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The Impact of Monetary Policy on the Economy: A Case of Sri Lanka

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Abstract: Central Banks (CB) formulate and implement monetary policy as a stabilization policy to achieve macroeconomic goals of countries' economic growth while maintaining low and steady inflation. Accordingly, this study focuses on empirical investigation of the impact of monetary policy to the macroeconomic variables in the Sri Lankan economy. This study uses the recursive Structural Vector Autoregressive (SVAR) methodology to determine the impact of monetary policy decisions on the Gross Domestic Product (GDP), Inflation, Weighted Average Call Money Rate (WACMR) and Exchange of Sri Lanka. The model captures time series data from 1990 to 2016 on a quarterly basis. The econometrics estimate follows cholesky factorizations to determine the contemporaneous impact on policy shocks to the given macroeconomic variables. The results of the study are interpreted by the variance decomposition and impulse response function. Further, the results of are broadly consistent with the theoretical expectations and empirical studies. The study finds that there is a positive impact of money supply growth to the GDP and negative relationship of interest rate to the GDP and to the exchange rate. But this analysis study fails to provide a significant relationship of money to inflation during the selected period. Hence, Central Bank of Sri Lanka (CBSL) must keep their attention on new policy formulations to strengthen aforementioned relationship. Further, this comprehensive assessment on monetary policy transmission towards key macroeconomic variables reduces the research gap in this field of economics in Sri Lanka.

Keywords: Monetary Policy, Macroeconomic Variables, SVAR, Variance Decomposition, Impulse Response Function

1. Introduction

1.1. Background of the Study

The role of monetary policy is vital in macroeconomic management. Central Banks (CB) use monetary policy as a stabilization policy to achieve macroeconomic goals of countries' economic growth, while maintaining low and steady inflation. Hence, the effectiveness of monetary policy formulation and implementation is very important to retain smooth functioning of the macro economy. To attain such ultimate targets, CB is following different monetary policy strategies.

Apart from selecting appropriate monetary policy framework, policy makers focus more on transmission of monetary policy. More importantly, there are several factors, which influence the transmission efficiency of such policy shocks to the macro economy. Such as openness of the economy, exchange rate regimes, performance of financial sector etc. Hence, each country requires continuous monetary policy assessment studies to evaluate the efficiency of policy formulation, implementation, and transmission to the macro economy.

CBs use multiple monetary policy tools to implement monetary policy decisions to achieve such macroeconomic policy targets. Open Market Operations (OMO), statutory reserve requirement and standing facilities are most common monetary policy tools used in CBs. In modern CBs, mostly select policy interest rates and monetary base as operating and intermediate targets of the monetary policy operations to achieve ultimate target of low and steady inflation, to maintain required standards of macroeconomic variables [1]. Considering the number of studies and attention of the economists, the impact of monetary policy on the macroeconomic variables is indisputably at the top of the study of monetary economics.

1.2. Monetary Policy to Macro-Economy

The vast number of empirical studies in global context investigate the relationship between monetary policies to macroeconomic variables. Those studies use different variables to measure the impact and in some instances the output generates inconsistent results. The main reason behind such inconsistency is the dynamic behavior of the economy due to various external and internal shocks. Those shocks affect macroeconomic variables in the long term and short term [2].

To address the challenge of identifying the impact of monetary policy on the economy, there are several econometrics models. In 1980, Sims introduced Vector Autoregressive (VAR) models to address this issue. Here in after the most studies followed this multivariate model to identify impact of monetary policy shocks to the macroeconomic variables. In 1992, again Sims and Zha presented advanced model of Structural VAR model with the contemporaneous restrictions. These models have become more popular among economists to identify the contemporaneous impact of the macro-economic variables after monetary policy shock.

Kilian, developed various VAR models to support different scenarios in monetary policy shocks [3]. Further, Walsh studied mostly on long run and short run impact of monetary policy to the economy and reasons for the inconsistencies in expected impact and the resultant impact [18]. In Sri Lankan context Amarasekara and Vinayagathasan used structural VAR models to investigate the impact of monetary policy to the macro economy [4, 5].

1.3. Significance of This Research to Sri Lanka

With the end of internal conflict in 2008, at percent the country is in an economic expansionary condition to go beyond the level of lower middle-income country. As a result of that the Central Bank of Sri Lanka (CBSL) follows accommodative monetary policy stances to facilitate to obtain higher economic growth with stable macro-economic environment.

As many other central banks, the objective of the Central Bank of Sri Lanka (CBSL) is to maintain economic and price stability and maintain financial sector stability. After the introduction of some monetary policy amendments in 2003, CBSL use indirect monetary policy instruments for monetary operations. From 2015 onwards Sri Lanka is gradually moving to the inflation targeting from the monetary targeting framework. At present, CBSL is following monetary targeting policy framework with the different monetary policy tools towards price stability.

CBSL targets reserve money levels and monitors economic growth, movements in the exchange rate market and interaction of monetary policy and fiscal policy. To observe such an impact on monetary policy to economy, CBSL requires continuing studies to identify their adoption of appropriate monetary policy [4].

The impact of monetary policy to the macro-economic variables is not extensively researched in Sri Lankan context. The studies on Amarasekara and Vinayagathasan examine the impact to the monetary policy broadly on inflation and GDP [4, 5]. But these studies do not focus on the impact of monetary shock on the interest rate and exchange rate. Hence, this study is going to determine the impact of these two variables as well. Further both of these studies used interpolation[1] of quarterly data to the monthly data, which may occur series impact in seasonality. More importantly the latest study done by Vinayagathasan captured data till 2011 and in this study focuses up to end 2016 [5]. As per economists, it is required to do continuous analysis of such impact.

Mainly, after 2011 CBSL introduce improvements to the monetary policy framework. For example, with the intention of smooth monetary transition and stimulation of the economy CBSL extend the Statutory Required Reserve (SRR) calculation and maintenance period, introduced weekly monetary policy auction system (other than overnight system) and improve the flexibility on market facilitation [6]. Depending upon all these reasons, this study is timely to analysis. Hence it is timely to do a study on the impact of monetary policy to the macro economy with consideration of additional variables, extended time period and amendments of the monetary operation.

1.4. Research Question and Objectives

This study focuses to empirically investigate the impact of monetary policy to the macroeconomic variables in the economy. Thus, the research question of the study is:

To what degree the monetary policy shocks affect the macroeconomic variables[2]?

This research question mainly determines the significance of the impact and its magnitude. Further, it identifies the time taken to die out the impact of monetary policy. As this study follows Recursive VAR methodology, it targets to determine contemporaneous impact among variables.

In order to work towards key objective, this study uses money supply, inflation, interest rate, GDP and exchange rate for the period of 1990 to 2016 as variables.

1.5. Methodology of the Study

Stationarity of the data series is more important in VAR analysis. In order to identify the stationarity of these macroeconomic variables, this study uses the standard unit root test of Augmented Dickey Fuller test. After determining the best lag length criteria by using information criteria, the best fitted VAR model can be identified. This selection is based on the residual correlogram.

Then this study uses best fitted stable[3] VAR model to generate Impulse Response Functions (IRS) and Variance Decomposition (VD) tables to determine the significance and magnitude of the shocks to the other variables and time taken to die out the shock. More importantly the Cholesky factorization is used to identify the restrictions of the equation system and it provides the contemporaneous impact order of the variables.

The study uses quarterly data of the selected macroeconomic variables for the period of 1990 to 2016 (108 data points). The key variables of the study are money supply,

Gross Domestic Product (GDP), inflation, Weighted Average Call Money Rate (WACMR), and exchange rate.

1.6. Structure of the Research

Along with the introduction, this study is mainly divided into seven sections. Following the introduction, section two details monetary and some macroeconomic theories, which is most commonly used in monetary economic and macro-economic analysis. Section 3 discusses the literature of the study in detail, and it identifies the gaps of the literature too.

Fourth section reviews the monetary policy in Sri Lanka. This section devotes details to monetary policy formulation, implementation and transmission. Section five explains econometric methods used for the study and then section 6 provides the results of the empirical analysis. Based on the results, the final section presents conclusions, policy implications and directions to directions to further studies.

2. Overview of Monetary and Some Macroeconomic Theories

2.1. Money Supply Theories

According to the monetary policy objectives, the central bank conducts different monetary policy operations to influence the money supply in the economy. The basic model of the money supply assumes that the sole authority of changing money supply is going to the CB. But monetarists believed that money supply is influenced by the different choices of money market participants, such as banks and individuals. Hence, there are several comprehensive models on the money supply that consider such behavior of market participants at present.

The Friedman-Schwartz Approach

Friedman and Schwartz formulate the following relationship in their study of money supply process in United States [7].

Broad money supply (Ms) of the central bank,

$$Ms = Cp + Dp \tag{1}$$

Cp - Notes and coins held by the non-bank private sector, Dp – bank deposits Monetary Base[4] (B)

$$B = Cb + Db + Cp \tag{2}$$

Cb-Banks holding of Notes and coins (Vault Cash), Db – deposits with the CB Total of Cb and Db generate bank reserves (R).

From equation 2,

$$B = R + Cp \tag{3}$$

Deriving money multiplier

$$\frac{M}{B} = \frac{Cp}{R} + \frac{Dp}{Cp} \tag{4}$$

$$\frac{M}{B} = \frac{\frac{Cp}{Dp}+\frac{Dp}{Dp}}{\frac{R}{Dp}+\frac{Cp}{Dp}} \tag{5}$$

Cp/Dp = α = non-bank private sector's 'cash ratio[5], R/Dp = β = banks reserve ratio[6]

$$M = B\left[\frac{\propto +1}{\propto +\beta}\right] \tag{6}$$

$$M = m * B \tag{7}$$

Base money, cash ratio and reserve ratio are main three determinants in money supply, and it shows the performance of the economy.

Change in monetary base is positively related to the money supply. A lower reserve ratio allows banks to create more loans. Banks create more money from each unit of their reserves. Decrease in the Reserve ratio increases the money multiplier and the money supply of the economy. Further, this is a good indicator to identify the bank's excess reserves. A lower cash ratio, less amount of currency holdings in the public creates opportunity for banks to make more money by using high reserve. Similarly, lower cash ratio also increases the money supply and the money multiplier [8].

2.2. Money Demand

Simply, money demand determines how much money that people are willing to hold. The money demand theories comprise the relationship with the money demand and other macroeconomic variables, which link with money and real sector. Out of three main functions of money, money demand captures the role of money as store of value or medium of exchange. In this section, the Quantity theory of money, the portfolio theory and the Baumol-Tobin transaction theory discuss as money demand theories.

2.2.1. Quantity Theory of Money

Quantity theory of money assumes that demand for real money balances is proportional to the income.

$$\frac{M^d}{p} = kY \tag{8}$$

M^d – Money Demand, P- Price Index, k- constant (how much money that people want to hold for every unit of income), Y- income. In general, realistic money demand function assumes that money demand is function of interest rate and income as Equation 9.

$$\frac{M^d}{p} = f(i, y) \tag{9}$$

This simple money demand function is used to explain IS-LM model.

2.2.2. Portfolio Theory of Money Demand

Portfolio theories of the money demand capture the function of money as store of value. This theory says, people hold money as an asset. Some of the economists suggest people hold money as a portfolio asset to minimize the risk, which encounters with investments in financial instruments like bonds and shares.

Portfolio theories money demand function can be written as

follows,

$$\frac{M^d}{p} = f(r, r_s, E_b, W_\pi) \quad (10)$$

r_s – Expected real return on stock, r_b – expected real return on bonds, E_π – expected inflation rate, W- Real wealth. By increasing the expected real returns in the bonds and stocks and the expected inflation, other assets become more attractive than holding money. Hence, money demand is decreasing. Contrasting to that, higher wealth creates larger portfolios and increases money demand. Portfolio theory does not provide good explanations in demand for money in base money stage, but it is more plausible in money demand in broad money.

Base money consists of reserves and currency with zero or very low rate of return. But there are some other assets[7] with higher returns with the same features and same risk as reserves and currency. Hence, portfolio theories cannot explain optimality in money demand by holding currency in people's hands. Contrasting to that broad money consists of more forms[8] of money than base money. Because of the lower risk in holding broad money than investing in bonds and shares, there is a reasonable reason in holding broad money. Hence, Portfolio theory is more reliable theory in quantifying money demand in base money [8].

2.2.3. Transaction Theories (Baumol -Tobin Model)

Transaction Theories of money demand emphasize the function of money as the medium of exchange. Unlike in portfolio theories, this theory explains why people prefer to hold base money, like currency. Transaction theories assume that money encounters cost of earning, low rate of return and money transactions are more convenient. Further, the money holding is determined by the trade-off between cost and benefit.

Baumol-Tobin Model is one of the prominent money demand models developed by William Baumol and James Tobin in 1950s. He analyzed the trade-off of cost and benefit of holding money. The benefit of holding money measures as the convenience of paying for goods and services and avoid a trip to the bank. The cost determines as the foregone interest that they would have received by that money in the saving deposits.

A person willing to spend Y amount of his real wealth over the period by assuming the price level and real spending is constant over the period. Average money holding depends upon the number of trips (N) to the bank in each year. Hence, in each trip that person withdraws Y/N amount of cash. Average money holding is Y/2N as money holding varies between 0 – Y/N. The cost on foregone interest is iY/2N. Cost per trip to the bank is FN. Hence the total cost is,

Total cost = Forgone interest + Cost of Trips

$$TC = \frac{iY}{2N} + FN \quad (11)$$

The larger number of trips to the bank increases the total cost. There is an optimal number of N that minimizes the total cost.

From Equation 10, optimal choice of N*,

$$\frac{d}{dN} TC = \frac{d}{dN}\left(\frac{iY}{2N} + FN\right) \quad (12)$$

$$N^* = \sqrt{\frac{iy}{2F}} \quad (13)$$

According to the Figure 1 N* denotes the number of trips to the bank with minimum cost.

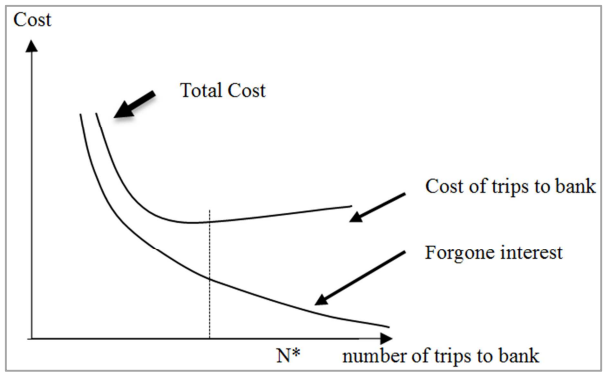


Figure 1. *The cost of money holding.*

But using a teller machine or internet banking reduces the fixed cost by decreasing the time to go to the bank. Hence, this model provides very specific money demand function by assuming all other factors remaining content over the time [8].

2.3. Money in IS/LM Model

IS/LM model, developed by Sir John Hicks (1937), supports understanding most of the important ideas of Keynes. Monetary policy and most of the other macroeconomic policies have been represented by the IS/LM model. There are minimal number of macroeconomic policies, which cannot be explained by this model. In this model, LM expresses the combination of income (Y) and interest rate(r) that are compatible with the money market equilibrium. Money Supply is assumed to be fixed as it is controlled by the CB.

Equation 7 proves that the broad money supply is a multiple of base money supply. Assuming that α and β are fixed and independent from the amount of base money LM can be derived as follows (Figure 2).

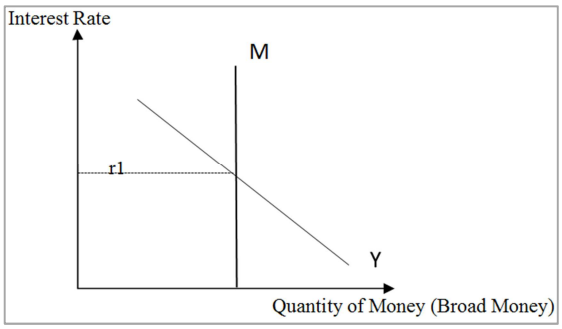


Figure 2. *LM curve representation.*

Money demand is negatively related to the interest rate [9].

Once the central bank decides to drop the interest rate, they increase the money supply accordingly. The effectiveness of the monetary policy relies on the elasticity between money supply and interest rate. The monetary policy is more efficient

in less elasticity, where interest rate falls more with the less amount of money supply to reach the money market equilibrium. IS/LM model shows the equilibrium condition of the money market and good market. Figure 3 shows the equilibrium level in those two markets, under expansionary monetary policy condition.

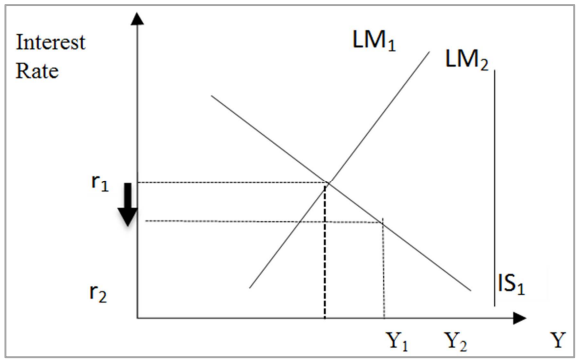


Figure 3. *Expansionary monetary policy in the IS-LM model.*

2.4. Monetary Policy Curve (MP)

As an approach to the more realistic model, developed a model by replacing LM curve with an interest rate in the vertical axis as a policy instrument determined by the CB. This model is more realistic these days, as CBs are targeting real interest rates. Hence, Romer [10] used the concept of positive relationship between output and determination of CB real interest rate target. Figure 4 shows the impact on output when CB increases real interest rate due to the higher inflation [10].

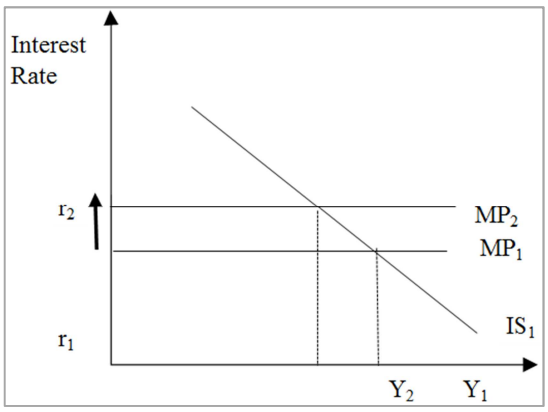


Figure 4. *Contractionary monetary policy in IS-MP model.*

2.5. Transmission of Monetary Policy to the Economy

Monetary policy decision on interest rate affects inflation and other economic activities by different channels. These transmission channels affect market rates, asset prices, expectations of the economic agents and the exchange rates. There are some theories to explain such transmission of monetary policy.

AD-AS Model

Monetary policy largely affects the economy via its influence on Aggregate Demand (AD). This is because monetary policy determines the price level of the goods and services of the economy. It varies purchasing power of the rational consumer.

In expansionary monetary policy,

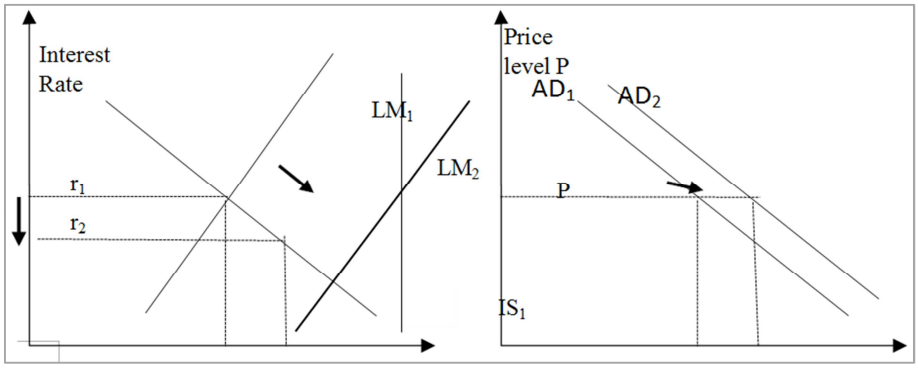


Figure 5. *Change in AD in expansionary monetary policy.*

For a given price level in P, increasing money supply will increase the real money balances. This will shift LM curve downward with lower interest rate and that results in growth in income/output. So, the economies' aggregate demand will increase. In the short run, as the price level is fixed and the output increases. But in the long run, as the economy is reaching the natural level of output the long run equilibrium level of inflation is lower than initial inflation [8].

2.6. The Taylor Rule

Analyzing the behavior of the Federal Open Market Committee decision making process, in 1993 Taylor introduced his new concept on monetary policy formulation as follows.

$$i_t = \pi_t + \rho + (\pi_t - \pi_t*) + (Y_t - \bar{Y}) \qquad (14)$$

i_t - Central bank targeted nominal interest rate
π_t - Existing price level
ρ - Natural rate of interest
θ_π, θ_Y - Policy parameters
π_t* - Central bank target (Inflation rate)
Y_t - Existing output level
$\bar{Y_t}$ - Natural level of output

Equation 14 explains that accurate forecast of policy

interest rates by the policy makers will balance the inflation rate, GDP rate and interest rate in the economy. Hence, this model allows economic agents to observe the big picture of the economy. According to the Taylor rule, CB should increase the policy interest rate, where inflation is exceeding the targeted level, or the GDP growth is far above the potential level. This model focuses on stabilizing the economy in the short run with stable inflation in the long run. According to the US economic history, during economic booms, this model served accurate results. But during the crisis period this model didn't perform well. Most of the CBs around the world are using this model to forecast their policy interest rates expect crisis periods. This model provides a better gauge of the interest rate, inflation output and guide to the appropriate levels of money supply as well [8].

2.7. Monetary Policy in Open Economy

In an open economy, the impact of the monetary policy on the economy is changing. The behavior of the exchange rate is highly influential to the economy. For example, the exchange rate affects the inflation rate and import and export sectors. This process makes external disturbance to the monetary policy transmission process. The Dornbusch overshooting model provides a good explanation for that.

Dornbusch Overshooting Model

Dornbusch overshooting model is the best model after the Mundell-Fleming model which explains behavior in macro economy in different exchange rate regimes.

The model is as follows,

$$\frac{dp}{dt} = \pi(y^d - Y) \tag{15}$$

$$Y^d = (e - p) + g \tag{16}$$

$$m = p + \varphi Y - \lambda i \tag{17}$$

$$i = i* + de/dt \tag{18}$$

p - Price of one good produced in domestically
π_t - Existing price level
e - Exchange rate
Y - Out put
y^d - Output demand
g - Government expenditure
I - Domestic nominal interest rate
$i*$ - Foreign interest rate
m - Money supply

All four equations provide relationships between the main macro variables in the economy. Further, Dornbusch evaluates the above equations in the case of unanticipated increase of money supply. He concludes, remaining all other variables constant, unexpected increase in money supply is positively influence on steady state of exchange rate and price level in same proportionate amount.

Further, Dornbusch states that the depreciation rate of exchange rate is higher than the increasing percentage of the money supply. Hence, CBs should pay attention to exchange rates once they are taking decisions on inflation targets. Accordingly. It is not a good approach to achieve an inflation target by manipulating exchange rates.

3. Literature Review

3.1. Monetary Policy and the Economy

The success of the anticipated macro-economic outcomes with the changes in monetary policy and the effectiveness of the monetary policy transmission mechanism. The success of those conventional policy channels[9] varies from country to country, which depends upon their structure of the economy. Further, the transmission mechanism is subjected to the selected macro-economic variables and the time lag. Most economists highlighted the reason behind this time inconsistency is the political intervention in monetary policy. So, the independent central bank[10] is the best solution in effective monetary policy transmission and low and steady long run inflation [11].

3.1.1. Monetary Policy Transmission

Having the monopoly power of issuing money, the CB has sole authority to control interest rates. The change in policy interest rates influences the money market interest rate directly and later, indirectly, it will transmit to the lending and deposit rates. CB's forward guidance policies can further strengthen future inflation expectations which make economic agents much comfortable on their decisions. Other than the above sectors, such policy changes affect asset prices, savings and investment decisions, credit creation, aggregate demand and finally price levels in different time lags [12].

According to the empirical evidence survey on monetary policy transmission in developing countries, Mishra and Montiel concluded that, with the methodological shortcomings of monetary policy practices leads to weak monetary policy transmission [13]. Further, they recommended appropriate stabilization policies to obtain efficient monetary transmission [13]. Providing more evidence to prove the conclusion of Mishra, Montiel and Das stated that, in India the bank lending channel is not efficient [13, 14]. In India, once central bank is following monetary tightening policies the speed of adjustment in deposit rate is less compared to the results in expansionary monetary policy [14]. Exchange rate channel is the most efficient channel in the monetary policy transmission in emerging countries which has higher degree of openness in economy[11]. This affects short run output and price levels [15].

Considering the recent empirical evidence on the monetary policy, the most dominated channel in Sri Lanka is interest rate channel [16]. Ghazanchyan also proved the above conclusion and further, he observed that similar to the other developing countries, bank lending, exchange rate and asset price channels must be strengthened in Sri Lanka. It takes at least five quarters to effect output change with the policy interest change. In addition to that he mentioned, with the relatively long transmission lag there may be some leakages in the monetary shocks to the economy. As a result of that, the

impact on above mentioned macro-economic variables may dilute [15].

3.1.2. Different Monetary Policy Frameworks and Economic Performance

Withstanding the adopted monetary policy framework and monetary policy instruments, the impact of monetary shocks will differ from country to country. Even though two countries are following the same monetary policy framework, the policy outcome may vary. This is because of exogenous factors like openness of the economy, exchange rate regimes, investments and savings, political stability, global economic stability etc [18]. Hence, the monetary policy impact varies from country to country.

In global practice, there are several monetary policy regimes namely, exchange rate targeting, monetary targeting and inflation targeting. The most common way of formulating exchange rate targeting policy is by linking domestic exchange rate to the major trading partner, who enjoys low and stable inflation. Mishkin, emphasized several benefits in exchange rate targeting frameworks. This framework is more suitable for the open economies, which are highly dependent upon the import of goods and services [1]. As currency anchoring controls imported inflation the county can maintain low and stable inflation. Further, with the additional rule provided by the exchange rate target the conduct of monetary policy also becomes more efficient and reduces the time inconsistency problem. Even though the mechanism is transparent and understandable, there are serious disadvantages. Mainly it dilutes the autonomy of monetary policy when the domestic country is highly depend on the economic performance of the anchor country. In addition to that, such countries are open to poor capital flows, in equilibrium in financial markets and speculative attacks [1]. But, with the trends of expansion in financial markets and increasing liberalization of countries' capital accounts, this framework will become outdated.

Monetary targeting framework focuses on the growth of monetary aggregates to control the level of inflation. The base of the monetary targeting approach is the money supply theories. Compared to the exchange rate targeting framework, monetary targeting framework has much CB independence. Further, the CB can easily monitor the targets as the data is available frequently. Hence, this framework is free from time inconsistency problems [1]. There are several drawbacks in monetary targeting framework. As monetary targeting depends highly on money to inflation relationship, at present it produces erroneous outcomes. Further, this target is not a proactive approach to the large hikes in inflation. In addition to that, there are some arguments among economists about the poor facilitation of monetary targeting approach to achieve other macroeconomic goals [19].

At present, Inflation targeting framework has become prominent monetary policy framework, as most of the other alternative monetary policy frameworks failed to absorb external shocks without generating higher volatility in inflation. Furthermore, CBs also preferred to use inflation targeting framework, as it provides reasonable guidance to macroeconomic performance and efficient conduct of monetary policy [19].

Considering the economic performance of the countries with the selected monetary policy framework, it provides different results as follows. Portugal money market follows the interest rate policy of European central bank. Sousa found out positive interest rate shock positively affects to the unemployment rate and negatively affects the GDP and price level. Further, such positive shock in interest rate influenced negative stock in market movements and drop in commodity price as well [20].

With the same variables explained in Sousa's study, Agbonlahor added real effective exchange rate and current account deficit as explanatory variables to his study for United Kingdom [21, 20]. Long run dynamics of the variables show significance results than the short run. This study explains that money supply and inflation rate are the key significant determinants in determining growth in GDP in United Kingdom. Contrasting to these specific variables Agbonlahor selected eight[12] different sectors in Malaysia and conduct a comprehensive study on the possible inequalities over monetary policy shock [21, 22]. He found that positive interest rate shock reduces the performance in manufacturing, insurance, finance, construction, business services and fishing sectors than other sectors. According to the conclusion, this disparity was because of the impact of credit growth in each sector by the policy shocks and the impact on international trade [22].

3.2. Econometric Approaches

Research mostly use VAR models to analyses the impact of such monetary impulses to the economy. Contrasting to ordinary least squares method, the most important feature of this model is as it can estimate with its own lags. Further, VAR is suitable for the small set of variables. In terms of theoretical restrictions there are three types of VAR models namely, reduced form VAR, recursive VAR and structural VAR. Even though reduced form VAR does not provide any theoretical foundation to the system, Structural VAR provides economic restrictions to the model. According to Stock and Watson, recursive VAR provides contemporaneous correlation among variables in mechanical method and structural VAR adds more economic sense to the model to identify correlations among variables [23]. But with the erroneous rational for the recursive ordering, the VAR interpretation becomes economically meaningless. But in Structural VAR, with the information delays, changes in market structure, physical constraints and high frequency data, it is difficult to identify short run restrictions [3].

Such VAR models were initially introduced by the Sims, as a solution to the massive simultaneous equation models [24]. Especially in VAR estimations equation identification is more important. Once the coefficients of the reduced form VAR shows the estimates of the parameters of the structural VAR equation that is called identification. VAR models can be used, only for the over identified or exact identified equation systems. Further, the results of the VAR can be evaluated by the Granger-causality

tests, impulse responses, and variance decompositions [25]. Selecting variables for the VAR model is a bit tricky. When we consider a VAR system with p lags and n variables then it can estimate (pn+1) n number of free parameters. The system will encounter omitted variable bias issue when it comes to few variable models. Hence, for monetary policy shock models, researchers use at least variables for aggregate economic activity (example, GDP), measure of price level and indicator for shocks in monetary policy [26].

According to Christiano, Eichenbaum, and Evans, in an open economy, the monetary policy shocks are subject to various exogenous factors than in a closed economy. They conclude, contractionary monetary policy stance leads to appreciation in real and nominal US exchange rate, decline in spared between US and foreign interest rate and creation of favorable uncovered interest rate parity for the US investments [27].

Ibrahim, Used VAR approach to his study to identify the impact of monetary policy to the macro-economy. He used cholesky factorizations for recursive ordering of economic variables [22]. Further, he generated Impulse Response Functions (IRF) to detect the direction of the variable changes over monetary policy shock and Variance Decomposition Functions (VDF) to indicate variable forecasting error. As all variables are stationary at first difference and existence of cointergration among variables, Agbonnlahor followed Vector Error Correction Model (VECM) to find out long run dynamics of the macro-economic variables. He forecasts the behavior of the variables over the next three decades as well [21].

Amarasekara, follows the simultaneous equation method of Structural VAR with economic restrictions to his system [4]. He used AD-AS model, quantity theory of money and monetary policy reaction function to incorporate such economic restrictions. As the model can adjust with the empirical theories and expectations, this method is more logical than reduced form models. Rather than incorporating meaning less coefficients to the system and mitigate missing information issue in VAR. Liu and Jansen used Structural Factor Augmented Vector Autoregressive (SFAVAR) to analyst effects of monetary policy in data rich environment [27].

After analyzing existing literature this study tries to fill the gap of required literature in the field of monetary economics. This analysis is more concerned with the selection of more exogenous variables which capture the background of the study environment. Hence it is assumed that errors of the model will decrease.

3.3. Sri Lankan Monetary Policy and Its Impact to the Macro-Economy

There are few empirical studies written on impact of monetary policy to the macro- economy in Sri Lanka. The researchers used different macro variables to evaluate such performance in monetary policy. Amarasekara selected reserve money, exchange rate, interbank call rate, inflation, and output as main macro variables for his study in assessing performance in monetary policy [4]. Further, including those variables Vinayagathasan used some other variables like exports imports and Treasury bill rate for their studies [5]. Study of Vinayagathasan is more or like an extension of Amarasekara, as he used same econometric analysis of Structural Vector Autoregressive (SVAR) approach and the similar sample period which covers from 1978 to 2009 [4, 5]. Aslam focused on the period from 1959 to 2013 and followed multiple regressions to analysis the significance of the impact of monetary policy to the macro-economic variable [29].

The conclusion of all three studies mentions that there is positive impact on monetary easing to the GDP. Amarasekara expanded his study towards long run and short run dynamic of the money supply to the inflation and GDP. Further, Vinayagathasan concludes interest rate is the better measure on monetary policy shock than monetary aggregates [4-5].

4. Monetary Policy and Macro Economy in Sri Lanka

4.1. Monetary Policy in Sri Lanka

The CBSL was established by the Monetary Law Act (MLA) of 1949 on August 28, 1950. Being the apex of the Sri Lanka's financial system CBSL responsible for safeguarding the value of Sri Lankan Rupee, banking system, and payment system. CB conducts monetary policy to attain price stability in the domestic economy. CBSL takes actions to influence monetary and financial condition in the economy. Since 1980's CBSL used monetary management framework to implement monetary policy in Sri Lanka.

As specified in the MLA in 1949, there were four objectives under stabilization and development. In line with the current global trends and targeting the development of the productive resources of Sri Lanka, CBSL restructured its objectives thereby amending the MLA in 2002. At present, maintaining economic and price stability and maintaining financial system stability are the core objectives. Under economic and price stability CBSL targets low and stable inflation which supports to achieve sustainable economic growth. Financial system stability means the smooth and effective functioning of the financial system and the absence of crises in the banking, currency, and balance of payments (BOP).

4.1.1. Monetary Policy Framework in Sri Lanka

According to the MLA amendments on monetary policy in 2002, currant CBSL's monetary policy framework is monetary targeting. As mentioned above, this framework targets economic and price stability. Three monetary definitions are used in Sri Lanka to analysis the monetary developments. The first is Monetary Base (MB) consisting of currency issued by the Central Bank and commercial banks' deposits with the Central Bank. This is also called base money or high-powered money, as commercial banks can create deposits based on reserve money which are components of a broader definition of money supply, through their process of creating credits and deposits. The second is Narrow Money (M1), defined as the sum of currency held by the public and demand deposits held by the public with commercial banks. The third is Broad Money

(M2) defined as the sum of currency held by the public and all deposits held by the public with commercial banks. Studies have shown that the most appropriate monetary variable to analyses the relationship between the money supply and the general price level is the broad money supply [30].

According to the current monetary targeting framework MB is the operating target and M2 acts as the intermediate target. The ultimate target of the monetary policy is price stability. Simply the Price stability is to be achieved by influencing changes in the broad money supply, which is linked to reserve money through a multiplier. Figure 6 summarizes the monetary targeting framework in Sri Lanka.

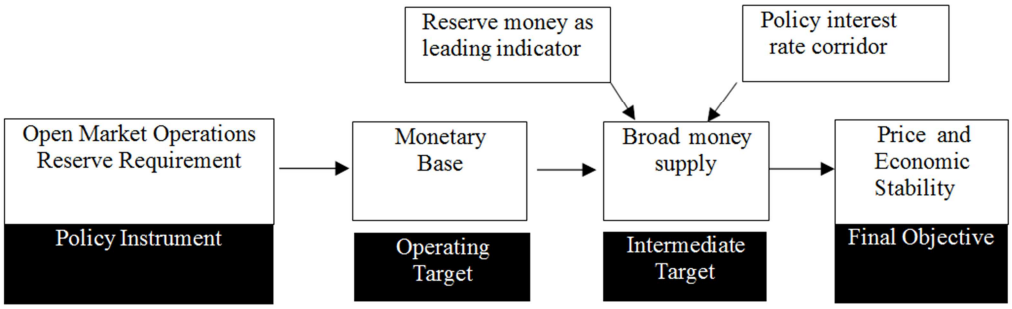


Figure 6. *Monetary Targeting Framework in Sri Lanka.*

To achieve such targets CBSL uses both direct and indirect monetary policy instruments to manage money supply to steer short term interest rate.

4.1.2. Monetary Policy Instruments

On 3rd March 2003 CBSL introduced active open market operations to implement monetary policy while managing market liquidity in an effective manner. Before that CBSL used passive open market operations which was based on direct monetary policy instruments.

The CBSL has a wide range of monetary policy tools to control money supply. There are three main indirect monetary policy instruments which are Policy interest rates, Open market operations and statutory reserve requirement. But during the crisis periods CBSL use direct instrument by using their regulatory powers to manage financial institutions. For example, credit ceilings, interest rate ceilings etc.

(i). Policy Interest Rate and Open Market Operations

The main objective of the OMO is to steer the overnight interbank interest rates in the rupee money market. In the process, the OMO will affect the market liquidity, while signaling the stance of the monetary policy. In steering the overnight interbank interest rates, the CBSL uses different instruments to supply or absorb liquidity as appropriate and in the volumes required to facilitate the maintenance of interbank market interest rate on the desired path, while being within the policy rate corridor. The policy rate corridor is defined in terms of Standing Deposit Facility Rae (floor) and the Standing Lending Facility Rae (ceiling) that will be subject to regular review (8 times in the year) by the CBSL [31].

A daily auction is conducted either to absorb liquidity by repurchase transactions, if there is excess liquidity or to inject liquidity through reverse repurchase transactions, if there is a shortage of liquidity. From that they maintain overnight interest rates steady around a level considered consistent with the path of reserve money targets. The auction is on a multiple bid, multiple price system. To address the longer-term liquidity issues, CBSL conducts term auctions for repurchase transactions and reverse repurchase transactions whenever necessary to manage long term market liquidity. The CBSL introduced foreign exchange SWAPs as an open market operation instrument in 2009, to provide more flexibility to absorb excess liquidity on a term basis.

Standing facilities are available for those participating institutions which were unable to obtain their liquidity requirements at the daily auction. That is, even after the daily auction, if a participant has excess money, he could enter into a repurchase transaction under the standing facility. Similarly, if a participant needs liquidity to cover a shortage, he could borrow funds on a reverse repurchase basis under the standing facility. Accordingly, these facilities manage wide fluctuations in interest rates. Outright transactions are conducted at the discretion of CBSL to address long-term liquidity issues. If a relatively large liquidity surplus exists and is likely to continue for a long period it is absorbed by selling Treasury bills outright out of the holdings of the CBSL, and if a sufficient stock of Treasury bills is not available, by issuing the CBSL's own securities. Similarly, a long-term liquidity shortage would be removed by purchasing Treasury bills and bonds in the secondary market and buying Treasury bills in the primary market [31].

(ii). Statutory Reserve Requirement

Under the MLA, License commercial banks are required to keep a proportion of their total deposit liabilities as a reserve in CBSL with the predetermined rate. This requirement is referred to as statutory reserve requirement. This was extensively used in the early days to control money supply in the economy. But the resilience on SRR as a day-to-day monetary management instrument has been reduced with financial market development and enhanced market orientation of monetary policy. As of 31 December 2015, banks are required to maintain 7.50 per cent of their rupee denominated deposit liabilities as SRR with CBSL. Increase of statutory reserve requirement by CBSL would reduce funds available for lending in the banking system while increasing cost of funds for banks as these reserves are not remunerated. Similarly, a decrease in SRR would inject additional funds into the banking system to lend while reducing its costs of

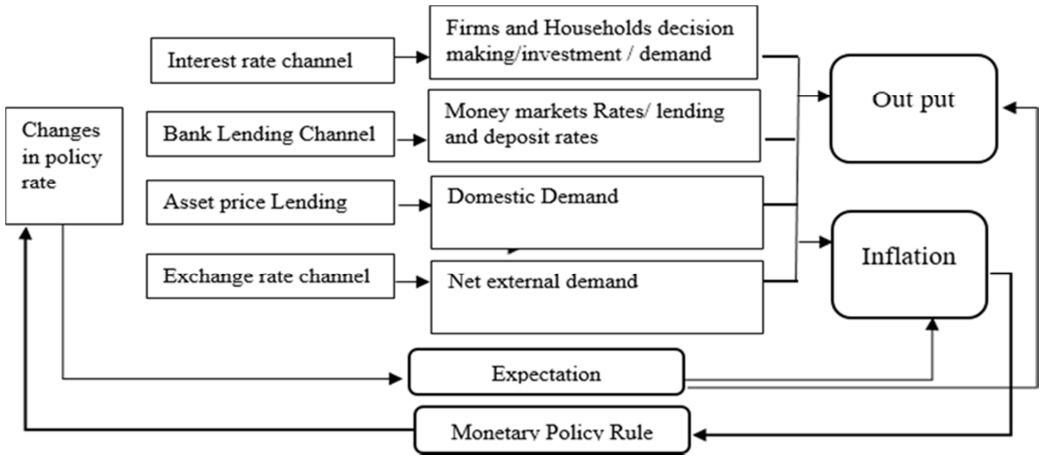
funds on reduced idle funds.

(iii). Standing Facilities

Participating institutions who are unable to fulfill their liquidity requirements in the morning auction, are coming to the standing facilities in the evening. Once the participating institution has excess money, they deposit those in a standing deposit facility. They withdraw money from the standing lending facility to cover their liquidity deficits. Standing facilities set floor and the ceiling for interest rate changes in the short-term money market. Accordingly, these facilities remove the necessity for banks to move significantly away from the interest rate desired by the CBSL. These facilities manage the last-minute liquidity requirements and support minimizing fluctuation in short-term interest rates.

4.1.3. Transmission Mechanism in Monetary Policy in Sri Lanka

The success of the monetary policy transmission channels varies from country to country, depending on the structure of their economy. Interest rate is the most important monetary policy transmission channel in Sri Lanka. This channel directly influences the decision making of economic agents. Further, according to the intertemporal profiles, the change in money supply affects savings, investments, household consumption and finally aggregate demand. But most importantly, the success of the policy implementation depends on similarity of expectation channel and its movement along short run and long run yield curve [32]. Figure 7 shows the transmission mechanism of monetary policy in Sri Lanka.



Source: Adopted from [4-16]

Figure 7. *Monetary policy Transmission Mechanism.*

4.2. Monetary Policy to Macro-Economy

Table 1 analyses the three critical eras of the Sri Lankan economy in terms of macroeconomic aggregates. Compared to the sluggish growth in 2000-2009 period due to internal conflict situation and global economic downturn, the macro-economic performance of 2010-2016 period shows rapid improvements. It highlighted higher economic growth under lower level of inflation and deficit balance in government budget and current account is decreasing. Such macroeconomic enhancement could be due to effective management of monetary policy [16].

Table 1. *Macro-economic performance in Sri Lanka.*

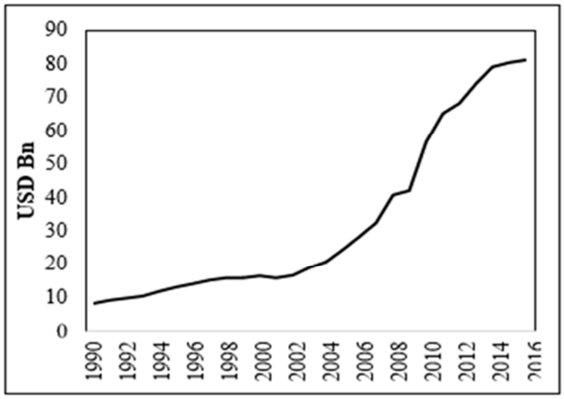
Item	1990-1999	2000-2009	2010-2016
GDP Growth (%)	5.2	4.7	6.2
CPI inflation	11.3	12.3	5.0
Budget deficit (% of GDP)	10.2	15.0	6.2
Current A/C balance (% of GDP)	-4.8	-3.8	-1.2
interest rate (91 Day T-Bill)	15.9	12.2	7.8
Exchange Rate (USD/LKR)	52.3	101.2	127.5
Broad Money Growth	16.8	14.9	17.0

Source: Updated and modified as per [16]

4.2.1. GDP

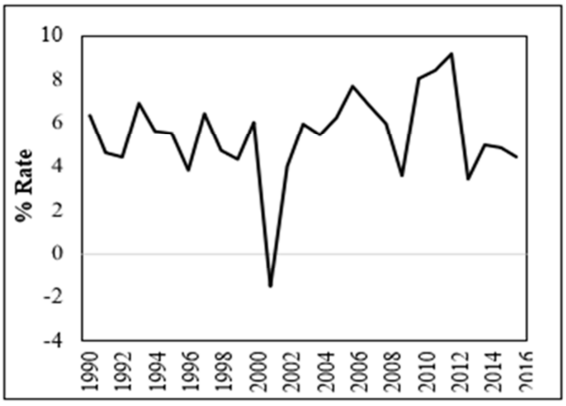
With the adverse impact of unfavorable weather conditions in 2016, the GDP growth rate was 4.4 percent. Even though the growth rate showed negative values in 2001 with the higher oil prices and negative external shocks, in the rest of the period the growth rate was averaging around 5.0 per cent (Figure 9). Throughout the history services sector contributes the majority to the GDP. Considering the evolution of the GDP from 1990 to 2016, the growth of GDP has increased after 2008 (Figure 8). The main reason behind this change is the end of the war which prevailed over 30 years. According to the recent market statistics in 2016, GDP at current market prices was USD 81.3 Bn. In 2016, GDP per capita rose by 6.9

per cent compared to 2015 and recorded USD 3,835.0. Agriculture, Forestry, and Fishing industry captured 7.1 per cent of GDP in 2016, where industries sector and services sector held 26.8 per cent and 56.5 per cent respectively. According to the medium-term outlook CBSL predicts the GDP growth rate will increase up to 7.0 percent in 2020 [31].



Source: World Bank (world development indicators)

Figure 8. *GDP (Current USD).*

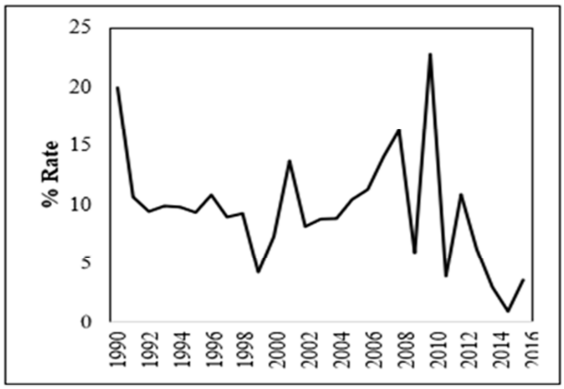


Source: World Bank (world development indicators)

Figure 9. *GDP growth (annual %).*

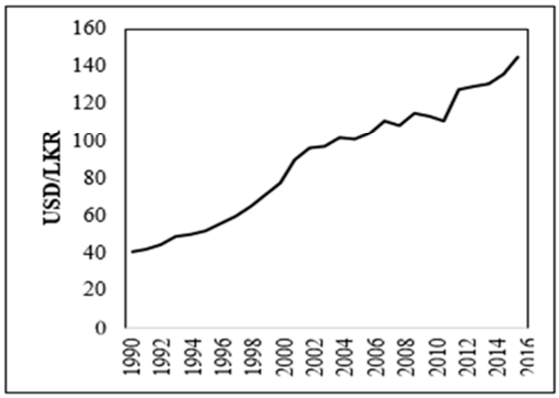
4.2.2. Inflation

Annual CPI (Consumer Price Index) Inflation showed the value on average 10.0 per cent from 1990 to 2008 (Figure 10). During the peak of war in 2008, it increased up to 22.6 percent and then showed drastic drop. In 2016, the annual CPI inflation recorded at the level of 3.7 per cent. According to the CBSL, the continuous growth in inflation is due to the expansionary monetary policy stance and growth in credit aggregates.



Source: World Bank (world development indicators)

Figure 10. *Inflation, consumer prices (annual).*



Source: World Bank (world development indicators)

Figure 11. *Official exchange rate.*

4.2.3. Exchange Rate

In the past six decades, the exchange rate system of Sri Lanka has evolved from a regime of fixed exchange rates to a managed float and finally to an independent float. A brief overview of the exchange rate regimes can be classified as shown in the following Table 2. Depending upon the various determinants like inflation, money supply, market interest rates and import-export market the USD/LKR rate varies [33]. According to Figure 11 the USD/LKR rate is in an increasing trend. The one of the main reasons behind this LKR depreciation is imported inflation. Sri Lanka is importing plenty of essential items including crude oil, milk powder and other food and nonfood items. Hence depreciation of LKR supports to demotivate unwanted imports.

Table 2. *Exchange Rate Regimes.*

Date	Major Changes	Exchange Rate Regime
1949	Rupee was linked to sterling pound	Fixed
22 Nov 1967	Rupee was depreciated by 20%	Fixed
06 May 1968	Introduced Foreign Exchange Entitlement Certificate Scheme	Dual exchange rate system
01 Aug 1971	Rupee was linked to US dollar	Dual exchange rate system
10 July 1972	Rupee was linked to sterling pound	Dual exchange rate system
24 May 1976	Rupee was pegged to a weighted average basket of currencies	Dual exchange rate system
12 March 1977	Rupee was depreciated by 20%	Dual exchange rate system
16 Nov 1977	Dual exchange rate system was abolished and managed floating exchange rate system was introduced	Managed floating with crawling band

Date	Major Changes	Exchange Rate Regime
20 June 2000	Band was widened	Managed floating with horizontal band
03 Nov 2000	Band was widened	Managed floating with crawling band
23 Jan 2001	Central Bank stopped announcing its buying and selling rates in advance	Independent floating
10 Feb 2012	The Central Bank decided to limit its intervention in the forex market	Independent floating

Source: Central bank Of Sri Lanka

4.2.4. Current Account Balance

The current account balance is in a deficit from 1990 to 2016 with the deterioration of the trade balance. The main reasons for this continuing trade deficit are inelastic demand in imported consumer goods and fuel energy requirement for rapidly increasing energy consumption. But with the favorable expansion in the services sector and increasing workers' remittances supports to control, the drastic drop in current account balance. In 2016, the current account deficit remained at the level of USD 1.942 Bn. This value is 2.4 per cent from the GDP in 2016.

4.2.5. Military Expenditure

Because of the civil war, military expenditure started to grow from 1980 to 2008. Military expenditure to GDP value increased from 1.6 percent in 1983 to 3.5 percent in 2008. The highest import bill for the military equipment returned to its highest level in year 2000, with the value of USD 274 Mn [34]. But the years 2015 and 2016 showed an increasing trend in military expenditure.

5. Data and Methodology

5.1. Data

This analysis considered 108 points of quarterly data from the first quarter of 1990 to the last quarter of 2016. This Study is going to analysis the following key variables (Table 3). In detail data description is in Appendix 1.

Table 3. *Data description.*

Variable	Notation	Unit of Measurement	Source
Real Money Supply (Broad Money)	MS	Trillions of LKR	CBSL
Real Gross Domestic Product	GDP	Trillions of LKR	World bank data
Inflation	INF	Percentage	DCS[xiii]
Weighted Average Call Money Rate	WACMR	Percentage	CBSL
Exchange rate	ER	USD/LKR	CBSL

5.2. Methodology

Most of the studies in domestic and global context used VAR modeling to determine the impact of monetary policy to the macroeconomic variables. The literature follows the different extensions of the VAR method to analysis this relationship [24]. With the difficulty in restriction identification in Sri Lankan contexts, recursive VAR is used to analysis the research problem. This study follows the recursive VAR modeling, which is similar to the Killian [3].

5.2.1. Unit Root Testing

Depending upon the availability of deterministic elements, there are three different regressions to check the unit root of given time series (Table 4). The augmenting lags of the Augmented Dickey Fuller test is determined by the Akaike information criterion or Bayesian information criterion.

Table 4. *Unit Root testing.*

Model	Hypothesis
$\Delta y_t = a_0 + \gamma y_{t-1} + a_2 t + \sum_{i=1}^{p} \Delta y_{t-1} + \varepsilon_t$	H_0: $\gamma = a_0 = a_2 0$, H_1: $a_0, a_2 \neq 0, \gamma < 0$
$\Delta y_t = a_0 + \gamma y_{t-1} + \sum_{i=1}^{p} \Delta y_{t-1} + \varepsilon_t$	H_0: $\gamma = a_0 = 0$, H_1: $a_0 \neq 0, \gamma < 0$
$\Delta y_t = \gamma y_{t-1} + a_2 t + \sum_{i=1}^{p} \Delta y_{t-1} + \varepsilon_t$	H_0: $\gamma = 0$, H_1 $\gamma < 0$

$H0$: $\gamma = 0$ Series has a unit root (series is nonstationary)
$H1$: $\gamma < 0$ Series has no unit root (series is stationary)

Critical values are taken from the Dickey Fuller statistics at 5.0 per cent level of significance.

5.2.2. Recursive VAR Methodology

As a proper solution to the existing large multivariate models with massive restrictions, Sims introduced unrestricted reduce form VAR, to treat all variables as endogenous [24]. These models are generalized of univariate Auto regressive models, and it treats all variables as endogenous. Because of the simple and flexible features of VAR model, it has a large number of extensions. For example, Vector error correction models for long run cointergartion analysis, VARX models which can incorporate exogenous variables, dynamic VARs, Factor-augmented VAR, regime switching VARs etc [35].

Structural VAR is denoted as follows,

$$A_0 X_t = \sum_{n=1}^{p} A_p X_{t-p} + e_t \qquad (19)$$

$(e)_t = 0$ and $(e) = \theta$ (constant) where θ is symmetric and

positive definite matrix.

$$A0Xt = A1Xt-1 + A2Xt-2 + \cdots + ApXt-p + et$$

$$A-1A0Xt = A-1A1Xt-1 + A-1\ A2Xt-2 + \cdots + A-1ApXt- + A-1et$$

$$Xt = A-1A1Xt-1 + A-1\ A2Xt-2 + \cdots + A-1ApXt-p + A-1et$$

Matrix interpretation of the above Equation 19 for five variables can be written as follows.

$$\begin{bmatrix} a_{31} & a_{3,2} & a_{3,3} & a_{3,4} & a_{3,5} \\ a_{41} & a_{4,2} & a_{4,3} & a_{4,4} & a_{4,5} \\ a_{51} & a_{52} & a_{5,3} & a_{5,4} & a_{5,5} \end{bmatrix} \begin{bmatrix} x_{3t} \\ x_{4t} \\ x_{5t} \end{bmatrix} = \begin{bmatrix} A_{31}(\mathrm{L}) & A_{3,2}(\mathrm{L}) & A_{3,3}(\mathrm{L}) & A_{3,4}(\mathrm{L}) & A_{3,5}(\mathrm{L}) \\ A_{41}(\mathrm{L}) & A_{4,2}(\mathrm{L}) & A_{4,3}(\mathrm{L}) & A_{4,4}(\mathrm{L}) & A_{4,5}(\mathrm{L}) \\ A_{51}(\mathrm{L}) & A_{52}(\mathrm{L}) & A_{53}(\mathrm{L}) & A_{5,4}(\mathrm{L}) & A_{5,5}(\mathrm{L}) \end{bmatrix} \begin{bmatrix} x_{3t-1} \\ x_{4t-1} \\ x_{5t-1} \end{bmatrix} + \begin{bmatrix} e_{3t} \\ e_{4t} \\ e_{5t} \end{bmatrix}$$

Where $A_{ij}(L) = (\gamma_{ij}{}^{14} + \gamma_{ij}L + \gamma_{ij}L^2 + \gamma_{ij}L^3 + \gamma_{ij}L^{415})$ with the individual coefficients denoted as $\gamma_{ij}(1)$, $\gamma_{ij}(2) + \gamma_{ij}(3) + \gamma_{ij}(4) + \gamma_{ij}(5)$.

Sims introduced the recursive VAR which is the simplest form with Cholesky decomposition of matrices [24]. Cholesky decomposition identifies structural shocks upon ordering of the variables. In this ordering, the most endogenous variable comes at the end of the order [36]. The exact identification can be obtained by the lower triangular metrics. This brings the recursive structure of the set of equations.

Let endogenous vector shown as $X_t = (INF_t, GDP_t, EXR_t, CALL_t, MS_t)$

According to the Equation 19 The coefficientsa_{21}, a_{31}, a_{32}…. shows the weights of each structural shock.

$$\begin{bmatrix} u_{\mathrm{INF}} \\ u_{\mathrm{GDP}} \\ u_{\mathrm{EXR}} \\ u_{\mathrm{CALL}} \\ u_{\mathrm{MS}} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 \\ a_{31} & a_{3,2} & 1 & 0 & 0 \\ a_{41} & a_{4,2} & a_{4,3} & 1 & 0 \\ a_{51} & a_{52} & a_{5,3} & a_{5,4} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon\mathrm{INF}_t \\ \varepsilon\mathrm{GDP}_t \\ \varepsilon\mathrm{EXR}_t \\ \varepsilon\mathrm{CALL}_t \\ \varepsilon\mathrm{MS}_t \end{bmatrix} \quad (20)$$

Where uMS – money supply shock, $uCALL$- interest rate shock, $uEXR$- Exchange rate shock, $uGDP$ – out put shock, $uINF$ – inflationary shock. εMS, εCAL, εEXR, εGDP, and εINF are reduced form residuals, which explains the unexpected movements of each regressors.

In Equation 20 the factorization is recursive named Cholesky Factorization, which decomposes residuals in triangular pattern. In this factorization the contemporaneous impact is in order. Exact identification requires that (n^2 - n)/2 (n number of variables) restrictions be placed on the relationship between the regression residuals and the structural innovations.

Equation 19 has ten restrictions, where this model is a fully identified model.

$$\frac{n^2-n}{2} = \frac{5^2-5}{2} = 10$$

According to the Killian, the first two equations explain the economic rational of the aggregate demand and aggregate supply [3]. The third equation represents the equilibrium in financial markets [5]. The fourth equation supports the quantity theory of money, and the last equation explains the monetary policy reaction function[16]. Hence, the rationale behind the Cholesky order of this model makes economic sense.

5.2.3. Testing Special Features of VAR

VAR stability and stationarity

For given first order autoregressive (AR (1)) model, (Equation 20) the stability condition is| a_1| < 1.

$$x_t = a_0 + a_1x_1 + e_t \quad (21)$$

From the Equation (19)

$$X_t = A_0 + \sum_{n=1}^{p} A_pX_{t-p} + e_t$$

I = unit metrics and after n iterations,

$$X_t = A_0(1 + A_1 + \cdots . A_1^n + + \sum_{i=0}^{n} A_1^i e_{t-i} + A_1^{n+1}x_{t-n-1} \quad (22)$$

To converge the polynomial in Equation 20, the An vanishes as an approach to infinity. The stability of the VAR is determined by the calculating roots of Equation 20 which is simplified in Equation 21.

$$(I_n - A_1L - A_2L^2 - \cdots)\ Xt = (L) \quad (23)$$

Characteristic polynomial is

$$(I_n - A_1z - A_2z^2 - \cdots) = \varphi_t \quad (24)$$

Roots of $|\varphi_t| = 0$ provides the facts on stationarity or nonstationary of the process. When all characteristic roots lie outside the unit circle[17] then the φ is full rank and all variables are stationary [35]. Stationarity of VAR corresponds to all eigenvalues of A_1 being less than one in absolute terms.

5.2.4. Determining the Lag Length

In order to find the best lag length in given VAR estimation Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC can be use. These information criteria[18] are suitable to multivariate generalizations. But multivariate AIC and SBC cannot be used to test statistical significance of alternative models as those used in univariate case [35].

$$AIC^* = \frac{-2\ln(L)}{T} + \frac{2N}{T} \quad (25)$$

$$SBC^* = \frac{-2\ln(L)}{T} + \frac{Nln(T)}{T} \quad (26)$$

L – Maximized value of the multivariate log likelihood function

N – Total number of parameters estimated in all equations

T – Usable information set

As VAR model consists of system of simultaneous equations, it may contain endogeneity[19] issue. Hence, the selection of the best fit lag length is important. Further, by

plotting the autocorrelations and cross-correlations of the residuals of the equations (Correlograms) it can identify the best fitted models.

5.2.5. Impulse Response Function

IRF measures dynamic effect of a structural shock εj on a variable Xi. IRF can be easily computed by the vector moving average model. The difference between the expected path with the shock and the expected path without the shock is considered as IR path. The IRF is the partial derivative of $(\partial X_{t+h})/\ \partial \varepsilon_t$ for all $h \geq 0$. Where h is given by IRF Impulse response path (θ_h) is given as follows with the unanticipated shock.

$$(\theta_h) = E(X_{t+h}|\varepsilon_t = 1, \varepsilon_{t-1}, \varepsilon_{t-2} \ldots) - E(X_{t+h}|\varepsilon_t = 0, \varepsilon_{t-1}, \varepsilon_{t-2} \ldots) \quad (27)$$

The IRF can be estimated in two ways by given stationary ARMA (p,q), (Linear process)

$$\text{Iteratively computing } (h) = (X_t+h|\varepsilon t = 1) - (\bar{X_t}+h|\varepsilon_t = 0) \quad (28)$$

Computing $\theta(L) = \frac{\beta(L)}{\alpha(L)}$ where,

As ARMA(p,q) can be expressed as $\alpha(L)y_t = \beta(L)\varepsilon_t$

MA representation is from Equation 28,

$$y_t / \varepsilon_t = \beta(L)/\ \alpha(L)$$

$$\theta(L) = \frac{\beta(L)}{\alpha(L)} \quad (29)$$

$$\beta(L) = 1 + \beta_1 L + \cdots + \beta_q L^q$$

$$\alpha(L) = 1 - \alpha_1 L - \cdots \alpha_p L^p$$

In multivariate case n x n matrices $\gamma h = A^h B^{-1}$ contains all the impulse response at horizon h.

The (i,j) elements of the γh matrices the impulse responses of variable i to a given shock to j plots the impulse responses against the time horizons 0, 1, 2, …h periods after the shock.

5.2.6. Variance Decomposition

The forecast error variance decomposition explains about the magnitude of the movements in an order because of its own shocks versus shocks to other variables.

6. Empirical Assessment

6.1. Testing for Stationarity

Augmented Dickey Fuller unit root test is used to analyze the stability of the five selected macroeconomic variables. The time series plots of the weighted average Call Rate and inflation rate do not show any deterministic trend. But the plots provide evidence of stochastic trends. According to the following figures, exchange rate, GDP and money supply there is enough evidence of having deterministic trend. Figures of the all-time series are in Appendix 2. In order to determine the stationarity of the above time series, Augmented Dickey Fuller is applied under following regression models in first difference and levels. According to the graphical interpretation there is a possibility of having both deterministic trend and stochastic trend. Equations for the data generating processes, which have constant and time trend.

In levels

$$\Delta Y_t = a_0 + \gamma y_{t-1} + a_2 t + \sum_{t=1}^{p} \beta_t \Delta y_{t-1}\ \varepsilon_t \quad \varepsilon_t \sim (0, \sigma^2) \quad (30)$$

In first difference

$$\Delta^2 Y_t = a_0 + \gamma^* y_{t-1} + \sum_{t=1}^{p-1} \beta_t^* \Delta^2 y_{t-1} + \varepsilon_t \quad \varepsilon_t \sim (0, \sigma^2) \quad (31)$$

Equations for the data generating processes which has constant only.

Unit root test results can be shown as follows (Table 5).

Table 5. *Unit root testing for key variables.*

	(P value)[20]	CALL	Ln(EXR)	Ln(GDP)	INF	Ln(MS)
Level	drift and deterministic trend	0.0783*	0.0992	0.9848	0.0000	0.9980
	drift and no trend	0.0904	0.9727	0.9995	0.0000	0.9329
	no Drift and no trends	0.1477	0.9999	1.0000	0.0110	0.9938
1st Difference	Constant	0.0000	0.0000	0.0001		0.0113
	None	0.0000	0.0000	0.0470		0.0422
Level of integration		I(1)	I(1)	I(1)	I(0)	I(1)

The unit root test results proved that other than the inflation rate all other variables have unit root at 5.0 per cent level of significance. Hence, the inflation is integrated at levels I(0) and other series are integrated at first order I (1). After the stationarity testing, the next section determines the most suitable recursive VAR model to the above macro- economic variables.

6.2. Selection of Best Suitable VAR Model

The appropriate recursive VAR model is generated for the selected stationary macro variables. To make the series stationery, the first difference of the CALL variables, and log

difference of the money supply have taken. The following equations show how to determine those stationarity series.

Table 6. *Stationary series.*

Stationary Variable	Equation	Order of integration
DCALL	$DCALL_t = CALL_t - CALL_{t-1}$	I(1)
DLEXR	$DLEXR_t = \ln(EXR_t) - \ln(EXR_{t-1})$	I(1)
DLGDP	$DGDP_t = \ln(GDP_t) - \ln(CALL_{t-1})$	I(1)
DLMS	$DLMS_t = \ln(MS_t) - \ln(MS_{t-1})$	I(1)
INF		I(0)

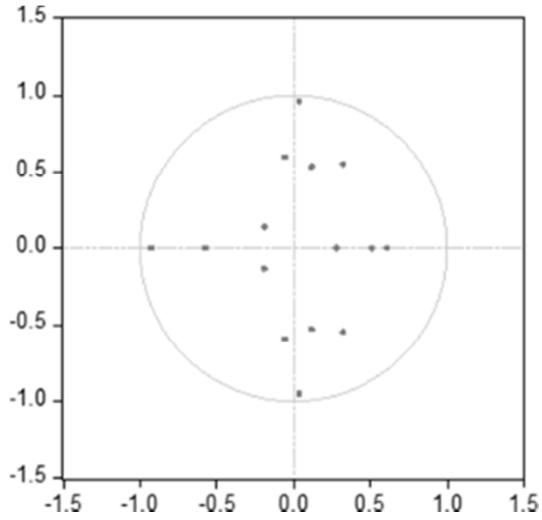


Figure 12. *Inverse Roots of AR Characteristic Polynomial.*

6.2.1. Selection of Best Suitable VAR Model

Before fitting the 5-VAR for the variable DCALL, DEXR, DGDP, DLMS and INF there is a requirement of finding the lag length of the VAR. According to Appendix 3, this test uses AIC, Hannan-Quinn information criterion (HQ) and Final prediction error (FEP) with 8 lags to determine the best lag length criteria. The above three information criteria select the lag 5. Since there is a clear determination of lags which is given by the three information criteria there is no requirement of going for standard practice[21].

In order to determine the parsimony of the selected VAR model there is a requirement to do residual testing to show there is no autocorrelation. Hence, we need to plot autocorrelation and cross-correlation of the residual of the five equations (Appendix 4). According to the plot of residual correlogram, even though it has several peaks outside the 2SE[22] bound, the majority of the correlation is well inside the bounds. Hence, the 5- VAR (5) model is the selected macroeconomic variables.

6.2.2. Stationarity of the VAR

To check the stability of the VAR, an AR unit graph is used. According to figure 12, as all its roots inside the unit circle the VAR is satisfying the stability condition.

5 -VAR (3) model

According to the model selection by the lag length criteria, residual correlogram analysis and the AR root graph, 5-VAR (3) model can be written as follows.

$$\begin{bmatrix} DLMS_t \\ DCALL_t \\ DLEXR_t \\ DLGDP_t \\ INF_t \end{bmatrix} = \begin{bmatrix} a_{11}(L) & a_{1,2}(L) & a_{1,3}(L) & a_{1,4}(L) & a_{1,5}(L) \\ a_{21}(L) & a_{2,2}(L) & a_{2,3}(L) & a_{2,4}(L) & a_{2,5}(L) \\ a_{31}(L) & a_{3,2}(L) & a_{3,3}(L) & a_{3,4}(L) & a_{3,5}(L) \\ a_{41}(L) & a_{4,2}(L) & a_{4,3}(L) & a_{4,4}(L) & a_{4,5}(L) \\ a_{51}(L) & a_{52}(L) & a_{5,3}(L) & a_{5,4}(L) & a_{5,5}(L) \end{bmatrix} \begin{bmatrix} DLMS_{t-1} \\ DCALL_{t-1} \\ DLEXR_{t-1} \\ DLGDP_{t-1} \\ INF_{t-1} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \\ e_{5t} \end{bmatrix} \quad (32)$$

Where $aij(L) = (\gamma ij^{23} + \gamma ijL + \gamma ijL2 + \gamma ijL3 + \gamma ijL4)$ with the individual coefficients denoted as $\gamma ij(1)$, $\gamma ij(2) + \gamma ij(3) + \gamma ij(4) + \gamma ij(5)$.

6.2.3. Impulse Response Function

Under this section, impulse response functions are used to explain different dynamic responses of the macroeconomic variables to the various monetary policy shocks. The impulse response functions of the variables lie over 10 quarters and one standard deviation period.

The impulse response functions generated from the recursive VAR shows that positive shock of money supply affects the growth of GDP by 0.01 per cent after one quarter of the shock. This follows the expected positive relationship between the money supply and the output. The impact dies out gradually and comes to equilibrium by three quarters. Similarly, the maximum impact of increasing WACMR to the GDP growth achieved after 2 quarters of the shock and the magnitude is 0.01 per cent decrease of GDP growth. Under the contractionary monetary policy, it is expected that output of the country will decline. This result follows the findings of the Vinayagathasan and Amarasekara [5, 4].

Further, the response of depreciation in domestic exchange rate (positive exchange rate shock) to the shock of WACMR growth shows immediate impact and the shock reaches equilibrium level after five quarters. According to the Vinayagathasan there is no significant impact on interest rate from the exchange rate shocks [5].

7. Conclusions Policy Implications and Further Studies

7.1. Summary and Conclusion of the Study

Similar to other countries, this research analyses the outcome of the recursive VAR to identify the impact of the monetary policy to the selected macro- economic variables. Such empirical research has a required role in selecting appropriate macroeconomic theories under different circumstances. The Review of the monetary and macroeconomic theories offers correct guidance to the expected results in model and to verify the correct ordering of the economic variables. Section 2 reviews the theories on money supply and money demand to identify the behavior of the monetary policy conduct of the country. Further, the chapter discussed the theories of AD-AS model and Taylor rule to identify monetary policy transmission and the economic forecasting. in addition to that the chapter discussed some theories relevant to the exchange rate as well.

Section 3 discussed empirical literature that is relevant to the research question. This chapter mainly discussed studies which based on the different monetary policy approaches and different macroeconomic environments. Both in global and domestic context most of the studies select inflation, money supply and GDP as key macroeconomic variables. Further, most of the studies proved that when a country is in a good economic condition, inflation targeting is the best selected monetary policy framework to adopt. It proved that developing countries have poor efficiency in monetary policy transmission than the developed countries. In terms of model selection of these studies, most of the researchs are based on the structural VAR approaches. Studies found that the effectiveness of the monetary policy transmission to the key macroeconomic variables are based on the different factors such as country's economic environment, openness of the economy, monetary policy stance etc.

section 4 reviewed the monetary policy and macroeconomic behavior in Sri Lanka. This review is more important as Sri Lanka has undergone to substantial financial and economic reforms. With the introduction of active open market operations in 2003, the vulnerability and efficiency of the monetary policy operations increased. Sri Lanka is targeting monetary aggregates as their intermediate target of monetary policy. They use interest rate corridor to manage in order to implement monetary policy they are using different kind of monetary policy tools. Such comprehensive analysis in section 4 provides good explanations in monetary policy stances of the country and the consecutive macroeconomic behavior.

Referring to the empirical literature, section 5 explained methodologies used in the study. The section presents rational of selecting recursive VAR model for this research problem. Further, it discussed shortcomings of the other econometric models as well. To determine the stationarity of the time series data this study uses ADF testing.

Section 6 discussed the empirical analysis based on the research question. The model uses quarterly data from 1990-2016. The best fitted recursive VAR model is selected with the appropriate choloskey factorisation. Impulse response functions elaborated the magnitude of the impact from the shock and time taken to become equilibrium level. Even though some variables did not produce expected outcomes, most of the variables produce expected relationships with the different policy shocks.

The results of the analysis are broadly in line with the outcomes of the existing empirical analysis. Similar to the Amarasekara, and Vinayagathasan [4, 5]. This analysis produces positive effects of money supply and GDP. According to the results, when interest rate is increasing GDP is decreasing. This result is in line with the expected relationship which is based on the theory. Further, increasing interest rates lead to depreciation in the domestic exchange rate. Even though the above results follow theoretical expectations, there are several puzzling results and insignificant relationships with the results. When money growth is increasing it is expected to increase inflation. But this study provides an unclear relationship with the money supply to inflation. In this case the impulse response function does not provide good significant results. As per results of the study, the time taken to reach maximum level of GDP growth due to money supply shock is reduced. It is for nine months to three months [4]. In general, the findings of the study prove that there is a significant impact of monetary policy on the economy.

According to Walsh, the incorrect measures and different scales of variables significantly affect the empirical estimates [18]. In general, the study tries to provide supplementary literature to the field of monetary policy to overcome identified drawbacks in similar studies [4].

7.2. Policy Implications

According to this analysis there is satisfactory evidence to show the significant impact of the monetary policy to the macro economy. It shows the direct impact of changing impact to the macroeconomic variables. But there isn't any significant impact on inflation which elaborates the weakening of money to inflation rational. Hence, CBSL should consider different policy approaches to strengthen this relationship in going forward. The best suggestion would be to select a direct inflation targeting framework by eliminating the existing monetary targeting framework.

7.3. Limitations of the Study

This study was conducted by using quarterly data. But for the period of 1990-1996 there is no quarterly data for GDP. Hence, linear interpolation method is used to generate quarterly GDP data from annual data. Such interpolation affects the accuracy of the econometric estimates. Further, reserve money data is taken from the end of month point, which does not always show random observation of the quarter.

7.4. Further Studies

This research uses recursive VAR with the cholesky factorization. But it would be more detailed if study uses structural factorization, which deals with more economic theories. Further, in advanced analysis the structural vector autoregressive model in a Bayesian framework can be used with time-varying parameters. As an extension to this analysis more variables can be used. For example, openness of the economy, different sectorial development, financial market developments fiscal interventions. Depending upon the data availability, larger sample period may increase the accuracy and generates real outcome.

Appendix

Appendix 1: Data Description

1) GDP captures the quantity of output (good and services) produce within Sri Lanka. The selected base year for the GDP (constant price) is 2013. In GDP quarterly data is available only from 1996 onwards. Hence to interpolate annual data to quarterly data, this research used linear interpolation method.
2) Money supply is determined by broad money which is defined as the total of currency held by the public and all reserves in central bank.
3) Inflation captures the increase in the general price level of goods and services. The base period of this is 2013. Used monthly data to take quarterly averages.
4) WACMR is the very short-term interest rate measured on the overnight basis as weighted average of the interbank uncollateralized money transaction rate.
5) Exchange rate of the USD/LKR is taken by the daily average.

Appendix 2: Unit Root Testing

Most of the economic time series appear to be nonstationary in the real world. In non- stationary series there are three main features. Such series doesn't exhibit long run mean reversion and there is no constant variance. Further, the theoretical correlogram does not diminish with the increasing lag length (there is no constant covariance). There are two types of nonstationary processes. Namely, deterministic trends and stochastic trends (Figure 8). Deterministic trend can be removed by the de-trending and stochastic trends, or unit root can be eliminating by differencing [35].

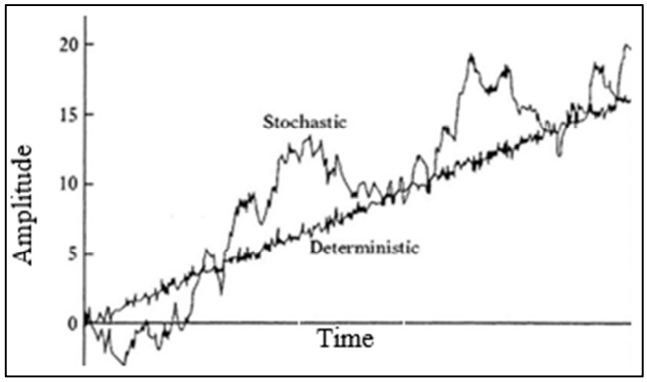


Figure 13. *Deterministic Vs Stochastic Trends.*

As a good solution to the critical mistake[24] in Monte Carlo experiment in unit root problem, Dickey and Fuller developed a formal test to find out the presence of unit root. But the Dickey Fuller test is accepted only if error terms are white noise. Contrasting to Dickey Fuller test, in Augmented Dickey Fuller test the lag of dependent variables was also considered for the testing to eliminate the autocorrelation in dependent variable.

There are a few points to be considered in using the Augmented Dickey Fuller test. This test is not suitable for the data series with seasonal patterns, as there is tendency in rejecting null hypothesis. Further this test is not suitable for the time series with structural breaks. The following regressions are used to determine the stationarity of the given time series.

Appendix 3: Lag Length Criteria

Table 7. *Lag length criterion.*

Sample: 1990Q1 2016Q4						
Included observations: 98						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-1754.207	NA	2.69e+09	35.90219	36.03408*	35.95554
1	-1707.840	87.05637	1.74e+09	35.46613	36.25745	35.78620
2	-1685.124	40.33342	1.83e+09	35.51273	36.96348	36.09953
3	-1624.949	100.7005	9.02e+08*	34.79488*	36.90506	35.64841*
4	-1600.705	38.09861	9.34e+08	34.81030	37.57991	35.93055
5	-1579.477	31.19122	1.04e+09	34.88729	38.31633	36.27427
6	-1567.403	16.51041	1.42e+09	35.15107	39.23954	36.80477
7	-1549.246	22.97338	1.75e+09	35.29074	40.03864	37.21116
8	-1506.468	49.76278*	1.33e+09	34.92791	40.33524	37.11506
* indicates lag order selected by the criterion						
LR: sequential modified LR test statistic (each test at 5% level)						
FPE: Final prediction error						
AIC: Akaike information criterion						

Sample: 1990Q1 2016Q4						
Included observations: 98						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
SC: Schwarz information criterion						
HQ: Hannan-Quinn information criterion						

Appendix 4: Autocorrelation and Cross-Correlation of the Residual of 5 -Var (3)

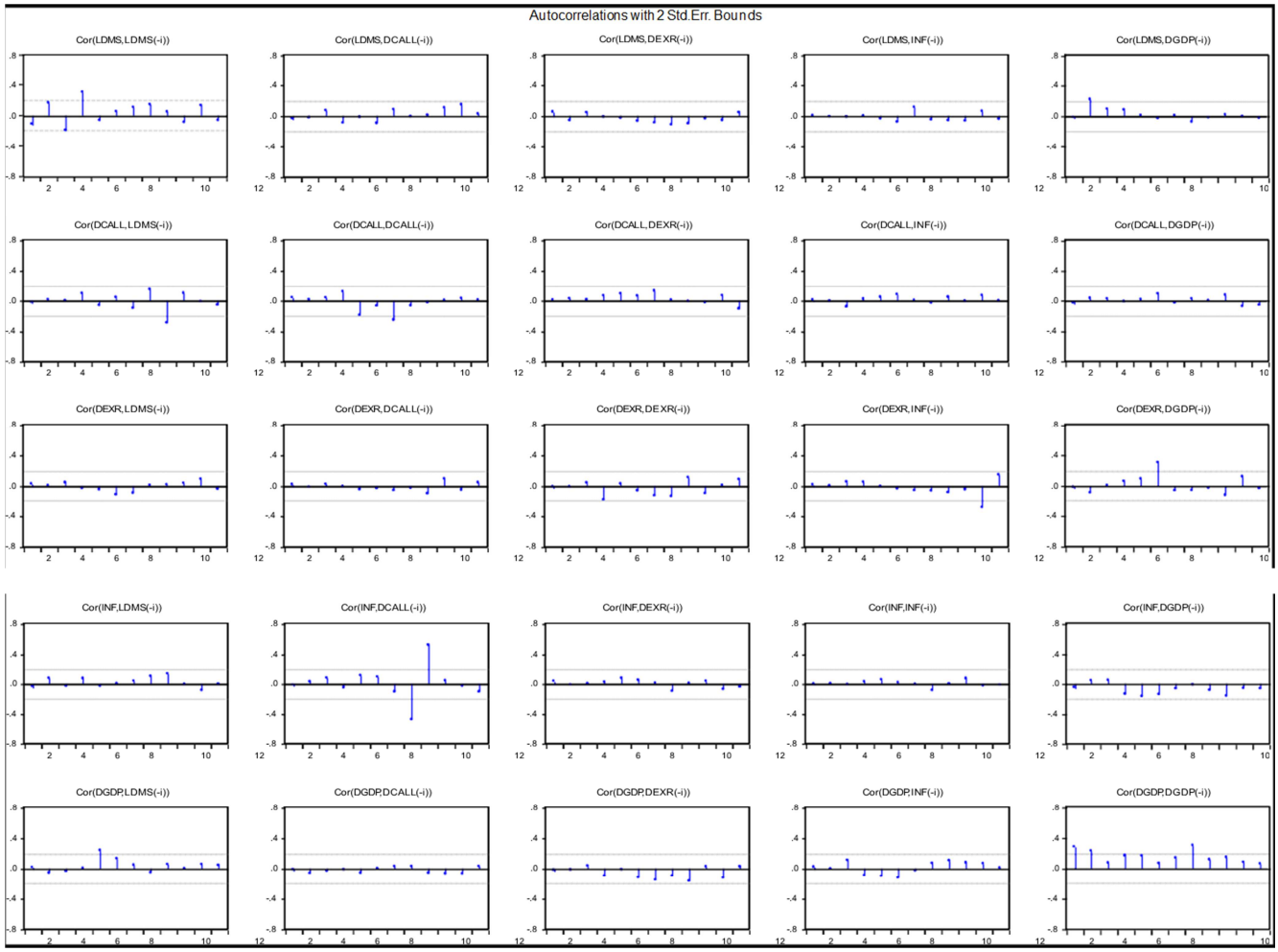


Figure 14. *Autocorrelation and Cross-Correlation of the Residual.*

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1 Quarterly GDP data is interpolated to the monthly data.

2 Inflation, Exchange Rate, Interest rate and GDP

3 AR root graph is used to check stability of the VAR

4 Base money is the sum of currency held by the public and the bank reserves.

5 Cash ratio reflects the preference of holding money as cash form, by the household

6 Reserve ratio is determined by the central bank. That is the number of deposits held by the banks in their current account in the central bank as reserves.

7 Treasury Bills, Savings accounts, Certificates of Deposits.

8 For example savings accounts and money market mutual funds.

9 Monetary policy transmission channels - interest rate, bank lending, exchange rate and asset price channels

10 Central bank Independency: no intervention from the government and political parties over decision making process of central bank.

11 Compared to the United States and developed countries in Euro area, the exchange rate channel in Romania, Poland, Hungary and CzechRepublic react quickly to transmit the impact of monetary policy to the consumer prices.

12 Agriculture, forestry and fishing, mining and quarrying, manufacturing, construction, electricity, gas and water, transport, storage, communication, wholesale and retail trade, hotels and restaurants, Finance, insurance, real estate and business services

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14 Shows the contemporaneous impact by the given shock at time t.

15 AIC information criteria selects lag 5 as the best lag length for this model.

16 Change in money supply will affect the other variables in order. This is called exogenous monetary policy shock. This shock change comes from the money supply variations in open market operations.

17 as necessary and sufficient condition for stability

18AIC: Akaike information criterion (smaller is better), SC: Schwarz information criterion (smaller is better), LR: Likelihood Ratio (bigger is better)

19 Dropping lag values of the variables adds to the error term and it relates with the explanatory variables ofthe model (Gottschalk, 2001).

20 *at 5 per cent level of significance

21 Once data is on a quarterly basis standard practice is to work with 4, 8 and 12.

22 Two Standard Deviations

23 Shows the contemporaneous impact by the given shock at time t.

24 Monte Carlo simulation referred to as an experiment as it draws selected numbers for testing. Hence the results are limited to sample size. The test value changes with the samplesize. Hence this test is suitable for small sample sizes in given time series data (Handry, et al., 1990).