On the Validity of Purchasing Power Parity (PPP): The Case of Sierra Leone

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Abstract:

This paper attempts to empirically validate the purchasing power parity (PPP) theory in the context of Sierra Leone. To achieve this objective, cointegration and error correction techniques were utilised to account for both long and short-run dynamics over the period 2007Q1 to 2019Q1. The Engel-Granger cointegration technique was utilised to ascertain the long-run relationship between the exchange rate and the price differential between Sierra Leone and the United States of America, while the redundant variable test was used to attain the parsimonious short-run error correction model. The results indicated a cointegrating relationship, while the coefficient on the price differential was greater than one (1), reflecting that the PPP does not hold for Sierra Leone. Moreover, the short-run results showed a rejection of the theory and rather endorses the presence of depreciation inertia, where past depreciation of the exchange rate is a major determinant of its current depreciating trend.

Keywords: *Purchasing Power Parity, Exchange Rate, Inflation, Cointegration, Sierra Leone*

JEL Classification: *E41, C32, F31*

1. Introduction

The issues of exchange rate and inflation are evolving topical concerns in Sierra Leone (see Jackson, 2020; Jackson et al, 2019; Jackson and Tamuke, 2018; Bangura et al, 2012; Kallon, 1994). This is anchored on the backdrop that development in these indicators holds significant implications for macroeconomic stabilization – especially for monetary policy efficacy, and the general wellbeing of citizens in the economy. Over the years, arguments by policy practitioners, researchers, and academics alike reflect that movements or impulses in the exchange rate to a greater extent trigger inflationary pressure. Moreover, persistent depreciation of the exchange rate in recent times is said to be followed by a buildup in inflationary pressures, which has made many to believe that controlling the exchange rate will ultimately help to ease price pressures.

However, Sierra Leone as a country is also fraught with several structural issues such as weak export base, low supply of foreign exchange, and agricultural bottlenecks – which, could also be responsible for the persistent inflationary pressures as well as the continued depreciation of the exchange rate. Moreover, given that the country is a small open economy, price developments in the country may result in a proportionate depreciation in the exchange rate, so that identical goods traded overseas should cost the same locally. Therefore, it is also believed that the theory of purchasing power parity holds for the case of Sierra Leone, wherein the price differential between Sierra Leone and its trading partners is a significant determinant of exchange rate movements in the country.

The PPP concept was proposed by Gustav Cassel in 1918, and states that the nominal exchange rate between two countries is equal to the ratio of their price levels (Khan and Qayyum, 2007). The theory builds on the foundation of the law of one price (otherwise known as absolute PPP), which indicates that in the absence of trade rigidities, and a system of competitive and flexible prices, identical goods should trade at the same price when quoted in a single currency (Khan and Qayyum, 2007). The relative PPP, on the other hand, suggests that the rate of depreciation of one currency should be balanced by the two countries' general price inflation (Nzimande, 2015).

1.1. Rationale, Objectives, and Structure of the Paper

Sierra Leone for decades has been battling with exchange rate perturbations, which is directly linked to the country's unproductive real sector and other structural bottlenecks (Warburton and Jackson, 2020; Jackson, 2016). This is believed to be one of the significant drivers of price movements, given that the country cannot provide sufficient foreign exchange to facilitate international transactions, which translates into demand pressures for forex, with the eventual impact being on prices through the import channel. Conversely, the pass-through may take a rear trajectory, where the difference in prices between Sierra Leone and its trading partners, especially the United States is the driver of exchange rate depreciation in the country (conditioned on the premise that the exchange rate would have to adjust to ensure that prices of identical goods traded abroad would cost the same locally). There has been a continuous depreciation of the Leone currency in recent times, which is an indication that the value of the trade differential is making it very much tangible for the PPP concept not to hold when it comes to Sierra Leone. To prove the assertion of the concept of PPP in Sierra Leone, the authors have made it as part of their knowledge exploration to empirically address the situation by applying the concept of the price differential between Sierra Leone and the United States and Exchange Rate as the variables of interest.

This research paper is grounded on the following core objectives:

- Determine the degree of correlation and causation between the exchange rate and the price differential between Sierra Leone and the United States of America.
- Application of cointegration and error correction methodologies to address the long and short-run relationship between exchange rate and price differential with the United States of America, for example.

Given the above introductory discourse and the rationale for the study, the remaining sections of the paper are divided as follows: Section two provides an outline of recent empirical literature around the topic of PPP, while section three looks at the specific methodology, sub-sectioned into the Theoretical Model, Data and Analysis of results. Section four addresses the discussion and conclusion of results from the empirical output.

2 Literature Review

2.1 Theoretical Overview

As expressed by Dornbusch (1985: 1), the theory of PPP is based on exchange rate determination; in short, it expresses that the exchange rate between two currencies over a while is determined by the change in the countries' relative price levels. The singling out of price as the main determinant of the exchange rate movement has carried the alternative name of '*inflation theory of exchange rates*'. The PPP theory has been likened to that of the Quantity Theory (QT) of Money, which asserts that disturbances in monetary operations, for example, hyperinflation will render the QT inappropriate and which may also create disturbances on exchange rate movement, and hence temporarily deviating from the PPP theory. Long-run adjustments in economic activities resulting from influences like changes in real income and financial innovations may likely bring about changes in relationships between money supply and prices, hence resulting in trend deviation on PPP. Equally, the differential in countries' growth potential may also account for trend changes in real exchange rates as viewed from the perspectives of PPP theorem.

The theoretical application of PPP is based on the '*law of one price*' – on this note, this can be expressed mathematically as:

$$e = {}^{P}/_{P*} = \frac{\$ \text{ price of standard market prices of goods}}{Le\ price\ of\ the\ same\ standard\ basket} \quad \ldots\ldots 1$$

In the case above, let:

P = Price of commodities at home, which can accommodate all the basket of items

P* = Price of a basket of commodities abroad, in the case of the USA, which is a major trading partner.

$ and Le are Dollar and Leone units of currency in the USA and Sierra Leone respectively.

Section 3.1 below provides the specifics of PPP's theory that will be applied to this study in assessing whether the theory holds for Sierra Leone or not.

2.2 Empirical Review

This section addresses a review of the literature around the Purchasing Power Parity (PPP) concept for different regions across the world and with attention focused on contemporary empirical studies in a bid to ensuring issues dealt with are recent, which will be most useful given the fact that not much has been done in the case of Sierra Leone. Given this, the undermentioned pieces of literature are focused on empirically observed studies undertaken during the period 2015-2019.

Huang and Yang (2015) carried out their study knowing that following the adoption of the euro currency, there is a high chance that the long-run purchasing power parity (PPP) will hold for countries in the region. The panel unit root test of the Pesaran (2007) approach was utilised for real exchange rate data for eleven euro countries during the period 195M01 - 2013M05. Contrary to the above intuition, the authors proved that evidence for mean-reverting in the real exchange rate is weak in the post-1998 euro period than in the pre-euro period. In contrast to the countries that did not uphold the euro (Norway, Sweden, Switzerland, and the UK), the mean-reverting in real exchange rates proved stronger both in the pre- and post-euro (post-1998) periods. Using panel data estimation for the error correction model and the common correlated effects (CCE) estimator, the study shows that the flexibility of nominal exchange rates is crucial for the adjustment of real exchange rates to PPP.

Jiang et al (2016) utilised a non-linear threshold unit-root test to check for the validity of purchasing power parity (PPP); this was also done in a bid to assess the non-stationary properties of the convergence of real exchange rates (RERs) as rooted in the Taylor rules for ten selected Central Eastern European countries. Non-linear threshold unit-root test was proven to have produced greater power than the linear method, on the condition that the true data generating process of RER convergence is a stationary non-linear process. The validity of Taylor rules from the non-linear perspective was confirmed through robust evidence, which shows that PPP holds for seven out of the ten Central Eastern European countries. In this vein, the result clearly shows that the choices and effectiveness of monetary policies in Central Eastern European economies are thought to be influenced by external factors, supposedly originating from the United States of America. The outcome also shows that RER for the selected countries have mean reversion, which converged towards the Taylor rules equilibrium in a non-linear manner. In addition, the findings also show that mean capital mobility, exchange rate market efficiency and monetary integration are non-linear in the Central Eastern European countries.

Iyke and Odhiambo (2017) produced a simultaneous exploration of exchange rate policies, trends, and the PPP for Zambia and Lesotho. The study shows that by implication, Lesotho is unlikely to profit from the trade and investment arbitrage. On the contrary, Zambia is more likely to profit from trade and investment arbitrage by trading with partner countries like the USA. The author's findings also show that the PPP doctrine can be thought of as a useful guide for the exchange rate and other macroeconomic adjustment policies in Lesotho, but not so much for Zambia.

Redda and Muzindusti (2017) employed the generalised purchasing power parity (GPPP) framework, which is consistent with the Optimal Currency Area (OCA) theory on price (or otherwise referred to as inflation rate) and exchange rate. The study utilised the Johansen cointegration test, vector error correction model, and Pedron`s panel cointegration test, with the findings suggesting that GPPP holds in the Southern African Development Community (SADC). The empirical outcome also testifies that bilateral real exchange rates in the SADC region exhibit a common long-run stochastic trend (with dissimilarity in the aggregate demand patterns, which indicate asymmetries in exchange rate adjustment process to disequilibrium in the region. Some common concerns were revealed from the study and these include business cycle synchronisation, and convergence of key macroeconomic variables (like the budget deficit, government debt, and foreign reserves cover), which is though should be systematically investigated before the implementation of the said economic union.

Akosah et al (2018) evaluated the degree of real exchange rate (REER) misalignment and its macroeconomic implications for the Ghanaian economy by utilising quarterly data for the period 2000Q1-2015Q3. Outcomes from the study made a salient discovery of misalignment in the actual REER from its equilibrium level throughout the sample period despite the closeness of the REER to its equilibrium level towards the end period of 2012. There was also a revelation of weak positive undervaluation-economic growth nexus for Ghana. Overvaluation seems to have exerted pressure on disinflationary pressures, while on the contrary, undervaluation intensifies inflationary pressures in Ghana. The study eventually suggested that the use of REER undervaluation

as a deliberate industrial policy instrument for sustained economic growth can prove counterproductive in the context of Ghana. This may also undermine the price stability objective of the central bank.

Akay et al. (2018) empirically explored the saving behavior of immigrants in response to changes in purchasing power parity between the source and host countries. The authors constructed a theoretical model using joint return-migration and saving decisions of temporary migrants – the implication of this was then tested by utilising data from the German Socioeconomic Panel on immigrants from 92 source countries. The outcome shows an increase in saving rate in the nominal exchange rate, but decreases in the source-country price level, while there was an increase in the absolute degree of both relationships nearer the time of retirement. The study also reveals that the absolute values of elasticity of savings concerning the nominal exchange rate and the source-country price level are close to unity during the median year of retirement. With the imposition of restriction on the sample to individuals, the outcome revealed both higher magnitudes and statistical significance.

Al-Gasaymeh et al (2019) applied the PPP approach in the case of India & Pakistan through the Co-integration method; the outcome shows that the exchange rates are in tandem with price movements, hence supporting PPP theorem. Effective management of economies and currencies is vital; in consideration of the latter, which seems to be falling is thought to be reducing the international standing of currencies in the two countries.

Salma and Ferit (2019) produced empirical research on the validity of PPP in Turkey using Structural Breaks around the period 200M01 – 2017M08. In this, the ADF, PP, and Lee-Strazicich fracture unit root tests were utilised. The outcome from the study shows that the real exchange rate was not stable in the classical unit root tests. In effect, evidence from three break dates determined by Lee-Strazicich fracture unit root test shows that PPP was valid in the case of structural breaks.

Adu et al (2019) examined real effective exchange rate (REER) responses to shocks in exchange rate determinants for the West African Monetary Zone (WAMZ) during the period 1980–2015. The analysis is based on VECM, with the use of macroeconomic variables like oil price, supply, and demand shocks - the study identified long-run restrictions by utilising structural VAR model. Significant differences in the response of REER to the real oil price, productivity (supply), and demand preference shocks were identified across the selected economies. Shock to REER movements in the short and long-run appeared to be different across economies, which is indicative of structural differences amongst the WAMZ countries. The outcome also shows that asymmetric shocks with inadequate adjustment mechanisms can prove costly in the event of a monetary union.

Given the above literature analysis, the undermentioned methodology and supported by the selection of appropriate data will determine whether the PPP concept can be held true or not for a small open economy like Sierra Leone.

3 Methodology, Data, and Analysis

3.1 Theoretical Model

The study employs cointegration and error correction modeling techniques to model both the long and short-run relationships between exchange rate and the price differential. Also, Unit root, correlation, and causality tests were conducted to establish stationarity, correlation, and causation, respectively. Finally, several residual and stability diagnostics were undertaken to ascertain the robustness of the model.
The functional form of the general model as specified in Eq. 1 above can be modified as follows:

$$NER = f\left(\frac{CPI^D}{CPI^F}\right) \text{.....2}$$

This is expressed econometrically as:

$$NER = \alpha_0 + \alpha_1\left(\frac{CPI^D}{CPI^F}\right) + \varepsilon_t \text{.....3}$$

Taking logs on both sides yields:

$$lnNER = \alpha_0 + \alpha_1 ln\left(\frac{CPI^D}{CPI^F}\right) + \varepsilon_t \text{.....4}$$

Where, $lnNER$ and $ln\left(\frac{CPI^D}{CPI^F}\right)$ are the natural logs of the nominal exchange rate and the ratio of domestic prices to foreign prices respectively, while ε_t is the error term. The equation indicates that a common basket of goods in the two countries will be the same. The coefficient α_0 according to Krichene (1998) captures 1) market

segmentation resulting from transportation costs, tariff and non-tariff barriers, which create a wedge in prices across countries, and 2) the fact that prices are expressed in terms of indices. The concept of PPP asserts that as domestic prices increase due to monetary expansion or unrestrained credit expansion, the exchange rate will depreciate proportionately so that identical goods in the two countries will cost the same (Khan and Qayyum, 2007). However, this can only materialize when $\alpha_0 = 0$ and $\alpha_1 = 1$.

3.2 Data

The study employed secondary data, spanning 2007Q1 – 2019Q2 that were sourced from the Bank of Sierra Leone (BSL), Statistics Sierra Leone (SSL), and the Federal Reserve Economic Data (FRED) databases.

3.3 Analysis of Results

3.3.1 Unit Root Tests

The Augmented Dickey-Fuller unit root test revealed that both variables were non-stationary at levels, but became stationary after first differencing at the one percent level of significance. This is captured in table 1 below.

Table 1: Augmented Dickey-Fuller (ADF) Test: Schwarz Bayesian Criterion (SBC)

Variable	Levels (I(0))	First Difference (I(1))
LNER	0.261479	-4.486925***
LPRICED	1.371359	-5.312785***

Note: *** = 1% significance

3.3.2 Correlation

The correlation matrix below indicates a strong positive correlation between the nominal exchange rate and the price differential between Sierra Leone and the United States of America.

Table 2: Correlation Matrix

	LNER	LPRICED
LNER	1.000000	
LPRICED	0.981701	1.000000

3.3.3 Pairwise Granger Causality

Ascertaining correlation does not imply causation, hence the rationale for undertaking the pairwise granger causality test, which revealed unidirectional causation from LPRICED to LNER. Despite weak (at the 10 percent level), this confirms that changes in the price differential can cause changes in the nominal exchange rate of the Leone relative to the US Dollar.

Table 3: Pairwise Granger Causality Test [Lags: 4]			
Null Hypothesis:	Obs	F-Statistic	Prob.
LPRICED does not Granger Cause LNER	45	2.13681	0.0962

LNER does not Granger Cause LPRICED	0.50451	0.7326

3.3.4 Cointegration

Obtaining the unit root properties of the variables prompted the utilization of a cointegration test to determine whether there is a long-run relationship between the exchange rate and the price differential between Sierra Leone and the United States of America. The Engel-Granger cointegration test was used over the Johansen and ARDL bound test because of its strength in modeling long-run relationships in bivariate models. This test asserts that two variables that are non-stationary in levels but stationary in first-differences, could have a linear relationship between them which is stationary. If this is satisfied, then there is a cointegrating relationship between the two variables. In essence, variables are cointegrated with one another if the residuals from the levels regression are stationary. The results indicate that the residual from the long-run model is stationary at the one percent level, implying that there is a long-run relationship between exchange rate and price differential. However, this does not confirm that the PPP concept holds for Sierra Leone. Therefore, to validate the PPP theorem for the case of Sierra Leone, the long-run static model was generated (See Appendix 1). It was deduced from the results that the PPP concept does not hold, contingent on the basis that the coefficient of LPRICED in the long-run, despite being significant at the one percent level, was greater than 1 percent (approximately 1.36 percent), and for the PPP to hold, the nominal exchange rate must adjust proportionately to the change in price differential. The cointegration test result is presented below

Table 4: Cointegration (Engel-Granger)

Unit Root on the ECT	
ECT	-5.485141***

Note: *** = 1% significance

Short-run Error Correction Model (ECM)

Once the cointegration between the exchange rate and price differential has been established, then an error correction model for the exchange rate also exists. The Hendry's General to Specific technique, otherwise known as the redundant variable test, was employed to ascertain the parsimonious error correction model. This test involves eliminating highly insignificant variables from the over-parameterized model to obtain the parsimonious error correction model (ECM).

The results revealed the presence of depreciation inertia, where depreciation of the exchange rate in the previous period feeds depreciation pressures in the current period. This was statistically significant at both the one and five percent levels for both lags 1 and 4. However, it is revealed that the PPP concept does not hold in the short-run as the coefficient is negative and insignificant at all conventional levels. The error correction term (ECT) which measures the speed of adjustment to long run equilibrium after changes in the independent variable was negative and significant at the five percent level, thus endorsing the mean-reversion feature of the error correction model.

Table 5: Parsimonious Short-run ECM

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLNER(-1)	0.499174	0.143615	3.475768	0.0013
DLNER(-4)	0.360044	0.149013	2.416199	0.0205
DLPRICED(-4)	-0.380393	0.300871	-1.264309	0.2136
ECT(-1)	-0.206785	0.076438	-2.705261	0.0101

C	0.011632	0.006810	1.708178	0.0956
R-squared	0.318696	**Mean dependent var**		0.024220
Adjusted R-squared	0.248818	**S.D. dependent var**		0.031087
S.E. of regression	0.026943	**Akaike info criterion**		-4.283519
Sum squared resid	0.028312	**Schwarz criterion**		-4.080770
Log-likelihood	99.23741	**Hannan-Quinn criter.**		-4.208330
F-statistic	4.560782	**Durbin-Watson stat**		2.198288
Prob(F-statistic)	0.004058			

3.3.5 Residual and Stability Diagnostics

To check for model robustness, some diagnostic tests including; serial correlation using the Breusch-Godfrey and Heteroskedasticity using the White test, were undertaken [See Appendix 4]. The results showed that the model has robust properties in that the estimated residuals from the model are serially uncorrelated and homoscedastic. In terms of Stability, the recursive estimates, notably the cumulative sum (CUSUM) and cumulative sum of squares (CUSUM Squares) were utilised. The result indicated that the model is stable [See Appendix 4].

4 Discussion and Conclusion

PPP as a concept reflects that the difference in prices between two countries is equal to the exchange rate, provided the criteria for competitive markets, and prices are met. It was construed that in the case of Sierra Leone, there is a long-run relationship between exchange rate movements and the price differential between the country and its trading partner, in this case, the United States. However, the PPP concept does not hold in the long-run as reflected in the coefficient of the price differential, which was greater that one, indicating that a one percent increase in the price differential leads to a more-than-proportionate depreciation in the exchange rate for the Leone currency. One glaring inference that can be drawn from the result is that despite failing to validate the PPP theorem, the price differential between Sierra Leone and the United States is a significant determinant of exchange rate movements in the long run.

The short-run story is different, given that the price differential exhibited a negative and insignificant impact on exchange rate movements in Sierra Leone. However, the issue of exchange rate inertia was evident in the results. This corroborates the image currently mirrored in the Sierra Leone economy, wherein past depreciation of the exchange rate is a significant driver of current exchange rate depreciation pressures – a typical reflection of economic agents' adaptive expectation. This is normally a reflection of the outcomes from studies associated with inflation forecast that have so far been produced using ARIMA[X], given the strong influence of the exchange rate as an exogenous determinant on the future outlook for price stability in Sierra Leone (Jackson and Tamuke, 2018).

Failing to validate the PPP theorem in Sierra Leone is simply a confirmation of the presence of market failures, which makes it impossible for the condition of a competitive market and a well-functioning price mechanism to hold (Jackson and Jabbie, 2019). The country is fraught with streams of structural rigidities that are preventing a smooth functioning of the market economy – this encourages arbitrage and other forms of market failures. Moreover, it suffices to indicate that focus should be on the difference in prices between Sierra Leone and the United States in the long-run. However, the immediate short term focus should be on stabilizing the value of the Leone through a boost in real sector activities, which will instill confidence in the market, while subduing further depreciation pressures, with the ultimate gains of stabilising domestic price pressures.

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APPENDICES

APPENDIX 1: LONG-RUN STATIC MODEL

Dependent Variable: LNER

Method: Least Squares

Date: 09/21/19 Time: 11:15

Sample: 2007Q1 2019Q1

Included observations: 49				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LPRICED	1.362933	0.038564	35.34242	0.0000
C	9.116392	0.020939	435.3806	0.0000
R-squared	0.963737	Mean dependent var		8.446638
Adjusted R-squared	0.962965	S.D. dependent var		0.323953
S.E. of regression	0.062343	Akaike info criterion		-2.672377
Sum squared resid	0.182671	Schwarz criterion		-2.595160
Log-likelihood	67.47325	Hannan-Quinn criteria.		-2.643081
F-statistic	1249.086	Durbin-Watson stat		0.271373
Prob(F-statistic)	0.000000			

APPENDIX 2: OVERPARAMETERISED ECM

Dependent Variable: DLNER

Included observations: 44 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLNER(-1)	0.533795	0.158656	3.364481	0.0019
DLNER(-2)	-0.030861	0.179826	-0.171616	0.8648
DLNER(-3)	0.205284	0.175778	1.167856	0.2510
DLNER(-4)	0.235912	0.175592	1.343523	0.1880
DLPRICED(-1)	-0.414504	0.331254	-1.251317	0.2194
DLPRICED(-2)	0.375194	0.355742	1.054679	0.2990
DLPRICED(-3)	0.254173	0.359431	0.707155	0.4843
DLPRICED(-4)	-0.484068	0.334605	-1.446683	0.1571
ECT(-1)	-0.215365	0.093423	-2.305259	0.0274
C	0.008113	0.008369	0.969422	0.3392
R-squared	0.404290	Mean dependent var		0.024220
Adjusted R-squared	0.246602	S.D. dependent var		0.031087
S.E. of regression	0.026983	Akaike info criterion		-4.190501
Sum squared resid	0.024755	Schwarz criterion		-3.785003
Log likelihood	102.1910	Hannan-Quinn criter.		-4.040123
F-statistic	2.563857	Durbin-Watson stat		2.111553
Prob(F-statistic)	0.022739			

APPENDIX 3: PARSIMONIOUS SHORT-RUN ECM

Dependent Variable: DLNER

Included observations: 44 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLNER(-1)	0.499174	0.143615	3.475768	0.0013
DLNER(-4)	0.360044	0.149013	2.416199	0.0205
DLPRICED(-4)	-0.380393	0.300871	-1.264309	0.2136
ECT(-1)	-0.206785	0.076438	-2.705261	0.0101
C	0.011632	0.006810	1.708178	0.0956
R-squared	0.318696	Mean dependent var		0.024220
Adjusted R-squared	0.248818	S.D. dependent var		0.031087
S.E. of regression	0.026943	Akaike info criterion		-4.283519
Sum squared resid	0.028312	Schwarz criterion		-4.080770
Log-likelihood	99.23741	Hannan-Quinn criteria.		-4.208330
F-statistic	4.560782	Durbin-Watson stat		2.198288
Prob(F-statistic)	0.004058			

APPENDIX 4: RESIDUAL DIAGNOSTICS

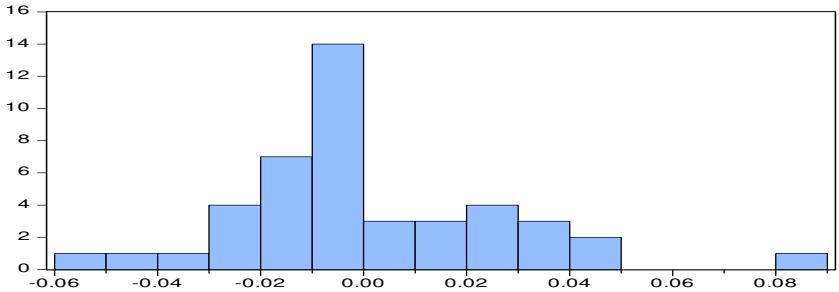
SERIAL CORRELATION

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.626935	Prob. F(2,37)	0.2103
Obs*R-squared	3.556684	Prob. Chi-Square(2)	0.1689

HETEROSCEDASTICITY

Heteroskedasticity Test: White			
F-statistic	1.085172	Prob. F(14,29)	0.4090
Obs*R-squared	15.12626	Prob. Chi-Square(14)	0.3696
Scaled explained SS	19.83403	Prob. Chi-Square(14)	0.1355

NORMALITY

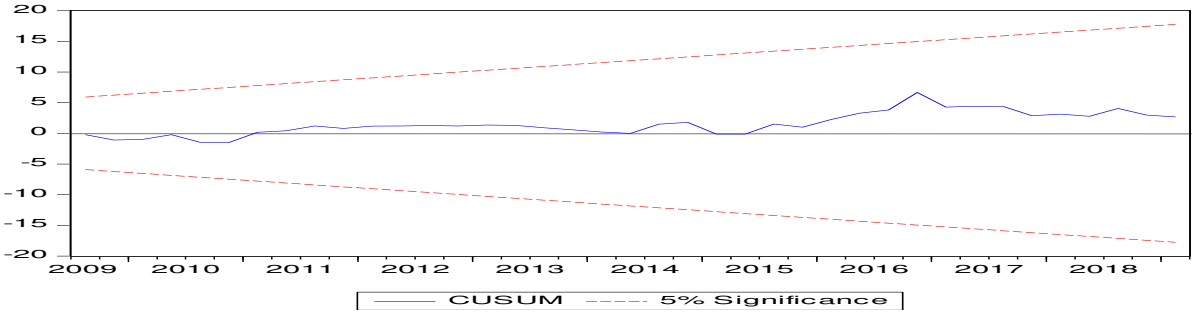


Series: Residuals
Sample 2008Q2 2019Q1
Observations 44

Mean	2.62e-18
Median	-0.006272
Maximum	0.084088
Minimum	-0.052513
Std. Dev.	0.025660
Skewness	0.816017
Kurtosis	4.337993
Jarque-Bera	8.165231
Probability	0.016863

STABILITY DIAGNOSTICS

CUSUM



CUSUM Square