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The Transmission Channel of Monetary Policy to the Real Economy Revisited: Evidence From Sierra Leone

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Abstract

This study examined the transmission channel of monetary policy to real economy in Sierra Leone using quarterly data from 2002 to 2018. The non-recursive structural vector autoregressive technique was employed to identify the channel of monetary policy transmission to the real economy. This technique was considered appropriate because it has two-way or bidirectional causal effects among endogenous variables and ordering of endogenous variables are considered flexible. Analysis of data shows that the exchange rate channel was found to be appropriate in transmitting monetary policy effect to real economy based on the results of impulse response and variance decomposition analysis. In light of the empirical findings, the study recommended that in a bid to have an effective monetary policy, the channels of monetary policy transmission, especially the exchange rate channel, should be taken into consideration in the design of monetary policy in Sierra Leone.

Keywords: monetary policy, monetary transmission mechanism, bank lending, SVAR

JEL Classification: E52, E44, E50, C32

1. Introduction

Several studies have been undertaken on the conduct of monetary policy in developed and developing countries over the last four decades with different approaches. Some focused on the effectiveness of monetary policy in a well-developed and functioning financial system (Cecchetti et al., 2006; Isakova, 2008). Others examined the transmission of such policy to the real economy as well as the instruments used in formulating an appropriate policy (McCallum, 1981 and McCallum 1989; Mishkin, 1995; Ouchchikh, 2017). Some of these studies assume a robust financial system that absorb the impact of an effective monetary policy (Kuttner & Mosser, 2002; Rasche & Williams, 2007; Mishra et al., 2012). However, others, especially those on countries with shallow market system like Sierra Leone focused their attentions on policy effect vis-à-vis framework, instruments, transmission channels, etc. (Davoodi & Pinter, 2013; Mansaray & Swaray, 2013; Zgambo & Chileshe, 2014; Were et al., 2014). For instance, Lavally and Nyambe (2019) used annual data from 1980 to 2012 to examine the transmission mechanisms of monetary policy in Sierra Leone within the framework of the vector autoregressive model. While Ogunkula and Tarawalie (2008) used the same framework but with quarterly data from 1990 to 20006 to investigate monetary policy transmission mechanism in Sierra Leone. Both studies found an ineffective transmission channel of monetary policy in Sierra Leone. However, the latter study revealed the bank landing channel as a moderate channel of monetary policy transmission. These results are not surprising because they were conducted prior to the introduction of the monetary policy committee in 2011 that is charged with the sole responsibility of conducting monetary policy in the country using the monetary policy rate as policy instrument.

Sierra Leone is a small open economy that is susceptible to the dynamics of activities with the outside world. The external sector of the country has grossly underperformed over the last three decades, as the country has been hit by chronic and persistent balance of payments crises owing partly to the country’s over reliance on the importations of everything consumable. The country persistently faces deficits in the current account, trade balance and fiscal balance. (Morlai et al., 2012). During the last thirty years, trade balance accounted for the country’s major indicator of the measure of the external sector performance (Korsu, 2014). Exports of goods, especially minerals contributed 80.0% of aggregate exports. Similarly, imports contributed 50.0% of the country’s aggregate imports consisting mainly of petroleum products and food. Official current transfers between 2002 and 2005 accounted for 17.9% of total output during this period on average. This figure however, dropped to 5.7% in 2007. With total reserve position of the Central

Bank hovering around US$500mn, over 40.0% of this amount is used for the importation of the country's staple food, rice annually. Making the Central Bank vulnerable to global shocks and the country's inability to import other essential commodities such as medical and capital intensive equipment. This has implication on the identification of the appropriate channel of monetary policy to the real economy.

Furthermore, it is argued in literature that the main transmission channels of monetary policy to real economy have been identified as both exchange rate and interest rate. Because monetary authorities believe that variation in exchange rate that emanate from drifts in the credibility of monetary policy are offset with the manipulation of the policy rate by the monetary authorities. In this light, the study attempts to examine the channel through which monetary policy is transmitted to real economy in Sierra Leone. This study departs from previous studies on Sierra Leone on the ground that it captures the period in which the monetary policy committee was formed using an innovative technique, the non-recursive structural vector autoregression. The non-recursive SVAR is flexible and has reciprocal effects among endogenous variables (bidirectional causality) and the errors are correlated with one another, which makes its application adequate and appropriate for this study. Similarly, if the study can establish the right channel of policy transmission, this helps monetary authorities formulate appropriate instrument that would target the nominal anchor of the Bank of Sierra Leone, which is broad money. The study is organized into five sections, beginning with the introductory section. Section two reviews the literature that comprises theoretical and empirical literature. Section three presents theoretical and empirical models as well as the estimation techniques of the study. Section four presents and discusses the empirical results of the study. Finally, section five concludes and proffers recommendations based on the major findings of the study.

2. Literature Review

Theoretically, it has been argued in the literature that monetary policy is nominally transmitted to the real economy through various channels and the relevance of these channels to a large extent depends on the degree of openness of the economy (Berument et al., 2014). From the point of view of open economies, the transmission channel of monetary policy is ambiguous because the channel occurs via several perspectives. However, the demand side and supply side effects have been considered as two key channels of policy transmission. From the demand side perspective, openness affects monetary policy through the demand for both local and foreign produced traded goods due to the response of the exchange rate to changes in monetary policy. The magnitude of this channel depends on expenditure switching between these two goods and the expenditure switching depends on the elasticity of substitution between these goods. From the supply side perspective, openness affects monetary policy through the impact of the exchange rate on prices of raw materials, inflationary expectation and wage formation. This supply side channel tends to exhibit stronger effect on prices and a weaker effect on output growth, depending on the nature of the economy (Berument et al., 2014).

Nonetheless, a credible monetary policy outcome has been accused of creating unwarranted consequences to the implementation of effective policy to policymakers. It is on this basis that Mishkin (1995) advised monetary authorities that in their quest to formulate monetary policy, they should first take into consideration both time and impact of such policy on the broader macroeconomy. Consequently, a successful policy demands in-depth understanding of the exact transmission channels that effectively transmit the effects of these policies on the financial sector and the overall economy.

2.1 Theoretical Literature

Mishkin (1995) identified four key channels in the existing literature that guarantee the transmission of policies to the broader economy. These channels have been identified as the interest rate channel, exchange rate channel, bank channel and asset-price channel. The four channels are discussed below. The interest rate channel of monetary policy transmission found its roots from Keynes' traditional perspective about monetary policy transmission. According to Keynes, an expansionary monetary policy or monetary loosening triggers a fall in the real interest rate. This allows economic agents to attract credit from the commercial banks at a lower interest rate. These funds are then used for either consumption or investment purposes (Bernanke and Gertler, 1995). This surplus fund in the economy propels investment, and subsequently promotes output growth in the economy. This view is supported by Were et al. (2014) in that they consider the interest rate channel to be more effective from the point of view of the short-end of the market interest rate like the inter-bank rate that gives power to commercial banks' lending rate with the ultimate goal of engendering output growth in the economy. This is because when there is a surge in the rate that commercial banks set for the pricing of their assets, it means that economic agents will have to reduce their investment spending since the real cost of attracting credit has increased. Consumption and investment expenditures ultimately decline owing to high cost of investment. Apparently, the consequence of this high interest rate is a decline in output. This scenario is presented schematically in tandem with Mishkin (1995).

$$CMP \downarrow :\Rightarrow \operatorname{int} erestrate \uparrow \Rightarrow investment \downarrow \Rightarrow consumption \downarrow \Rightarrow output \downarrow$$

According to the scheme, when policymakers are faced with contractionary monetary policy (CMP), this action creates high interest rate as the commercial banks' lending to the public now becomes more expensive. The impact of this high cost of fund trickles down to the households directly, making it tough for them to attract funds from the banking system. This creates a wedge between consumption and investment. Investment and consumption fall, economic activities slowdown which ultimately amounts to low economic growth in the country. The exchange rate channel forms the basis of this study and is considered critical in the transmission of policy to the real economy as documented in literature (Mishkin, 1995) and (Bernanke & Gertler, 1995). This channel is key in that, it has direct bearing on other channels especially the interest rate channel already discussed. In other words, the exchange rate channel can best be described in line with the uncovered interest parity (UIP) theory which states that when prices are rigid downward, the change that emanates from nominal exchange rate manifests itself through depreciation in the exchange rate (Mishra et al., 2010). This depreciation forces households to alternate expenditures between goods that are produced locally and their foreign counterparts. However, the ability of monetary authorities to allow the market forces of demand and supply to determine the exchange rate confirms effectiveness of the exchange rate. Put differently, the market forces of demand and supply describe the trajectory of the exchange rate. But under circumstances that warrant large pass-through effect of the exchange rate on locally produced commodities, the effects of expenditure switching by households are likely to occur from volatilities in real exchange rate, which often emanates from the nominal exchange rate, thereby exploding the actual value of the local currency. This higher trend in the local currency translates into expensive domestically produced goods than their foreign counterparts. Net exports fall as a result. The overall effect is decrease in economic growth and development. This action is schematically described.

$$CMP \downarrow :\Rightarrow \text{int}\, erestrate \uparrow \Rightarrow exchangerate \uparrow \Rightarrow net\, \text{exp}\, ort \downarrow \Rightarrow output \downarrow$$

In this regard, a contractionary monetary policy or monetary tightening increases real interest rate. This effect appreciates the domestic currency but reduces net export and by extension a fall in output. Given that the exchange rate is key for most less developed economies such as Sierra Leone, with high import propensity, it is argued that the exchange rate effects cause direct and indirect consequences on these economies through imported inflation from the importation of raw materials and other commodities (Bernanke and Gertler, 1995). The high prices of these raw materials trickle down to the prices of final products. Indirectly, the exchange rate affects least developed economies through imported inflation emanating from the importation of final consumption goods such as rice, sugar and so on. In the case of Sierra Leone, rice is the staple food and more than 40% of the nation's external reserves is used for the importation of rice. The bank lending channel exposes certain borrowers especially those that are considered risky in nature. According to Mishkin (1995), expansionary policy creates credit booms in deposits available to the commercial banks. This means banks have the propensity to extend more loans to their customers. As customers attract these loans, they are expected to put these excess funds into investment purposes (Zgambo and Chileshe, 2014). The boost in investment removes the wedge between consumption and investment, thus engendering domestic demand in the economy. Consequently, the efficacy of the bank lending channel hinges on reserves of the Central Banks. Hence, when monetary authorities decide to contract the cash reserve ratio, it enables commercial banks to attract more funds from the Central Bank. This increases their lending capacity to the private sector. As private sector borrowing increases, investment activities also increase. This boost aggregate demand in the economy (Mishkin, 1995; Were et al., 2014 and Alam, 2015). Similarly, a contractionary policy tends to reduce deposits available to banks, this impedes the quantity of funds commercial banks will be ready to give out as loans to their customers. Investment opportunity decline and output as well. A schematic representation of this framework is showed below.

$$CMP \downarrow :\Rightarrow deposits \downarrow \Rightarrow loans \downarrow \Rightarrow investment \downarrow \Rightarrow output \downarrow$$

The other asset price channel has been regarded as key conduit through which monetary authorities' policy impacts the overall economy. The asset price channel of transmission finds its root from Tobin's "q" theory of investment and the effect of such investment on households' income and consumption. The Tobin's "q" theory of investment has been considered as the main channel of policy transmission to the financial system. This theory takes into consideration the importance households attach to assets. The value of q determines the market value firms placed on equity. When q is large, implies market price of equity is large with respect to the replacement cost of capital and vice versa. In terms of monetary policy, a contractionary policy reduces the disposable income of households and their purchasing power of consumption goods. This action is schematically translated to describe how asset price transmits the actions of policymakers on the financial system.

$$CMP \downarrow :\Rightarrow equityprice \downarrow \Rightarrow Q \downarrow \Rightarrow investment \downarrow \Rightarrow output \downarrow$$

According to the scheme, contractionary policy reduces replacement cost of capital, this leads to a decline in q and firms become powerless to invest in goods since their market value is now less with respect to the price of capital. Similarly, an increase in nominal interest rate creates a corresponding increase in real interest rate and the user cost of capital (Kuttner and Mosser, 2002).

2.2 Empirical Literature

The transmission channel of monetary policy has been an empirical debate since the 1990s. The contention has been on identifying the right channels through which monetary authorities' policy trickle down to the real sector of the economy. Several studies over the years have tried to establish the effectiveness of monetary policy with the identification of the exact channel of transmission of the policy to the overall economy. According to Romer (1996), an effective monetary policy is expected to positively trigger activities in the financial sector. In an attempt to identify among a menu of channels in the literature, policymakers have found it difficult to come out with an appropriate channel that suits developing countries (Bahmani-Oskooee and Gelan, 2009). Different authors have used different approaches and methodologies to reach at a consensus. Consequently, Ndung'u (1999) investigated how monetary policy suffers in the hands of the exchange rate in Kenya using quarterly data from 1970 to 1995. Applying vector autoregressive model and the dynamic error correction mechanisms, the results revealed that real income drives stability in the exchange rate, while money supply and inflation propelled volatility in the normal exchange rate. Furthermore, prices and money supply were responsible for the depreciation of the nominal exchange, while fluctuation in output causes depreciation in real exchange rate in Kenya.

In another development, Aleem (2010) investigated the channels of monetary policy transmission in India using quarterly data from 1996 to 2007. A benchmark model was adopted based on Bernanke and Blinder's (1992) VAR framework. The results indicate that the inclusion of exogenous policy indicators in the model solve the problem of the so-called price-puzzle, and that, unexpected monetary policy shock impacted on the overnight call money rate that was included in the model. Also, the impulse responses show that prices and output declined simultaneously. Similarly, Alam (2015) applied the SVAR technique to assess the efficacy of monetary authorities' policy in Bangladesh. Quarterly data from 1995 to 2011 on output, monetary aggregate, inflation, exchange rate, three-month Treasury bill rate and world commodity prices were used with treasury bills as policy instrument. Preliminary findings suggested that when the monetary policy instrument was increased, there was corresponding increase in prices. However, this action reveals further decline in output as well as stability in the exchange rate. The study found that monetary policy was ineffective in controlling volatility in real GDP especially in the immediate term. Similar study was undertaken in Kenya by Were et al. (2014). They applied simulation from macroeconometric model to assess the impact of monetary authorities' policy on the Kenyan economy. The study examined two key channels of transmission of monetary policy including interest rate and bank lending channels. The monetary policy rate and cash reserve ratio were used as instruments of the two channels. To provide empirical results, quarterly data from 1996 to 2009 were used. Findings from simulation exercise involved increasing both the Central Bank policy rate by 400 basis points, cash reserve ratio by 200 basis points respectively. Prior estimation involved performing cointegration test to establish long-run relationship while the error correction mechanism enabled them to construct a single equation that captured the combined effects in the short-run and long-run. The outcomes of these exercise were analyzed using real GDP growth, consumer price index, real consumption, real investment and inflation as key variables. The results showed that the Central Bank rate posited a strong relationship with the short-term rates (inter-bank and Treasury bill rates). Also, the cash reserve ratio posited a strong influence on inflation. Hence, the study concluded that while interest rate channel was robust in influencing other rates in the short-term, the bank lending channel was effective in impacting inflation and output growth. Apere and Karimo (2014) investigated whether monetary policy was effective on the stability of output growth and inflation in Nigeria. Annual data from 1970 to 2011 were applied to variables that were mostly used as proxies. The Central Bank of Nigeria's monetary policy rate proxies short-term interest rate (inter-bank lending rate). Real GDP and consumer price indices were used as proxies for real output and inflation respectively. Broad money was represented by M2 in their model. Empirical findings found evidence that broad money growth and CPI inflation exhibited positive and significance effect on real GDP. Also, the short-term interest rate and inflation were more influential in enhancing output growth in the country.

Ndikumana (2014) investigated the implication of monetary authorities' policy effect on domestic credit to the private sector and investment for 37 SSA countries including Sierra Leone using annual data from 1980 to 2012 and dynamic panel data estimation technique. Key variables employed included domestic investment as percentage of GDP and domestic credit. Discount rate, treasury bill rate and lending rate were used as indicators of monetary policy. The result suggested that domestic credit to private entities emerged as major channel which triggers domestic investment in SSA. However, the result found this variable to be infinitesimal in SSA, limiting its potency to propel investment. Structural and institutional encumbrances also emerged as sources that worsen the already limited lending facilities to private economic agents. In this regard, it was concluded that contractionary monetary policy achieved through high discount rate was inimical to domestic investment. Hence, domestic investment can only be enhanced with moderate interest rate.

In the case of Sierra Leone, Tucker (2005) investigated the channels of monetary policy using quarterly data from 1981 to 2005. Applying the VAR framework, three separate models were estimated. The first model was described as the basic model that comprises four key variables namely treasury bills rate, broad money, consumer price index and real GDP. This basic model was extended by incorporating additional variables that represented each of the channels using credit to private sector as proxy for bank lending channel and nominal exchange rate to represent the exchange rate channel. Finally, the basic model was used to describe the interest rate channel. Open market operation was used in the study as instrument of monetary policy, while treasury bills rate was used as instrument of the BSL's policy. Empirical findings arrived at inconclusive outcomes with no evidence of appropriate channel of policy transmission. This result supports Lavally and Nyambe (2019). They applied annual data from 1980 to 2012 on interest rate, exchange rate, private domestic credit and GDP per capita. The Johansen cointegration technique was used to establish whether cointegration existed among the variables especially in the long-run. Empirical findings support ineffectiveness of any of the channels in transmitting policy actions to the economy.

Ogunkola & Tarawalie (2008) examined policy transmission in Sierra Leone using quarterly data from 1980 to 2006. The following variables were used to estimate three models that describe the channels of transmission of monetary policy namely income, CPI inflation, effective exchange rate in real terms, private sector credit, short-term interest rate, treasury bills rate, United States funds rate and global oil price. The Johansen cointegration technique was applied to establish cointegration effect. Empirical results provide evidence that the bank lending channel was appropriate in transmitting policy actions to the economy.

Similarly, Toe' et al. (2009) applied the VAR technique on monthly data spanning from February 2002 to December 2007 on real output, CPI inflation, 91-day treasury bills rate (as stance of monetary policy) and exchange rate to investigate channels of transmission of monetary policy in Sierra Leone. Stability in the VAR model was confirmed using Chow's structural breakpoint test. Treasury bills rate and market interest rates (lending rate and deposit rate) proxy the interest rate channel. Granger causality test results confirm interest rate pass through effect from authorities' policy instrument to market rates. Results further confirm exchange rate channel as robust way of monetary policy transmission to inflation but not output. Sharifi-Renani (2010) found that the application of the structural VAR technique to quarterly data from 1989 to 2009 on gross domestic product, CPI inflation, narrow money, required or borrowed reserve (as monetary policy variable), nominal exchange rate and house price index identified credit as appropriate transmission channel of policy in Iran.

In Tunisia, Mgadmi and Chrigui (2015) applied the SVAR technique on annual data from 1960 to 2013 on narrow and broad monetary aggregates, exchange rate in nominal terms and market rate. Empirical findings provide evidence of stability in the demand for money model. Interestingly, further findings confirm that three key channels including interest rate, exchange rate and credit were effective in the transmission of the actions of the Central Bank to the Tunisian economy. However, Arwatchanakarn (2017) in his empirical findings revealed that interest rate channel and narrow money were robust in transmitting the actions of monetary authorities to the economy in Thailand. Notwithstanding, exchange rate channel, was however moderately useful in channeling monetary policy effects in the Thai economy. Structural VAR was applied to quarterly data from the period 1997q3 to 2014q4 on global oil price index, US federal funds rate, output, consumer price index, narrow money, Bank of Thailand's monetary policy rate and effective exchange rate in nominal terms.

3. Methodology and Data

Following Davoodi (2013), Arwatchanakarn (2017) and Bwire (2019), a standard SVAR is formulated starting with a generalized reduced-form VAR of order p with autoregression denoted below.

$$x_t = E_0 + E_1 x_{t-1} + E_2 x_{t-2} + E_3 x_{t-3} + \ldots + E_p x_{t-p} + \mu_t \quad (1)$$

where $x_t = (\tau \times 1)$ vector of variables in the equations; $E_0 = (\tau \times 1)$ vector of constants; $E_j = (\tau \times \tau)$ coefficient matrices and $\mu_t = (\tau \times 1)$ vector of disturbances at a given time period and is expected to satisfied all the assumptions of a normal distribution. That is, identically and independently distributed with zero mean and constant variance. The following assumptions should for the errors to be normal: Mean of the error term is zero ($E(\mu_t) = 0$); homoscedastic error terms ($E(\mu_t^2 = \delta^2)$); no autocorrelation or uncorrelated error terms ($E(\mu_t \mu_{t-j}) = 0$ for all $j \neq 0$ and variance covariance matrix ($E(\mu_t \mu_t^{'}) = \Omega$) so that the error term is white noise with $\Omega = (\tau \times \tau)$. It is expected that the reduced form VARs provide summary of the data set while the SVAR interprets the data. Hence, in compact form, equation (1) is transformed as, again we assume the error term to be white noise.

$$q_t = Mq_{t-1} + \mu_t \tag{2}$$

Accordingly, equations of the system are presented in structural form as

$$Eq_t = D(L)q_{t-1} + F\varepsilon_t \tag{3}$$

Equation (16) is divided through by E to yield a structural VAR of the form:

$$q_t = E^{-1}D(L)q_{t-1} + E^{-1}F\varepsilon_t \tag{4}$$

ε_t is vector of normally distributed structural shocks and follows $N(0, \Psi)$ where Ψ is a diagonal matrix and normalizing it gives the identity $E(\varepsilon_t \varepsilon_t^{'}) = \Psi = I_N$ for all ε_t follows N (0, 1). The error term in equation (4) assumes uncorrelated disturbances and that Ψ is a diagonal matrix.

However, it is assumed that the matrices E and F and D's in equation (23) are not independently observable from the variance-covariance identity $E(\mu_t \mu_t^{'}) = \Omega$ of the reduced form shocks μ_t. From equation (4), q_t contains the vector on non-monetary policy variables, E and E contain contemporaneous relationship among the variables in the structural VAR and matrix of reduced form shocks, respectively. The problem of identification in the SVAR warrants the recovering of equation (1) from equation (2) with the imposition of restrictions on the unrestricted VAR in equation (1) based on economic theory. There are generally two forms of restrictions that are imposed on structural VARs in identifying monetary policy shocks and they include short-run and long-run restrictions. However, emphasis has been put on the short-run restrictions since policy effect is normally assumed to be neutral in the long-run with zero contemporaneous impact on the series in the SVAR system (Bwire, 2019). Based on this analogy, a recursive ordering technique was used to impose parametric short-run restriction on matrix E and the random disturbance shock (ε_t) in equation (20). This is achieved by estimating the random disturbance $E^{-1}F\varepsilon_t$ in equation (2) from the error term μ_t of the reduced form VAR in equation (1). Thus, from equations (1) and (2), we have the following relations

$$\mu_t = E^{-1}F\varepsilon_t \tag{5}$$

Multiplying both sides of equation (24) by E^{-1} gives the reduced form SVAR as

$$E\mu_t = F\varepsilon_t \tag{6}$$

The short-run restriction is now imposed on the E, F matrices of equation (6) and following from equation (6) yields

$$\mu_t \mu_t^{'} = E^{-1} F \varepsilon_t \varepsilon_t^{'} F^{'} (E^{-1})^{'} \tag{7}$$

Taking expectations on both sides of equation (7) generates

$$E(\mu_t \mu_t^{'}) = E\{E^{-1} F \varepsilon_t \varepsilon_t^{'} F^{'} (E^{-1})^{'}\}$$

$$E(\mu_t \mu_t^{'}) = E^{-1} F F^{'} E(\varepsilon_t \varepsilon_t^{'})(E^{-1})^{'}$$

$$E(\mu_t \mu_t^{'}) = E^{-1} F F^{'} (E^{-1})^{'}; E(\varepsilon_t \varepsilon_t^{'}) = I_N \tag{8}$$

The structural and reduced form VAR nexus is captured by equation (8). Now recall the identities: $E(\varepsilon_t \varepsilon_t^{'}) = \Psi = I_N; E(\varepsilon_t \varepsilon_t^{'}) = \Omega$. From equation (8),

$$E(\mu_t \mu_t^{'}) = \Omega = E^{-1} F F^{'} (E^{-1})^{'} \tag{9}$$

where Ω is a symmetric matrix with $\frac{\tau(\tau+1)}{2}$ elements of different magnitude. This restriction identifies the structural VAR system. To impose short-run restriction, equation (9) hinges on the precondition that the VAR system is exactly identified, implying that the variance-covariance matrix of the residual in equation (2), $E(\mu_t \mu_t^{'}) = \Omega$, means that we impose $\frac{\tau(\tau+1)}{2}$ restrictions on the $2\tau^2$ of unknown elements in each of the E and F matrix, so that we now have $2\tau^2 - \frac{\tau(\tau+1)}{2} = \frac{(3\tau^2-\tau)}{2}$ restrictions in the two matrices to generate the recursive identification of the system by imposing further restriction on the SVAR model in equation (2).

Unlike the recursive case, where the ordering of the endogenous variables is mandatory to start from the non-policy variable and end with policy variable, for the non-recursive case, the ordering could start with policy endogenous variables and end with non-policy variables. Importantly, the ordering is expected to be based on economic interpretation. The imposition of short-run restrictions is similar to that of the recursive case discussed earlier. Hence, based on the ordering reserve money, exchange rate, treasury bills rate, broad money, inflation and real GDP, a non-recursive identification procedure is formulated for the E, F model as follows:

$$E = \begin{pmatrix} 1 & e_{12} & e_{13} & e_{14} & e_{15} & e_{16} \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & e_{32} & 1 & 0 & 0 & 0 \\ 0 & e_{42} & e_{43} & 1 & 0 & 0 \\ 0 & e_{52} & e_{53} & e_{54} & 1 & 0 \\ 0 & e_{62} & e_{63} & e_{64} & 0 & 1 \end{pmatrix}; F \begin{pmatrix} f_{11} & 0 & 0 & 0 & 0 & 0 \\ 0 & f_{22} & 0 & 0 & 0 & 0 \\ 0 & 0 & f_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & f_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & f_{55} & 0 \\ 0 & 0 & 0 & 0 & 0 & f_{66} \end{pmatrix} \tag{10}$$

Based on the non-recursive identification scheme in equation (10), the first row shows contemporaneous effect of reserve money on exchange rate, treasury bills rate, broad money, inflation and real GDP. The second row indicates contemporaneous effect of exchange rate on itself. The third row shows contemporaneous effect of treasury bills rate on broad money and treasury bills rate on inflation and real GDP etc. Therefore, the above restrictions are imposed in matrix form as:

$$E=\begin{pmatrix}1 & NA & NA & NA & NA & NA\\ 0 & 1 & 0 & 0 & 0 & 0\\ 0 & NA & 1 & 0 & 0 & 0\\ 0 & NA & NA & 1 & 0 & 0\\ 0 & NA & NA & NA & 1 & 0\\ 0 & NA & NA & NA & 0 & 1\end{pmatrix};F\begin{pmatrix}NA & 0 & 0 & 0 & 0 & 0\\ 0 & NA & 0 & 0 & 0 & 0\\ 0 & 0 & NA & 0 & 0 & 0\\ 0 & 0 & 0 & NA & 0 & 0\\ 0 & 0 & 0 & 0 & NA & 0\\ 0 & 0 & 0 & 0 & 0 & NA\end{pmatrix} \quad (11)$$

Moreover, this identification scheme is mostly followed by countries on the IMF Extended Credit Facility (ECF) programme, which adopt reserve money targeting framework. The Sierra Leone economy is one with a lot of institutional and structural encumbrances that have contributed a lot to the current predicament of the country. Hence, to test the hypothesis on the transmission channel of monetary policy in Sierra Leone, the study adopts a non-recursive structural VAR technique as described above.

Hence, estimating the SVAR requires a baseline model that captures four variables including reserve money, broad money, CPI inflation and real GDP. Following Tucker (2005), Ogunkola and Tarawalie (2008) and Davoodi et al. (2013) and Ngalawa & Viegi (2017), the vector of endogenous variables that are incorporated is given below. This baseline model comes with the identification scheme that has been earlier discussed in the equation.

$$\begin{pmatrix}1 & 0 & 0 & 0\\ e_{21} & 1 & 0 & 0\\ 0 & 0 & 1 & 0\\ 0 & 0 & e_{43} & 1\end{pmatrix}\begin{pmatrix}\mu_t^{rm}\\ \mu_t^{rm2}\\ \mu_t^{\inf}\\ \mu_t^{rgdp}\end{pmatrix}=\begin{pmatrix}f_{11} & 0 & 0 & 0\\ 0 & f_{22} & 0 & 0\\ 0 & 0 & f_{33} & 0\\ 0 & 0 & 0 & f_{44}\end{pmatrix}\begin{pmatrix}\varepsilon_t^{rm}\\ \varepsilon_t^{rm2}\\ \varepsilon_t^{\inf}\\ \varepsilon_t^{rgdp}\end{pmatrix} \quad (12)$$

Equation (9) provides the platform to investigate how policy actions trickle down to real sector variables in Sierra Leone by incorporating the indicator of each transmission channel into the baseline model respectively. The interest rate channel functions within the framework of the IS-LM model, where households and firms alter decisions on consumption and investment decisions that are based on prevailing interest rate in the market. In general, an increase in real interest rate triggers a decline in investment decisions of economic agents. This trickle down to consumption, and thus leads to a fall in output (Mishkin, 1995). The 91-day treasury bills rate is used as indicator of the interest rate channel, and is thus included in the baseline model as follows.

$$\begin{pmatrix}1 & 0 & 0 & 0 & 0\\ e_{21} & 1 & 0 & 0 & 0\\ e_{31} & e_{32} & 1 & 0 & 0\\ 0 & 0 & 0 & 1 & 0\\ 0 & e_{52} & e_{53} & 0 & 1\end{pmatrix}\begin{pmatrix}\mu_t^{rm}\\ \mu_t^{tbr}\\ \mu_t^{rm2}\\ \mu_t^{\inf}\\ \mu_t^{rgdp}\end{pmatrix}=\begin{pmatrix}f_{11} & 0 & 0 & 0 & 0\\ 0 & f_{22} & 0 & 0 & 0\\ 0 & 0 & f_{33} & 0 & 0\\ 0 & 0 & 0 & f_{44} & 0\\ 0 & 0 & 0 & 0 & f_{55}\end{pmatrix}\begin{pmatrix}\varepsilon_t^{rm}\\ \varepsilon_t^{tbr}\\ \varepsilon_t^{rm2}\\ \varepsilon_t^{\inf}\\ \varepsilon_t^{rgdp}\end{pmatrix} \quad (13)$$

The exchange rate channel is represented by the nominal exchange rate and given that Sierra Leone is a high import dependent country, the effect of exchange rate can be felt on both economic growth and inflation. Hence, the nominal exchange rate has been included in the baseline model to capture the effect of external sector on the country's economy as follows:

$$\begin{pmatrix}1 & 0 & 0 & 0 & 0\\ e_{21} & 1 & 0 & 0 & 0\\ e_{31} & e_{32} & 1 & 0 & 0\\ 0 & 0 & e_{43} & 1 & 0\\ 0 & 0 & e_{53} & e_{54} & 1\end{pmatrix}\begin{pmatrix}\mu_t^{rm}\\ \mu_t^{exr}\\ \mu_t^{rm2}\\ \mu_t^{\inf}\\ \mu_t^{rgdp}\end{pmatrix}=\begin{pmatrix}f_{11} & 0 & 0 & 0 & 0\\ 0 & f_{22} & 0 & 0 & 0\\ 0 & 0 & f_{33} & 0 & 0\\ 0 & 0 & 0 & f_{44} & 0\\ 0 & 0 & 0 & 0 & f_{55}\end{pmatrix}\begin{pmatrix}\varepsilon_t^{rm}\\ \varepsilon_t^{exr}\\ \varepsilon_t^{rm2}\\ \varepsilon_t^{\inf}\\ \varepsilon_t^{rgdp}\end{pmatrix} \quad (14)$$

The bank lending channel of monetary policy transmission belongs to the credit market channel where costly information as a results of asymmetric information in the credit market creates moral hazard and adverse selection between borrowers and lenders. According to Bernanke and Gertler (1995), this channel functions well in situations where emphases are laid on the quantum of credit available in the market instead of the price of credit given out to customers. Hence, an increase in the quantity of credit propels investment and economic growth while a decrease impedes growth and investment. Thus, the main indicator used to represent this channel is credit available to the private sector. It is believed that deposits taking institutions normally take time to grant customers credit as a result of information asymmetry and so credit to private sector is often ordered after the policy rate (Davoodi et al. (2017).

$$\begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ e_{21} & 1 & 0 & 0 & 0 \\ e_{31} & e_{32} & 1 & 0 & 0 \\ 0 & 0 & e_{43} & 1 & 0 \\ 0 & 0 & e_{53} & e_{54} & 1 \end{pmatrix} \begin{pmatrix} \mu_t^{rm} \\ \mu_t^{cps} \\ \mu_t^{rm2} \\ \mu_t^{\inf} \\ \mu_t^{rgdp} \end{pmatrix} = \begin{pmatrix} f_{11} & 0 & 0 & 0 & 0 \\ 0 & f_{22} & 0 & 0 & 0 \\ 0 & 0 & f_{33} & 0 & 0 \\ 0 & 0 & 0 & f_{44} & 0 \\ 0 & 0 & 0 & 0 & f_{55} \end{pmatrix} \begin{pmatrix} \varepsilon_t^{rm} \\ \varepsilon_t^{cps} \\ \varepsilon_t^{rm2} \\ \varepsilon_t^{\inf} \\ \varepsilon_t^{rgdp} \end{pmatrix} \tag{15}$$

From equations (12), (13), (14) and (15), $\mu_t^{rm}, \mu_t^{rm2}, \mu_t^{\inf}, \mu_t^{rgdp}, \mu_t^{tbr}, \mu_t^{exr}, \mu_t^{cps}$ are the structural disturbances of reserve money shock, broad money shock, inflation shock, real GDP shock, treasury bill rate shock, exchange rate shock and credit to private sector shock respectively, while $\varepsilon_t^{rm}, \varepsilon_t^{rm2}, \varepsilon_t^{\inf}, \varepsilon_t^{rgdp}, \varepsilon_t^{tbr}, \varepsilon_t^{exr}, \varepsilon_t^{cps}$ are reduced form residuals that describe the unexpected movements of each regressor in the SVAR model.

Table 1. Summary of data, measurement and sources

Variable	**Measurement**	**Sources**
Real Gross Domestic Product (RGDP)	Gross Domestic Product at constant prices using 2005 as base year	Statistics Sierra Leone (Stats SL)
Nominal Exchange Rate (ER)	Quarterly average of the price of one US dollar against the Leone	Bank of Sierra Leone (BSL)
Monetary aggregates (M1 and M2)	Net claims on government plus currency in circulation at hands of the public and in commercial banks' vaults	Bank of Sierra Leone (BSL)
Inflation (INF)	Growth rate of the consumer price index	Bank of Sierra Leone (BSL)
Treasury Bill Rate (TBR)	91-Day Treasury Bill Rate	Bank of Sierra Leone (BSL)
Reserve Money	Currency issued plus commercial banks' reserves	Bank of Sierra Leone
Lending Rate	Commercial banks' rate	International Financial Statistics
Credit to the Private Sector	Credit to Other Depository Corporations	Bank of Sierra Leone

Source: Compiled by Author from the Bank of Sierra Leone (various sources)

4. Presentation and Analysis of Empirical Results

Ouliaris, Pagan and Restrepo (2018) presented three techniques that determine the lag length of the VAR model. These include theoretical constructs, rule of thumb and some statistical criteria that off set fit against the number of parameters to be fitted. The study adopted statistical criteria including the AIC, SC and HQ information criteria while using log likelihood as measure of fit. Appendix A1 presents results of the lag order selection criteria. It reveals that the model chooses lag one based on the Schwarz Information, lag two based on the Hannan-Quinn Information and lag three based on the Akaike Information Criteria respectively. This is not a surprise because the SC prefers smaller models compared to the AIC and HQ. Thus, the SC is normally preferred to the other criteria since it is unreasonable to estimate a large number of parameters with small sample as is the case in this study.

Rummel (2015) suggested the matrix form restrictions as a means of identifying short-run restrictions. This is done by creating two matrices based on the Blanchard and Quah (1989) model. Short-run restrictions are imposed as a way to exhume the structural shocks that are inherent in the VAR model. Table 2 presents the short-run restrictions of the structural VAR estimates. The table shows that the structural VAR model exhibits convergence and that the model is exactly identified. This warrants plots of the impulse response functions and variance decomposition analysis.

Table 2. Short-run Restrictions of Structural VAR Results

Log Likelihood: 466

Estimated E matrix:		
1.0000	0.0000	0.0000
-0.2553	1.0000	0.0000
-0.1285	0.1646	1.0000
0.0388	0.0000	0.0000
0.0000	0.0343	0.0000
0.0000	0.0000	0.0101
Estimated F matrix:		
0.0388	0.0000	0.0000
0.0099	0.0343	0.0000
0.0034	-0.0057	0.0101
0.1320	0.0829	0.0699
0.0472	0.1047	0.0224
0.0524	0.0483	0.0875

Source: Author's Estimation using E-Views 10

Two key results from the VAR outputs are discernable, which include the impulse response functions; which trace how a shock to an innovation of a VAR system impacts the endogenous variables in the model, and the forecast error variance decomposition. However, for identified and convergence structural vector autoregression, emphasis is placed on how the various indicators in the system react to structural shocks through dynamic interactions between endogenous variables in the VAR model (Rummel, 2015). Thus, the moment the structural VAR was identified and estimated, the IRF and VDA were then used to analyse the impacts of the structural shocks. This was done by bootstrapping the standard error bands through structural decomposition. The method of bootstrapping is relevant when the sample size is very small as is the case in this study. Figures 13 and 14 depict the respective structural shocks in response to standard deviation innovations to each of the series in the baseline model. These results are discussed below, using outputs from the IRF and VDA.

The baseline model in this study was based on Fisher (1911) equation of exchange or quantity theory of money given that Sierra Leone's monetary policy framework is based on targeting the monetary aggregates (quantity of money) in the economy. In this regard, reserve money is a critical variable and was used in this study as one of the instruments of monetary policy. Reserve money has been widely used as indicator of policy instrument in several jurisdictions, especially for countries on the IMF extended credit facility programme that use monetary aggregate targeting framework using reserve money as the main policy target (Davoodi et al., 2013). Figure 1 depicts results of the impulse response function to shocks in reserve money for the baseline model. The figures depict that an expansionary monetary policy through increase in reserve money induces expansion of broad money, and consequently, triggers increase in inflation as posited in the quantity theory of money.

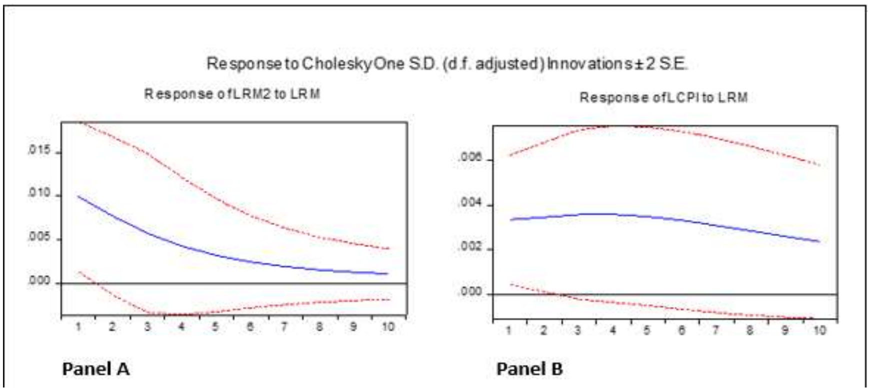

Figure 1. The effect of Expansionary Policy Shocks on Broad Money and prices (Baseline Model)

However, the baseline model is further augmented by introducing nominal exchange rate to ascertain the effect of expansionary policy on nominal exchange rate and inflation. Similarly, Figure 2 depicts impulse response function of shock to reserve money and its impact on exchange rate and inflation. The figure depicts that expansionary monetary policy leads to an increase in broad money.

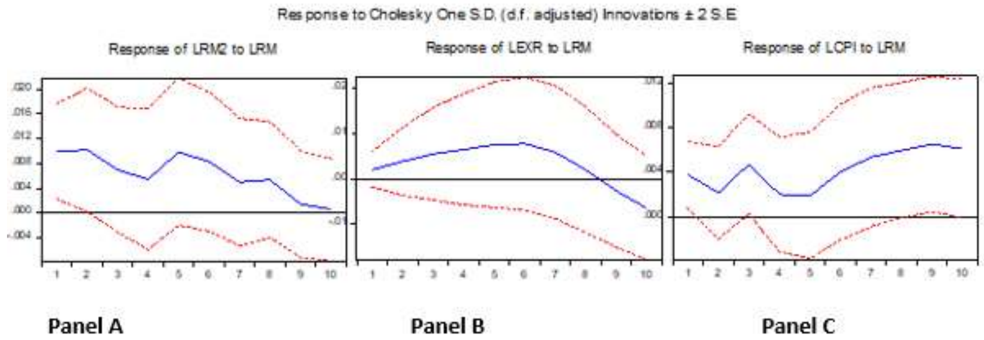

Figure 2. The impact of Expansionary Monetary shocks on Broad Money, Nominal Exchange Rate and CPI Inflation

The expansion in broad money further creates hike in inflation, and this ultimately depreciate the exchange rate. This depreciation makes the Leone less competitive in the international market.

In line with the third hypothesis of the study, channels of the transmission of monetary policy in Sierra Leone were presented and discussed going forward. According to theory, if the money multiplier is constant, it implies change in reserve money translates into change in broad money by an amount equivalent to the coefficient of the money multiplier (Bahmani-Oskooee & Wang, 2007). The key channels of monetary policy transmission that have been identified in the literature for the case of Sierra Leone consist of the exchange rate channel, bank lending channel and the interest rate channel. The impulse response functions of each of the channels are presented below:

The exchange rate channel has been accounted for with the introduction of nominal exchange rate variable in the baseline model. The ordering is based on the Uncovered Interest Rate Parity (UIP) theory. The UIP theory assumes that an expansionary monetary policy triggers either currency substitution or import or a combination of both. This results to exchange rate pressure and thus culminates into inflation through pass-through effect of exchange rate to inflation phenomenon (Bangura, Caulker & Pessima, 2012). Figure 3 depicts impulse response functions of the exchange rate channel of the transmission of monetary policy in Sierra Leone.

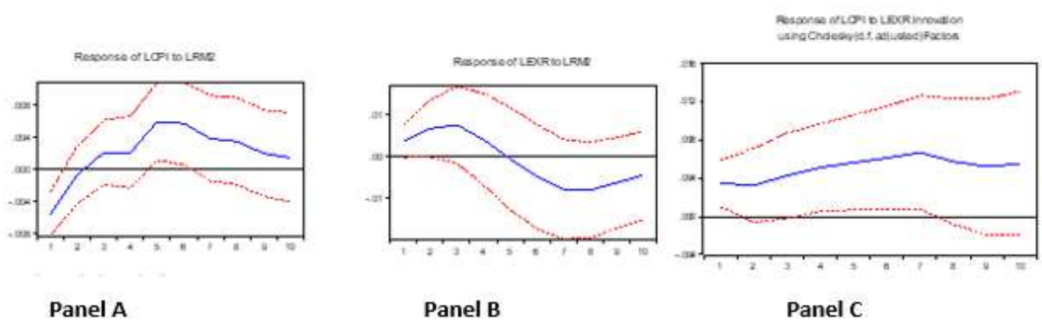

Figure 3. The exchange rate channel

Panel A shows that shocks to broad money propels inflation after quarter two and onwards. Panel B shows that shocks to broad money creates exchange rate pressure leading to depreciation of the domestic currency. Finally, Panel C indicates that shocks to exchange rate induces high and persistent inflation rate. Intuitively, expansionary monetary policy shocks lead to inflationary pressure through exchange rate pass-through. This result supports Tucker (2005), Toe' et al. (2009) and Morlai et al. (2012), but contradicts Ogunkola & Tarawalie (2008) and Lavally & Nyambe (2019). Hence, the exchange rate channel has been identified to be effective in the transmission of policy effects to the economy. The exchange rate has proved to be a disturbance in the conduct of monetary policy in Sierra Leone because of its persistence depreciation over the last decade. Currently, it is in the region of Le10,500/US$. If the monetary authorities are able to minimize fluctuations in the exchange rate, it will go a long way in enhancing other macroeconomic indicators and thus propels smooth policy implementation in the country.

The bank lending channel of monetary policy transmission was investigated with the inclusion of credit to private sector as proxy for bank lending variable into the baseline model. Figure 4 depicts impulse response function of this channel. According to the figure, shock to reserve money does not impact credit to private sector, but does impact both broad money and inflation.

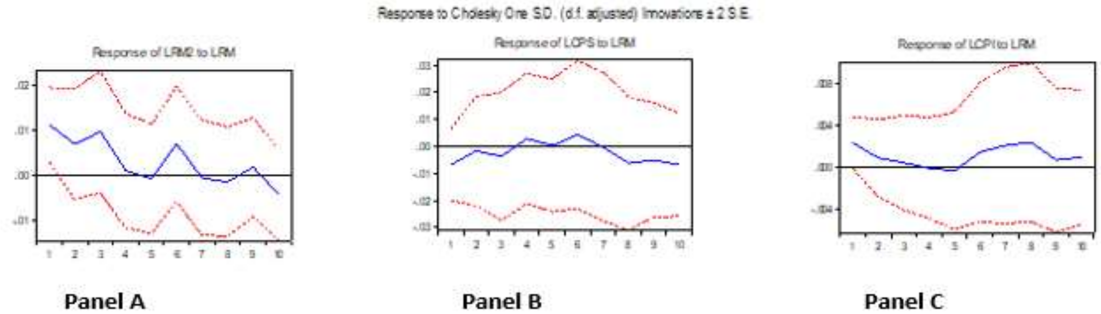

Figure 4. The bank lending channel

The implication is that, the bank lending channel of monetary policy transmission is not effective and perhaps, might be attributable to the risk averse behavior of banks and thus, only extend credit to risk free asset such as government securities instead of extending credit to the private sector. This is not surprising, as Sierra Leone records one of the highest non-performing loans (NPLs) in the ECOWAS sub-region.

The interest rate channel is examined with Treasury bill in the baseline model. The results are depicted below in Figure 5. Figure depicts that shock to reserve money leads to increase in broad money. The increase in broad money spurs inflationary pressure but with a low interest rate. The low interest rate means economic agents have the propensity to attract more credit from the banks, and ultimately propels consumption and investment in the economy. The ultimate effect is an increase in inflation, making this channel ineffective in transmitting monetary policy effect to the economy.

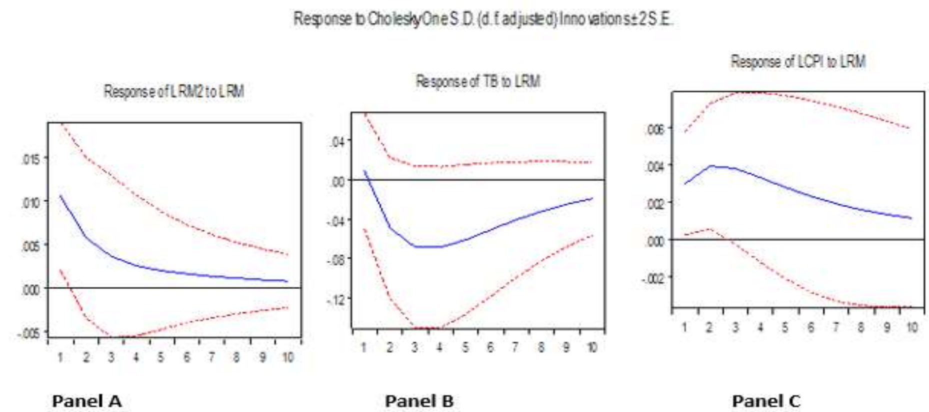

Figure 5. Interest rate channel

The variance decomposition analysis helps to explain systematically the forecast error variance decomposition of all the key variables in the structural vector autoregressive model. This was done with reference to short-run and long-run analyses. The study considered ten quarters as the forecast period. This means the short-run is indicated by quarter one through quarter five, while the long-run is indicated by quarter six through quarter ten. Tables 2 to 5 present the variance decomposition analyses of the respective models. First to describe is the variance decomposition of the baseline model.

Table 2.Variance Decomposition Result of the Baseline Model

Period	S. E.	Reserve Money	Broad Money	CPI Inflation
1	0.0388	7.6977	21.9055	70.3968
2	0.0453	9.8687	13.6656	76.4658
3	0.0453	11.5833	11.9186	76.4982
4	0.0500	12.8709	12.8677	74.2614
5	0.0513	13.8311	14.5312	71.6377
6	0.0521	14.5501	16.1608	69.2886
7	0.0528	15.0933	17.5414	67.3653
8	0.0533	15.5052	18.6497	65.8451
9	0.0536	15.8198	19.5204	64.6598
10	0.0539	16.0615	20.1993	63.7393
Cholesky Ordering: Reserve Money (RM) Broad Money (RM2) CPI-Inflation (CPI)				

Source: Author's Estimation using E-Views 10

According to the table, about 31% of variance in inflation is explained by reserve money and broad money in quarter one. However, it is observed in the long-run that about 30% of the variance in inflation is explained by reserve money and broad money. This trend continues up to the tenth quarter. The implication is that; inflation is indeed a monetary phenomenon in Sierra Leone. Hence, to achieve price stability, the BSL should focus on the control of reserve money and broad money.

Results of the VDAs are presented in tables 3, 4 and 5 respectively. Consequently, table 3 presents the variance decomposition analysis of the exchange rate channel. The table shows that during the period, reserve money accounted moderately about 0.3% on average of the forecast error variance in exchange rate in the short-run and about 4.0% in the long-run. This means that reserve money moderately predicts exchange rate. Similarly, broad money accounted for between 5.0% to 9.0% of the forecast error variance in exchange rate, thus indicating that broad money relatively predict exchange rate than reserve money.

Table 3. Variance Decomposition Result for Exchange Rate Channel

Period	S.E.	LRM	LRM2	LEXR	LCPI
1	0.0362	0.3473	5.7641	93.8886	0.0000
2	0.0417	0.2169	8.1492	90.5082	1.1258
3	0.0435	0.2008	9.2370	87.2054	3.3568
4	0.0442	0.3067	9.3583	83.9584	6.3766
5	0.0445	0.5967	8.9001	80.5928	9.9104
6	0.0446	1.1125	8.1884	77.0058	13.6933
7	0.0447	1.8544	7.4621	73.2055	17.4781
8	0.0448	2.7852	6.8728	69.2842	21.0578
9	0.0448	3.8455	6.4956	65.3740	24.2849
10	0.0449	4.9695	6.3483	61.6061	27.0762
Cholesky Ordering: Reserve Money (RM) Broad Money (RM2) Nominal Exchange Rate (EXR) CPI-Inflation (CPI)					

Source: Author's Computation using E-Views 10

Also, inflation accounts for 9.0% of the variation in exchange rate in the short-run and around 27% in the long-run. This shows that inflation is a stronger predictor of the exchange rate compared to reserve money and broad money. This is consistent with the purchasing power parity (PPP) theory which assumes that exchange rate is determined by the relative price of the ratio of both domestic and foreign inflation (Tucker, 2005; Ogunkola & Tarawalie, 2008; Ngalawa & Viegi, 2011). Finally, about 93% of the forecast error variance in exchange rate is explained by itself in the short-run, while 62% of the variation is explained by itself in the long-run. This means that current pricing decisions in the foreign exchange market are effects of the past decisions. This exhibits strong inertia. Hence, any stabilization policy on exchange rate should take into consideration the past dynamic behaviour of exchange rate. This shows why the exchange rate channel has been considered potent in the transmission of monetary policy effect to the real sector. Similarly, table 4 presents the variance decomposition of the bank lending channel. According to table 5, in the short-run, throughout the quarters, the forecast error variance of both reserve money and broad money account weakly to variation in credit to private sector. However, inflation accounts for about 3.0% and 17% of the forecast error variance in credit to private sector. Accordingly, 99% of the variance in credit to private sector is accounted by itself in the short term, and at the same time 78% in the long term thereby rendering this channel weak in transmitting monetary policy to the real sector. This should not be surprising, as the financial market in the country is still underdeveloped with a lot of structural rigidities.

Table 4. Variance Decomposition Result of the Banking Lending Channel

Period	S.E.	LRM	LRM2	LCPS	LCPI
1	0.0373	0.1426	0.7716	99.0859	0.0000
2	0.0445	0.1372	1.4871	97.0609	1.3148
3	0.0475	0.1424	1.9661	94.3058	3.5857
4	0.0489	0.1261	2.1342	91.4833	6.2564
5	0.0496	0.1661	2.0928	88.7846	8.9568
6	0.0500	0.3148	1.9925	86.2477	11.4450
7	0.0502	0.5780	1.9531	83.8864	13.5825
8	0.0503	0.9284	2.0343	81.7237	15.3137
9	0.0504	1.3257	2.2420	79.7867	16.6456
10	0.0505	1.7312	2.5491	78.0958	17.6239
Cholesky Ordering: Reserve Money (RM) Broad Money (RM2) Credit to Private Sector (CPS) CPI-Inflation (CPI)					

Source: Author's Computation using E-Views 10

Finally, table 5 describes VDA of the interest rate channel in which Treasury bill is used as short-term interest rate. Table 5 shows that about 10% of the variation in reserve money is attributable to interest rate, while 16% of the variance in reserve money is explained by variation in interest rate. Similarly, inflation accounts weakly to the forecast error variance interest rate. However, about 99% of the variation in interest rate is explained by itself in the short-run, while 68% of the forecast error variance in interest rate is explained by itself in the long-run. Thus, the interest rate channel is ineffective in transmitting monetary policy to the real sector of the economy.

Table 5. Variance Decomposition Result of the Interest Rate Channel

Period	S.E.	LRM	LRM2	TBR	LCPI
1	0.0364	0.0005	0.5897	99.4098	0.0000
2	0.0427	3.0779	6.0303	90.8634	0.0285
3	0.0449	6.8067	9.6227	83.4081	0.1626
4	0.0458	10.0245	11.1081	78.4300	0.4375
5	0.0462	12.5025	11.3652	75.2916	0.8407
6	0.0465	14.2764	11.1447	73.2512	1.3277
7	0.0467	15.4693	10.8812	71.8070	1.8425
8	0.0468	16.2280	10.7488	70.6860	2.3371
9	0.0469	16.6882	10.7680	69.7630	2.7808
10	0.0470	16.9569	10.8956	68.9875	3.1601
Cholesky Ordering: Reserve Money (RM) Broad Money (RM2) 91-Day Treasury Bill Rate (TBR) CPI-Inflation (CPI)					

Source: Author's Computation using E-Views 10

The validity of the structural VAR model is based on both diagnostic and parameter stability tests. For all the SVAR models, tests for autocorrelation and normality were performed. Similarly, the stability of the SVAR model is guaranteed by roots of the characteristic polynomial and the inverse of the AR characteristic polynomial. If all the roots of the inverse AR characteristic polynomial lie inside the unit circle, it implies that the VAR model is stable. The implication is that, the impulse response functions generated from the coefficients of the models are valid. Hence, Appendences A1 to A5, B1 to B5, C1 to C5 and D1 to D5 describe the lag length selection criteria, diagnostic and parameter stability tests of the respective structural VAR models. The tests show that all the models passed the diagnostic and parameter stability tests.

5. Conclusion and Policy Recommendations

The structural VAR technique has been adopted to examine the transmission mechanism of monetary policy effect to the real economy in Sierra Leone. A baseline model was first estimated to establish the monetary policy reaction function of the Bank of Sierra Leone using reserve money as policy instrument. The choice of reserve money as instrument of monetary policy is well documented in the literature especially for countries that are on the IMF's extended credit facility programme that target monetary aggregates. The baseline model was then augmented with the inclusion of the 91-day treasury bills rate as proxy for the interest rate channel, credit to private sector as proxy for the bank lending channel and nominal exchange rate as indicator of the exchange rate channel. Results of the impulse response and variance decomposition identified the exchange rate channel as the ideal conduit through which monetary policy effect might be transmitted to the real sector of the Sierra Leonean economy. This reinforces the importance of the external sector in the country. Hence, efforts to reduce the degree of openness in the country in a bid to reduce burden on the reserve positions of the BSL should be enhanced. Monetary policy has been challenged in the country as a result of imported inflation via the pass-through effect of exchange rate to domestic prices. Given that the country's main staple food is rice and more than 40% of the country's foreign exchange reserves is spent annually on the importation of rice, it is advisable that the agricultural sector be revamped to enable the country produce rice locally. This will lessen the burden on the foreign exchange and give the Central Bank the leeway to control prices in the country. In other words, the potency of the exchange rate channel of transmitting monetary policy did not come as a surprise because in countries with weak macroeconomic fundamental, they tend to be exposed by the exchange rate and the exchnage rate has proved to be the key channel of transmitting policy in most developing countries including Sierra Leone with high import propensity. This is vital in the case of Sierra Leone given that Morlai et al. (2012) confirmed that the pass-through effect of exchange rate to prices is mostly attributable to the continuous and persistent depreciation in the exchange rate against the dollar. Hence, monetary policy should be geared towards stabilizing the exchange rate in both the short-run and long-run.

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APPENDICES

STRUCTURAL VECTOR AUTOREGRESSIVE SPECIFICATION TESTS

A. Baseline Model:

A1: Test for Optimal Lag Length

Lag	LogL	LR	FPE	AIC	SC	HQ
0	349.245	NA	3.79e-09	-10.879	-10.467	-10.717
1	443.700	167.580	2.41e-10*	-13.635*	-12.915*	-13.353
2	446.506	4.708	2.96e.-10	-13.436	-12.406	-13.032
3	453.453	10.981	3.20e-10	-13.369	-12.031	-12.844
4	466.309	19.076*	2.87e-10	-13.494	-11.847	-12.847
5	468.550	3.109	3.66e-10	-13.276	-11.320	-12.508
6	472.814	5.501	4.42e-10	-13.123	-10.859	-12.234

Source: Author's estimation. Note: * denotes lag order selected by the criterion; LR-Log Ratio; FPE- Final Prediction Error, AIC-Akaike Information Criterion, SC-Schwarz Information Criterion and HQ-Hannan-Quinn Information Criterion.

A2: Test for Stability

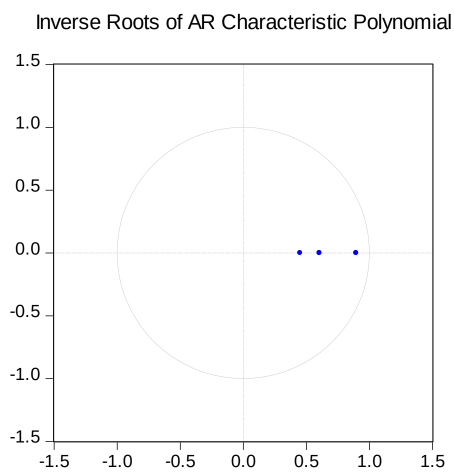
Roots of Characteristic Polynomial

Root	Modulus
0.8958	0.8958
0.6048	0.6048
0.4516	0.4516

No root lies outside the unit circle

VAR satisfies stability condition

A3: Inverse Roots of AR Characteristic Polynomial



A4: VAR Residual Serial Correlation LM Tests

Lag	LRE*stat	df	Prob.	Rao F-stat	df	Prob.
1	3.2556	9	0.9533	0.3567	(9, 134.0)	0.9533

*Edgeworth expansion corrected likelihood ratio statistic

A5: VAR Residual Normality Tests

Component	Skewness	Chi-sq	df	Prob.*
1	0.3173	1.1246	1	0.2889
2	-0.2274	0.5773	1	0.4474
3	0.1866	0.3890	1	0.5328
Joint		2.0908	3	0.5538

Component	Kurtosis	Chi-sq	df	Prob.

1	2.8691	0.0478	1	0.8269
2	4.0158	2.8807	1	0.0896
3	3.1908	0.1016	1	0.7499
Joint		3.0302	3	0.3870

Component	Jarque-Bera	df	Prob.
1	1.1724	2	0.5564
2	3.4580	2	0.1775
3	0.4905	2	0.7825
Joint	5.1210	6	0.5284

*Approximate p-values do not account for coefficient estimation

B. Exchange Rate Channel:

B1: Test for Optimal Lag Length

Lag	LogL	LR	FPE	AIC	SC	HQ
0	436.837	NA	1.70e-11	-13.446	-12.760	-13.177
1	610.772	297.373	1.05e-13	-18.541	-17.306*	-18.056
2	634.903	38.143	8.22e-14	-18.803	-17.019	-18.103*
3	648.223	19.335	9.26e-14	-18.717	-16.384	-17.801
4	670..020	28.828*	8.10e-14*	-18.904	-16.022	-17.772
5	680.636	12.670	1.05e-13	-18.730	-15.299	-17.383
6	698.593	19.115	1.11e-13	-18.793	-14.814	-17.231

Source: Author's estimation. Note: * denotes lag order selected by the criterion; LR-Log Ratio; FPE- Final Prediction Error, AIC-Akaike Information Criterion, SC-Schwarz Information Criterion and HQ-Hannan-Quinn Information Criterion.

B2: Test for Stability

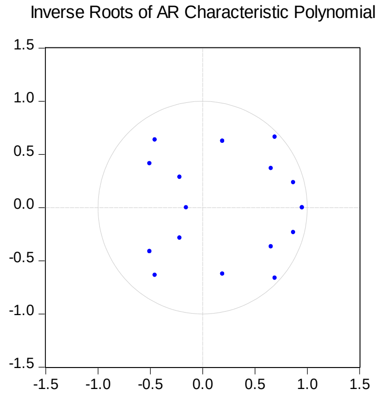
Roots of Characteristic Polynomial

Root	Modulus
0.691812 - 0.662642i	0.957965
0.691812 + 0.662642i	0.957965
0.952383	0.952383
0.868504 – 0.234629i	0.899638
0.868504 – 0.234629i	0.899638
-0.454494 – 0.636180i	0.781850
-0.454494 – 0.636180i	0.781850
0.655742 – 0.367521i	0.751711
0.655742 + 0.367521i	0.751711
0.191192 – 0.624630i	0.653236
0.191192 – 0.624630i	0.653236
-0.505122 – 0.413681i	0.652902
-0.505122 – 0.413681i	0.652902
-0.217605 – 0.285508i	0.358980
-0.217605 – 0.285508i	0.358980
-0.155873	0.155873

No root lies outside the unit circle

VAR satisfies the stability condition

B3: Inverse Roots of AR Characteristic Polynomial



B4: VAR Residual Serial Correlation LM Tests

Lag	LRE*stat	df	Prob.	Rao F-stat	df	Prob.
1	10.6284	16	0.8318	0.6538	(16, 110.6)	0.8326
2	24.1850	16	0.0855	1.5783	(16, 110.6)	0.0864
3	22.3820	16	0.1313	1.4491	(16, 110.6)	0.1324
4	21.1945	16	0.1712	1.3651	(16, 110.6)	0.1725

Lag	LRE*stat	df	Prob.	Rao F-stat	df	Prob.
1	10.6284	16	0.8318	0.6538	(16, 110.6)	0.8326
2	36.4481	32	0.2694	1.1624	(32, 119.6)	0.2761
3	48.9786	48	0.4336	1.0203	(48, 109.9)	0.4547
4	79.5718	64	0.0907	1.3067	(64, 96.2)	0.1164

*Edgeworth expansion corrected likelihood ratio statistic

B5: VAR Residual Normality Tests

Component	Skewness	Chi-sq	df	Prob.*
1	0.2328	0.5780	1	0.4471
2	-0.5521	3.2508	1	0.0714
3	-0.1816	0.3519	1	0.5531
4	0.0708	0.0534	1	0.8172
Joint		4.2340	4	0.3753

Component	Kurtosis	Chi-sq	df	Prob.
1	4.6040	6.8606	1	0.0088
2	4.0283	2.8197	1	0.0931
3	2.6154	0.3945	1	0.5299
4	2.5945	0.4384	1	0.5079
Joint		10.5133	4	0.0326

Component	Jarque-Bera	df	Prob.
1	7.4386	2	0.0243
2	6.0705	2	0.0481
3	0.7464	2	0.6885
4	0.4918	2	0.7820
Joint	14.7473	8	0.0642

*Approximate p-values do not account for coefficient estimation

C: Bank Lending Channel:

C1: Test for Optimal Lag Length

Lag	LogL	LR	FPE	AIC	SC	HQ
0	472.394	NA	7.02e-12	-14.335	-13.375	-13.958
1	553.652	133.682	8.64e-13	-16.440	-14.931*	-15.848*
2	565.318	17.688	1.02e-12	-16.301	-14.242	-15.492
3	576.091	14.943	1.26e-12	-16.132	-13.525	-15.108
4	598.896	28.690	1.08e-12	-16.352	-13.195	-15.112
5	618.044	21.618	1.08e-12	-16.453	-12.748	-14.998
6	650.538	32.495*	7.33e-13*	-16.985*	-12.731	-15.315

Source: Author's estimation. Note: * denotes lag order selected by the criterion; LR-Log Ratio; FPE- Final Prediction Error, AIC-Akaike Information Criterion, SC-Schwarz Information Criterion and HQ-Hannan-Quinn Information Criterion.

C2: Test for Stability

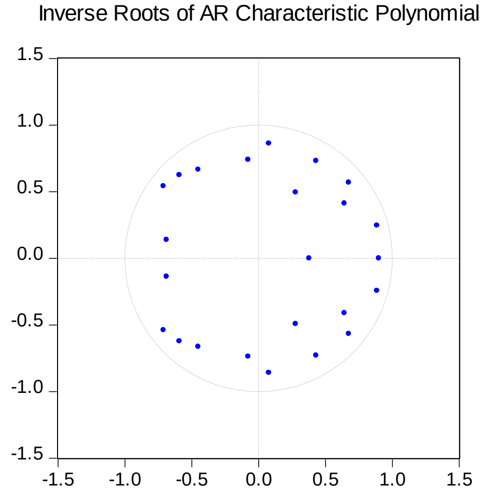
Roots of Characteristic Polynomial

Root	Modulus
0.887038 – 0.245102i	0.920278
0.887038 + 0.245102i	0.920278
0.901293	0.901293
-0.709348 + 0.540876i	0.892032
-0.709348 - 0.540876i	0.892032
0.676349 – 0.567780i	0.883075
0.676349 + 0.567780i	0.883075
0.078807 – 0.860038i	0.863641
0.078807 + 0.860038i	0.863641
-0.592019 + 0.623431i	0.859740
-0.592019 - 0.623431i	0.859740
0.432587 + 0.730904i	0.849325
0.432587 - 0.730904i	0.849325
-0.449253 – 0.664374i	0.802011
-0.449253 + 0.664374i	0.802011
0.644353 – 0.411893i	0.764752
0.644353 + 0.411893i	0.764752
-0.077439 – 0.738726i	0.742774
-0.077439 + 0.738726i	0.742774
-0.685680 – 0.137720i	0.699374
-0.685680 + 0.137720i	0.699374
0.278982 – 0.494054i	0.567380
0.278982 + 0.494054i	0.567380
0.379029	0.379029

No root lies outside the unit circle

VAR satisfies the stability condition

C3: Inverse Roots of AR Characteristic Polynomial



C4: VAR Residual Serial Correlation LM Tests

Lag	LRE*stat	df	Prob.	Rao F-stat	df	Prob.
1	14.5188	16	0.5601	0.9080	(16, 77.0)	0.5630
2	6.9534	16	0.9741	0.4153	(16, 77.0)	0.9744
3	19.0657	16	0.2653	1.2262	(16, 77.0)	0.2683
4	14.2826	16	0.5777	0.8920	(16, 77.0)	0.5805
5	25.7924	16	0.0570	1.7296	(16, 77.0)	0.0584
6	12.0383	16	0.7413	0.7416	(16, 77.0)	0.7434

Lag	LRE*stat	df	Prob.	Rao F-stat	df	Prob.

1	14.5188	16	0.5601	0.9080	(16, 77.0)	0.5630
2	29.1857	32	0.6097	0.8989	(32, 79.0)	0.6230
3	49.4081	48	0.4167	1.0213	(48, 67.5)	0.4627
4	67.9898	64	0.3430	1.0326	(64, 53.2)	0.4548
5	102.9899	80	0.0428	1.3343	(80, 37.9)	0.1641
6	151.9327	96	0.0002	1.8487	(96, 22.3)	0.0491

*Edgeworth expansion corrected likelihood ratio statistic

C5: VAR Residual Normality Tests

Component	Skewness	Chi-sq	df	Prob.*
1	0.0250	0.0065	1	0.9360
2	-0.1365	0.1924	1	0.6609
3	-0.1421	0.2086	1	0.6479
4	-0.2275	0.5349	1	0.4646
Joint		0.9424	4	0.9184

Component	Kurtosis	Chi-sq	df	Prob.
1	3.2119	0.1160	1	0.7334
2	2.4637	0.7431	1	0.3887
3	3.0076	0.0001	1	0.9903
4	2.2023	1.6439	1	0.1998
Joint		2.5032	4	0.6441

Component	Jarque-Bera	df	Prob.
1	0.1224	2	0.9406
2	0.9356	2	0.6264
3	0.2088	2	0.9009
4	2.1788	2	0.3364
Joint	3.4456	8	0.9034

*Approximate p-values do not account for coefficient estimation

D: Interest Rate Channel:

D1: Test for Optimal Lag Length

Lag	LogL	LR	FPE	AIC	SC	HQ
0	332.322	NA	4.96e-10	-10.0749	-9.389	-9.805
1	454.274	208.499	1.64e-11*	-13.493*	-12.258*	-13.008
2	462.930	13.682	2.11e-11	-13.256	-11.472	-12.555
3	475.637	18.446	2.42e-11	-13.150	-10.817	-12.234
4	500.082	32.330*	1.95e-11	-13.422	-10.540	-12.290
5	507.605	8.979	2.78e-11	-13.149	-9.718	-11.802
6	522.584	15.946	3.24e-11	-13.116	-9.136	-11.553

Source: Author's estimation. Note: * denotes lag order selected by the criterion; LR-Log Ratio; FPE- Final Prediction Error, AIC-Akaike Information Criterion, SC-Schwarz Information Criterion and HQ-Hannan-Quinn Information Criterion.

D2: Test for Stability

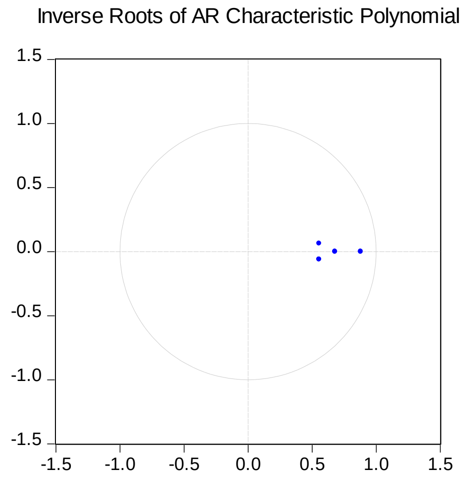
Roots of Characteristic Polynomial

Root	Modulus
0.881255	0.881255
0.679889	0.679889
0.556814 – 0.062245i	0.560282
0.556814 + 0.062245i	0.560282

No root lies outside the unit circle

VAR satisfies the stability condition

D3: Inverse Roots of AR Characteristic Polynomial



D4: VAR Residual Serial Correlation LM Tests

Lag	LRE*stat	df	Prob.	Rao F-stat	df	Prob.
1	10.9666	16	0.8115	0.6786	(16, 156.4)	0.8120

*Edgeworth expansion corrected likelihood ratio statistic

D5: VAR Residual Normality Tests

Component	Skewness	Chi-sq	df	Prob.*
1	0.3368	1.2665	1	0.2604
2	-0.1023	0.1169	1	0.7324
3	-0.0936	0.0978	1	0.7545
4	-0.0006	4.17E-06	1	0.9984
Joint		1.4811	4	0.8300

Component	Kurtosis	Chi-sq	df	Prob.
1	2.8167	0.0938	1	0.7595
2	4.4868	6.1715	1	0.0130
3	4.0389	3.0132	1	0.0826
4	2.6598	0.3230	1	0.5698
Joint		9.6015	4	0.0477

Component	Jarque-Bera	df	Prob.
1	1.3602	2	0.5066
2	6.2884	2	0.0431
3	3.1110	2	0.2111
4	0.3230	2	0.8509
Joint	11.0827	8	0.1971

*Approximate p-values do not account for coefficient estimation