CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The policymakers and economists in macroeconomics long have been given much attention on the factors determining the relationship between consumption and savings. In past theoretical and empirical researches of those factors have focused as the concept of the consumption function. Lists of variables that influence on consumption and their magnitude with direction of their effects have investigated. Income plays pivotal role on any such list and much of recent investigations have concerned the nature, reliability and measurement of the dependence of the consumption on income.

There is a principal reason of economists that have interested in the division of income between consumption and savings. That is the savings for accumulation of the wealth of nations help for growth in their capacity to produce goods and services. In other words consumption uses productive resources in the present while savings enhance the resources available for production and consumption in the future.

Keynes, John M. (1936) stated the current consumption expenditure is a highly dependable and stable function of current income-that is "the amount of aggregate consumption mainly depends on the amount of aggregate income (both measured in terms of wage units)". He termed it a "fundamental physiological rule of any modern community that, when it's real income is increased, it will not increase its consumption by an equal absolute amount," and stated somewhat less that "as a rule….a greater proportion of income … (is) saved as real income increases."

The life-cycle theory of consumption was developed by Franco Modigliani, Albert Ando and Richard E. Brumberg in the early 1960s. It is commonly known as "life-cycle hypothesis". The life-cycle hypothesis rejects the Keynesian consumption theory that current consumption depends on current income. The life-cycle hypothesis postulates that the individual sustains a constant or slightly increasing level of consumption over his life-cycle. It maintains that individuals stabilize their consumptions over a period of time as their consumption streams to the expected lifetime income stream.

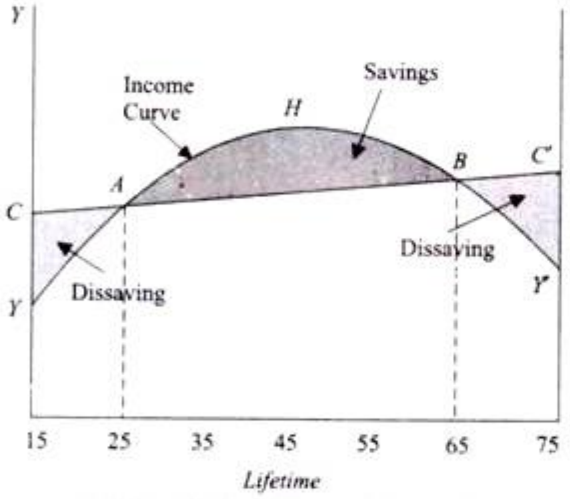


Figure 1.1: Relationship between income and consumption: The life-cycle hypothesis.

The income starts from the year when the individual begins with full-time employment, reaches a maximum when he approaches his middle years and falls thereafter. The curve C depicts the consumption stream, curves as an upward sloping line showing consumption level that increases steadily with time. If an individual decides not to make any assignment, then he will try at making the present value of his income stream equal to the present value of his consumption stream. Simply it implies that he would spend his entire income on consumption over the period of his life.

The permanent income hypothesis was developed by Milton Friedman in 1957. It is also known as Friedman's theory of consumption. Friedman's theory postulates that consumption is the function of permanent income. Permanent income is the mean of all the incomes anticipated by the households in the long run. The method of estimating permanent income is an approximation of incomes anticipated from all human wealth such as training, education, skill and intelligence and non-human wealth such as assets as money, stocks, bonds, real estates and consumer durables.

Wagner's law, also known as the explosion theory of government activities, was proposed by Adolf Wagner, a leading scholar of the German School of social policy.

After investigating the industrialization of America, France, Germany, Japan and other countries during the British Industrial revolution, he offered an explanation on the increase of fiscal expenditures from the perspective of the expansion of government functions. It is unclear whether the increase of public expenditures mentioned in Wagner's law refers to an increase in the proportion of public expenditures in GDP or only to that of absolute amount.

Wagner's law tells that when the domestic income increases, the public expenditure will increase faster. The proportion of government expenditures in GDP increases with income per capita, which is called the relative increase of fiscal expenditures.

1.2 Problem Statement

Though there are studies addressing the macroeconomic variables government public expenditures, gross domestic product, gross national income and gross domestic savings and some economic laws, there are no studies addressing causal relationship among household final consumption expenditure, gross domestic product, gross domestic savings, and gross national income for the case of Sri Lanka in the post economic liberalization. This attempt is to fill the gap of this relationship in Sri Lanka after over the period 1978 to 2016 by using multivariate co-integration approach.

1.3 Objectives of the Study

This study is going to investigate the behaviors of gross domestic product, gross domestic savings and gross national income on household final consumption expenditure in Sri Lanka. The following are addressed by the study:

- Examine the existence of long run relationship among gross domestic product, gross domestic savings, and gross national income to household final consumption expenditure.
- Examine the existence of short run relationships among gross domestic product, gross domestic savings, and gross national income to household final consumption expenditure.

- Through the variables above, develop an appropriate time series model.

1.4 Research Questions

- Can use gross domestic product, gross domestic savings and gross national income to predict household final consumption expenditure in Sri Lanka?
- Are there long run relationship exist among variables gross domestic product, gross domestic savings and gross national income on household final consumption expenditure in Sri Lanka?
- Are there short run relationship exist among variables gross domestic product, gross domestic savings and gross national income exist on household final consumption expenditure in Sri Lanka?

1.5 Significance of the Study

The results of the study will be useful lessons for policymakers, economists and future researches and academicians those who are interest on household consumptions, economic growth, savings and income. The study gives important discussion for economists and policymakers about the relationships among income, savings and economic growth towards household consumption expenditures.

The division of income between consumption and savings is the importance of savings for accumulation of the wealth of nations and for growth in their capacity to produce goods and services. In other words consumption uses productive resources in the present while savings enhance the resources available for production and consumption in the future. Therefore, this will be helpful to make policies on household consumption expenditures for policymakers. For economists, this will be useful to understand, explain theories which associate with consumption expenditures. For researches this will be helpful to understand the impact of gross domestic product, gross domestic savings and gross national income on household final consumption expenditure in Sri Lanka.

1.6 Scope of the Study

Although several factors effect on household final consumption expenditures, this study concentrate on gross domestic product, gross domestic savings and gross national income in Sri Lanka.

The annual data of household final consumption expenditure, gross domestic product, gross domestic savings, and gross national income from 1978 to 2016 are taken from the statistical bulletin of the World Bank website

1.7 Outline

This report is organized as follows. Chapter two represents the literature review concentrating consumption expenditures and other macroeconomic variables. Chapter three represents the methodology and introduces the data that will be used. Data analysis, results and discussion of this research are given in chapter four. Conclusion and recommendations are reported in chapter five.

CHAPTER 2

LITERATURE REVIEW

The casual relationships to consumption expenditure have been the subject to many empirical studies in both the developed and developing economies. Empirical evidence on consumption expenditure relationships is diverse. Most of the empirical studies focus on government's consumption expenditure. For example, Ranasinghe, R.A.S.K., Ichihashi, M. (2014) concluded that both government investment and consumption have a positive and significant impact on economic growth in Sri Lanka. Further, investigated though government consumption in Agriculture, Health, government investment in Education, Agriculture, Transportation and Communication have a positive and statistically significant impact on economic growth, government consumption in Education and Defence have negative and significant impact on economic growth in Sri Lanka.

Dandan, M.M. (2011) investigated that the government expenditure at the aggregate level has positive impact on the growth of gross domestic product in Jordan. It was also found the interest payment is proven to have no influence of GDP growth in Jordan. Cheng, B.S., Lai, T.W. (1997) found that there was bidirectional causality between government expenditures and economic growth in South Korea. It is also found that money supply affects economic growth as well. They used Vector Auto Regression model to evaluate it.

Ebong, F., Ogwumike, F., Udongwo, U. (2016) both short and long run effects of government capital expenditures on economic growth in Nigeria were estimated drawing on error correction and co-integration specifications, an OLS technique. Further they investigated; capital expenditures on agriculture did not exert any significant influence on growth both in the long and short runs. Similarly, the corresponding short-run and long-run impacted on growth of capital expenditures on education.

Amin, S.B. (2011) has revealed a long run co-integrating relationship between final consumption expenditure and economic growth in Bangladesh. Further, investigated it was long run unidirectional causal relationship running from economic growth to consumption expenditure.

Verter, N., Osakwe, C.D. (2014) investigated the impact of some selected variables net disposal income, GDP per capita growth, inflation rate cross cultural dynamics on household spending in the Czech Republic, using Granger causality test based on a Vector Autoregressive model. It has shown net disposable income, cross –cultural dynamics, inflation rate and household saving rate have a significant relationship with household expenditure in the Czech Republic within the period under study (1993-2012). In addition to that the Granger causality analysis has proven a positive relationship between household expenditure and social globalization index. The findings also indicated bidirectional causality between household saving rate and household expenditure as well as between the inflation rate and household expenditure. On the contrary, there was a unidirectional Granger causality running from household rate and household expenditure to both net disposable income and GDP per capita growth.

Mallik, L., Pradhan, K.C. (2012) studied the relationship between per capita consumption expenditure and personal income in India using Granger Causality method. They found a unidirectional causality running from per capita consumption expenditure to personal disposal income in the country.

Mohammad, S.D. (2010) attempted to find both long run and short run determinant of trade deficit and household expenditure with reference to Pakistan using Johansen co-integration and ECM approaches. He suggested that domestic household expenditure is negatively correlated and significantly affect the trade deficit in Pakistan.

Bonsu, C.O., Muzindutsi, P. (2017) investigated that income and inflation have long run effect on household consumption expenditure in Ghana using VAR model and Johansen co-integration approach. They used income, inflation and real exchange rate as macroeconomic variables. They found that changes in household expenditure patterns do not only effect economic growth or income, but also affect the Ghanaian currency market.

Guisan, M.C. (2004) analyzed the causal relationship between real consumption and real GDP in Mexico and the United States of America. He found that there was no causality in Mexico but there was bilateral causality in the United States. Further, the co-integration results showed that the long-run relationship was uncertain in the case of Mexico. Gerstberger, C., Yaneva, D. (2013) investigated that domestic disposal income and prices levels have a significant effect on household consumption expenditure.

CHAPTER 3

METHODOLOGY

3.1. Introduction

This study examines the effect of variables gross domestic product, gross domestic savings, gross domestic income on household final consumption expenditure in Sri Lanka from the period 1978 to 2016 using error correction mechanism. Annual data of household final consumption expenditure, gross domestic product, gross domestic savings and gross national income during period 1978 to 2016 were taken to study. Annual data of household final consumption expenditure, gross domestic product, gross domestic savings and gross domestic income were taken from statistical bulletin of the World Bank website. The description of variables used in this research study as follows:

HFCE– Household Final Consumption Expenditure

GDP– Nominal Gross Domestic Product

GDS– Gross Domestic Savings

GNI– Gross National Income

3.1.1. Household Final Consumption Expenditure (HFCE)

Household final consumption expenditure is one of the most important statistic for economists and for government officials charged with day-to-day management of the economy. It is typically the largest component of final uses of gross domestic product.

Household final consumption expenditure covers all purchases made by resident households (home and abroad) to meet their everyday needs: foods, clothing, household services (rents), energy, transport, durable goods, spending on health, on leisure and on miscellaneous services. It also included a number of imputed expenditures, for example agricultural products produced for own-consumption but the most significant imputation is typically owner-occupiers' imputed rents. The other main imputed item of expenditure relates to income in kind (employees may receive goods and services either free of charge or at very low price as part of their wage).

3.1.2. Gross Domestic Product (GDP)

The gross domestic product is the monetary value of all goods and services produced in a nation during a given time period, usually one year. Nominal GDP is economic output without the inflation adjustment.

While GDP is one of the primary indicators used to gauge to health of country's economy. Gross signifies that no deduction has been made for the depreciation of machinery, buildings and other capital products used in production. Domestic means that it is production by the resident institutional units of the country.

3.1.3. Gross Domestic Savings (GDS)

The purpose of saving is increasing future resources available for consumption and to protect against unexpected changes in income. Gross domestic saving is GDP minus final consumption expenditure. Gross Domestic Saving consists of savings of household sector, private corporate sector and public sector. Final consumption expenditure consists of expenditure incurred by resident institutional units on goods or services that are used for the direct satisfaction of individual needs or wants, or the collective needs of members of the community.

3.1.4. Gross National Income (GNI)

Gross national income is the broadest measure of national income, measures total value added from domestic and foreign sources claimed by residents. GNI comprises gross domestic product (GDP) plus net receipts of primary income from foreign sources. It does not count income earned by foreigners located in the country though.

GNI measures all income of a country's residents and businesses, regardless of where it's produced. Gross domestic product, on the other hand, measures the income of anyone within a country's boundaries, regardless of who produces it. It includes anything earned by foreigners, including foreign businesses, while they are in the country. GDP measures production while GNI measures income.

3.2. Model Specification

The model for this study can be expressed in equation(1) .

$$\mathrm{HFCE} = \mathrm{f}(\mathrm{GDP}, \mathrm{GDS}, \mathrm{GNI}) \tag{1}$$

The data used in this study was transformed into natural logarithms as results given by Box-Cox transformations. The log transformation can decrease the variability of data and make data more conform more close to the normal distribution. In log linear form the function becomes:

$$\ln(\mathrm{HFCE_t}) = \alpha_0 + \alpha_1 \ln(GDP_t) + \alpha_2 \ln(GDS_t) + \alpha_3 \ln(GNI_{t)} + e_t \tag{2}$$

where α_0 is a constant, α_1, α_2 and α_3 are the coefficients of the explanatory variables and e_t is error correction term.

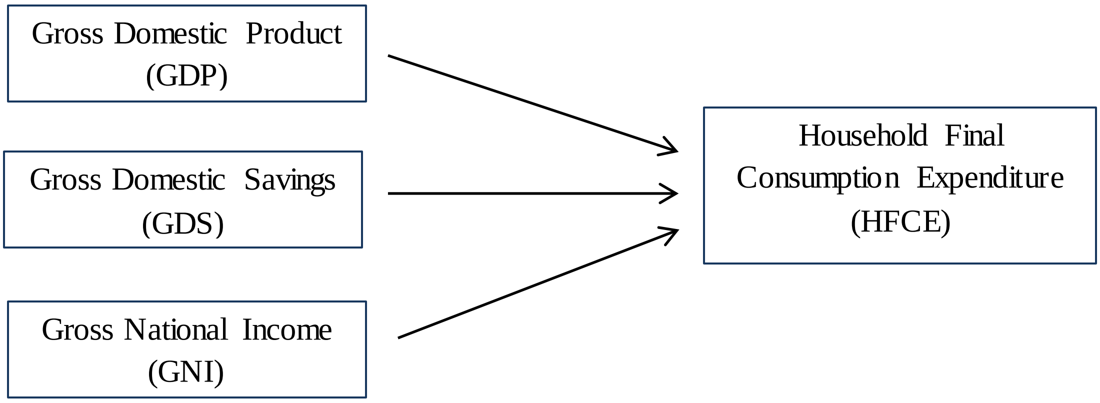


Figure 3.1: Conceptual framework of dependent variable and independent variables

3.3. Procedure of Analysis

In order to analyse the effect of gross domestic product, gross domestic savings, and gross national income on household final consumption expenditure, time series plots of each variable are plotted to visually identify the behaviours of the time series.

Since non-stationary invalidates many standard empirical results, Then Box-Cox transformation is done to identify appropriate exponent of the series to convert data into normality. Next step to develop appropriate model is to determine the stationary properties of the relevant series. Augmented Dickey-Fuller unit root test (ADF) is the main instruments for studying the stationarity properties of the series. In here Augmented Dickey-Fuller (ADF) unit root test is applied for this purpose. Phillips-Perron (PP) test is used to further confirmation of stationarity of series.

After examining the stationary properties of variables, if all variables are found out to be non-stationary, i.e. integrated of order 1, a possible co-integrating relationship between these variables should be searched. The co-integration test has a pivotal role in deciding the appropriate model used in detecting the relationship among household final consumption expenditure, gross domestic product, gross national income and gross domestic savings. In here the Johansen multivariate co-integration technique, proposed by Johansen (1988) and Johansen and Juselius (1990), is used in order to apply co-integration test. This technique provides two different likelihood tests based on trace statistic and maximum eigenvalue statistics.

After obtaining co-integration test results, a vector error correction (VEC) model is a restricted VAR designed for use with non-stationary series that are known to be co-integrated. The VEC has co-integration relations built into the specification so that it restricts the long-run behaviour of the endogenous variables to converge to their co-integrating relationships while allowing for short-run adjustments. The co-integration term is known as the error correction term since deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments. The Wald test is applied to identify significance of explanatory variables in the model.

Then the influence of exogenous shocks on the variables of the model is evaluated using tools which are used to evaluate exogenous shocks Impulse Response Function (IRF) and Variance Decomposition (VDC). The ordering of the variables is important to calculate for the Impulse Response Function (IRF) when there is a contemporaneous correlation between the residuals. Therefore, the Cholesky decomposition of the estimated residual covariance matrix is used.

Finally, residual diagnostic tests Breush-Godfrey serial correlation LM test for serial correlation, Breusch-Pargon-Godfrey test for Heteroskedasticity, Jarque-Bera test for normality, CUSUM test for stability of the model are carried out to identify the accuracy of the fitted model.

3.4. Box-Cox Transformation

Box-cox transformation which is developed by Georde Box and David Cox is a commonly used method to normalize data. Box-cox transformation will manipulate non normal data and suggest the appropriate factor to be used to change the data into normal data. It helps to identify an appropriate exponent that can transform data into "normal shape". The λ value indicates the power to which all data should be raised.

Table 3.1: Common Box-Cox Transformations

λ value	Transformed data (X)
-1	$1/x_t$
-0.5	$\sqrt{}(1/x_t)$
0	$\ln(x_t)$
0.5	$\sqrt{}x_t$
1	x_t

3.5. Unit Root Test

Stationary of a series is important phenomenon because it can influence its behaviour. In a time series analysis, the ordinary least squares (OLS) regression results might provide a spurious regression if the data series are non-stationary.

Time series stationary is the statistical characteristics of a series such as its mean and variance over time. If both are constant over time, then the series said to be stationary process (i.e. is not a random walk/has unit root). Differencing operations produces other set of observations such as the first-differenced values, second differenced values so on.

level: y_t

1st differenced value: $y_t - y_{t-1}$ (3)

If a series is stationary without any differencing it is called as I(0), or integrated of order 0. On the other hand, a series that has stationary first differences is called I(1), or integrated of order one. Augmented Dickey-Fuller test and Phillips-Perron (PP) test have been used to test stationary of variables.

3.5.1. Augmented Dickey- Fuller (ADF) Test

Augmented Dickey-Fuller test (ADF) is a test for a unit root in a time series sample. It is an augmented version of the Dickey-Fuller test for a larger and more complicated set of time series models. The augmented Dickey-Fuller (ADF) statistic, used in the test, is a negative number. The more negative it is, the stronger the rejection of the hypothesis that there is a unit roots at some level of confidence. The ADF test entails regressing the first difference of a variable Y on its lagged level, exogenous variable(s) and k lagged first differences which can be given as follows.

$$\Delta Y_t = \alpha + \beta T + \rho Y_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta Y_{t-i} + e_t \tag{4}$$

where Y_t is the variable in period t, T denotes a time trend, Δ is the difference operator, e_t is an error term disturbance with mean zero and variance σ^2 and k represents the number of lags of the differences in the ADF equation.

H_0: Series has a unit root

H_1: Series hasn't a unit root

The ADF is restricted by its number of lags. It decreases the power of the test to reject the null hypothesis of a unit root, because the increased number of lags necessitates the estimation of additional parameters and a loss of degree of freedom. The number of lags is being determined by minimum number of residuals free from autocorrelation. This could be examined for the standard approach for instances

Akaike's Information Criterion (AIC) and Schwartz Bayesian Criterion (SBC). The augmented specification is then used to test:

$H_0: \rho = 0 \quad Vs \;\; H_1: \rho < 0$

The null hypothesis of unit root is rejected against the one-sided alternative if t-statistic of ρ is less than the MacKinnon critical values. This means that the variable is stationary.

Test statistic

$$t_\rho = \frac{\hat{\rho}}{SE(\widehat{\rho})}$$

where $\hat{\rho}$ is the estimate of ρ, and $SE(\widehat{\rho})$ is the coefficient standard error.

3.5.2. Phillips-Perron (PP) Test

Phillips and Perron (1988) developed a number of unit root tests that have become popular in the analysis of financial time series. The Phillips-Perron (PP) unit root tests differ from the ADF tests mainly in how they deal with serial correlation and heteroskedasticity in the errors. In particular, where the ADF tests use a parametric auto regression to approximate the where ARMA structure of the errors in the test regression, the Phillips-Perron (PP) tests ignore any serial correlation in the test regression.

Consider a model

$Y_t = \theta_0 + \phi Y_{t-1} + a_t$

Where a_t is serially correlated. Then Phillips-Perron test equation can be written as,

$\Delta Y_t = \theta_0 + \delta Y_{t-1} + a_t$

The hypothesis to be tested is,

$H_0: \delta = 0$

$H_1: \delta < 0$

The PP tests correct for any serial correlation and heteroskedasticity in the errors a_t of the test regression by directly modifying the test statistics $t_{\delta=0}$ and $n\hat{\delta}$. These modified statistics, denoted Z_t and Z_δ are given by,

$$Z_t = \sqrt{\frac{\hat{\sigma}^2}{\hat{\lambda}^2}} t_\delta - \frac{1}{2}\left(\frac{\hat{\lambda}^2 - \hat{\sigma}^2}{\hat{\lambda}^2}\right)\left(\frac{n(s.e.(\hat{\delta}))}{\hat{\sigma}^2}\right)$$

$$Z_\delta = n\hat{\delta} - \frac{1}{2}\left(\frac{n^2\left(s.e.(\hat{\delta})\right)}{\hat{\sigma}^2}\right)(\hat{\lambda}^2 - \hat{\sigma}^2)$$

The terms $\hat{\sigma}^2$ and $\hat{\lambda}^2$ are consistent estimates of the variance parameters

$$\sigma^2 = \lim_{n\to\infty} n^{-1} \sum_{t=1}^{n} E(a_t^2) \quad \text{and} \quad \sigma^2 = \lim_{n\to\infty} \sum_{t=1}^{n} E\left(\frac{1}{n}\sum_{t=1}^{n} a_t^2\right)$$

Under the null hypothesis that $\delta = 0$, the PP Z_t and Z_δ statistics have the same asymptotic distributions as the ADF t-statistic and normalized bias statistics.

3.6. Co-integration Test

Co-integration (Engle and Granger, 1987) is an econometric technique for testing the relationship between non-stationary time series variables. If two or more series each have a unit root, but a linear combination of them is stationary, then the series are said to be co-integrated.

3.6.1. Johansen Co-integration Test

The Johansen test can be seen as a multivariate generalization of the augmented Dickey-Fuller test. The generalization is the examination of linear combination of variables for unit roots. The Johansen test and estimation strategy–maximum likelihood–makes it possible to estimate all co-integrating vectors when there are more than two variables. If there are three variables each with unit roots, there are at most two co-integrating vectors. More generally, if there are n variables which all have unit roots, there are at most $n - 1$ co-integrating vectors. The Johansen test provides estimates of all co-integrating vectors.

The Johansen tests are likelihood-ratio tests. There are two tests:

1. The maximum eigenvalue test
2. The trace test

3.6.1.1. Maximum Eigenvalue Test

The maximum eigenvalue test examines whether the largest eigenvalue is zero relative to that the next largest eigenvalue is zero. The first test is a test whether the rank of the matrix Π is zero. The null hypothesis is that the rank Π = 0 and the alternative hypothesis is that rank Π = 1. For further tests, the null hypothesis is that rank Π = 1,2,3… and alternative hypothesis is that rank Π = 2,3….

In more details, the first test is the test of rank Π = 0 and the alternative hypothesis is that rank Π =1. This is a test using the largest eigenvalue. If the rank of the matrix is zero, the largest eigenvalue is zero, there is no co-integration and tests are done. If the largest eigenvalue λ_1 is non-zero, the rank of the matrix is at least one and there might be more co-integrating vectors. Then test whether the second largest eigenvalue λ_2 is zero. If this eigenvalue is zero, the tests are done and there is exactly one co-integrating vector. If the second largest eigenvalue $\lambda_2 \neq 0$ and there are more than two variables, there might be more co-integrating vectors. Then test whether the third largest eigenvalue λ_3 is zero. And so on until the null hypothesis of an eigenvalue equal to zero cannot be rejected.

The test of the maximum eigenvalue is a likelihood ratio test. The test statistic is:

$$LR_{max}\,(r,r+1) = -T * \ln\left(1-\hat{\lambda}_{r+1}\right) \tag{5}$$

Where $LR_{max}\,(r,r+1)$ is the likelihood ratio test statistic for testing whether rank Π = r versus the alternative hypothesis that rank Π = r + 1. λ is the maximum eigenvalue and T is the sample size.

3.6.1.2. Trace Test

The trace test is a test whether the rank of the matrix Π is r. the null hypothesis is that rank Π = r. The alternative hypothesis is that r < rank Π ≤ n, where n is the maximum number of possible co-integrating vectors. For the succeeding test if this null hypothesis is rejected, the next null hypothesis is that rank Π = r +1 and the alternative hypothesis is that r +1 < rank Π ≤ n.

The likelihood ratio test statistic is

$$LR_{tr}\ (r,n) = -T * \sum_{i=r+1}^{n} \ln\left(1 - \hat{\lambda}_i\right) \tag{6}$$

Where, $LR_{tr}\ (r,n)$ is the likelihood ratio statistic for testing whether rank Π = r versus the alternative hypothesis that rank Π ≤ n. λ is the largest eigenvalue and T is the sample size.

3.7. Lag Selection Criterion

A lag refers to a difference in time between an observation and a previous observation. The first difference of a time series is defined by:

$$\Delta Y_t = Y_t - Y_{t-1} \tag{7}$$

This means when the order i is applied, can get i^{th} order lag of the random variable Y. The purpose of this i^{th} differenced series is to remove time varying mean. The new series will become a mean that constant across time period t. It gives a simple way to control for historical factors that could impact on dependent variable at the current time period t.

There are several criterions for selecting the optimal lag length in time series for instances AIC: Akaike Information Criterion, SBC: Schwarz’s Bayesian Criterion.

3.7.1. Akaike Information Criterion (AIC)

Akaike information criterion (AIC) (Akaike, 1973) is a fined technique based on in-sample fit to estimate the likelihood of a model to predict/estimate the future values It is a measure of the relative quality of statistical models for the given set of data. Given a collection of models for the data, AIC estimates the quality of each model, relative to each of other models. It is defined as:

$$AIC(k) = -2lnL + 2k \quad (8)$$

where L is the value of the likelihood, k is the number of estimated parameters.

3.7.2. Schwartz's Bayesian Criterion (SBC)

The Bayesian Information Criterion (BIC) or Schwarz's Bayesian Criterion (SBC) is a criterion for model selection among a finite set of models, the model with the lowest SBC is preferred. It is based, in part, on the likelihood function and it is closely related to the Akaike Information Criterion (AIC)

$$SBC\ (k) = -2\ ln(L) + kln(n) \quad (9)$$

where L is the value of the likelihood, k is the number of estimated parameters. n is the number of observations.

3.7.3. Hannan–Quinn Information Criterion (HQ)

Hannan and Quinn (1979) provided a selection procedure of the same type as that of AIC named Hannan–Quinn Information Criterion. HQ criterion can be considered as an alternative to Akaike information criterion (AIC) and Bayesian information criterion (BIC). The model with the lowest HQ is preferred.

$$HQ = -2L + 2kln(ln\,n) \quad (10)$$

where L is the log-likelihood, k is the number of parameters and n is the sample size.

3.8. Vector Error Correction Model

Engle and Granger showed that once a number of variables are co-integrated, there always exists a corresponding error-correction representation that implies that changes in the dependent variable are a function of the level of disequilibrium in the co-integrating relationship as well as changes in other explanatory variables. In other words, if co-integration has been detected between variables that indicate there exists a long term equilibrium relationship between variables. The regression equation form of vector error correction model as follows:

$$\begin{aligned}\Delta \mathrm{Y}_t = \alpha_y &+ \sum_{i=0}^{n} \beta_{y,i}\, \Delta \mathrm{Y}_{t-i} + \sum_{i=0}^{n} \delta_{y,i}\, \Delta \mathrm{X}_{t-i} + \sum_{i=0}^{n} \gamma_{y,i}\, \Delta \mathrm{Z}_{t-i} + \sum_{i=0}^{n} \tau_{y,i}\, \Delta \mathrm{M}_{t-i} \\ &+ \sum_{i=0}^{n} \epsilon_{y.i}\, \mathrm{ECT}_{t-i} + \mu_{y,t}\end{aligned} \tag{11}$$

$$\begin{aligned}\Delta \mathrm{X}_t = \alpha_x &+ \sum_{i=0}^{n} \beta_{x,i}\, \Delta \mathrm{Y}_{t-i} + \sum_{i=0}^{n} \delta_{x,i}\, \Delta \mathrm{X}_{t-i} + \sum_{i=0}^{n} \gamma_{x,i}\, \Delta \mathrm{Z}_{t-i} + \sum_{i=0}^{n} \tau_{x,i}\, \Delta \mathrm{M}_{t-i} \\ &+ \sum_{i=0}^{n} \epsilon_{x,i}\, \mathrm{ECT}_{t-i} + \mu_{x,t}\end{aligned} \tag{12}$$

$$\begin{aligned}\Delta \mathrm{Z}_t = \alpha_z &+ \sum_{i=0}^{n} \beta_{z,i}\, \Delta \mathrm{X}_{t-i} + \sum_{i=0}^{n} \delta_{z,i}\, \Delta \mathrm{Y}_{t-i} + \sum_{i=0}^{n} \gamma_{z,i}\, \Delta \mathrm{Z}_{t-i} + \sum_{i=0}^{n} \tau_{z,i}\, \Delta \mathrm{M}_{t-i} \\ &+ \sum_{i=0}^{n} \epsilon_{z,i}\, \mathrm{ECT}_{t-i} + \mu_{z,t}\end{aligned} \tag{13}$$

$$\begin{aligned}\Delta \mathrm{M}_t = \alpha_m &+ \sum_{i=0}^{n} \beta_{m,i}\, \Delta \mathrm{X}_{t-i} + \sum_{i=0}^{n} \delta_{m,i}\, \Delta \mathrm{Y}_{t-i} + \sum_{i=0}^{n} \gamma_{m,i}\, \Delta \mathrm{Z}_{t-i} + \sum_{i=0}^{n} \tau_{m,i}\, \Delta \mathrm{M}_{t-i} \\ &+ \sum_{i=0}^{n} \epsilon_{m,i}\, \mathrm{ECT}_{t-i} + \mu_{m,t}\end{aligned} \tag{14}$$

Where Δ is a first difference notation.Y (natural logarithms of household final consumption expenditure), X (natural logarithms of gross domestic product), Z (natural logarithms gross domestic savings), M (natural logarithms of gross national income) are variables in time series model. ECT refers error correction terms derived from long run co-integrating relationship via the Johenson maximum likelihood procedure, μ_t (for t = 1,2,3…) are serially uncorrelated random error terms with mean zero. i refers the number of lags. In this case Equation 11 will be used to test causation from gross domestic product, gross domestic savings and gross domestic income to household final consumption expenditure.

3.9. Wald Test

Wald test is a way of testing the significance of particular explanatory variables in a statistical model. The Wald test, described by Polit (1996) and Agresti (1990), is one of a number of ways of testing whether the parameters associated with a group of explanatory variables are zero.

If for a particular explanatory variable, or group of explanatory variables, the Wald test is significant, then would conclude that the parameters associate with these variables are not zero, so that the variables should be included in the model. If the Wald test is not significant, then these explanatory variables can be omitted from the model.

Null hypothesis and alternative hypothesis of Wald test as follows:

$H_0: \theta = \theta_0$

$H_1: \theta \neq \theta_0$

Under Wald statistical test, the maximum likelihood estimate $\hat{\theta}$ of the parameter of interest θ_0, with assumption that the $\hat{\theta}$ is asymptotically normally distributed.

The Wald test statistic is given by

$$W = \frac{(\hat{\theta} - \theta_0)^2}{Var(\hat{\theta})} \sim \chi_1^2$$

Wald test is followed chi-squired distribution.

3.10. Innovation Accounting

Innovation accounting can be used to evaluate the influence of exogenous shocks on the variables of a VEC model. There are several tools to evaluate the influence of exogenous shocks on the variables of a VECM.

1. Impulse response functions (IRF)
2. Variance Decomposition (VD)

Though the result of VECM indicates the exogeneity or endogeneity of a variable in the system and the direction of Granger-Causality within the sample period, it does not provide the dynamic properties of the system. The analysis of the dynamic interactions among the variables in the post-sample period is conducted through Impulse response functions (IRFs) and variance decompositions (VDs).

3.10.1. Impulse Response Function (IRF)

Impulse responses are used to trace out the dynamic response of the equations in the VECM to a set of identified shocks. Because these are moving average for generally stationary autoregressive processes, expect that these shocks will die off or return to zero. In addition, the identification of the shocks typically assumes that the magnitude of the shocks is one standard deviation of the residuals in the VECM. These initial responses are then traced out as function of time.

The IMF is represented as follows:

$$X_t = \alpha_t + \sum_{j=1}^{\infty} \varphi_j \, \alpha_{t-j}$$

where $\sum_{j=0}^{\infty} \varphi_j^2 < \infty$ and the α_t are white noise with variance σ^2.

3.10.2. Variance Decomposition (VD)

The variance decomposition of a VAR gives information about the relative importance of each of random innovations in the explanation of each variable in the system. This is done through an analysis of the forecast error of each variable.

3.11. Diagnostic Tests for the Fitted Models

It is important to determine whether all the necessary model assumptions are valid before performing inference. If there are any violations, subsequent inferential procedures may be invalid resulting in faulty conclusions. Therefore, it is crucial to perform appropriate model diagnostics.

3.11.1. The Breusch-Godfrey LM test for Serial Correlation

Correlation is a common concept used to describe the strength of the relationship between variables. Serial correlation is the common concept used to describe the relationship between observations on the same variable over periods of time. If the serial correlation of observation is zero, observations are said to be independent. However, if serial correlation has statistically significant, it means observations do not come from in a random process, but rather observations are related to their prior observation values. In this case, observations may exhibit positive or negative serial correlation.

Breusch (1978) and Godfrey (1978) developed a Lagrange Multiplier (LM) test that can be examined the higher order of serial correlation when lagged dependent variable is used.

Consider the model:

$$\mathrm{Y_t} = \beta_1 + \beta_2 \mathrm{X}_{2,t} + \beta_3 \mathrm{X}_{3,t} + \ \ldots\ldots. + \beta_k \mathrm{X}_{kt} + \mathrm{u_t} \tag{15}$$

Where

$$u_t = \rho_1 u_{t-1} + \rho_2 u_{t-2} + \cdots + \rho_p u_{t-p} + \varepsilon_t \tag{16}$$

The Breusch-Godfrey LM test combines these two equations:

$$Y_t = \beta_1 + \beta_2 X_{2,t} + \beta_3 X_{3,t} + \ \ldots\ldots. + \beta_k X_{kt} + \rho_1 u_{t-1} + \rho_2 u_{t-2} + \cdots + \rho_p u_{t-p} + \varepsilon_t$$

the null and the alternative hypothesis are:

$$H_0: \rho_1 = \rho_2 = \ \ldots\ldots.. = \rho_p = 0 \ no\ autocorrelation$$

$$H_1: at\ least\ one\ of\ the\ \rho_s\ is\ not\ zero, thus\ serial\ correlation$$

Test statistics for Breusch-Godfrey LM test:

$$LM\ test\ statistic = (T - p)R^2$$

where T is the number of observations in the basic series. p is number of lags of the error term. R^2 is coefficient of determination. The LM test statistics follows the chi-squired distribution.

$$(T - p)R^2 \sim \chi_p^2,$$

3.11.2. The Breusch-Pagan-Godfrey test for Heteroskedasticity

Heteroskedasticity is the violation of assumption which is the observations of the error terms are drawn from a distribution that has a constant variance. The assumption of constant variances for observations of the error term (homoscedasticity) is not always realistic. In general, heteroskedasticity is more likely to take place in cross-sectional models than in time series models.

The Breusch-Pagan test developed in 1979 by Trevor Breusch and Adrian Pagan is used to test heteroskedasticity in a linear regression.

Consider the regression model

$$y = \beta_0 + \beta_1 x + u \tag{17}$$

And obtain from above fitted model a set of value for $\hat{u}$ the residuals. Ordinary least squares constraints these so that their mean is 0 and so, given the assumption that their variance does not depend on the independent variables, an estimate of this variance can be obtained from the average of the squared values of the residuals. If the assumption is not held to be true, a simple model might be that the variance is linearly related to independent variables. Such a model can be examined by regressing the squared residuals on the independent variables, using an auxiliary regression equation of the form:

$$u^2 = \gamma_0 + \gamma_1 x + \vartheta \tag{18}$$

Test statistics of the Breusch-Pagan test is as follows:

$$LM = nR^2$$

Where n is sample size and R^2 is the coefficient of determination of the auxiliary regression. The test statistic is asymptotically distributed as x_{p-1}^2 under null hypothesis of homoscedasticity.

3.11.3. The Jarque-Bera Test for Normality

There are numerous formal tests for normality. One of most popular tests for the normality is the Jarque-Bera test. The Jarque-Bera test involves a statistic that is a function of skewness and excess kurtosis of the sample.

$$JB = \left(\frac{n}{6}\right)[S^2 + \left(\frac{(K-3)^2}{4}\right)]$$

Where JB is the Jarque-Bera test statistic, n is the number of observations, S is the skewness of the sample, and K is the excess kurtosis of the sample. The Jarque-Bera test is more powerful when the number of observation is larger. The test statistics follows chi-squired distribution under the null hypothesis normality with 2 degree of freedom.

$$JB \sim x_2^2$$

3.11.4. CUSUM Test

The standard CUSUM test was introduced by Brown, Durbin and Evans (1975). CUSUM test is one of the tests on structural change with unknown break point. This test based on recursive residuals which are independently distributed under the null hypothesis. The CUSUM test takes the cumulative sum of recursive residuals then plots its value against the upper and lower bounds of the 95% confidence interval at each pint. The CUSUM of squares statistic is a cumulative sum of squares residuals, expressed as a fraction of sum of squared residuals summed over all observations. The test is plotted with 5% confidence bounds. The test parameter is considered as instability when the cumulative sum of squares goes outside the area between the two critical lines.

The CUSUM statistic is as follows:

$$W_t = \frac{\sum_{r=k+1}^{N} u_r}{s} \; ; t = k+1, \dots, N$$

where u is the recursive residual, and s is the standard error of the regression fitted to all N sample points.

CHAPTER 4

ANALYSIS OF DATA

4.1. Introduction

This chapter wills analysis the collected and calculated data with intention of finding the forecasting model for household final consumption expenditure in Sri Lanka. For this analysis used the collected data of household final consumption expenditure, gross domestic product, gross domestic savings, and gross national income for the period 1978 to 2016.

4.2. Time Series Plots of Data

The time series plots are used to evaluate pattern and behaviors of data over time.

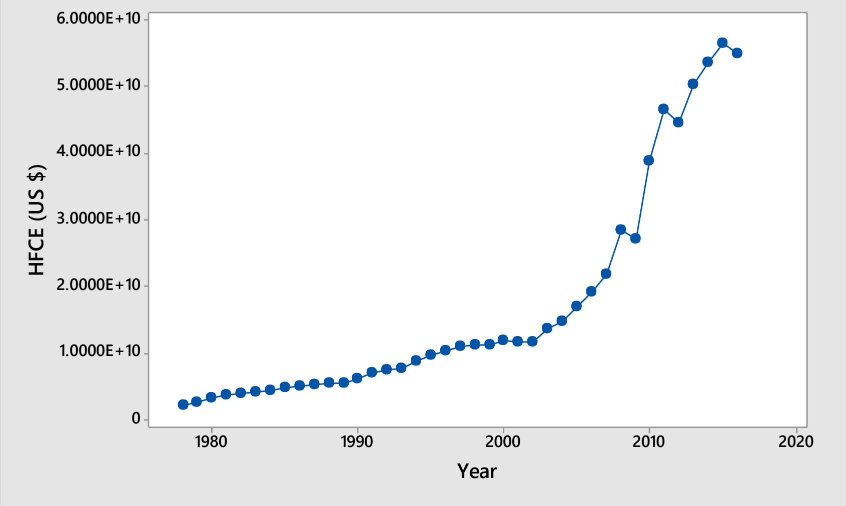


Figure 4.1: Graph of HFCE (US $) from 1978 to 2016

Figure 4.1 indicates the household final consumption expenditure is gradually increasing from 1978 to 2016 with three significant drops in 2009, 2012 and 2016. At glance the series of HFCE (US $) is non-stationary due to unavailability of constant mean and variance.

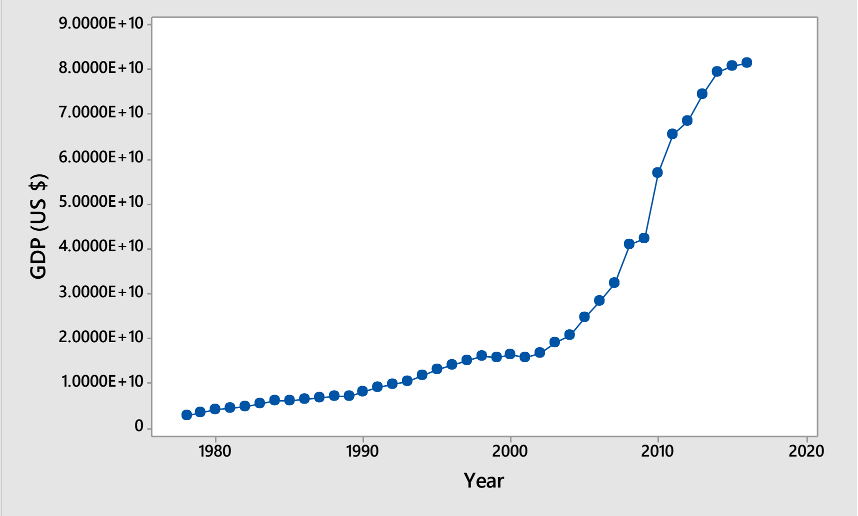


Figure 4.2: Graph of GDP (US $) from 1978 to 2016

Figure 4.2: shows the GDP (US $) is gradually increasing with year without having constant mean and constant variance. At glance the series of GDP (US $) is non-stationary.

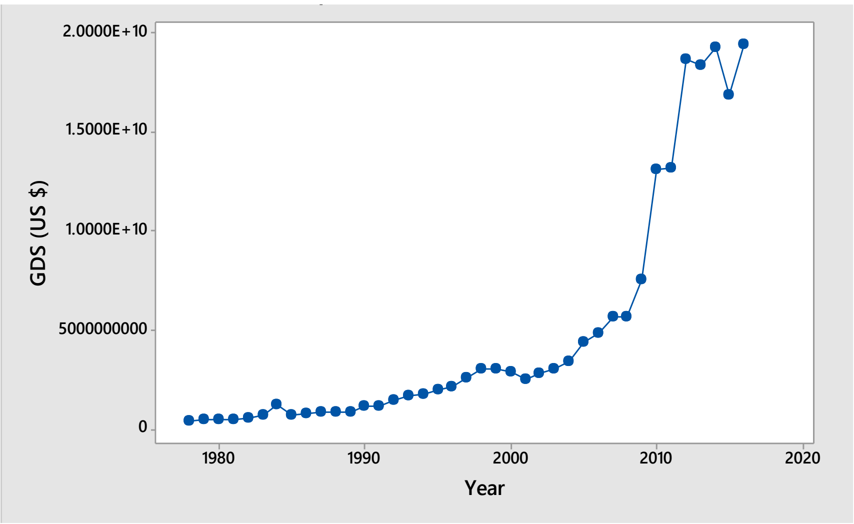


Figure 4.3: Graph of GDS (US $) from 1978 to 2016

According to figure 4.3, the series of (GDS US $) series is increasing having significant drops in 2013 and 2015. At glance the series (GDS US $) is non-stationary due to unavailability of constant mean and constant variance.

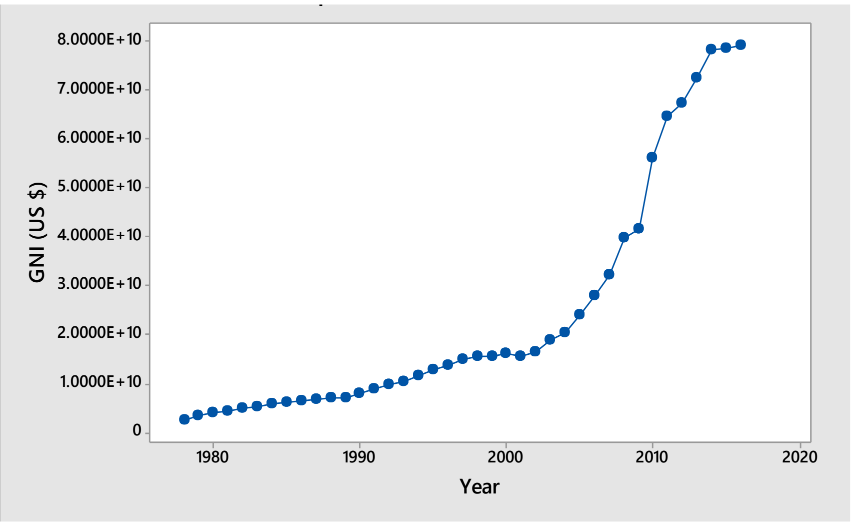


Figure 4.4: Graph of GNI (US $) from 1978 to 2016

Figure 4.4: shows the series of gross national income is non-stationary due to unavailability of constant mean and constant variance throughout the series.

4.3. Box-Cox Transformations

Box-Cox transformation is used to identify appropriate exponent of data series to transfer into normal data series by reducing variability of data.

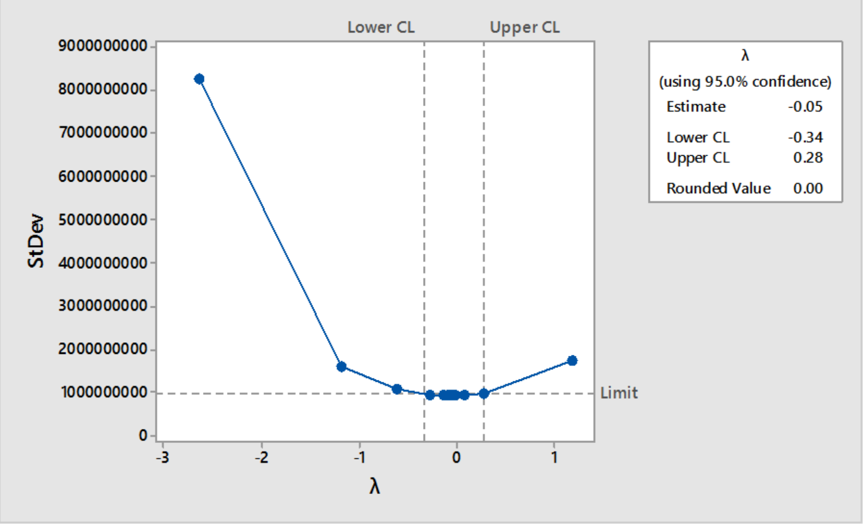


Figure 4.5: Box-Cox plot of HFCE

Figure 4.5 shows appropriate λ value is 0.00. Therefore, the natural log transformation can be used to decrease the variability of HFCE series and make series more close to the normal.

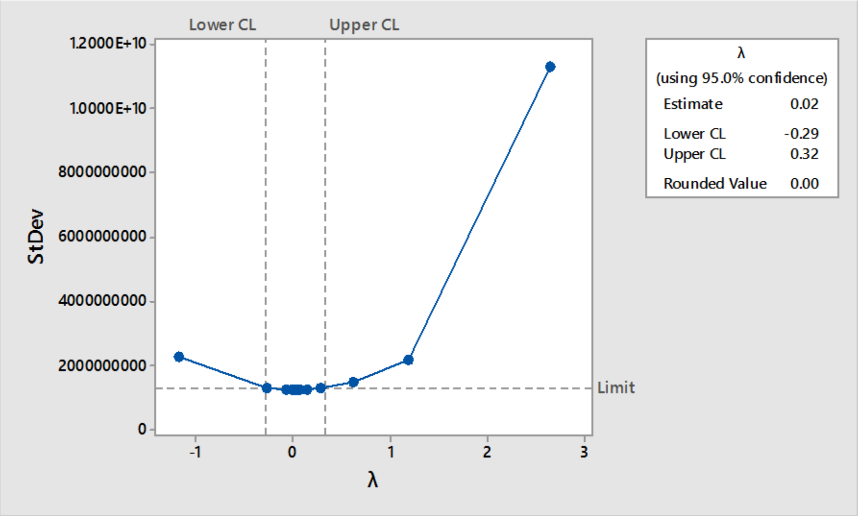


Figure 4.6: Box-Cox plot of GDP

Figure 4.6 shows appropriate λ value is 0.00. Therefore, the natural log transformation can be used to decrease the variability of GDP series and make series more close to the normal.

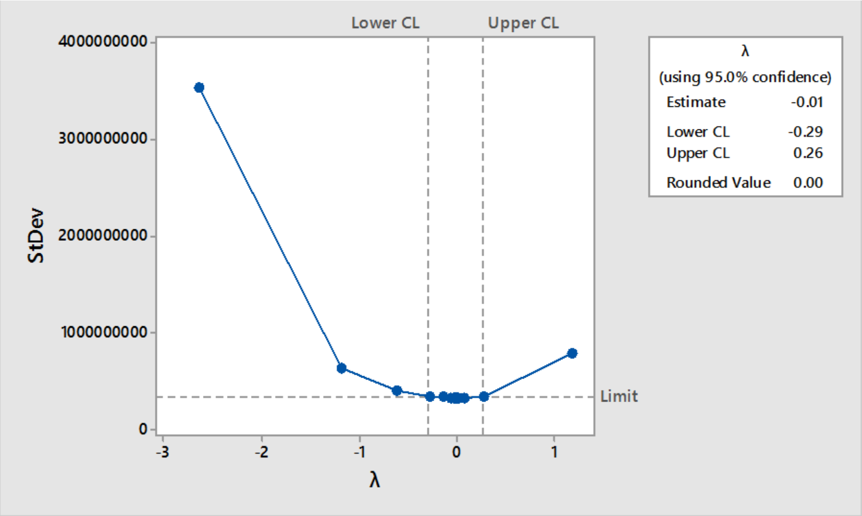


Figure 4.7: Box-Cox plot of GDS

According to figure 4.7, appropriate λ value for GDS data series is 0.00. Therefore, the natural log transformation can be used to decrease the variability of GDS series and make series more close to the normal.

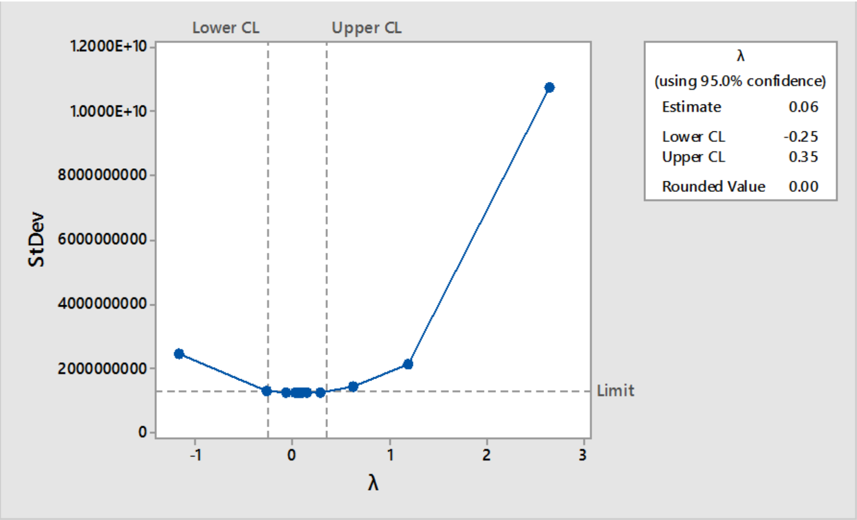


Figure 4.8: Box-Cox plot of GNI

Figure 4.8 indicates the natural log transformation of GNI series can be used to decrease variability of GNI series and make series more close to the normal.

The data series of household final consumption expenditure (HFCE), gross domestic product (GDP), gross domestic savings (GDS) and gross national income (GNI) are converted into natural log series to reduce the skewness of data. The log transformation can decrease the variability of data and make data more conform more close to the normal distribution.

4.4. Test for Stationarity

Two standard procedures of unit root test namely the Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) tests were performed to check the stationary nature of the series.

4.4.1. Augmented Dickey-Fuller Unit Root Test

Table 4.1: Augmented Dickey-Fuller Unit Root Test at Level

Variable	t-statistic	Probability Value	Decision
LNHFCE	0.481721	0.9609	Non Stationary
LNGDP	0.730092	0.9913	Non Stationary
LNGNI	0.441699	0.9823	Non Stationary
LNGDS	0.479846	0.9838	Non Stationary

Table 4.1 indicates that the null hypothesis of the unit root is present at levels for all log transformed times series LNHFCE, LNGDP, LNGNI, LNGDS are accepted due to probability values of all log transformed time series are greater than 0.05. Further, it is concluded that all log transformed time series need to be differences to make it stationary.

Table 4.2: Augmented Dickey-Fuller Unit Root Test at First Difference

Variable	t-statistic	Probability Value	Decision
LNHFCE	-7.053813	0.0000	Stationary
LNGDP	-6.795404	0.0000	Stationary
LNGNI	-7.083770	0.0000	Stationary
LNGDS	-8.047335	0.0000	Stationary

Table 4.2 indicates that the null hypothesis of the unit root is present at first differenced time series is rejected at 5% significance level due to probability values of all log transformed time series are less than 0.05. Further, concluded that it is not necessary further differencing to make times series to make it stationary.

4.4.2. Phillips-Perron (PP) Test

Table 4.3: Phillips-Perron (PP) Test at Level

Variable	t-statistic	Probability Value	Decision
LNHFCE	0.481721	0.9839	Non Stationary
LNGDP	0.774708	0.9923	Non Stationary
LNGNI	0.493788	0.9844	Non Stationary
LNGDS	0.613928	0.9884	Non Stationary

Table 4.3 indicates that the null hypothesis of the unit root is present at levels for all log transformed times series LNHFCE, LNGDP, LNGNI, LNGDS are accepted due to probability values of all log transformed time series are greater than 0.05. Further it is concluded that all log transformed time series need to be differences to make it stationary.

Table 4.4: Phillips-Perron Test (PP) at First Difference

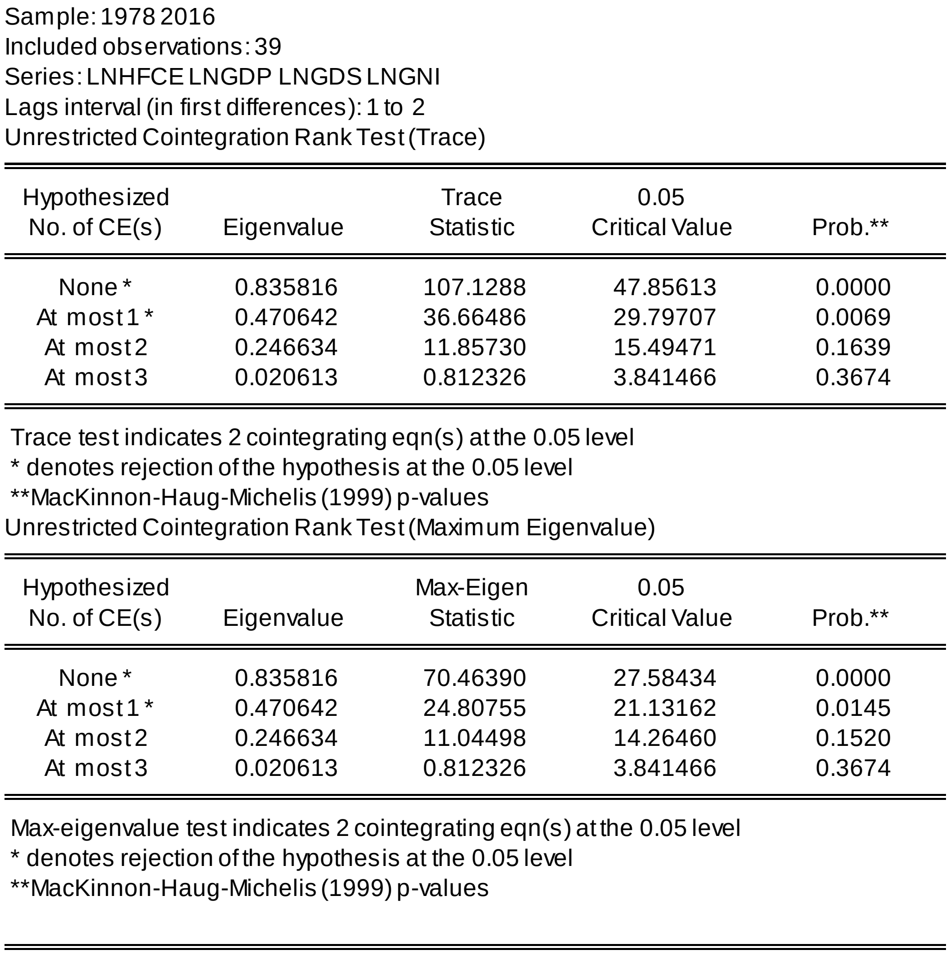
Variable	t-statistic	Probability Value	Decision
LNHFCE	-7.051849	0.0000	Stationary
LNGDP	-6.776567	0.0000	Stationary
LNGNI	-7.051811	0.0000	Stationary
LNGDS	-7.938711	0.0000	Stationary

Table 4.4 indicates that the null hypothesis of the unit root is present at first differenced time series is rejected at 5% significance level due to probability values of all log transformed time series are less than 0.05. Further, concluded that it is not necessary further differencing to make times series to make it stationary.

Results got from Augmented Dickey-Fuller Unit Root Test and Phillips-Perron test prove that log transformed time series LNHFCE, LNGDP, LNGNI, and LNGDS are integrated of order one.

4.5. Johansen Co-integration Test

According to Augmented Dickey-Fuller unit root test and Phillips-Perron test results all log transformed times series variables LNHFCE, LNGDP, LNGNI, and LNGDS are non-stationary at level. When convert all variables into first differenced, and then they are become stationary. All the variables integrate into same order. Therefore, Johansen test of co-integration can be applied.



```
Sample: 1978 2016
Included observations: 39
Series: LNHFCE LNGDP LNGDS LNGNI
Lags interval (in first differences): 1 to 2
Unrestricted Cointegration Rank Test (Trace)
=========================================================================
 Hypothesized                   Trace          0.05
  No. of CE(s)    Eigenvalue    Statistic      Critical Value    Prob.**
=========================================================================
    None *         0.835816      107.1288       47.85613         0.0000
  At most 1 *      0.470642      36.66486       29.79707         0.0069
  At most 2        0.246634      11.85730       15.49471         0.1639
  At most 3        0.020613      0.812326       3.841466         0.3674
=========================================================================
 Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
 * denotes rejection of the hypothesis at the 0.05 level
 **MacKinnon-Haug-Michelis (1999) p-values
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)
=========================================================================
 Hypothesized                   Max-Eigen      0.05
  No. of CE(s)    Eigenvalue    Statistic      Critical Value    Prob.**
=========================================================================
    None *         0.835816      70.46390       27.58434         0.0000
  At most 1 *      0.470642      24.80755       21.13162         0.0145
  At most 2        0.246634      11.04498       14.26460         0.1520
  At most 3        0.020613      0.812326       3.841466         0.3674
=========================================================================
 Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
 * denotes rejection of the hypothesis at the 0.05 level
 **MacKinnon-Haug-Michelis (1999) p-values

=========================================================================
```

Figure 4.9: Results of Co-integration Tests

Co-integration rank is estimated using Johansen methodology. Johansen's approach derives two likelihood estimators for co-integration rank: trace test and a minimum

Eigen value test. The co-integration rank can be formally tested with trace and the maximum Eigen value statistics. The trace statistic and the Eigen value statistic either rejects the null hypothesis of no co-integration among the variables or does not reject the null hypothesis that there is one co-integration relation between the variables. Starting by testing Ho: r = 0. If it rejects, repeat for Ho: r = 1. When a test is not rejected, stop testing there and that value of r is commonly used estimate of the number of co-integrating relations.

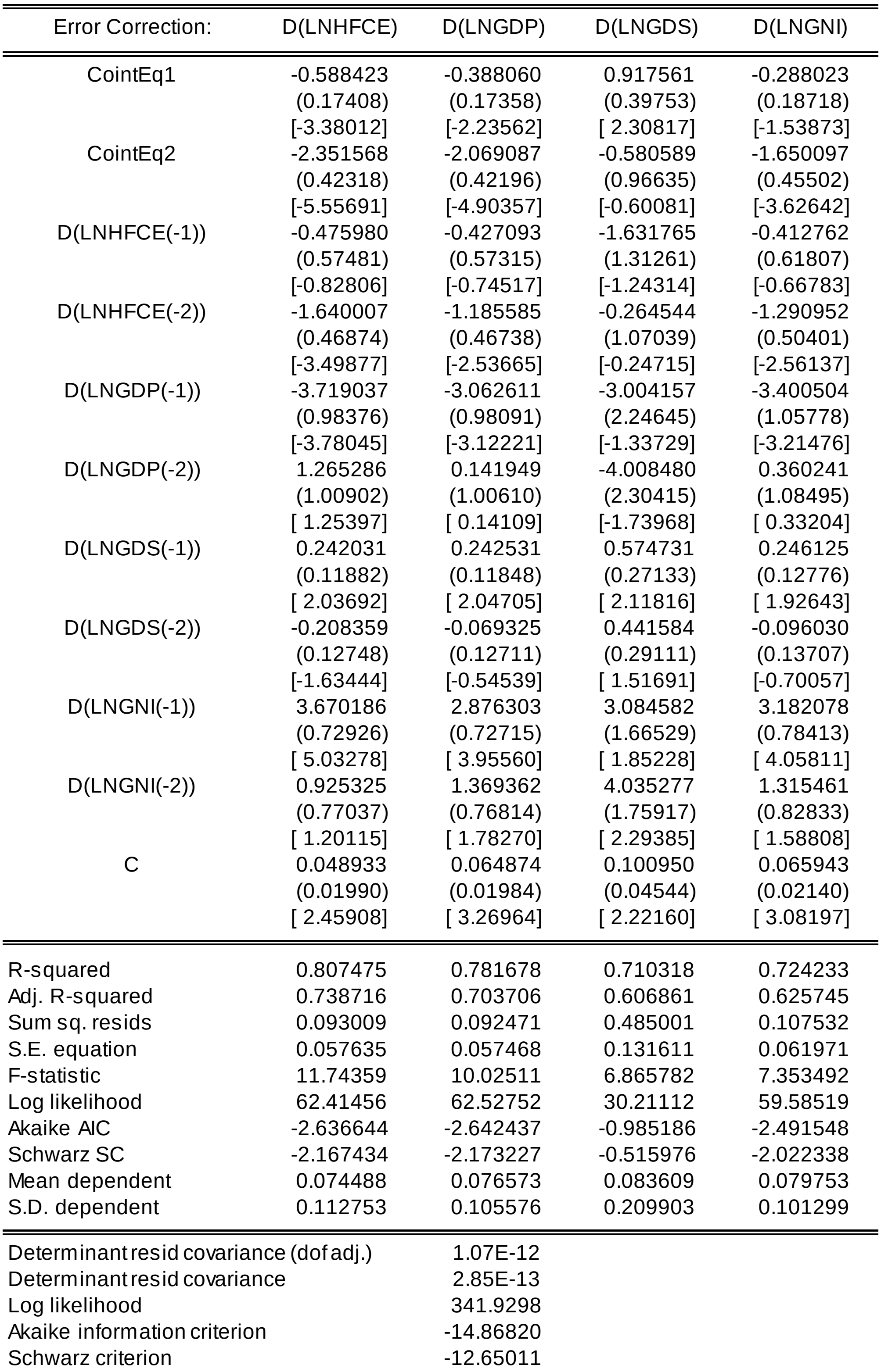
According to Figure 4.9, co-integration rank test $H_0: r = 0$ is rejected due to critical value is less than trace statistic (47.856<107.129) at the 5% level of significance. When consider $H_0: r = 1$ is also rejected due to critical value is less than the trace statistic (29.797<36.665) at 5% significance level. But when consider $H_0: r = 2$ critical value is greater than the trace statistics (15.495>11.857) therefore, null hypothesis do not rejected at 5% significant level. Similar result is given by through maximum Eigen value statistics also. In other words the trace statistics and the maximum Eigen value statistic test results do not reject the null hypothesis that these four variables are not co-integrated. The final numbers of co-integrated vectors are equal to two.

4.6. Vector Error Correction Model

The presence of co-integration among variables suggests a long run relationship among the variables of LNHFCE, LNGDP, LNGNI and LNGDS. Then, the Vector error correction model can be applied. The long run relationship among LNHFCE, LNGDP, LNGNI and LNGDS with two co-integrating vectors for Sri Lanka in the period from 1978 to 2016 is displayed below.

Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	CointEq2
LNHFCE(-1)	1.000000	0.000000
LNGDP(-1)	0.000000	1.000000
LNGDS(-1)	-1.320151	0.360878
	(0.24512)	(0.07106)
	[-5.38567]	[5.07820]
LNGNI(-1)	0.685355	-1.453895
	(0.29917)	(0.08673)
	[2.29082]	[-16.7626]
C	-10.61990	2.809226



Error Correction:	D(LNHFCE)	D(LNGDP)	D(LNGDS)	D(LNGNI)
CointEq1	-0.588423	-0.388060	0.917561	-0.288023
	(0.17408)	(0.17358)	(0.39753)	(0.18718)
	[-3.38012]	[-2.23562]	[2.30817]	[-1.53873]
CointEq2	-2.351568	-2.069087	-0.580589	-1.650097
	(0.42318)	(0.42196)	(0.96635)	(0.45502)
	[-5.55691]	[-4.90357]	[-0.60081]	[-3.62642]
D(LNHFCE(-1))	-0.475980	-0.427093	-1.631765	-0.412762
	(0.57481)	(0.57315)	(1.31261)	(0.61807)
	[-0.82806]	[-0.74517]	[-1.24314]	[-0.66783]
D(LNHFCE(-2))	-1.640007	-1.185585	-0.264544	-1.290952
	(0.46874)	(0.46738)	(1.07039)	(0.50401)
	[-3.49877]	[-2.53665]	[-0.24715]	[-2.56137]
D(LNGDP(-1))	-3.719037	-3.062611	-3.004157	-3.400504
	(0.98376)	(0.98091)	(2.24645)	(1.05778)
	[-3.78045]	[-3.12221]	[-1.33729]	[-3.21476]
D(LNGDP(-2))	1.265286	0.141949	-4.008480	0.360241
	(1.00902)	(1.00610)	(2.30415)	(1.08495)
	[1.25397]	[0.14109]	[-1.73968]	[0.33204]
D(LNGDS(-1))	0.242031	0.242531	0.574731	0.246125
	(0.11882)	(0.11848)	(0.27133)	(0.12776)
	[2.03692]	[2.04705]	[2.11816]	[1.92643]
D(LNGDS(-2))	-0.208359	-0.069325	0.441584	-0.096030
	(0.12748)	(0.12711)	(0.29111)	(0.13707)
	[-1.63444]	[-0.54539]	[1.51691]	[-0.70057]
D(LNGNI(-1))	3.670186	2.876303	3.084582	3.182078
	(0.72926)	(0.72715)	(1.66529)	(0.78413)
	[5.03278]	[3.95560]	[1.85228]	[4.05811]
D(LNGNI(-2))	0.925325	1.369362	4.035277	1.315461
	(0.77037)	(0.76814)	(1.75917)	(0.82833)
	[1.20115]	[1.78270]	[2.29385]	[1.58808]
C	0.048933	0.064874	0.100950	0.065943
	(0.01990)	(0.01984)	(0.04544)	(0.02140)
	[2.45908]	[3.26964]	[2.22160]	[3.08197]
R-squared	0.807475	0.781678	0.710318	0.724233
Adj. R-squared	0.738716	0.703706	0.606861	0.625745
Sum sq. resids	0.093009	0.092471	0.485001	0.107532
S.E. equation	0.057635	0.057468	0.131611	0.061971
F-statistic	11.74359	10.02511	6.865782	7.353492
Log likelihood	62.41456	62.52752	30.21112	59.58519
Akaike AIC	-2.636644	-2.642437	-0.985186	-2.491548
Schwarz SC	-2.167434	-2.173227	-0.515976	-2.022338
Mean dependent	0.074488	0.076573	0.083609	0.079753
S.D. dependent	0.112753	0.105576	0.209903	0.101299

Determinant resid covariance (dof adj.)	1.07E-12
Determinant resid covariance	2.85E-13
Log likelihood	341.9298
Akaike information criterion	-14.86820
Schwarz criterion	-12.65011

Figure 4.10: Vector Error Correction Estimates

The long-run co-integrating relation among LNGDP, LNGDS and LNGNI on LNHFCE is given by:

LNHFCE(-1) = -10.6199 – 1.320151*LNGDS(-1) + 0.685355*LNGNI(-1)

According to co-integration relation to LNHFCE, there is a significantly negative relation with LNGDS in the long run. A 1% increase in the LNGDS leads a 1.32% decrease in LNHFCE in the long run. Further, there is a significantly positive relation with LNGNI in the long run. A 1% increase in the LNGNI leads 0.69% increase in LNHFCE in the long run.

Vector Error Correction Model

D(LNHFCE) = - 0.588*(LNHFCE(-1) - 1.320*LNGDS(-1) + 0.685*LNGNI(-1) - 10.620) - 2.352*(LNGDP(-1) + 0.361*LNGDS(-1) -1.454*LNGNI(-1) + 2.809) - 0.476*D(LNHFCE(-1) -1.640*D(LNHFCE(-2)) – 3.719*D(LNGDP(-1)) + 1.265*D(LNGDP(-2)) + 0.242*D(LNGDS(-1)) - 0.208*D(LNGDS(-2)) +3.670*D(LNGNI(-1)) + 0.925*D(LNGNI(-2)) + 0.050

4.7. Determination Long Run Causality

```
Dependent Variable: D(LNHFCE)
Included observations: 39
D(LNHFCE) = C(1)*( LNHFCE(-1) - 1.320151049*LNGDS(-1) +
      0.68535540374*LNGNI(-1) - 10.6199013863 ) + C(2)*( LNGDP(-1) +
      0.360878013262*LNGDS(-1) - 1.45389478742*LNGNI(-1) +
      2.80922604085 ) + C(3)*D(LNHFCE(-1)) + C(4)*D(LNHFCE(-2)) + C(5)
      *D(LNGDP(-1)) + C(6)*D(LNGDP(-2)) + C(7)*D(LNGDS(-1)) + C(8)
      *D(LNGDS(-2)) + C(9)*D(LNGNI(-1)) + C(10)*D(LNGNI(-2)) + C(11)

==========================================================================
                      Coefficient    Std. Error    t-Statistic    Prob.
==========================================================================
         C(1)          -0.588423      0.174083     -3.380120     0.0021
         C(2)          -2.351568      0.423179     -5.556906     0.0000
         C(3)          -0.475980      0.574814     -0.828060     0.4146
         C(4)          -1.640007      0.468738     -3.498767     0.0016
         C(5)          -3.719037      0.983756     -3.780445     0.0008
         C(6)           1.265286      1.009023      1.253971     0.2202
         C(7)           0.242031      0.118822      2.036921     0.0512
         C(8)          -0.208359      0.127480     -1.634443     0.1134
         C(9)           3.670186      0.729256      5.032782     0.0000
        C(10)           0.925325      0.770369      1.201146     0.2398
        C(11)           0.048933      0.019899      2.459080     0.0204
==========================================================================
```

```
R-squared              0.807475   Mean dependent var       0.074488
Adjusted R-squared     0.738716   S.D. dependent var       0.112753
S.E. of regression     0.057635   Akaike info criterion   -2.636644
Sum squared resid      0.093009   Schwarz criterion       -2.167434
Log likelihood         62.41456   Hannan-Quinn criter.    -2.468295
F-statistic            11.74359   Durbin-Watson stat       2.058305
Prob(F-statistic)      0.000000
```

Figure 4.11: Coefficients estimates

$C(1)$ and $C(2)$ are coefficients of the co-integrating models. Those are also called error correction terms and as well as speed of adjustment towards long run equilibrium. According to Figure 4.11: $C(1)$ is negative and significant (probability value of $C(1)$ is 0.0021<0.05).Therefore, there is long run causality running from LNHFCE(-1), LNGDS(-1) and LNGNI(-1) towards D(LNHFCE). This suggests that with absence of changes in first lag value of variables LNHFCE, LNGDS and LNGNI, deviation of the model from the long run part is corrected by 59% increase in D(LNHFCE) per annually. This means that deviation from the long run relationship takes approximately 1.7 (1/0.588) years to eliminate disequilibrium.

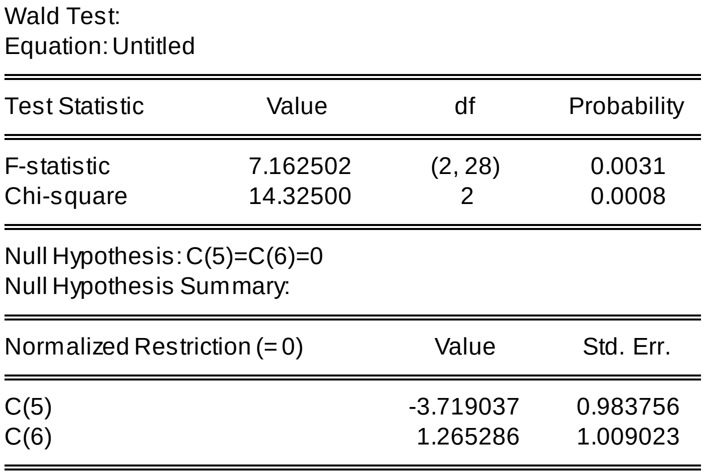
$C(2)$ is also negative and significant (probability value of $C(1)$ is 0.0000<0.05).Therefore there is long run causality running from LNGDP(-1), LNGDS(-1) and LNGNI(-1) towards D(LNHFCE). This suggests that with absence of changes in first lag value of LNGDP, LNGDS and LNGNI, deviation of the model from the long run part is corrected by 235% increase in D(LNHFCE) per annually. This means that deviation from the long run relationship takes approximately 0.4 (1/2.35) years to eliminate disequilibrium.

In addition, coefficients of D(LNHFCE(-2)) ($C(4)$) is significant and negative. It is implied that the differencing value of LNHFCE of previous two years effect to the future value of D(LNHFCE). Further, negative values of coefficient implied the value of D(LNHFCE(-2)) goes down D(LNHFCE) is goes up. Coefficients of D(LNGDP(-1)) ($C(5)$) is significant and negative. It is implied the differencing value of LNGDP of previous year significantly effect to the future values of D(LNHFCE). Further, negative sign of that implied when the LNGDP(-1) goes down LNHFCE goes up. Further coefficient of D(LNGNI(-1)) ($C(9)$) is significant and positive. It is showed that differencing value of LNGNI of previous year effect towards D(LNHFCE). Further, it is illustrated when D(LNGNI(-1)) goes up D(LNHFCE) also goes up.

The Coefficient of determination (R^2) value is 0.81. Therefore, 81% of total variation in the D(LNHFCE) is explained by all other explanatory variables.

4.8. Determination Short Run Causality

4.8.1. Determination Short Run Causality between LNHFCE and LNGDP

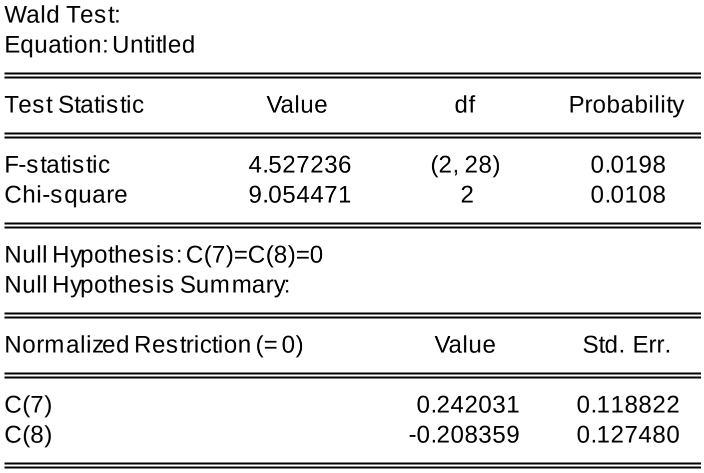


```
Wald Test:
Equation: Untitled
=========================================================
Test Statistic          Value          df      Probability
=========================================================
F-statistic           7.162502      (2, 28)      0.0031
Chi-square            14.32500         2         0.0008
=========================================================
Null Hypothesis: C(5)=C(6)=0
Null Hypothesis Summary:
=========================================================
Normalized Restriction (= 0)           Value     Std. Err.
=========================================================
C(5)                               -3.719037     0.983756
C(6)                                1.265286     1.009023
=========================================================
```

Figure 4:12 Wald Test for LNGDP coefficients

Null Hypothesis of Wald test is rejected due to probability value of chi-square test statistic is 0.0008 (0.0008<0.05). Therefore, coefficients of LNGDP not equal to zero. It is implied there is short run causality between LNGDP and LNHFCE.

4.8.2. Determination Short Run Causality between LNHFCE and LNGDS

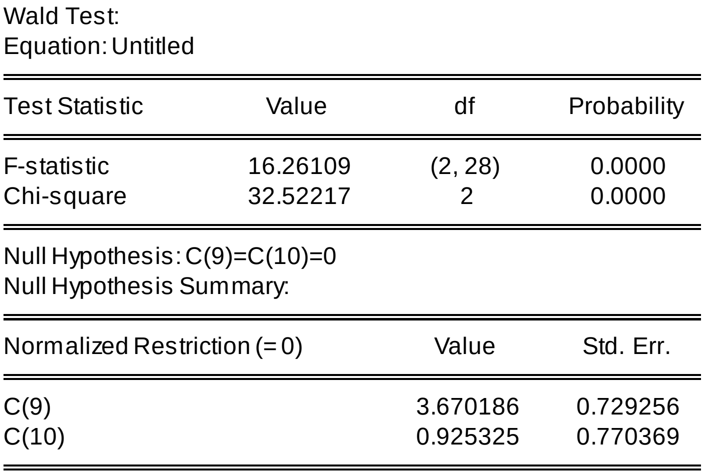


```
Wald Test:
Equation: Untitled
=========================================================
Test Statistic          Value          df      Probability
=========================================================
F-statistic           4.527236      (2, 28)      0.0198
Chi-square            9.054471         2         0.0108
=========================================================
Null Hypothesis: C(7)=C(8)=0
Null Hypothesis Summary:
=========================================================
Normalized Restriction (= 0)           Value     Std. Err.
=========================================================
C(7)                                0.242031     0.118822
C(8)                               -0.208359     0.127480
=========================================================
```

Figure 4:13 Wald Test for LNGDS coefficients

According to Figure 4:13 there is evidence to reject null hypothesis of Wald test due to probability value of Chi-square is 0.0108 (0.0108<0.05). Therefore, it is concluded that there is short run causality between LNGDS and LNHFCE.

4.8.3. Determination Short Run Causality between LNHFCE and LNGNI

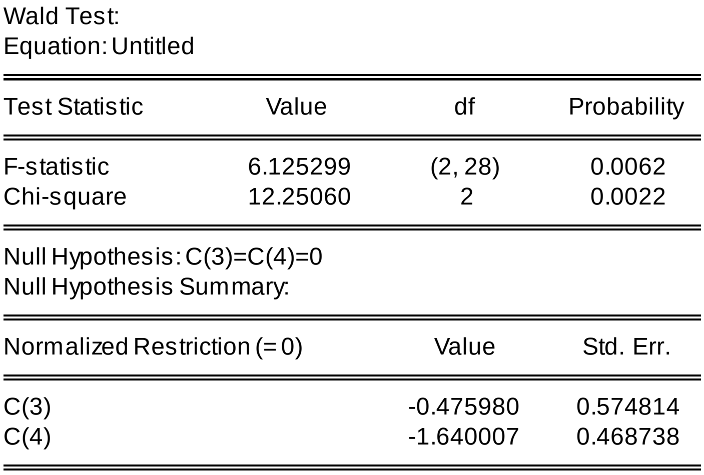


```
Wald Test:
Equation: Untitled

Test Statistic        Value          df        Probability

F-statistic          16.26109      (2, 28)       0.0000
Chi-square           32.52217        2           0.0000

Null Hypothesis: C(9)=C(10)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)         Value        Std. Err.

C(9)                               3.670186      0.729256
C(10)                              0.925325      0.770369
```

Figure 4:14 Wald Test for LNGNI coefficients

Figure 4:14 is implied there is short run causality between LNGNI and LNHFCE due to availability of strong evidence to reject null hypothesis (probability value of Chi-square statistic is 0.0000 (0.0000<0.05)).

4.8.4. Determination Short Run Causality between LNHFCE Coefficients



```
Wald Test:
Equation: Untitled

Test Statistic        Value          df        Probability

F-statistic          6.125299      (2, 28)       0.0062
Chi-square           12.25060        2           0.0022

Null Hypothesis: C(3)=C(4)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)         Value        Std. Err.

C(3)                              -0.475980      0.574814
C(4)                              -1.640007      0.468738
```

Figure 4:15 Wald Test for LNHFCE coefficients

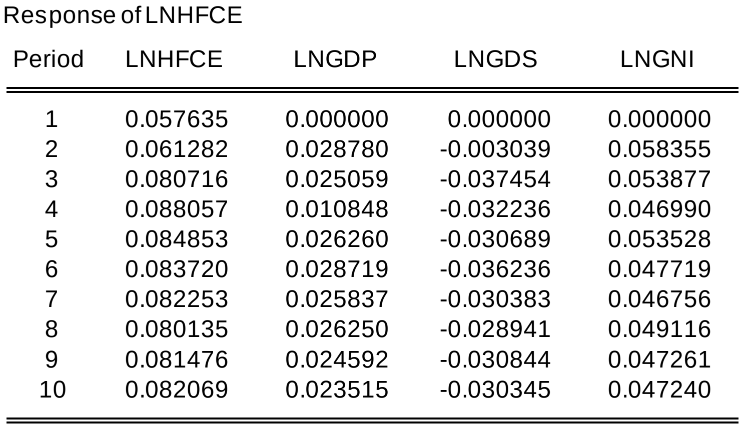
Figure 4:15 shows there is strong evidence to reject null hypothesis of Wald test due to probability value of Chi-square is 0.0022 (0.0022<0.05). Therefore, it is concluded that there is short run causality between LNHFCE coefficients.

4.9. Innovation Accounting

Innovation accounting can be used to evaluate the influence of exogenous shocks on the variables of a model.

4.9.1. Impulse Response Function

Impulse response analysis allows an analysis of the dynamics of a VEC model in its vector moving average (VMA) representation. Substantively, this allows us to trace out the dynamic impacts of changes in each of the endogenous variables over time. One of the issues in the specification of the VMA process and subsequent impulse response analysis is the ordering of the contemporaneous correlations. Here ordering of the contemporaneous correlations based on a Cholesky decomposition of the estimated residual covariance matrix are presented.



Response of LNHFCE

Period	LNHFCE	LNGDP	LNGDS	LNGNI
1	0.057635	0.000000	0.000000	0.000000
2	0.061282	0.028780	-0.003039	0.058355
3	0.080716	0.025059	-0.037454	0.053877
4	0.088057	0.010848	-0.032236	0.046990
5	0.084853	0.026260	-0.030689	0.053528
6	0.083720	0.028719	-0.036236	0.047719
7	0.082253	0.025837	-0.030383	0.046756
8	0.080135	0.026250	-0.028941	0.049116
9	0.081476	0.024592	-0.030844	0.047261
10	0.082069	0.023515	-0.030345	0.047240

Figure 4.16: Impulse Response Analysis

According to impulse response analysis shown in figure 4.16, when one standard deviation of positive impulse is given on LNHFCE, LNHFCE is laid in positive direction in short runs as well as long run. Further, when one standard deviation of positive impulse is given on LNGDP, the LNHFCE is fluctuated in positive direction. But when one standard deviation of positive impulse is given on LNGDS, the LNHFCE is laid in negative direction, when one standard deviation of positive impulse is given on LNGNI the LNHFCE is decreased in positive direction when goes to from short runs to long runs

4.9.2. Variance Decomposition

Variance Decomposition of LNHFCE:

Period	S.E.	LNHFCE	LNGDP	LNGDS	LNGNI
1	0.057635	100.0000	0.000000	0.000000	0.000000
2	0.106396	62.51951	7.317119	0.081605	30.08176
3	0.150893	59.69757	6.395983	6.201640	27.70481
4	0.184086	62.99162	4.644652	7.233331	25.13040
5	0.213505	62.62333	4.965603	7.443414	24.96765
6	0.238764	62.36887	5.417277	8.255124	23.95872
7	0.259905	62.65075	5.560083	8.333345	23.45583
8	0.279126	62.56164	5.705102	8.300247	23.43301
9	0.297219	62.69112	5.716253	8.397352	23.19528
10	0.314293	62.88339	5.671828	8.441980	23.00280

Figure 4.17: Variance Decomposition Results

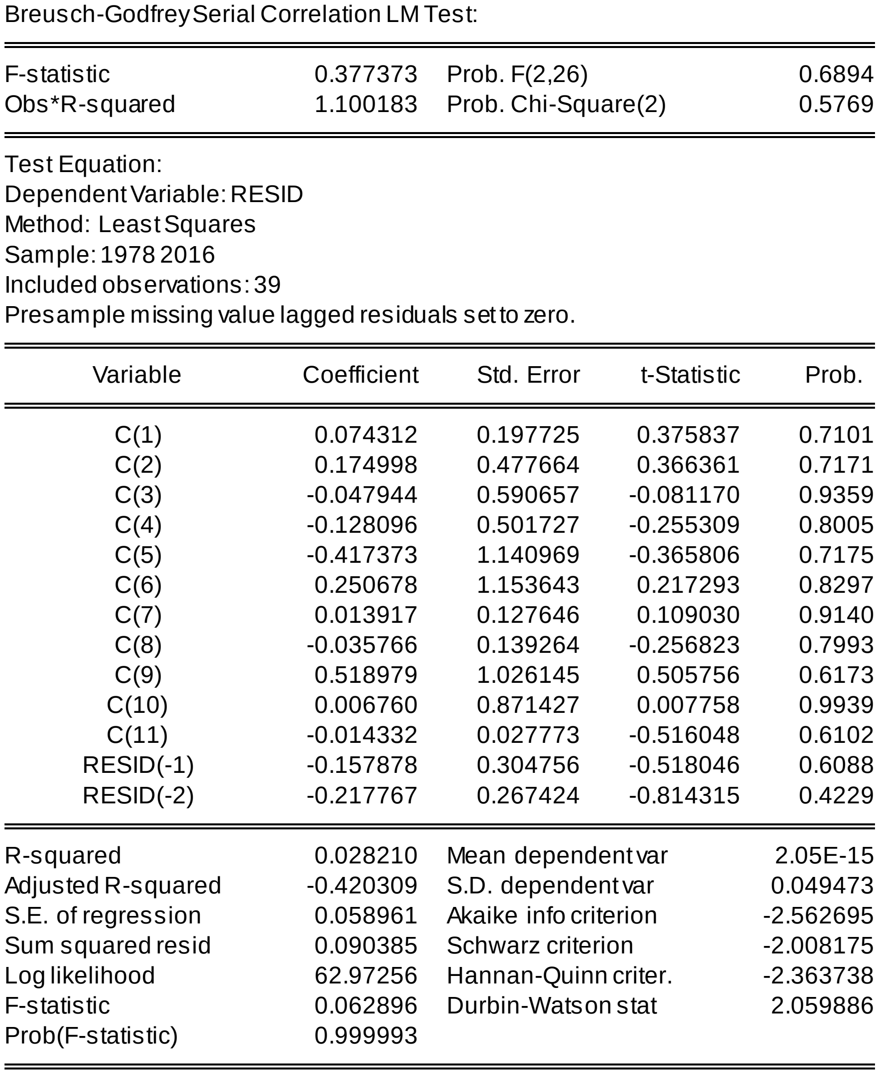
According to Variance decomposition of LNHFCE results, the impulse to LNHFCE is caused to keep approximately constant the variance fluctuations of LNHFCE from short run to long run. For example at the period 2, it contributes 62.52% variance fluctuation of LNHFCE. At the period 10, LNHFCE contribute 62.88% variance fluctuation of LNHFCE. Further, the impulse on LNGDP is caused to decrease the variance fluctuation of LNHFCE from short run to long run. For example at the period 2, impulse on LNGDP can cause 7.32% variance fluctuation of LNHFCE. At the period 10, impulse on LNGDP can cause 5.67% variance fluctuation of LNHFCE. The impulses on LNGDS is contributed much variance fluctuation of LNHFCE in long runs than short run. At the period 2, LNGDS contributes 0.82% variance fluctuation of LNHFCE. At the period 10, it has increased up to 8.44%. But impulse on LNGNI is caused to decrease variance fluctuations of LNHFCE gradually from short run to long run. For example at the period 2, LNGNI can cause 30.08% variance fluctuation of LNHFCE. At the period 10, it becomes 23.00%.

4.10. Residual Diagnostics Tests

Model accuracy is checked using diagnostic tests Breusch-Godfrey serial correlation LM test for serial correlation, Breusch-Pargon-Godfrey Test for Heteroskedasticity, Jarque-Bera test for normality, CUSUM test for stability of the model.

4.10.1. Serial Correlation

Serial correlation is also called as autocorrelation. It is the relationship between a given variable and itself over various time periods.



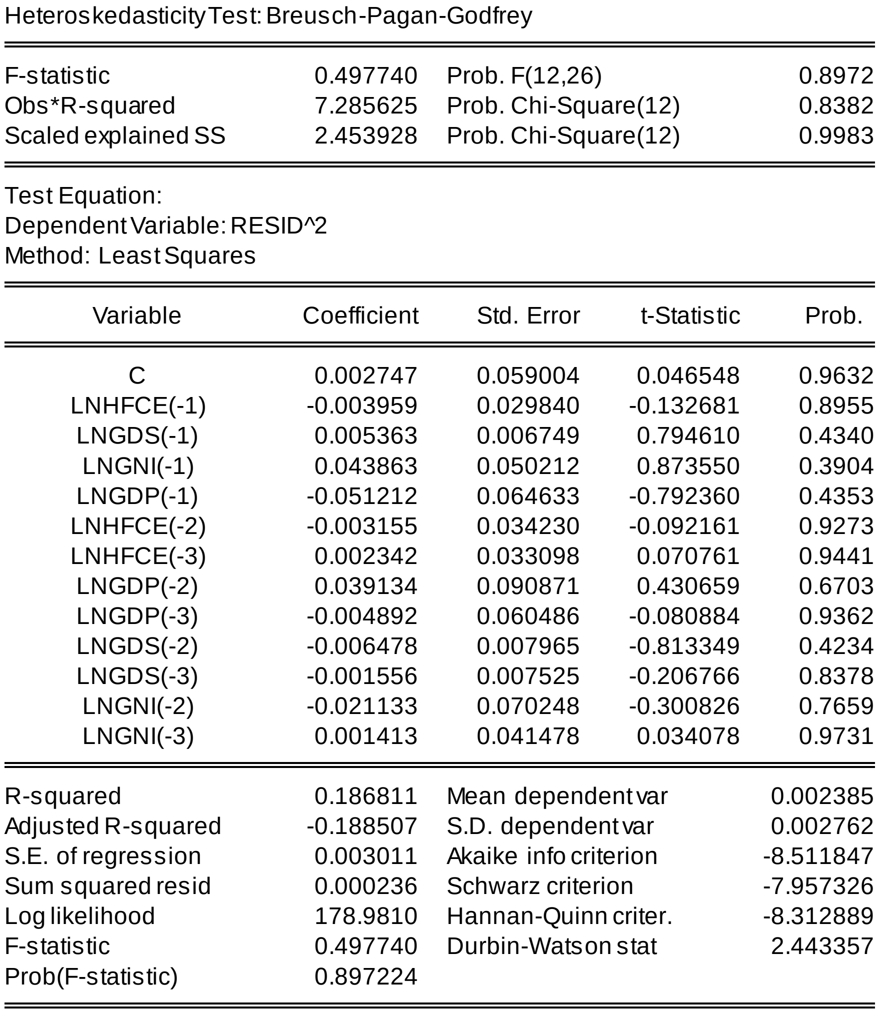
```
Breusch-Godfrey Serial Correlation LM Test:

F-statistic              0.377373   Prob. F(2,26)               0.6894
Obs*R-squared            1.100183   Prob. Chi-Square(2)         0.5769

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Sample: 1978 2016
Included observations: 39
Presample missing value lagged residuals set to zero.

        Variable          Coefficient    Std. Error    t-Statistic     Prob.

          C(1)              0.074312      0.197725      0.375837      0.7101
          C(2)              0.174998      0.477664      0.366361      0.7171
          C(3)             -0.047944      0.590657     -0.081170      0.9359
          C(4)             -0.128096      0.501727     -0.255309      0.8005
          C(5)             -0.417373      1.140969     -0.365806      0.7175
          C(6)              0.250678      1.153643      0.217293      0.8297
          C(7)              0.013917      0.127646      0.109030      0.9140
          C(8)             -0.035766      0.139264     -0.256823      0.7993
          C(9)              0.518979      1.026145      0.505756      0.6173
          C(10)             0.006760      0.871427      0.007758      0.9939
          C(11)            -0.014332      0.027773     -0.516048      0.6102
        RESID(-1)          -0.157878      0.304756     -0.518046      0.6088
        RESID(-2)          -0.217767      0.267424     -0.814315      0.4229

R-squared                0.028210   Mean dependent var        2.05E-15
Adjusted R-squared      -0.420309   S.D. dependent var        0.049473
S.E. of regression       0.058961   Akaike info criterion    -2.562695
Sum squared resid        0.090385   Schwarz criterion        -2.008175
Log likelihood           62.97256   Hannan-Quinn criter.     -2.363738
F-statistic              0.062896   Durbin-Watson stat        2.059886
Prob(F-statistic)        0.999993
```

Figure 4.18: Breusch-Godfrey Serial Correlation LM Test

Figure 4.18 implied the probability value of chi square Breusch-Godfrey serial correlation LM test (0.5769) is not less than the 0.05. Therefore, there is no strong evidence to reject null hypothesis of the Breusch-Godfrey serial correlation LM

Test. Therefore, we can be concluded that there is no serial correlation in model residuals.

4.10.2. Testing Heteroskedasticity



Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.497740	Prob. F(12,26)	0.8972
Obs*R-squared	7.285625	Prob. Chi-Square(12)	0.8382
Scaled explained SS	2.453928	Prob. Chi-Square(12)	0.9983

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.002747	0.059004	0.046548	0.9632
LNHFCE(-1)	-0.003959	0.029840	-0.132681	0.8955
LNGDS(-1)	0.005363	0.006749	0.794610	0.4340
LNGNI(-1)	0.043863	0.050212	0.873550	0.3904
LNGDP(-1)	-0.051212	0.064633	-0.792360	0.4353
LNHFCE(-2)	-0.003155	0.034230	-0.092161	0.9273
LNHFCE(-3)	0.002342	0.033098	0.070761	0.9441
LNGDP(-2)	0.039134	0.090871	0.430659	0.6703
LNGDP(-3)	-0.004892	0.060486	-0.080884	0.9362
LNGDS(-2)	-0.006478	0.007965	-0.813349	0.4234
LNGDS(-3)	-0.001556	0.007525	-0.206766	0.8378
LNGNI(-2)	-0.021133	0.070248	-0.300826	0.7659
LNGNI(-3)	0.001413	0.041478	0.034078	0.9731

R-squared	0.186811	Mean dependent var	0.002385
Adjusted R-squared	-0.188507	S.D. dependent var	0.002762
S.E. of regression	0.003011	Akaike info criterion	-8.511847
Sum squared resid	0.000236	Schwarz criterion	-7.957326
Log likelihood	178.9810	Hannan-Quinn criter.	-8.312889
F-statistic	0.497740	Durbin-Watson stat	2.443357
Prob(F-statistic)	0.897224		

Figure 4.19: Breusch-Pagan-Godfrey Test for Heteroskedasticity

According to figure 4.19 there is no heteroskedasticity of this model due to unavailability of evidences to reject null hypothesis of heteroskedasticity test (Probability value of observed R squared is 0.8382) which model residuals is homoscedastic at 5% significance level.

4.10.3. Normality Test

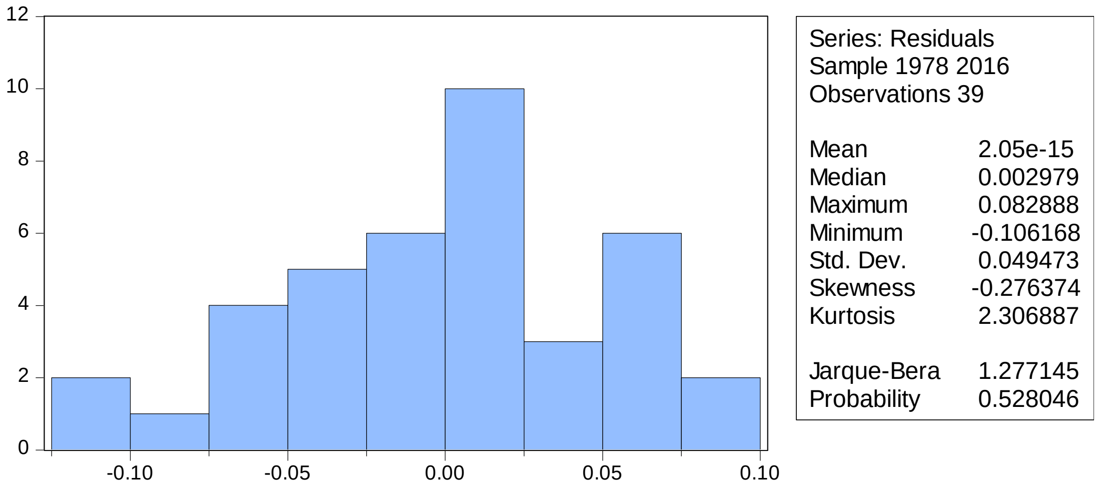


Figure 4.20: Histogram of Normality Test

The probability of Histogram of Normality test is 0.528 which is greater than the 0.05. Therefore, there is no strong evidence to reject null hypothesis which residuals are normally distributed. Hence, we can conclude that residuals of this model are normally distributed.

4.10.4. CUSUM Test

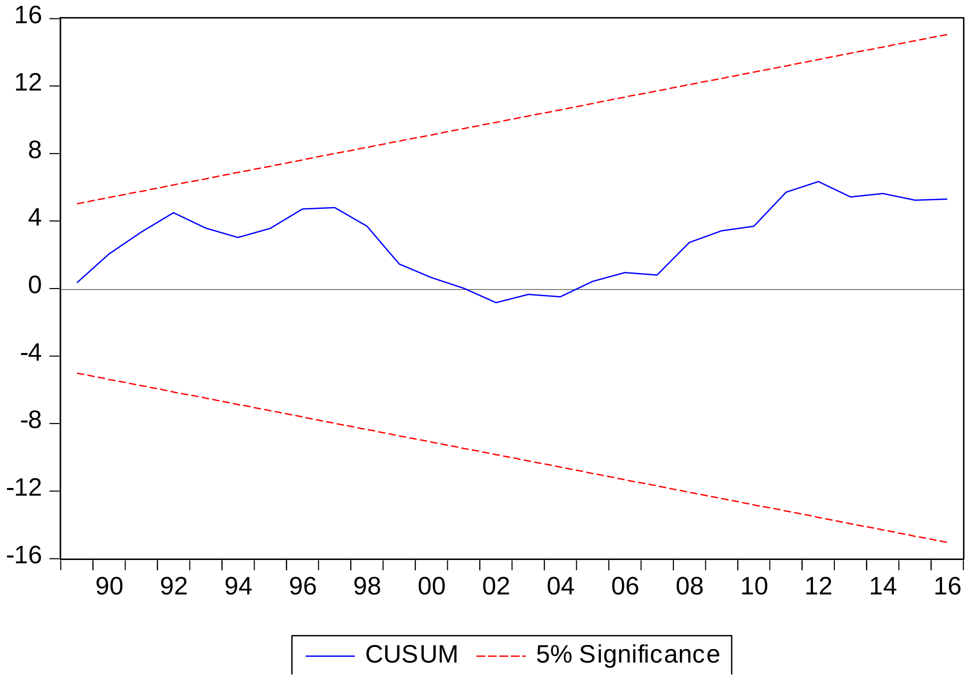


Figure 4.21: Recursive Estimates-CUSUM Test

According to CUSUM test results in figure 4.21 model lies within the 5% significance boundary. Therefore, Test finds parameter stability that parameter constancy exists in the sample period.

4.11. Chapter Summary

- Box-Cox Transformations implied appropriate λ value is 0.00 for Household final consumption expenditure, Gross domestic product, Gross national income, Gross domestic saving. Therefore, natural log transformation was applied to decrease the variability of all series to make series more close to normal.
- Augmented Dickey–Fuller and Phillips-Perron (PP) tests proved that log transformed series LNHFCE, LNGDP, LNGNI, LNGDS are integrated at order one.
- Johansen co-integration test show final numbers of co-integrated vectors are equal to two.
- LNHFCE show significantly negative relation with LNGDS in the long run. Further, LNHFCE show significantly positive relation with LNGNI in the long run.
- The Wald test results depicted that coefficient of LNHFCE, LNGDP, LNGDS, LNGNI were significant.
- Impulse response analysis revealed that one standard deviation of positive impulse on LNHFCE, LNGNI and LNGDP caused to give positive impact on LNHFCE. But LNGDS has negative impact on LNHFCE.
- The Variance decomposition analysis revealed that major proportion of the forecast error variability in the LNHFCE was explained by its own innovations.
- The Coefficient of determination (R^2) was 0.81. Therefore, almost 81% of total variation of LNHFCE is explained by all other explanatory variables.
- The residual diagnostics confirmed the accuracy of the fitted model.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study investigated the behaviours of macroeconomic variables namely gross domestic product, gross domestic savings and gross national income on household final consumption expenditure in Sri Lanka.

The appropriate exponents of Box-Cox transformations of all macroeconomic variables namely household final consumption expenditure, gross domestic product, gross domestic savings and gross national income is 0.00. Therefore, natural log transformation was applied to all macroeconomic variables which considered in this analysis. According to Augmented Dickey-Fuller unit root test and Phillips-Perron test results all log transformed times series variables namely LNHFCE, LNGDP, LNGNI, and LNGDS are non-stationary at level. When convert all variables into first differenced, and then they become stationary. All the variables integrate into same order. Therefore, Johansen test of co-integration was applied.

The lowest value of Akaike Information Criterion and Hannan-Quinn Information Criterion showed at lag 2. Therefore, took lag 2 as optimum lag for this analysis. The Johansen co-integration test proved that the LNHFCE co-integrated with LNGDP, LNGDS and LNGNI also it has long run relationship among the variables LNGNI and LNGDS.

In the vector error correction model analysis in Figure 4.11 shows that error correction term C(1) is negative and significant. That suggests that with absence of changes in first lag value of variables namely LNHFCE, LNGDS and LNGNI, deviation of the model from the long run part is corrected by 59% increase in D(LNHFCE) per annually. This means that deviation from the long run relationship takes approximately 1.7 (1/0.588) years to eliminate disequilibrium.

Furthermore, error correction term C(2) is negative and significant. That suggests that with absence of changes in first lag value of variables namely LNGDP, LNGDS and LNGNI, deviation of the model from the long run part is corrected by 235% increase in D(LNHFCE) per annually. This means that deviation from the long run relationship takes approximately 0.4 (1/2.35) years to eliminate disequilibrium.

According to Wald test results coefficients of LNHFCE, LNGDP, LNGDS and LNGNI are significant. That implies that the model shows short run effects from LNHFCE, LNGDP, LNGDS and LNGNI.

According to Variance decomposition of LNHFCE results, the impulse to LNHFCE causes to keeping approximately constant the variance fluctuations in LNHFCE short run as well as long run. Further, the impulse on LNGDP causes to decrease the fluctuation of variance in LNHFCE from short run to long run. The impulse on LNGDS contributes much fluctuation of variance in LNHFCE in long runs than short run. But impulse on LNGNI tends to decrease fluctuation of variance in LNHFCE gradually from short run to long run. The variance decomposition analysis reveals that major proportion of the forecast error variability in the LNHFCE is explained by its own innovations.

Impulse response analysis shows that the one standard deviation of positive impulse on LNHFCE, LNHFCE is laid in positive direction in short runs as well as long runs. When given one standard deviation of positive impulse on LNGDP and LNGNI, those have positive impact on LNHFCE. One standard deviation of positive impulse on LNGDS, It has negative impact on LNHFCE in short runs as well as in long runs.

The study proves that the macroeconomic variables gross domestic savings and gross national income are significantly impact on household final consumption expenditure in Sri Lanka in the long run.

This study gives important guidance for policymakers, economists and researches those who are great deal of interest on consumption expenditures, economic growth and savings. It proposed that household consumption in Sri Lanka is the function domestic income and domestic savings. It also proved the statement of Keynes, John M. (1936) which is the current consumption expenditure is a highly dependable and stable function of current income. Further, it proved the statement that when real income is increased it will not increase its consumption by an equal amount.

5.2 Recommendations

The results of the study provide useful lessons for policymakers, economists and future researches and academicians those who are great deal of interest on household consumptions, economic growth, savings and income. The study gives important discussion for economists and policymakers about the relationships among income, savings and economic growth towards household consumption expenditures.

The division of income between consumption and savings is the importance of savings for accumulation of the wealth of nations help for growth in their capacity to produce goods and services. In other words consumption uses productive resources in the present while savings enhance the resources available for production and consumption in the future. In this study gives positive relationship between household final consumption expenditure and gross national income and significantly negative relationship with gross domestic savings in long run. Therefore, it is essential to make policies to enhance the national income and domestic savings. It will be useful to enhance productive resources which are used in consumptions and also enhance savings for the resources available for production and consumption in the future.

5.3 Suggestion for Further Research

In this study macroeconomic variables namely gross domestic product, gross domestic savings and gross national income were used to identify effects on household final consumption expenditure. In addition to that other macroeconomic variables, for instances exchange rate, inflation rate, interest rate, unemployment rate and other variables particularly price of oil, price of gold might be affected to household final consumption expenditure. Therefore, future researches can extend including those variables as well.

For this study annual data from 1978 to 2016 were used. But if use longer data periods than that, would be able to get more comprehensive results.

In practice household consumption expenditures depends on the individual income and rather than the gross national income. Therefore, better get variable which represent the accurate individual income for the future studies.

5.4 Limitations

There might be many factors which effect to the household consumption expenditure for instances exchange rate, inflation rate, interest rate, unemployment rate, price of oil, price of gold. Current study limits only three variables gross domestic product, gross domestic savings, and gross national income.

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```
Null Hypothesis: LNHFCE has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)
==========================================================================
                                                  t-Statistic     Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic             0.481721      0.9839
--------------------------------------------------------------------------
Test critical values:        1% level             -3.610453
                             5% level             -2.938987
                             10% level            -2.607932
==========================================================================
*MacKinnon (1996) one-sided p-values.
==========================================================================
      Variable           Coefficient    Std. Error    t-Statistic    Prob.
==========================================================================
     LNHFCE(-1)            0.009712      0.020162      0.481721     0.6328
          C               -0.149387      0.465096     -0.321195     0.7499
==========================================================================
R-squared                  0.006233    Mean dependent var           0.074488
Adjusted R-squared        -0.020626    S.D. dependent var           0.112753
S.E. of regression         0.113910    Akaike info criterion       -1.456904
Sum squared resid          0.480089    Schwarz criterion           -1.371593
Log likelihood             30.40963    Hannan-Quinn criter.        -1.426295
F-statistic                0.232055    Durbin-Watson stat           1.849553
Prob(F-statistic)          0.632841
==========================================================================
```

Appendix I: Augmented Dickey –Fuller Test of LNHFCE at level

```
Null Hypothesis: D(LNHFCE) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)
==========================================================================
                                                  t-Statistic     Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic            -7.053813      0.0000
--------------------------------------------------------------------------
Test critical values:        1% level             -3.610453
                             5% level             -2.938987
                             10% level            -2.607932
==========================================================================
*MacKinnon (1996) one-sided p-values.
==========================================================================
      Variable           Coefficient    Std. Error    t-Statistic    Prob.
==========================================================================
   D(LNHFCE(-1))          -1.157842      0.164144     -7.053813     0.0000
          C                0.086746      0.022116      3.922287     0.0004
==========================================================================
R-squared                  0.573518    Mean dependent var          -0.003172
Adjusted R-squared         0.561991    S.D. dependent var           0.170536
S.E. of regression         0.112865    Akaike info criterion       -1.475336
Sum squared resid          0.471321    Schwarz criterion           -1.390025
Log likelihood             30.76905    Hannan-Quinn criter.        -1.444727
F-statistic                49.75628    Durbin-Watson stat           1.532478
Prob(F-statistic)          0.000000
==========================================================================
```

Appendix II: Augmented Dickey –Fuller Test of LNHFCE at First Difference

```
Null Hypothesis: LNGDP has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)
========================================================================
                                                 t-Statistic    Prob.*
========================================================================
Augmented Dickey-Fuller test statistic            0.730092     0.9913
------------------------------------------------------------------------
Test critical values:       1% level             -3.610453
                            5% level             -2.938987
                           10% level             -2.607932
========================================================================
*MacKinnon (1996) one-sided p-values.
========================================================================
      Variable         Coefficient    Std. Error    t-Statistic    Prob.
========================================================================
     LNGDP(-1)           0.013023      0.017837      0.730092     0.4699
         C              -0.227697      0.417101     -0.545902     0.5884
========================================================================
R-squared                0.014202    Mean dependent var          0.076573
Adjusted R-squared      -0.012441    S.D. dependent var          0.105576
S.E. of regression       0.106230    Akaike info criterion      -1.596494
Sum squared resid        0.417541    Schwarz criterion          -1.511183
Log likelihood           33.13162    Hannan-Quinn criter.       -1.565885
F-statistic              0.533034    Durbin-Watson stat          1.579488
Prob(F-statistic)        0.469931
========================================================================
```

Appendix III: Augmented Dickey –Fuller Test of LNGDP at Level

```
Null Hypothesis: D(LNGDP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)
========================================================================
                                                 t-Statistic    Prob.*
========================================================================
Augmented Dickey-Fuller test statistic           -6.795404     0.0000
------------------------------------------------------------------------
Test critical values:       1% level             -3.610453
                            5% level             -2.938987
                           10% level             -2.607932
========================================================================
*MacKinnon (1996) one-sided p-values.
========================================================================
      Variable         Coefficient    Std. Error    t-Statistic    Prob.
========================================================================
    D(LNGDP(-1))        -1.112405      0.163700     -6.795404     0.0000
         C               0.085539      0.021456      3.986727     0.0003
========================================================================
R-squared                0.555168    Mean dependent var         -0.003200
Adjusted R-squared       0.543146    S.D. dependent var          0.157295
S.E. of regression       0.106318    Akaike info criterion      -1.594853
Sum squared resid        0.418226    Schwarz criterion          -1.509542
Log likelihood           33.09963    Hannan-Quinn criter.       -1.564244
F-statistic              46.17751    Durbin-Watson stat          1.311334
Prob(F-statistic)        0.000000
========================================================================
```

Appendix IV: Augmented Dickey –Fuller Test of LNGDP at First Difference

Null Hypothesis: LNGNI has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.441699	0.9823
Test critical values:	1% level	-3.610453	
	5% level	-2.938987	
	10% level	-2.607932	

*MacKinnon (1996) one-sided p-values.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNGNI(-1)	0.007565	0.017126	0.441699	0.6613
C	-0.096873	0.400213	-0.242052	0.8101

R-squared	0.005245	Mean dependent var	0.079753
Adjusted R-squared	-0.021640	S.D. dependent var	0.101299
S.E. of regression	0.102389	Akaike info criterion	-1.670147
Sum squared resid	0.387893	Schwarz criterion	-1.584837
Log likelihood	34.56788	Hannan-Quinn criter.	-1.639539
F-statistic	0.195098	Durbin-Watson stat	1.722956
Prob(F-statistic)	0.661278		

Appendix V: Augmented Dickey –Fuller Test of LNGNI at Level

Null Hypothesis: D(LNGNI) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.083770	0.0000
Test critical values:	1% level	-3.610453	
	5% level	-2.938987	
	10% level	-2.607932	

*MacKinnon (1996) one-sided p-values.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNGNI(-1))	-1.153698	0.162865	-7.083770	0.0000
C	0.092547	0.021158	4.374053	0.0001

R-squared	0.575590	Mean dependent var	-0.003488
Adjusted R-squared	0.564119	S.D. dependent var	0.153655
S.E. of regression	0.101445	Akaike info criterion	-1.688674
Sum squared resid	0.380773	Schwarz criterion	-1.603363
Log likelihood	34.92913	Hannan-Quinn criter.	-1.658065
F-statistic	50.17979	Durbin-Watson stat	1.396118
Prob(F-statistic)	0.000000		

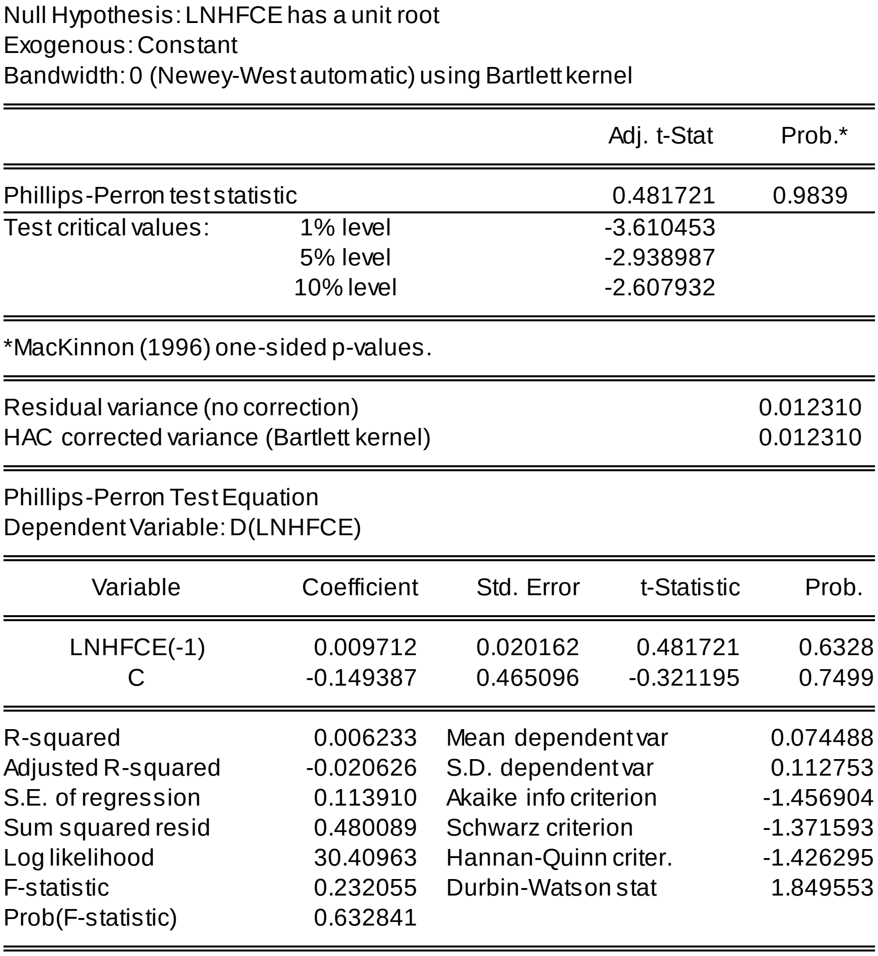
Appendix VI: Augmented Dickey –Fuller Test of LNGNI at First Difference

```
Null Hypothesis: LNGDS has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)
==========================================================================
                                                 t-Statistic     Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic            0.479846       0.9838
--------------------------------------------------------------------------
Test critical values:        1% level            -3.610453
                             5% level            -2.938987
                             10% level           -2.607932
==========================================================================
*MacKinnon (1996) one-sided p-values.
==========================================================================
      Variable          Coefficient    Std. Error    t-Statistic    Prob.
==========================================================================
     LNGDS(-1)           0.014389      0.029988      0.479846      0.6342
         C              -0.226302      0.646747     -0.349907      0.7284
==========================================================================
R-squared                0.006185    Mean dependent var          0.083609
Adjusted R-squared      -0.020675    S.D. dependent var          0.209903
S.E. of regression       0.212062    Akaike info criterion      -0.213955
Sum squared resid        1.663902    Schwarz criterion          -0.128644
Log likelihood           6.172128    Hannan-Quinn criter.       -0.183346
F-statistic              0.230252    Durbin-Watson stat          2.051829
Prob(F-statistic)        0.634162
==========================================================================
```

Appendix VII: Augmented Dickey –Fuller Test of LNGDS at Level

```
Null Hypothesis: D(LNGDS) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)
==========================================================================
                                                 t-Statistic     Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic           -8.047335       0.0000
--------------------------------------------------------------------------
Test critical values:        1% level            -3.610453
                             5% level            -2.938987
                             10% level           -2.607932
==========================================================================
*MacKinnon (1996) one-sided p-values.
==========================================================================
      Variable          Coefficient    Std. Error    t-Statistic    Prob.
==========================================================================
    D(LNGDS(-1))        -1.245365      0.154755     -8.047335      0.0000
         C               0.105762      0.035800      2.954213      0.0054
==========================================================================
R-squared                0.636398    Mean dependent var         -0.006676
Adjusted R-squared       0.626571    S.D. dependent var          0.336847
S.E. of regression       0.205843    Akaike info criterion      -0.273484
Sum squared resid        1.567742    Schwarz criterion          -0.188174
Log likelihood           7.332946    Hannan-Quinn criter.       -0.242876
F-statistic              64.75960    Durbin-Watson stat          1.545917
Prob(F-statistic)        0.000000
==========================================================================
```

Appendix VIII: Augmented Dickey –Fuller Test of LNGDS at First Difference



```
Null Hypothesis: LNHFCE has a unit root
Exogenous: Constant
Bandwidth: 0 (Newey-West automatic) using Bartlett kernel
=========================================================================
                                                  Adj. t-Stat   Prob.*
=========================================================================
Phillips-Perron test statistic                     0.481721     0.9839
-------------------------------------------------------------------------
Test critical values:        1% level             -3.610453
                             5% level             -2.938987
                             10% level            -2.607932
=========================================================================
*MacKinnon (1996) one-sided p-values.
=========================================================================
Residual variance (no correction)                              0.012310
HAC corrected variance (Bartlett kernel)                       0.012310
=========================================================================
Phillips-Perron Test Equation
Dependent Variable: D(LNHFCE)
=========================================================================
     Variable        Coefficient    Std. Error    t-Statistic     Prob.
=========================================================================
    LNHFCE(-1)         0.009712      0.020162      0.481721      0.6328
        C             -0.149387      0.465096     -0.321195      0.7499
=========================================================================
R-squared              0.006233   Mean dependent var         0.074488
Adjusted R-squared    -0.020626   S.D. dependent var         0.112753
S.E. of regression     0.113910   Akaike info criterion     -1.456904
Sum squared resid      0.480089   Schwarz criterion         -1.371593
Log likelihood         30.40963   Hannan-Quinn criter.      -1.426295
F-statistic            0.232055   Durbin-Watson stat         1.849553
Prob(F-statistic)      0.632841
=========================================================================
```

Appendix IX: Phillips-Perron Test of LNHFCE at level

```
Null Hypothesis: D(LNHFCE) has a unit root
Exogenous: Constant
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel
=========================================================================
                                                  Adj. t-Stat    Prob.*
=========================================================================
Phillips-Perron test statistic                    -7.051849      0.0000
-------------------------------------------------------------------------
Test critical values:       1% level              -3.610453
                            5% level              -2.938987
                            10% level             -2.607932
=========================================================================
*MacKinnon (1996) one-sided p-values.
=========================================================================
Residual variance (no correction)                                0.012085
HAC corrected variance (Bartlett kernel)                         0.012144
=========================================================================
Phillips-Perron Test Equation
Dependent Variable: D(LNHFCE,2)
Method: Least Squares
=========================================================================
      Variable          Coefficient    Std. Error    t-Statistic    Prob.
=========================================================================
   D(LNHFCE(-1))        -1.157842      0.164144      -7.053813      0.0000
         C               0.086746      0.022116       3.922287      0.0004
=========================================================================
R-squared                0.573518   Mean dependent var       -0.003172
Adjusted R-squared       0.561991   S.D. dependent var        0.170536
S.E. of regression       0.112865   Akaike info criterion    -1.475336
Sum squared resid        0.471321   Schwarz criterion        -1.390025
Log likelihood           30.76905   Hannan-Quinn criter.     -1.444727
F-statistic              49.75628   Durbin-Watson stat        1.532478
Prob(F-statistic)        0.000000
=========================================================================
```

Appendix X: Phillips-Perron Test of LNHFCE at First Difference

```
Null Hypothesis: LNGDP has a unit root
Exogenous: Constant
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel
==========================================================================
                                                  Adj. t-Stat     Prob.*
==========================================================================
Phillips-Perron test statistic                     0.774708      0.9923
--------------------------------------------------------------------------
Test critical values:        1% level             -3.610453
                             5% level             -2.938987
                             10% level            -2.607932
==========================================================================
*MacKinnon (1996) one-sided p-values.

==========================================================================
Residual variance (no correction)                                0.010706
HAC corrected variance (Bartlett kernel)                         0.010054
==========================================================================
Phillips-Perron Test Equation
Dependent Variable: D(LNGDP)
Method: Least Squares
==========================================================================
      Variable          Coefficient    Std. Error    t-Statistic    Prob.
==========================================================================
      LNGDP(-1)          0.013023      0.017837      0.730092      0.4699
          C             -0.227697      0.417101     -0.545902      0.5884
==========================================================================
R-squared                0.014202    Mean dependent var           0.076573
Adjusted R-squared      -0.012441    S.D. dependent var           0.105576
S.E. of regression       0.106230    Akaike info criterion       -1.596494
Sum squared resid        0.417541    Schwarz criterion           -1.511183
Log likelihood           33.13162    Hannan-Quinn criter.        -1.565885
F-statistic              0.533034    Durbin-Watson stat           1.579488
Prob(F-statistic)        0.469931
==========================================================================
```

Appendix XI: Phillips-Perron Test of LNGDP at level

```
Null Hypothesis: D(LNGDP) has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel
==========================================================================
                                                    Adj. t-Stat   Prob.*
==========================================================================
Phillips-Perron test statistic                       -6.776567    0.0000
--------------------------------------------------------------------------
Test critical values:        1% level                -3.610453
                             5% level                -2.938987
                             10% level               -2.607932
==========================================================================
*MacKinnon (1996) one-sided p-values.
==========================================================================
Residual variance (no correction)                                0.010724
HAC corrected variance (Bartlett kernel)                         0.011712
==========================================================================
Phillips-Perron Test Equation
Dependent Variable: D(LNGDP,2)
Method: Least Squares
==========================================================================
     Variable          Coefficient    Std. Error    t-Statistic    Prob.
==========================================================================
   D(LNGDP(-1))         -1.112405     0.163700      -6.795404     0.0000
        C                0.085539     0.021456       3.986727     0.0003
==========================================================================
R-squared                0.555168   Mean dependent var          -0.003200
Adjusted R-squared       0.543146   S.D. dependent var           0.157295
S.E. of regression       0.106318   Akaike info criterion       -1.594853
Sum squared resid        0.418226   Schwarz criterion           -1.509542
Log likelihood           33.09963   Hannan-Quinn criter.        -1.564244
F-statistic              46.17751   Durbin-Watson stat           1.311334
Prob(F-statistic)        0.000000
==========================================================================
```

Appendix XII: Phillips-Perron Test of LNGDP at First Difference

```
Null Hypothesis: LNGNI has a unit root
Exogenous: Constant
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel
========================================================================
                                                Adj. t-Stat     Prob.*
========================================================================
Phillips-Perron test statistic                   0.493788      0.9844
------------------------------------------------------------------------
Test critical values:        1% level           -3.610453
                             5% level           -2.938987
                             10% level          -2.607932
========================================================================
*MacKinnon (1996) one-sided p-values.
========================================================================
Residual variance (no correction)                              0.009946
HAC corrected variance (Bartlett kernel)                       0.009050
========================================================================
Phillips-Perron Test Equation
Dependent Variable: D(LNGNI)
Method: Least Squares
========================================================================
     Variable         Coefficient    Std. Error    t-Statistic     Prob.
========================================================================
     LNGNI(-1)          0.007565      0.017126      0.441699      0.6613
         C             -0.096873      0.400213     -0.242052      0.8101
========================================================================
R-squared               0.005245    Mean dependent var          0.079753
Adjusted R-squared     -0.021640    S.D. dependent var          0.101299
S.E. of regression      0.102389    Akaike info criterion      -1.670147
Sum squared resid       0.387893    Schwarz criterion          -1.584837
Log likelihood          34.56788    Hannan-Quinn criter.       -1.639539
F-statistic             0.195098    Durbin-Watson stat          1.722956
Prob(F-statistic)       0.661278
========================================================================
```

Appendix XIII: Phillips-Perron Test of LNGNI at level

```
Null Hypothesis: D(LNGNI) has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel
=========================================================================
                                                 Adj. t-Stat     Prob.*
=========================================================================
Phillips-Perron test statistic                   -7.051811      0.0000
-------------------------------------------------------------------------
Test critical values:        1% level            -3.610453
                             5% level            -2.938987
                             10% level           -2.607932
=========================================================================
*MacKinnon (1996) one-sided p-values.
=========================================================================
Residual variance (no correction)                                0.009763
HAC corrected variance (Bartlett kernel)                         0.010637
=========================================================================
Phillips-Perron Test Equation
Dependent Variable: D(LNGNI,2)
Method: Least Squares
=========================================================================
     Variable          Coefficient     Std. Error     t-Statistic     Prob.
=========================================================================
   D(LNGNI(-1))        -1.153698       0.162865       -7.083770      0.0000
        C               0.092547       0.021158        4.374053      0.0001
=========================================================================
R-squared               0.575590    Mean dependent var       -0.003488
Adjusted R-squared      0.564119    S.D. dependent var        0.153655
S.E. of regression      0.101445    Akaike info criterion    -1.688674
Sum squared resid       0.380773    Schwarz criterion        -1.603363
Log likelihood          34.92913    Hannan-Quinn criter.     -1.658065
F-statistic             50.17979    Durbin-Watson stat        1.396118
Prob(F-statistic)       0.000000
=========================================================================
```

Appendix XIV: Phillips-Perron Test of LNGNI at First Difference

```
Null Hypothesis: LNGDS has a unit root
Exogenous: Constant
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel
==========================================================================
                                                  Adj. t-Stat     Prob.*
==========================================================================
Phillips-Perron test statistic                     0.613928      0.9884
--------------------------------------------------------------------------
Test critical values:        1% level             -3.610453
                             5% level             -2.938987
                            10% level             -2.607932
==========================================================================
*MacKinnon (1996) one-sided p-values.
Residual variance (no correction)                                0.042664
HAC corrected variance (Bartlett kernel)                         0.036230
==========================================================================
Phillips-Perron Test Equation
Dependent Variable: D(LNGDS)
Method: Least Squares
==========================================================================
        Variable        Coefficient    Std. Error    t-Statistic    Prob.
==========================================================================
       LNGDS(-1)          0.014389      0.029988      0.479846     0.6342
           C             -0.226302      0.646747     -0.349907     0.7284
==========================================================================
R-squared                 0.006185   Mean dependent var          0.083609
Adjusted R-squared       -0.020675   S.D. dependent var          0.209903
S.E. of regression        0.212062   Akaike info criterion      -0.213955
Sum squared resid         1.663902   Schwarz criterion          -0.128644
Log likelihood            6.172128   Hannan-Quinn criter.       -0.183346
F-statistic               0.230252   Durbin-Watson stat          2.051829
Prob(F-statistic)         0.634162
==========================================================================
```

Appendix XV: Phillips-Perron Test of LNGDS at level

```
Null Hypothesis: D(LNGDS) has a unit root
Exogenous: Constant
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel
==================================================================
                                             Adj. t-Stat    Prob.*
==================================================================
Phillips-Perron test statistic                -7.938711     0.0000
------------------------------------------------------------------
Test critical values:       1% level          -3.610453
                            5% level          -2.938987
                           10% level          -2.607932
==================================================================
*MacKinnon (1996) one-sided p-values.
==================================================================
Residual variance (no correction)                         0.040199
HAC corrected variance (Bartlett kernel)                  0.044949
==================================================================
Phillips-Perron Test Equation
Dependent Variable: D(LNGDS,2)
Method: Least Squares
==================================================================
     Variable        Coefficient   Std. Error   t-Statistic   Prob.
==================================================================
  D(LNGDS(-1))        -1.245365    0.154755    -8.047335    0.0000
       C               0.105762    0.035800     2.954213    0.0054
==================================================================
R-squared              0.636398   Mean dependent var      -0.006676
Adjusted R-squared     0.626571   S.D. dependent var       0.336847
S.E. of regression     0.205843   Akaike info criterion   -0.273484
Sum squared resid      1.567742   Schwarz criterion       -0.188174
Log likelihood         7.332946   Hannan-Quinn criter.    -0.242876
F-statistic            64.75960   Durbin-Watson stat       1.545917
Prob(F-statistic)      0.000000
==================================================================
```

Appendix XVI: Phillips-Perron Test of LNGDS at First Difference