3C) to $(\pi - \pi^*)$, $(y - y^*)$, $E$, and $R_m$ so that the inflation gap is placed before the output gap. The results show within a 95% confidence interval, that the reserve money continue to respond negatively to a one standard deviation shock in the output gap and positively to the lagged reserve money. Also the response of reserve money to a one standard deviation shock in the exchange rate was also negative and insignificant after the first two year while the response to inflation gap was insignificant. Furthermore, up to 60.38%, 5.19%, 20.45, and 13.96% of the variation in reserve money
is explained by the lagged reserve money, inflation gap, output gap and exchange rate, respectively. Ultimately, the change of the ordering has not changed the outcomes significantly. This shows that our results are robust enough to structural breaks and specification errors and thus can be used in forecasting and policy analysis.

**SUMMARY AND CONCLUSION**

The objective of the study has been to examine the monetary policy reaction function for Sierra Leone using the extended Taylor rule. An unrestricted VAR model was estimated to compute impulse response including variance decomposition. The author found that the reserve money responds negatively to a shock to the output gap as well as exchange rate, and positively to the lagged reserve money. These findings suggest that the BSL would tighten monetary policy (reduce reserve money) if the output gap widens and/or when the Leone depreciates. In addition, the empirical results show that we can rank the relative influence on reserve money in the following order: the lagged reserve money, output gap, exchange rate and inflation gap.

Several policy implications are conceived. The Taylor rule can be applied and extended to Sierra Leone’s monetary policy by using reserve money as the policy instrument and adding the exchange rate and lagged reserve money. The lagged reserve money can explain about 60% of the variance in reserve money hence any omission of the lagged reserve money would result in a specification error. The finding that the output gap is more influential in explaining the variance in reserve money than the inflation gap and exchange rate suggests that BSL stresses output stabilization (pursuing full employment) more than price or exchange rate stability in the formulation of its monetary policy. Furthermore, that exchange rate is more influential than the inflation gap implies that the BSL focuses the formulation of monetary policy more on stabilizing the value of the Leone to prevent it from potentially deviating from its equilibrium value than on stabilizing prices. On the contrary, that the inflation gap does not play any role in the conduct of monetary policy is typical of the history of high inflation recorded for most periods of the study when monetary management was more or less ineffective and implies that inflation targeting would not be appropriate.

Overall, the findings indicate learning by the Sierra Leonean authorities to follow rule-like decision making procedures in their choice of policy given the economically costly adjustments undertaken by the country for most of the period under study (Section 2). However, it would be vital for the BSL to adopt an explicit monetary policy rule in order to enhance the efficacy of its monetary policy.
REFERENCES


World Bank (Various Issues) “World Development Indicators” World Bank Database
### Appendix 1: VAR Lag Order Selection Criteria

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* indicates lag order selected by the criterion

### Appendix 2: Impulse of Reserve Money

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Cholesky Ordering: (y - y*), (π – π*), E, Rm
Standard Errors: Analytic
### Appendix 3A: Variance Decomposition of Reserve Money

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*Cholesky Ordering: ($y - y^*$), ($\pi - \pi^*$), E, Rm

### Appendix 3B: Variance Decomposition of Reserve Money with Change of Ordering

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*Cholesky Ordering: ($\pi - \pi^*$), ($y - y^*$), E, Rm

### Appendix 3C: Impulse Response Function of Reserve Money with Change of Ordering

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*Cholesky Ordering: ($\pi - \pi^*$), ($y - y^*$), E, Rm
Appendix 4: Output Gap and Inflation Gap (percent), 1970 - 2010

Output gap
Inflation gap

Appendix 5: Log of Reserve Money and Exchange Rate Differential, 1970-2010

Log $R_m$

$\Delta E$