# A STUDY ON USE OF BUSINESS INTELLIGENCE TO IMPROVE MACROECONOMIC FORECASTING IN SRI LANKA.

Kruwitage Dona Uththara Harshani

(159109K)

Thesis submitted in partial fulfillment of the requirements for the degree of Master of Business Administration in Information Technology

Department of Computer Science and Engineering

University of Moratuwa

Sri Lanka

March 2016

# A STUDY ON USE OF BUSINESS INTELLIGENCE TO IMPROVE MACROECONOMIC FORECASTING IN SRI LANKA.

Kruwitage Dona Uththara Harshani

(159109K)

Thesis submitted in partial fulfillment of the requirements for the degree of Master of Business Administration in Information Technology

Department of Computer Science and Engineering

University of Moratuwa

Sri Lanka

March 2016

# Declaration

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis/dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

K. D. Uththara Harshani                                         Date:

The above candidate has carried out research for the master's thesis under my supervision.

Dr. Amal Shehan Perera                                         Date:

# Abstract

This research discusses the use of Business Intelligence in macroeconomic forecasting and how the improved forecasting will assist better monetary policy decision making in Sri Lanka. Various macroeconomic factors are analyzed and forecasted in order to make accurate policy decisions. Forecasting is usually done over diverse statistical models and techniques. The effective policy decision making will help the government for maintaining price stability, for making right decisions over perceiving future of the economy and for futuristic planning.

The research was based on qualitative case study methodology. A case study was conducted at the Central Bank of Sri Lanka and data was collected through personal interviews by using semi structured questionnaire. The main focus is to understand the process of monetary policy decision making, how macroeconomic forecasting has been done, limitations of the existing forecasting process and the possibility of using Business Intelligence in forecasting to improve policy decision making.

Interviews were carried out with experts in Department of Economic Research, Department of statistics, Central Bank of Sri Lanka, Institute of Policy Studies and with other experts in field of econometrics and economic modeling. The research further discussed how limitations of current approaches could be addressed over today's emerging concepts like business intelligence, neural networks. This study would provide guidance in developing a better forecasting model for Sri Lanka in the future.


**Keywords:** Business Intelligence (BI), Macroeconomic forecasting**,** monetary policy decision making

# Acknowledgement

# Table of Contents

# List of Figures

# List of Tables

# List of Abbreviations

| | |
|---|---|
| ANN | Artificial Neural Networks |
| CBSL | Central Bank of Sri Lanka |
| BI | Business Intelligence |
| GDP | Gross Domestic Product |
| ARMA | Auto regressive and moving average |
| ARIMA | Autoregressive integrated moving average |
| VAR | Vector Auto Regression |
| DSGE | Dynamic Stochastic General Equilibrium |
| VECM | Vector Error Corrections Model |
| GA | Genetic Algorithms |
| CCPI | Colombo Consumer Price Index |

# 1. INTRODUCTION

## 1.1. Chapter Overview

This research focuses on improving the effectiveness of the monetary policy decision making by using Business Intelligence approaches in macroeconomic forecasting. The study has been carried out at the Central Bank of Sri Lanka. Purpose of this study is to find out how macroeconomic forecasting can be improved over Business Intelligence, thereby, aid better monetary policy decision making process.

This chapter provides information associated with the background and motivation of the research, research problem, research objectives, research design and the significance of the study.

## 1.2. Background and Motivation

Today in the highly globalized and highly unpredictable environment, economic forecasting is emerging as a rapidly developing research area with wide applicability in business and government. To achieve an advanced position of global economic growth one must quickly identify good opportunities and take advantage of them in a fast and effective manner. More and more business organizations and governments are visualizing that it is of great importance to make their decisions by using Business Intelligence (BI) technologies.

Economic forecasting is the process of attempting to predict the future condition of the economy. It is the projection or estimation of statistical measures of the performance of a country, group of countries, industry, firm or community. This involves the use of these techniques utilizing variables sometimes called indicators. Some of the most well-known economic indicators include inflation and interest rates, GDP growth/decline, retail sales and unemployment rate. While economic forecasting is not

an exact science, it remains an important decision-making tool for businesses and governments as they formulate financial policy and strategy.

### 1.2.1. Forecasting

Forecasting generally refers to make statements on what likely to happen in the future, in other terms, predicting the likely path of future events over period of time based on past and present data. Most common forecasting techniques are univariant, multi-variant and qualitative analysis. Time series are used to forecast future trends including Autoregressive integrated moving average (ARIMA), exponential smoothing and trend analysis. Multivariant methods consist of multi regression model, econometrics and state space.

Delphi marketing research, situational analysis and historical analogue, come under qualitative methods. These forecasting methods forecast trends over different time horizons. The time length is considered when using these forecasting methods, it is evident that univariant performs better than multivariat as multivariat models have more parameters than univariate, additional parameters may give additional error in sampling variation. (Box et al., 1994)

In economic forecasting, Forecasting with linear and non- linear regression models, forecasting with confidence intervals, Forecasting with time series including seasonal, ARIMA, exponential and stochastic series are widely used among many different forecasting techniques. Today intelligence forecasting techniques including fuzzy models, neural network models, expert systems, meta- heuristics models, grey theory models and integrated models of these have emerged.

The type of pattern experienced and the type of data available are the two main dimensions in forecasting. The type of pattern can be where the historical pattern expected to repeat in the future.

And the pattern can be dependent on both external factors and historical observations. In certain forecasting situations quantitative historical data are available.

The past data are paramount importance for forecasting. The accuracy of forecasting result is affected by the quality of past data as well as the method of forecasting.

The real world data are normally noisy and erroneous and can be missing observations. Therefore, the forecasting results may not be accurate when the forecasts are generated from erroneous or noisy data.

### 1.2.2. Development of Macroeconomic Forecasting

In early 90s, two common approaches were very popular in macroeconomic forecasting. One is structural approach and the other is reduced form approach. Later, in 1970s it was found that the Keynesian structural approach was defective, since then nonstructural forecasting models were explored. As a result later in 1920s auto regression model was introduced. Auto regression performed well in macroeconomic forecasting. One significant milestone in the development of nonstructural forecasting was introduction of time series analysis. Box and Jenkins, two mathematicians, experimented with "Stochastic trend" where the trend was exposed to random shocks. Stochastic trend was controlled by the cumulative effects, generated from random shocks.

ARMA was a combination of auto regressive and moving average models. Since ARMA models were univariate, multivariate vector autoregressive models were introduced. Another significant development was dynamic factor model in 1997. Dynamic factor model considered that certain economic shocks are common across sectors while others are distinctive. This model was useful for long horizon data sets. Stock and Watson (2002) clarified that inferred common factors can be estimated by principal component analysis in large data sets. According to the research Stock and Watson strived forecasting macroeconomic indicators using principal component analysis; latent factors were estimated by principal component analysis and then relation between the dependent variable and the latent common factors was estimated by linear regression.

Stock and Watson (2005) compared several models and concluded that forecasting accuracy is higher in factor models.

However, variations in a few variables cannot represent the changes in entire economy. Researches combined principal component analysis with various other models and tried to develop better models while maintaining higher accuracy in forecasting output.

### 1.2.3. Business Intelligence in Macroeconomic forecasting

In recent years emerging Business Intelligence techniques play a vital role in economic forecasting. Business Intelligence in economic forecasting includes techniques; neural networks, support vector machine, genetic programming, clustering analysis, fuzzy systems, text mining, and many more. Forecasting techniques have a widespread area from simple regression to complex meta-heuristics like neural networks and genetic algorithms. And from classical logic to fuzzy logic and from meta-heuristic techniques (e.g. neural networks) to integrated meta-heuristics (e.g. neuro-fuzzy).

Neural network based forecasting and fuzzy time series has been recognized recently as emerging approach to predict the future rates in a situation where a trend is hidden, a pattern in variations of time series is hardly visualized, data is unclear and there are many uncertainties in the relationships. Neural networks are found to be useful in forecasting volatile economic variables such as economic growth, exchange rates, stock performance etc. that is difficult to forecast with traditional forecasting methods.

Today there has been a rising attention on neural networks for macroeconomic forecasting as their robust ability to detect and reproduce linear and nonlinear relationships among a set of variables. Forecasting accuracy of the neural network is known to be higher and lower the error comparing with well-established linear

regression models. Researchers suggested that neural networks show higher accuracy than linear models in economic forecasting of output and various other economic variables such as stock prices. Literature revealed that a two-layer feedforward neural network with an identity activation function is identical to a linear regression model. Therefore, it has become a powerful tool to identify and reproduce complex nonlinear data generating processes in time-series data. Whether studying growth of real GDP, inflation, employment growth or exchange rates, the neural network should, in theory, be able to detect and duplicate any complex nonlinear pattern in the data.

### 1.2.4. Monetary policy decision making

Forecasts pay a vital role in economic policy analysis and decision making as economic consequences of a policy decision is typically intended to remain for a considerable period. Therefore, predict the future direction of the economy is important, before deciding which policy to adopt. It is necessary to have tools that can provide policy guidance and that can help to determine the economic implications of monetary/ fiscal policy changes.

Providing a suggestion for Tinbergen's (1952) theory of economic policy, Theil, (1958)stated that policy makers should predict forthcoming changes in the economic environment, then they should prepare forecasts of the consequences of adjustments in the policy instrument and based on these forecasts a plan of policy actions must be developed.

For instance, the budget deficit is expected to rise in coming years, what are the factors that control budget deficit? The policy-maker should take steps to adjust the policies in order to lower the level. Moreover, policy makers frequently need to decide on the size of the government budget, how to finance and how to spend it. Furthermore, budgetary forecasts are influenced in turn by economic developments. Fiscal authorities consider modifications in taxation, debt or spending policies that require forward-looking impact assessments.

## 1.3. Research Problem

Macroeconomic forecasting is of great importance in practice. It helps governments and companies perceive the future of the economy and make right decisions. It is identified that policy makers need better forecasting tools than economic models that project likely path of important macroeconomic indicators like GDP, inflation, unemployment rate etc.in order to take accurate monetary policy decisions to maintain economic and price stability in a country.

Today emerging Business Intelligence techniques play a vital role in economic forecasting. Business Intelligence in economic forecasting includes techniques; neural networks, support vector machine, genetic programming, clustering analysis, fuzzy systems, text mining, and many more. The literature reveals that BI techniques especially neural networks predict financial data better than the other statistical methods while addressing the issues and limitations of data and statistical models. Therefore, the use of Business Intelligence in economic forecasting and ultimately how these forecasts improve monetary policy decision making in Sri Lanka will be discussed in this research.

## 1.4. Research Objectives

The monetary policy decision making is very important in economic stability. Thus, the first objective of this research is to understand monetary policy decision making framework in Sri Lanka. Key inputs for the policy decision making process are the macroeconomic variables. A set of macroeconomic variables are analyzed and forecasted in order to make right policy decisions. Then the second objective is to understand the relationship between policy decision making and macro-economic analysis and forecasting. The existing analysis and forecasting methods will be studied and the limitations of the current modeling and forecasting will be discussed. Today Business Intelligence plays a vital role in analyzing and forecasting economic data. And address the various issues find in statistical time series forecasting. Thus the third objective is to find the awareness and readiness for using Business Intelligence in forecasting economic data. Adapting new technologies always make a process efficient and effective. Then the fourth objective is to find out the impact of Business Intelligence on improving forecast accuracy thereby aid better monetary policy decision making.

The research objectives can be summarized in to four key areas.

- To understand the monetary policy framework in Sri Lanka
- To understand the relationship between macroeconomic forecasting and monetary policy decision making process.
- To understand the awareness and readiness for using Business Intelligence approaches in forecasting and visualizing economic data.
- Impact of Business Intelligence on improving forecast accuracy thereby aid better monetary policy decision making process.

## 1.5. Importance and the Benefits of the study

Macroeconomic forecasting helps governments to perceive the futuristic decision making. This research focuses on looking at how macroeconomic forecasting is done at present in Sri Lanka. A case study is carried out in central bank of Sri Lanka. And identifies limitations of current approaches. This research discusses how these limitations can be addressed over todays emerging concepts like business intelligence, neural networks.

The literature reveals how business intelligence can be used in addressing unsolved issues in macroeconomic forecasting. This research is expected to provide a guidance in developing a better forecasting model for Sri Lanka in macroeconomic forecasting.

## 1.6. Chapter Summary

In this chapter, information on background and motivation, research problem, research objectives, research design and the significance of the study were discussed in detail. The background and motivation, an introduction to forecasting, development of macroeconomic forecasting including various econometrics and models were further discussed. A description on Business Intelligence in economic forecasting was provided and finally an introduction to monetary policy decision making was given in this chapter. In short, research problem was expressed as an endeavor to find out issues and limitations of existing forecasting process at the CBSL and how forecasting accuracy could be improved over Business Intelligence while addressing the existing issues and limitations, the final outcome would be improved policy decision making. Adapting new technologies would improve efficiency and effectiveness of a process.

This research is expected to provide guidance in developing a better forecasting model for Sri Lanka in macroeconomic forecasting.

# 2. LITERATURE REVIEW

## 2.1. Chapter Overview

The diverse literature associated with macroeconomics, traditional statistical approaches and Machine Leaning approaches in macro-economic forecasting will be discussed in this chapter. Many previous researches has been carried out in forecasting macroeconomic indicators in advanced economies as well as in less advanced economies. A very few researches has been carried out forecasting inflation in Sri Lanka. This chapter provides a background for this research. And it consists of detailed descriptions of macroeconomic forecasting, development of forecasting models, traditional regression models and their limitations and advanced machine learning approaches in macroeconomic forecasting.

## 2.2. Macroeconomic Forecasting

Forecasting involves the use of information at hand to make statements about the likely course of future events. Economic forecasting is the process of making predictions about the economy. Such forecasts help for the basis of planning. Basic approaches to forecasting simply extrapolate the past; more sophisticated models attempt to understand the sources of past changes and build them into their forecasts.

There are many types of economic forecasting techniques. Forecasting techniques have a widespread area from simple regression to complex meta-heuristics like neural networks and genetic algorithms.

These techniques can be classified as follows: Forecasting with linear and nonlinear regression models, forecasting with confidence intervals, forecasting with time series including seasonal, ARIMA, exponential, and stochastic series. For a few decades, intelligence forecasting techniques including fuzzy models, neural network models, expert systems, meta-heuristics models, grey theory models, and integrated models have been emerged during the past few years for identifying useful and valid

correlations and patterns in data. Business Intelligence can be considered a recently developed methodology and technology coming into prominence in 1994 (Trybula, 1997). It has been defined as a process of selecting, exploring and modeling large amounts of data to uncover unknown patterns in data (SAS Institute, 1998).

Economic forecasting is the projection or estimation of statistical measures of the performance of a country. These statistical measures are sometimes called indicators. Some of the most well-known macroeconomic indicators are inflation, interest rates, GDP and unemployment rate. Economic forecasting is an important decision-making tool for businesses and governments as they formulate financial policy and strategy.

The Central Bank maintains inflation within a monetary targeting framework. When high inflation is projected the Central Bank tightens its monetary policy stance. The Central Bank brings down reserve money growth targets and raise policy rates to hold the price rise and to maintain the economic stability.

## 2.3. Development of Economic Forecasting Models

There are two general statistical approaches in forecasting; nonstructural macroeconomic forecasting methods and structural macroeconomic forecasting methods.

Nonstructural methods capitalize on the reduced-form correlations in observed macroeconomic time series, less bounded to an economic theory. Whereas structural models, use a particular macroeconomic theory in order to observe and interpret economic data ex. structural Keynesian macroeconomic theory. In late of 1970s Kaynesian theory and the structural forecasting started receding due to various issues.

Nonstructural models are Auto regressions, an appropriate and robust structure for modeling and forecasting various economic time series (Slutsky, Yale, 1927).

In regression models, current value of a variable is expressed as a weighted average of its own past values and a random shock. Autoregressive processes are connected to moving average processes, in moving average, the current value of a variable is expressed as a weighted average of current and lagged random shocks alone. In certain conditions, an autoregressive process can be converted to a moving average process.

Autoregressive moving average (ARMA) is a combination of autoregressive and moving average models, and has the ability to approximate dynamics more parsimoniously than pure auto regression and moving average models. Autoregressive Integrated Moving Average ARIMA is a technique to find the most suitable pattern from a group of data basically by curve fitting. ARIMA utilize past and current data to make short term forecasting. ARIMA consists of three basic concepts namely identification, assessment and testing phase and the diagnostic phase. However, macroeconomic forecasting considers multivariate relationships while ARMA model is univariate.

Box − Jenkins focused on cross variable relationships however, basic Box- Jenkins models were univariate. Thus, vector auto regression models were introduced.

Many multivariate extensions of Box- Jenkins models are implemented in the vector autoregressive framework, where cross variables relationships can be automatically incorporated.

Another important contribution was dynamic factor model by Sargent and Sims (1977). Dynamic factor model considered that certain economic shocks were common across sectors and some were idiosyncratic.

Singh and Sensarma (2006) applied vector error correction representation to identify the important variables that could be used for predicting the interest rates. The analysis is revealed that the long term interest rate is co- integrated with various variables that are macroeconomic in nature. And it is concluded that Money Supply, Stock Index and the Real Effective Exchange rate are the three important variables that help to predict the long term interest rates with a high credibility. When compared to other models, the parsimonious model (Singh and Sensarma, 2006) is identified as the best model for forecasting long term interest rates.

Empirical research in both macroeconomics and financial economics is widely based on time series (Soulas and Shasha, 2013). Online clustering and data mining systems used first level analysis of time series.

A time series is a series of numerical measurements related through time, Time series are a common form for collected data as companies and analysts are often concerned with discovering patterns in time such that they may be capable of predicting future

patterns. Examples include stock prices, periodic temperature readings and other measurements made over time.

Machine Learning and related techniques have produced some of the financial predictions that significantly profitable trading strategies during past two decades. The demand for Machine Learning is constantly increasing in the today's competitive environment as trade execution and financial decision making has become more automated and competitive.

Moreover, Machine Learning themes include reinforcement learning, optimization methods, recurrent and state space models, on-line algorithms, evolutionary computing etc. Two distinct categories of machine learning; supervised and unsupervised learning, in supervised learning the system receives a dataset as an input and uses it to make decisions and classifications, from which it infers a mathematical function that maps every element in the input to the output. On the contrary unsupervised learning is a pure learning process where the system must classify and make decisions based on the sequence of its past actions via trial and error. Unsupervised learning techniques are complex as system can set up hypothesis, no human can figure out. One would also run the risk of obtaining hypothesis too complex or specific to aid researches.

Kanevski*et al.* (2007) mapped Swiss Franc interest rates and visualized the interest rate curves based on spatial statistics and machine learning. Mapping interest rates gives a good summary view on interest rate evolution. And good results on forecasting are obtained using Artificial Neural Networking. Further it is identified the interest rate mapping can be improved by using the hybrid models based on geostatistics and machine learning and incorporating time series tools into modeling and forecasting procedure.

Similarly, Turan*et al.* (2009) proposed an innovative way of applying dynamic term structure models for capturing interest rate movements to predict future changes in interest-rate portfolios.

An unobserved component model with stochastic volatility was developed by Stock and Watson (2007) in order to overcome the parameter instability identified in univariate inflation forecasting.

### 2.3.1. Statistical models in Macroeconomic forecasting

Banbura*et al. (*2010) experimented with improving forecast accuracy by adding more variables and found that the large-Bayesian VAR model with 130 variables provide better forecasting results than traditional small BVAR models. Kalu (2001) carried a research in 14 emerging economies to identify the factors that highly influence the inflation. And concluded that food, oil prices and exchange rate changes create a larger portion of movements in inflation in emerging economies. Unemployment influence slightly and the output gap is minimal to the inflation. In India, the instable international oil prices and domestic food supply dynamics are the challenges in forecasting movements in inflation (Kapur, 2012).When forecasting output, inflation and short- term interest rate, large Bayesian VAR produces high forecast accuracy over longer horizon than other univariate and multivariate forecasting methods in India (Mumtaz and Kumar, 2012).

Furthermore, Smets and Wouters (2004) worked on a DSGE model to perform both conditional and unconditional forecasts and concluded that forecast accuracy of the DSGE model could be improved over longer horizon compared with other models. Recommended DSGE model for forecasting at the central banks.

There were some attempts to model inflation in Sri Lanka, Bandara (2011) pointed out based on the co-integration method that the money supply and exchange rate movements directly influence the rate of inflation in long run. However, it is revealed money supply has no impact by using error correction model, yet exchange rate depreciation and import price have considerable impact on rate of inflation.

Moreover, five main determinants of inflation in Sri Lanka has been identified over vector autoregressive (VAR) analysis, the output gap obtained from seasonally adjusted log-form gross domestic product (GDP) using the Hodrick – Prescott (HP) filter, money supply, rice price (point to point growth), interest rate (91 day Treasury bill rate) and exchange rate depreciation (quarter- on – quarter growth).

Ratnasiri (2009) revealed that money supply and rice price controls inflation in long run, whereas exchange rate depreciation and output gap have no considerable impact on inflation. The rice price is the most significant element in the short run while

money supply growth, exchange rate and output gap have no considerable effect on short run inflation. Price of rice has been identified as the most significant factor in long run as well as the short run. A large percentage (60 percent) of price index has been allocated for food, therefore, it is recommended to increase the supply of rice to bring down the inflation. The study has been conducted using VAR based co-integration approach.

Amarasekara (2008) worked on recursive structures and semi structural VARs with quarterly GDP, CCPI, the special drawing rights SDR exchange rate, reserve money and the interbank call rate to analyze the effects of interest rates, monthly growth and movements in nominal exchange rate on real GDP growth and inflation. It is revealed upper interest rates caused the rise in exchange rate and declined the output and inflation.

Anad, Ding and Peris (2011) built a forecasting and policy analysis model, (FPAS) based on New Keynesian Phillips Curve. The model suggested that macroeconomic volatility and anchor inflationary expectations could be reduced by open economy inflation targeting rule given the size and type of shocks faced by the economy.


The baseline Bayesian Vector Auto Regression (BVAR) is widely used in central banks in many developed countries. Bayesian Vector Auto regression consist of 03 fundamental economic variables; GDP growth, inflation and short-term interest rate. These variables largely capture future movements of output and inflation in economies with less frictions. However, these fundamental variables may not be sufficient for Sri Lanka to forecast output and inflation as small open economy in transition Sri Lanka is vulnerable to shocks arising from external environment.


Domestic supply and external shocks play a vital role in explaining the movements of key economic fundamentals in Sri Lanka (Cooray &Ratnasiri, 2009).
It is revealed that adding variables to capture domestic supply side and external sector movements could improve forecast accuracy in BVAR. Therefore, a large BVAR (LBVAR) model is considered with a few more additional variables. Exchange rate,

international oil price, monetary aggregate, international trade, current account dynamics and output gap are included to the large BVAR model.

Moreover, fixed parameter models are often criticized because of the possibility of parameters changing over time and with policy interventions. In order to deal with this issue Time Varying Parameter BVAR (TVP-BVAR) model with 03 fundamental variables is introduced. However, it is revealed that computational difficulties prevents all the variables of large BVAR model come into TVP-BVAR approach.

Univariate Unobserved Component Trend-Cycle model with stochastic volatility (UC_SV) proposed by Stock and Watson (2007). In this model the forecast variable is represented as the sum of permanent stochastic trend component and a serially uncorrelated transitory component. It has been successful in forecasting inflation in the USA. All the technique discussed above are data driven univariate and multivariate models. Parameters of these models are based on the data.

Fully micro-found Dynamic Stochastic General Equilibrium models (DSGE) are increasingly becoming popular both in policy analysis and forecasting. Thus the DSGE model has estimated for Sri Lanka (Jegajeevan, 2016).

The forecast obtained from all the above models are compared with the forecast of univariate ARMA model to assess whether these methods are successful in beating the forecast performance of ARMA model. Univariate AR, ARMA and ARIMA models are commonly used in macroeconomic forecasting like output and inflation.

### 2.3.2. Business Intelligence in Macroeconomic forecasting

Business Intelligence techniques especially neural networks and decision tree concepts have been prioritized as dominant approaches to predictive modeling (Chung and Gray, 1999). Furthermore, logistic regression is considered as traditional data mining technique whereas neural networks and decision trees are non- traditional data mining techniques, used for modeling complex non – linear relationships (Berry and Linoff, 1997).

Recent research also suggests that neural networks may prove useful to forecast volatile financial variables that are difficult to forecast with conventional statistical methods, such as exchange rates (Verkooijen, 1996) and stock performance (Refenes, Zapranis and Francis, 1994). Neural networks have also been successfully applied to macroeconomic variables such as economic growth (Tkacz, 1999), industrial production (Moody, Levin and Rehfuss, 1993) and aggregate electricity consumption (McMenamin, 1997). Applications to macroeconomics are quite novel and are still considered to be at the frontier of empirical economic methods.

Ahmad and Shahzadi (2013) applied Neural Network model for forecasting foreign exchange rates and concluded that the accuracy of estimation and the forecasting, based on Neural Network model is high. The Artificial Neural Network model is identified as the best fitting model (Ahmad and Shahzadi, 2013) for accurate interest rate prediction and for accurate exchange rate prediction, to measure the economic position of a country.

Artificial neural network has been widely used in many applications because of its ability to solve non-parametric problems; ANN is also recognized as a good and widely used tool in forecasting stock prices. Traditionally stock forecasting in Indonesia used time series analysis. And forecasting using ANN method has smaller error than ARIMA- Autoregressive Integrated Moving Average method. (Napitupulu T. A., Wijaya Y.B., 2013)

ANN is a mathematical model that is structured like the way the human brain works to identify patterns in a number of variables. ANN approach consists of three stages. Training, testing and forecasting. In the first stage, ANN model will be input with past data. This data will make the ANN model become intelligent and suitable with the problem. After ANN get enough learning from data, this model will come to the next stage, to be tested with another certain set of data. After reaching small enough error rate, the model will be used for future value or data.

One of ANN methods is a back propagation. A back – propagation ANN, is trained to perform specific tasks. During the training period, the teacher evaluates whether the ANN's output is correct. If it is correct the neural weightings that produced that output

are reinforced; if the output is incorrect, those weights are replaced. In many studies ANN has proven to be an efficient tool for non-parametric data model in the form of nonlinear function, such as business forecasting, credit scoring, bond rating, business prediction, medicine, pattern recognition and image processing.

Hill et al. (1994) conducted a research on comparing the forecasting performance of neural networks and statistical models. It is concluded neural networks performed better than standard statistical techniques in forecasting macroeconomic factors, measured in terms of the mean absolute percentage error. In time-series applications, neural networks produce more accurate results for higher frequency data that contain more nonlinearities.

Tkacz (1999) compared the accuracy of linear models and neural networks in forecasting Canada's real GDP growth using a series of financial indicators. At the 1-quarter and 4-quarter horizons, neural networks produced more accurate out-of-sample forecasts than the linear models. It is concluded that the networks capture some nonlinearities in the relationship between real GDP growth and financial indicators. In general the improvements in forecasting accuracy obtained by the networks is considered as statistically significant.

Similarly, Fu (1998) found that neural networks outperformed linear regression models for out-of-sample forecasts of US real GDP growth. The neural networks were able to reduce the out-of-sample sum of squared residuals by between 10 and 20 per cent. Moody, Levin and Rehfuss (1993) obtained analogous results when forecasting the growth rate of the U.S. Index of Industrial Production.

Considering all the forecast horizons which ranged from 1 to 12 months ahead, their two neural networks were found to be more accurate than a univariate autoregressive model and a multivariate linear regression model. An augmented neural network for forecasting real GDP growth is showed in figure 2.1.
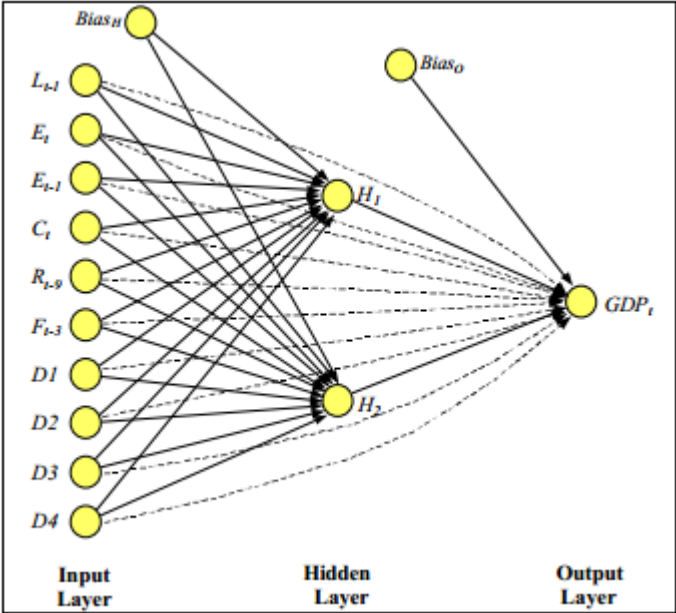


*Figure 2.1:* An augmented neural network for forecasting real GDP growth

Stock and Watson (1998) researched on forecasting macroeconomic time series that includes neural networks. Univariate forecasting methods including neural networks and various forecast pooling procedures were used to forecast U.S. monthly macroeconomic time series at three forecasting horizons. The various pooling procedures provided the most accurate out-of-sample forecasts, suggesting that neural networks may help improve forecasting accuracy when combined with other forecasts.

Samant S. (2015)  researched on applications of data mining techniques for stock investment and it is identified certain data mining techniques such as decision trees, have weaker capabilities to handle numerical attributes as there are infinitely many possible ways to enumerate relations among data. And other soft computing methods based on association rule mining, fuzzy logic, neural networks, and genetic algorithms are now used in predicting the financial markets.

Genetic algorithms have shown greater capability on solving high dimensional problems, and high capacity to deal with numerical data and relations of numerical data.

Moreover, Association rule discovery is too identified as a good predictive approach. Associative classification rules are extracted from an available data set and then build an associative classification model. Classification is one of the popular tasks in data mining that forecast the class of an unseen instance as accurately as possible.

It is concluded that association rule mining algorithms cannot handle numerical data efficiently so that a modified GA is being used for the representation of the stock market data and to generate rules among the various technical indicators. Association rule mining algorithm help in generation of the frequent rule set along with the class label and then predict the class label for the new test data. Overall a new method was proposed for stock market prediction using a combination of Generic and Association rule mining algorithm which can handle numerical data. The prediction performance had 95% of accuracy.

## 2.4. Chapter Summary

In this chapter diverse literature associated with macroeconomic forecasting and its development over the years were provided. This chapter further included descriptions of macroeconomic forecasting, development of forecasting models, traditional regression models and their limitations and advanced machine learning approaches in economic forecasting. Moreover, early researches carried out in comparing and contrasting various statistical models and advantages of machine learning techniques over traditional regression models were discussed.

# 3. RESEARCH METHODOLOGY

## 3.1. Chapter Overview

In this chapter, the research methodology will be discussed in detail. The factors identified in the literature review and the conceptual framework is further elaborated.

The conceptual framework is designed to give a clear understanding of the factors, considered in this research. The qualitative research approach is used for this research. Furthermore, this chapter provides the theoretical background on research methodologies including Qualitative research methodologies, Qualitative case study methodology, Qualitative research design and Qualitative Data Analysis.

## 3.2. Research Methodology

Quantitative research involves handling independent variables and dependent variables, whereas other variables are considered to be held constant. However, qualitative research requires no manipulation of variables instead it considers developing explanations of social phenomena, considering the social aspects.

The research objectives are complex and very subjective. Personal experience, practices and expert judgment influence the end results yet cannot be expressed numerically. Therefore, the qualitative research approach is used for this study.

## 3.3. Research Methodology Justification

After studying many different types of qualitative research methodologies, the case study methodology is selected for this research.

In case study method, a single person, program, event, process, institution, organization, social group or phenomenon is investigated within a specified time frame using a combination of appropriate data collection methods.

The process or the core phenomenon investigated in this research, is monetary policy decision making at the CBSL and macroeconomic projections influence the core phenomenon. The technology improves the accuracy of projections and ultimately the effectiveness of the process is increased. Senior officials of Department of Economic Research, Department of Statistics at the CBSL, and experts at the Institute of Policy Studies and Sri Lankan state universities are interviewed by using a semi structured questionnaire.

Propositions are helpful in any case study, specific propositions limits the scope of the study and increase the feasibility of completing the project on time. Propositions may come from the literature, personal/professional experience and from theories. In this research, propositions from the literature, personal experience of professionals are included.

This research develops preliminary conceptual framework based on literature and the pilot study, later, it is further developed to the final conceptual framework. The refined conceptual framework includes all the themes that have emerged from data analysis.

The process of monetary policy decision making is independent of the technology yet it depends on the forecast accuracy. Forecast accuracy can be improved through different technologies. Therefore, considering all the facts, the author justifies the case study methodology is appropriate for conducting this research.

## 3.4. Qualitative Data Analysis Methods

Grounded theory approaches has become increasingly popular in the IS research as the method is extremely useful in developing context-based, process oriented descriptions and explanations of a phenomenon. Grounded theory is a research method that develops a theory based on data collected in the study.

This qualitative research conducts a case study at the CBSL to study the process of monetary policy decision making. Interviews are carried out by using semi structured questionnaire. The questionnaire consists of open ended questions and is designed to obtain information, personal experience and expert ideas. This research further discusses the factors influence the process and what actions improve the process. Macroeconomic factors are monitored, forecasted and analyzed in order to make right policy decisions. The accuracy of decisions depends on the accuracy of forecasts. Accuracy of forecasts depends on the quality of data, method of forecasting and the nature of the economy. The issues and the limitations of the process can be addressed by new technologies like Business Intelligence/Machine Learning over existing statistical/regression models.

## 3.5. Research Design Methodology

This section describes the research design methodology embraced for this research and it is represented in Figure 3.1 in a diagrammatic view.
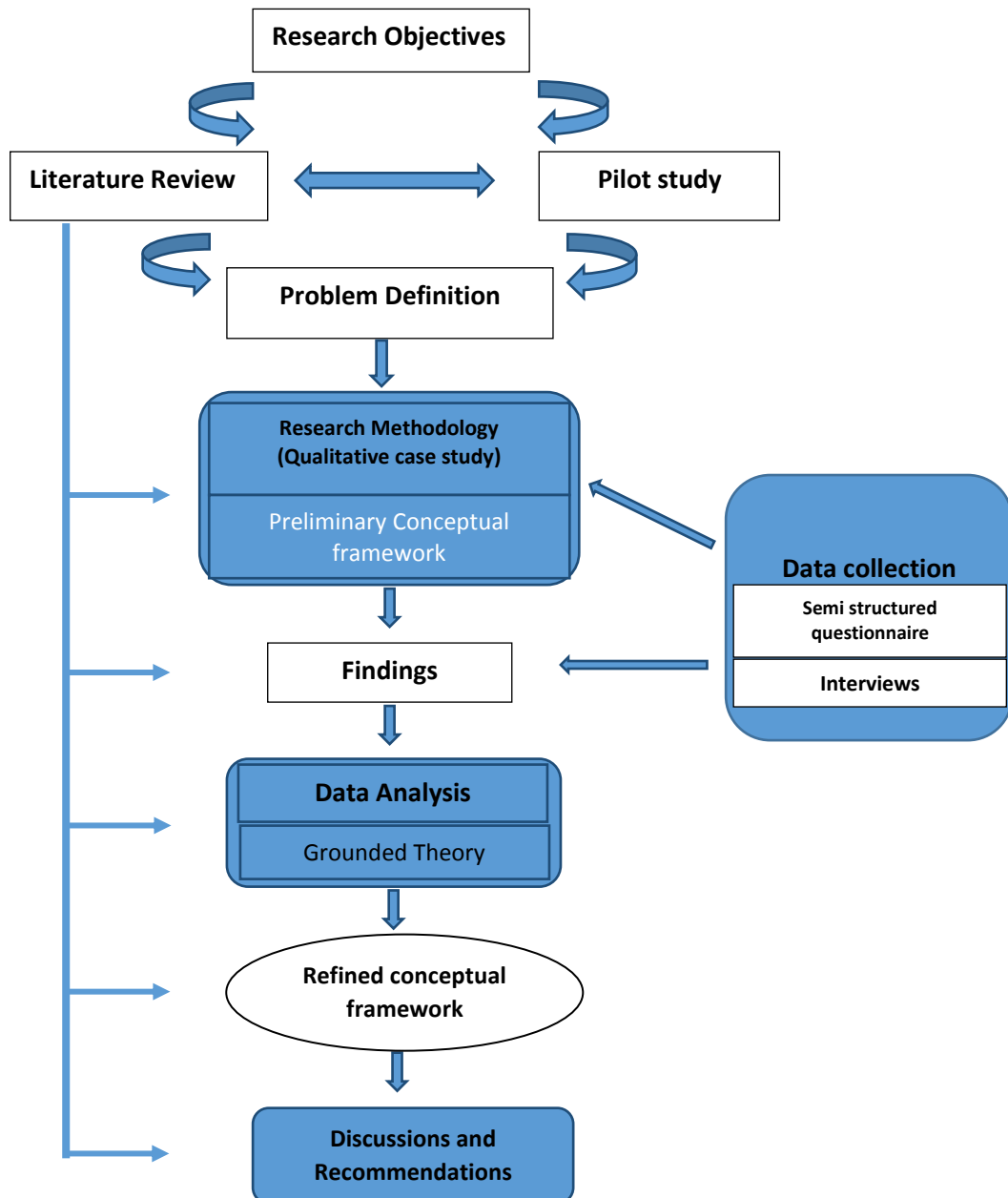


*Figure 3.1:* The research methodology design

### 3.5.1. The Pilot Study

The pilot study is conducted with experts in the field of economic forecasting at the Central Bank of Sri Lanka. The purpose of this pilot study is to build a preliminary conceptual framework and to find necessary data for re-designing the questionnaire. The pilot study is conducted via face to face interviews. Through this study the author finds the necessary information on research scope and the limitations of the research. The basic conceptual model is designed by using experiential knowledge and ideas gathered from preliminary interviews and from the literature. It further facilitates refining the research scope and refining the conceptual framework.

### 3.5.2. The Preliminary Conceptual Framework

A conceptual framework is used in this research to outline possible courses of action and to present a preferred approach to an idea. Conceptual frameworks (theoretical frameworks) are a type of intermediate theory that attempts to connect to all aspects of an inquiry i.e. problem definition, literature review, methodology, purpose, data collection, analysis etc.

The conceptual framework helps for identifying who will and will not be included in the study; (b) for describing what relationships should present based on logic, theory and/or experience; and (c) for providing the researcher with opportunity to gather general constructs into intellectual "bins".

The information gathered at the pilot study supports in refining the initial conceptual framework.

Figure 3.2 describes the basic preliminary conceptual framework that is developed based on preliminary literature and based on the pilot study.

```
┌─────────────────────┐          ┌─────────────────────┐
│    Availability of  │          │   Use of Business   │
│  Business Intelligence ═══▷    │    Intelligence     │
│     approaches      │          │     approaches      │
└─────────────────────┘          └─────────────────────┘
                                            ║
                                            ▽
┌─────────────────────┐          ┌─────────────────────┐
│  Effectiveness of the│         │   Improvements in   │
│   monetary policy   │  ◁═══    │     forecasting     │
│  decision making    │          │      accuracy       │
│     process         │          │                     │
└─────────────────────┘          └─────────────────────┘
         ║                                  ║
         ▽                                  ▽
┌───────────────────────────────────────────────────────┐
│            Impact on the price stability in            │
│                      Sri Lanka                         │
└───────────────────────────────────────────────────────┘
```
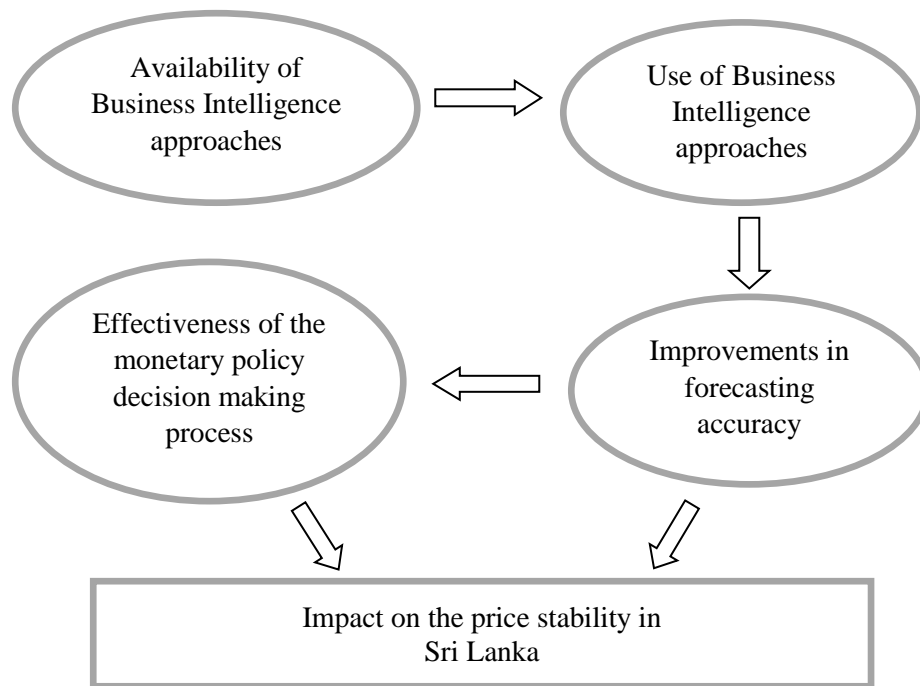
*Figure: 3.2*: The conceptual framework

The conceptual framework consists of five major areas.

Business Intelligence is an umbrella term that inherits from many technologies. There are different types of BI approaches available today in economic forecasting ex: ANN, GA etc. ANN is used for forecasting GDP growth in advanced economies like Canada and the USA. BI approaches improve the forecast accuracy by addressing limitations of the existing process.

Improved forecast accuracy increases the effectiveness of the monetary policy decision making process. Forecast accuracy and the effectiveness of the process impact on price stability in the country.

### 3.5.3. Refined Conceptual Framework

The conceptual framework is used merely for gathering facts during the data collection process. The preliminary conceptual framework is further developed by using literature and preliminary discussions the author had with selected domain experts.

The objective of a conceptual framework is to collect decent responses to the research questions and analyze them methodically. Three main themes and measurable characteristics of each theme, are identified based on research questions, the research objectives, preliminary framework and based on the literature.

**Research Questions**

1. What is the monetary policy decision making process at the Central Bank of Sri Lanka?
2. What is the role of Business Intelligence (BI) in economic forecasting and how it has been defined in the literature?
3. How the macroeconomic analysis and forecasting is being done at present at the CBSL?
4. What is the usage of BI in economic forecasting at the CBSL?
5. How does BI impact on improving forecast accuracy?

There are three main themes developed based on the research questions and it is listed in the Table 3.1.

Table 3.1*:* The Main Themes

| 1 | **Macroeconomic Forecasting** |
|---|---|
| 2 | **Business Intelligence** |
| 3 | **Monetary policy decision making** |

This is an exploratory research, which aims carrying out a deep analysis on existing forecasting processes at the central bank of Sri Lanka. The conceptual framework is further developed by considering the preliminary framework, preliminary interviews and the literature. Figure 3.3 depicts the refined conceptual framework with identified themes.

**Macroeconomic Forecasting**

**Monetary policy decision making**

**Macroeconomic Forecasting process**

Existing approaches
Issues in forecasting

**Improved monetary policy decision making**

Issues that can be addressed
Level of accuracy of the forecasting results

**Business Intelligence**

**Awareness of BI**

Business Awareness
Technical Awareness

**Use of BI**

Use of BI in macroeconomic forecasting

*Figure: 3.3:* The refined conceptual framework

### 3.6. Data Collection

There are various methods of gathering information;
**Questionnaire:** A questionnaire is prepared and provided to the experts in the relevant area of study. This is very popular data collection method in quantitative research.
**Observation:** In the context of qualitative research, direct observations provide the opportunity for absorbing and noting details of the field environment. Not all qualitative data collection approaches requires direct interaction with people. Observation is a technique that can be used when data collection is difficult through other means.

**Documentation:** A wide range of written materials can produce qualitative information. Those include policy documents, mission statements, annual reports, minutes of meetings, codes of conduct, web sites etc.

**Interviews:** Most of the qualitative literature describes three basic approaches to collect qualitative data through in-depth interviews. It can be informal conversational, general interview guide approach and standardized open-ended interviews. And it can be Open-ended, Semi-structured and Structured interviews. Interviewing is a better way to learn detailed information from an individual or from a group of individuals. It is very useful when someone needs to gain expert opinion on a particular subject area.

### 3.6.1. Data Collection Strategy

This qualitative research conducts three types of interviews (a) Face to face, (b) Over the phone and (c) Email interviews with selected experts from the CBSL, IPS and state and foreign universities using a "semi-structured" questionnaire which consist of open ended questions. The questionnaire is prepared based on the conceptual model to obtain information, personal experience and expert ideas.

Data collection in a qualitative study takes a great deal of time. Data is recorded accurately and systematically using field notes, diagrams and audio tapes.

Data collection is more important and challenging when dealing with external parties. Therefore, it is important to plan prior to the data collection.

1) Prepare a semi-structured questionnaire for the interview.

2) Identify potential experts i.e. experts from the CBSL, IPS, state and foreign universities, between the age of 43- 50 years, Masters and PhD holders, expertise in macroeconomics, econometrics, economic modeling and forecasting, Business Intelligence and Artificial neural networking.

3) Introduce the author over the phone or through an email and make an appointment for the interview.

4) Forward the Questionnaire prior to the interview so that the candidate could prepare for the interview.

5) Conduct the interview and record the conversation with his or her permission.

Owing to the nature of this research a qualitative data analysis is conducted using open coding method. Data is transcribed and analyzed. The representation of data collection methodology is below in figure 3.4.
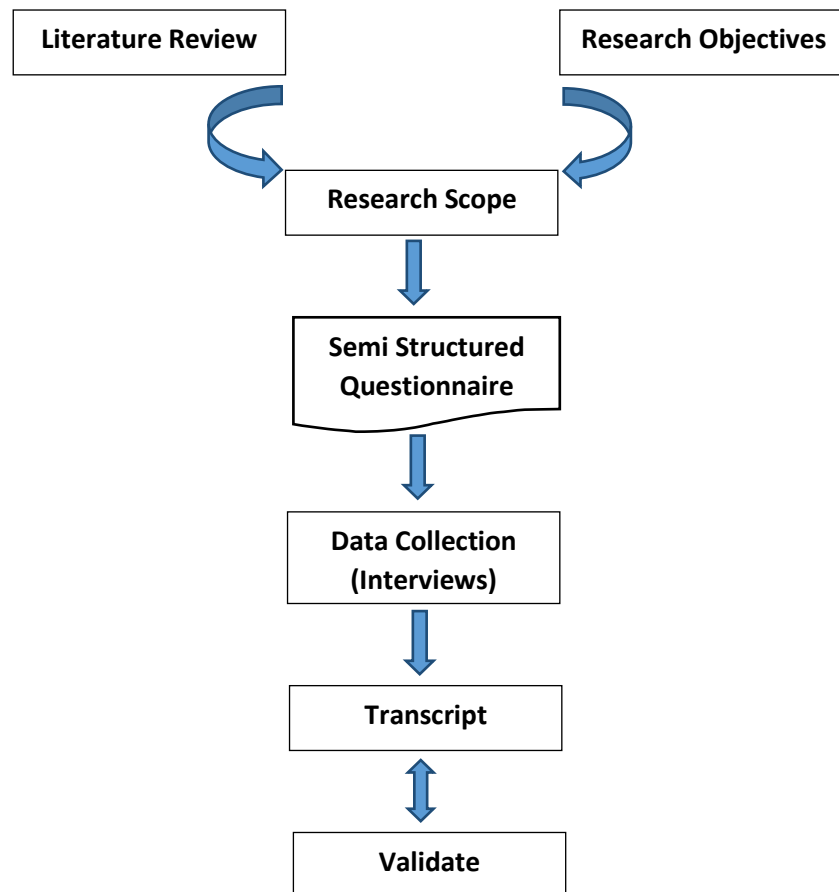


*Figure 3.4:* Data collection methodology

### 3.6.2. Semi Structured Questionnaire

The questions of each set of questionnaire are mapped with the conceptual factors and vice versa. Mapping questionnaire with research objectives and research questions is shown in Table 3.2.

Table 3.2: Mapping questionnaire with research objectives

| Research Objectives | Research Question | Questionnaire |
|---|---|---|
| Understand the monetary policy decision making process in Sri Lanka | How do you describe the monetary policy decision making process in Sri Lanka? | **Q1.** What is monetary policy decision making?<br><br>a) Why do you need a monetary policy decision making process?<br>b) Who are the people& units involved in?<br>c) What are the key inputs and how does it happen? |
| Understand the relationship between macroeconomic forecasting and monetary policy decision making | How macroeconomic forecasting is involved in monetary policy decision making? | **Q2.** What is the relationship between forecasting and monetary policy analysis?<br><br>a) What are the key inputs for policy analysis process?<br>b) How do you find accurate inputs for policy analysis process? |
| | How the macroeconomic forecasting is being done at present? | **Q3**. Policy makers still use traditional statistical methods for macroeconomic forecasting.<br><br>a) What are the tools/techniques/models use in economic forecasting at the CBSL?<br>b) Do you think traditional regression models are effective in producing highly accurate forecasts? |

| | | |
|---|---|---|
| | | c) What are the issues/disadvantages/limitations of current process of forecasting? <br> d) What are the issues/limitations in traditional models? <br> e) Do you think use of traditional time series models effective in better policy analysis? |
| Understand the awareness and readiness of using BI approaches | What is the level of business and technical awareness of BI? <br><br> What is the usage of BI in economic forecasting in SL? | **Q4.** <br> Business Intelligence is considered as forecasting approach as well. There are many common BI techniques available such as ANN, GA. <br> a) What do you think "the level of awareness on BI in economic forecasting" among top level researches in your organization? <br> b) What is the common understanding of BI in economic forecasting? <br> c) How to improve the awareness? <br> d) Are you aware that BI can use to improve forecast accuracy? <br> e) Are you aware the BI techniques like ANN address the limitations of traditional regression models? <br> f) Are you ready to use BI in forecasting? |

| Impact of BI on improving forecast accuracy thereby aid better monetary policy decision making | Up to what extent BI tools and techniques can be used in improving forecast accuracy of economic indicators and how would impact on improving policy analysis outcome? | **Q5.**<br>Do you think BI can be used to improve forecast accuracy in Sri Lanka?<br>a) What type of BI tools suitable for Sri Lanka? Ex. ANN?<br>b) How do they address issues/limitations in current forecasting process?<br>c) What is your opinion, improved forecasting, will increase the effectiveness of monetary policy decision making process?<br>d) What do you think, what are the advantages of using BI? |
| --- | --- | --- |

## 3.7. Chapter Summary

In this chapter, the research methodology was discussed in detail and the reason for selecting qualitative case study methodology was justified. Developing a conceptual framework, data collection and developing a semi structured questionnaire mapping with research objectives and how interviews conducted were described in detail. Further, data analysis was expected to carry out using grounded theory.

Moreover, the theoretical background on research methodologies including Qualitative research methodologies, Qualitative case study methodology, Qualitative research design and Qualitative data analysis was provided.

# 4. FINDINGS AND ANALYSIS

## 4.1. Chapter Overview

This chapter provides a detailed analysis and discussion on the observations and the results obtained in the present study. The Research Findings section has been basically derived from the interview transcripts and are presented under theme headings as shown in Table 4.1 below. The data collected from Central Bank of Sri Lanka using a specially designed questionnaire which is documented under a separate subsection in the research finding section. This chapter further describes the qualitative research analysis theoretical frameworks and then it elaborates the research findings based on the research framework. It has basically captured the responses of the interviewees.

Table 4.1 Mapping research objectives with research findings

| Research Objectives | Research Findings – Sub Headings |
|---|---|
| Understand the monetary policy framework in Sri Lanka | Monetary Policy framework in Sri Lanka |
| Understand the relationship between macroeconomic forecasting and monetary policy decision making process. | Macroeconomic forecasting and monetary policy decision making<br><br>Macroeconomic forecasting in Sri Lanka<br><br>Limitations of current process of forecasting |
| Understand the awareness and readiness for using Business Intelligence approaches in forecasting and visualizing economic data. | Awareness and use of BI |
| Impact of Business Intelligence on improving forecast accuracy thereby aid better monetary policy decision making process. | Advantages of BI over other statistical models |

## 4.2. Monetary Policy framework in Sri Lanka

The Central bank is the government authority that responsible for the monetary policy. The monetary policy has become the central tool for macroeconomic stabilization. Central bank's monetary policy actions affect interest rates, credit and money supply, all of which have impact on aggregate output and inflation.

According to Central Bank responder the main objectives of the central bank are maintain the economic and price stability and maintain the financial system stability. Price stability and the economic stability is achieved through monetary policy. The monetary policy is expressed in terms of the central bank's influence on cost (interest) and availability of money (Money supply) in the country. And the monetary policy is linked to price levels (inflation). Strategy of achieving price stability is depicted in figure 4.1.
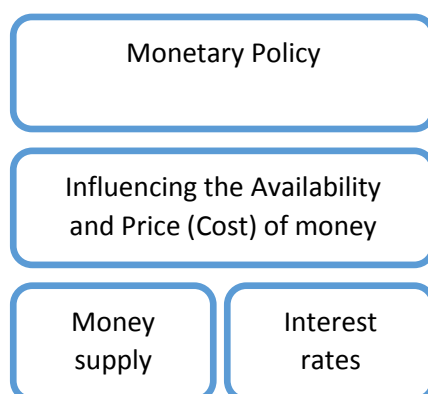


*Figure 4.1*: Strategy of achieving price stability

Price stability maintains low and stable price levels over time. Economic and price stability is a situation where there are no wide fluctuations in the general price level in the economy. It is best when inflation is low and stable over time, IPS responder further added.   Economic and price stability is achieved through monetary policy of the CBSL.CBSL responder stated that the monetary programme set out monetary targets (projections). The desired path for monetary growth and the level of money required is based on expected economic growth and inflation. Monetary policy framework of Sri Lanka is illustrated below in figure 4.2.
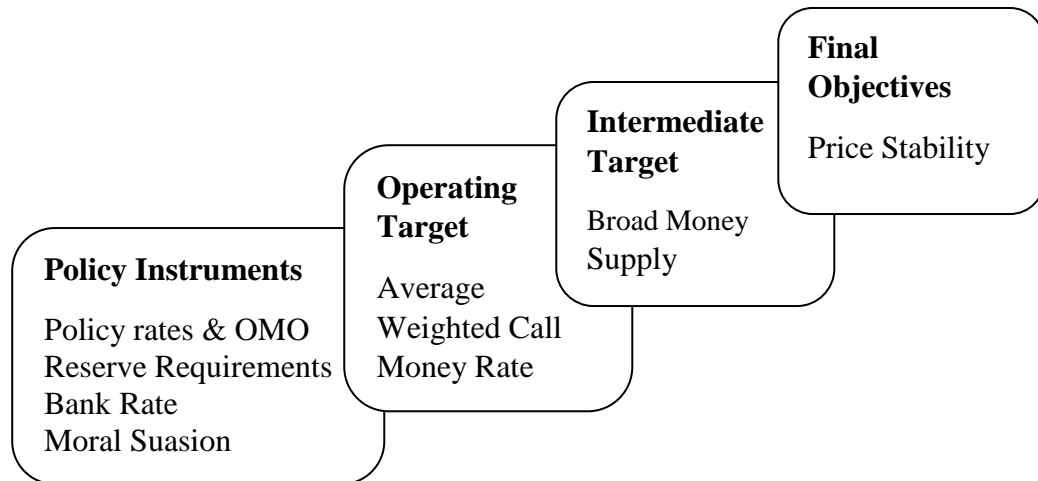
*Figure 4.2*: Monetary Policy Framework of Sri Lanka

Source: Central Bank of Sri Lanka

Monetary policy is important when central bank attempt to achieve its objective of price stability, by influencing the cost (interest rates) and availability of money (credit). A central bank has policy instruments to conduct of monetary policy. The most widely used instruments are statutory reserve requirements (SRR) and open market operations (OMO). Under the SRR, the CBSL can impose a requirement on commercial banks to keep a part of their deposits with the CBSL. By changing the SRR the CBSL can influence the credit creating ability of commercial banks and hence, broad money supply and market interest rates. Under open market operations, the CBSL influences money supply and market interest rates by changing policy interests applicable for its transactions with commercial banks and/or by trading Treasury bills and Central Bank Securities. The CBSL responder stated. The process by which the changes in monetary policy instituted by a central bank affects the general price level and output in the economy is referred to as the monetary policy transmission mechanism.

The CBSL has been following a monetary targeting framework, with reserve money as the operating target and broad money as the intermediate monetary policy target. It has gradually moved towards more market oriented policy instruments in monetary management and at present places greater reliance on OMO. Similarly, CBSL can tighten the monetary policy stance by raising its policy rates

and/or selling Treasury bills from its portfolio or issuing its own securities. These OMO activities have an almost immediate impact on interest rates in the call money market (i.e., the money market among commercial banks) and the rupee liquidity available in the banking system, influencing their credit supply activities. The CBSL responder further pointed out. An extended version of monetary policy decision making framework is represented in figure 4.3.
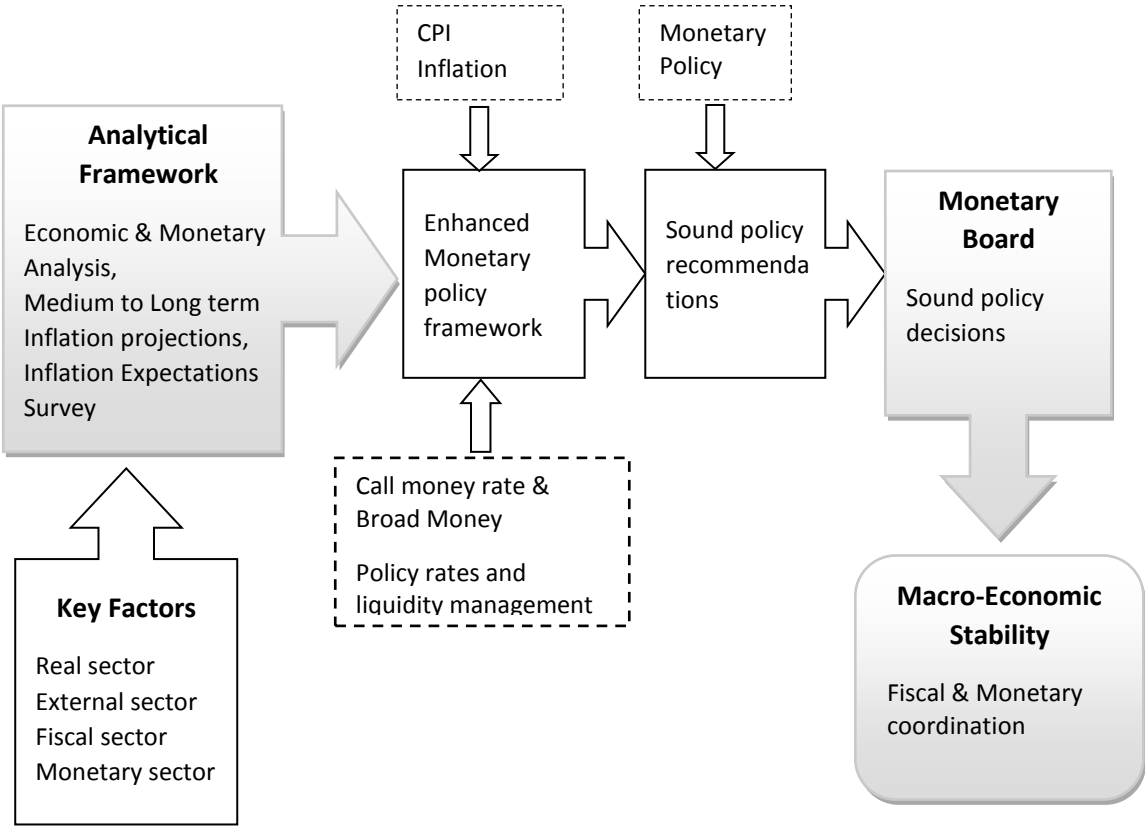


*Figure 4.3*: Multi-faced framework of decision making

Source: Central Bank of Sri Lanka

Key factors are the inputs for the policy decision making process. Real sector factors are GDP growth, Inflation and unemployment rate etc. Exchange rate, imports and exports represent the external factors that influence the monetary policy decision making. Fiscal sector includes budget deficit and debt. Interest rate and money supply comes under the monetary sector. Changes in each variable affect the country's

macroeconomic stability, CBSL responder has further explained. Analytical framework plays a very important role in this process. Different types of tools and techniques are used in analyzing the above variables and for long term predictions, will be discussed further in latter sections. Based on the analytics the monetary policy decision making will be done. Monetary policy decision making process is simply illustrated below in figure 4.4.
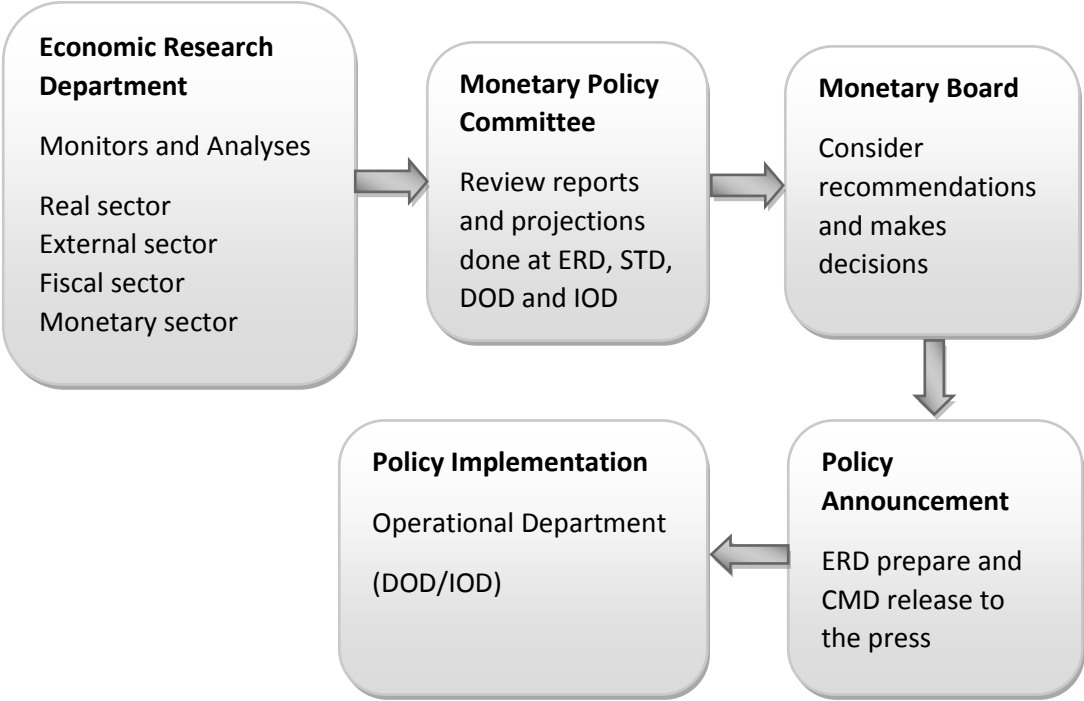


*Figure 4.4*: Monetary policy decision making process at the CBSL

A primary function of the Central Bank, as stated in the Monetary Law Act, is the determination and implementation of monetary policy for the country. Since the economy and the financial sector has become more sophisticated the central bank's duty in determining and implementing monetary policy have also become complex. Hence, as a part of the Bank's ongoing process of adapting itself to meet new challenges, and as a step towards improving the transparency of the decision making process, a formal monetary policy committee (MPC) was established in early 2001, to

study and make recommendations on monetary policy for the consideration of the Monetary Board.

Key inputs for the monetary policy decision making process are the real sector factors, external sector factors, fiscal sector factors and monetary sector factors. Real sector factors are GDP growth, Inflation and unemployment rate etc. Exchange rate, imports and exports represent the external factors that influence the monetary policy decision making. Fiscal sector includes budget deficit and debt. Interest rate and money supply comes under the monetary sector. Department of Economic Research at the CBSL is responsible for monitoring and analyzing the above factors which are direct inputs for the monetary policy decision making process. Further, Department of Economic Research and Department of Statistics analyze past data and predict the future behavior of output and inflation. Then the monetary policy committee review reports and predictions given from above departments. The Monetary Policy Committee (MPC) is chaired by the Deputy Governor in charge of Price Stability and includes the following members:

**Chairperson**
- Deputy Governor responsible for Price Stability

**Members**
- Deputy Governor responsible for Financial Stability
- Assistant Governor responsible for Price Stability
- Assistant Governor responsible for Financial Stability
- Director of Economic Research
- Additional Director of Economic Research responsible for Money and Banking
  (Alternate, Deputy Director, Economic Research responsible for Money and Banking)
- Director, International Operations (Alternate, Deputy Director, International Operations)
- Director, Domestic Operations (Alternate, Deputy Director, Domestic Operations)

**Secretary to the MPC**

The Deputy Director, Economic Research responsible for Money and Banking

(Alternate, Head of Division, Money and Banking).

The primary function of the MPC would be to forecast and evaluate emerging monetary and macro-economic developments and make recommendations on appropriate future directions of monetary policy for consideration by the Governor and the Monetary Board.

The MPC would meet at regular intervals, at least once a month. At these meetings, members would consider reports prepared by the Economic Research Department and other departments on monetary, foreign exchange market and price developments, together with developments in the fiscal, external and real sectors, which would serve as the bases for the deliberations of the MPC, in the formulation of recommendations to the Governor and the Monetary Board.

Changes in monetary policy, including information on the rationale for such changes, are notified to the public, including all market participants, through press releases, press statements made by senior officials of the Central Bank and posting on the Bank's website. The Central Bank's website is updated whenever necessary. Usually, press conferences are held by senior Central Bank officials if the changes are significant. In addition, senior officials of the Central Bank are frequently interviewed by the media.

The Communications Department of the Central Bank, which is responsible for disseminating information to the public, handles matters relating to press releases and press briefings. Information is disseminated by way of monthly bulletins, news surveys, press releases, the Annual Report and other publications. When substantive changes to the policy are proposed, consultations would usually be held with organizations affected by the proposed changes e.g., Bankers' Association, Primary Dealers' Association. Monthly meetings are held by the Governor with chief executive officers of commercial banks and licensed specialized banks, at which the monetary situation and likely monetary policy measures are discussed. Meetings with

primary dealers are held by senior officials of the Central Bank once a week. An advance release calendar of monthly monetary policy announcements is published in the Central Bank's website at the beginning of each year and monthly announcements on the monetary policy stance are made on these dates.

Policy implementation is done by Domestic Operation Department and International Operation Department at the CBSL. DOD is dealing with local banks and IOD controls the international reserves etc.

### 4.3. Macroeconomic forecasting and monetary policy decision making

Data needed for the monetary policy decision making process is provided by the department of economic research and department of statistics at the CBSL. As illustrated above in figure 4.3 analytical framework for decision making process consist of economic and monetary analysis, medium to long term inflation projections and inflation expectations survey. Department of economic research and department of statistics at the CBSL analyze and forecast the macroeconomic indicators in real sector, external sector, fiscal sector and monetary sector.

Real sector macroeconomic factors are GDP growth, Inflation and unemployment rate etc. Exchange rate, imports and exports represent the external factors that influence the monetary policy decision making. Fiscal sector includes budget deficit and debt. Interest rate and money supply comes under the monetary sector. Department of Economic Research at the CBSL is responsible for monitoring and analyzing the above factors which are direct inputs for the monetary policy decision making process. Further, based on historical data Department of Economic Research and Department of Statistics analyze past data and predict the future behavior of output and inflation.

## 4.4. Macroeconomic forecasting in Sri Lanka

GDP growth and the inflation are the commonly used macroeconomic indicators for forecasting in Sri Lanka. It is known that Sri Lankan GDP growth is relatively less volatile.

According to the IPS responder, GDP growth in Sri Lanka has remained stable during past decades. However, a recession has appeared in recent years starting in 2001 due to domestic supply side turbulences and several other global factors. The global financial crisis did not course the recession.

Inflation in Sri Lanka is measured using Colombo Consumer Price Index (CCPI). 2006/2007 is the base year, starting from 2008 to the present.

A responder from Department of Census and Statistics states that Consumer price index differs country to country according to variances in the expenditure patterns of the consumer groups, for instance, food represent relatively larger portion in a developing country's index. Despite the fact that high inflation rate recorded in the past, Sri Lanka's inflation has steadied to a single digit at present (6.8 percent year-on-year in February, 2017). It is known that the Sri Lankan inflation is more volatile compared to the advanced economies, inflation in developing countries fluctuates widely.

When inflation is volatile from year to year it is difficult to accurately predict the rate of price inflation in the near future. The CBSL responder further states that the volatile inflation may damage both individuals and businesses and the economy as a whole. Accurate predictions will help individuals and businesses make right decisions and these predictions enable the governing bodies such as Central Bank to adjust the monetary policy in order to achieve price stability.

There has been some endeavors to model inflation in the recent times in Sri Lanka. Vector Error Correction Model -VECM is one of the models used to identify the main determinants of inflation. According to the CBSL responder, monetary aggregates and rice price influence the movement of inflation. Later, it has been identified the exchange rate, import price and the supply side factors highly influence the price level in Sri Lanka. Moreover, during the period of 1993-2008, exchange rate, money supply

and the GDP were the main elements to describe the movements in inflation. There has been no comprehensive model developed so far to forecast inflation and output in Sri Lanka, the Central Bank of Sri Lanka relies on some international models for its monetary policy decision making.

At the CBSL, VAR variations are used to forecast output. ARIMA, VAR/VECM, Bayesian technologies ex. BVAR and DSGE - Dynamic Stochastic General Equilibrium models based QPM – Quarterly Projection Model are used to project inflation. In DSGE the whole economy is modeled as a collection of representative agents. DSGE (dynamic stochastic general equilibrium), stochastic means the model incorporate techniques that account for the possibility of random economic events and general equilibrium means that each model is built as a whole system and everything within the system depends on everything else (prices determine what people do, but what people do also determines prices).

The bottom-up approach that goes from the micro to the macro level makes DSGE models better-suited to constructing conditional forecasts and comparing different policy scenarios. DSGE models have a number of other advantages over large-scale models. Decision rules are usually well approximated by linear rules. The DSGE model is known as a very good union of modern macroeconomic theory and nonstructural times-series econometrics the CBSL responder added.

At present forecast is done by using both Bayesian VAR and DSGE for medium term horizons for 6months to 2 years. And an average is taken in to consideration.
Univariate AR, ARMA and ARIMA models have been commonly used in forecasting both output and inflation previously.
The baseline Bayesian Vector Auto Regression (BVAR) consists of 3 fundamental economic variables; GDP growth, inflation and short-term interest rate. These variables largely capture future movements of output and inflation in economies with less friction. Baseline BVAR performed reasonably well in forecasting both GDP growth and inflation.
It is argued that adding variables to capture domestic supply side and external sector movements could improve forecast accuracy in BVAR. Therefore, a large BVAR

(LBVAR) model is introduced with a few more additional variables. Exchange rate, international oil price, monetary aggregate, international trade, current account dynamics and output gap are included to the large BVAR model. However, adding more variables in the model did not improve forecast accuracy of inflation forecasts in normal times, yet, performed well in volatile times.

According to the CBSL responder large BVAR model is found as the best model to forecast GDP growth, while DSGE model is the best model for forecasting inflation at forecast horizons above 2 quarters. No model could beat the benchmark ARMA model in forecast inflation at the immediate quarter. Baseline BVAR model is successful in both GDP growth and inflation forecast. The CBSL responder further added. DSGE model has been forecasting both of these variables better in highly volatile times at longer horizons.

Forecasting and policy analysis model, (FPAS) is based on New Keynesian Phillips Curve is going to be introduced to the CBSL. The model suggested that macroeconomic volatility and anchor inflationary expectations can be reduced by open economy inflation targeting rule given the size and type of shocks faced by the economy.

These advanced models can be used to model and forecast key economic variables in developing countries too. The Central bank of Sri Lanka can employ these models to carry out informed policy analysis and to take better policy decisions, the CBSL responder further stated.

**4.5. Limitations of current process of forecasting**

None of the economic models predict future perfectly regardless of quality of data (ex: size of the sample), the method of forecasting (ex: complexity of the model) and the nature of the economy.
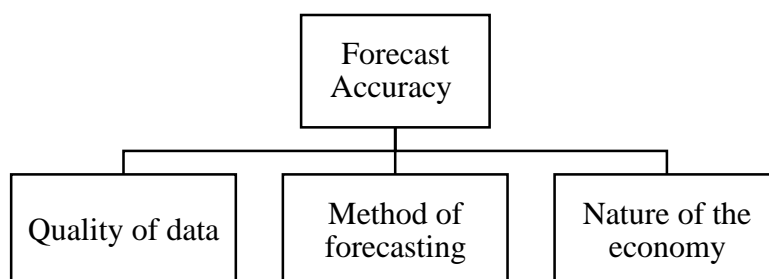


*Figure 4.5:* Factors affect the forecast accuracy

It is a known fact that less advanced economies suffer from limitation in availability of high frequency data spanning over long period of time.

Forecasting with shorter sample of around 20 years or less is commonly done in developing countries. The assumptions used in regression models are suitable for larger data sets, shorter sample with heavy assumptions may reduce the forecast accuracy. Moreover, noisy, erroneous economic data, missing observations and complex nonlinear patterns in data largely affect the forecast accuracy. However, Time series forecasting require continuous data.

On the other hand method of forecasting and complexity of the model have a significant impact on producing an accurate result. The baseline Bayesian Vector Auto Regression (BVAR) consist of 03 fundamental economic variables; GDP growth, inflation and short-term interest rate. These variables largely capture future movements of output and inflation in economies with less friction. The CBSL responder explained these fundamental variables may not be sufficient for Sri Lanka to forecast output and inflation as small open economy in Sri Lanka is vulnerable to shocks arising from external environment. However, adding variables to capture domestic supply side and external sector movements could improve forecast accuracy.

Moreover, fixed parameter models are often criticized because of the possibility of parameters changing over time with policy interventions. In order to deal with this issue Time Varying Parameter BVAR (TVP-BVAR) model with 03 fundamental variables is introduced. It is revealed that computational difficulties prevent all the variables of large BVAR model come into TVP-BVAR approach.

The variables that are helpful in capturing the dynamics of inflation in the advanced economies may not be successful in developing countries. And there might be a need to include additional variables especially supply side variables such as prices of food categories and oil to essentially improve the modeling and forecasting of inflation in Sri Lanka, the CBSL responder stated. However, all these regression models consider only historical data and make predictions, the existing behavior of the economy is not taken in to consideration.

Domestic supply and external shocks play a vital role in explaining the movements of key economic fundamentals in Sri Lanka. When inflation is volatile from year to year it is difficult to accurately predict the rate of price inflation in the near future.

## 4.6. Advantages of BI over other statistical models

Generally economic data is noisy and incomplete. Neural Networks are found to be the principle tool for dealing with this sort of issues in data. Neural Networks are non-linear mapping structures, take data samples rather than entire data sets to arrive at solutions. Previous researches have been concluded that neural networks are more accurate for high frequently data as more nonlinearities is seen in high frequency data, an expert from a state university explained. Time series forecasting requires continuous data, and it is difficult in Sri Lanka. On the other hand in recent years ANN has become more popular in economic forecasting, as its potential to detect and reproduce linear and nonlinear relationships among a set of variables. In early researches ANN has proved its ability to forecast volatile financial variables.

It is revealed that neural networks successfully model nonlinear relationships first; neural networks with nonlinear activation functions are more effective than linear regression models in dealing with nonlinear relationships the responder further added.

A linear function can give a reasonable approximation of the local behavior of a nonlinear function so that neural networks are more accurate than other models in the later periods of the forecast horizon.

Many nonlinear functions can be linearized using relatively simple mathematical transformations, the researchers need to have some prior knowledge of the nature of the nonlinearity that enables him to identify the appropriate transformation to apply on data. However, such information is hardly obtainable in macroeconomic forecasting.

Nonlinear regression techniques and neural networks perform well in a nonlinear phenomenon. However, in practice, the estimation of a nonlinear regression model requires the econometrician to assume and a priori functional form for the relationship studied. Selecting the wrong functional form will lead to imprecise coefficient estimates and in accurate forecasts. On the other hand, when estimating a neural network, the researcher does not really need to worry about the functional form of the phenomenon studied because the "universal approximator" property of networks will allow it to imitate almost any functional form. No priori knowledge is necessary to obtain                                    precise                                    forecasts.
Another advantage of neural networks stems from the relative flexibility of network architectures. A wide spectrum of statistical techniques (e.g. linear regression, a binary probit model, autoregressive models, etc.) can be specified by simply making minor modifications to the activation functions and the network structure (such as changing the number of units in each layer).

Today in highly globalized and highly unpredictable environment, economic forecasting is emerging as a rapidly developing research area with wide applicability in business and government. Forecasting has been revolutionized over a period of time in advance economies whereas recently introduced to developing countries, many such models are built on regression based or Vector Autoregression (VAR) based methodology.  Emerging new technologies has been advanced forecasting and its accuracy over traditional methods. Therefore, it is vital to implement and see the applicability of these forecasting techniques in Sri Lanka. A good, highly accurate

forecasting aid better monetary policy decision making and result in price stability within the country.

## 4.7. Awareness and use of BI

According to literature there are number of Business Intelligence approaches for macroeconomic analysis and forecasting, however, the CBSL respond stated that the awareness of Business Intelligence in economic forecasting in department of economic research and in department of statistics is relatively less. And the technical awareness is very low. Common understanding on BI was to use BI in analyzing data and visualizing in useful forms, thereby improve efficiency of the monetary policy decision making process. There is no awareness on using ANN based BI approaches to improve forecast accuracy of economic data. At present no BI based approach is used in macroeconomic forecasting and analysis at the CBSL. However, there are number of other economic models and econometrics are used. The CBSL responder further added that the awareness among the staff on ANN based tools and techniques that are useful in forecasting and analysis can be improved through training programs, They are not aware of the technical aspects of the BI based approaches and especially ANN, and advantages over traditional regression models. After discussing the strengths and weaknesses of ANN based forecasting approaches the CBSL responder claimed that they would be able to improve the forecasting accuracy over BI approaches in the future.

## 4.8. Chapter Summary

In this chapter, research findings based on the research framework was presented and was basically the responses of the interviewees. Further a detailed analysis and a discussion based on research findings were presented. This section basically derived from the interview responses and was presented under sub headings. Each sub heading mapped the objectives with findings.

# 5. CONCLUSION AND RECOMMANDATIONS

## 5.1. Chapter Overview

This chapter provides a conclusions and recommendations on the analysis of the qualitative results obtained in the present study. Conclusion points categorized in to research objectives are shown in Table 3.2.

Table 5.1: Conclusion points categorize in to research objectives.

| Research Objectives | Conclusion Point No. |
|---|---|
| Understand the monetary policy framework in Sri Lanka | 5.2.1 |
| Understand the relationship between macroeconomic forecasting and monetary policy decision making process. | 5.2.2 5.2.3 5.2.4 5.2.5 |
| Understand the awareness and readiness for using Business Intelligence approaches in forecasting and visualizing economic data. | 5.2.6 |
| Impact of Business Intelligence on improving forecast accuracy thereby aid better monetary policy decision making process. | 5.2.7 |

## 5.2. Concluding Remarks

Macroeconomic forecasting plays a vital role in the conduct of monetary policy decision making. Policymakers need to predict the future direction of the economy before they can decide which policy to adopt. Policymakers need forecasting tools that do more than project the likely path of important economic indicators like inflation, output or unemployment. They need tools that can provide them with policy guidance that determine the economic implications of monetary-policy changes, what

will the economy look like under the original monetary policy and what will it look like after the change? For this reason, there has been an effort over the past years to develop empirical forecasting models that are able to provide policymakers with this kind of guidance. Three broad categories of macroeconomic models have arisen during this time, structural, nonstructural and large-scale models. Structural models are built using the fundamental principles of economic theory to predict key macroeconomic variables like GDP, prices, or employment. While nonstructural models are statistical time-series models; represent correlations of historical data. The lack of economic structure makes them less useful in terms of interpreting the forecast; these unconditional forecasts are typically accurate when policy regimes do change frequently.

The third category, large-scale models, is a kind of middle ground between the structural and nonstructural models. Such models are a hybrid; one advantage is that relationships can be selected from a huge variety of data series, the main disadvantage is the complexity.

## 5.2.1.

Country's economic stability and the price stability are achieved through monetary policy. The monetary policy is expressed in terms of the central bank's influence on cost (interest) and availability of money (Money supply) in the country. And the monetary policy is linked to price levels (inflation). Price stability maintains low and stable price levels over time. It is best when inflation is low and stable over time, Economic and price stability is achieved through monetary policy of the CBSL. Key inputs for the monetary policy decision making process are the real sector factors, external sector factors, fiscal sector factors and monetary sector factors. Department of Economic Research at the CBSL is responsible for monitoring and analyzing the above factors which are direct inputs for the monetary policy decision making. Further, Department of Economic Research and Department of Statistics analyze past data and predict the future behavior of output and inflation.

**5.2.2.**

VAR variations, useful in analyzing multivariate time series have been commonly used in Sri Lanka for forecasting inflation during past years. ARIMA, VAR/VECM, Bayesian technologies ex. BVAR and DSGE - Dynamic Stochastic General Equilibrium models based QPM – Quarterly Projection Model are used to project inflation. At present forecast is done by using Bayesian VAR and DSGE then an average is taken in to consideration. It is revealed the existing forecasting techniques such as ARMA model, baseline BVAR, large BVAR, time varying BVAR, unobserved component model and DSGE have been performed better for Sri Lanka in forecasting inflation and output. Therefore, it can be concluded that forecasting approaches use in advanced economies suit for developing economies as well, despite of economy is highly unstable and volatile. However, these models with fundamental variables may not be sufficient for Sri Lanka to obtain highly accurate results as there are a considerable number of issues and limitations.

**5.2.3.**

The variables that are good in capturing the dynamics of inflation in developed countries might not be fruitful in developing countries. And there might be a need to add additional variables especially supply side variables such as prices of food categories and oil to improve the modeling and forecasting of inflation in Sri Lanka. Domestic supply and external shocks play a vital role in explaining the movements of key economic factors in Sri Lanka. When inflation is volatile from year to year, it is difficult to predict the rate of price inflation accurately in the near future. However, all these regression models consider only historical data and make predictions; the existing behavior of the economy is not taken in to consideration. The type of pattern experienced and the type of data available are the two main dimensions in forecasting. The type of pattern can be where the historical pattern expected to repeat in the future.

And the pattern can be dependent on both external factors and historical observations. In certain forecasting situations, no sufficient quantitative historical data are available. The accuracy of forecasting result is affected by the quality of past data as well as the method of forecasting.

The real world data are normally noisy and erroneousness and can be missing observations. Therefore, the forecasting results may not be accurate when the forecasts are generated from erroneous or noisy data.

None of the economic models predict future perfectly regardless of the complexity of the model, size of the sample and the nature of the economy, it should be accepted that these advanced models can be used to model and forecast key economic variables for a developing country to carry out informed policy analysis and to take better policy decisions.

### 5.2.4.

The right information with regard to the economic situation of the country and the behavior of macroeconomic indicators is necessary to develop an effective monetary policy. This information would help forecasting the future movements of macroeconomic indicators, like inflation and to respond the shocks in economy accordingly. In developing countries economy is highly unstable and volatile and macroeconomic data is often erroneous due to various reasons including measurement error, imperfect methods of measuring etc. On the other hand determinants of macroeconomic indicators like inflation vary across the countries. An effective monetary policy is dependent on the country's understanding of ongoing economic situation and ability to forecast the future behaviors.

### 5.2.5.

A thorough review of the literature suggests that neural networks are generally more accurate than linear models for out-of-sample forecasting of economic output and various financial variables. Economic data is often noisy and incomplete. Neural Networks are found to be the principle tool for dealing with this sort of issues in data. Neural Networks are non- linear mapping structures.

Previous many researchers concluded that neural networks are more accurate for high frequent data. More nonlinearities are seen in high frequency data. Two-layer feedforward neural network with an identity activation function is identical to a linear regression model. Therefore, it has become a powerful tool to identify and reproduce complex nonlinear data generating processes in time-series data. Whether studying growth of real GDP, inflation, employment growth or exchange rates, the neural network should, in theory, be able to detect and duplicate any complex nonlinear pattern in the data. The full potential of neural networks can probably be expanded by using them combining with linear regression models. Hence, neural networks should be viewed as an additional tool to be included in the toolbox of macroeconomic forecasters. ANN based models improve forecast accuracy of economic data comparing to other statistical models. ANN based approaches are being used in India and Pakistan for economic forecasting.

**5.2.6.**

However, at present no BI based approach is used in macroeconomic forecasting and analysis at the CBSL. Common understanding on BI among the staff is a tool for collecting, analyzing and visualizing data in useful forms, thereby improve efficiency of decision making. There is a significant potential to use and to improve the policy decision making process over BI approaches in the future at the CBSL.

**5.2.7.**

One of the pre-requisites for a successful inflation targeting framework is an effective methodology for macroeconomic analysis and forecasting. It is required to strengthen its technical capacity in data collection, controlling, modeling and forecasting of key macro variables at the CBSL. It is revealed advanced macroeconomic models can successful in Sri Lanka as well, in understanding the economy, evaluating potential risks and their impact on the future path of key macro variables. Hence, these models can increase the robustness of the policymaking process. Therefore, it can be concluded use of Business

Intelligence tools and techniques in analyzing, economic modeling and forecasting can improve monetary policy decision making at the CBSL.

## 5.3. Recommendations

**5.3.1** In order to further strengthen its policy formulation and modelling capacity at the CBSL, it is necessary to develop their own a cost effective model-based reliable forecasting and policy analysis tool that cater for the unique characteristics of the Sri Lankan economy.

**5.3.2** It is revealed that International Monetary Fund (IMF) is in developing structural model based forecasting and policy analysis tool for Sri Lanka, it is recommended to seek the ability of developing a hybrid model, a kind of middle ground between the structural and nonstructural models, based on ANN that address the issues like smaller sample size, erroneous and inconsistency data, nonlinear relationships, lack of prior knowledge, highly unstable and volatile economy often vulnerable to external random shocks, common in Sri Lanka. The structural models usually attempt to linear the non –linear relationships, this may reduce the accuracy of forecasts and there are a lot of other limitations as well.

**5.3.3** CBSL should take initiatives to upgrade the technical capabilities of relevant staff to strengthen all macroeconomic projections.

**5.3.4** Lack of expertise on BI and macro-economic forecasting, serves a good opportunity for educational institutes and universities to design specialized training programs and prepare qualified professionals to meet the related demand.

**5.3.5** BI solution providers should take initiatives in developing customized versions, providing customized training and technical assistance for improving the awareness among policy makers.

**5.3.6**   The CBSL should acquire the expertise from other developing countries like India and Pakistan that already use ANN based advanced approaches for macroeconomic modeling and forecasting.


## 5.4  Limitations

It is extremely difficult to find information on macro-economic forecasting and monetary policy decision making as it has been carried out only at the CBSL. And the subject experts are relatively less and therefore, number of interviewees is also relatively less. The author has to contact relevant other experts in IPS and in state universities as well. Owing to that the questionnaire is designed to obtain the information, the personal experience and expert ideas though the interviews.

Interviewees contributed to the research based on their own perceptions. The effectiveness of BI could not be properly evaluated owing to the limited usage of BI in the CBSL.


## 5.5  Chapter Summary

In this chapter the final conclusion points of the research was provided. In addition the recommendations of the research and certain limitations encountered during the conduct of this research exercise were also given.

# 6. REFERENCES

Turan, B.A.L.I, Massound, H.E.I.D.A.R.I, &Liuren, W.U. (2009). Predictability of interest rates and interest rate portfolios. *American Statistical Association Journal of Business & Economic Statistics, 27*(4), 517-527. doi: 10.1198/jbes.2009.06124

Ahamd, Z., Shahzadi, L. (2013). Forecasting exchange rate using Neural Network model.*Middle-East Journal of Scientific Research, 18* (10), 1436-143. doi: 10.5829/idosi.mejsr.2013.18.10.12417

Tong, X. (2014). Modeling Corporate Default Rates. *International Journal of Economics and Finance, 6* (8), 1-14.doi:10.5539/ijef.v6n8p1

Harischandra, P. (2010), Investigating inflation persistence in Sri Lanka: Has the inflationprocesschanged? *Proceedings of 3rd International Research Conference*, *Central Bank of Sri Lanka.*

Samant, S. (2015). Prediction of Financial Performance Using Genetic Algorithm and Associative Rule Mining. *International Journal of Engineering Research and General Science*, *3*(1), 1035-1045.

David, T., Spinelli, F. (2012). Interest-rate-growthdifferentials and government debt dynamics, *OECD Journal; Economic Studies*, *2012*(1), 103-122. http://dx.doi.org/10.1787/eco_studies-2012-5k912k0zkhf8

Koh, H.C., Low, C.K. (2004). Going concern prediction using data mining techniques, *Managerial Auditing Journal, 19* (3), 462-476.

Dai, Q., Singleton, K. (2000), Specification Analysis of Affine Term Structure Models, *Journal of Finance*, *55* (5), 1943–1978.

Wang, J., Wang, S. (2010).*Business Intelligence in Economic Forecasting:TechnologiesandTechniques*.DOI: 10.4018/978-1-61520-629-2

Napitupulu, T.A., Wijaya Y.B. (2013), Prediction of stock price using Artificial Neural Network: A case of Indonesia, *Journal of theoretical and Applied Information Technology*, *54* (1), 104-108.

Bissoondeeal, R.K., Gazely, A. and Mootanah, V.P. (2008), Forecasting Exchange Rates with Linear and nonlinear models, *Global Business and Economics Review, 10*(4), 414-429.

Sheikhan, M. and Movaghar, B. (2009), Exchange Rates Prediction Using an Evolutionary Connectionist   Model, *World Applied Sciences Journal, 7*(3), 08-16.

Pradhan, R.P. and Kumar, R. (2010) Forecasting Exchange Rate in India: An Application of Artificial Neural Network, Model *Journal of Mathematics Research, 2*(4), 111-117.

Singh, K., Sensarma, R. (2006). *Forecasting long term interest rate: An econometric exercise for India* (Unpublished master's thesis). Indian Institute of Management, Lucknow, India.

Kanevski, M., Maignan, M., Pozdnoukhov, A., &Timonin, V. (2007). *Interest rate mapping* (Unpublished master's thesis). University of Lausanne, Lausanne, Switzerland.

Kapur, M. (2012), Inflation forecasting: Issues and challenges in India, *RBI Working PaperSeries* (01/2012).

Ratnasiri, H. (2009), The determinants of inflation in Sri Lanka- a VAR based analysis, *CentralBank of Sri Lanka, Staff Studies* **39**(1&2).

Stock, J., H. & Watson, M., W. (2003), Forecasting output and inflation: The role of asset prices, *Journal of Economic Literature* **XLI**, 788–829.

Jegajeevan, S. (2016), on the applicability of Advanced Forecasting Techniques to Developing Economies – A case of Sri Lanka. Unpublished Manuscript.

Cooray, A. V. (2008), A model of inflation for Sri Lanka, *Review of Applied Economics* **4**(1-2).

Bandara, R. (2011), The determinants of inflation in Sri Lanka: An application of the vectorautoregression model, *South Asia Economics Journal* **12**(2).

## Appendix A: Semi Structured Questionnaire

## THE USE OF BUSINESS INTELLIGENCE IN MACRO-ECONOMIC FORECASTING TO IMPROVE MONETARY POLICY DECISION MAKING IN SRI LANKA.

**Research Objectives:**

- To understand the monetary policy framework in Sri Lanka
- To understand the relationship between macroeconomic forecasting and monetary policy decision making process.
- To understand the awareness and readiness for using Business Intelligence approaches in forecasting and visualizing economic data
- Impact of Business Intelligence on improving forecast accuracy thereby aid better monetary policy decision making process

**Q1.**

How do you describe the monetary policy decision making process in Sri Lanka?

a) Why do you need a monetary policy decision making process?
b) Who are the people and key units involve in the process?
c) How does it happen?

**Q2.**

What is the relationship between macroeconomic forecasting and monetary policy decision making process?

a) What are the key inputs?
b) How do you find accurate inputs for monetary policy decision making process?

**Q3**.

Policy makers still use traditional statistical methods for macroeconomic forecasting.

a) What are the approaches use in economic forecasting in Sri Lanka and other countries?
b) Do you think traditional regression models are effective in producing highly accurate forecasts?
c) What are the issues/limitations in traditional regression models in time series forecasting?

**Q4.**

Not only for analyzing and visualizing data, Business Intelligence is considered as forecasting approach as well. There are many common BI techniques available such as ANN, GA, Machine Learning etc in economic forecasting.

a) What is the common understanding of BI among the staff?
b) What do you think "the level of awareness on BI in economic forecasting" among top level researches in your organization?
c) Are you aware that BI can use to improve forecast accuracy?
d) How do you think to improve the awareness?
e) Are you aware the BI techniques like ANN address the limitations of traditional regression models?
f) Are you ready to use BI in forecasting?

**Q5.**

Do you think BI can be used in improving forecast accuracy in Sri Lanka?

a) Are you using ANN based any approach at present?
b) Do you consider ANN as a good forecasting approach? Why / Why not
c) What type of BI approaches suitable for Sri Lanka in economic forecasting? Ex. ANN?
d) How do BI address issues/limitations in current forecasting process?
e) What are the special features of ANN over traditional regression models?
f) What are the advantages of using ANN in forecasting time series, high frequency data?
g) What do you think, what are the advantages of using BI?
h) How do they address issues in current forecasting process?
i) What is your opinion, improved forecasting, will increase the effectiveness of monetary policy decision making?

**Q6.**

What do you think the future of BI/ ANN usage in economic forecasting?

**Q7.**

Do you have anything else to add or comment on?

**End of Questionnaire**

# Appendix B: Interview Transcripts

| Name of the responder | Dr. Chandranath Amarasekara |
| --- | --- |
| Organization | Central Bank of Sri Lanka Department of Economic Research |
| Designation | Additional Director |

**Q1.**
**How do you describe the monetary policy decision making process in Sri Lanka?**

**a) Why do you need a monetary policy decision making process?**

A primary function of the Central Bank, as stated in the Monetary Law Act, is the determination and implementation of monetary policy for the country. Since the economy and the financial sector has become more sophisticated the central bank's duty in determining and implementing monetary policy have also become complex. Hence, as a part of the Bank's ongoing process of adapting itself to meet new challenges, and as a step towards improving the transparency of the decision making process.

**b) Who are the people and key units involve in the process?**

Department of Economic Research, Department of Statistics, Monetary policy committee, monetary board and Operational Departments

**c) How does it happen?**

Department of Economic Research at the CBSL is responsible for monitoring and analyzing the macroeconomic factors which are direct inputs for the monetary policy decision making process. Further, Department of Economic Research and Department of Statistics analyze past data and predict the future behavior of output and inflation. Then the monetary policy committee review reports and predictions given from above departments. The Monetary Policy Committee (MPC) is chaired by the Deputy Governor in charge of Price

Stability. The primary function of the MPC would be to forecast and evaluate emerging monetary and macro-economic developments and make recommendations on appropriate future directions of monetary policy. Policy implementation is done by Domestic Operation Department and International Operation Department at the CBSL. DOD is dealing with local banks and IOD controls the international reserves etc.

**Q2.**
**What is the relationship between macroeconomic forecasting and monetary policy decision making process?**

**a) What are the key inputs?**

Key inputs for the monetary policy decision making process are the real sector factors, external sector factors, fiscal sector factors and monetary sector factors. Real sector factors are GDP growth, Inflation and unemployment rate etc. Exchange rate, imports and exports represent the external factors that influence the monetary policy decision making. Fiscal sector includes budget deficit and debt. Interest rate and money supply comes under the monetary sector.

**b) How do you find accurate inputs for monetary policy decision making process?**

Data needed for the monetary policy decision making process is provided by the department of economic research and department of statistics at the CBSL. Department of economic research and Department of statistics at the CBSL analyses and forecasts the macroeconomic indicators in real sector, external sector, fiscal sector and monetary sector.

Real sector macroeconomic factors are GDP growth, Inflation and unemployment rate etc. Exchange rate, imports and exports represent the external factors that influence the monetary policy decision making. Fiscal sector includes budget deficit and debt. Interest rate and money supply comes under the monetary sector. Department of Economic Research at the CBSL is

responsible for monitoring and analyzing the above factors which are direct inputs for the monetary policy decision making process. Further, based on historical data Department of Economic Research and Department of Statistics analyze past data and predict the future behavior of output and inflation.

**Q3.**
**Policy makers still use traditional statistical methods for macroeconomic forecasting.**

a) **What are the approaches use in economic forecasting in Sri Lanka and other countries?**

Vector Error Correction Model –VECM, VAR variations, ARIMA, VAR/VECM, Bayesian technologies ex. BVAR and DSGE - Dynamic Stochastic General Equilibrium models based QPM – Quarterly Projection Model,
Forecasting and policy analysis model (FPAS) - to further strengthen its policy formulation and modelling capacity, it initiated developing a structural model with assistance from the International Monetary Fund (IMF).

b) **Do you think traditional regression models are effective in producing highly accurate forecasts?**

Advanced macroeconomic models can help in gathering a thorough understanding of the economy and evaluating potential risks and their impact on the future path of key macro variables. Hence, these models can increase the robustness of the policymaking process. Further, monetary policy impacts inflation and output through a complex transmission mechanism which involves a number of linkages among macroeconomic variables and expectations of economic stakeholders.

c) **What are the issues/limitations in traditional regression models in time series forecasting?**

The IMF is in developing a structural model-based Forecasting and Policy Analysis System (FPAS) to strengthen the monetary policy decision making process. FPAS is a medium term pre-emptive policy analysis system which brings together information and judgment in a coherent and logical manner. It includes collecting, analyzing and processing information and assumptions for the formulation of forward-looking policies, with preference often given to long term stabilization. FPAS combines several tools and processes which equip staff with the ability to conduct high-quality macroeconomic analysis and forecasting exercises that will support decision making.

**Q4.**
**Not only for analyzing and visualizing data, Business Intelligence is considered as forecasting approach as well. There are many common BI techniques available such as ANN, GA, Machine Learning etc in economic forecasting.**

**a) What is the common understanding of BI among the staff?**

BI is a tool for gathering, analyzing and representing data in a useful manner that supports decision making.

**b) What do you think "the level of awareness on BI in economic forecasting" among top level researches in your organization?**

Awareness of BI in economic forecasting may be less.

**c) Are you aware that BI can use to improve forecast accuracy?**

May be

**d) How do you think to improve the awareness?**

Customized training programs can be organized to educate the staff.

**e) Are you aware the BI techniques like ANN address the limitations of traditional regression models?**

A little awareness

**f)  Are you ready to use BI in forecasting in the future?**

Yes, the CBSL will adapt new technologies like FPAS that is very similar to a BI tool. And we need to development of a highly specialized pool of macroeconomic forecasting and research staff.
Development of institutional knowledge about the monetary transmission mechanism and the impact of emerging shocks or disturbances is a must.

**Q5.**
**Do you think BI can be used in improving forecast accuracy in Sri Lanka?**

**a)  Are you using ANN based any approach at present?**

Not really

**b)  Do you consider ANN as a good forecasting approach? Why / Why not**

It seems like a good approach

**c)  What type of BI approaches suitable for Sri Lanka in economic forecasting? Ex. ANN?**

No idea

**d)  How do BI address issues/limitations in current forecasting process?**

**e)  What are the special features of ANN over traditional regression models?**

**f)  What are the advantages of using ANN in forecasting time series, high frequency data?**

**g)  What is your opinion, improved forecasting, will increase the effectiveness of monetary policy decision making?**

**Q6.**

**What do you think the future of BI/ ANN usage in economic forecasting?**

FPAS can be considered as a BI tool.

The CBSL has begun to enunciate its policies through a public policy document, to develop in-house macroeconomic forecasting tools, to publish expected path for future inflation and to commence the conducting of the inflation expectations survey over this period, the CBSL has also strengthened its technical capacity in data collection and management, and modelling and forecasting of key macroeconomic variables.

**Q7.**

**Do you have anything else to add or comment on?**

**End of Questionnaire**

| Name of the responder | Mr. Vishuddhi Jayawickrema |
|---|---|
| Organization | Central Bank of Sri Lanka<br>Department of Economic Research |
| Designation | Senior Economist |

## Q1.
**How do you describe the monetary policy decision making process in Sri Lanka?**

**a) Why do you need a monetary policy decision making process?**

The Central bank is the government authority that responsible for the monetary policy. The monetary policy has become the central tool for macroeconomic stabilization. Central bank's monetary policy actions affect interest rates, credit and money supply, all of which have impact on aggregate output and inflation.

**b) Who are the people and key units involve in the process?**

Department of Economic Research, Department of Statistics are responsible for monitoring and analyzing macroeconomic factors which are direct inputs for the monetary policy decision making process

Monetary policy committee - Review reports and projections done at Economic Research Department, Statistics Department, Domestic Operations Department and International Operations Department

**Chairperson -** Deputy Governor responsible for Price Stability

**Members**

Deputy Governor responsible for Financial Stability

Assistant Governor responsible for Price Stability

Assistant Governor responsible for Financial Stability

Director of Economic Research

Additional Director of Economic Research responsible for Money and Banking

(Alternate, Deputy Director, Economic Research responsible for Money and

Banking)

Director, International Operations (Alternate, Deputy Director, International Operations)

Director, Domestic Operations (Alternate, Deputy Director, Domestic Operations)

**Secretary to the MPC**

The Deputy Director, Economic Research responsible for Money and Banking (Alternate, Head of Division, Money and Banking).

Monetary board- Consider recommendations and makes decisions

Operational Departments – Policy Implementation

## c) How does it happen?

Department of Economic Research at the CBSL is responsible for monitoring and analyzing the macroeconomic factors which are direct inputs for the monetary policy decision making process. Further, Department of Economic Research and Department of Statistics analyze past data and predict the future behavior of output and inflation. Then the monetary policy committee review reports and predictions given from above departments. The Monetary Policy Committee (MPC) is chaired by the Deputy Governor in charge of Price Stability. The primary function of the MPC would be to forecast and evaluate emerging monetary and macro-economic developments and make recommendations on appropriate future directions of monetary policy. Policy implementation is done by Domestic Operation Department and International Operation Department at the CBSL. DOD is dealing with local banks and IOD controls the international reserves etc.

**Q2.**
**What is the relationship between macroeconomic forecasting and monetary policy decision making process?**

**a) What are the key inputs?**

Key inputs for the monetary policy decision making process are the real sector factors, external sector factors, fiscal sector factors and monetary sector factors. Real sector factors are GDP growth, Inflation and unemployment rate etc. Exchange rate, imports and exports represent the external factors that influence the monetary policy decision making. Fiscal sector includes budget deficit and debt. Interest rate and money supply comes under the monetary sector.

**b) How do you find accurate inputs for monetary policy decision making process?**

Data needed for the monetary policy decision making process is provided by the department of economic research and department of statistics at the CBSL. Department of economic research and Department of statistics at the CBSL analyze and forecast the macroeconomic indicators in real sector, external sector, fiscal sector and monetary sector.

Real sector macroeconomic factors are GDP growth, Inflation and unemployment rate etc. Exchange rate, imports and exports represent the external factors that influence the monetary policy decision making. Fiscal sector includes budget deficit and debt. Interest rate and money supply comes under the monetary sector. Department of Economic Research at the CBSL is responsible for monitoring and analyzing the above factors which are direct inputs for the monetary policy decision making process. Further, based on historical data Department of Economic Research and Department of Statistics analyze past data and predict the future behavior of output and inflation.

**Q3.**

**Policy makers still use traditional statistical methods for macroeconomic forecasting.**

**a) What are the approaches use in economic forecasting in Sri Lanka and other countries?**

FPAS is a medium term pre-emptive policy analysis system. It includes collecting, analyzing and processing information and assumptions for the formulation of forward-looking policies, Moreover, FPAS combines several tools and processes which equip staff with the ability to conduct high-quality macroeconomic analysis and forecasting exercises that will support decision making. The structural model at the core of FPAS facilitates quality policy discussions about forecasts, potential risks to forecasts and appropriate responses to various shocks, and allows to construct policy scenarios. The prevalence of a structured FPAS system entails several other benefits.

CBSL has finalized the development of the baseline version of a semi-structural QPM for forecasting and analysis of monetary policy. The benchmark model consists of four main behavioral equations, which represent aggregate demand (Investment-Saving or IS curve), aggregate supply (Phillips curve), the uncovered interest rate parity (UIP)condition, and the monetary policy-reaction function (Taylor-type interest rate rule combined with a foreign exchange rule).

The QPM also accounts for multiple shocks that the Sri Lankan economy is prone to. These are broadly categorized as aggregate demand, supply, exchange rate, monetary policy and risk premium shocks. Currently the CBSL utilizes several econometric models to conduct near term forecasting (NTF) exercises for GDP and inflation. A set of advanced NTF models is supposed to complement the QPM in better capturing the idiosyncratic shocks to inflation and GDP over the short-term.

**Q4.**

**Not only for analyzing and visualizing data, Business Intelligence is considered as forecasting approach as well. There are many common BI techniques available such as ANN, GA, Machine Learning etc in economic forecasting.**

**b) What is the common understanding of BI among the staff?**

BI is a tool for gathering, analyzing and representing data in a useful manner that supports decision making.

**c) What do you think "the level of awareness on BI in economic forecasting" among top level researches in your organization?**

Awareness of BI in economic forecasting may be less.

**d) Are you aware that BI can use to improve forecast accuracy?**

May be

**e) How do you think to improve the awareness?**

Customized training programs can be organized to educate the staff.

**f) Are you aware the BI techniques like ANN address the limitations of traditional regression models?**

A little awareness

**g) Are you ready to use BI in forecasting in the future?**

Yes, the CBSL will adapt new technologies like FPAS that is very similar to a BI tool.

**Q5.**

**Do you think BI can be used in improving forecast accuracy in Sri Lanka?**

**a) Are you using ANN based any approach at present?**

Not really

**b) Do you consider ANN as a good forecasting approach? Why / Why not**

It seems like a good approach

**c) What type of BI approaches suitable for Sri Lanka in economic forecasting? Ex. ANN?**

ANN seems to be a suitable approach for Sri Lanka, IMF is developing a tool, FPAS similar to a BI tool that enhance efficiency and effectiveness in monetary policy decision making process.

**d) How do BI address issues/limitations in current forecasting process?**

We don't have a large data sets so it will be a huge disadvantage and will reduce the forecast accuracy. And data is noisy erroneous due various reasons, Nonlinear relationships, economy is vulnerable to random shocks, economy is volatile and unstable

**e) What are the special features of ANN over traditional regression models?**


**f) What are the advantages of using ANN in forecasting time series, high frequency data?**

It is a good approach for addressing nonlinear relationships
Less assumptions on data

**g) What is your opinion, improved forecasting, will increase the effectiveness of monetary policy decision making?**

Advanced macroeconomic models can help in gathering a thorough understanding of the economy and evaluating potential risks and their impact on the future path of key macro variables. Hence, these models can increase the robustness of the policymaking process. Further, monetary policy impacts inflation and output through a complex transmission mechanism which involves a number of linkages among macroeconomic variables. Therefore, it is vital to possess reliable forecasting and policy analysis tools that also take into account the unique characteristics of the Sri Lankan economy.

**Q6.**
**What do you think the future of BI/ ANN usage in economic forecasting?**

When developing forecasting models the CBSL can consider of advantages of approaches like ANN over traditional regression models.


**Q7.**
**Do you have anything else to add or comment on?**

Other than forecasting and analysis, improved communication among all staff engaged in the forecast and policy debates is very important. A tool that facilities communication of potential risks, identify and communicate key policy issues should be developed.


**End of Questionnaire**

| Name of the responder | Dr. SujeethaJegajeevan |
|---|---|
| Organization | Department of Economic Research, CBSL |
| Designation | Head of modeling and forecasting unit |

**Q1.**
**How do you describe the monetary policy decision making process in Sri Lanka?**

a) **Why do you need a monetary policy decision making process?**

The Central Bank of Sri Lanka (CBSL) is currently improving its monetary policy framework and increasingly aligning it with a flexible inflation targeting (FIT) framework. In a broad sense, FIT denotes the setting of policy rates in a manner so as to stabilize inflation around the targeted rate with due regard to the stability of the economy Therefore, within a FIT framework, the inflation forecast will be the centric element to manage and communicate the short run output-inflation trade off.

In the transition to a FIT regime, it is essential that a central bank becomes increasingly transparent and forward-looking. The use of structural models for medium term projections and policy analysis has become indispensable for this purpose. These models would equip the central bank with the ability to determine the path of monetary policy actions needed to bring inflation to its medium term objective while stabilizing real output at its potential level. The model outcomes can also pave the way for structured debate about underlying assumptions, risks and policy issues, and will permit greater transparency in policy decisions and communication.

b) **Who are the people and key units involve in the process?**

Department of Economic Research, Department of Statistics are responsible for monitoring and analyzing macroeconomic factors which are direct inputs for the monetary policy decision making process

Monetary policy committee - Review reports and projections done at Economic Research Department, Statistics Department, Domestic Operations Department and International Operations Department

Monetary board- Consider recommendations and makes decisions

Operational Departments – Policy Implementation

c) **How does it happen?**

**Q2.**
**What is the relationship between macroeconomic forecasting and monetary policy decision making process?**

a) **What are the key inputs?**

Key inputs for the monetary policy decision making process are the real sector factors, external sector factors, fiscal sector factors and monetary sector factors. Real sector factors are GDP growth, Inflation and unemployment rate etc. Exchange rate, imports and exports represent the external factors that influence the monetary policy decision making. Fiscal sector includes budget deficit and debt. Interest rate and money supply comes under the monetary sector.

b) **How do you find accurate inputs for monetary policy decision making process?**

By analyzing and forecasting macroeconomic factors

**Q3.**
**Policy makers still use traditional statistical methods for macroeconomic forecasting.**

a) **What are the approaches use in economic forecasting in Sri Lanka and other countries?**

ARIMA, Baseline BVAR, Large BVAR, Time Varying Parameter BVAR, Unobserved Component model with stochastic volatility (UC-SV model)

DSGE - Dynamic Stochastic General Equilibrium models

Large BVAR model is found to be the best of all the models to forecast GDP growth, and DSGE model is the best model for forecasting inflation at forecast horizons above 2 quarters.

No model could beat the benchmark ARMA model in forecast inflation at the immediate quarter. Baseline BVAR model is successful in both GDP growth and inflation forecast. DSGE model is good at forecasting both of these variables better in highly volatile times at longer horizons.

### b) Do you think traditional regression models are effective in producing highly accurate forecasts?

The sample size is limited by the availability of quarterly GDP and other data series. It is a known fact that less advanced economies suffer from the limitation in availability of high frequency data spanning over long period of time. Modelling with shorter sample of around 20 years is not uncommon for developing country based studies. However, the outcome of time-varying BVA Rand unobserved component model forecasts have to be interpreted carefully, as first 20 quarterly data points are taken as training sample leaving only a shorter sample for estimation.

Empirical studies for advanced economies have a long history and the forecasting methodology is being improved constantly in the recent years. Studies covering emerging and developing countries are just a handful and are only in the evolutionary stage. Moreover, many such studies are built on regression based or Vector Auto regression (VAR) based methodology.

Recent advances in forecasting techniques have several superiority over these traditional approaches and were successful in forecasting key economic variables in advanced economies, at least before the recent financial crisis. It is worth applying these methods to a country like Sri Lanka to check their applicability to economies in transition. The advanced forecasting methods developed and applied in advanced economies are found to be working for Sri Lanka, then these techniques could be applied to any other developing and emerging economy that share similar characteristics of Sri Lankan economy.

**c) What are the issues/limitations in traditional regression models in time series forecasting?**

The baseline BayesianVector Autoregression (BVAR) consisting of 3 fundamental economic variables, such as GDP growth, inflation and short-term interest rate. These variables largely capture future movements of output and inflation in economies with less frictions. However, these fundamental variables may be inadequate to forecast Sri Lankan output and inflation. As a small open economy in transition Sri Lanka is vulnerable to shocks emanating from external environment. Also there is
empirical evidence that domestic supply and external shocks play an important role in explaining the movements of key economic fundamentals in Sri Lanka. Adding variables to capture domestic supply side and external sector movements could improve forecast accuracy. Therefore, in addition to the baseline model a large BVAR (LBVAR) model is also being considered in this study. Exchange rate, international oil price, monetary
aggregate, international trade and current account dynamics and output gap are examples of such variables included in the large BVAR model.
Fixed parameter models are often criticized because of the possibility of parameters changing over time and with policy interventions. In order to deal with this issue Time Varying Parameter BVAR (TVP-BVAR) model with 3 fundamental variables is included as the third technique. Due to computational difficulties all the variables included in the large BVAR could not be included in TVP-BVAR approach. Univariate Unobserved Component Trend-Cycle model with stochastic volatility (UC_SV) proposed by Stock and Watson (2007), In this model the forecast variable is represented as the sum of permanent stochastic trend component and a serially uncorrelated transitory component. It has been successful in forecasting inflation in the USA. All the technique discussed above are data driven univariate and multivariate models. Parameters of these models are based on the data. Fully micro-found Dynamic Stochastic General Equilibrium models (DSGE) are increasingly becoming popular both in policy analysis and forecasting. A less-advanced country that

suffers from data limitations. Density forecasts have a merit over the point forecast since it provides details of uncertainties surrounding the point forecasts. Due to this reason density forecasts have become popular in forecasting exercises in the recent periods, especially after the financial crisis. Also, density forecasts contain useful information for the policy makers since prediction about future uncertainties are made available. Forecast accuracy of point forecasts is mainly evaluated by Root Mean Squared Error (RMSE).

**Q4.**
**Not only for analyzing and visualizing data, Business Intelligence is considered as forecasting approach as well. There are many common BI techniques available such as ANN, GA, Machine Learning etc in economic forecasting.**

**a) What is the common understanding of BI among the staff?**

BI is a tool for gathering, analyzing and representing data in a useful manner that supports decision making.

**b) What do you think "the level of awareness on BI in economic forecasting" among top level researches in your organization?**

Awareness of BI in economic forecasting may be less.

**c) How do you think to improve the awareness?**

Customized training programs can be organized to educate the staff.

**d) Are you aware the BI techniques like ANN address the limitations of traditional regression models?**

Yes to some extent.

**e) Are you ready to use BI in forecasting?**

Yes. We are working on developing a tool called FPAS. Not only for forecasting but also for streamlining the entire monetary policy decision making process.

**Q5.**
**Do you think BI can be used in improving forecast accuracy in Sri Lanka?**
**a) Are you using ANN based any approach at present?**

Not really.

**b) Do you consider ANN as a good forecasting approach? Why / Why not**

Seems a good approach

**c) How do BI address issues/limitations in current forecasting process?**

We don't have a large data sets so it will be a huge disadvantage and will reduce the forecast accuracy. And data is noisy erroneous due various reasons, Nonlinear relationships, economy is vulnerable to random shocks, economy is volatile and unstable.

**d) What are the special features of ANN over traditional regression models?**

**e) What are the advantages of using ANN in forecasting time series, high frequency data?**

Neural networks could be used as a powerful tool to identify and reproduce complex nonlinear data generating processes in time-series data. Whether studying growth of real GDP, inflation, employment growth or exchange rates, the neural network should, in theory, be able to detect and duplicate any complex nonlinear pattern in the data. Furthermore, no priori knowledge of the data generating process is necessary, as would be the case with standard nonlinear regression. It is sufficient to use a general functional form, but with a greater number of hidden units.

**f) How do they address issues in current forecasting process?**

When dealing with small samples, the decomposition of the sample into training, validation and test sets can leave too few observations in each set to obtain reliable results. This issue can be addressed in ANN method.

**g) What is your opinion, improved forecasting, will increase the effectiveness of monetary policy decision making?**

Of course, forecasting accuracy is vital for better policy analysis and decision making,

**Q6.**
**What do you think the future of BI/ ANN usage in economic forecasting?**

FPAS can be considered as a BI tool that facilitates data analysis, management, modeling and forecasting.

**Q7.**
**Do you have anything else to add or comment on?**

The forecasting models that work well in advanced economies are successful in forecasting key economic variables in developing economies too. These models have reported good forecasting performance regardless of the shorter sample of data and high volatility of inflation in Sri Lanka.
Previous forecasting exercises suggest that forecast accuracy of density forecasts of statistical models can be used at the Central Bank of Sri Lanka for policy discussions, since density forecasts provide complete description of forecast uncertainty. It is revealed that the baseline BVAR, performs reasonably well in forecasting both GDP growth and inflation. Adding more variables in the model does not play any big role in improving forecast accuracy of inflation forecasts in the normal times, though large BVAR model is helpful at volatile times. Expanding sample could improve forecast accuracy of time varying model and unobserved component model that are based on prior estimated from training sample. Improving sample will help these models to capture the break and changes in parameters well. Further, micro-found DSGE model is successful in producing better forecasts for inflation. However, none of the economic models predict future perfectly regardless of the complexity of the model, size of the sample and the nature of the economy, it should be accepted that advanced models can be used to model and forecast key economic variables for a developing country to carryout informed policy

analysis and to take better policy decisions. It is recommended that the Central bank of Sri Lanka can employ these models, including the benchmark ARMA model, as a starting point in its forecasting exercise for forecasting macro variables for policy analysis.

**End of Questionnaire**

| Name of the responder | Dr. DamayanthiEkanayeke |
|---|---|
| Organization | Central Bank of Sri Lanka<br>Department of Statistics |
| Designation | Additional Director General |

**Q1.**
**How do you describe the monetary policy decision making process in Sri Lanka?**
 a) **Why do you need a monetary policy decision making process?**
 b) **Who are the people and key units involve in the process?**
 c) **How does it happen?**

The CBSL has already met certain prerequisites of an inflation targeting framework. Along with the CBSL's independence in selecting operating instruments and with a mandate to maintain price stability, it has taken several initiatives during the recent past to further equip the monetary policy framework for inflation targeting. Accordingly, the CBSL has begun to enunciate its policies through a public policy document, developed in-house macroeconomic forecasting tools, published expected path for future inflation and commenced the conducting of the inflation expectations survey. Over this period, the CBSL has also strengthened its technical capacity in data collection and management, and modelling and forecasting of key macroeconomic variables.

**Q2.**
**What is the relationship between macroeconomic forecasting and monetary policy decision making process?**

a) **What are the key inputs?**

b) **How do you find accurate inputs for monetary policy decision making process?**

**Q3**.
**Policy makers still use traditional statistical methods for macroeconomic forecasting.**

c) **What are the approaches use in economic forecasting in Sri Lanka and other countries?**

d) **Do you think traditional regression models are effective in producing highly accurate forecasts?**

The unavailability of quarterly GDP and other data is the main reason for the short sample. Extend the sample period and forecast evaluation period need to be extended in order to get a better outcome. On the other hand adding more variables increases the

Complexity of models and doesn't produce accurate forecasts.

e) **What are the issues/limitations in traditional regression models in time series forecasting?**

There are limitations. Our economy is volatile and unstable, vulnerable to shocks. There are issues in data. Small sample size, erroneous data will affect the accuracy of forecasts.

Regression models linearize, nonlinear data and taken in to normal distribution, and a lot of assumptions are made on data. These models good for larger data sets.

**Q4.**
**Not only for analyzing and visualizing data, Business Intelligence is considered as forecasting approach as well. There are many common BI techniques available such as ANN, GA, Machine Learning etc in economic forecasting.**

a) **What is the common understanding of BI among the staff?**

BI as a data analyzing tool and supports for better decision making

**b) What do you think "the level of awareness on BI in economic forecasting" among top level researches in your organization?**

Less awareness

**c) Are you aware that BI can use to improve forecast accuracy?**

A little awareness

**d) How do you think to improve the awareness?**

Educating the staff, organizing workshops etc.

**e) Are you aware the BI techniques like ANN address the limitations of traditional regression models?**

A little awareness

**f) Are you ready to use BI in forecasting?**

FPAS is kind of a BI tool going to be implemented in the future at the CBSL

**Q5.**
**Do you think BI can be used in improving forecast accuracy in Sri Lanka?**
**a) Are you using ANN based any approach at present?**

No

**b) Do you consider ANN as a good forecasting approach? Why / Why not**

Yes of course

**c) What are the advantages of using ANN in forecasting time series, high frequency data?**

**d) How do they address issues in current forecasting process?**

**e) What is your opinion, improved forecasting, will increase the effectiveness of monetary policy decision making?**

Highly accurate forecasts aid better monetary policy decision making.


**Q6.**
**What do you think the future of BI/ ANN usage in economic forecasting?**

**Q7.**
**Do you have anything else to add or comment on?**


**End of Questionnaire**

| Name of the responder | Professor.VidhuraTennakoon |
|---|---|
| **Organization** | Indiana University |
| **Designation** | Assistant professor |

**Q1.**

**How do you describe the monetary policy decision making process in Sri Lanka?**

   a) **Why do you need a monetary policy decision making process?**
   b) **Who are the people and key units involve in the process?**
   c) **How does it happen?**

   Read this and you will find answers to all these questions.
   http://www.cbsl.gov.lk/htm/english/04_mp/m_2.html#3

**Q2.**

**What is the relationship between macroeconomic forecasting and monetary policy decision making process?**

   a) **What are the key inputs?**

   It is a compressive list which includes 100-200 variables, practically all macroeconomic indicators you would have heard of plus some additional financial variables and also social and political other factors.

   b) **How do you find accurate inputs for monetary policy decision making process?**

   They are either compiled by CBSL staff and/or collected from the original sources.

**Q3.**

**Policy makers still use traditional statistical methods for macroeconomic forecasting.**

   a) **What are the approaches use in economic forecasting in Sri Lanka and other countries?**

Sophisticated models used in most other central banks of developed countries were used in Sri Lanka when I was there (10-15 years ago) and there's no reason why they should be behind than they were then. But, they were all model-based statistical techniques (ARMA, SVAR and VECM). GA, ANN or

Machine Learning was not widely used for economic forecasting 10-12 years ago in any central bank. I have no idea about the current situation.

**b) Do you think traditional regression models are effective in producing highly accurate forecasts?**

Not just the traditional regression models but also the more sophisticated models are not capable of producing "highly accurate" forecasts. Always, there's a substantial forecasting error. But, the good thing is that we have an estimate of the error margin too.

**c) What are the issues/limitations in traditional regression models in time series forecasting?**

Future is not deterministic. So, you can't predict future exactly as it will happen no matter which technique you use.

**Q4.**
**Not only for analyzing and visualizing data, Business Intelligence is considered as forecasting approach as well. There are many common BI techniques available such as ANN, GA, Machine Learning etc. in economic forecasting.**

**a) What is the common understanding of BI among the staff?**

Not relevant to me since my organization is a research University in US. Obviously the researchers here do use these techniques and also work on improving.

**b) What do you think "the level of awareness on BI in economic forecasting" among top level researches in your organization?**
**c) Are you aware that BI can use to improve forecast accuracy?**
**d) How do you think to improve the awareness?**
**g) Are you aware the BI techniques like ANN address the limitations of traditional regression models?**
**h) Are you ready to use BI in forecasting?**

**Q5.**

**Do you think BI can be used in improving forecast accuracy in Sri Lanka?**

The econometric techniques are not correctly used by most people, so they don't get the full advantage.

a) **Are you using ANN based any approach at present?**
b) **Do you consider ANN as a good forecasting approach? Why / Why not**

Their potential to detect and reproduce linear and nonlinear relationships among a set of variables is high. The forecasting accuracy of the neural network is found to be superior to a well-established linear regression models. However, a little improvement in forecasting accuracy is statistically significant. Neural networks are generally more accurate than linear models for out-of-sample forecasting of economic output and various financial variables such as stock prices.

c) **What type of BI approaches suitable for Sri Lanka in economic forecasting? Ex. ANN?**
d) **What are the special features of ANN over traditional regression models?**

Research suggests that neural networks may prove useful to forecast volatile financial variables that are difficult to forecast with conventional statistical methods, such as exchange rates and stock performance, neural networks have also been successfully applied to macroeconomic variables such as economic growth, industrial production and aggregate electricity consumption. Applications to macroeconomics are quite novel and are still considered to be at the frontier of empirical economic methods. As it will be shown, the simplest types of neural networks are closely linked to standard econometric techniques.

e) **What are the advantages of using ANN in forecasting time series, high frequency data?**

Neural networks could be used as a powerful tool to identify and reproduce complex nonlinear data generating processes in time-series data. Whether studying growth of real GDP, inflation, employment growth or exchange rates, the neural network should, in theory, be able to detect and duplicate any complex nonlinear pattern in the data.

ANN can successfully model nonlinear relationships, neural networks with nonlinear activation functions should be more effective than linear regression models in dealing with nonlinear relationships.

ANN do not require a priori information on the functional form of a relationship

Many nonlinear functions can be linearized using relatively simple mathematical transformations, researcher need some priori knowledge of the nature of the nonlinearity that enables him to identify the appropriate transformation to apply to the data. Needless to say, such information is rarely available in the field of macroeconomic forecasting.

Another advantage of neural networks stems from the relative flexibility of network architectures. As illustrated at the beginning of this paper, a wide spectrum of statistical techniques (e.g. linear regression, a binary probit model, autoregressive models, etc.) can be specified by simply making minor modifications to the activation functions and the network structure (such as changing the number of units in each layer). The same basic architecture is therefore very flexible and can accommodate both discrete and continuous dependent variables.


**f) How do they address issues in current forecasting process?**

When dealing with small samples, the decomposition of the sample into training, validation and test sets can leave too few observations in each set to obtain reliable results. This issue can be addressed in ANN method.

**g) What is your opinion, improved forecasting, will increase the effectiveness of monetary policy decision making?**

Of course. Since monetary policy decisions directly dependent on macroeconomic data, accurate forecasts are very important for better decision making.

**Q6.**
**What do you think the future of BI/ ANN usage in economic forecasting?**

BI is a broader term which includes many techniques which includes "traditional" econometric methods such as MCMC, Bayesian methods. ANN is becoming popular as an economic forecasting tool.

**Q7.**
**Do you have anything else to add or comment on?**

**End of Questionnaire**

# Appendix C: Summarized Findings

**Q1.**

**How do you describe the monetary policy decision making process in Sri Lanka?**

**a) Why do you need a monetary policy decision making process?**

A primary function of the Central Bank, as stated in the Monetary Law Act, is the determination and implementation of monetary policy for the country. Since the economy and the financial sector has become more sophisticated the central bank's duty in determining and implementing monetary policy have also become complex. Hence, as a part of the Bank's ongoing process of adapting itself to meet new challenges, and as a step towards improving the transparency of the decision making process.

The Central bank is the government authority that responsible for the monetary policy. The monetary policy has become the central tool for macroeconomic stabilization. Central bank's monetary policy actions affect interest rates, credit and money supply, all of which have impact on aggregate output and inflation. The Central Bank of Sri Lanka (CBSL) is currently improving its monetary policy framework and increasingly aligning it with a flexible inflation targeting (FIT) framework. In a broad sense, FIT denotes the setting of policy rates in a manner so as to stabilize inflation around the targeted rate with due regard to the stability of the economy Therefore, within a FIT framework, the inflation forecast will be the centric element to manage and communicate the short run output-inflation trade off.

In the transition to a FIT regime, it is essential that a central bank becomes increasingly transparent and forward-looking. The use of structural models for medium term projections and policy analysis has become indispensable for this purpose. These models would equip the central bank with the ability to determine the path of monetary policy actions needed to bring inflation to its medium term objective while stabilizing real output at its potential level. The

model outcomes can also pave the way for structured debate about under lying assumptions, risks and policy issues, and will permit greater transparency in policy decisions and communication.

The CBSL has already met certain prerequisites of an inflation targeting framework. Along with the CBSL's independence in selecting operating instruments and with a mandate to maintain price stability, it has taken several initiatives during the recent past to further equip the monetary policy framework for inflation targeting. Accordingly, the CBSL has begun to enunciate its policies through a public policy document, developed in-house macroeconomic forecasting tools, published expected path for future inflation and commenced the conducting of the inflation expectations survey. Over this period, the CBSL has also strengthened its technical capacity in data collection and management, and modeling and forecasting of key macroeconomic variables.

**b) Who are the people and key units involve in the process?**

Department of Economic Research, Department of Statistics are responsible for monitoring and analyzing macroeconomic factors which are direct inputs for the monetary policy decision making process

Monetary policy committee - Review reports and projections done at Economic Research Department, Statistics Department, Domestic Operations Department and International Operations Department

**Chairperson -** Deputy Governor responsible for Price Stability

**Members**

Deputy Governor responsible for Financial Stability

Assistant Governor responsible for Price Stability

Assistant Governor responsible for Financial Stability

Director of Economic Research

Additional Director of Economic Research responsible for Money and Banking
(Alternate, Deputy Director, Economic Research responsible for Money and Banking)

Director, International Operations (Alternate, Deputy Director, International Operations)

Director, Domestic Operations (Alternate, Deputy Director, Domestic Operations)

**Secretary to the MPC**

The Deputy Director, Economic Research responsible for Money and Banking (Alternate, Head of Division, Money and Banking).

Monetary board- Consider recommendations and makes decisions

Operational Departments – Policy Implementation

### c) How does it happen?

Department of Economic Research at the CBSL is responsible for monitoring and analyzing the macroeconomic factors which are direct inputs for the monetary policy decision making process. Further, Department of Economic Research and Department of Statistics analyze past data and predict the future behavior of output and inflation. Then the monetary policy committee review reports and predictions given from above departments. The Monetary Policy Committee (MPC) is chaired by the Deputy Governor in charge of Price Stability. The primary function of the MPC would be to forecast and evaluate emerging monetary and macro-economic developments and make recommendations on appropriate future directions of monetary policy. Policy implementation is done by Domestic Operation Department and International Operation Department at the CBSL. DOD is dealing with local banks and IOD controls the international reserves etc.

### Q2.
**What is the relationship between macroeconomic forecasting and monetary policy decision making process?**
**a) What are the key inputs?**

Key inputs for the monetary policy decision making process are the real sector factors, external sector factors, fiscal sector factors and monetary sector

factors. Real sector factors are GDP growth, Inflation and unemployment rate etc. Exchange rate, imports and exports represent the external factors that influence the monetary policy decision making. Fiscal sector includes budget deficit and debt. Interest rate and money supply comes under the monetary sector. Plus some additional financial variables and also social and political other factors.

## b) How do you find accurate inputs for monetary policy decision making process?

Data needed for the monetary policy decision making process is provided by the department of economic research and department of statistics at the CBSL. Department of economic research and Department of statistics at the CBSL analyses and forecasts the macroeconomic indicators in real sector, external sector, fiscal sector and monetary sector. Real sector macroeconomic factors are GDP growth, Inflation and unemployment rate etc. Exchange rate, imports and exports represent the external factors that influence the monetary policy decision making. Fiscal sector includes budget deficit and debt. Interest rate and money supply comes under the monetary sector. Department of Economic Research at the CBSL is responsible for monitoring and analyzing the above factors which are direct inputs for the monetary policy decision making process. Further, based on historical data Department of Economic Research and Department of Statistics analyze past data and predict the future behavior of output and inflation.

## Q3.
**Policy makers still use traditional statistical methods for macroeconomic forecasting.**
**a) What are the approaches use in economic forecasting in Sri Lanka and other countries?**

Vector Error Correction Model –VECM, VAR variations, ARIMA, VAR/VECM, Bayesian technologies ex. BVAR and DSGE - Dynamic

Stochastic General Equilibrium models based QPM – Quarterly Projection Model, Forecasting and policy analysis model (FPAS) - to further strengthen its policy formulation and modelling capacity, it initiated developing a structural model with assistance from the International Monetary Fund (IMF).

FPAS is a medium term pre-emptive policy analysis system. It includes collecting, analyzing and processing information and assumptions for the formulation of forward-looking policies, Moreover, FPAS combines several tools and processes which equip staff with the ability to conduct high-quality macroeconomic analysis and forecasting exercises that will support decision making. The structural model at the core of FPAS facilitates quality policy discussions about forecasts, potential risks to forecasts and appropriate responses to various shocks, and allows to construct policy scenarios. The prevalence of a structured FPAS system entails several other benefits. CBSL has finalized the development of the baseline version of a semi structural QPM for forecasting and analysis of monetary policy. The benchmark model consists of four main behavioral equations, which represent aggregate demand (Investment-Saving or IS curve), aggregate supply (Phillips curve), the uncovered interest rate parity (UIP) condition, and the monetary policy-reaction function (Taylor-type interest rate rule combined with a foreign exchange rule). The QPM also accounts for multiple shocks that the Sri Lankan economy is prone to. These are broadly categorized as aggregate demand, supply, exchange rate, monetary policy and risk premium shocks. Currently the CBSL utilizes several econometric models to conduct near term forecasting (NTF) exercises for GDP and inflation. A set of advanced NTF models is supposed to complement the QPM in better capturing the idiosyncratic shocks to inflation and GDP over the short-term.

ARIMA, Baseline BVAR, Large BVAR, Time Varying Parameter BVAR, Unobserved Component model with stochastic volatility (UC-SV model) DSGE - Dynamic Stochastic General Equilibrium models Large BVAR model is found to be the best of all the models to forecast GDP growth, and DSGE model is the best model for forecasting inflation at forecast

horizons above 2 quarters. No model could beat the benchmark ARMA model in forecast inflation at the immediate quarter. Baseline BVAR model is successful in both GDP growth and inflation forecast. DSGE model is good at forecasting both of these variables better in highly volatile times at longer horizons.

**b) Do you think traditional regression models are effective in producing highly accurate forecasts?**

Advanced macroeconomic models can help in gathering a thorough understanding of the economy and evaluating potential risks and their impact on the future path of key macro variables. Hence, these models can increase the robustness of the policymaking process. Further, monetary policy impacts inflation and output through a complex transmission mechanism which involves a number of linkages among macroeconomic variables and expectations of economic stakeholders.

The sample size is limited by the availability of quarterly GDP and other data series. It is a known fact that less advanced economies suffer from the limitation in availability of high frequency data spanning over long period of time. Modelling with shorter sample of around 20 years is not uncommon for developing country based studies. However, the outcome of time-varying BVAR and unobserved component model forecasts have to be interpreted carefully, as first 20 quarterly data points are taken as training sample leaving only a shorter sample for estimation. Empirical studies for advanced economies have a long history and the forecasting methodology is being improved constantly in the recent years. Studies covering emerging and developing countries are just a handful and are only in the evolutionary stage. Moreover, many such studies are built on regression based or Vector Autoregression (VAR) based methodology. Recent advances in forecasting techniques have several superiority over these traditional approaches and were successful in forecasting key economic variables in advanced economies, at least before the recent financial crisis. It is worth applying these methods to a country like Sri Lanka to check their applicability to economies in transition.

The advanced forecasting methods developed and applied in advanced economies are found to be working for Sri Lanka, then these techniques could be applied to any other developing and emerging economy that share similar characteristics of Sri Lankan economy.

The unavailability of quarterly GDP and other data is the main reason for the short sample. Extend the sample period and forecast evaluation period need to be extended in order to get a better outcome. On the other hand adding more variables increases the Complexity of models and doesn't produce accurate forecasts.

Not just the traditional regression models but also the more sophisticated models are not capable of producing "highly accurate" forecasts. Always, there's a substantial forecasting error. But, the good thing is that we have an estimate of the error margin too.

### c) What are the issues/limitations in traditional regression models in time series forecasting?

The IMF is in developing a structural model-based Forecasting and Policy Analysis System (FPAS) to strengthen the monetary policy decision making process. FPAS is a medium term pre-emptive policy analysis system which brings together information and judgment in a coherent and logical manner. It includes collecting, analyzing and processing information and assumptions for the formulation of forward-looking policies, with preference often given to long term stabilization. FPAS combines several tools and processes which equip staff with the ability to conduct high-quality macroeconomic analysis and forecasting exercises that will support decision making.

The baseline Bayesian Vector Autoregression (BVAR) consisting of 3 fundamental economic variables, such as GDP growth, inflation and short term interest rate. These variables largely capture future movements of output and inflation in economies with less frictions. However, these fundamental variables may be inadequate to forecast Sri Lankan output and inflation. As a

small open economy in transition Sri Lanka is vulnerable to shocks emanating from external environment. Also there is empirical evidence that domestic supply and external shocks play an important role in explaining the movements of key economic fundamentals in Sri Lanka. Adding variables to capture domestic supply side and external sector movements could improve forecast accuracy. Therefore, in addition to the baseline model a large BVAR (LBVAR) model is also being considered in this study. Exchange rate, international oil price, monetary aggregate, international trade and current account dynamics and output gap are examples of such variables included in the large BVAR model. Fixed parameter models are often criticized because of the possibility of parameters changing over time and with policy interventions. In order to deal with this issue Time Varying Parameter BVAR (TVP-BVAR) model with 3 fundamental variables is included as the third technique. Due to computational difficulties all the variables included in the large BVAR could not be included in TVP-BVAR approach. Univariate Unobserved Component Trend-Cycle model with stochastic volatility (UC_SV) proposed by Stock and Watson (2007). In this model the forecast variable is represented as the sum of permanent stochastic trend component and a serially uncorrelated transitory component. It has been successful in forecasting inflation in the USA. All the technique discussed above are data driven univariate and multivariate models. Parameters of these models are based on the data. Fully micro-found Dynamic Stochastic General Equilibrium models (DSGE) are increasingly becoming popular both in policy analysis and forecasting. A less-advanced country that suffers from data limitations. Density forecasts have a merit over the point forecast since it provides details of uncertainties surrounding the point forecasts. Due to this reason density forecasts have become popular in forecasting exercises in the recent periods, especially after the financial crisis. Also, density forecasts contain useful information for the policy makers since prediction about future uncertainties are made available. Forecast accuracy of point forecasts is mainly evaluated by Root Mean Squared Error (RMSE).

There are limitations. Our economy is volatile and unstable, vulnerable to shocks. There are issues in data. Small sample size, erroneous data will affect the accuracy of forecasts. Regression models linearize, nonlinear data and taken in to normal distribution, and a lot of assumptions are made on data. These models good for larger data sets.

Future is not deterministic. So, you can't predict future exactly as it will happen no matter which technique you use.

**Q4.**

**Not only for analyzing and visualizing data, Business Intelligence is considered as forecasting approach as well. There are many common BI techniques available such as ANN, GA, Machine Learning etc in economic forecasting.**

**a) What is the common understanding of BI among the staff?**

BI is a tool for gathering, analyzing and representing data in a useful manner that supports decision making.

**b) What do you think "the level of awareness on BI in economic forecasting" among top level researches in your organization?**

Awareness of BI in economic forecasting may be less.

**c) Are you aware that BI can use to improve forecast accuracy?**

May be

**d) How do you think to improve the awareness?**

Customized training programs can be organized to educate the staff.

Organizing workshops etc.

**e) Are you aware the BI techniques like ANN address the limitations of traditional regression models?**

A little awareness

**f) Are you ready to use BI in forecasting in the future?**

Yes, the CBSL will adapt new technologies like FPAS that is very similar to a BI tool. FPAS is not only for forecasting but also for streamlining the entire monetary policy decision making process. FPAS is a kind of BI tool going to be implemented in the future at the CBSL. And we need to development of a highly specialized pool of macroeconomic forecasting and research staff. Development of institutional knowledge about the monetary transmission mechanism and the impact of emerging shocks or disturbances is a must.

**Q5.**
**Do you think BI can be used in improving forecast accuracy in Sri Lanka?**
**a) Are you using ANN based any approach at present?**

Not really

**b) Do you consider ANN as a good forecasting approach? Why / Why not**

It seems like a good approach

The econometric techniques are not correctly used by most people, so they don't get the full advantage.

**c) What type of BI approaches suitable for Sri Lanka in economic forecasting? Ex. ANN?**

ANN seems to be a suitable approach for Sri Lanka, IMF is developing a tool, FPAS similar to a BI tool that enhance efficiency and effectiveness in monetary policy decision making process.

**d) How do BI address issues/limitations in current forecasting process?**

We don't have a large data sets so it will be a huge disadvantage and will reduce the forecast accuracy. And data is noisy erroneous due various reasons, Nonlinear relationships, economy is vulnerable to random shocks, economy is volatile and unstable.

Neural Network's potential to detect and reproduce linear and nonlinear relationships among a set of variables is high. The forecasting accuracy of the neural network is found to be superior to a well-established linear regression models. However, a little improvement in forecasting accuracy is statistically significant. Neural networks are generally more accurate than linear models for out-of-sample forecasting of economic output and various financial variables such as stock prices. ANN is a powerful complement to standard econometric methods, rather than a substitute. The full potential of neural networks can probably be exploited by using them in conjunction with linear regression models. Hence, neural networks should be viewed as an additional tool to be included in the toolbox of macroeconomic forecasters.

When dealing with small samples, the decomposition of the sample into training, validation and test sets can leave too few observations in each set to obtain reliable results. This issue can be addressed in ANN method.

### e) What are the special features of ANN over traditional regression models?

Research suggests that neural networks may prove useful to forecast volatile financial variables that are difficult to forecast with conventional statistical methods, such as exchange rates and stock performance, neural networks have also been successfully applied to macroeconomic variables such as economic growth, industrial production and aggregate electricity consumption. Applications to macroeconomics are quite novel and are still considered to be at the frontier of empirical economic methods. As it will be shown, the simplest types of neural networks are closely linked to standard econometric techniques.

**f) What are the advantages of using ANN in forecasting time series, high frequency data?**

It is a good approach for addressing nonlinear relationships

Less assumptions on data

The majority of applications in econometrics assume a linear relationship between the dependent variable and the regressors. The simplicity of the 81 linear model and the possibility of linearizing certain nonlinear relationships make the linear regression model a very attractive and powerful tool. However, making nonlinear relationships, linear does not produce accurate forecasts. ANN can successfully model nonlinear relationships, neural networks with nonlinear activation functions should be more effective than linear regression models in dealing with nonlinear relationships. ANN does not require priori information on the functional form of a relationship although many nonlinear functions can be linearized using relatively simple mathematical transformations, this supposes that the researcher has some a priori knowledge of the nature of the nonlinearity that enables him to identify the appropriate transformation to apply to the data. Needless to say, such information is rarely available in the field of macroeconomic forecasting. One could argue that nonlinear regression techniques would perform as well as neural networks when dealing with a nonlinear phenomenon. In theory, this is absolutely true. However, in practice, the estimation of a nonlinear regression model requires the econometrician to assume an a priori functional form for the relationship studied. Selecting the wrong functional form will lead to imprecise coefficient estimates and bad forecasts. On the other hand, when estimating a neural network, the researcher does not really need to worry about the functional form of the phenomenon studied because the "universal approximator" property of networks will allow it to mimic almost any functional form. No *a priori* knowledge is necessary to obtain precise forecasts. Another advantage of neural networks stems from the relative flexibility of network architectures. As illustrated at the beginning of this paper, a wide spectrum of statistical

techniques (e.g. linear regression, a binary probit model, autoregressive models, etc.) can be specified by simply making minor modifications to the activation functions and the network structure (such as changing the number of units in each layer). The same

basic architecture is therefore very flexible and can accommodate both discrete and continuous dependent variables.

Neural networks could be used as a powerful tool to identify and reproduce complex nonlinear data generating processes in time-series data. Whether studying growth of real GDP, inflation, employment growth or exchange rates, the neural network should, in theory, be able to detect and duplicate any complex nonlinear pattern in the data. Furthermore, no *a priori* knowledge of the data generating process is necessary, as would be the case with standard nonlinear regression. It is sufficient to use a general functional form, but with a greater number of hidden units.

**g) What is your opinion, improved forecasting, will increase the effectiveness of monetary policy decision making?**

Advanced macroeconomic models can help in gathering a thorough understanding of the economy and evaluating potential risks and their impact on the future path of key macro variables. Hence, these models can increase the robustness of the policy making process. Further, monetary policy impacts inflation and output through a complex transmission mechanism which involves a number of linkages among macroeconomic variables. Therefore, it is vital to possess reliable forecasting and policy analysis tools that also take into account the unique characteristics of the Sri Lankan economy.

Forecasting accuracy is vital for better policy analysis and decision making, highly accurate forecasts aid better monetary policy decision making.

Since monetary policy decisions directly dependent on macroeconomic data, accurate forecasts are very important for better decision making.

**Q6.**

**What do you think the future of BI/ ANN usage in economic forecasting?**

FPAS can be considered as a BI tool. The CBSL has begun to enunciate its policies through a public policy document, to develop in-house macroeconomic forecasting tools, to publish expected path for future inflation and to commence the conducting of the inflation expectations survey over this period, the CBSL has also strengthened its technical capacity in data collection and management, and modelling and forecasting of key macroeconomic variables.

When developing forecasting models the CBSL can consider of advantages of approaches like ANN over traditional regression models.

BI is a broader term which includes many techniques which includes "traditional" econometric methods such as MCMC, Bayesian methods. ANN is becoming popular as an economic forecasting tool.

**Q7.**

**Do you have anything else to add or comment on?**

Other than forecasting and analysis, improved communication among all staff engaged in the forecast and policy debates is very important. A tool that facilities communication of potential risks, identify and communicate key policy issues should be developed.

The forecasting models that work well in advanced economies are successful in forecasting key economic variables in developing economies too. These models have reported good forecasting performance regardless of the shorter sample of data and high volatility of inflation in Sri Lanka. Previous forecasting exercises suggest that forecast accuracy of density forecasts of statistical models can be used at the Central Bank of Sri Lanka for policy discussions, since density forecasts provide complete description of forecast

uncertainty. It is revealed that the baseline BVAR, performs reasonably well in forecasting both GDP growth and inflation. Adding more variables in the model does not play any big role in improving forecast accuracy of inflation forecasts in the normal times, though large BVAR model is helpful at volatile times. Expanding sample could improve forecast accuracy of time varying model and unobserved component model that are based on prior estimated from training sample. Improving sample will help these models to capture the break and changes in parameters well. Further, micro-found DSGE model is successful in producing better forecasts for inflation. However, none of the economic models predict future perfectly regardless of the complexity of the model, size of the sample and the nature of the economy, it should be accepted that advanced models can be used to model and forecast key economic variables for a developing country to carry out informed policy analysis and to take better policy decisions. It is recommended that the Central bank of Sri Lanka can employ these models, including the benchmark ARMA model, as a starting point in its forecasting exercise for forecasting macro variables for policy analysis.

**End of Questionnaire**