IDENTIFICATION OF IMPACT OF PUBLIC DEBT ON ECONOMIC GROWTH OF SRI LANKA USING AUTO REGRESSIVE DISTRIBUTED LAG MODELLING APPROACH

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DECLARATION

I declare that this is my own work and this dissertation 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.

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ABSTRACT

Nowadays, in Sri Lanka, the emergent public debt and its servicing costs are an unadorned burden on the economy. The main aim of the present study is to develop a model which reflects the relationship between public debt and economic growth in Sri Lanka using Non-Linear Auto Regressive Distributed Lag model. Economic growth was reflected by the annual GDP growth. Data were acquired from Department of Census and Statistics abstract reports and annual reports of Central Bank of Sri Lanka. As the first step data were analyzed to invent that relationship between Public debt and annual GDP growth is linear, using Auto Regressive Distributed Lag model and it was confirmed that there was no any significant linear relationship among variables (GDP growth and Public Debt). Then Non-linear Auto Regressive Distributed Lag model was fitted using GDP growth and Public Debt as variables. The Bound's test and Wald's test indicated the presence co-integration among variables GDP growth and Public Debt. The estimated Auto Regressive Distributed Lag model affirms the presence of asymmetries in GDP Growth behavior in long run. In the short run, it can be concluded that, if one-point positive change of fourth lag in Gross Total Public Debt will lead to 1.17 increase in GDP Growth and one-point increase in first and third lags of first difference of Real GDP Growth will lead to 1.07 and 0.26 increase in GDP Growth when all the other variables are constant. Furthermore, in the long run, one-point positive change of first lag in Gross Total Public Debt will leads to 0.35 decrease in GDP Growth while one-point negative change in first lag in Gross Total Public Debt will lead to 1.1 increase in GDP Growth when all the other variables are constant. All the changes reflected significant influence on the GDP Growth behavior. The both dynamic and static forecast values estimated from the developed Non-Linear ARDL model for the period during 1970 to 2017 were almost the same with actuals. However, the dynamic forecasting is more superior than the static forecast. The errors from both dynamic and static models were found to be random.

Keywords: Auto Regressive Distributed Lag, Non-Linear Auto Regressive Distributed Lag, Real GDP Growth

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LIST OF ABBREVIATIONS

Abbreviation	Description
ARDL	Auto Regressive Distributed Lag Model
DW	Durbin Watson
ECM	Error Correction Model
Ex	Example
GNP	Gross National Production
NARDL	Non- Linear Auto Regressive Distributed Lag Model
OLS	Ordinary Least Squares
RWM	Random Walk Model
TIPS	Treasury Inflation Protected Securities
VECM	Vector Error Correction Model

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CHAPTER 1

INTRODUCTION

Most of the third world developing countries are faced a globally acknowledged fact of scarcity of fund to invest their major infrastructure development projects within their countries. Hence, those governments hunt for money from various internal and external sources. However, a supplement from revenues and other earnings are very low with compared to the other developed countries. Therefore, massive indebtedness is a major challenge that most of the developing countries faced including Sri Lanka.

According to the millennium goals which introduced in the past decade, eradicating poverty and low-income people within Sri Lanka is a puzzling job due to numerous reasons (Weerasinghe & Madhuwanthi, n.d). Still, the country cannot be able to attain higher economic growth since this heavier debt burden. However, promoting higher economic growth is a crucial factor for reducing poverty in Sri Lanka. The debt level in the country directly affects the development programs in the economy in a regressive and progressive manner. Effective and broad sighted debt management policy will help to enhance the faster economic growth rate in the country within less period. In that case, empirical studies play a vital role since the conclusions are developed based on practical real-time findings (Weerasinghe & Madhuwanthi, n.d).

When considering the empirical studies which were done under this topic followed regression techniques most of the time that focused on short-run relationship. Unfortunately, researchers do not consider the essential vigorous features of most of the time series data when analysing. Therefore, this kind of analysis produce traditional regression models though they know that there is a long run relationship theoretically. Thus, the estimated models were used to analyse theories formulated at primary level. These theories also used to forecast and evaluate models and stimulate policies by using these fitted models. However, various time series show various behaviours, sometimes they behave as stationary and non-stationary, the presence of autocorrelation, heteroskedastic like features. Therefore, the traditional estimation of coefficients of variables which are with this kind of relationship or behaviours will give misleading inferences most time (Nkoro & Uko, 2016).

1.1 Problem Identification

Nowadays, the increment of public debt and their interest payments which is known as servicing costs are an unadorned burden on the economy in Sri Lanka (Kumara & Cooray, 2013).

The few resources can be implied for developmental expenditure since the highest expenditure on debt servicing cost. Therefore, this debt and its servicing cost causes a detrimental impact on macroeconomic fundamentals. Finally, this huge debt burden bases for adverse effects on long term economic development. (Olasode & Babatunde, 2016).

Sri Lankan government borrows from domestic banking sources to facilitate the debt and their servicing cost. As a result of that,inflationary pressures will increases by weakening the economy. Fixed wage earners and pensioners impose lot of hardships due to the struggle of the rising of costs of living. And the final result of this is industrial unrest. Since workers are demanding higher wages and it leads to increase the costs of production and wears away the country's competitiveness.

The highest expenditure of the government is paying the interest amount for the loans or debt servicing cost. This cost is itself a factor that raises the shortfall of government income and it's spending and also increases the public debt. The suppression of public debt and debt servicing costs are domineering to disrupt the debt cycle (Sanderatne, 2011).

1.2 Problem Justification

Developing a model which represents the relationship between public debt/external debt or domestic debt and other macro-economic factors will help central government and policymakers in order to understand the future behaviour of debt. Hence it will be easy to prepare a debt management procedure according to the developed model.

The accumulating of large fiscal deficits over the years leads to drastic increase of the public debt and high servicing costs generate inflationary pressures. The high inflationary pressure increases the production costs.

Since this higher cost, products of the country are unable to compete with the products of other countries. This occurs eradication of competitiveness in international market. As a result of this, export earnings reduce and loss of employment occurs. Workers in industries gain lower income. Sri lankan garment industry face this kind of situation recently.

The high loss of government income and it’s spending will lead to high borrowing and high borrowing comes with colossal debt servicing costs. The economic development was obstructed by the massive public debt and crippling debt servicing costs. Furthermore, this will lead to a change of public expenditure priorities (Kumarasinghe & Purankumbure, 2015).

A massive public debt has a serious destabilisation effect. Expenditure which cover by present revenues postpone for future years by borrowings. A vast expenditure such as war necessitates is an example for this kind of borrowing.

However, war expenditure is a threat to economic development. This creates endemic inflationary impact, if war expenditure is continuing over long period of time. The reason for that is war expenditure does not produce any goods or services only a of extraordinarily inflationary owing to its magnitude (Kumarasinghe & Purankumbure, 2015).

Hence, it is essential to manage public debt and creates policies and procedures to manage public debt. This should be started as soon as possible. However, many studies have not been done in Sri Lanka on the impact of public debt in Sri Lanka.

The only few studies are “The effect of Public Debt on Economic Growth in Sri Lankan Economy” by Kumarasinghe and Purankumbure done in 2015, “Relationship Between Domestic Debt and Gross Domestic Production: A Time Series Analysis” done by Madhuwanthi and Weerasinghe, and “Public Debt and Economic Growth in Sri Lanka: Is There Any Threshold Level for Pubic Debt?” by Kumara and Cooray done in 2013.

1.3 Significance of the Study

According to the literature, it can be seen that most empirical studies related to economic analysis were based on Ordinary Least Square estimation methods in regression.

The most time series variables are non-stationary at their original level, and they become to stationary time series after differencing. However, using differenced variables for regression analysis indicate a loss of suitable long-run properties and loss of evidence of the equilibrium relationship between the variables under consideration. Therefore, Co-integration test helps to retrieve suitable long-run dynamics of the relationship between considered differed (first differenced) variables. Co-integration test assimilates short-run dynamics with long-run equilibrium as well (Nko & Uko, 2016).

1.4 Limitations of the Study

The most common limitation of this study is collection of accurate data. In some years there was no accurate data for public debt variable. It contains rough values of public debt. Sometimes, statistics in Central Bank reports and Census and Statistics Department reports were not tallying. In that case, data in the Department of Census and Statistics reports considers as accurate data.

1.5 Objectives of the Study

On the view of the above, the objectives of the present study are:

1. To develop a model which represents the relationship between public debt and GDP Growth in Sri Lanka using the ARDL model.
2. To forecast future values for the upcoming ten years using the developed model.

1.6 Outline of the Dissertation

This section contains a brief overview of the dissertation. The dissertation contains five chapters. CHAPTER 1 described the problem identification, justification, significance, limitations and objectives of the study. The details about the past studies were discussed in CHAPTER 2. The materials and methods which used to this research are addressed in CAPTER 3. CAPTER 4 Contains the details about developed model and results of tested models. A brief conclusion of this study and recommendations for future studies are addressed in CHAPTER 5.

CHAPTER 2

LITERATURE REVIEW

2.1 Terminologies and Concepts relate to Public Debt and GDP

2.1.1 Public Debt

Public debt means the amount of money; a particular country owes to lenders outside itself. This public debt includes individuals, other governments and business. Usually, public debt only refers to national debt. However, some countries include debts in states, provinces, and municipalities as well. Public debt is the final output of money which government leaders are spending over years more than they take in via tax revenues. A nation's deficit affects its debt and vice-versa (Amadeo, 2018).

2.1.2 Sovereign Debt

Sovereign Debt refers to how much a country's government owes. This is also known as national debt. The word "Sovereign" means the national government. That is why the term public debt is used interchangeably with the term sovereign debt (Amadeo, 2018).

2.1.3 Classification of Public Debt

Public debt can be classified according to the following criteria (Figure 2.1): -

- Internal and External
- Short term and long term
- Productive and unproductive
- Voluntary and compulsory
- Redeemable and irredeemable
- Funded and unfunded

2.1.3.1 Internal and External

Internal public debt – debt which owed to banks, institutions within a country

External public debt – owed to foreigners, foreign governments or institutions.

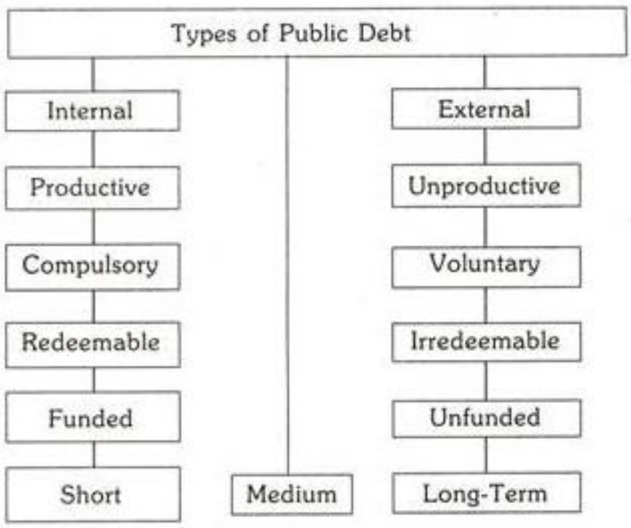

Figure 2.1: Types of Public Debt

Source: http://www.yourarticlelibrary.com, 2018

2.1.3.2 Productive and unproductive

Productive public debt – Debt which is expected to create an asset and this asset will give sufficient income to pay the principal amount and interest amount on the loan.

Unproductive public debt – Debt with deadweight that is not created any asset is considered as unproductive public debt. Ex- Loans rose for war (Amadeo, 2018)

2.1.3.3 Short term and Long term

Short term public debt – They fulfill the gap between current revenue and current expenditure temporarily. This is known as floating debt. It is a loan or debt which is repayable after a short interval of time. Example for short term public debt is treasury bills.

Long term public debt – This is also called funded debt. Loans which are payable after a long time can be categorized into this group (Amadeo, 2018).

2.1.3.4 Voluntary and Compulsory

Voluntary public debt - This type of debt is provided by the public members on a voluntary basis. The interest rate of these loans is higher than the compulsory debt. The reason for that is inspiring the people to provide loans to the government. Examples are market loans and bonds.

Compulsory public debt – These loans are provided on special circumstances considering compulsory aspects. The only difference of tax and compulsory debt is that tax is not rapid, but these loans are rapid. Example is Compulsory deposit scheme (Amadeo, 2018).

2.1.3.5 Redeemable and Irredeemable

Redeemable public debt - The kind of debt which government agreed to pay off the debt and it's servicing cost at some known future date.

Irredeemable public debt – Though the repayment date is not fixed, interest will pay regularly (Amadeo, 2018).

2.1.3.6 Funded and Unfunded

Funded public debt – Repayable period is long. Sometimes it may be thirty years or more. Government should pay fixed sum of interest to cover the principle. Government can repay the principle before maturity, if market conditions are good.

Unfunded public debt - Unfunded debts which acquired to fullfill the temporary needs of the governments. There is a short debts duration compared with other debt duration. It may be a year. Unfunded debt has a responsibility to pay at the due date with the interest (Hanif, 2002).

2.1.4 Component of Public Debt

Public debt includes Treasury bills, notes and bonds. When civilians purchase savings bonds or Treasury Inflation Protected Securities (TIPS), they are the owner of public debt. Intra-governmental debt is the amount which Treasury owes to some federal retirement trust funds like Social Security Trust Fund.

These components may vary from country to country. In Sri Lanka, they consider both external and internal debt as public debt. It also includes debt owed by states, provinces, and municipalities as well (Amadeo, 2018).

2.1.5 Objectives of Public Debt

Most of the third world countries face the scarcity of finance for their infrastructure projects. Therefore, they find funds from various external and internal supplements like debts.

On the other hand, public debt helps to meet budget deficits. When public expenditure exceeds the total revenue of a country, government will try to fill the gap by changing the tax system. However, it is not a proper decision at all. Therefore, it is better to consider whether the transaction is casual or regular. When the budget deficit is casual, loan will increase to fill the deficit. When the deficit is regular, revenue will raise by taxation or reducing its expenditures.

Most developing countries use public debt to meet emergencies like war or disasters (http://www.economicsdiscussion.net, 2018).

2.1.6 Good and Bad side of Public Debt

When the government is used public debt in a correct manner, it will help to improve the living condition of the citizens and country. Country is in the safe side in such cases since there is no foreign direct investment.

Public debt is a proper technique to get extra funds to invest in their economic growth in short run and appropriate way for foreigners to invest by buying government bonds (Amadeo, 2018).

When the government tends to borrow more money from outsiders, which is more than the government economic output, the level of risk will be increased since these investors inspired to put high-interest rate on such countries. In this case, Debt burden will be increasing day by day (Amadeo, 2018).

Total economic output of a country is represented by Gross Domestic Production. Debt to GDP ratio indicates how likely this debt can be pay off.

Huge public debt in long run is similar to driving with the emergency brake on. Investors drive up interest rates. The return is greater risk of default. This leads to expensiveness of components of economic expansion, such as housing, business growth, and auto loans (Amadeo¸, 2018).

2.2 Burden of Public Debt

The government should pay the principal and interest both to other foreign countries, if it is external debt. This payment should be paid back by foreign exchange or gold. If debtor nation does not have enough stock of foreign exchange, the creditor nation will force the debtor to export debtor nation's production to the creditor nation. Therefore, the debtor should create sufficient exportable surplus by limiting its domestic consumption. This will result in a reduction of society's consumption possibilities. Society's consumption involves a net subtraction from the resources available to people in the debtor's country to meet their current consumption needs. It causes an inward shift in the society's production possibilities curve. This burden can be measured by debt- service ratio (Amadeo¸, 2018).

If there is an internal debt, significant burden is efficiency and welfare losses from taxation. When the government borrows money from its own country, civil citizens should pay more taxes since the government should pay the interest by imposing a tax on people. As a result of this, people work hard to earn more money but save less to pay tax. Therefore, the efficiency of welfare in poor society will reduce, but people who have to be a tax –holder and bondholder at the same time will gain an advantage from this. It will create an imbalance of welfare effects in society (Amadeo¸, 2018).

The other major problem of the internal debt burden is capital displacement effect. When the government borrows money from people by selling bonds limited capital in the country will deviate from productive private to unproductive public. The shortage of capital in productive private will increase the rate of interest (Figure 2.2).

While selling bonds, the government competes for borrowing funds in the financial market. This will lead to a rise up the interest rate for all borrowers. It discourages borrowing for private investments. This effect is known as “Crowding Up”. Then the rate of economic growth will decrease (Amadeo, 2018).

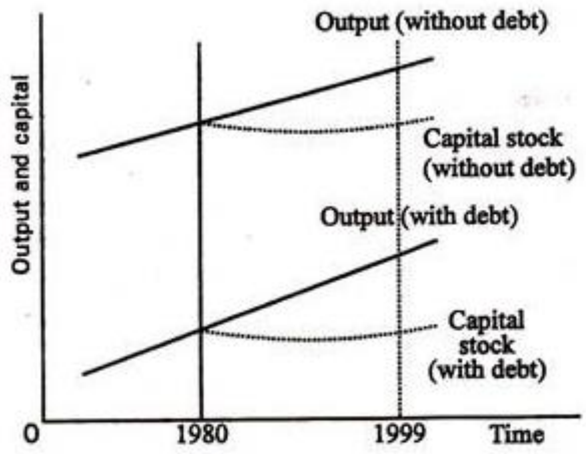

Figure 2.2: Relationship of Public debt, capital and Economic growth
Source: http://www.yourarticlelibrary.com, 2018

2. 3 Management of Public Debt

According to the International Monetary Fund definition, public debt management means “the process of establishing and executing a strategy for managing the government's debt in order to raise the required amount of funding, achieve its risk and cost objectives, and to meet any other public debt management goals the government may have set, such as developing and maintaining an efficient market for government securities” (https://www.imf.org, 2018).

2. 3.1 Importance of Public Debt Management

- It helps borrowers to manage the vast debts. It helps in: -
  - Debt negotiation
  - Debt consolidation
  - Debt elimination
- Helps to uplift personal finance stability
- Helps debtor to reduce pressure in creditor
- Public debt policy plays an vital role in formation of economic policies in a country. Increasing or decreasing public debt affects directly to economic behavior of the country.
- This gives the knowledge of actual amount of requirement and condition in implementing of certain policies like planning policies.
- The way of utilization of public debt decides the economic development of a country ((https://www.imf.org, 2018).

2.3.2 Objectives of Public Debt Management

- Ensuring the finance needs of the government
- Minimizing money borrowing cost
- Maintaining risks at an acceptable level
- Supporting the development of domestic market

  (Joy, 2018)

2.3.3 Principles of Public Debt Management

- Minimum cost of interest of servicing public debt
- Satisfaction of the investors
- Funding the short term debt to long term debt
- Coordination with fiscal and monetary policies
- Proper adjustment of maturities

(Joy, 2018)

2. 3.4 Debt Management Plan

This a plan to pay the personal unsecured debt which is offered by debt management companies to relieve the stress of payment and to manage money by using useful tips (Joy, 2018).

2.4 Public Debt and Economic Growth

Economic growth means increasing in the market value of the goods and services produced by an economy over period of time. The market value is the value excluding the inflation. Economic growth is measured as the percent rate of increase in real gross domestic product or in other words real GDP.

Public debt has a detrimental effect on economic performance. It may have differed from country to country. Mainly, three reasons for the differences in the relationship between public debt and economic growth across countries. Main one is difference of production technology. The high tolerance levels of debt may depend on some country-specific characteristics, related to past crises and disasters. The last reason is vulnerability to public debt depends on debt levels as well as debt composition. Debt composition means the collection of domestic versus external debts, foreign or domestic currency denominated or long-term versus short term debts. (Gómez-Puig and Sosvilla-Rivero, 2017).

2.5 Current Situation in Sri Lanka

2.5.1 Economic Growth in Sri Lanka

The year 2017 is a challenging year to Sri Lanka. The prevailed political situation changed to a complex environment. And the impact of natural disasters like drought and flood also weak the economy. The macroeconomic performance slow down drastically. The growth rate declined to 3.1 percent in 2017. The lowest it has been since 2001 (International Monetary Fund,2018).

However, a primary surplus was recorded for the very first time in decades.

Hence, There is a sharp increase in interest expenditure. As a result of that, the overall deficit has slightly increased.

The primary surplus and low currency depreciation result to the decreasing of public debt to GDP ratio (https://www.imf.org, 2018).

World Bank supported to the government to carry out fiscal reforms, improve public financial management, increase public and private investments. This program helped to address infrastructure constraints in the country and improve competitiveness of the goods of the country in international market (https://www.imf.org, 2018).

But the political uncertainty of the country slow down the continued fiscal consolidation and progress of reforms which enhance the competitiveness though there is high commitment of the government. Since these reforms are critical for sustained growth and key risks remain a favourable outlook is uncertain (https://www.imf.org, 2018).

Though the macro economic performance reduction due to prolonged drought and floods in 2017 Fiscal and monetary policy measures contributed to stabilization. However, the adverse economic impact of a prolonged drought caused a drastic increase of inflation (6.6 percent, annual average) (https://www.imf.org, 2018).

2.5.2 Situation of Public Debt in Sri Lanka

As a result of uninterrupted sizeable fiscal deficit, the total public debt stock in Sri Lanka has swiftly accumulated since 1950 (Kumarasinghe and Purankumbure, 2015). The public debt rose at Rs.6 trillion in 2012 (79.1 per cent of GDP), while the figure for 1950 was only s.654 million (16.9 per cent).

As a percentage of GDP, the total debt in the 1950s was only 23.79 per cent and the ratio has increased to 52.64, 64.51, 85.76, 94.26, and 94.14 per cent levels in the 1960s, 1970s, 1980s, 1990s and 2000s, respectively (Kumarasinghe and Purankumbure, 2015).

This ratio peaked at 108.7 per cent in 1989, and was above 100 per cent during the periods of 1988-89 and 2001-2004.

From 1950 to 1983 and from 1997 to date, the leading share of public debt was domestic debt because the budget deficit was heavily supported through domestic borrowing. During the last decade, the highest value of the ratio was 105.6 per cent, which was recorded in 2002, while the figure was 79.1 per cent in 2012. Public debt in Sri Lanka consists of both external and domestic debt. Domestic debt in terms of GDP was approximately 13.7 per cent in 1950 and reported the highest in the amount of 60.0 percent in 2002 (Kumara and Cooray, 2013).

Figure 2.3: Sri Lanka Government Debts

Source: https://tradingeconomics.com/sri-lanka/government-debt ,2017

In 2002 to 2017 period, Sri Lankan total debt was increased from 83.56% while real GDP was increased from 87.61% when considering available data.

Sri Lanka's debt burden has increased drastically after the civil war period (Figure2.4).

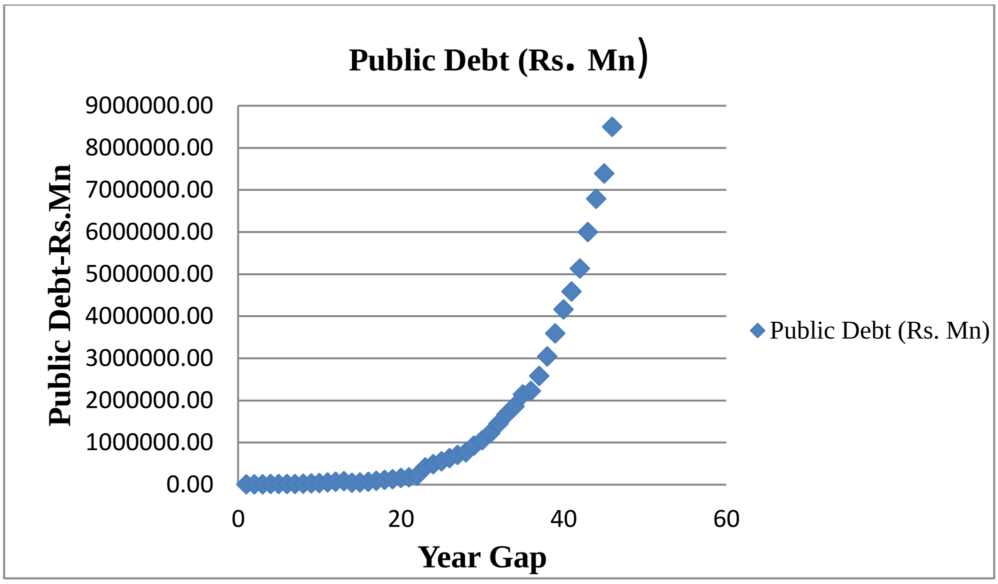

Figure 2.4: Sri Lanka Government Debts

Source: Department of Census and Statistics abstract report, 2017

2.6 Similar Studies and Findings

Many empirical studies were conducted to recognise the relationship between Debt and economic growth. Among them, some were focused on external debt. Some were on domestic debt. Moreover, also various macro-economic factors were considered.

One study carried out with the aid of Asian and the Asia Pacific countries throughout 18 years were found that overall external debt has no negative impact on economic growth. Parameters used for this research were Gross National Production (GNP) and external debt. Economic growth was measured by GNP (Chowdhury, 1994).

A study on advanced and emerging economies revealed that 10% of an increase in the level of debt would reduce long-run economic growth rate by .2 %. This was conducted through various robustness techniques like Ordinary Least Squares (OLS), fixed effect regression and SGMM. Nevertheless, it has been analyzed the behaviour of various channels that determine the economic growth rate and their relationship with debt (Kumar and Woo, 2010).

A major study conducted on developing economies discovered that economic growth has a non-linear relationship with public debt.

Data has been used from 1990 to 2008 in each developing country and used econometric tools and techniques on estimation, robustness and model specification (Presbitero, 2010).

A study conducted in Jordan concluded that external debt below the threshold level 53% of GDP has a positive relationship with real GDP and after that it shows a negative relationship (Maghyereh, 2002). Meanwhile, another research concluded that, the threshold level of debt which is below 21% of GDP associates positively with economic growth. Above that level, it acts as negative and significant. The total effect of high debt is significantly adverse. When public debt is doubled, productivity growth reduces of about 1.5% (Balvy, 2006).

Another attempt of research which has been done in industrialised and developing countries separately produced results that, there is a linear and negative relationship between economic growth and external debt whereas no linear or nonlinear relationship exists in industrialised countries.

Meanwhile, it concluded that the external debt might lower capital accumulation resulting in crowding out economic activities in developing countries (Schclarek, 2004).

There was another study which has been covering data in 16 developing countries from 1971 to 1979 focused on the impact of total debt and economic growth. According to this, the negative relationship exists between economic growth and total debt (Cunningham, 1993).

Another empirical study revealed that there is a negative relationship between foreign debt and economic growth which has been done using cross-section data for 77 countries. Two variables were foreign debt and GDP per-capita. Furthermore, it has been concluded that Asian and other developing countries have a positive and insignificant relationship. (Lin and Sosin, 2001).

There was a study which exploited a long time series data during the period of 200 years and 3700 annual observations of 44 countries.

As per this, they tried to find a relationship between high public debt, economic growth and inflation. They categorised countries according to their debt-to-GDP ratio and there were three categories namely:

- Low debt- below 30%
- Medium debt- 30-60%
- High debt – 60-90%
- Very high debt – over 90%

There is a weak relationship between growth and debt normally (Reinhart & Rogoff, 2010).

Another research which has been examined the effect of external debt on economic growth in Pakistan suggested that external debt and debt servicing negatively affect economic growth in Pakistan. They used simple linear econometric model, time series data for the period of 1972-2005, GDP growth as the dependent variable and external debt and debt servicing as independent variables (Muhammad *et al.*, 2010).

Studies on the public debt-related concepts are very few in Sri Lanka. One empirical study has used stationary and co-integration concepts to analyse debt sustainability in low-income countries (including Sri Lanka) using the data from 1950 to 1999. This study confirmed that the fiscal situation in Sri Lanka is stable during that period (Jha, 2001).

Another study has shown that the public debt stock in Sri Lanka has increased over the years, and debt servicing has become high. It has been suggested that a reduction of government expenditures and an elimination of waste as a short-term solution for this problem, and in the long run, a sustainable level of high growth should be achieved (Fonseka and Ranasinghe, 2008).

The research conducted with debt sustainability and identified the key fiscal and macro-economic variables that affect debt sustainability in Sri Lanka. This has been used the real interest rate, the exchange rate and economic growth rate as determinants of the debt-to-GDP ratio.

This paper revealed that one standard deviation positive growth shock results in a reduction in the debt to GDP ratio by 2.4 per cent by 2015. The author argued that if the country can maintain an annual growth rate of 8 per cent in the medium run, the debt-to-GDP ratio would reach approximately 65 per cent by 2015 assuming other macroeconomic variables remain unchanged (Ekanayake, 2011).

Kumara & Cooray (2013) suggested that there is a nonlinear relationship between the public debt-to-GDP ratio and GDP per capita growth in Sri Lanka. They produced two models and the second one was the most successful. They used public debt- to- GDP per-capita as the main variable and data from 1960-2010 periods.

Kumarasinghe & Purankumbura (2015) studied the impact of continued increase in public debt on economic growth and development using over the past 50 years' data from1963-2002. Two types of models have been developed using linearity assumptions and power quadratic form. However, the linear relationship between debt and growth does not produce significant results. Further, it is revealed that annual changes in the debt level have a negative relationship with the economic growth rate.

Weerasinghe & Madhuwanthi (n.d) analysed the empirical relationship between domestic debt volume and economic growth of Sri Lanka. This study concluded that the GDP of Sri Lanka is not a function of domestic debt, but the domestic debt of Sri Lanka is a function of its gross domestic product. The functional relationship does not hold for the reverse direction. Furthermore, it was estimated that the relationship between GDP growth rates and domestic debt is non-linear. The shape of the non-linear curve is an inverted 'U' shape.

2.7 Summary of Literature Review

This chapter contains an extended overview of public debt and GDP which includes in past research papers. Moreover, also, details on statistical methods, non-statistical methodologies and conclusions used in similar researches which were done in Sri Lanka as well as various other countries.

CHAPTER 3

MATERIALS AND METHODS

3.1 Data Acquisition

These datasets were acquired from Annual Abstract Reports from 1970 to 2017 in Department of Census and Statistics- Sri Lanka. Rather than that, the World Bank and Central bank open source websites also used to verify the missing data. Missing data were acquired via the World Bank Data site (http://databank.worldbank.org) and Central Bank Sri Lanka site (http://www.cbsl.gov.lk).

3.2 Variables

There were two main variables used for the research. Economic growth is the dependent variable and Public debt is the independent variable. Economic growth was measured by GDP growth at constant prices in each year. Both GDP growth and public debt were continuous variables and measured by Rupees Million unit. GDP growth was produced using the following equation:

Real GDP Growth= (Current Real GDP-Previous Real GDP)

3.3 Descriptions of Variables in the Study

3.3.1 Public Debt

AS per the Central Bank report, Sri Lanka's public debt composition was showed in Figure 3.1.

3.3.2 GDP (Gross Domestic Production)

According to the definition of Department of Census and Statistics, Sri Lanka "GDP is the monetary value of all the finished goods and services produced within a country's borders in a specific period. GDP includes all private and public consumption; government outlays, investments and exports minus imports that occur within a defined territory. GDP is a broad measurement of a nation's overall economic activity" (Department of Census and Statistics,2018).

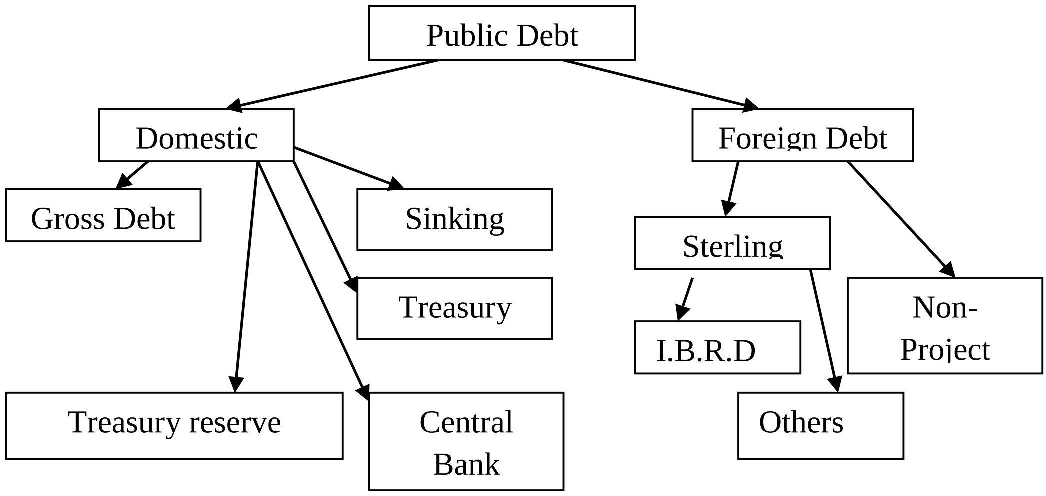

Figure 3.1: Sri Lanka's Public debt composition

3.4 Statistical Methods for Analyzing

This research used time series analysis statistical technique to analyse the data to identify the relationship between variables. The primary statistical method used to conduct the research was Auto Regressive Distributed Lag Model (ARDL).

3.4.1 Auto Regressive Distributed Lag Model (ARDL)

Autoregressive distributed lag model means a model which consists of the dependent variable which is a function of its own past lagged values ,current and past values of other explanatory variables. Also, it may contain both long run and short-run dynamics (Chen, 2015).

Regresses include lagged values of the dependent variable and current value and lagged values of one or more explanatory variables. This model allows us to determine what would be the effects if there is any change in the policy variable. The Auto-Regressive Distributed Lag model is a combination of Auto-Regressive models and Distributed Lag Models (Chen, 2015).

An ARDL (p, r) is defined as:

$$Y_t=\gamma+\sum_{i=1}^{p}\gamma_i\, Y_{t-i}+\sum_{j=o}^{r}\beta_i\, X_{t-j}+\epsilon \qquad (3.0)$$

In Equation (3.0), Y_t denotes the predicted variable for the current year. γ signifies the constant term. γ_i is the coefficient of Y_{t-i} while Y_{t-i} denotes the previous year's values of p^{th} predicted variable. β_i is the coefficients of X_{t-j} variable or independent variable and ε indicates the error term. P to i and j to r shows the appropriate lag structure.

$Y_t=\mu+B(L)X_t+\varepsilon_t$: Where

$$C\ (L)=1-\gamma_1 L-\gamma_2 L^2-\ldots-\gamma_p L^p \qquad (3.1)$$

and

$$B\ (L)=\beta_0-\beta_1 L-\beta_2 L^2-\ldots-\beta_r L^r \qquad (3.2)$$ (Yoder, 2007)

C (L) indicates the equation for short-run model including long-run dynamics while B (L) denotes the expansion term for long-run dynamics. μ is the constant term. ε_t is the error term for time t (Since this is a short run relationship).

L term refers to the lag structure (L^2 means second lag structure), and γ and β signify the coefficients for short-run dynamics and long-run dynamics respectively. If the model is dynamically stable C (L) and B (L) should be equal to zero in equations (3.1) and (3.2). These equations are called "Characteristics Equations".

3.4.1.1 Assumptions in the ARDL Model

ARDL model can be run with stationarity in their first difference. If variables are stationary at their original level and/or their first difference, ARDL model can be run.

The second assumption is that the proposed Lag structure is appropriate to select a suitable model. According to the equation (3.1), it is needed to be selected the appropriate values as the maximum lag length. Maximum lag length is determined by the VAR model and Lag Structure procedures in E-Views software.

The third assumption is that errors must be serially independent in equation (3.0). Errors must be serially independent means that error terms in a time series from one period to another should not correlate with error terms in a time series from subsequent another period to subsequent next period. This can be tested using Q-statistic and the Breusch-Godfrey LM test.

The fourth assumption is that the model should be dynamically stable. Y parameter of the model is affected by X_t and X_{t-1} both. Further, it reveals that the model will be stationary if the roots of the characteristic equation lie out of the unit circle in equation (3.1). If it is according to the equation (3.2) roots of the characteristic equation should be fall within the unit circle.

The fifth assumption is that data must be free from Heterosckedisty, autocorrelation should be standard. Autocorrelation or serial correlation means the correlation of a series with its own lagged values.

$$\rho_j = \text{Corr}(Y_t, Y_{t-j}) = \frac{\text{Corr}(Yt, Yt\text{-}j)}{\sqrt{\text{var}}(Yt), \text{var}(Yt\text{-}j)} \qquad (3.3)$$

The equation 3.3 denotes the j^{th} autocorrelation by $\rho j = \text{Corr}(Y_t, Y_t\text{-}j)$. It can be calculated using the correlation of current year (Y_t) and correlation of the difference of current year and j^{th} year (Y_{t-j}) by the variance of current year and difference of the current and j^{th} year.

The autocorrelation at lag zero is always one since a series is perfectly correlated with its data. At lag one the autocorrelation value is close to one which means that data at a given week are very similar to the next week (either before or after). This should be zero to perform this test (Yonder, 2007).

3.4.1.2 Advantages in Applying the ARDL Model

There are many advantages of applying the ARDL model. One is all variables can be considered as endogenous variables since each of the underlying variables stand in a single equation because it is free of residual correlation (Nkro & Uko, 2016).

There is an ARDL procedure between dependent and explanatory variables when there is a single long-run relationship. It can be distinguished by the assumption of only a single reduced form relationship exists between the dependent variable and the exogenous variables (Pesaran *et al*., 2001).

Co-integration means that the variances and means of the time series are not constant that of independent with the time. Ordinary Least Squares (OLS) method cannot be applied, if the time series are co-integrated. Hence, there is no way to estimate long-run parameters or equilibrium in data series using OLS. However, in ARDL model helps to recognise co-integration vectors, if there are multiple cointegrating vectors available (Nkro & Uko, 2016).

The Error Correction Model (ECM) can be derived from ARDL model through a simple linear transformation. The Error Correction Model integrates short-run adjustments with long-run equilibrium without losing long-run dynamics. The associated ECM model takes a sufficient number of lags. This sufficeint lags help to generate data in general to specific modelling frameworks (Nkro & Uko, 2016).

3.5 Theoretical Framework in Auto Regressive Distributed Lag Model

ARDL Model used to recognise a model in a particular time series data. Time series data are data collected on the same observational unit at the known multiple periods. We can use time series data to develop a forecasting model and estimate dynamic casual effect mainly.

Dynamic casual effects mean, the effect of X_t and X_{t-1} variables on Y variable. If the rate of interest is increased in t time, how it effects public debt and economic growth rate. If the rate of interest is increased in t -1time, how it effects public debt and economic growth rate *etc*.

The newly emerged technical issues with time series data are: how to estimate dynamic casual effect and conditions underestimation, serial and autocorrelation over time, time lags, calculation of standard errors when errors are serially correlated. ARDL model gives sufficient answers to the above mentioned problems.

3.5.1 Stationary and Non- Stationary Concept

According to the definition, a time series Y_t is stationary if its probability distribution does not change over time. Furthermore, it means that if the joint distribution of (Y_{s+1}, Y_{s+2}…......,Y_{s+T}) does not depend on s; otherwise, Y_t is said to be Non-stationary.

A pair of time series is said to be jointly stationary if the joint distribution of (X_{s+1}, Y_{s+1}, X_{s+2}, Y_{s+2}…... X_{s+T}, Y_{s+T}) does not depend on s. Stationarity requires the future to be like the past, at least in a probabilistic sense (Yonder, 2007).

A stochastic process with unit roots or structural breaks is known as non-stationary time series. Presence of unit root is the major clue which reveals that it is a non-stationary time series.

3.5.2 Unit Root Test

A specific Random Walk Model (RWM) can be defined as:

$$Y_t = \rho Y_{t-1} + \varepsilon_t \qquad (3.4)$$

$-1 \leq \rho \leq 1$; If ρ =1-unit root problem occurs. In this case the variance of Y_t is not stationary.

Equation 3.4 signifies that the value of the current year Yt is depended on the value of previous year Y_{t-1} and error term ε_t. ρ denotes the coefficient.

A series with unit root does not tend to return a long-run deterministic path, and the variance of the series is depend on the time. Time series that contain unit root in regression analysis, the standred results of the regression may be misleading.

The various methods of testing unit roots are:

- Durban – Watson test (DW)
- Dickey-Fuller test (DF)
- Augmented Dickey-Fuller test (ADF)
- Philip-Perron test (PP)
- Kwiatkowski-Phillips-Schmidt-Shin test (KPSS)

3.5.3 Co-Integration Test

Cointegration can be used to reflect the long-run information in a time series model.

Co-integration is an econometric concept that imitates the existence of a long-run equilibrium among underlying economic time series that touches over time by illustrating various changes within the period considered. This concept has been invented by Granger (1981) and, Engle and Granger (1987) initially. It provides a strong foundation for the error correction model or the vector error correction model which indicates both long and short-run equilibrium. There are several co-integration tests such as Engle and Granger procedure, Walds co-integration test, Bounds co-integration test and Johannes co-integration test (Nkro & Uko, 2016).

3.5.4 Re-parameterization

Autoregressive Distributed Lag (ARDL) approach to co-integration assist in recognising the cointegrating vector(s). It is not like the Johansen and Juselius co-integration procedure. Each of the underlying variables reflects as a single long-run relationship equation. If one co-integrating vector is identified, the ARDL model of the cointegrating vector is re-parameterised into ECM. The re-parameterised result indicates both short-run dynamics or traditional ARDL model and the long-run relationship of the variables in a single model (Nkro & Uko, 2016).

3.6 Model Formulation

The main aim of this empirical study was to develop a model to recognise the relationship between GDP and Public debt. There was a developed, cross-sectional regression model to fill the gap between economic theories and practical studies in the form of:sss

$$\gamma=\alpha+\beta_1X_1+\beta_2X_2+\ldots\ldots\ldots\ldots..+\beta_nX_n+\varepsilon_t \qquad (3.5)$$

γ is the vector of the rates of economic growth. X_1……. X_n signifies the vectors of probable explanatory variables which can vary from researcher to researcher.

Based on the above model, various proposed models are available in Sri Lanka to describe the relationship between economic growth and public debt.

Among them, there was only one autoregressive model which has been developed by Kumara and Cooray (2013) discussed the relationship between GDP per capita growth and public debt.

Thus, this study initiated an initial model based on theories with the introduction of an autoregression of Real GDP Growth. The initial model was:

Real GDP Growth $_t$=α_1+ α_2 Gross Total Public Debt $_t$+α_3 Real GDP Growth $_{(t-1)}$+ε
(3.6)

Where:

Real GDP Growth $_t$ means the predicted value for the Real GDP Growth and α_1 is the constant term while α_2 and α_3 are the coefficients for Gross Total Public Debt of the current year (Public Debt $_t$) and GDP Growth for the previous year (GDP Growth$_{(t-1)}$) respectively.

Once the data went through the transformation techniques, initial equation modified according to that criteria by adding both long run and short run equilibrium:

ARDL model for the short run: -

$$\Delta \text{Log Real GDP Growth}_t=\alpha_0 + \alpha_1\Delta\text{Log Real GDP Growth}_{t-1}+ \beta_1\Delta\text{Log Public Debt}_{t-1}+\beta_2\Delta\text{ Log Public Debt}_t+\varepsilon_t \quad (3.7)$$

ARDL model for long-run: -

$$\text{Log Real GDP Growth}_t=\alpha_0 + \alpha_1\text{Log Real GDP Growth}_{t-1}+ \beta_1\text{Log Public Debt}_{t-1}+\beta_2\text{ Log Public Debt}_t+\varepsilon_t \quad (3.8)$$

α_0 is the constant and α_1, β_1 and β_2 are long-run coefficients. Log Real GDP Growth$_t$ signifies the natural logarithmic of Real GDP Growth for the current year and Log Real GDP Growth $_{t-1}$ is the natural log of Real GDP Growth for the previous year. Log (Public Debt (t)) means the natural log of public debt for the current year and Log (Public Debt (t-1)) is the natural log of public debt for the previous year. Δ represents the difference value.

3.6.1 Formation of Re- Parameterized Model

Since there is long-run relationship among two data series, the model was improved as per the below structure by adding an error correction model to the short run model.

ΔLog Real GDP Growth$_t$=α_0 + $\alpha_1$$\Delta$Log Real GDP Growth $_{t-1}$+ $\beta_1$$\Delta$Log Public Debt $_{t-1}$+$\beta_2$$\Delta$ Log Public Debt$_t$+λ_1ECM$_{t-1}$+ε_t (3.9)

ECM means Error Correction Model.

γ_1Log Real GDP Growth $_{t-1}$+ γ_2Log Public Debt $_{t-1}$= λ ECM (t-1) means long run relationship/equilibrium. Log Real GDP Growth$_t$ signifies the natural logarithmic of Real GDP Growth for the current year and Log Real GDP Growth $_{t-1}$is the natural log of Real GDP Growth for the previous year. Log (Public Debt (t)) means the natural log of public debt for the current year and Log (Public Debt (t-1)) is the natural log of public debt for the previous year.

3.6.2 Formation of Non-Linear ARDL Model

The equation for non-linear ARDL model was postulated based on the model which was suggested by Shin *et al* (2014).

ΔLog Real GDP Growth$_t$=α_0 + $\alpha_1$$\Delta$Log Real GDP Growth $_{t-1}$+β_1 Δ LogPublic Debt$_t^+$+β_2 Δ Log Public Debt$_t^-$+ $\beta_1$$\Delta$Log Public Debt $_{t-1}$+$\beta_3$$\Delta$ Log Public Debt$_t$+γ_1Log Public Debt$_t^+$+γ_2Log Public Debt$_t^-$+ε_t (3.10)

Since the proposed equation based on a symmetric relationship (linear ARDL) was not given any satisfying results Equation (3.10) suggested investigating the asymmetric effect of considered variables.

The decomposition regression is as $a_t=U^+b_t^++U^-b_t^-+\varepsilon_t$

Where; u+ and u− are allied with long-term coefficients and b_t is a vector of regresses decomposed as: $b_t=b_t^++b_t^-$

Where;

b^+ b^- are the independent variables, which are decomposed into partial sum of negative and positive changes of independent variable. Similar to that,

Log Public $Debt_t^+$ + Log Public $Debt_t^-$ = Log Public $debt_t$.

3.7 Data Preprocessing Methodology

3.7.1 Data Preprocessing and Descriptive Statistics

The data set was not cleaned using any methods since there were no missing values in each variable. However, descriptive statistics were calculated.

3.7.2 Data Validation

Assumptions which needed to be checked before analyze the data were tested in this step. Data validation was done by checking the normality and stationary or non-stationary using unit root tests or stationary tests. In this dataset, there was a dependent variable as well as the independent variable. The independent variable was the Gross Total Public Debt. The dependent variable was Real Gross Domestic Production Growth (GDP Growth). Data validation was performed using Normality test and Unit Root test.

Two data series were checked for the normality using Jarque & Bera test.

Test Statistics: JB= Skewness/ (6/n) + $(\text{Kurtosis} - 3)^2$/ (24/n)

Under H0: JB ˜ X^2_2

H0: Data is normally distributed

H1: Data is not normally distributed

3.7.3 Data Transformation

Then not normal data were transformed by natural log transformation to get the normalized data set and remove the heteroskedastic effect. After the transformation, new data series again validate.

3.7.3.1 Natural Log Transformation

Highly skewed distributions transformed to less skewed distribution using any data transformation technique. The natural log transformation is also same. This is valueble in making more interpretable patterns and meet the assumptions of inferential statistics (Lane, n.d).

Ý = Log (Y)

3.7.4 Unit Root Test for Checking Stationarity

The unit root test was performed to test the stationary of time series. Augmented Dickey-Fuller test and Phillips- Perron test were employed to do the unit root test (Olesode & Babutunde, 2016).

H0: There is unit root in the series.

H1: There is no unit root in the series.

3.7.4.1 Differencing

Natural logarithmic values of both variables were converted into first difference of natural logarithmic values of both GDP and public debt variables to get the stationary data series.

3.8 Data Analyzing

3.8.1 Estimate the ARDL Model

The short run model was determined using the ARDL method in E views 9.5 software. Lag 4 was given automatically as the maximum lag length criteria for both dependent and independent variables. Trend specification was tested for assuming there is constant with unrest trend. This assumption was taken based on the behaviour of the normalized data series. Since both normalized data series was shown a constant and unrestricted trend, this option was selected. Akaike Information Criterion (AIC) used as the model selection criteria.

3.8.2 Determine the Evidence for Long Run Relationship

The Bounds co-integration test was performed followed by ARDL estimation method to recognise whether there is a long run relationship between Gross Domestic Public Debt and Real GDP Growth data. Since the application of ARDL approach to co-integration, it can be produced realistic and efficient estimates (Nkro & Uko, 2016).

Bounds Test hypothesis;

H0: There is cointegration between variables.

H1: There is no cointegration between variables.

3.8.3 Determine Optimal Lag Structure

The optimal lag structure was determined by the unrestricted VAR method available in E views software. Natural log value of GDP Growth considered as the endogenous variable and Natural log value of public debt considered as the exogenous variable. The lag structure was estimated up to 4 lags (Obi, 2017).

3.8.4 Determine the Short Run and Long Run Coefficients

Once the optimum model was recognised, the proposed equation was used to identify the short run and long-run coefficients. In this step, Ordinary Least Square (OLS) method was applied and no need to extend it to general to Specific stage. Following Hypothesis of probability t- Statistics were used to get a conclusion.

The hypothesis for t-statistics:

H0: Parameter coefficients are not significant from zero.

H1: Parameter coefficients are significant from zero.

3.8.5 Model Re- Parameterization

Since there is a long run relationship among Real GDP Growth and Gross Total Public Debt data it should be reflected under the proposed model by adding ECM or VECM.

If there is co-integration among both variables towards both sides, VECM should be employed to the model. Since there is only one endogenous variable, the model can be re-parameterized by adding ECM term that was written as Equation 3.9.

3.8.6 Model Validation and Stability Checking

The short run and long run model stability was checked using the Breusch-Godfrey LM test for serial correlation in residuals, normality distribution of residuals and homoscedasticity in residuals in the proposed model and model stability was checked by Ramsey Reset Test for ARDL and Cumsum and Cumsums of Squares test for NARDL.

Hypothesis for Ramsey Reset Test is:

H0: Model is specified correctly.

H1: Model is not correctly specified.

Auto correlation of initial model was tested using LM test and Q –Statistics. DW statistics is not a valid test for auto correlation testing since this is an auto regressive model (Hossain, 2015).

For both LM test and Q statistics:

H0: There is no serial correlation in the residuals up to specified order.

H1: There is a serial correlation in the residuals up to specified order.

Lag order 2 was selected for LM test and Q statistics was tested for lag order 10 and 20 both.

Heteroscedasticity problem arises when data is cross sectional. Time series data are not showing this problem. Since this is annual data of 48-year period, it is better to test the heteroscedasticity. This was checked by using Harvey method and Breusch-Pegan-Godfrey tests.

H0: Residuals are Homoscedastic.

H1: Residuals are heteroscedastic.

Histogram- Normality test was performed to ensure whether residuals are normally distributed or not. Hypothesis considered were:

H0: Residuals are normally distributed.

H1: Residuals are not normally distributed.

Since the proposed model using ARDL approach were not given any satisfied answers to reveal that the linear relationship between Real GDP Growth and Gross Domestic Public Debt is linear, Non-linear ARDL model was employed.

3.9 Non – Linear ARDL Model

Non-Linear ARDL model was employed using stepwise least square method. Unidirectional relationship was tried to recognise using the backward selection method under 5% critical level. The goal is to select the appropriate model specification with appropriate lags for the differenced regressors (Shine *et al*, 2014).

For testing co-integration under NARDL, Shin *et al* recommended to use joint null hypothesis of level (non-differenced) variables and to compare the critical values of bound testing in Pesran *et al* (2001). If the calculated F statistics is greater than the upper critical value it can be concluded that there is an evidence of co-integration. If not, evidence of co-integration is not found.

3.9.1 Asymmetric Co-Integration Test

The presence of co-integration was performed by Wald's test coefficient restriction method in E- views 10. Asymmetric impact also calculated by Wald's test.

hypothesis for Wald's-statistics:

H0: There is a short run/ long run causality.

H1: There is no short run/ long run causality.

In this step, it was tested that there may be a statistical difference in positive and negative change which have a long run positive effect on Real GDP Growth.

3.9.2 Presence of Asymmetry

The long-run coefficient for positive change in Gross Total Public Debt was calculated by dividing short-run coefficient of positive changes in Gross Total Public Debt in short run coefficient of Real GDP Growth. The negative change in Gross Total Public Debt was calculated by dividing short-run coefficient of negative changes in Gross Total Public Debt in short run coefficient of Real GDP Growth.

If both were equal, it could be concluded that there is no asymmetry and there is no evidence on asymmetry.

The hypothesis for Wald's-statistics to test the symmetry:

H0: There is asymmetry.

H1: There is no asymmetry.

Moreover, competency of dynamic specifications has been evaluated by various diagnostic tests and statistics before conclusions. Jarque–Bera, Durbin–Watson, and Breusch–Pagan–Godfrey tests have been applied to analyse the issues of normality in error term or residuals, serial correlation, and heteroscedasticity respectively.

Since the proposed model with symmetric co-integration concepts was not given the stable model asymmetric impact of the variables was considered to produce a stable model (Meo *et al*, 2018). But the asymmetric form of variables GDP and public debt were not stationary in I (1) or I (0).

Therefore, two new variables were produced namely GDP rate and Debt to GDP ratio based on empirical studies (Kumarasinghe & Purankumbura, 2015).

3.10 Forecasting

Forecasting were performed using both dynamic and static forecasting methods. If it is one-step forecast, then both forecasts are the same. The difference arises when forecasting further. Dynamic forecast will take previously forecasted values while static forecast will take actual values to make next step forecast.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Descriptive Statistics

Descriptive statistics values for both independent and dependent variables were illustrated in Table 4.1.

Table 4.1: Descriptive Statistics

Criteria	Gross_Total_Public_Debt(Rs.Mill)	Real_GDP Growth(Rs.Mill)
Mean	1747822	38106.77
Median	517419.5	11
Maximum	853227	4110850
Minimum	7873.2	-3671381
Std.Dev.	2483864	829789.4
Skewness	1.448	0.649297
Kurtosis	3.806	21.32
Jarque-Bera	18.095	675.19
Probability	0.0001	0
Sum	83894482	1829125
Observations	48	48

According to Table 4.1, it can be concluded that Real GDP Growth data varies within 4,11,0850 Rupees Millions to -3,67,1381 Rupees Millions with the mean of 11 Rupees Millions and standard deviation of 8,29,789.40 Rupees Millions. Meanwhile Gross Total Public Debt data series varies within 7873.20 Rupees Millions to 8,53,227 rupees Million with the mean of 1,74,780,2.00 rupees Million and standard deviation of 2,48,386,4.00 rupees Millions.

According to Figure 4.1, there was a slight increase of Gross Total Public Debt from 1970 to1990. Then a drastic increase was experienced from 1991 to 2015. The main reason for that was thirty years of civil war and development projects during post-war periods.

There was a slight decrease from 2015 to 2016 since a portion of debts were paid by the government. But again there was a increase of total debt from 2016 to 2017.

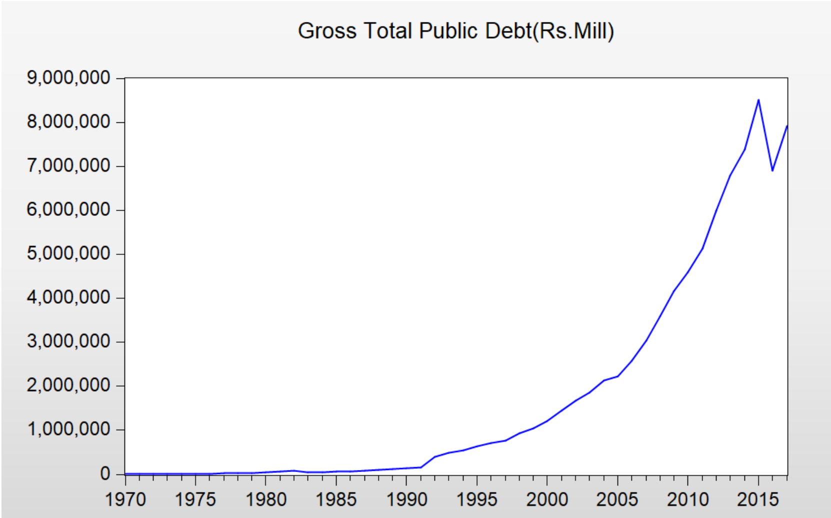

Figure 4.1: Graph of Gross Total Public Debt Varies with Time

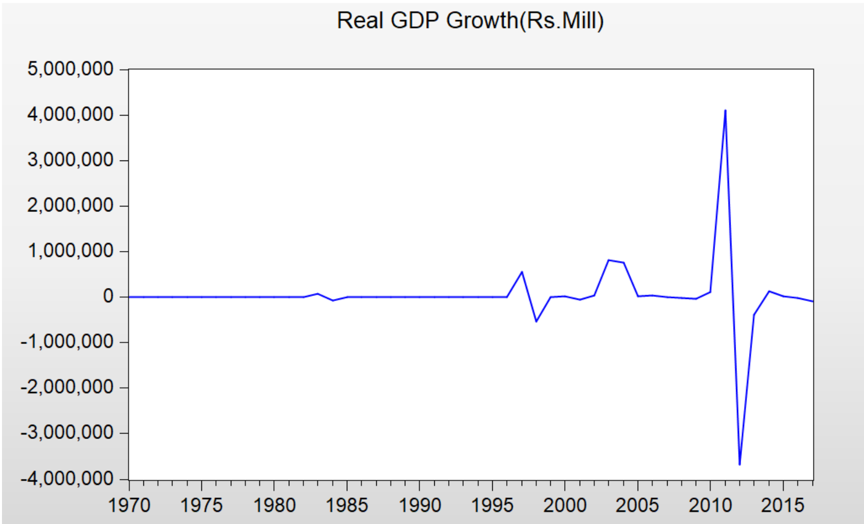

Figure 4.2: Graph of Real GDP Growth Varies with Time

According to Figure 4.2, there is no specific pattern of variation in Real GDP growth data series. A static variation was experienced from 1970 to1996. In 1982 and 1984 there was minus growth and the slight decrease and drastic decrease were experienced from 1997 to 1998 and 2011 to 2012 respectively. The main reason for this decrease is civil war in Sri Lanka in those periods. Government took debts for war and there was no production of goods within the country comparatively.

The increase of growth showed from 2010 to 2011 and minor increase from 1996 to 1997. The reason for this increase may be the “ceased fire period”. During this time, since the domestic production was increased, GDP growth was increased.

4.2 Data Validation

4.2.1 Normality Test

According to the results in Figure 4.3, it can be concluded that Gross Total Public Debt data series are not normally distributed. In this data series corresponding P value 0.0% which is less than the 5%. Therefore, the null hypothesis, (The data is normally distribute) was rejected, and the alternative hypothesis (The data is not normally distributed) was accepted. Therefore, it can be concluded that the original data series of Gross Total Public Debt was not suitable to continue with the ARDL model.

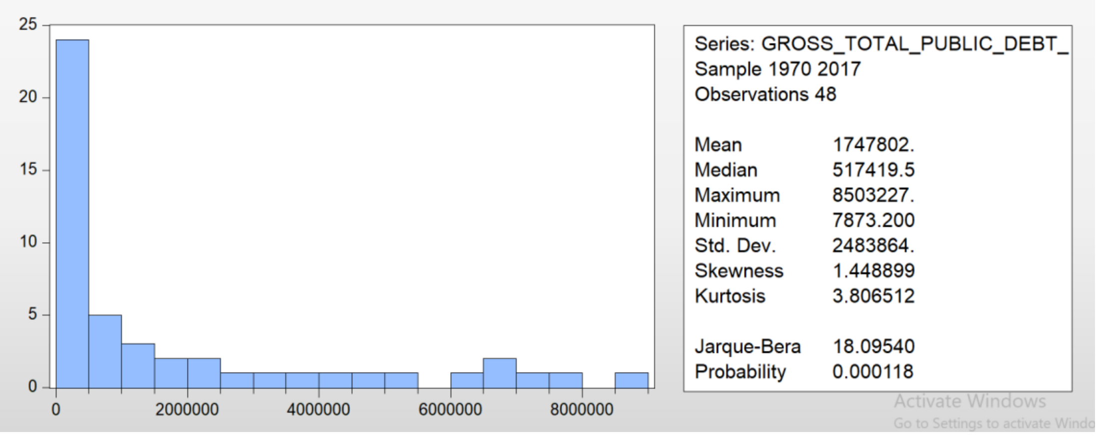

Figure 4.3: Jarque & Bera Test Results for Original Gross Total Public Debt Series

According to the results in Figure 4.4, it can be concluded that the Real GDP Growth data series is not normally distributed. In this data series corresponding P value 0.0 is less than the 5%. Therefore, the null hypothesis (H0: The data is normally distributed.) was rejected, and the alternative hypothesis (H1: The data is not normally distributed) was accepted. The original data series of Real GDP Growth was not suitable to continue with the ARDL model. Therefore, data transaformation of original data series was done to get the suitable data series for analysis.

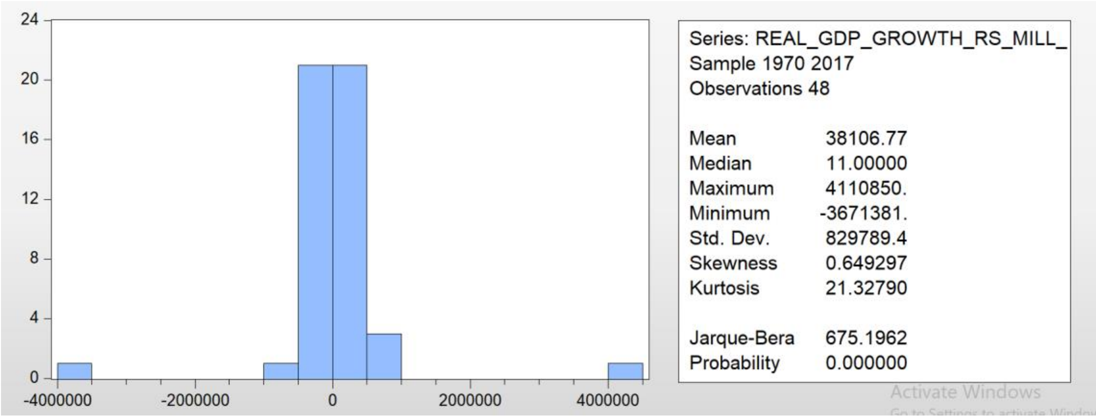

Figure 4.4: Jarque & Bera Test Results for Original Real GDP Growth Series

4.3 Data Transformation

4.3.1 Results of Normality Test after Natural Log Transformation

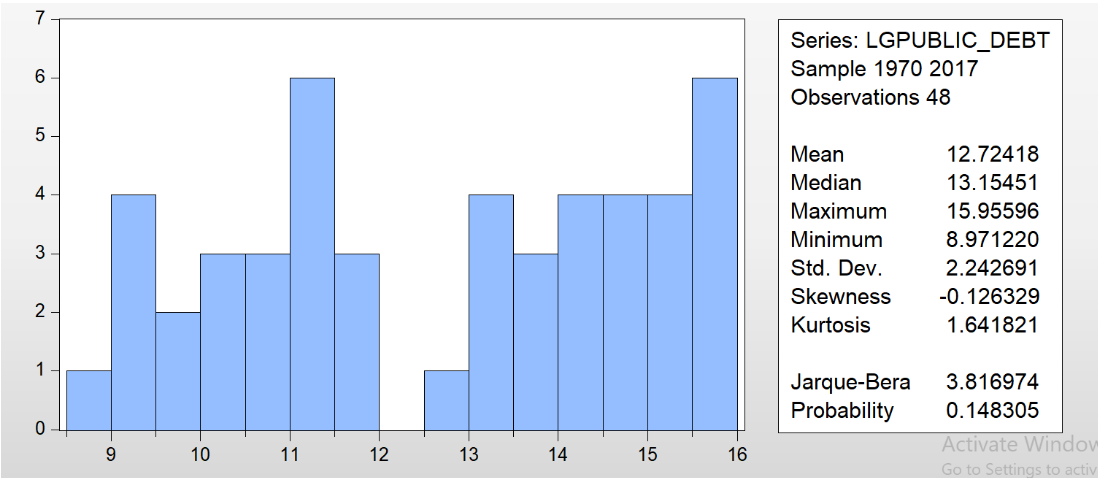

Figure 4.5: Jarque & Bera Test Results for Log values of Gross Total Public Debt

According to the results in Figure 4.5, it can be concluded that log transformed Gross Total Public Debt data series is normally distributed. In this data series corresponding P value 0.148 is greater than the 5%. Therefore, the null hypothesis (H0: The data is normally distributed) was accepted, and the alternative hypothesis (H1:The data is not normally distributed) was rejected. The natural log-transformed data series of Gross Total Public Debt was a suitable series to performe ARDL model.

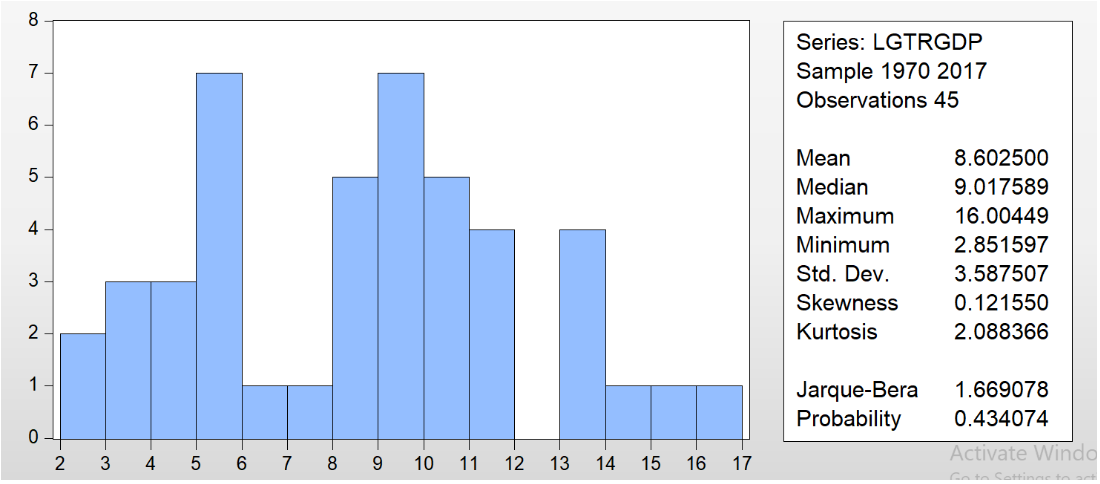

Figure 4.6: Jarque & Bera Test Results for Log values of Real GDP Growth

According to the results in Figure 4.6, it can be concluded that log transformed Real GDP Growth data series is normally distributed. In this data series corresponding P value 0.434 is greater than the 5%. Therefore, the null hypothesis (H0:The data is normally distributed) was accepted, and the alternative hypothesis (H1: The data is not normally distributed) was rejected. The natural log-transformed data series of Real GDP Growth was a suitable series to performe ARDL model.

4.4 Unit Root Test

According to the results of Augmented Dickey-Fuller Test given in Table 4.2, absolute values of t – statistics of transformed series of Real GDP Growth, under all test equation were less than the value of test statistics in 5% level. (t-statistics=0.54, Test statistics in 5%=1.94). Hence it could be said that the null hypothesis (H0: There is unit root in the series/Data is not stationary) can be accepted. Therefore, it could be concluded that transformed series of Real GDP Growth was not stationary in their original level.

However, absolute values of t – statistics of transformed series of Gross Total Public Debt, under all test equation were less than the value of test statistics in 5% level. (t-statistics=1.8, Test statistics in 5%=1.94).

Table 4.2: Results of Augmented Dickey-Fuller Test in Original Level of Transformed Data

Variable	t-Statistics	Test Statistics
		5%
Public Debt	1.8	1.94
Real GDP	0.54	1.94

Hence it could be said that the null hypothesis (H0: There is unit root in the series/data is not stationary) cannot be rejected. Therefore, it could be concluded that transformed series of Gross Total Public Debt was not stationary in their original level.

Table 4.3: Results of Augmented Dickey-Fuller Test in First Difference Level of Transformed Data

Variable	t-Statistics	Test Statistics
		5%
Public Debt	4.2	1.94
Real GDP	9	1.94

Table 4.3 showed the results of the Augmented Dickey-Fuller Test in first difference level of transformed data of Gross Total Public Debt series and Real GDP Growth data series. The absolute values of t – statistics of transformed series of Gross Total Public Debt, under the test equation were greater than the value of test statistics in 5% level. (4.2, Test statistics in 5%=1.94). Hence it could be said that the null hypothesis (H0: There is a unit root/ data is not stationary) can be rejected. Therefore, it could be concluded that transformed series of Gross Total Public Debt was stationary in their first difference level.

Absolute values of t – statistics of transformed series of Real GDP Growth, under all test equation were greater than the value of test statistics in 5% level. (t-statistics=9.0 Test statistics in 5%=1.94).

Hence it could be said that the null hypothesis (H0: There is a unit root/ data is not stationary) is rejected. Therefore, it could be concluded that transformed series of Real GDP Growth was stationary in their first difference level.

Hence, ARDL model could proceed with first difference level of normalised data in Real GDP Growth (I (1)) and first difference of normalised data in Gross Total Public Debt (I (1)).

4.5 Determine Optimal (Profit Lag) Lag Structure

The optimal lag structure or the profit lag length criteria is important in model estimation. According to the results of Table 4.7 and 4.8, it can be concluded that optimal lag length for Real GDP Growth variable was 3 and Gross Total Public Debt variables was 1.

Table 4.4: Results of Optimal Lag Length for Real GDP Growth

VAR Lag Order Selection Criteria
Endogenous variables: LGTRGDP
Exogenous variables: C
Date: 07/17/19 Time: 13:02
Sample: 1970 2017
Included observations: 41

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-108.2887	NA	12.10102	5.331157	5.372952	5.346377
1	-84.13659	45.94797	3.911752	4.201785	4.285374	4.232223
2	-76.54141	14.07887	2.836168	3.880069	4.005452	3.925727
3	-63.37318	23.76706*	1.567124*	3.286496*	3.453674*	3.347373*
4	-63.32420	0.086011	1.642518	3.332888	3.541860	3.408984

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 4.5: Results of Optimal Lag Length for Gross Total Public Debt

VAR Lag Order Selection Criteria
Endogenous variables: LGPUBLIC_DEBT
Exogenous variables: C
Date: 07/17/19 Time: 13:01
Sample: 1970 2017
Included observations: 44

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-93.55565	NA	4.306453	4.297984	4.338534	4.313022
1	13.11343	203.6410*	0.035332*	-0.505156*	-0.424057*	-0.475081*
2	13.12579	0.023034	0.036960	-0.460263	-0.338614	-0.415150
3	13.17986	0.098303	0.038595	-0.417266	-0.255067	-0.357115
4	13.22106	0.073038	0.040333	-0.373685	-0.170936	-0.298496

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

4.6 Selection of the ARDL Model

According to the results of Table 4.6, it can be concluded that ARDL (4,0) is the optimum model to represent the relationship among variables Real GDP Growth and Gross Total Public Debt, once typical conventional ARDL approach used. This conclusion was made upon the AIC value of different models checked (Figure 4.7). The model which had the lowest AIC value (3.34) was selected as the optimum model.

Table 4.6: Results of ARDL Model Selection

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
DLGGDP(-1)	0.647217	0.167863	3.855633	0.0005
DLGGDP(-2)	-0.971579	0.194406	-4.997679	0.0000
DLGGDP(-3)	0.125257	0.192461	0.650821	0.5195
DLGGDP(-4)	-0.318876	0.159221	-2.002719	0.0532
DPD	0.409613	1.068240	0.383447	0.7038
C	0.275551	0.267276	1.030961	0.3098

R-squared	0.700357	Mean dependent var	0.179983
Adjusted R-squared	0.656292	S.D. dependent var	2.056706
S.E. of regression	1.205777	Akaike info criterion	3.349607
Sum squared resid	49.43256	Schwarz criterion	3.602939
Log likelihood	-60.99214	Hannan-Quinn criter.	3.441204
F-statistic	15.89367	Durbin-Watson stat	2.095700
Prob(F-statistic)	0.000000		

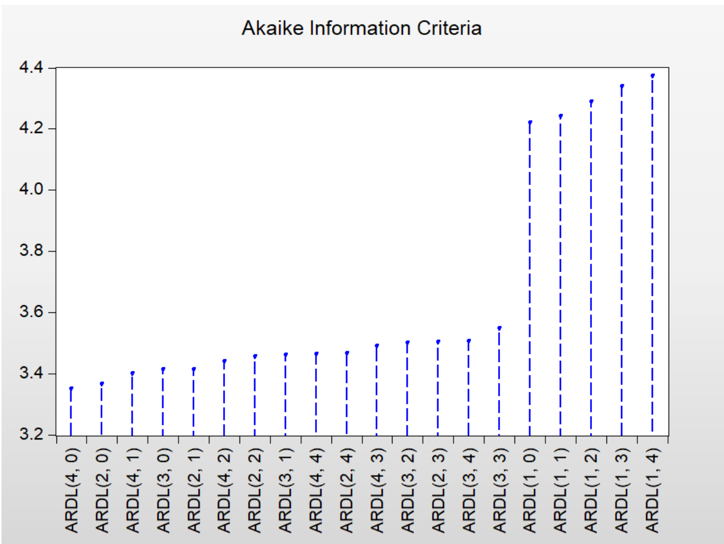

Figure 4.7: Graph of AIC values of Tested Models

4.7 Determine the Evidence for Long Run Relationship

According to the results of Table 4.7, it can be concluded that there was a long run relationship among variables Real GDP Growth and Gross Total Public Debt. The F-statistic value (9.25) is greater than the upper bound (4.56) of 5% significant level; null hypothesis do not reject. Therefore, it can be concluded that there is co-integration between dependent and independent variables or there is equilibrium long run relationship between two variables.

Table 4.7: Results of Bounds Co-Integration Test for Long Run Relationship

F-Statistics	Significant Level	I(0)	I(1)
9.25	5%	3.62	4.56

4.8 Determine the Short Run Relationship

According to the Table 4.8, it can be concluded that corresponding probability values of third lag of first difference of lag of Real GDP Growth, first difference of log Gross Public Debt variable and constant were not significantly different from zero at 5% level (P Values = 0.5195,0.7038, 0.3098 respectively). However, the corresponding P value of the first lag of first difference of Real GDP Growth, second lag of first difference of Real GDP Growth, fourth lag of first difference of Real GDP Growth were significantly different from zero at 5% level (P Values= 0.005,0.00,0.005 respectively). Hence, it can be concluded that, the first lag of first difference of Real GDP Growth, second lag of first difference of Real GDP Growth, fourth lag of first difference of Real GDP Growth can be included as model variables in short run model.

Table 4.8: Results of Short Run Coefficients for Real GDP Growth and Public Debt

Variable	Coefficient	Probability	AIC	3.34
DLGDP(-1)	0.647217	0.0005	**SC**	3.6
DLGDP(-2)	-0.9715	0	**HQ**	3.44
DLGDP(-3)	0.1252	0.5195	**R-Sq**	70.00%
DLGDP(-4)	-0.3188	0.0532	**Ad-Rsq**	65.60%
DLGPDebt	0.4096	0.7038	**F-Stat**	15.89
C	0.2755	0.3098	**Durb-Wat**	2.09

Therefore, short run model was written as:

$$\Delta \text{Log Real GDP Growth}_t =$$

$$0.2755 + 0.6472\Delta \text{Log Real GDP Growth}_{t-1} - 0.9715\Delta \text{Log Real GDP Growth}_{t-2}$$

$$-0.3188\Delta \text{Log Real GDP Growth}_{t-4} + \varepsilon_t \qquad (4.0)$$

Nevertheless, it (Equation 4.0) was revealed that, once the first lag of first difference of log value of Real GDP Growth increases in one unit, first difference of log value of Real GDP Growth increases in 0.6472 when all other variables are constant.

$$\Delta \text{Log Real GDP Growth}_t \propto \Delta \text{Log Real GDP Growth}_{t-1}$$

Once the second lag of first difference of log value of Real GDP Growth decreases in one unit, first difference of log value of real GDP Growth increases in 0.9715 when all other variables are constant (Equation 4.0).

$$\Delta \text{Log Real GDP Growth}_t \propto \frac{1}{\Delta \text{Log Real GDP Growth}_{t-2}}$$

Once the fourth lag of first difference of log value of Real GDP Growth increases in one unit, first difference of log value of real GDP Growth decreases in 0.3188 when all other variables are constant (Equation 4.0).

$$\Delta \text{Log Real GDP Growth}_t \propto \frac{1}{\Delta \text{Log Real GDP Growth}_{t-4}}$$

The estimated model had low AIC, HQ and SC values (3.34,3.44,3.60) and Durbin - Watson statistics was near to 2 (2.09) (Equation 4.0).

However, the estimated model described 70.0% of the actual model (R-SQ =0.70) (Table 4.8). There was no given sufficient clue to conclude that, this model was suitable to reveal the relationship between Real GDP Growth and Gross Total Public Debt in Sri Lanka since this model was based on a relationship between dependent variable and its own lags. But this model was a stable model. Following test results were proved that. But this model will not help to get any idea of the relationship between Gross Domestic Public Debt and Real GDP Growth in short runs.

4.8.1 Model Diagnostics and Stability Checking for Short Run Model

Table 4.9: Results of the Breusch-Godfrey LM Test for Short Run Model

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	1.977687	Prob. F(2,32)	0.1549
Obs*R-squared	4.400314	Prob. Chi-Square(2)	0.1108

According to the results of the Breusch-Godfrey Serial Correlation LM Test (Table 4.9), the corresponding probability value of F-statistics was higher than the 5% level (P Value= 0.1549). Therefore, the null hypothesis (H0: There is no serial correlation in residuals up to specific order) cannot be rejected and confirmed that residuals were free from serial correlation.

Table 4.10: Results of Heteroscedasticity Test for Short Run Model

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	1.430085	Prob. F(5,34)	0.2386
Obs*R-squared	6.950524	Prob. Chi-Square(5)	0.2243
Scaled explained SS	6.665134	Prob. Chi-Square(5)	0.2468

According to the results of Heteroscedasticity test (Table 4.10), it can be concluded that the residuals were homoscedastic since the probability value is greater than the 5% significance boundary (P Value=0.2386).

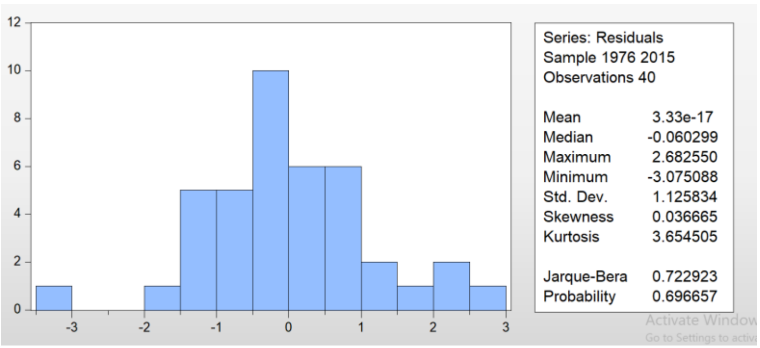

Figure 4.8: Results of Normality Test for Short Run Model

According to the results of normality test (Figure 4.8), it can be concluded that the residuals were normally distributed since the probability value is greater than the 5% significance boundary (P Value=0.6966).

According to the results of Ramsey Reset test (Table 4.11), it can be concluded that model was sufficiently specified since the probability value is greater than the 5% significance boundary and accept the null hypothesis (P Value=0.9402).

Table 4.11: Results of Ramsey Reset Test for Short Run Model

Ramsey RESET Test
Equation: UNTITLED
Omitted Variables: Squares of fitted values
Specification: DLGGDP DLGGDP(-1) DLGGDP(-2) DLGGDP(-3) DLGGDP(-4) DPD C

	Value	df	Probability
t-statistic	0.075542	33	0.9402
F-statistic	0.005707	(1, 33)	0.9402
Likelihood ratio	0.006917	1	0.9337

4.9 Determine the Long Run Coefficients

According to the Table 4.12, it can be concluded that corresponding probability values of first lag of first difference of log Real GDP Growth variable, third lag of first difference of log Real GDP Growth variable and first lag of first difference of log Real GDP Growth variable (long run form) were significantly different from zero at 5% level (P Values = 0.000, 0.05,0.00). Hence, the long run model was developed using those variables.

Table 4.12: Results of Long Run Coefficients

Variable	Coefficient	Probability
D(DLGDP(-1))	1.165	0.00
D(DLGDP(-2))	0.1936	0.28
D(DLGDP(-3))	0.3188	0.005
DLGGDP(-1)	-1.517	0.00
DPD	0.409	0.73
C	0.2755	0.309

The model with long-run coefficients was written as:

$$\Delta \text{Log Real GDP Growth}_t = 0.2755 + 1.165\Delta \text{Log Real GDP Growth}_{t-1}$$

$$+0.3188\Delta \text{Log Real GDP Growth}_{t-3} - 1.517 \text{Log Real GDP Growth}_{t-1} + \varepsilon_t \qquad (4.1)$$

Furthermore, it (Equation 4.1) was revealed that, once the first lag of first difference of log value of Real GDP Growth increases in one unit, first difference of log value of Real GDP Growth increases in 1.165 when all other variables are constant.

$$\Delta \text{Log Real GDP Growth}_t \propto \Delta \text{Log Real GDP Growth}_{t-1}$$

Once the third lag of first difference of log value of Real GDP Growth increases in one unit, first difference of log value of Real GDP Growth increases in 0.3188 when all other variables are constant (Equation 4.1).

$$\Delta \text{Log Real GDP Growth}_t \propto \Delta \text{Log Real GDP Growth}_{t-3}$$

Once the first lag of log value of Real GDP Growth increases in one unit, first difference of log value of real GDP Growth decreases in 1.517 when all other variables are constant. This is the long run form of the equation (Equation 4.1).

$$\Delta \text{Log Real GDP Growth}_t \propto \frac{1}{\Delta \text{Log Real GDP Growth}_{t-1}}$$

Once long run model established, there was no given sufficient clue to conclude that, this long run model was enough to reveal the relationship between Real GDP Growth and Gross Total Public Debt in Sri Lanka since this model was also based on a relationship between dependent variable and its own lags. But this model was a stable model. Model diagnostics results which were same as produced in short run model were proved that. But this model will not help to get any idea of the relationship between Gross Domestic Public Debt and Real GDP Growth in once included long run coefficients to short runs (Table 4.12).

4.9.1 Model Diagnostics and Stability Checking for Long Run Model

Model diagnostics and stability checking results were same as in the short run model. Therefore, it can be concluded that this model is stable model but does not reveal the relationship between Real GDP Growth and Gross Public Debt.

4.10 Model Re-parameterization

According to the Table 4.13, it can be concluded that corresponding probability values of first lag of first difference of log Real GDP Growth variable, third lag of first difference of log Real GDP Growth variable and Error Correction Model (ECM) term were significantly different from zero at 5% level (P Values = 0.000, 0.04,0.00 respectively). Hence, re-parameterized model was developed using those variables.

Table 4.13: Results of ECM Model Coefficients

Variable	**Coefficient**	**Probability**	**AIC**	3.29
D(DLGDP(-1))	1.165	0.00	**SC**	3.51
D(DLGDP(-2))	0.1936	0.28	**HQ**	3.37
D(DLGDP(-3))	0.3188	0.049	**R-Sq**	74.20%
CointEq(-1)	-1.517	0.00	**Ad-Rsq**	71.30%
C	0.2755	0.172	**Durb-Wat**	2.09

The error correction model was written as:

$$\Delta \text{Log Real GDP Growth}_t = 0.2755 + 1.165\Delta \text{Log Real GDP Growth}_{t-1}$$

$$+0.3188\Delta \text{Log Real GDP Growth}_{t-3} - 1.517\text{ECM}_{t-1} + \varepsilon_t \qquad (4.2)$$

Furthermore, it (Equation 4.2) was revealed that, once the first lag of first difference of log value of Real GDP Growth increases in one unit, first difference of log value of Real GDP Growth increases in 1.165 when all other variables are constant.

$$\Delta \text{Log Real GDP Growth}_t \propto \Delta \text{Log Real GDP Growth}_{t-1}$$

Once the third lag of first difference of log value of Real GDP Growth increases in one unit, first difference of log value of Real GDP Growth increases in 0.3188 when all other variables are constant (Equation 4.2).

$$\Delta \text{Log Real GDP Growth}_t \propto \Delta \text{Log Real GDP Growth}_{t-3}$$

Once the first lag of ECM increases in one unit, first difference of log value of real GDP Growth decreases in 1.517 when all other variables are constant. This is the long run error correction form of the equation (Equation 4.2).

$$\Delta \text{Log Real GDP Growth}_t \propto \frac{1}{\text{ECM}_{t-1}}$$

Further, it discussed that 15.1% dis-equilibrium was corrected in each year. But according to the Bounds Test results, it can be revealed that there is a long run equilibrium should be in between independent and dependent variable. As per this model, contradictory results were found. Instead of an equilibrium, 15.1% dis-equilibrium manifested.

Anyhow, the estimated model had low AIC, HQ and SC values (3.29,3.51,3.37) and Durbin -Watson statistics was near to 2 (2.09). However, the estimated model described 74.20% of the actual model (R-SQ =0.742) (Table 4.13).

Once based on the above mentioned facts, it can be concluded that this model was not enough to reveal the relationship between Real GDP Growth and Gross Total Public Debt in Sri Lanka.

4.10.1 Model Diagnostics and Stability Checking for Reparametrized Model

As mentioned in long run form coefficient finding section, Model diagnostics and stability checking results were same as in the short run model. Therefore, it can be concluded that this model is stable model but does not reveal the relationship between Real GDP Growth and Gross Public Debt.

Results produced by the above three models revealed that there was no linear relationship between Real GDP Growth and Gross Total Public Debt variables. And also, those were not provided any clue to prove stability of long run model or long run equilibrium. Hence it was not given strength models to describe the actual relationship between these two variables. Furthermore, it reveals that there is no symmetric relationship between Real GDP Growth and Gross Total Public Debt.

Therefore, asymmetric relationship between these two variables should be found out by using Non- Linear techniques.

Nevertheless, it is essential to carry out the nonlinear method because Gross Total Public Debt affects Real GDP Growth in two different ways. It is also critical to consider the possibility of a relationship between Gross Total Public Debt changes and Real GDP Growth which reveals the asymmetric nature. The effect of Real GDP Growth may be varied as per the positive and negative changes in Gross Total Public Debt. To recognise the asymmetric nature between these variables Non-Linear ARDL model which is the extension of linear ARDL model was used this study for more accurate and detailed model formation (Rocher, 2017).

4.11 Estimation of Non-Linear ARDL Model

This non-linear technique represents the relationship among variables Real GDP Growth, Positive changes of Gross Total Public Debt and Negative Changes of Gross Total Public Debt.

This conclusion of short run and long run models were made upon the AIC value of different models checked. The model which had the lowest AIC value was selected as the optimum model.

4.12 Determine the Evidence for Long Run Relationship of NARDL Model

According to the results of Table 4.14, it can be concluded that there was a long run relationship among variables Real GDP Growth, positive changes of Gross Total Public Debt and negative changes of Gross Total Public Debt.

The F-statistic value (4.62) is greater than the upper bound of 5% significant level; null hypothesis can be rejected by accepting alternative hypothesis which is coefficients of variables in long run form are significantly different from zero.

Table 4.14: Results of Bounds Co-Integration Test for NARDL

F-Statistics	Significant Level	I(0)	I(1)
4.62	5%	3.1	3.87

4.13 Determine the Short Run Coefficients for NARDL Model

According to the Table 4.15, it can be concluded that, corresponding probability values of fourth lag of positive changes of log Gross Public Debt variable, first lag of first difference of Real GDP Growth, and third lag of first difference of Real GDP Growth were significantly different from zero at 5% level (P Values = 0.00, 0.006,0.005). Hence, for the short run model of NARDL model, fourth lag of positive changes of log Gross Public Debt variable, first lag of first difference of Real GDP Growth, and third lag of first difference of Real GDP Growth and constant were included.

Table 4.15: Results of short run coefficients for NARDL

Variable	Coefficient	Probability	AIC	2.9
DLGDP(-1)	1.07	0.00	**SC**	3.2
LGPublicDebt_P(-4)	1.17	0.006	**HQ**	3.02
DLGDP(-3)	0.26	0.005	**R-Sq**	80.95%
C	4.69	0.00	**Ad-Rsq**	77.59%
			F-Stat.	24.09
			Durb-Wat	1.68

The short run model for NARDL approach was written as:

$$\Delta \text{Log Real GDP Growth}_t = 4.69 + 1.17\Delta \text{Log Gross Total Public Debt}^{+}_{t-4}$$

$$+0.26\Delta \text{Log Real GDP Growth}_{t-3} \quad (4.3)$$

This model was revealed that, once the third lag of first difference of log value of Real GDP Growth increases in one unit, first difference of log value of Real GDP Growth increases in 0.26 when all other variables are constant (Equation 4.3).

$$\Delta \text{Log Real GDP Growth}_t \propto \Delta \text{Log Real GDP Growth}_{t-3}$$

Once the fourth lag of positive changes of first difference of log value of Gross Total Public Debt increases in one unit, first difference of log value of real GDP Growth increases in 1.17 when all other variables are constant (Equation 4.3).

$$\Delta \text{Log Real GDP Growth}_t \propto \Delta \text{Log Gross Total Public Debt}^{+}_{t-4}$$

The estimated short run model had low AIC, HQ and SC values (2.9,3.2,3.02) and Durbin -Watson statistics was near to 2 (1.68). However, the estimated model described 80.95% of the actual model (R-SQ =0.8095). Therefore, this model can be accepted to reveal the short run relationship between Real GDP Growth and Gross Total Public Debt in Sri Lanka.

4.14 Determine the Long Run Coefficients for NARDL Model

According to the Table 4.16, it can be concluded that, corresponding probability values of first lag of positive changes of log Gross Public Debt variable, first lag of negative changes of log Gross Public Debt variable and first lag of Real GDP Growth were significantly different from zero at 5% level (P Values = 0.00, 0.005,0.002). Hence, for the short run model of NARDL model, first lag of positive changes of log Gross Public Debt variable, first lag of negative changes of log Gross Public Debt variable and first lag of Real GDP Growth and constant were included.

Table 4.16: Long Run Coefficients for NARDL Model

Variable	Coefficient	Probability	AIC	2.9
LGDP(-1)	-1.07	0.00	**SC**	3.2
LGPublicDebt_P(-1)	-0.35	0.005	**HQ**	3.02
LGPublicDebt_N(-1)	1.1	0.002	**R-Sq**	80.95%
C	4.69	0.00	**Ad-Rsq**	77.59%
			F-Stat.	24.09
			Durb-Wat	1.68

The long-run model was written as:

$$\text{Log Real GDP Growth}_t = 4.69 - 0.35\text{Log Gross Total Public Debt}^{+}_{t-1}$$

$$+1.1\text{Log Gross Total Public Debt}^{-}_{t-1} - 1.07\text{Log Real GDP Growth}_{t-1} \quad (4.4)$$

This long run model was revealed that, once the first lag of log value of Real GDP Growth increases in one unit, first difference of log value of Real GDP Growth decreases in 1.07 when all other variables are constant (Equation 4.4).

$$\text{Log Real GDP Growth}_t \propto \frac{1}{\text{Log Real GDP Growth}_{t-1}}$$

Once the first lag of positive changes of log value of Gross Total Public Debt increases in one unit, log value of Real GDP Growth increases in 1.1 when all other variables are constant (Equation 4.4).

$$\Delta \text{Log Real GDP Growth}_t \propto \text{Log Gross Total Public Debt}^{-}_{t-1}$$

Once the first lag of negative changes of log value of Gross Total Public Debt increases in one unit, log value of Real GDP Growth decreases in 0.35 when all other variables are constant (Equation 4.4).

$$\Delta \text{Log Real GDP Growth}_t \propto 1/\text{Log Gross Total Public Debt}^{-}_{t-1}$$

The estimated Long run model had low AIC, HQ and SC values (2.9,3.2,3.02) and Durbin -Watson statistics was near to 2 (1.68). However, the estimated model described 80.95% of the actual model (R-SQ =0.8095). Therefore, this model can be accepted to reveal the Long run relationship between Real GDP Growth and Gross Total Public Debt in Sri Lanka.

4.14.1 Model Diagnostics and Stability Checking for NARDL Model

According to the results of the Breusch-Godfrey Serial Correlation LM Test (Table 4.17), the corresponding probability value of F-statistics was higher than the 5% level (P Value = 0.3957). Therefore, the null hypothesis cannot be rejected and confirmed that residuals were free from serial correlation by accepting null hypothesis.

Table 4.17: Results of the Breusch-Godfrey LM Test for NARDL Model

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	0.954614	Prob. F(2,32)	0.3957
Obs*R-squared	2.308467	Prob. Chi-Square(2)	0.3153

According to the results of Heteroscedasticity test (Table 4.18), it can be concluded that the residuals were homoscedastic since the probability value is greater than the 5% significance boundary (P Value=0.3588).

Table 4.18: Results of the Breusch-Pegan-Godfrey Heteroscedasticity Test for NARDL Model

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	1.143699	Prob. F(6,34)	0.3588
Obs*R-squared	6.885336	Prob. Chi-Square(6)	0.3316
Scaled explained SS	4.250244	Prob. Chi-Square(6)	0.6429

According to the results of normality test (Figure 4.9), it can be concluded that the residuals were normally distributed since the probability value is greater than the 5% significance boundary and accept the null hypothesis (P Value=0.719).

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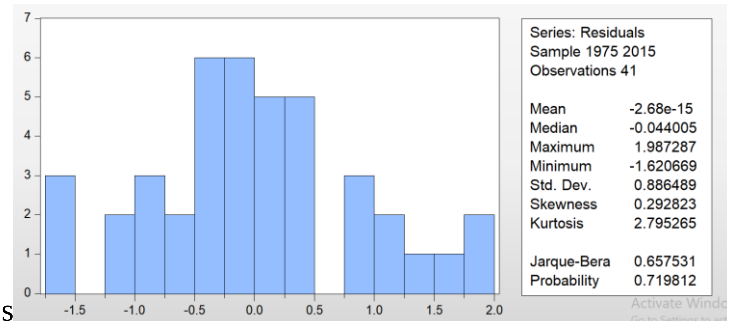

Figure 4.9: Results of the Normality Test for NARDL Model

According to the results of Ramsey Reset test (Table 4.19), it can be concluded that model was sufficiently specified since the probability value of F-Statistics is greater than the 5% significance boundary and accept the null hypothesis (P Value=0.6407).

Table 4.19: Results of the Ramsey Reset Test for NARDL Model

Ramsey RESET Test
Equation: UNTITLED
Omitted Variables: Squares of fitted values
Specification: DLGTRGDP C LGTRGDP(-1) LGPUBLICDEBT_P(-1) LGPUBLICDEBT_N(-1) DLGTRGDP(-1) LGPUBLICDEBT_P(-4) DLGTRGDP(-3)

	Value	df	Probability
t-statistic	0.471120	33	0.6407
F-statistic	0.221954	(1, 33)	0.6407
Likelihood ratio	0.274838	1	0.6001

According to the results of CUSUM of test (Figure 4.10), it can be concluded that the model is stable since the model was lying within the 5% significance boundary.

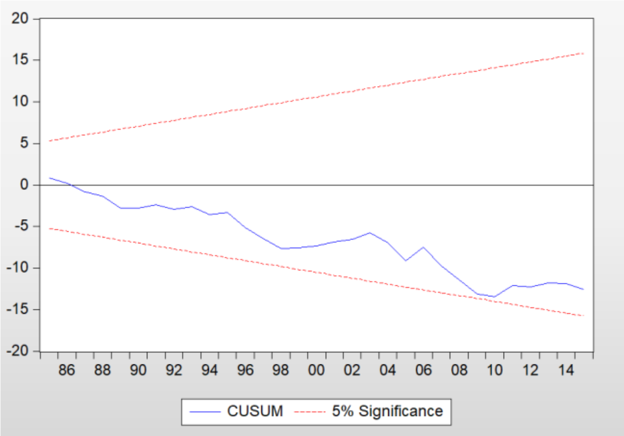

Figure 4.10: Results of Cusum Test for NARDL Model

4.15 Checking for Long Run Asymmetry

According to the results in Table 4.20, it can be revealed that corresponding P value of F-statistics was higher than the 5% significant level (F-Statistics = 2.86, P Value=0.0709). Therefore, it can be concluded that there was a long run co-integration between variables or the other hand, it concludes that there is a long run asymmetry in this.

Hence, it can be exposed that there are positive and negative change of Gross Domestic Production which have a long run positive effect on Real GDP Growth. Furthermore, in this step, it was given the evidence of both positive and negative change of Gross Domestic Production which have a long run negative effect on Real GDP Growth.

4.16 Testing the Presence of Short Run Asymmetry

According to the results in Table 4.21, it can be revealed that corresponding P value of F-statistics was less than the 5% significant level (F-Statistics = 44.03, P Value=0.00). Therefore, it can be concluded that there was no short run asymmetry in this model.

Table 4.20: Results of Wald's Test for Short Run Asymmetries

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	2.862899	(2, 34)	0.0709
Chi-square	5.725798	2	0.0571

Null Hypothesis: C(2)=C(3)=C(4)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(2) - C(4)	-2.179369	1.036344
C(3) - C(4)	-1.461982	1.234075

It was further revealed that there was no statistically different both of the positive and negative change which have a short run positive effect on Real GDP Growth. It means there is no asymmetry.

Table 4.21: Results of Wald's Test for Presence of Long Run Asymmetries

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	44.03873	(2, 34)	0.0000
Chi-square	88.07745	2	0.0000

Null Hypothesis: C(5)=C(6)=C(7)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(5) - C(7)	0.812559	0.087734
C(6) - C(7)	1.512829	0.613925

Results produced by the above non-linear ARDL model revealed that there was a non-linear relationship between Real GDP Growth and Gross Total Public Debt variables.

And also, this model was provided sufficient clues to prove stability of long run model or long run equilibrium.

Hence this was a strength model to describe the actual relationship between these two variables. Furthermore, it reveals that there is a long run asymmetric relationship between Real GDP Growth and Gross Total Public Debt.

Nevertheless, the effect of Real GDP Growth may be varied as per the positive and negative changes in Gross Total Public Debt. To recognise the asymmetric nature between these variables Non-Linear ARDL model which is the extension of linear ARDL model was used this study for more accurate and detailed model formation. According to the results, produced by the non-linear ARDL model, one unit of positive change of Gross Total Public Debt will lead to a 0.35 negative change of Real GDP Growth when all the other variables are constant (Equation 4.4). One unit of negative change of Gross Total Public Debt will lead to a 1.1 positive change of real GDP Growth in long run form when all the other variables are constant (Equation 4.4).

One unit of positive change of Gross Total Public Debt will lead to a 1.17 positive change of Real GDP Growth in short run form (Equation 4.4). Though this shows a long run asymmetry in nature there is no short run asymmetries. Therefore, there is no equilibrium to rectify in short run form.

4.17 Forecasting

Dynamic forecasting methods were given the forecasted series results with 2.89 Root Mean Squared value, 0.87 Mean Absolute Error value, 0.23 Mean Absolute Percentage Error. Graph of dynamic forecasting is reported in Figure 4.22. According to the forecasted graph the forecasted and real values are in lined to each other from 1975 to 2002. Then slight deviation was experienced from 2003 to 2010. A drastic deviation was shown afterwards (Figure 4.11and Table 4.22).

While Graph of static forecasting is reported in Figure 4.12. According to this graph, the forecasted values and actual values are in-lined with slight deviations. The Root Mean Squared value, Mean Absolute Error value, Mean Absolute Percentage Error value for static forecasting were 0.87, 0.67, 0.1% respectively (Table 4.22).

Therefore, based on above results, it can be concluded that the proposed model is a good model for forecasting.

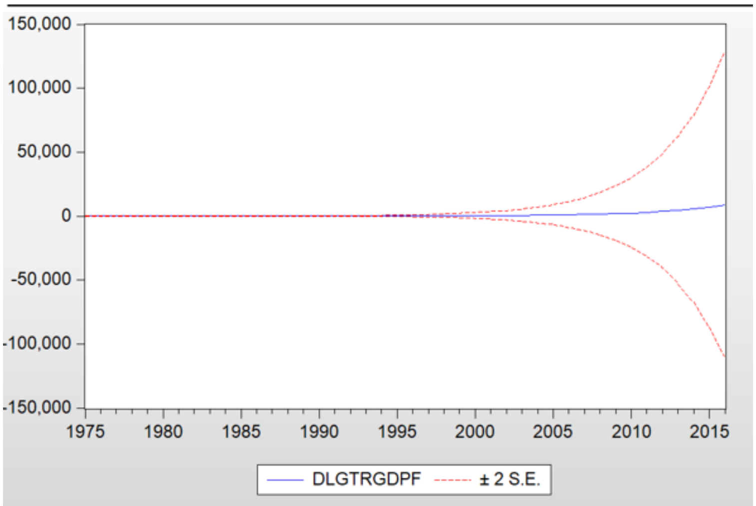

Figure 4.11: Graph of Dynamic Forecasting

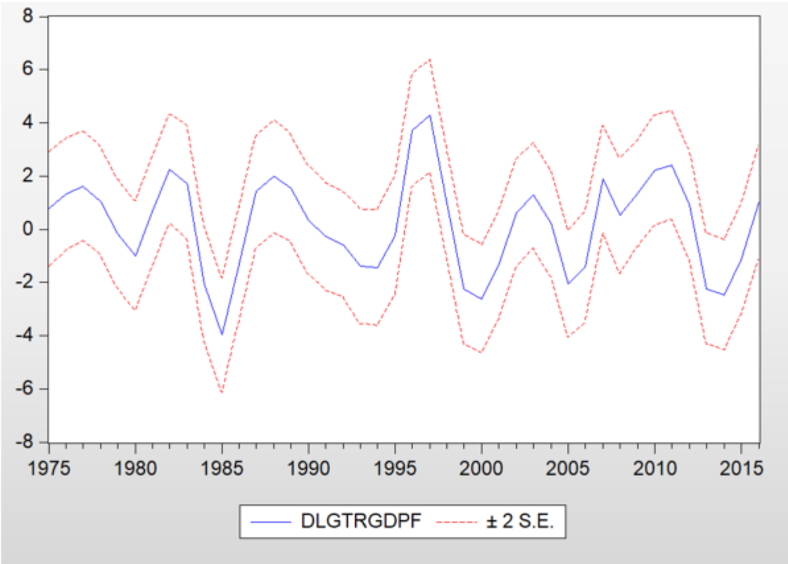

Figure 4.12: Graph of Static Forecasting

Table 4.22: Forecasting Models' Error results

Catergory	Dynamic	Static
Root Mean Squared Error	2.89	0.8756
Mean Absolute Error	0.87	0.67
Mean Absolute Percent Error	0.20%	0.10%

4.18 Summary of Results and Discussion

This chapter contains all the results that have been obtained from the study. Both linear and non-linear models were tested. Produced results proved that there is a no linear relationship between Gross Total Public Debt and Real GDP growth. But it revealed that there is a non-linear relationship between Gross Total Public Debt and Real GDP growth in Sri Lanka.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study focused on recognising a relationship between public debt and economic growth to develop a proper model to forecast the economic growth in Sri Lanka. Economic growth was measured by the Real GDP Growth. Among all tested models, the optimum model was developed using a first difference of log value of Real GDP Growth and positive changes of log value of Gross Total Public Debt for the short run and log value of Real GDP Growth and positive and negative changes of log value of Gross Total Public Debt for the long run using Non-Linear ARDL techniques. The presence of co-integration was estimated. Nevertheless, there is a significant long run and short-run relationships between variables. However, the impact of short run asymmetries was not reflected but long run asymmetries were shown in the present study. The results of residual diagnostics and model stability were given strong evidence of a stable and proper and sufficiently specified model. Furthermore, the present study was given the evidence that there is no linear relationship between Real GDP Growth and Gross Total Public Debt in Sri Lanka but there is a strong non-linear relationship Real GDP Growth and Gross Total Public Debt in Sri Lanka.

5.2 Recommendations

This study does not focus on dynamic multipliers and threshold level statistics. These two topics can be studied by another research in a detailed manner. This research mainly focused on Gross Total Public Debt variable to recognize a behavior of Economic growth in Sri Lanka. Instead of this, Economic growth behavior can be recognized by using variables like unemployment rate, inflation rate, population of the country and external debt etc. Another extended study can be performed to train a neural network to predict Real GDP Growth which reflects the economic growth in Sri Lanka or apply a machine learning technique to develop predictive model by a machine and this will really help to policy makers in Sri Lanka.

Logistic Regression concept in machine learning can be applied to predict a Real GDP Growth value. To train a neural network, LSTM which is a famous neural network training concept to train time series data can be applied.

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APPENDIX I

PROGRAM CODES IN E VIEWS

The estimated equation was

dlgtrgdp c lgtrgdp(-1) lgtrgdp(-2) lgtrgdp(-3) lgpublicdebt_p(-1) lgpublicdebt_n(-1)

The E Views codes are:

genr pos= dlgpublicdebt>=0

genr dlgpublicdebt_p=pos*dlgpublicdebt

genr dlgpublicdebt_n=(1-pos)*dlgpublicdebt

genr lgpublicdebt_p=@cumsum(dlgpublicdebt_p)

genr lgpublicdebt_n=@cumsum(dlgpublicdebt_n)

****

Model I

1. genr lnGDP =LOG (gdp__rs__mn_)

2. genr lnpud =LOG (public_debt__rs__mn_)

3. genr dlnpud =lnpud -lnpud(-1)

4. genr dlnGDP =lnGDP -lnGDP(-1)

5. genr pos =dlnpud>=0

6. genr dlnpud_p = pos*dlnpud

7. genr dlnpud_n = (1-pos)*dlnpud

8. genr lnpud_p = @CUMSUM (dlnpud_p)

9. genr lnpud_n = @CUMSUM (dlnpud_n)

Estimate Equation:

dlnGDP c lnGDP(-1) lnpud_p lnpud_n

List of search regressors:

dlgtrgdp(-1 to -3) lgpublicdebt_p(0 to -1) lgpublicdebt_n(0 to -1)-
****

Model II

1.genr dgdpr =gdp_rate-gdp_rate(-1)

2. genr ddebt_gdp =debt_gdp -debt_gdp(-1)

3. genr pos =ddebt_gdp>=0

4. genr ddebt_gdp_p = pos*ddebt_gdp

5. genr ddebt_gdp_n = (1-pos)*ddebt_gdp

6. genr debt_gdp_p = @CUMSUM (ddebt_gdp_p)

7. genr debt_gdp_n = @CUMSUM (ddebt_gdp_n)

Estimate Equation:

gdp c gdp_rate(-1)debt_gdp_p debt_gdp_n

List of search regressors:

gdp_ (-1 to -4) ddebt_gdp_p(0 to -4) ddebt_gdp_n(0 to -4)

Model III

genr debt_gdp_p2 = debt_gdp_p^2

genr debt_gdp_n2 = debt_gdp_n^2

Estimate Equation:

gdp_ c gdp_ (-1)debt_gdp_p2 debt_gdp_n2

List of search regressors:

gdp_rate(-1 to -4) debt_gdp_p2(0 to -4) debt_gdp_n2(0 to -4)

****

Model IV

genr series lnpud

genr lnpud = LOG (public_debt__rs__mn_)

genr POlnpud=lnpud^2

genr dPOlnpud =POlnpud -POlnpud(-1)

genr pos1 =dPOlnpud>=0

genr dPOlnpud_p = pos*dPOlnpud

genr dPOlnpud_n = (1-pos)*dPOlnpud

genr POlnpud_p = @CUMSUM (dPOlnpud_p)

genr POlnpud_n = @CUMSUM (dPOlnpud_n)

Estimate Equation:

gdp_rate c gdp_rate(-1)POlnpud_p POlnpud_n

List of search regressors:

gdp_rate(-1 to -4) POlnpud_p(0 to -4) POlnpud_n(0 to -4)

APPENDIX II

FORECASTED VALUES

Year	Actual Value	Dynamic	Static
1970	0.00	0.00	0.00
1971	0.00	0.00	0.00
1972	2.90	2.76	2.15
1973	-1.54	-1.23	-1.21
1974	-1.44	-1.02	-1.32
1975	0.14	0.77	0.77
1976	0.88	0.00	0.91
1977	1.57	1.43	1.61
1978	1.20	2.89	1.04
1979	-1.19	-2.01	-1.16
1980	-1.78	-1.72	-0.99
1981	0.50	0.56	0.67
1982	4.15	3.98	4.66
1983	3.05	2.97	2.90
1984	-2.31	-2.12	-2.04
1985	-3.88	-3.87	-3.97
1986	-0.94	-1.08	-1.31
1987	1.38	1.64	1.41
1988	1.81	1.89	1.97
1989	0.82	0.94	1.53
1990	0.36	0.31	0.32
1991	0.60	0.56	0.56
1992	0.24	0.28	0.32
1993	-1.04	-1.07	-1.39
1994	-2.42	-2.34	-1.43
1995	-0.58	-0.55	-0.43
1996	3.72	3.72	3.72
1997	4.21	4.31	4.27
1998	0.59	0.53	0.43
1999	-1.98	2.08	2.24
2000	-2.21	-2.13	-2.60
2001	-0.50	-0.42	-0.36
2002	1.62	1.54	1.61
2003	2.86	2.35	2.27
2004	-0.07	-0.09	-0.21
2005	-3.65	-3.02	-2.04
2006	0.56	0.41	0.42

Year	Actual Value	Dynamic	Static
2007	0.26	0.34	0.28
2008	-0.67	-0.72	-0.71
2009	-0.17	-0.91	-0.19
2010	1.76	1.78	2.08
2011	3.59	3.43	3.21
2012	0.77	0.72	0.73
2013	-1.77	-1.22	-1.32
2014	-2.44	-2.34	-2.09
2015	-1.73	-1.72	-1.72
2016	1.12	1.02	1.08
2017	2.01	2.00	2.31
2018	1.18	1.04	1.03
2019	N/A	1.06	1.02
2020	N/A	1.05	1.01

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