



The Relationship between Electric Power Consumption, Foreign Direct Investment and Economic Growth in Sri Lanka

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Purpose: This paper investigates the long run relationship between electricity consumption, foreign direct investment and economic growth in Sri Lanka.

Design/Methodology/Approach: The annual time series data over the period 1970–2017 is considered to this study. Augmented Dickey–Fuller (ADF) unit root analysis is employed for examining the stationary properties of the variables. Consequently, Autoregressive Distributed Lag (ARDL) analysis is employed to examining the short- run and long-run relationship between electricity consumption, foreign direct investment and economic growth in Sri Lanka. Further, this study used the diagnostic tests such as the residual normality test, heteroskedasticity and serial autocorrelation tests for misspecification to validate the parameter estimation outcomes achieved by the estimated model. CUSUM test is applied to test the stability of the model. Collected data were analyzed using STATA version 15.

Findings: The findings of the bound test confirm that the variables are cointegrated. Further the results reveal that there is a statistically positive significant relationship between electricity consumption, foreign direct investment and economic growth in Sri Lanka in the long run and short term. The empirical finding reveals that one percent increase in electricity consumption and foreign direct investment increases the GDP by 1.5 percent and 12.9 percent in the long run respectively.

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1. INTRODUCTION

Electricity consumption plays a vital role in stimulates economic growth in developed, emerging and developing economies. The relationship between the use of energy and economic growth has been a subject of greater investigation as energy is one of the important driving forces of economic growth in all economies [1]. Further, Wang et al. [2] found in his study on an aggregate or general level, electricity consumption is strongly related to economic growth, economic growth depends highly on energy inputs. Electricity consumption is highly correlated with the growth of GDP [3].

Foreign direct investment is one of the vital sources of economic growth in developing countries. It offers capital to generate positive externalities such as generating employment opportunities, technology transfer as the local workforce gains knowledge of the manufacturing processes, managerial skills, management practices, productivity gains, marketing expertise, research and development, different opportunities to access the market and new ways of production in the country. Also, it stimulates local investors to invest in the country. Sri Lanka is a liberalized country and successive governments have attempted to provide various incentives to foreign investors to attract foreign investments.

FDI is the main source of technology transfer from developed countries to developing countries, which provides assists to promote the domestic industry. Further, the value-added in these industries contribute to GDP growth and earning foreign exchange through exports. FDI brings opportunities to invest in more energy-efficient modes of production [4]. Therefore, it contributes to foreign earnings, creating employment opportunities and increases in incomes of the country, especially skilled and semi-skilled workers in these industries [3].

Energy is an indispensable input to economic productivity and production growth helps to increase the energy demand as a result of an increase in energy consumption [5]. The level of energy consumption is directly associated with the overall development of a nation. Energy security plays an important role in promoting and sustaining economic growth (EG), especially for industrializing, emerging economies [6]. The inflow of FDI encourages greater electric power

consumption, justifying the rationale of studying electric power consumption and FDI relationship. Energy consumption straightly contributes to the growing capabilities of an economy; the utilization of energy, causes for greater growth and it will enhance the overall development of the economy of the country [7].

To the best of knowledge, no empirical study has been conducted in Sri Lanka to examine the flow of FDI, power consumption and its impact on economic growth. Therefore, this paper aims to analyze the causality among the FDI, the power consumption and the economic growth in Sri Lanka. Thus, the main objective of this study is to examine the causal link between electricity consumption, foreign direct investment and economic growth for Sri Lanka using the time series data spanning from 1970 to 2017.

Following this, section 2 explains the overview of the power and energy sector of Sri Lanka and the contribution of FDI to the development of this sector. Section 3 analyses the research work completed by other researchers on the relationship between FDI, energy consumption and economic growth. Section 4 explores data collection, empirical models. Section 5 demonstrates the empirical results of this research. Finally, section 6 includes the conclusion of the study and policy recommendation.

2. ELECTRICITY CONSUMPTION, FOREIGN DIRECT INVESTMENT AND ECONOMY IN SRI LANKA

The Power sector in Sri Lanka is administrated by the Sri Lanka Electricity Act, No. 20 of 2009. Ceylon Electricity Board (CEB), established by a CEB Act No. 17 of 1969 (as amended), is under a legal obligation to develop and maintain an efficient, coordinated and economical system of electricity supply by any Licenses issued. CEB is the sole Transmission Licensee in the country while being accountable for most of the generation and supply of electricity as well. CEB has been issued a generation license, a transmission license and four distribution licenses. Lanka Electricity Company (LECO), a subsidiary of CEB is the other distribution licensee and there are several Independent Power Producers, whose production is also purchased by CEB. The Public Utilities Commission of Sri Lanka (PUCSL) is the

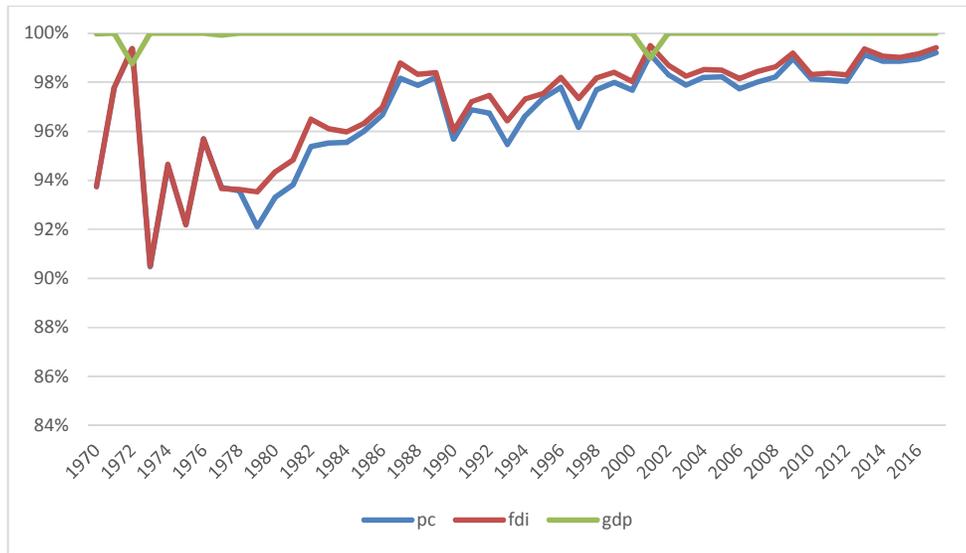


Fig. 1. Growth rates of electricity demand foreign direct investment and GDP from 1970 to 2017
 Source: Various reports of Central Bank, Sri Lanka

regulator of the sector and was established by the PUCSL Act No. 35 of 2002 and empowered by the Electricity Act. The Sri Lankan system has a total dispatchable installed capacity of approximately 2970 MW. The maximum demand recorded in 2016 was 2406.4 MW [8].

Fig. 1 shows the growth rates of electricity demand and GDP from 2010 to 2016. Electricity demand growth rate in the past has most of the time revealed a direct correlation with the growth rate of the country's economy.

CEB methodically plans its development activities to provide reliable, quality electricity to the entire nation at affordable prices [9].

Biomass or fuelwood, petroleum and hydro are the major primary energy supply sources, which cater to the Sri Lanka energy demand with per-capita consumption of about 0.4 tons of oil equivalent (TOE). Biomass or fuelwood, which is mainly a non-commercial fuel, at present provides approximately 46 percent of the country's total energy requirement. Petroleum turns out to be the major source of commercial energy, which covers about 42 percent of the energy demand [10].

Foreign Direct Investments play a significant role in developing the economic growth of Sri Lanka. Sri Lanka is one of the emerging countries and has huge opportunities to attract "Foreign Direct Investment" (FDI) inflows. The FDI in Sri Lanka increasing steadily every year. In 2017 the

country reaches \$1710 billion which is more 53% in 2016 [11].

3. LITERATURE REVIEW

Abdullah Alam [12] investigated the causality relationships between electric power consumption, foreign direct investment and economic growth for India and Pakistan using Granger causality tests for estimating the short and long-run relationships between the variables, along with the adoption of co-integration and error correction mechanism covering a period of 1975-2008. He found long-run causalities for electric power consumption and foreign direct investment boosting economic growth, electric power consumption and economic growth impacting foreign direct investment for India. Further, he found causality between foreign direct investment and economic growth inducing electric power consumption in the long run in Pakistan [3].

Mavikela et al. [13] studied the relationship between energy consumption, foreign direct investment and economic growth in Argentina employing annual data covering the period from 1970 to 2016. To determine the long-run relationship and the direction of causality among the variables, the Autoregressive Distributed Lag (ARDL) bounds testing approach and Vector Error Correction Model (VECM) techniques are applied, respectively. The ARDL bounds tests suggested the existence of a long-run relation-

ship between energy consumption, foreign direct investments, economic growth and capital. More specifically, it was established that a 1% increase in foreign direct investments leads to a 0.013% increase in energy consumption, while a 1% increase in economic growth boots energy consumption by 0.35% in the long run. The VECM Granger-causality results suggested a unidirectional causality flowing from foreign direct investments and capital to energy consumption. A bidirectional causality flowing between energy consumption and economic growth was also established [10].

Ibrahiema [14] studied the relationship between renewable electricity consumption, foreign direct investment and economic growth in Egypt. He used Auto Regressive Distributed Lag (ARDL) bounds testing approach over time series data from the period 1980 to 2011. The study found that the variables in the study are cointegrated and indicating the existence of long-run relationships among them. Further, he found, renewable energy consumption and foreign direct investment have a long-run positive outcome on economic growth. Granger causality test indicates that there exists unidirectional causality running from foreign direct investment to economic growth, addition, there is bidirectional causality between economic growth and renewable electricity consumption. This result supports the feedback hypothesis. Finally, the stability of the model was also checked.

Rashid and Lin [4] analyzed the causality among the FDI in the power and energy sector, the energy consumption and the economic growth of Pakistan for the period 1990–2017. The Johansen co-integration and Granger causality tests were employed to find the causal relationships among the variables in the short-run and the long-run. The power and energy sector of Pakistan (PESP) has comparatively received a higher amount of FDI than other sectors in recent years. Moreover, trends in energy production and energy usage state a significant gap in the preceding years. The findings of the study confirm a positive bi-directional short-run causal relationship between economic growth and energy consumption. The results also reveal the presence of long-run causality in the equation of energy consumption.

Pham et al. [15] explored the causal relationship between electricity consumption, foreign direct investment (FDI) and economic growth in Vietnam during the period 1990-2015, by using

the Toda-Yamamoto approach and autoregressive distributed lag approach. They concluded that a strong statistical relationship between electricity consumption, FDI with economic growth in Vietnam in both the short term and long term.

Tuyen and Winai [16] investigated the relationship between electricity consumption (EC), economic growth, exports and foreign direct investment (FDI) in Vietnam using time series data from 1980 to 2013. The results indicated that real gross domestic product (GDP), EC, exports (EX) and FDI in Vietnam are cointegrated. They concluded that unidirectional Granger causality between real GDP to EC, EX and FDI, but not vice versa. The data also show that there is bidirectional Granger causality between EC and EX.

4. RESEARCH METHODOLOGY

4.1 Data

To examine the relationship between electricity consumption, foreign direct investment and economic growth the current study considers the time series data from 1970–2017 in Sri Lanka. The data were extracted from the World Bank Development Indicators [17]. Electricity consumption (EC) in kWh per capita, foreign direct investment net inflows percent of GDP (FDI) while Economic growth as the annual percent growth rate (GDP). Table 1 shows the summary description of the data employed in this study.

4.2 Model

Model and Methodology: The general objective of this paper is to examine the impact of electricity consumption (pc), foreign direct investment (fdi) on economic growth (gdp) in the Sri Lankan economy. The following model is identified for the empirical analysis.

$$\text{Ingdp}_t = b_0 + b_1 \text{dlnpc}_t + b_2 \text{Infdi}_t + \varepsilon_t \quad (1)$$

where;

Ingdp is GDP growth rate
 dlnpc is electricity consumption
 Infdi is Foreign direct investment
 ε_t is error term

Where, b_0 , b_1 and b_2 , are the parameters to be estimated.

Table 1. Demographic and economic indicators of Sri Lanka

Variables Year	Mid-year population millions	Population growth rate %	GDP real growth rate %	GDP /Capita (Market prices) US\$	Exchange rate (Avg.) LKR/US\$	GDP const 2010 prices mill LKR
2010	20.19	0.68	8.01	2,808	113.1	6,413,668
2011	20.89	0.58	8.40	3,213	110.6	6,952,720
2012	20.27	0.54	9.14	3,350	127.6	7,588,517
2013	20.58	0.50	3.39	3,608	129.1	7,846,202
2014	20.77	0.47	4.96	3,818	130.6	8,235,429
2015	20.71	0.51	5.00	3,842	135.9	8,633,890
2016	20.79	0.41	4.46	3,857	145.6	9,012,026

Source: Various reports of Central Bank, Sri Lanka

Cointegration analysis (ARDL)

$$\ln gdp_t = b_0 + b_1(\ln pc)_{t-1} + b_2(\ln fdi)_{t-1} + \sum_{t=1}^n b_3 \Delta \ln pc_{t-1} + \sum_{t=1}^n b_4 \ln fdi_t + \varepsilon_t \quad (2)$$

Error Correction model specification: The following equation (3) develops for an error correction model to examine the short-run dynamics and to check the stability of the parameters of the long-run.

$$\ln gdp_t = b_0 + \sum_{t=1}^n b_1 \Delta \ln pc_{t-1} + \sum_{t=1}^n b_2 \Delta \ln fdi_{t-1} + \lambda ECT_{t-1} + \varepsilon_t \quad (3)$$

4.3 Data and Variables

This study combines three variables, GDP growth rate (percent) a proxy of economic growth denoted by (gdp), electric power consumption as kWh per capita denoted by (pc) and Foreign direct investment, net inflows percent of GDP, denoted by (fdi). The data (series) of variables (gdp, pc and fdi) under consideration are expressed in logarithm.

In this study, time series data have been used for a period of 47 years (1970 to 2017). All data has been gathered from the official database of the World Bank (Available at <http://data.worldbank.org/indicator>) [18].

5. RESULTS AND DISCUSSION

5.1 Descriptive Statistics and Correlations of the Variables

Table 2 explains the summary of the variables used in this study. Forty-seven of the sample is covering the period of 1970 to 2017. The means value of Electricity consumption (pc) is 9.953192 with a standard deviation of 13.06762. It shows that the mean value is scattered by 13.06762. Likewise, the mean value is -.4071451 and

1.500684 with the standard deviation of 1.300521 and 0.4942594 of foreign direct investment (fdi) and Economic Growth (Ingdp) respectively.

The stationary level of the variables is illustrated in Figs. 2 and 3. Fig. 2 shows the data series of all variables except GDP growth rate and foreign direct investment (fdi) only electricity power consumption (pc), is non-stationary at the level. In this situation, it is essential to convert the data into stationary. Fig. 3 presents the view of stationary of the variable electricity power consumption (pc) at the first difference.

5.2 Unit Root Test

Augmented Dickey Fuller (ADF) unit root test is used to find the stationary level of the variables. This test is performed to ensure that none of the variables are I (2) too. The results are shown in Table 3. The table shows electricity power consumption is none stationary at the level and becomes stationary at first difference but variables foreign direct investment and gross domestic product growth rate are stationary at the level which means they are integrated of order zero, I (0). This implies that the unit root results validated a combination of I (0) and I (1).

Table 4 reports the optimal lag length of four (4) out of a maximum of 4 lag lengths as selected by four different criteria: Final Prediction Error (FPE), Akaike information criteria (AIC), Schwarz Information Criterion and Hannan-Quinn Information Criterion.

5.3 ARDL Bounds Test for Cointegration

Following the unit root test and establishing that none of the variables are I(2), the study examines the long-run relationship among the variables. Starting with the gross domestic

product growth rate as the dependent variable, the calculated F-statistics is 17.224. The critical values ranges are $I(0) = 5.722$ and $I(1) = 7.043$ at 1% level of significance [10]. Therefore, comparing the F-statistics with the critical values, it indicates that F-statistics is greater than the upper critical value at 1% level of significance [3]. This suggests that the null hypothesis of no cointegration will be rejected indicating the existence of long-run relationship between the variables. Nevertheless since two co-integration equations validate the existence of a long run relationship between the variables, here the study concludes that there is a long run relationship between electricity power consumption and foreign direct investment in Sri Lanka.

The study next involves estimating the long run coefficients and the results are demonstrated in Table 6. According to the Table 6, the electric power consumption and foreign direct investment are statistically significant and positively correlated with the gross domestic product

growth rate in the long run. Specifically, the coefficient of electric power consumption is 0.0153276, which implies that a 1% increase in electric power consumption leads to 0.0153276% increase in gross domestic product growth. The results are consistent with studies conducted by Mavikela et al. [13] and Abdullah Alam [12]. The coefficient of foreign direct investment is 0.1299428, which means that a 1% increase in foreign direct investment results in an increase of about 0.1299428% in gross domestic product growth. The results are consistent with studies conducted by Ibrahiema [14], Rashid and Lin [4] and Pham et al. [15].

ADJ in the output section indicates the negative speed-of-adjustment coefficient. It shows how strongly the dependent variable reacts to a deviation from the equilibrium relationship in one period or how quickly such an equilibrium distortion is corrected. The short-run coefficients are reported in the output section SR. They justify that for short-run fluctuations not due to deviations from the long-run equilibrium [10].

Table 2. Summary statistics of electricity consumption, foreign direct investment and economic growth

Variables / Descriptions	Electricity consumption (dlnpc)	Foreign direct investment (Infdi)	Economic growth (Ingdp)
Observations	48	48	48
Mean	9.953192	-.4071451	1.500684
Maximum	46.35999	1.047319	2.208274
Minimum	-25.97003	-4.60517	.2700271
Std. Dev.	13.06762	1.300521	.4942594
Skewness	.5352467	-2.192487	-1.527231
Kurtosis	4.354181	6.924061	5.257698
Variance	170.7627	1.691356	.2442923

Source: WD indicators & Author calculations

Table 3. Unit root test

Variables	Level I (0)		1 st Difference I (1)	
	Test statistic	5% critical value	Test statistic	5% critical value
Ingdp	-5.142	-2.938	-	-
Infdi	-4.002	-2.941	-	-
Inpc	-1.304	-2.938	-5.670	-2.941

Table 4. Lag length selection

Lag	LR	FPE	AIC	HQIC	SBIC
0	0.0000	9.67919*	10.7836*	10.8289*	10.9065*
1	6.41459	12.6924	11.053	11.2343	11.5445
2	7.0068	16.5074	11.3087	11.6259	12.1688
3	11.221	19.6623	11.4663	11.9195	12.6951
4	20.195*	19.3011	11.4153	12.0043	13.0127

*Indicates lag order selected by the criteria

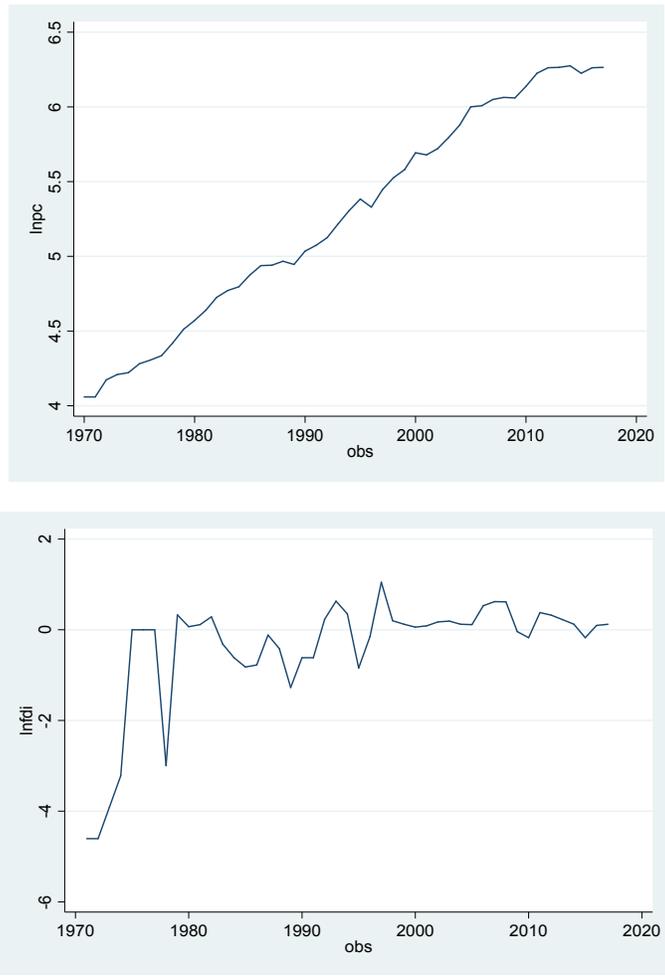
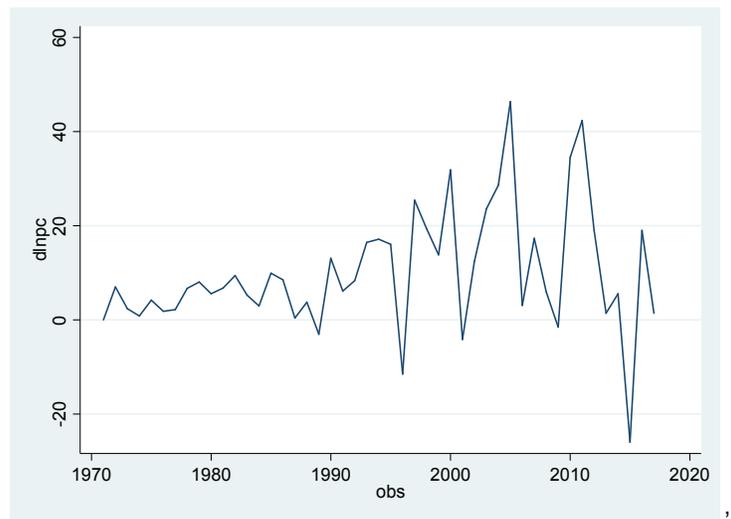


Fig. 2. Graphical illustration of data with level I (0)



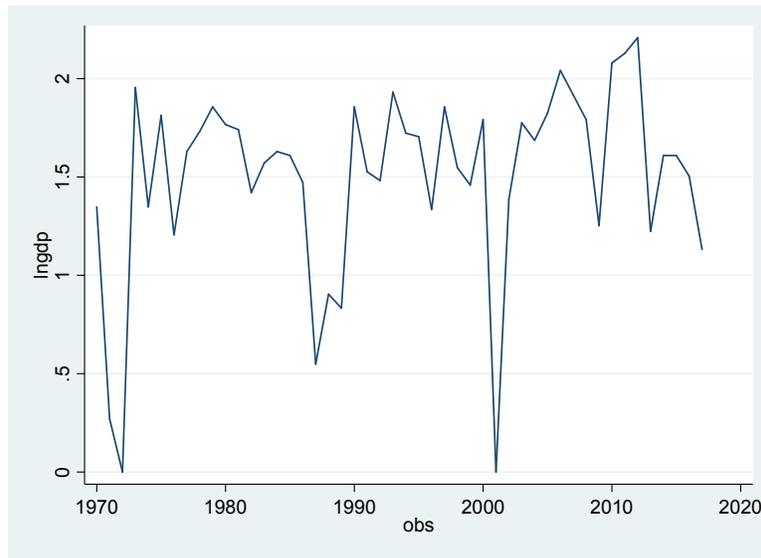


Fig. 3. Graphical Illustration of data on first difference

Table 5. ARDL bound test for cointegration

ARDL Co-integration test			
Lag length		F-statistic	
ARDL (1,0,0)		17.224***	
Significance level	Critical values *		
	Lower bounds I (0)	Upper bounds I (1)	
1 percent	5.722	7.043	
5 percent	4.039	5.142	
10 percent	3.309	4.304	
Diagnostic tests			
Normal	Serial	Heteroskedasticity	White
0.3989 (0.1200)	1.984674 (0.9949)	0.5638 (0.333)	11.55 (0.6728)

Table 6. Long run coefficients estimated through the ARDL approach

Variable	Coefficients	Standard error	T-statistics	Probability
dlnpc	.0153276	.0059124	2.59	0.013
dlnfdi	.1299428	.0545356	2.38	0.022

Table 7. Short run analysis

Dependent variable = ln gdp (Gross domestic product growth rate)				
Short term results				
Variable	Coefficients	Standard error	T-statistics	Probability
Cons	1.286774	.2364568	5.44	0.000
ADJ ln gdp r [ECM (-1)] L1.	-.916598	.1396329	-6.56	0.000
R ²	0.5458			
Adj R-squared	0.5141			

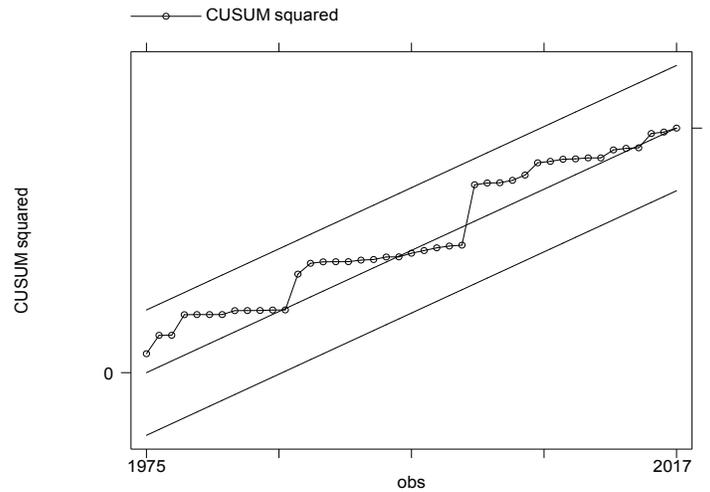


Fig. 4. Cumulative sum squares (CUSUMSQ) tests

Table 7 illustrates the short run results and the speed of adjustment coefficient (ADJ). It is established that the coefficient of the adjustment (-.916598) is negative and statistically significant at the 1% level of significance. This indicates that approximately 91% of the disequilibrium of gross domestic production growth rate shock of the previous year will result in the adjustment back to the long run rate equilibrium of gross domestic product growth rate and should be corrected in the current year. The specified variables are found to have a positive and statistically significant effect on gross domestic product growth rate except for gross fixed capital formation and remittance in the short run. Gross fixed capital formation and remittance have a negative effect on domestic production growth rate but they are statistically significant [10].

Results of the diagnostic tests show that the estimated ARDL model and the error-correction models do not have serial correlation, heteroscedasticity, specification error, and nonnormality at the 5% significance level. As is evident from Table 5, all the *P* values of the diagnostic tests are greater than 5%, implying that the null hypotheses of no serial correlation, homoscedasticity, normality, and specification error cannot be rejected at the 5% significance level.

5.4 Stability Tests

Finally, this study explored the stability of the long-run trends together with the short-run movements of the variables. Cumulative sum squares (CUSUMSQ) tests were applied to explore the stability of the long run which

proposed by Borensztein et al. [19]. This same process has been applied by Pesaran and Pesaran [20], Mohsen et al. [21] and Suleiman [22] to test the stability of the long-run parameters.

Fig. 4 plot the CUSUM of squares statistics and CUSUMSQ stays within the critical 5% bounds that confirms the long-run relationships among variables and thus shows the stability of the coefficient.

6. CONCLUSION

This study investigated the relationship between gross domestic growth rate, foreign direct investment and electricity power consumption of Sri Lanka during the period of 1970 to 2017 by employing the ARDL bound test approach. Bound test suggested that the foreign direct investment and electricity power consumption have the long run positive relationship with economic growth of Sri Lanka. The model is the best model, because it has no serial correlation, no heteroskedasticity and residuals are normally distributed. The model is also stable. The model has to get towards long run equilibrium at the speed of -.916598. The model has short run causality from independent variables to the dependent variables. Also, it has long run association among the variables and they move together. The error correction term of these models is highly significant and correctly signed. This shows the adjustment to long term equilibrium in the dynamic model. The coefficients of error correction are (-.916598). This indicates that deviations from foreign direct investment and electricity power consumption to

economic growth adjust quickly. Pham et al [15] and Rashid and Lin [4] findings have supported the coefficient on the error correction term, ECM (-1), is significant and negative at the 1 percent level, which permits the existence of the long-run relationship among the variables in this model found by the F-test.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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