FACULTY OF SOCIAL SCIENCE

DEPARTMENT OF ECONOMICS

TESTING THE PURCHASING POWER PARITY THEORY FOR PULA/RAND AND PULA/US DOLLAR EXCHANGE RATES IN BOTSWANA

BY

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DECLARATION

I declare that this study has not been undertaken previously and that the contents are my original work except where references have been made. The work in this paper shall not be submitted to any other institution besides the University of Botswana for the award of any degree.

Name:…………………………………………….

Signiture:…………………………..

Date:………………………..

CERTIFIGATE OF APPROVAL

This dissertation has been examined and approved as meeting the requiremnts for the partial fulfillmetnt of the Masters of Art Degree in Economics.

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Dr.Bakwena

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DEDICATION

I dedicate this dissertation to my daughter who has at a young age spent some nights away from me so that I could finish with school work. The emotional strain I put you through when you missed me and I was away has surely paid off. We will laugh at these moments one day in the future.

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I would like to thank my supervisor Professor Narain Sinha for his support, patience and constructive comments. Your input and guidance throughout this paper has made this journey an invaluable learning experience and I cherish the time we have spent together to work on the paper. My sincere appreciation also goes to my MA classmates for their support, encouragement and positive comments which helped improve the quality of the paper. Lastly, I would like to thank my family for the love and support they gave me. You have been a great support system socially and financially.

ABSTRACT

This paper tested the Purchasing Power Parity (PPP) theory between Pula/Rand and Pula/US dollar exchange rates in Botswana. The cointegration method, error correction model (ECM) and autoregressive distribution lag model (ARDL) were estimated to determine the validity of the theory between Botswana and South Africa and between Botswana and United States of America. The Engle-Granger cointegration method did not establish a relationship between the two exchange rates and prices and agreed with the results of studies by Tshipinare (2006), Rapelana (2014) and Sinha, Rapelana and Motlaleng (2018) that the PPP does not hold for Pula/Rand exchange rate. However, the estimated error correction model (ECM) showed rapid deviation of the variables to the long-run equilibrium, indicating a short-run relationship for Pula/Rand and Pula/US dollar exchange rates in Botswana. This contradicted the results of Rapelana (2014) and Sinha, Rapelana and Motlaleng (2018) and corroborated with Atta, Jefferis and Monnathoko (1996) for the Pula/Rand exchange rate and corroborated with Paul and Motlaleng (2008) in the case of Pula/US dollar exchange rates.

A further investigation of a long-run PPP was conducted using the autoregressive distribution lag model (ARDL). The ARDL bound tests were conducted and they showed that the variables were cointegrated with each other for both Botswana and South Africa and between Botswana and United States of America. This indicated a long-run association between the variables and validated the long-run PPP theory between Botswana and South Africa and between Botswana and United States of America. The validity of the Pula/Rand and Pula/US dollar exchange rates indicates that Botswana has strong trade relations with the two countries. Hence, it is recommended that monetary authorities should try to balance the weights in the Pula basket to promote both the importing and exporting sectors.

CHAPTER 1: INTRODUCTION

1.1 Introduction

The exchange rate determination is centred on the Purchasing Power Parity (PPP) theory which explains changes in the exchange rate between two currencies as a result of their inflation rate differentials. The PPP theory has two versions and they are the absolute PPP and the relative PPP. The absolute PPP is based on the law of one price, that the price of identical basket of goods and services sold in two countries should be the same when expressed in the same currency (Lafrance & Schembri, 2002). This is because the absolute PPP assumes that there are no barriers to trade. On the other hand, the relative PPP is more realistic in that it takes into account market distortions. That is, it considers the presence of transportation cost, tariffs and quotas. According to the relative PPP, changes in the exchange rate between two countries should be equivalent to changes in their inflation rate differentials (Lafrance & Schembri, 2002).

The PPP theory has been used extensively in macroeconomics as an exchange rate determination model and as a model for international price determination (Pollard & Pakko, 2003). It explains the behaviour and responses of the exporting and importing sectors relative to changes in the cost of basket of goods and services in the national market (Drine & Rault, 2008). Based on this relationship, the PPP theory becomes important for policy makers to assess the levels of exchange rate in a bid to evaluate whether the currency is overvalued or undervalued. Thus, it guides policy makers of the right choice of economic policy or economic policy mix in response to inflation rate changes when making exchange rate decisions. In so doing, it assist policy makers to achieve a balance between economic policies and promote all sectors of the economy without undermining the growth of others.

Testing for the validity of the PPP theory has attracted many researchers and empirical studies on the theory have varying conclusions. Contrary to Atta, Jefferis and Monnathoko (1996) who validated the PPP for Pula/Rand exchange rate, Tshipinare's (2006), Rapelana (2014) and Sinha, Rapelana and Motlaleng (2018) found that the PPP does not hold for the Pula/Rand exchange rate while Paul and Motlaleng (2008) validated the PPP for Pula/US dollar exchange rate in Botswana. Elsewhere in other countries, Ebiringa and Anyaogu (2014), Iran, Monfared and Akin (2017) and Jiramyakul and Batavia (2009) supported the

PPP theory that it holds while Drine and Rault (2008) and Enders (1988) did not validate the theory.

In the case of Botswana, testing the PPP theory for the two exchange rates is essential as major exports (diamonds) in the country rely on the Pula/US Dollar exchange rate while imports depends on the Pula/Rand exchange rate. According to the 2019 Budget by the Ministry of Finance and Economic Development (MFED), mineral revenues accounted for 32 percent of total revenues and customs and excise receipts accounted for 31 percent of total revenues in 2017/18 fiscal year. When combined, mineral revenues and customs and excise receipts accounted for 63 percent of total revenues during the period. This indicates the importance of trade and how critical policy maker's decision on the exchange rate policy can influence the growth the economy.

The Bank of Botswana implements the crawling band exchange rate policy introduced in 2005 with the aim to maintain a stable and competitive real effective exchange rate. The Pula is pegged to a basket of currencies comprising of the South African Rand and the International Monetary Fund's (IMF) Special Drawing Rights (SDR) which consist of the US Dollar, Japanese Yen, British Pound, Euro and the Chinese Renminbi. In 2019, the weights on the Pula basket were maintained at 45 percent the South African Rand and 55 percent SDR while the rate of crawl was adjusted upwards to 0.30 percent per annum in 2019 from a downward crawl of 0.30 percent per annum (Ministry of Finance and Economic Develoment, 2018).

1.2 Problem Statement

The South African Rand has always had a larger weight of the Pula basket than the SDR. There are two reasons why this is the case. Firstly, Botswana depends more on imports from South Africa including imports of raw materials used by the export market to produce tradeable goods. Secondly, movements in the Pula/Rand exchange rate are indirectly influenced by movements of the Rand/US Dollar exchange rate.

Similarly, major exports for Botswana (including diamonds) depend on the Pula/US dollar exchange rate. An appreciation of the Pula against the Rand will exert domestic pressure as goods and services produced in Botswana lose their price competiveness against imports. At the same time, the Pula depreciates against the US dollar and reduces the Pula value of US dollar denominated goods and services e.g. diamonds. Given that Botswana diamonds account for about 70 percent of total exports and that government revenue depends mostly on mineral revenue, the depreciation of the Pula against the US dollar affects both the current account and the balance of payments.

Testing the Purchasing Power Parity (PPP) for both the Pula/Rand exchange rate and the Pula/US dollar exchange rate for the same period is imperative as both exchange rates are the major currencies in the Pula basket of currencies to which the Pula is pegged. Consequently, they are important for trade in Botswana. The available studies in Botswana, Tshipinare (2006), Paul and Motlaleng (2008), Rapelana (2014) and Sinha, Motlaleng and Rapelana (2018), have considered the PPP for Pula/ Rand and Pula/US dollar exchange rates separately for different time periods. Tshipinare (2006) used monthly data for the period 1985 to 2005 while Rapelana (2014) and Sinha, Motlaleng and Rapelana (2018) used monthly data for the period 1985 to 2013. On the other hand, Paul and Motlaleng (2006) used data covering the period of 1992 Q3 to 2002 Q4. The present study considers the two exchange rates namely Pula/Rand and Pula/US dollar exchange rates together using annual data for the period from 1975 when the Pula was introduced as the Botswana currency to 2016.

Moreover, Rapelana (2014) and Sinha, Motlaleng and Rapelana (2018) has recommended an empirical study which tests the PPP for both currencies together as they are important currencies used for trade in Botswana.

1.3 Significance of the Study

The study is an addition to the existing empirical literature that has tested and validated the Purchasing Power Parity (PPP) theory. Unlike the other studies that have been conducted in Botswana, the present study intends to test the PPP for both Pula/Rand and the Pula/US dollar exchange rates together and covering the same period from 1975 to 2016. Previous studies in Botswana (Tshipinare (2006), Rapelana (2014), Sinha, Motlaleng and Rapelana (2018) and Paul and Motlaleng (2008)) has focused on testing the PPP theory for one exchange rate only – the Pula/Rand or the Pula/US dollar exchange rate. These studies have not tested the PPP for the two exchange rates jointly, hence, this study adds to the literature by testing the PPP for the two exchange rates together.

It fills the gap in the existing literature in Botswana by testing the validity of the PPP theory for two exchange rates which are important in the country's trade together in a single paper for the same period. Unlike the other studies which have used only the error correction model (ECM) to estimate the short-run and long-run relationship between the exchange rate and price level, the study make use of the autoregressive distributed lag model's (ARDL) bound tests approach (superior to the ECM) to examine these relationships and overcome the weaknesses in the ECM. In so doing, assess whether previous empirical findings are consistent in the results.

1.4 Objectives of the Study

The study has two objectives which are to;

- Test the Purchasing Power Parity (PPP) theory for Pula/Rand exchange rate
- Test the Purchasing Power Parity (PPP) theory for Pula/US dollar exchange rate

1.5 Hypothesis of the Study

- The PPP theory does not holds for the Pula/Rand and Pula/US dollar exchange rates.

- The PPP theory holds for the Pula/Rand and Pula/US dollar exchange rates. This is because the two currencies are important for trade in Botswana. Normally, the PPP would holds in countries which are more open to trade and are similar in size (Atta, Jefferis, Monnathoko, & Siwawa-Ndai, 1999)

CHAPTER 2: BOTSWANA'S MACROECONOMIC ENVIRONMENT

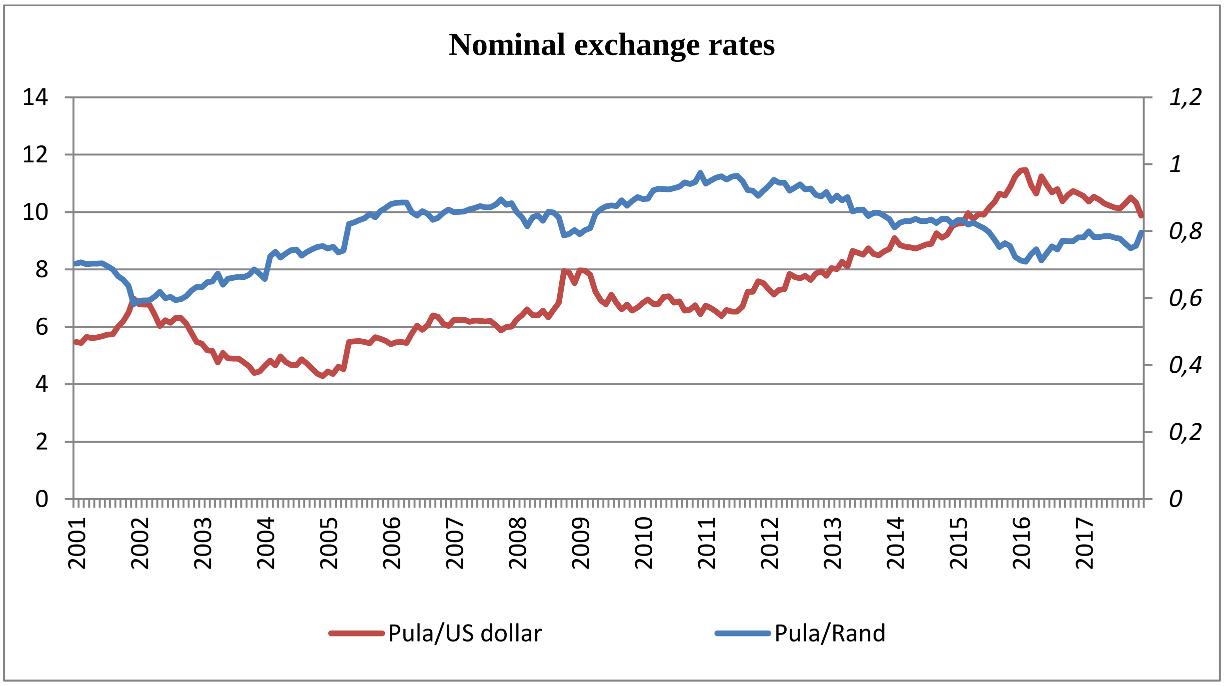
2.1 Exchange Rate Policy in Botswana

Botswana was part of the Rand Monetary Area (RMA) from 1966 when it attained independence until 1976 after establishing the Bank of Botswana and introducing the Pula currency. The decision to have monetary independence was to have legislated control of interest rates, credit and exchange controls (Masalila & Phetwe, 2001). Monetary independence had three broad objectives of supporting balance of payments, maintaining a liberal foreign exchange regime and avoiding sharp shifts in aggregate demand (Tsheole, 2006). The objective of monetary policy is to achieve price stability as reflected by low and stable inflation rate in the medium to long term (Masalila & Phetwe, 2001). The Bank of Botswana's has an inflation rate objective range is 3-6% in the medium-term (Bank of Botswana, 2017).

Botswana operates a crawling peg exchange rate regime, adopted in May 2005. Since the adoption of the crawling peg exchange rate regime, the exchange rate has been stable with minimal variations to the Pula exchange rate (Motlaleng, 2009). Under the crawling peg exchange rate, the Pula is pegged to a basket of currencies consisting of the South African Rand, US dollar, British Pound, Japanese Yen, Euro and the Chinese Renmimbi. The weights in the basket are 45 percent for the Rand and 55 percent for the International Monetary Fund's (IMF) Special Drawing Rights (SDR) and the crawling peg/band is 0.30 per annum (Bank of Botswana, 2017). The SDR comprises of the US dollar, Yen, Euro, Pound and the Renminbi. The choice of the pegged exchange rate regime is important for the economy of Botswana to maintain a stable and competitive real effective exchange rate, and allowing the nominal exchange rate to automatically adjust to changes in external factors. It mitigate against the vulnerabilities of the floating exchange rate regime and the problems associated with a complete fixed exchange rate regime and Botswana can take advantage of the two extreme exchange rate regimes (Motlaleng, 2009). That is, the choice of the pegged exchange rate enables Botswana to promote both the importing and exporting sectors without undermining the other.

Botswana's tradeables are largely denominated in South African Rand and the US dollar. Most of the country's imports such as food items, machinery, clothing, fuel and chemicals are imported from South Africa while the main exports (diamonds and beef) are sold in the US dollar denominated currency. Hence, Botswana trade mostly in Rand and US dollar. The two currencies are correlated and the relationship between them is evident in the graph below. according to the graph, the Pula/Rand is indirectly affected by changes in the Rand/US dollar movements. That is, when the rand depreciates against the US dollar the indirect effect will be an appreciation of the Pula against the US dollar. Hence, the Pula/Rand and Pula/US dollar are positively related.

Figure 1: The Pula/Rand and Pula/US dollar exchange rates



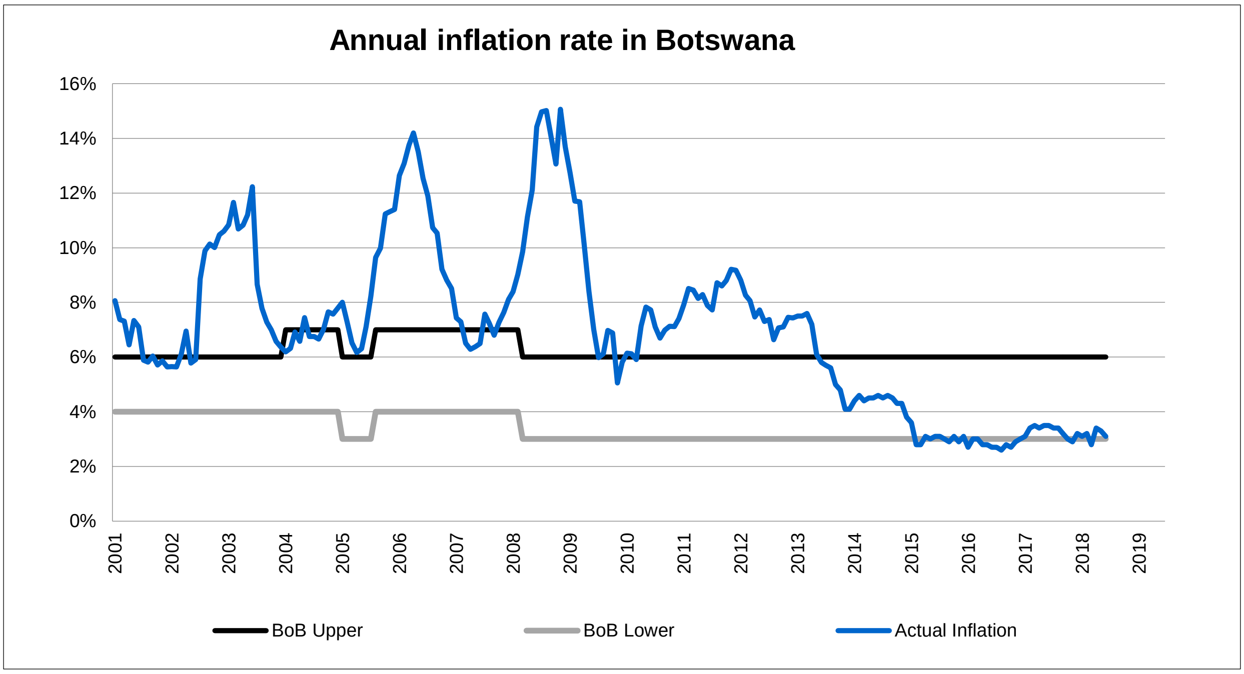
Source: Bank of Botswana

It can be seen from the graph that until 2015, the Pula/Rand and the Pula/US dollar was in equilibrium for the first time in history. Since then, the Pula has been appreciating against the Rand largely influenced by political events in South Africa.

2.2 Inflation Rate

It can be seen from figure 2 that inflation rate in Botswana has varied a lot over the years, but the general trend is downwards. Despite the Bank of Botswana's targeted inflation objective, inflation rate has, for most of the time, not been within the central bank's objective range and varied a lot around the upper bound of the central bank's objective range. However, in 2013 inflation was within the bank's objective range, breaking through the lower bound for the first time in 2015. Since then, inflation rate has varied around the lower bound of the objective range of 3-6%.

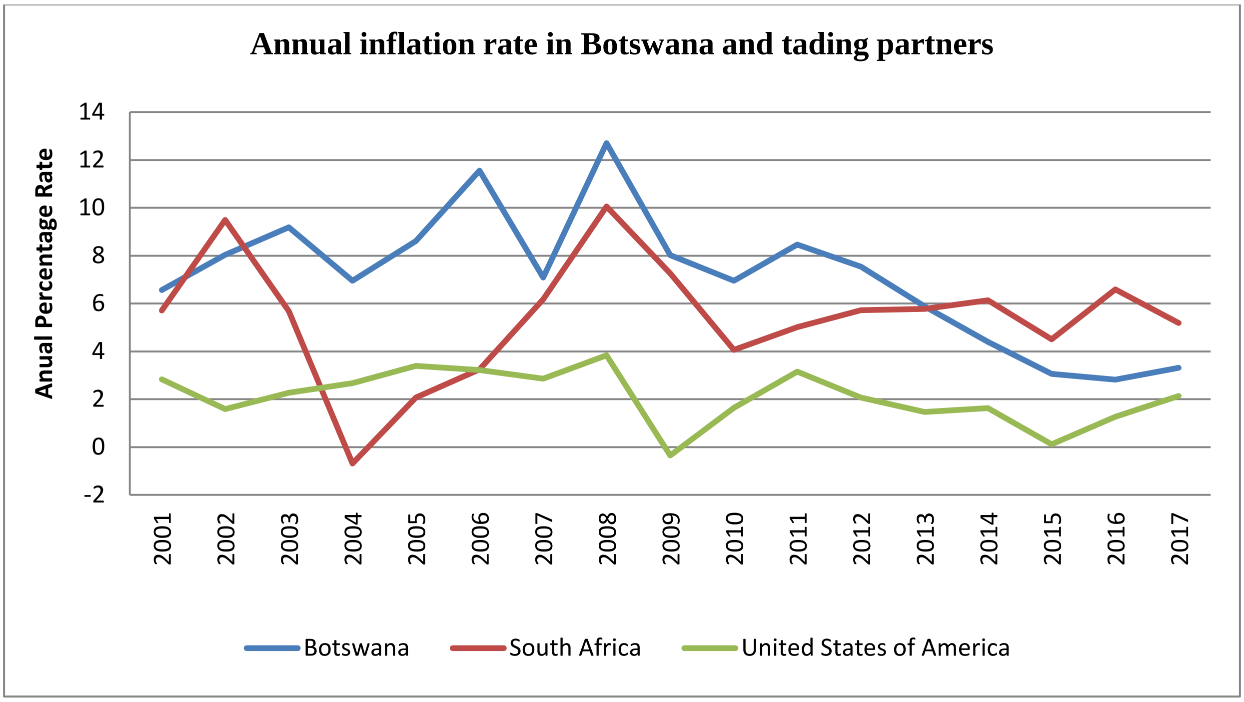
Figure 2: Annual inflation rate in Botswana



Source: Statistics Botswana and Bank of Botswana

In figure 3 below, trends in inflation rate for all countries is very much related and move in a similar direction. Inflation rate in Botswana has been higher than that of South Africa for most of the years while inflation in the United States has always been lower. In 2004, inflation in South Africa reached a lower rate of -0.7% before increasing significantly 2.1% in 2005. These variations in inflation rate reflect the decision by the authorities to devalue the Pula in 2004 as well as adopting the crawling peg mechanism in 2005 so as to maintain a stable and competitive real effective exchange rate. The crawling peg system was necessary for Botswana to mitigate external inflation pressures by allowing the exchange rate to vary along a pre-determined peg/band rate.

Figure 3: Annual inflation rate in Botswana, South Africa and United States of America



Source: Made from the World Bank' World Development Indicators (WDI)

CHAPTER 3: LITERATURE REVIEW

3.1 Theoretical Literature Review

This section explores the theoretical literature of the Purchasing Power Parity (PPP) theory.

The Purchasing Power Parity (PPP) theory has its origins from the Salamanca School in the 16thcentury and was first used as the theory of exchange rate determination by Gustav Cassel in 1918 (Lafrance & Schembri, 2002). The theory posit that equilibrium between two countries' exchange rates is determined by the ratios of their purchasing powers, therefore, equilibrium is achieved at a point where the two currencies are equal (Ebiringa & Anyaogu, 2014). If the PPP holds for both countries then it should be possible to purchase the same basket of goods in either country for the same amount. Discrepancies between the two countries' inflation rate will cause disequilibrium between the countries' exchange rates, and negatively change the current account of the high inflation country. This implies that when inflation rate increases in one country relative to the other, it will experience a decrease in exports and an increase in imports (Ebiringa & Anyaogu, 2014). Thus, the deepening current account deficit depresses the high inflation country's currency. The PPP theory has two types which are the absolute PPP theory and the relative PPP theory.

The absolute form of PPP states that nominal exchange rates between the currencies of two countries should be equal to their price ratios in the long-run (Ebiringa & Anyaogu, 2014). Hence, the exchange rate must adjust to equate price differentials of goods and services between two countries to maintain the purchasing power parity (Lafrance & Schembri, 2002). Algebraically, the absolute PPP is given by;

$$e = \frac{P^d}{Pf} \qquad (1)$$

Where e represents the nominal exchange rate, P^d represents the domestic price level and P^f is the foreign price level. If $P^d > P^f$ then it implies that the domestic exchange rate has appreciated against the foreign exchange rate. Exports become expensive while imports are cheaper. Also, if $P^d < P^f$ then it means that the domestic exchange rate has depreciated against the foreign exchange rate. In this case, exports are cheaper relative to imports which have become expensive. Thus, in both case the PPP does not exist.

The relative PPP theory on the other hand takes into account the realisation that markets are not perfect. It considers the presence of transportation costs, tariffs and quotas (Madura, 2012). The theory states that changes in the exchange rate should be equivalent to the difference in inflation rate between countries (Tang & Butiong, 1994). The relative PPP theory is given by equation 2 below;

$$\Delta e = \Delta P^d - \Delta P^f \qquad (2)$$

Where Δe represent the change in the exchange rate, ΔP^d represents the change in domestic inflation level and ΔP^f represent the change in foreign inflation level.

The relative PPP implies that the exchange rate between two countries should adjust to account for inflation rate differences over time (Lafrance & Schembri, 2002). Hence, the relative form of PPP taking the ratio between time period *t* and time *o* is;

$$\frac{e_t}{e_0} = \frac{P_t^d / P_0^d}{P_t^f / P_0^f} \qquad (3)$$

According to Lafrance and Schembri (2002), the relative form of PPP theory is useful in explaining movements on the exchange rate if most of the shocks are monetary rather than the real shocks.

Limitations of the PPP: The law of one price postulated by the PPP that there are no barriers to trade and transportation costs is not realistic. Trade between countries require openness and such costs incurred in exporting and importing of tradeables cannot be foregone. Hence, it may not be applicable in a small, landlocked and open economy like Botswana. The PPP also assumes homogeneity of goods between countries. However, technology and the technical skills in human resource cannot be the same.

3.2 Empirical Literature

The theoretical underpinnings relating to the exchange rate determination has attracted a lot of interest from researchers. Many researchers have empirically tested these correlations and there are mix findings. A few of the available studies in Botswana has validation the purchasing power parity for one exchange rate of either Pula/Rand or Pula/US dollar and not both exchange rates together.

Atta, Jefferis and Monnathoko (1996) are one of the earliest authors to empirically establish the relationship between the exchange rate and inflation rate in Botswana. The results from their study indicated that there was a long-run relationship between the Pula/Rand exchange rate and domestic prices. However, as the economy grow and become less reliant on South Africa for imports, the relationship between the variables becomes less significant. The study reveals that in the mid-1970s and mid-1980s the relationship was strong. However, post the time period it began to fall as the economy was expanding. Hence, in the absence of imports from South Africa the PPP would not hold (Atta, Jefferis, & Monnathoko, 1996).

Tshipinare's (2006) unpublished postgraduate study of the PPP between South Africa and Botswana could not validate the PPP. The results of the study failed to establish cointegration between the variables. Hence, the study failed to support the long-run PPP between South Africa and Botswana. On the other hand, Rapelana (2014) and Sinha, Rapelana and Motlaleng (2018) found that the PPP does not hold in Botswana. The findings from the study indicated that the PPP holds when there is perfect competition in the two economies but that was not the case in South Africa and Botswana. Moreover, the countries are not of the same size are indicated by volumes of import into Botswana from South Africa.

When testing the PPP between the Pula/US dollar, Paul and Motlaleng (2008) validated the PPP theory in Botswana that there exist a long-run relationship between the Pula/US dollar and domestic prices. The authors' findings are that there was no trade- off in export competitiveness through devaluation of the Pula and inflation in the long-run.

In Iran, Monfared and Akin (2017) tested the relationship between the exchange rate and inflation rate using two models, the Hendry General to Specific Modelling method and the Vector Auto Regression (VAR) model. The two models gave similar results of the positive correlation between exchange rates and inflation rates. The results of the VAR model when the money supply variable was added showed that both the exchange rate and money supply positively affected inflation rate but not by the same magnitude (Monfared & Akın, 2017). Money supply significantly affected inflation rate than the exchange rate.

In another study, Ebiringa and Anyaogu (2014) investigated the inter-relationships between exchange rate movements and inflation rate in Nigeria. The author found that changes in the exchange rate trends positively influenced inflationary trends in Nigeria in the short and long run (Ebiringa & Anyaogu, 2014). These results implied that the variables are cointegrated with each other. Similarly, the exchange rate had a delayed effect on the inflation rate in the case of Romania, showing a long run relationship between the exchange rate and inflation rate in Romania (Morosan & Zubas, 2015). Muco, Sanfey and Taci (2004) discovered that exchange rate stability was important in keeping inflation rate low in Albania.

Enders (1988) used the cointegration technique to test the PPP theory. A panel analysis of three countries of Canada, Japan and Germany concluded that the PPP theory was not valid for the countries for both periods of fixed exchange rate regime and flexible exchange rate regime. Drine and Rault (2008) also applied panel cointegration technique to test the PPP for 80 developed and developing countries. The results showed that the PPP strongly holds for Organisation for Economic Cooperation and Development (OECD) countries while the theory was weak for Middle East and North Africa (MENA) countries. According to the authors, the PPP theory was not valid to explain the long-run behaviour of the real exchange rate in Africa, Asia, Latin America and CEE countries. Moreover, the validity of the PPP is not conditioned by the nature of the exchange rate regime of a country, and countries with high than low inflation are more likely to accept the PPP theory (Drine & Rault, 2008). Rapelana (2014) considered the impact of the adoption of the crawling peg on the exchange rate in Botswana. The author found that the change in the exchange rate regime was positively related to exchange rate in Botswana.

Baharumshah, Mohd and Soon (2011) tested the PPP theory for ten African countries namely Algeria, Botswana, Burundi, Ghana, Kenya, Madagascar, Mauritius, Malawi, Nigeria and South Africa. Using the ARDL approach, the long-run PPP holds in the ten countries on the black market exchange rate and the official exchange rates. The theory holds more for the official exchange rate market than the black exchange rate market.

Nagayasu (1998) used panel data for 16 African countries to validate the PPP theory. The long-run PPP was established by using the cointegration test, and the results of the study showed that the change in the exchange rates in the African countries was consistent with the long-run PPP theory (Nagayasu, 1998).

In the case of Thailand, the PPP theory did not hold. Jiramyakul and Batavia (2009) analysed bilateral exchange rates between Thailand and six countries namely United States, Japan, United Kindom, Indonesia, Malaysia and Singapore by using bound test for cointegration.

The authors found that the PPP does not hold as a result of dissimilarities in economic sizes between Thailand and other countries.

3.3 Conclusion of the Literature

Empirical literature on the PPP theory has found inconclusive result about the validity of the theory. There are studies which validate the theory while other studies provide empirical evidence about the validity of the PPP theory. Similarly, the studies which have been conducted in Botswana are also inconclusive in the findings. The study follows the Enders (1988) to test the cointegration of the PPP theory for real and nominal exchange rates of Pula/Rand and Pula/US dollar by using time-series data. The previous studies in Botswana have tested the PPP theory for either the Pula/Rand exchange rate or the Pula/US dollar exchange rate separately for different periods. In this study, the tests for the PPP theory in Botswana for the two exchange rates will be done over the same period. Moreover, it employs the ARDL bound test approach to validate the long-run PPP theory between the variables.

CHAPTER 4: METHODOLOGY

4.1 Introduction

The study uses cointegration approach to investigate the Purchasing Power Parity (PPP) theory of the two exchange rates namely the Pula/Rand and Pula/US dollar. The two exchange rates are important because Botswana depends more on imports from South Africa while most exports like diamonds are denominated in US dollar currency. Hence, South Africa and the United States are important trade partners of Botswana. To estimate whether the PPP holds in Botswana, the study follows Enders (1988) to test the cointegration of the PPP theory for real and nominal exchange rates of Pula/Rand and Pula/US dollar. It also uses the ARDL model to assess the long-run causality of the variables. Time-series data covering the time period from 1975 (when the Pula was introduced as the currency) to 2016 will be used to validate the PPP theory between Botswana and South Africa and between Botswana and United States of America.

4.2 Specification of the Model

Several studies have tested the purchasing power parity theory using annual, quarterly and monthly time series data. Tang and Butiong (1994) tested the purchasing power parity for the major Asian Developing Countries using monthly data while Atta et al (1999) used the PPP to model inflation when examining price and inflation relationship in Botswana and South Africa. Enders (1988) employed quarterly time series data to test the purchasing power parity for three countries which are major trading partners of the USA. The author also examined the impact of a shift in exchange rate regimes, from a fixed to a flexible exchange rate regime. Based on Enders (1988) and Sinha, Motlaleng and Rapelana (2018) the absolute purchasing power parity model is specified as:

$$\ln e_t = \ln P_t^d - \ln P_t^f \qquad (1)$$

Where $\ln P_t^d$ and $\ln P_t^f$ are the logarithms of domestic and foreign price indices at time t respectively and $\ln e_t$ denotes the logarithm of the nominal exchange rates between domestic and foreign countries. The model for estimation is therefore

$$\ln e_t = \propto + \beta_1 \ln P_t^d + \beta_2 \ln P_t^f + \varepsilon_t \qquad (2)$$

Where $\propto$, β_1 and β_2 are the intercept and coefficient parameters and ε_t is the error term. The absolute form assumes the non-existence of trade barriers. As such, the restrictions imposed are $\propto = 0$, $\beta_1 = 1$ and $\beta_2 = -1$. In this way, any deviations from the unit coefficient can be maintained.

The relative form of the PPP is expressed as

$$\ln e_t = \beta\left(\ln P_t^d - \ln P_t^f\right) \qquad (3)$$

And the variables are denoted as in the absolute PPP.

When this is the case, the relative PPP is specified as

$$\ln e_t = \propto + \beta_1 \ln P_t^d + \beta_2 \ln P_t^f + \varepsilon_t \qquad (4)$$

Where β's are the estimated coefficients and ε_t is the white noise.

The PPP only holds when the variables are stationary (Enders, 1988). If they are stationary, then the long-run relationship between the variables can be tested, and the specified model be estimated. If the variables are stationary at first difference I(1) and not cointegrated, then the equation will be specified in first difference of the variables. However, if the variables are cointegrated the equation will be specified in terms of an error-correction model (Rutto & Ondiek, 2014).

According to Enders (1988), the PPP considering the real exchange rates is defined as

$$r_t = e_t + \mathrm{P}_t^d - \mathrm{P}_t^f \qquad (5)$$

In equation (5) above, P_t^d and P_t^f denotes the logarithms of domestic and foreign price levels, e_t denotes the logarithm of the nominal exchange rate and r_t is the real exchange rate. Ender (1988) asserts that the long-run PPP holds only if the real exchange rate is stationary. If non-stationary, the PPP is rejected.

4.3 Unit Root Test for Stationarity

The Augmented Dickey Fuller (ADF) method has been used to test the stationarity of the variables in time-series data. The series is considered stationary if the calculated ADF statistic is less than the ADF critical value. In this case unit root exist, and the non-stationary variables are differenced until they are stationary. However, the null hypothesis of no unit root is rejected if the computed ADF statistic is greater than the ADF critical value. In this case unit root does not exist and the variables are stationary.

According to Enders (1988), the purchasing power parity implies;

$$e_t = P_t^d - P_t^f + d_t \qquad (6)$$

Where P_t^d and P_t^f denotes logarithms of domestic and foreign price levels respectively, e_t is the logarithm for nominal exchange rates between two countries and d_t represents the deviation from the PPP in period *t*. Hence, if d_t is non-stationary, the PPP is rejected as the PPP does not allow for persistent deviations (Enders, 1988). Ender (1988) asserts that the long-run PPP holds only if the real exchange rate in equation (5) is stationary. If it is non-stationary, then PPP is rejected.

4.4 Cointegration Test Analysis

Most of the literature on exchange rates Rapelana (2014), Atta, Jefferis and Monnathoko (1996), Paul and Motlaleng (2008) and Sinha, Motlaleng and Rapelana (2018) indicates that the variables are stationary at first difference. If they are stationary at first difference I(1) then the PPP holds indicating that there is a long-run relationship between the two nominal exchange rates namely Pula/Rand and Pula/US dollar and the relative prices. Therefore, the test for cointegration in the proposed study is used to establish the long-run relationship between the exchange rates and relative prices. The decision rule for cointegration is based on the *F*-statistic. If the *F*-statistic is greater than the critical value then the series is cointegrated. However, if the *F*-statistic is less than the critical value, the null hypothesis of no cointegration is not rejected. The Engle-Granger cointegration and Johansen's cointegration methods will be used to test the long-run PPP. If there exist a long run relationship between the variables exchange rates and price ratios then the test for PPP will be specified in terms of an error correction model.

4.4.1 The Engle-Granger Cointegration Method

The Engle-Granger cointegration approach uses two variables only to determine the existance of a long-run relationship between the variables. At first, unit root tests are employed to determine the stationarity of the variables and their order of integration using the ADF and the PP tests. There are three ways in which the decision is made as to whether to continue with the procedure or not proceed with the procedure (Asteriou & Hall, 2007):

- If both the variables are integrated of the same order as require by the cointegrationapproache, then the procedure will be done,
- If the variables are stationary at levels i.e I(0), then the classical regression analysis is applied and the cointegration method may not be followed,
- But if the variables are integrated of different order i.e not integrated of the same order, then it is possible to conclude that there is no long-run relationship between the variables since there is no cointegrated between the variables.

After identifying the order of integration for the variables, the long-run PPP equation 4 will be estimated and the residual series obtained from the equation denoted by ε_t which is the error term. The ADF test is then performed on the residual series ε_t. In this case, the decision of unit root existance will be based on the comparison of the critical values generated by MacKinnon (1996) and the calculated ADF t-statistic. If the calculated ADF t-statistic is greater than the critical values generated by MacKinnon (1996) at all levels then we fail to reject the null hypothesis of non-stationary. Hence, the existence of unit root in the residual series ε_t will imply that there is no cointegration between the variables. Therefore, PPP theory relationship is not valid.

If the calculated ADF t-statistic is less than the critical values generated by MacKinnon (1996) at all levels then we reject the null hypothesis that the variables are stationary. Hence, in presence of no unit root in the residual series ε_t will imply that the variables are cointegrated and an ECM can be estimated.

4.4.2 The Johansen Cointegration Method

The Johansen cointegration test is performed when there are more than two variables involved as the number of cointegration vectors can be determined by the method which the Engle-Granger method cannot treat. If the variable are non-stationary at levels I(0) and become stationary after first difference I(1), then the ARDL equation 8 below will be estimated.

4.5 Error Correction Model Analysis

If the exchange rates (Pula/Rand and Pula/US dollar) and the price ratios are cointegrated, the cointegrated residuals are used as error correction term in the error correction model (ECM). The ECM corrects for disequilibrium and describes the process by which the first difference variables in the model adjust to equilibrium (Sinha, Motlaleng, & Rapelana, 2018). The model is used to examine how the endogenous variables quickly adjust towards the long-run equilibrium. Hence, the ECM can also be used to establish the short-run relationships between the variables. The specified error correction model is then given as;

$$\Delta y_t = \alpha + \beta \Delta X_t + \gamma Res_{-1} \qquad (7)$$

Where Δy_t change in the exchange rate, Res_{t-1} is the ECM residual and ΔX_t is changes in the endogenous variables.

The ECM has some weaknesses in that it requires that the variables to be integrated of the same order. To overcome this limitation, an Autoregressive Distributed Lag model (ARDL) bound test will be conducted. The ARDL bound test model is superior than the ECM in that it does not require the variables to be purely of either order $I_{(0)}$ or $I_{(1)}$ (Jacques, 2010). Hence, the long-run relationship between the exchange rate and price level can be estimated even when the variables are not of the same order. The specified ARDL bound model becomes:

$$\Delta y_t = \alpha + \beta \Delta X_t + \alpha_1 y_{t-1} - \alpha_2 x_{t-1} \qquad (8)$$

and test the hypothesis:

$H_0 \quad \alpha_1 = \alpha_2 \qquad\qquad H_1 \quad \alpha_1 \neq \alpha_2$

If the *F*-statistic is less than the computed values, we fail to reject the null hypothesis of no long-run relationship between the variables. However, if the *F*-statistic is greater than the computed values, we reject the null hypothesis of no long-run relationship between the variables.

4.6 Data Type and Sources

The study uses time-series annual data covering the period from when the Pula was first introduced as the Botswana currency has been used (the period from 1975 to 2016). The data is obtained from the Bank of Botswana, World Development Indicators (WDI) and Statistics Botswana. The data is analysed using E-views 9 to test the purchasing power parity theory for the two exchange rates namely the Pula/Rand and Pula/US dollar exchange rates. The data is given in Table 2 as follows:

Table 1: Type of data

Set A	**Set B**
Pula/Rand nominal exchange rate	Pula/US Dollar nominal exchange rate
CPI Botswana and CPI South Africa	CPI Botswana and CPI United States of America
The Pula/Rand real exchange rate	The Pula/US dollar real exchange

- The nominal exchange rate (NER) is defined as the domestic currency per foreign currency i.e Pula/Rand and Pula/US dollar. An increase in the NER means that the Pula is depreciating against the foreign currency while a decrease in the NER means that the Pula is appreciating against the foreign currency.

- The consumer price index (CPI) is defined as an index which measures changes in prices of goods and services over a reference period. The base year for this study is December 2010. The CPI of Botswana (CPI_BOT) is expected to be positively related to both the Pula/Rand (LNNER_PR) and Pula/US dollar (LNNER_PD) nominal exchange rates. The CPI of South Africa (CPI_RSA) is expected to be negatively related to the LNNER_PR while the CPI of the United States of America (CPI_USA) is expected to be positively related to the LNNER_PD.

- The real exchange rate (RER) calculation is given by nominal exchange rate multiplied by the ratio of foreign prices to domestic prices (Atta J. K., Jefferis, Monnathoko, & Siwawa-Ndai, 1999). The RERs were calculated using NERs and CPIs data from all the three countries.

CHAPTER 5: RESULTS ESTIMATION AND REGRESSION ANALYSIS

5.1 Introduction

In this chapter, an estimation and analysis of the results are discussed. Unit root tests are first conducted to determine the order of integration of the variables and to determine if the long-run PPP holds for the two exchange rates. The study then tests the long-run PPP by employing a cointegration test on the variables. To estimate the model, the study then estimates the Error Correction Model and the Autoregressive Distributed Lag Model (ARDL). The ARDL model is estimated to overcome the weaknesses of the ECM as it does not require that the variables to be integrated of the same order.

5.2 Unit root Stationarity Analysis

Two test of unit root have been used to determine the stationarity of the variables. These are the Augmented Dickey Fuller (ADF) method and the Phillips-Perron (PP) test. The series has a unit root if the calculated ADF statistic is less than the ADF critical value. In this case the variables are non-stationary and are differenced until they are stationary. If the calculated ADF statistic is greater than the ADF critical value, the null hypothesis is rejected. In this case unit root does not exist and the variables are stationary. In other terms, if the probability of the t-statistic is less than the 10% significance level, then the study rejects the null hypothesis that the series is stationary. However, if the probability of the t-statistic is greater than the 10% significance level then the study fails to reject the null hypothesis that the series is non-stationary.

The study tests the stationarity of the real exchange rates of the Pula/Rand exchange rate and the Pula/US dollar exchange rate to investigate whether the purchasing power parity holds. Enders (1998) states that the purchasing power parity holds if the real exchange rate series is stationary. If it is non-stationary, then the PPP will be rejected. That is, the PPP theory will not be supported. The real exchange rate is given by multiplying the nominal exchange rate with the ratio of foreign price level to domestic price level as (Atta J. K., Jefferis, Monnathoko, & Siwawa-Ndai, 1999):

$$RER = NER * \frac{CPI_f}{CPI_d} \qquad (9)$$

The Table below presents the results for the unit roots of the real exchange rate for Pula/Rand and Pula/US dollar real exchange rates

Table 2: Unit root test for Pula/Rand and Pula/US dollar real exchange rates

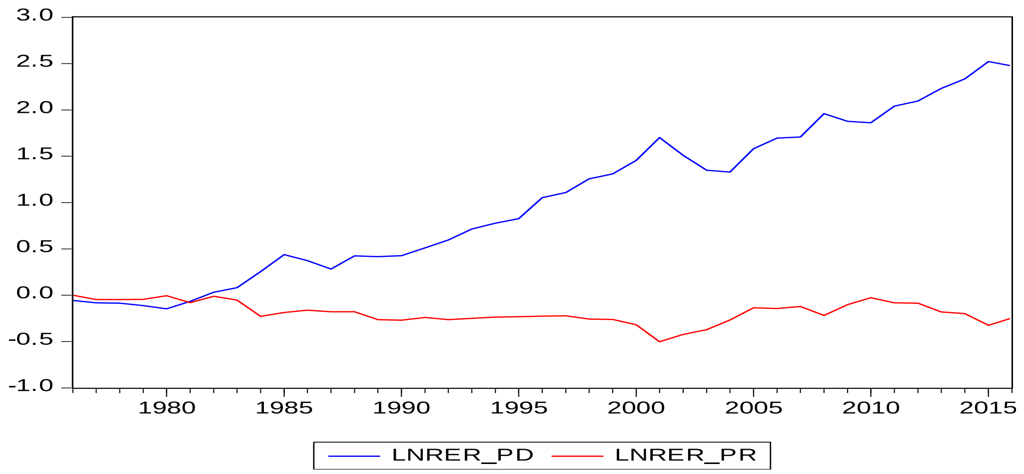
	Augumented Dickey-Fuller Test			**Phillips-Perron Test**		
Variable	t-Statistic	Probability	Stationarity Level	t-Statistic	Probability	Stationarity Level
Lnrer_pd	0.437242	0.9822	I(0)	0.979939	0.9956	I(0)
Lnrer_pr	-2.344548	0.1636	I(0)	-2.344542	0.1636	I(0)
Lnrer_pd	-5.928800	0.0000	I(1)	-6.361198	0.0000	I(1)
Lnrer_pr	-6.276896	0.0000	I(1)	-6.276626	0.0000	I(1)

Where:

- lnrer_pd and lnrer_pr denotes the logarithms of the real exchange rates of Pula/US dollar and Pula/Rand respectively.
- I(1) indicates stationarity after first difference

The results of the Augumented Dickey-Fuller and the Phillips-Ferron tests indicate that the Pula/Rand and the Pula/US dollar real exchange rates are non-stationary at levels and stationary at first difference. The results suggest that the PPP theory between Botswana and South Africa and between Botswana and United States of America maybe supported when the variables are integrated of order 1.

Figure 4: Pula/Rand and Pula/US dollar real exchange rates



Source: Calculated based on Bank of Botswana data

Figure 4 above shows the plots of the Pula/Rand and Pula/US dollar real exchange rates from the period when Pula was first introduced as the Botswana currency in 1975 to 2016. As shown in the graph, there is a relationship between the Pula/Rand real exchange rate and Pula/US dollar real exchange rate. During periods when the Pula/US dollar real exchange rates appreciated the Pula/Rand real exchange rate depreciated. Ender (1995) stated that the PPP theory does not allow for a deterministic time trend. Given that there is a relationship between the two real exchange rates at any time period as shown in the graph it is not possible to conclude that there is trend stationarity for the two exchange rates. Paul & Motlaleng (2008) also states that if the nominal and real exchange rate series' move in a similar direction then it is possible to conclude that the PPP theory holds for the two exchange rates.

Having established the stationary of the Pula/Rand and Pula/US Dollar real exchange rates as in Table 2 above, the study then tests the stationarity of the consumer price indices for Botswana, South Africa and United States of America and the results are given in Table 3 below:

Table 3: Nominal exchange rates and consumer price indices stationarity test results

	Augumented Dickey-Fuller Test			**Phillips-Perron Test**		
Variable	t-Statistic	Probability	Stationarity Level	t-Statistic	Probability	Stationarity Level
lnrer_pd	-5.928800	0.0000	I(1)	-6.361198	0.0000	I(1)
lnrer_pr	-6.276896	0.0000	I(1)	-6.276626	0.0000	I(1)
lnner_pd	-5.769393	0.0000	I(1)	-6.100531	0.0000	I(1)
lnner_pr	-6.120431	0.0000	I(1)	-6.120478	0.0000	I(1)
lncpi_bots	-8.717553	0.0000	I(2)	-3.753784	0.0068	I(0)
lncpi_rsa	-5.625898	0.0000	I(2)	-4.992058	0.0002	I(0)
lncpi_usa	-7.851099	0.0000	I(0)	-7.851099	0.0000	I(0)

Where:

- lnner_pd and lnner_pr denotes the logarithms of the nominal exchange rates of Pula/US dollar and Pula/Rand respectively.
- Lncpi_bot, lncpi_rsa and lncpi_usa denotes the logarithms of consumer price indices for Botswana, South Africa and United States respectively.
- I(0) indicates stationarity after first difference
- I(1) indicates stationarity after first difference
- I(2) indicates stationarity after second difference

The results of the ADF test show that most of the variables had unit root at levels and were stationary at second difference or integrated of order I(2). On the other hand, the results of the PP test indicated that most of the variables where stationary at levels while two variables are stationary at first difference and second difference meaning that they were non-stationary at levels. Only lncpi_usa variable was stationary at levels when using both the ADF test and PP test.

5.3 Cointegration Analysis

The cointegration test has been performed to test the validity of the Purchasing Power Parity theory between three countries being Botswana, South Africa and the United States of America. Using annual data for the period 1975 to 2016 (41 observations), the cointegration technique is used to analyse the long-run relationship between the Pula/Rand and Pula/US dollar exchange rates and the price levels.

Two methods of cointegration tests, the Engle-Granger cointegration test and the Johansen cointegration test, have been performed to test the long-run relationship of the two nominal exchange rates (Pula/Rand and Pula/US dollar) and the price ratios (CPI_{RSA}/CPI_{BOT} and CPI_{USA}/CPI_{BOT}). The PPP theory depits a long-run relationship between the nominal exchange rates and the price ratios between two countries. This is because changes in the real exchange rates will be offset by changes in the domestic prices by an equal amount, and the adjustment may not be instantaneous and takes a longer time (Atta J. K., Jefferis, Monnathoko, & Siwawa-Ndai, 1999). If there is cointegration between the variables then the PPP is valid and if there is no cointegration between the variables then the PPP theory will not hold. The cointegration method requires the variables to be integrated of the same order. The stationary tests results from the Phillips-Perron tests in 5.2 above showed that the variables were stationary after first difference. Hence, all of the variables have been entered in the order of integration of first difference to determine whether the series of the nominal exchange rates of the Pula/Rand and Pula/US dollar and the price ratios have a stationary long-run relationship.

5.3.1 The Engle-Granger Cointegration Method Results

All the variables are integrated in the same order of first difference. The Engle-Granger cointegration test was then performed on the series of the nominal exchange rate of Pula/Rand and the price ratio of South Africa and Botswana and also on the series of the nominal exchange rate of Pula/US dollar and the price ratio of United States of America and Botswana. The long-run PPP equations for Pula/Rand and Pula/US dollar nominal exchange rates (equation 4) were then estimated using the standard regression method. The residual series ε_t was then tested for unit root using the ADF test. The estimated equations are:

$$\text{lnner}_{\text{pr}_t} = 0.1091 + 0.4930\text{lncpi}_{\text{bot}} - 0.5539\text{lncpi}_{\text{rsa}}$$
$$[2.3590] \quad [6.7520] \qquad [-7.3753]$$

$$\text{lnner}_{\text{pd}_t} = -1.0038 + 0.7723\text{lncpi}_{\text{bot}} - 0.1064\text{lncpi}_{\text{usa}}$$
$$[-0.9517] \quad [6.0467] \qquad [-0.3035]$$

The results of the ADF test for the residual series ε_t for both South Africa and United States of America are presented in the Table below:

Table 4: ADF unit root test results

MacKinnon (1996) critical values for cointegration for 3 values with a constant		
1%: -4.29	5%: -3.74%	10%: -3.45%
	ADF	
Res_{pr}	t-statistic: -3.3683	
Res_{pd}	t-statistic: -3.1736	

The results from Table 4 above showed that both of the residuals ε_t for South Africa and the United States of America were non-stationary. The t-statistics for the residual ε_t for the two countries were greater than the MacKinnon (1995)'s calculated critical values at all levels. This indicates that the residuals from both countries are non-stationary, hence, the study fails to reject the null hypothesis for non-stationary. In this case, the variables are not cointegrated and the PPP theory could not hold. The results of the Engle-Granger were also consistent with those of Sinha, Rapelana and Motlaleng (2018) that the PPP does not hold between the Pula/Rand exchange rates after the crawling peg system was introduced.

5.3.2 The Johansen Cointegration Test

The variables have shown to be integrated after first difference. The optimal lag length of the unrestricted VAR model was determined before the cointegration test was performed using the five lag length selection criteria. The maximal lag length considered was 8.

Table 5 below shows that the five criterions suggested different lag lengths. The choice of the appropriate lag length to use is important as long lag lengths quickly assumes the degrees of freedom while short lag lengths can lead to misspecification (Akinboade & Makina, 2006). Two lag lengths of the AIC have been chosen and the lag length was applied to the VAR models of South Africa and United States of America to test for cointegration.

Table 5: The unrestricted VAR optimal lag lengths

	LR	FPE	AIC	SC	HQ
South Africa	1 lag	2 lags	2 lags	1 lags	1 lags
Unite States of America	1 lag	2 lags	2 lags	1 lag	2 lags

The results of the Johansen cointegration tests are shown in Tables 6 and 7 below for South Africa and United States of America respectively. The trade statistic and the maximum eigenvalues are used to determine whether there are cointegrating vectors. If there is no cointegration, the Johansen results will give 0 cointegrating equations. However, if there is cointegration, the Johansen results will give at least one cointegratingequations.

Table 6: Johansen cointegration results for South Africa

Trace test results				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Probability**
None *	0.471174	38.96088	29.79707	0.0034
At most 1	0.216807	14.75125	15.49471	0.0645
At most 2 *	0.133952	5.464963	3.841466	0.0194
Trace test indicates 1 cointegratingeqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level				
Maximum Eigenvalue test results				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Probability**
None *	0.471174	24.20963	21.13162	0.0178
At most 1	0.216807	9.286288	14.26460	0.2631
At most 2 *	0.133952	5.464963	3.841466	0.0194
Max-eigenvalue test indicates 1 cointegratingeqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level				

The results from Table 6 above show that at least one equation is cointegrated for both the trace statistic and the maximum eigenvalue at 5% significance level. Hence, the null hypothesis of no cointegration is rejected at 5% significance level. This indicates the existence of a long-run relationship between the variables and suggests that the PPP hold between Botswana and South Africa.

Table 7: Johansen cointegration results for United States of America

Trace test results				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Probability**
None *	0.655901	65.67198	29.79707	0.0000
At most 1 *	0.418390	25.13261	15.49471	0.0013
At most 2 *	0.112574	4.538345	3.841466	0.0331
Trace test indicates 3 cointegratingeqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level				
Maximum Eigenvalue test results				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Probability**
None *	0.655901	40.53937	21.13162	0.0000
At most 1 *	0.418390	20.59426	14.26460	0.0044
At most 2 *	0.112574	4.538345	3.841466	0.0331
Max-eigenvalue test indicates 3 cointegratingeqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level				

In the case of the United States of America, the Johansen cointegration results presented in Table 7 above indicates that atleast three equations were cointegrated at 5% significance level for both the trace statistic and the maximum eigenvalue. This indicates that the null hypothesis of no cointegration is rejected. This implies that there is a long-run equilibrium relationship between the variables and the PPP theory may hold between Botswana and the United States of America.

Based on the results from the two cointegration tests the error correction model (ECM) can be estimated for both countries to determine the validity of the PPP theory between Botswana and South Africa and between Botswana and the United States of America. Rapelana (2014), Sinha, Rapelana and Motlaleng (2018), Paul and Motlaleng (2008) and Chocholata (2009) have estimated the ECM once the variables were cointegrated. Only the study by Tshipinare (2006) did not estimate the ECM as the variables were not cointegrated.

5.4. The Error Correction Model (ECM) Results

The error correction model has been estimated and the residual error correction term (ECT). The ECT is used in the model to determine the speed of adjustment of the endogenous variables towards the long-run equilibrium as well as determine the short-run relationships between the variables. The results of the ECM and the ECT are presented in Table 13 below.

Table 8: Short-run LNNER_PR and LNNER_PD equations

Cointegrating Form LNNER_PR				
Variable	Coefficient	Standard Error	t-Statistic	Probability
D(LNNER_PR(-1))	0.234123	0.173874	1.346508	0.1876
D(LNCPI_BOT)	0.236154	0.652957	0.361669	0.7200
D(LNCPI_BOT(-1))	1.142106	0.580177	1.968548	0.0577
D(LNCPI_RSA)	-0.356018	0.119338	-2.983262	0.0054
ECT	-0.628894	0.163103	-3.855802	0.0005
Cointegrating Form LNNER_PD				
Variable	Coefficient	Standard Error	t-Statistic	Probability
D(LNNER_PD(-1))	0.290800	0.146638	1.983117	0.0560
D(LNCPI_BOT)	-1.787267	1.041244	-1.716472	0.0957
D(LNCPI_BOT(-1))	-1.412744	1.034992	-1.364981	0.1818
D(LNCPI_USA)	0.754787	0.381013	1.980998	0.0562
ECT	-0.701647	0.146506	-4.789206	0.0000

From Table 13 above, the coefficient of the ECT in the LNNER_PR model is -0.6289 and has a probability of 0.0005 which is significant. The ECT is negative and significant, hence, there is a short-run causality between the price levels and the nominal exchange rate at 62.9% speed of adjustment towards equilibrium in the long-run. This is contrary to the study by Sihna, Rapelana and Motlaleng (2018) which found that the ECM had the expected sign but not significant or not close to 1, hence, it rejected cointegration between the Pula/Rand nominal exchange rate and prices. The results on Table 13 above also indicates that the

LNNER_PR is positively affected by its previous lag value as well as the previous lag value of the CPI_BOT.

The ECT was also negative and significant in the case of United States of America and corroborated with Paul and Motlaleng's (2008) study on the PPP between the Pula/US dollar exchange rate. The coefficient of the ECT is -0.7016 and its probability is 0.0000 indicating that there is a short-run relationship between the variables. This shows that the ECT is significant and its speed of adjustment to the long-run equilibrium is a 70.2% response rate. Atta, Jefferis and Monnathoko (1999) also found that the ECM for the Pula/US dollar exchange rate was strongly significant when adjusting to the long-run PPP by about 2% every month. Paul and Motlaleng's (2008) study on validating the Pula/US dollar exchange rate also showed that the adjustment to the PPP took many years by some 2% every quarter to reach equilibrium. The LNNER_PD is also affected by previous lag values of the LNNER_PD nominal exchange rate and the domestic prices. The current LNNER_PD would be positively affected by its previous lag value by 0.29 while it will be negatively affected by the CPI_BOT previous lag value by -1.41.

5.5. The Autoregressive Distributed Lag Model (ARDL) Results

The ARDL model was used to determine further the long-run association of the nominal exchange rates of the Pula/Rand and the Pula/US dollar and the respective price levels. The ARDL model was used and deemed the appropriate model as it overcomes some of the limitations in the ECM. The ARDL model does not require the variables to be integrated in the same order. That is, the ARDL model can be estimated even when the variables are not integrated in the same order. The ARDL model has been estimated for each of the Pula/Rand and Pula/US dollar nominal exchange rates and the presented in Table 10 below:

Table 9: LNNER_PR estimated ARDL model

Variable	Coefficient	Standard Error	t-Statistic	Probability
LNNER_PR(-1)	0.605229	0.187940	3.220335	0.0029
LNNER_PR(-2)	-0.234123	0.173874	-1.346508	0.1876
LNCPI_BOT	0.236154	0.652957	0.361669	0.7200
LNCPI_BOT(-1)	1.238788	1.019551	1.215033	0.2332
LNCPI_BOT(-2)	-1.142106	0.580177	-1.968548	0.0577
LNCPI_RSA	-0.356018	0.119338	-2.983262	0.0054
C	-0.076531	0.096652	-0.791816	0.4343
R-squared	0.754512	Log likelihood		54.41958
Adjusted R-squared	0.708483	F-statistic		16.39210
S.E. of regression	0.066179	Prob(F-statistic)		0.000000
Sum squared resid	0.140147	Durbin-Watson stat		2.098561

The estimated ARDL model for LNNER_PR is a good model proven by the R^2 which is 0.75 and the probability of the F-statistic of 0.00. Diagnostic tests also indicate that there are no time-series problems such as serial correlation and heteroscedasticity. The Durbin-Watson statistic is significant at 2.09. The ARDL model was further tested for its stability and the model was proved to be stable by the cusum test.

Table 10: LNNER_PD estimated ARDL model

Variable	Coefficient	Standard Error	t-Statistic	Probability
LNNER_PD(-1)	0.589153	0.161027	3.658722	0.0009
LNNER_PD(-2)	-0.290800	0.146638	-1.983117	0.0560
LNCPI_USA	0.754787	0.381013	1.980998	0.0562
LNCPI_BOT	-1.787267	1.041244	-1.716472	0.0957
LNCPI_BOT(-1)	0.587755	1.633180	0.359884	0.7213
LNCPI_BOT(-2)	1.412744	1.034992	1.364981	0.1818
C	-2.790562	1.154763	-2.416566	0.0215
R-squared	0.983318	Log likelihood		34.10857
Adjusted R-squared	0.980190	F-statistic		314.3669
S.E. of regression	0.111403	Prob(F-statistic)		0.000000
Sum squared resid	0.397137	Durbin-Watson stat		2.047926

The estimated ARDL model for LNNER_PD is a good model proven by the R^2 which is 0.78 and the probability of the F-statistic of 0.00. Diagnostic tests also indicate that there are no time-series problems such as serial correlation and heteroscedasticity and the Durbin-Watson statistic is significant at 2.04. The ADRL model was further tested for its stability and the cusum test proved the model to be stable.

To analyse cointegration, the ARDL bound tests have been estimated to determine the long-run relationship between the two exchange rates and price levels. Two bound tests for LNNER_PR and LNNER_PD has been estimated and are presented in Table 10 below.

Table 11: ARDL bound cointegration tests

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Significance	I(0)	I(1)
LNNER_PR			Asymptotic: n=1000	
F-statistic	5.663651	10%	3.17	4.14
K	2	5%	3.79	4.85
		1%	5.15	6.36

LNNER_PD				
F-statistic	8.542638	10%	3.17	4.14
K	2	5%	3.79	4.85
		1%	5.15	6.36

If the F-statistic is greater than the upper bound then the null hypothesis of no cointegration is rejected (Tia & Ma, 2009). If the F-statistic is less than the upper bound then there is no cointegration between the variables. However, if the value of the F-statistic lies between the lower and the upper bounds then the results are inconclusive. The F-statistic for LNNER_PR is 5.66 and is greater than the upper bound of 4.85 at 5% significance level. The results of the F-statistic from the ARDL bound test for LNNER_PR indicate that there is a long-run association of the CPI_BOT and CPI_RSA to the LNNER_PR nominal exchange rate.

Similarly, the F-statistic of the LNNER_PD is 8.54 and is also greater than the upper bound of 6.36 at 1% significance level. The results of the F-statistic from the ARDL bound test for LNNER_PD indicate that there is a long-run association of the CPI_BOT and CPI_USA to the LNNER_PD nominal exchange rate. The existence of a long-run relationship between the LNNER_PR nominal exchange rate and price levels and between the LNNER_PD nominal exchange rate and price levels suggest that the PPP theory holds for Botswana and South Africa and also holds for Botswana and United States of America.

After establishing that the variables are cointegrated with each other, the long-run equations of the ARDL are estimated and presented as follows:

$$\underset{}{LNNER\_PR} = \underset{[0.1600]}{-0.1217} + \underset{[0.1095]}{0.5292}LNCPI\_BOT - \underset{[0.1105]}{0.5661}LNCPI\_RSA$$

$$\underset{}{LNNER\_PD} = \underset{[1.6991]}{-3.9771} + \underset{[0.2024]}{0.3039}LNCPI\_BOT + \underset{[0.5699]}{1.0757}LNCPI\_USA$$

The coefficients of the long-run LNNER_PR and LNNER_PD equations are both significant and indicate that there is a long-run relationship between the price levels and their respective nominal exchange rates. Also, all the coefficients in the long-run equations have the expected signs. In the long-run, a 1% increase in the CPI_BOT will lead to 52.9% increase in the LNNER_PR and 30.4% increase in the LNNER_PD. That is, a rise in the domestic price level is expected to positively affect both the Pula/Rand nominal exchange rate and the Pula/US dollar nominal exchange rate by increasing their value i.e the Pula/Rand and the Pula/US dollar nominal exchange rates both depreciate. If the CPI_RSA decreases by 1% this will lead to 56.6% increase in the Pula/Rand nominal exchange rate or LNNER_PR. Price levels in the USA positively affect the Pula/US dollar exchange rate i.e a 1% increase in the CPI_USA will increase the LNNER_PD by 107.6%.

The results also show that foreign prices in South Africa and United States of America affect the nominal exchange rates differently. This may be because majority of Botswana's imports come from South Africa while a large proportion of Botswana's exports (diamonds) are sold to the international market in US dollar denominated currency.

In the case of South Africa, an increase in domestic prices will lead to a fall in the exchange rate. The Pula loses its worth and buy less of South Africa's Rands. When the exchange rate depreciates against the rand, locally produced goods and services loses their price competitiveness as imports become relatively cheap than exports which have become relatively expensive. The balance of trade (BOT) will be a deficit as the imports value will be higher than the value of exports. However, if the price level increases in South Africa then the nominal exchange rate will increase. Conversely, the BOT will fall into a surplus as exports increases relative to imports which has become expensive.

In the case of the United States of America, an increase in price level in the USA will positively affect the nominal exchange rate. Diamond exports accounts for a larger proportion of Botswana's export sector and are sold in US dollar terms. A rise in the USA prices will positively increase diamond exports and diamonds value in Pula terms (the exchange rate effect). The effect on BOT will be a surplus. Conversely, if the international prices for diamonds are weak the Pula value of diamonds (denominated in US dollar currency) will fall as a result of the exchange rate effect. The BOT will be a deficit as exports would have fallen.

5.6. Conclusion

The cointegration techniques, ECM and ARDL models were used to establish the long-run relationship between the Pula/Rand and Pula/US dollar exchange rates. The Engle-Granger cointegration method did not establish a long-run relationship between the two exchange rates and price levels respectively, rejecting the PPP theory. Based on the results of the Johansen cointegration method that the variables are cointegrated, the ECM and ARDL models were estimated. The ECT terms for both the Pula/Rand and Pula/US dollar exchange rates were negative and significant and the ARDL bound test for both exchange rate had expected signs. Hence, the ECM and ARDL tests validated the PPP theory for Pula/Rand and Pula/US dollar exchange rates. The results corroborated with Atta, Jefferis and Monnathoko (1996) and Paul and Motlaleng (2008) for Pula/Rand and Pula/US dollar exchange rates respectively, and contradicted with Rapelana (2014) and Sinha, Rapelana and Motlaleng (2018) for the Pula/Rand exchange rate.

CHAPTER 6: CONCLUDING SUMMARY AND POLICY RECOMMENDATION

6.1: Concluding Summary

The cointegration techniques were used to establish the long-run relationship between the Pula/Rand and Pula/US dollar exchange rates. The Engle-Granger did not establish the long-run relationship between the Pula/Rand nominal exchange rate and the price levels and between the Pula/US dollar exchange rate and the price levels. Hence, according to the method PPP theory did not hold between Botswana and South Africa (RSA) and between Botswana and the United States of America (USA). The Johansen cointegration method showed that the variables were cointegrated with each other for Botswana and South Africa and Botswana and the USA suggesting that the PPP holds between Botswana and RSA and between Botswana and USA. Cointegration for a long-run relationship between the variables was also supported in the Rapelana (2014) and Sinha, Rapelana and Motlaleng (2018) for the Pula/Rand exchange rate and price level and by Paul and Motlaleng (2008) for the Pula/US dollar exchange rates and price levels. However, estimated ECT was not significant and did not support the PPP theory for Pula/Rand exchange rate in studies by Rapelana (2014) and Sinha, Rapelana and Motlaleng (2018).

Based on the present study's cointegration result, the ECM model was estimated to assess the short-run relationship between the variables. The ECT terms for both the Pula/Rand and Pula/US dollar exchange rates indicated that there was a short-run relationship as there was a rapid response of the variables towards a long-run PPP equilibrium. The ECT for Pula/Rand nominal exchange rate showed that the endogenous variables adjust by 0.629 towards the long-run equilibrium while the ECT term for Pula/US dollar nominal exchange rate showed that there was 0.702 speed of adjustment of the endogenous variables towards long-run equilibrium. This is a rapid adjustment; hence, there was a short-run relationship between the nominal exchange rate and the price levels.

The results of the ECM did not agree with the findings of Rapelana (2014) and Sinha, Rapelana and Motlaleng (2018) that the PPP holds for Pula/Rand exchange rate while corroborating with Atta, Jefferis and Monnathoko (1996) and Paul and Motlaleng (2008) for Pula/Rand exchange rate and Pula/US dollar exchange rate respectively. The ECT for Pula/US dollar exchange rate in studies by Atta, Jefferis and Monnathoko (1996) and Paul and Motlaleng (2008) was found to be strongly significant and took many years to reach the long-run PPP in both studies, thus, validating the theory in Botswana. Tshipinare's (2006) unpublished dissertation for validating the PPP theory for Pula/Rand exchange rate did not estimate the ECM because the results from cointegration techniques did not show a relationship between the variables.

A long-run causality of the variables was estimated using the ARDL bound testing which is superior to the ECM. Previous studies done on the PPP theory in Botswana did not estimated the ARDL model and the model overcomes the weaknesses of the ECM that the variables be integrated of the same order. The results of the ARDL model in the present study showed that there was an existence of a long-run relationship between the Pula/Rand exchange rate and prices and between the Pula/US dollar exchange rate and prices. This validated the PPP theory between Botswana and RSA and between Botswana and USA.

It is worth noting that the previous studies on the PPP theory in Botswana have employed data for different periods as well as the frequency is not the same. The study employed annual data for the period from 1975 to 2016 while other studies have used monthly or quarterly data. Tshipinare's (2006) unpublished dissertation used monthly data covering the period from 1985 to 2005 as well as Atta, Jefferis and Monnathoko (1996) (period from 1976 to 1994), Rapelana (period from 1985 to 2013) and Sinha, Rapelana and Motlaleng (2018) (period from 1985 to 2013). It is only Paul and Motlaleng (2008) who have used quarterly data covering the period from Q3 1992 to Q4 2002. Hence, the difference in the frequency of the data may influence the difference in the empirical studies results.

6.2: Policy Recommendations

According to Atta et al. (1999) the PPP theory performs better for countries which have high trade linkages and who are close to each other geographically. South Africa and the United States of America are the major trading partners of Botswana. Botswana imports most of its goods and services from South Africa while it exports diamonds to large developed countries including the USA and in US dollar denominated currency. Hence, Botswana's trade linkage with these two countries is high. The results of the ECM showed that the short-run deviations between the Pula/Rand are weak compared to the short-run deviations between Pula/US dollar. Taking this into account for the exchange rate regime in Botswana, a change from a fixed crawling peg exchange rate regime to a flexible exchange rate regime at the present time may not be necessary. For example, suppose there is a shift in the exchange rate regime to a flexible exchange rate. During the De Beers Global Sightholder Sales (DBGSS) the exchange rate will move quickly and be volatile over a short period of time as there are only ten DBGSS taking place annually in Botswana. On the other hand, trade between Botswana and South Africa happens approximately every day. Hence, it would not make economic sense to move from the current exchange rate regime to a flexible exchange rate regime. What is required would be for the authorities to try to balance the weights of the Rand and the US dollar in the Pula basket of weights so as to not promote one sector and undermine the other sectors.

Given that exports have not yet diversified (according to the latest trade statistics from Statistics Botswana diamonds accounted for 89% of total exports in Botswana in 2018), an important policy shift for the country should be to move to an export-oriented approach from the import-substitution approach. This would require government commitment with its policies, by aligning policies to promote domestic production and foreign domestic investment. This includes choosing the appropriated basket weights to promote the non-traditional export industries.

APPENDICES

APPENDIX 1: Engle-Granger Cointegration Test output

a) LNNER_PR

Dependent Variable: LNNER_PR
Method: Least Squares
Date: 05/14/19 Time: 22:53
Sample: 1976 2016
Included observations: 41

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNCPI_RSA	-0.553896	0.075101	-7.375342	0.0000
LNCPI_BOT	0.493019	0.073018	6.752037	0.0000
C	0.109138	0.046264	2.359024	0.0236

R-squared	0.636908	Mean dependent var	-0.202696
Adjusted R-squared	0.617798	S.D. dependent var	0.126385
S.E. of regression	0.078134	Akaike info criterion	-2.190421
Sum squared resid	0.231988	Schwarz criterion	-2.065038
Log likelihood	47.90364	Hannan-Quinn criter.	-2.144764
F-statistic	33.32834	Durbin-Watson stat	0.929524
Prob(F-statistic)	0.000000		

Null Hypothesis: ECT2 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.368324	0.0182
Test critical values:	1% level	-3.605593	
	5% level	-2.936942	
	10% level	-2.606857	

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

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ECT2(-1)	-0.464482	0.137897	-3.368324	0.0017
C	-0.000893	0.010451	-0.085486	0.9323

b) LNNER_PD

Dependent Variable: LNNER_PD
Method: Least Squares
Date: 05/14/19 Time: 22:17
Sample: 1976 2016
Included observations: 41

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNCPI_USA	-0.106421	0.350662	-0.303486	0.7632
LNCPI_BOT	0.772334	0.127728	6.046720	0.0000
C	-1.003761	1.054750	-0.951658	0.3473

R-squared	0.964608	Mean dependent var	1.121251
Adjusted R-squared	0.962745	S.D. dependent var	0.825850
S.E. of regression	0.159401	Akaike info criterion	-0.764433
Sum squared resid	0.965529	Schwarz criterion	-0.639050
Log likelihood	18.67088	Hannan-Quinn criter.	-0.718775
F-statistic	517.8472	Durbin-Watson stat	0.775073
Prob(F-statistic)	0.000000		

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.173612	0.0291
Test critical values:	1% level	-3.605593	
	5% level	-2.936942	
	10% level	-2.606857	

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

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ECT(-1)	-0.404007	0.127302	-3.173612	0.0030
C	-0.003423	0.019725	-0.173530	0.8632

APPENDIX 2: Johansen Cointegration Test output

a) LNNER_PR

Date: 05/13/19 Time: 20:27
Sample (adjusted): 1981 2016
Included observations: 36 after adjustments
Trend assumption: Linear deterministic trend
Series: LNNER_PR LNCPI_BOT
LNCPI_RSA
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.461794	40.07639	29.79707	0.0023
At most 1 *	0.261592	17.77386	15.49471	0.0223
At most 2 *	0.173421	6.856533	3.841466	0.0088

Trace test indicates 3 cointegratingeqn(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 No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.461794	22.30253	21.13162	0.0341
At most 1	0.261592	10.91732	14.26460	0.1584
At most 2 *	0.173421	6.856533	3.841466	0.0088

Max-eigenvalue test indicates 1 cointegratingeqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LNNER_PR	LNCPI_BOT	LNCPI_RSA
27.88910	-14.06777	12.85605
-18.70104	14.80837	-16.02693
6.741022	3.204596	-1.416376

Unrestricted Adjustment Coefficients (alpha):

D(LNNER_PR)	-0.037314	0.017710	-0.005164
D(LNCPI_B	0.000601	-0.002049	-0.006366

D(LNCPI_BOT)			
D(LNCPI_RSA)	0.004807	0.004983	-0.003968

1 Cointegrating Equation(s):	Log likelihood	259.7866

Normalized cointegrating coefficients (standard error in parentheses)

LNNER_PR	LNCPI_BOT	LNCPI_RSA
1.000000	-0.504418	0.460970
	(0.06897)	(0.06673)

Adjustment coefficients (standard error in parentheses)

D(LNNER_PR)	-1.040657
	(0.32434)
D(LNCPI_BOT)	0.016749
	(0.09404)
D(LNCPI_RSA)	0.134053
	(0.08671)

2 Cointegrating Equation(s):	Log likelihood	265.2453

Normalized cointegrating coefficients (standard error in parentheses)

LNNER_PR	LNCPI_BOT	LNCPI_RSA
1.000000	0.000000	-0.234046
		(0.09728)
0.000000	1.000000	-1.377858
		(0.17394)

Adjustment coefficients (standard error in parentheses)

D(LNNER_PR)	-1.371855	0.787184
	(0.36936)	(0.22467)
D(LNCPI_BOT)	0.055067	-0.038791
	(0.11227)	(0.06829)
D(LNCPI_RSA)	0.040858	0.006178
	(0.09812)	(0.05968)

VAR Lag Order Selection Criteria
Endogenous variables:
LNNER_PR
Exogenous variables: C LNCPI_BOT

LNCPI_RSA
Date: 05/15/19 Time: 13:54
Sample: 1976 2016
Included observations: 33

Lag	LogL	LR	FPE	AIC	SC	HQ
0	35.72168	NA	0.008063	-1.983132	-1.847086	-1.937357
1	41.68493	10.48085*	0.005972	-2.283935	-2.102540*	-2.222901*
2	42.73896	1.788663	0.005960*	-2.287210*	-2.060466	-2.210917
3	43.10445	0.598071	0.006204	-2.248754	-1.976662	-2.157204
4	43.53668	0.681090	0.006437	-2.214344	-1.896903	-2.107535
5	43.99938	0.701062	0.006672	-2.181780	-1.818991	-2.059713
6	44.73878	1.075498	0.006808	-2.165987	-1.757848	-2.028661
7	44.76655	0.038705	0.007261	-2.107064	-1.653576	-1.954479
8	47.16921	3.203551	0.006715	-2.192074	-1.693238	-2.024230

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

b) LNNER_PD
c)

Date: 05/13/19 Time: 20:46
Sample (adjusted): 1981 2016
Included observations: 36 after adjustments
Trend assumption: Linear deterministic trend
Series: LNNER_PD LNCPI_BOT LNCPI_USA
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.579853	54.20321	29.79707	0.0000
At most 1 *	0.304356	22.98582	15.49471	0.0031
At most 2 *	0.240867	9.920796	3.841466	0.0016

Trace test indicates 3 cointegratingeqn(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 No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.579853	31.21739	21.13162	0.0014
At most 1	0.304356	13.06502	14.26460	0.0767
At most 2 *	0.240867	9.920796	3.841466	0.0016

Max-eigenvalue test indicates 1 cointegratingeqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LNNER_PD	LNCPI_BOT	LNCPI_USA
-5.262605	-10.38963	50.42664
-3.084010	18.11348	-49.31662
-18.42835	10.08093	3.079901

Unrestricted Adjustment Coefficients (alpha):

D(LNNER_PD)	0.027307	0.013245	0.046887
D(LNCPI_BOT)	-0.000766	-0.009231	0.000926
D(LNCPI_USA)	-0.004847	-0.001821	0.001786

1 Cointegrating Equation(s):		Log likelihood	270.2117

Normalized cointegrating coefficients (standard error in parentheses)

LNNER_PD	LNCPI_BOT	LNCPI_USA
1.000000	1.974236	-9.582068
	(0.72738)	(2.41585)

Adjustment coefficients (standard error in parentheses)

D(LNNER_PD)	-0.143704
	(0.11356)
D(LNCPI_BOT)	0.004033
	(0.01891)
D(LNCPI_USA)	0.025507
	(0.00720)

2 Cointegrating Equation(s):		Log likelihood	276.7442

Normalized cointegrating coefficients (standard error in parentheses)

LNNER_PD	LNCPI_BOT	LNCPI_USA
1.000000	0.000000	-3.148574
		(0.25320)
0.000000	1.000000	-3.258726
		(0.09638)

Adjustment coefficients (standard error in parentheses)

D(LNNER_PD)	-0.184553	-0.043786
	(0.13049)	(0.44672)
D(LNCPI_BOT)	0.032502	-0.159245
	(0.01833)	(0.06276)
D(LNCPI_USA)	0.031124	0.017363
	(0.00800)	(0.02739)

VAR Lag Order Selection Criteria
Endogenous variables:
LNNER_PD
Exogenous variables: C LNCPI_BOT
LNCPI_USA
Date: 05/15/19 Time: 15:08
Sample: 1976 2016
Included observations: 33

Lag	LogL	LR	FPE	AIC	SC	HQ
0	18.07568	NA	0.023493	-0.913677	-0.777631	-0.867902
1	23.12902	8.881634*	0.018389	-1.159334	-0.977940*	-1.098301
2	24.60204	2.499672	0.017890*	-1.188002*	-0.961259	-1.111710*
3	24.75425	0.249063	0.018866	-1.136621	-0.864529	-1.045070
4	25.70351	1.495816	0.018970	-1.133546	-0.816105	-1.026737
5	25.70788	0.006618	0.020217	-1.073205	-0.710415	-0.951137
6	25.78379	0.110416	0.021474	-1.017200	-0.609061	-0.879873
7	26.25389	0.655288	0.022297	-0.985084	-0.531597	-0.832500
8	27.99589	2.322671	0.021462	-1.030054	-0.531218	-0.862211

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

APPENDIX 3: Autoregressive Distribution Lag Model (ARDL)

a) LNNER_PR

Dependent Variable: LNNER_PR
Method: ARDL
Date: 05/16/19 Time: 16:59
Sample (adjusted): 1978 2016
Included observations: 39 after adjustments
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic): LNCPI_BOT
LNCPI_RSA
Fixed regressors: C
Number of models evalulated: 18
Selected Model: ARDL(2, 2, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LNNER_PR(-1)	0.605229	0.187940	3.220335	0.0029
LNNER_PR(-2)	-0.234123	0.173874	-1.346508	0.1876
LNCPI_BOT	0.236154	0.652957	0.361669	0.7200
LNCPI_BOT(-1)	1.238788	1.019551	1.215033	0.2332
LNCPI_BOT(-2)	-1.142106	0.580177	-1.968548	0.0577
LNCPI_RSA	-0.356018	0.119338	-2.983262	0.0054
C	-0.076531	0.096652	-0.791816	0.4343

R-squared	0.754512	Mean dependent var	-0.211840
Adjusted R-squared	0.708483	S.D. dependent var	0.122570
S.E. of regression	0.066179	Akaike info criterion	-2.431773
Sum squared resid	0.140147	Schwarz criterion	-2.133185
Log likelihood	54.41958	Hannan-Quinn criter.	-2.324643
F-statistic	16.39210	Durbin-Watson stat	2.098561
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.667511	Prob. F(2,30)	0.5204
Obs*R-squared	1.661588	Prob. Chi-Square(2)	0.4357

Test Equation:
Dependent Variable: RESID
Method: ARDL
Date: 05/16/19 Time: 17:00

Sample: 1978 2016
Included observations: 39
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNNER_PR(-1)	0.527818	0.503604	1.048081	0.3030
LNNER_PR(-2)	-0.215067	0.310091	-0.693559	0.4933
LNCPI_BOT	-0.121737	0.670026	-0.181690	0.8570
LNCPI_BOT(-1)	-0.179507	1.064926	-0.168563	0.8673
LNCPI_BOT(-2)	0.143239	0.631559	0.226801	0.8221
LNCPI_RSA	0.175680	0.197768	0.888313	0.3814
C	-0.021075	0.107263	-0.196475	0.8456
RESID(-1)	-0.591723	0.524075	-1.129080	0.2678
RESID(-2)	-0.109053	0.282021	-0.386683	0.7017

R-squared	0.042605	Mean dependent var	-2.53E-16
Adjusted R-squared	-0.212701	S.D. dependent var	0.060730
S.E. of regression	0.066877	Akaike info criterion	-2.372748
Sum squared resid	0.134176	Schwarz criterion	-1.988849
Log likelihood	55.26859	Hannan-Quinn criter.	-2.235009
F-statistic	0.166878	Durbin-Watson stat	1.997717
Prob(F-statistic)	0.993765		

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.411323	Prob. F(6,32)	0.8660
Obs*R-squared	2.792441	Prob. Chi-Square(6)	0.8344
Scaled explained SS	4.539266	Prob. Chi-Square(6)	0.6041

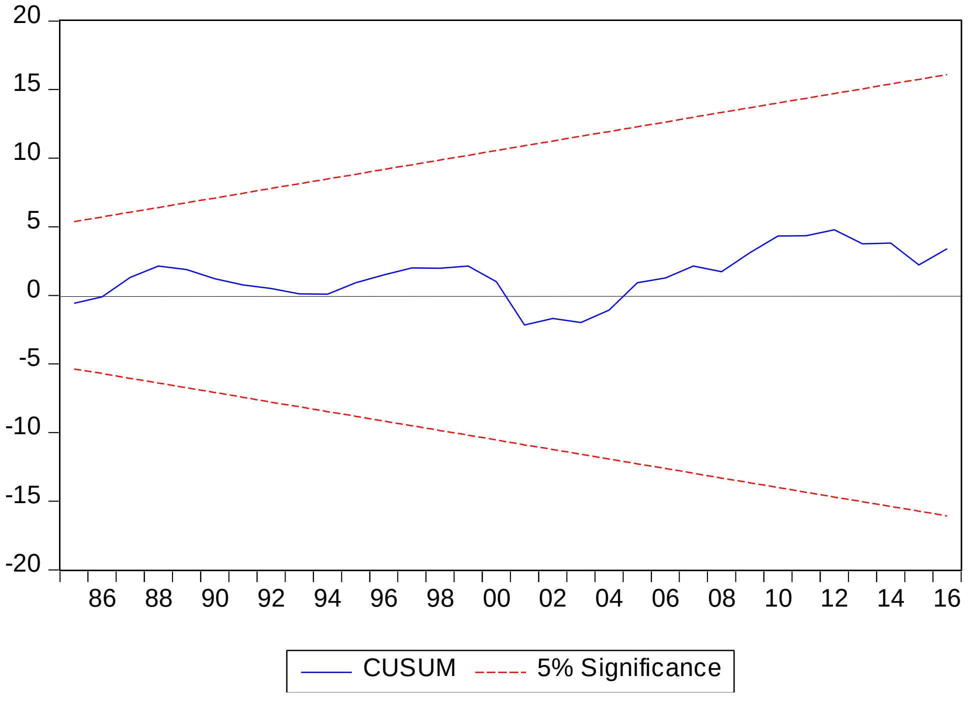
Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 05/16/19 Time: 17:01
Sample: 1978 2016
Included observations: 39

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.014447	0.012268	1.177608	0.2476
LNNER_PR(-1)	-0.002760	0.023855	-0.115689	0.9086
LNNER_PR(-2)	-0.003989	0.022069	-0.180735	0.8577
LNCPI_BOT	-0.087542	0.082879	-1.056264	0.2988
LNCPI_BOT(-1)	0.090714	0.129410	0.700981	0.4884
LNCPI_BOT(-2)	-0.001416	0.073641	-0.019229	0.9848
LNCPI_RSA	-0.002876	0.015147	-0.189872	0.8506

R-squared	0.071601	Mean dependent var	0.003594
Adjusted R-squared	-0.102474	S.D. dependent var	0.008000
S.E. of regression	0.008400	Akaike info criterion	-6.560044

Sum squared resid	0.002258	Schwarz criterion	-6.261456
Log likelihood	134.9209	Hannan-Quinn criter.	-6.452913
F-statistic	0.411323	Durbin-Watson stat	2.300169
Prob(F-statistic)	0.865981		

CUSUM TEST



ARDL bound test output

ARDL Bounds Test
Date: 05/16/19 Time: 17:02
Sample: 1978 2016
Included observations: 39
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	5.663651	2

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Test Equation:

Dependent Variable: D(LNNER_PR)
Method: Least Squares
Date: 05/16/19 Time: 17:02
Sample: 1978 2016
Included observations: 39

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNNER_PR(-1))	0.331639	0.181629	1.825916	0.0772
D(LNCPI_BOT)	0.054850	0.628244	0.087307	0.9310
D(LNCPI_BOT(-1))	1.301349	0.582565	2.233826	0.0326
C	-0.132265	0.094956	-1.392908	0.1732
LNCPI_BOT(-1)	0.375929	0.119939	3.134330	0.0037
LNCPI_RSA(-1)	-0.392357	0.125675	-3.122001	0.0038
LNNER_PR(-1)	-0.685763	0.172749	-3.969695	0.0004

R-squared	0.363850	Mean dependent var	-0.005063
Adjusted R-squared	0.244572	S.D. dependent var	0.075365
S.E. of regression	0.065504	Akaike info criterion	-2.452272
Sum squared resid	0.137303	Schwarz criterion	-2.153684
Log likelihood	54.81930	Hannan-Quinn criter.	-2.345141
F-statistic	3.050432	Durbin-Watson stat	2.137379
Prob(F-statistic)	0.017859		

b) LNNER_PD

Dependent Variable: LNNER_PD
Method: ARDL
Date: 05/21/19 Time: 12:34
Sample (adjusted): 1978 2016
Included observations: 39 after adjustments
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic): LNCPI_BOT LNCPI_USA
Fixed regressors: C
Number of models evaluated: 18
Selected Model: ARDL(2, 2, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*

LNNER_PD(-1)	0.589153	0.161027	3.658722	0.0009
LNNER_PD(-2)	-0.290800	0.146638	-1.983117	0.0560
LNCPI_BOT	-1.787267	1.041244	-1.716472	0.0957
LNCPI_BOT(-1)	0.587755	1.633180	0.359884	0.7213
LNCPI_BOT(-2)	1.412744	1.034992	1.364981	0.1818
LNCPI_USA	0.754787	0.381013	1.980998	0.0562
C	-2.790562	1.154763	-2.416566	0.0215

R-squared	0.983318	Mean dependent var	1.187169
Adjusted R-squared	0.980190	S.D. dependent var	0.791500
S.E. of regression	0.111403	Akaike info criterion	-1.390183
Sum squared resid	0.397137	Schwarz criterion	-1.091595
Log likelihood	34.10857	Hannan-Quinn criter.	-1.283052
F-statistic	314.3669	Durbin-Watson stat	2.047926
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.882053	Prob. F(2,30)	0.1698
Obs*R-squared	4.347816	Prob. Chi-Square(2)	0.1137

Test Equation:
Dependent Variable: RESID
Method: ARDL
Date: 05/21/19 Time: 12:35
Sample: 1978 2016
Included observations: 39
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNNER_PD(-1)	0.438657	0.378853	1.157856	0.2561
LNNER_PD(-2)	-0.022963	0.229463	-0.100072	0.9210
LNCPI_BOT	0.578141	1.068954	0.540847	0.5926
LNCPI_BOT(-1)	0.157184	1.598031	0.098361	0.9223
LNCPI_BOT(-2)	-0.909643	1.151202	-0.790168	0.4356
LNCPI_USA	-0.323943	0.437429	-0.740562	0.4647
C	1.355436	1.428072	0.949137	0.3501
RESID(-1)	-0.537699	0.429165	-1.252897	0.2199
RESID(-2)	-0.434082	0.248182	-1.749045	0.0905

R-squared	0.111482	Mean dependent var	3.54E-16
Adjusted R-squared	-0.125456	S.D. dependent var	0.102230
S.E. of regression	0.108453	Akaike info criterion	-1.405820

Sum squared resid	0.352864	Schwarz criterion	-1.021921
Log likelihood	36.41349	Hannan-Quinn criter.	-1.268080
F-statistic	0.470513	Durbin-Watson stat	1.918510
Prob(F-statistic)	0.867070		

Heteroskedasticity Test: Breusch-Pagan-Godfrey

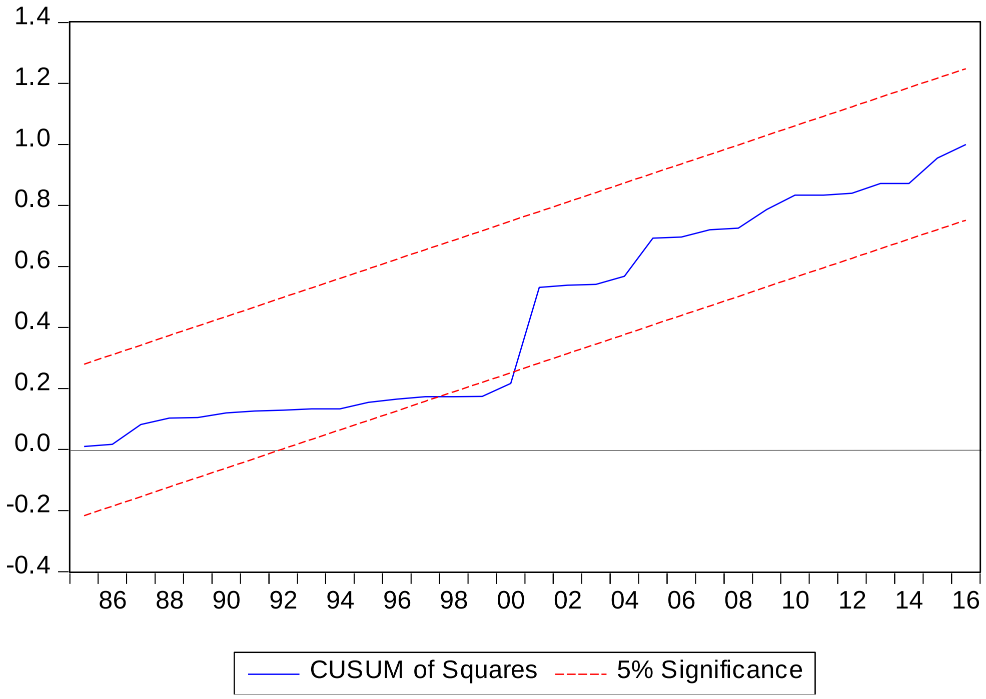
F-statistic	0.552778	Prob. F(6,32)	0.7641
Obs*R-squared	3.662579	Prob. Chi-Square(6)	0.7222
Scaled explained SS	2.649154	Prob. Chi-Square(6)	0.8514

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 05/21/19 Time: 12:36
Sample: 1978 2016
Included observations: 39

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.009223	0.162595	0.056721	0.9551
LNNER_PD(-1)	0.021700	0.022673	0.957094	0.3457
LNNER_PD(-2)	0.009753	0.020647	0.472355	0.6399
LNCPI_BOT	-0.024191	0.146611	-0.164998	0.8700
LNCPI_BOT(-1)	0.003822	0.229957	0.016623	0.9868
LNCPI_BOT(-2)	-0.008040	0.145730	-0.055168	0.9563
LNCPI_USA	0.014769	0.053648	0.275302	0.7849

R-squared	0.093912	Mean dependent var	0.010183
Adjusted R-squared	-0.075979	S.D. dependent var	0.015122
S.E. of regression	0.015686	Akaike info criterion	-5.310965
Sum squared resid	0.007873	Schwarz criterion	-5.012377
Log likelihood	110.5638	Hannan-Quinn criter.	-5.203834
F-statistic	0.552778	Durbin-Watson stat	2.108294
Prob(F-statistic)	0.764128		

CUSUM TEST



ARDL Bounds Test
Date: 05/21/19 Time: 12:37
Sample: 1978 2016
Included observations: 39
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	8.542638	2

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Test Equation:
Dependent Variable: D(LNNER_PD)
Method: Least Squares
Date: 05/21/19 Time: 12:37
Sample: 1978 2016

Included observations: 39

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNNER_PD(-1))	0.279342	0.147310	1.896288	0.0670
D(LNCPI_BOT)	-1.507088	0.989987	-1.522331	0.1377
D(LNCPI_BOT(-1))	-1.593459	1.043050	-1.527692	0.1364
C	-2.400767	0.948418	-2.531337	0.0165
LNCPI_BOT(-1)	0.262230	0.141946	1.847397	0.0740
LNCPI_USA(-1)	0.634393	0.315746	2.009187	0.0530
LNNER_PD(-1)	-0.726942	0.147842	-4.917016	0.0000

R-squared	0.449739	Mean dependent var	0.065489
Adjusted R-squared	0.346565	S.D. dependent var	0.137599
S.E. of regression	0.111229	Akaike info criterion	-1.393309
Sum squared resid	0.395898	Schwarz criterion	-1.094721
Log likelihood	34.16953	Hannan-Quinn criter.	-1.286178
F-statistic	4.359029	Durbin-Watson stat	2.033892
Prob(F-statistic)	0.002522		

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