Purchasing Power Parity Theory For Pula/Rand and Pula/Us Dollar Exchange Rates In Botswana

Botswana is heavily dependent on mineral exports which are influenced by Pula Dollar exchange rate. On the otherhand, imports in Botswana are influenced by the Pula Rand exchange rate. This paper attempts to examine the Purchasing Power Parity (PPP) theory considering both exchange rates namely Pula/Rand and Pula/US dollar in Botswana for a period of 1976-2016. Five cointegration methods have been employed to determine the validity of the theory between these two exchange rates. The analysis of the results showed that there was no long-run relationship between the variables in both cases of Pula/Rand and Pula/US dollar exchange rates when using the Engle-Granger cointegration method. Johansen cointegration test inidicates one cointegrating vector. However, error correction model (ECM) showed rapid deviation of the variables to the long-run equilibrium, indicating a short-run cointegration relationship for Pula/Rand and Pula/US dollar exchange rates. A further investigation of a long-run PPP was conducted using the autoregressive distribution lag model (ARDL) bond approach. The results 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.

Keywords: *Purchasing power parity, Botswana, exchange rates, trade relations, cointergration*

Introduction

The exchange rate determination is centred on the Purchasing Power Parity (hereafter 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 namely; the absolute PPP and the relative PPP. The absolute PPP is based on the law of one price, which says 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. Thus, it assists policy makers to achieve a balance between economic policies and promotion of all sectors of the economy without undermining the growth of others.

Testing for the validity of the PPP theory has attracted much research and empirical studies on the theory leading to varying conclusions. 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. Testing the Purchasing Power Parity (PPP) for both the Pula/Rand and the Pula/US dollar exchange rates for the common period is imperative as both currencies are important in the Pula basket of currencies to which the Pula is pegged.

After the introduction, section 2 describes the macroeconomic environment of Botswana. Section 3 deals wwith the review of literature.

Botswana's Macroeconomic Environment

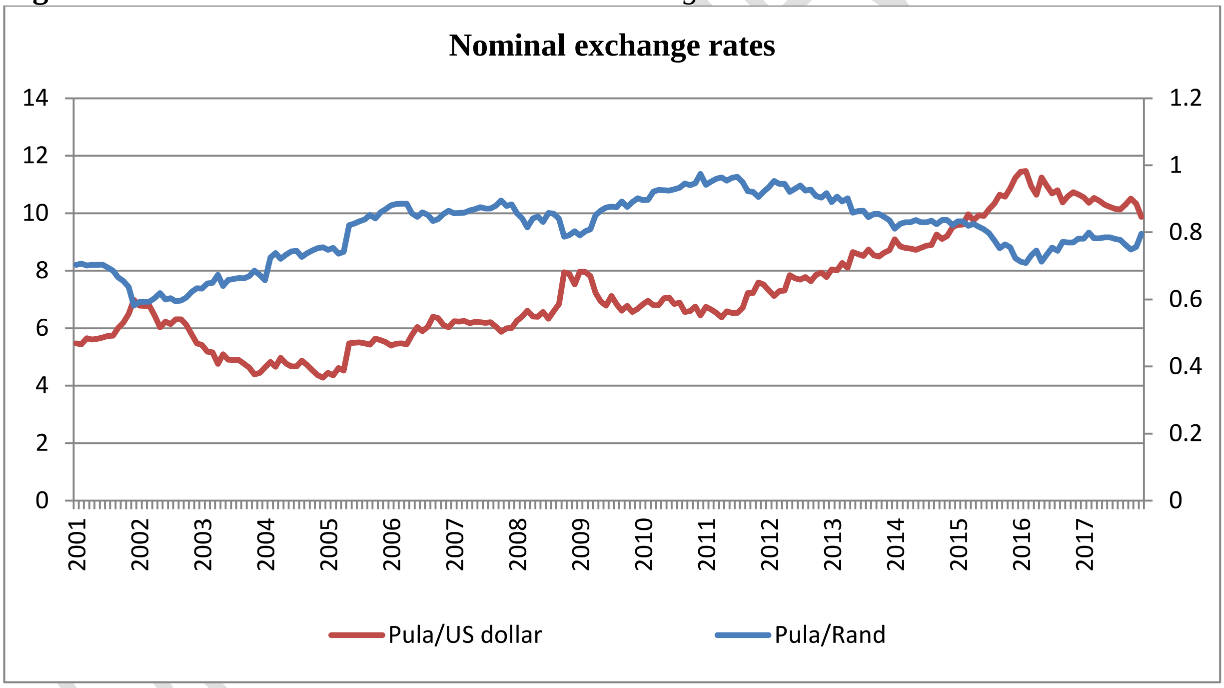
Botswana was part of the Rand Monetary Area (RMA) from 1966 when it attained independence until 1976 after establishing the Bank of Botswana and introducing the Pula currency. The decision to have monetary independence was to have legislated control of interest rates, credit and exchange controls (Masalila & 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).

Introduced in 2005, the Bank of Botswana implements the crawling band exchange rate policy 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). The South African Rand has always had a larger weight of the Pula basket than the SDR for two reasons. 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. Major exports for Botswana (including diamonds) depend on the Pula/US dollar exchange rate. An appreciation of the Pula against the Rand exerts 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.

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 Rand area while the main exports (diamonds and beef) are traded 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*

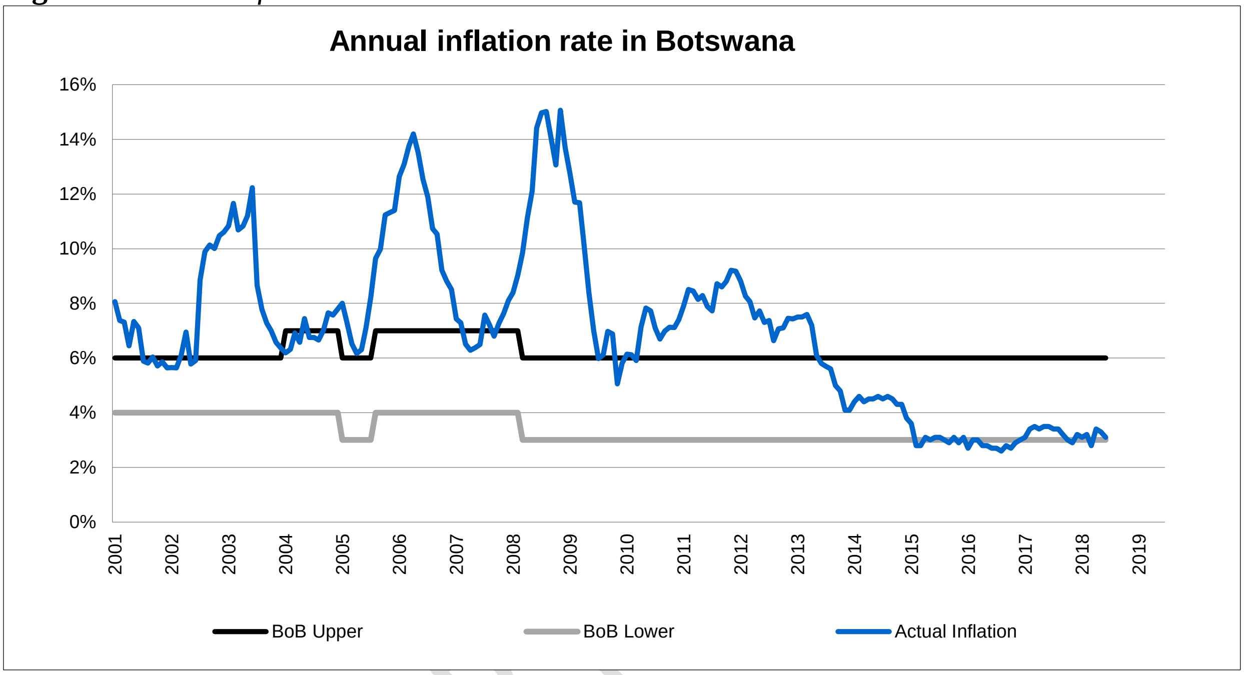


Source: Bank of Botswana

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.

Inflation Rate: It can be seen from figure 2 below 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%.

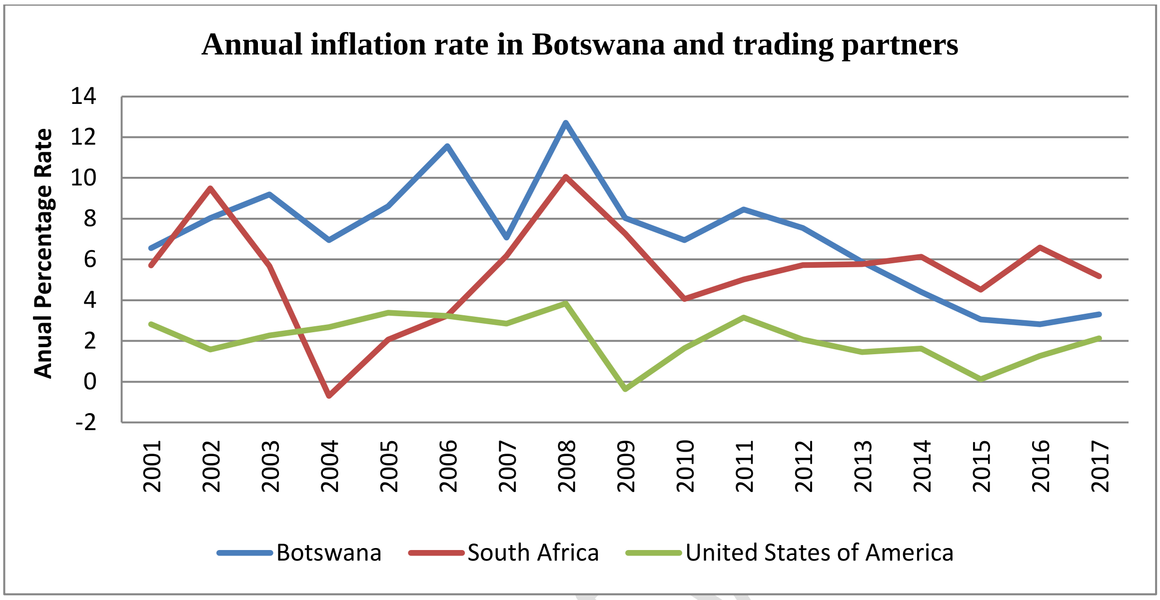
Figure 2. *Annual inflation rate in Botswana*



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)

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). 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). The deepening current account deficit depresses the high inflation country's currency. The PPP theory is expressed in two versions namely absolute PPP theory and relative PPP theory.

Absolute version 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;

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

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.

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 validate the purchasing power parity for one exchange rate of either Pula/Rand or Pula/US dollar . No attempt is made to consider both exchange rates together. Study by Atta *et al.* (1996) is one of the earliest study to empirically establish the relationship between the exchange rate and inflation rate in Botswana. The study indicated that there was a long-run relationship between the Pula/Rand exchange rate and domestic prices. However, as the economy of Botswana grows and become less reliant on South Africa for imports, the relationship between the variables becomes less significant. The study further 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).

Contrary to Atta, Jefferis and Monnathoko (1996), Tshipinare (2006), Rapelana (2014) and Sinha, Rapelana and Motlaleng (2018) found no evidence of PPP for the Pula/Rand exchange rate. Considering the Pula/US dollar exchange rate Paul and Motlaleng (2008) validated the PPP for 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.

The available studies in Botswana, Tshipinare (2006), Rapelana (2014) and Sinha *et al.* (2018), consider the monthly data on Pula/ Rand while Paul and Motlaleng (2008) consider quarterly data on Pula/US dollar exchange rate for different time periods. Tshipinare considered the period 1985 to 2005 while Rapelana and Sinha *et al*. used the period 1985 to 2013. On the other hand, Paul and Motlaleng (2008) cover the period 1992 to 2002. We have considered 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, for both of these two currencies are important currencies in Botswana. The PPP between South Africa and Botswana could not be validated and the earlier results failed to establish cointegration between the variables (Tshipinare, 2006). Hence, the study failed to support the long-run PPP between South Africa and Botswana. Similarly, Rapelana (2014) and Sinha *et al.* (2018) find that the PPP in Pula/ Rand exchange rate does not hold in Botswana while considering monthly frequency. Generally 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 as indicated by volumes of import into Botswana from South Africa. When testing the PPP between the Pula/US dollar, Paul and Motlaleng (2008) considering quarterly data validated the PPP theory in Botswana that there exist a long-run relationship between the Pula/US dollar and domestic prices and observed 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) applying the panel cointegration technique to test the PPP for 80 developed and developing countries 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).

Impact of the adoption of the crawling peg on the exchange rate in Botswana was considered by Rapelana (2014) who found that the change in the exchange rate regime was positively related to exchange rate. 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 ARDL bound test for cointegration. The PPP does not hold as a result of dissimilarities in economic sizes between Thailand and other countries (Jiranyakul & Batavia, 2009). Similarly, the studies which have been conducted in Botswana are also inconclusive in the findings.

Empirical literature on the PPP theory has been inconclusive about the validity of the theory. There are studies provide empirical evidence about the validity of the PPP theory. 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.

Methodology

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 on imports from South Africa while most exports like diamonds are denominated in US dollar. 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. Besides Engle Granger test, Johansen cointegration test and error correction mechanism, the ARDL nond test is also employed to assess the long-run causality of the variables. Time-series annual data covering the period from 1975 (when the Pula was introduced as the currency) to 2016 is used to validate the PPP theory between Botswana and South Africa and between Botswana and United States of America.

Data and Definition of Variables: The study uses time-series annual data covering the annual data for the period 1975 to 2016. The data is obtained from the Bank of Botswana, World Bank Development Indicators (WBDI) and Statistics Botswana. The data is given in the table below:

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.

Specification of the Model: Several studies have attempted to test 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. Further, the paper examined the impact of a shift in exchange rate regimes, from a fixed to a flexible exchange rate regime. Based on Enders (1988) 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

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

The variables are denoted as in the absolute PPP, 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 holds when the variables are stationary (Enders, 1988), then the long-run relationship between the variables can be tested. 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 stationary the equation will be specified in terms of an error-correction model (Rutto & Ondiek, 2014). Following Enders (1988), the PPP considered in terms of the real exchange rates 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. The long-run PPP holds only if the real exchange rate is stationary (Enders, 1988). If non-stationary, the PPP is rejected.

Empirical Estimation

Stationarity tests: The Augmented Dickey Fuller (ADF) method and the Phillips-Perron (PP) unit root tests were 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 results showed 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 is supported when the variables are integrated of order 1 (see appendix 1)

Furthermore, the study then tested the stationarity of the consumer price indices for Botswana, South Africa and United States of America and the results indicated 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 (logarithm of the consumer price index of the USA) variable was stationary at levels when using both the ADF test and PP test (see appendix 2)

Cointegration Analysis: To test the validity of the PPP theory between three countries being Botswana, South Africa and the United States of America the cointegration technique was used to analyse the long-run relationship between the Pula/Rand and Pula/US dollar exchange rates and the price levels. Four methods of cointegration tests are employed. Besides the Engle-Granger cointegration test and the Johansen cointegration test, error correction mechanism and ARDL bond tests have also been employed to test for 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 depicts 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 , Jefferis, Monnathoko, & Siwawa-Ndai, 1999). If there is cointegration between the variables then the PPP is valid and if no cointegration between the variables then the PPP theory does not hold. The cointegration method requires the variables to be integrated of the same order. The stationary tests results from the ADF and the Phillips-Perron tests have shown that the variables are stationary after first difference. Hence, all of the variables enter into 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.

Engle-Granger Cointegration Test: 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 $\boldsymbol{\varepsilon_t}$ was then tested for unit root using the ADF test. The results of the ADF test for the residual series $\boldsymbol{\varepsilon_t}$ for both South Africa and United States of America were found to be non-stationary. 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 et al. (2018) who observed that the PPP does not hold between the Pula/Rand exchange rates after the crawling peg system was introduced.

Johansen Cointegration Test: The variables are 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 (see appendix 3). The choice of the appropriate lag length 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. The results indicated that at least one equation is cointegrated for both the trace statistic and the maximum eigenvalue at 5% significance level. This indicated the existence of a long-run relationship between the variables and suggests that the PPP holds between Botswana and South Africa. In the case of the United States of America, the Johansen cointegration results showed that at least three equations were cointegrated at 5% significance level. This implied 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 (see appendix 6).

The results of the Johansen cointegration tests are as shown in the appendix 5 for South Africa and United States of America. The trade statistic and the maximum eigenvalues are used to determine whether there are cointegrating vectors. If there is no cointegration, the Johansen results gives 0 cointegrating equations and, if there is cointegration, it gives at least one cointegrating equation.

Error Correction Model (ECM) : Based on the results from the two cointegration tests the error correction model (ECM) was 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.The

Error Correction Term (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 (Asteriou & Hall, 2007). The results of the ECM revealed that the coefficient of the ECT in both cases is negative and significant, hence, implying a short-run causality between the price levels and the nominal exchange rate. Speed of adjustment for LNNER_PR towards equilibrium in the long-run is 62.9%. This is contrary to the study by Sinha *et al.* (2018) 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 for monthly data. The results above also indicate that the LNNER_PR is positively affected by its previous lag value as well as the previous lag value of the CPI_BOT (refer to appendix 7 for the results).

The ECT was also negative and significant in the case of United States of America and corroborated with Paul & Motlaleng's (2008) study on the PPP between the Pula/US dollar exchange rate. This represented a short-run relationship between the variables, and speed of adjustment to the long-run equilibrium is a 70.2% response rate. Atta et al. (1999) also found that the ECM for the Pula/US dollar exchange rate strongly significant when adjusting to the long-run PPP by about 2% every month. Paul & 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 (see appendix 7 for the results).

Autoregressive Distributed Lag Model (ARDL) Bond Test: 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 (Pesaran, Shin, & Smith, 2001). The ARDL deemed the appropriate model as it overcomes some of the limitations in the ECM model was used. The ARDL model does not require the variables to be 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 are as presented in appendix 8.

The estimated ARDL models for LNNER_PR and LNNER_PD were good models as shown by the R^2 which was 0.75 and 0.78 repectively, and the probability of the F-statistic of 0.00 in both cases. Diagnostic tests also indicated no time-series problems such as serial correlation and heteroscedasticity. Further, the ARDL proved to be stable as tested through cusum test. 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[1] and LNNER_PD[2] has been estimated and showed that:

The F-statistic for LNNER_PR is 5.66 and is greater than the upper bound of 4.85 at 5% significance level (see (Tia & Ma, 2009). Therefore, these results 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. This implies 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:

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

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

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.

[1]denotes the logarithms of the nominal exchange rates of Pula/Rand.
[2]denotes the logarithms of the nominal exchange rates of Pula/US dollar
*denotes the logarithms of consumer price indices for Botswana, South Africa and United States respectively

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.

Conclusion

The present study is based on annual data considering the period 1975-2016 and two major exchange rates for Botswana. 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. Accordingly the PPP theory did not hold between Botswana and South Africa (RSA) and between Botswana and the United States of America (USA). However, 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 et al. (2018) for the Pula/Rand exchange rate and price level and by Paul & 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 & 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. 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.

The present study is an addition to existing literature on the validity of the PPP theory in Botswana and presented interesting insights by either supporting or contrasting earlier studies in Botswana. The results of the present study did not agree with the findings of Tshipinare (2006), Rapelana (2014) and Sinha et al. (2018), but agreed with Atta et al. (1996) and Motlaleng & Paul (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 et al.(1996) and Paul & Motlaleng (2008) were found to be strongly significant, thus validating the theory in Botswana. Furthermore, the ARDL bound test validated the long-run PPP theory in Botswana between the Pula/Rand and Pula/US dollar exchange rates and price levels.

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.

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APPENDIX

1. Unit root test for Pula/Rand and Pula/US dollar real exchange rates

Variable	Augumented Dickey-Fuller Test			Phillips-Perron Test		
	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 denote the logarithms of the real exchange rates of Pula/US dollar and Pula/Rand respectively and I(1) indicates stationarity after first difference

2. Nominal exchange rates and consumer price indices stationarity test results

Variable	Augumented Dickey-Fuller Test			Phillips-Perron Test		
	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 differenc

3. 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

4. ADF unit root test results

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

5. Johansen Cointegration results for South Africa and United States of America

Hypothesized No. of CE(s)	Trace test results							
	SA				***United States of America*** USD			
	Eigenvalue	Trace-stat	Critical V	P**	Eigenvalue	Trace-Stat	Critical V	P**
None *	0.471174	38.96088	29.79707	0.0034	0.655901	65.67198	29.79707	0.0000
At most 1	0.216807	14.75125	15.49471	0.0645	0.418390	25.13261	15.49471	0.0013
At most 2 *	0.133952	5.464963	3.841466	0.0194	0.112574	4.538345	3.841466	0.0331
Trace test indicates 1 cointegratingeqn(s) at the 0.05 level								
* denotes rejection of the hypothesis at the 0.05 level								
Hypothesized No. of CE(s)	Maximum Eigenvalue test results							
	SA				***United States of America*** USD			
	Eigenvalue	Max-Eigen	0.05 Crtical	P**	Eigenvalue	Trace-Stat	5%	P**
None *	0.471174	24.20963	21.13162	0.0178	0.655901	40.53937	21.1316	0.0000
At most 1	0.216807	9.286288	14.26460	0.2631	0.418390	20.59426	14.2646	0.0044
At most 2 *	0.133952	5.464963	3.841466	0.0194	0.112574	4.538345	3.84146	0.0331
Max-eigenvalue test indicates 1 cointegratingeqn(s) at the 0.05 level								
* denotes rejection of the hypothesis at the 0.05 level								

Table 7. *Short-run LNNER_PR and LNNER_PD equations*

Variable	Cointegrating LNNER_PR		Cointegrating LNNER_PD	
	Coefficient	Probability	Coefficient	Probability
D(LNNER_PR(-1))	0.234123	0.1876		
D(LNNER_PD(-1))			0.290800	0.0560
D(LNCPI_BOT)	0.236154	0.7200	-1.787267	0.0957
D(LNCPI_BOT(-1))	1.142106	0.0577	-1.412744	0.1818
D(LNCPI_RSA)	-0.356018	0.0054		
D(LNCPI_USA)			0.754787	0.0562
ECT	-0.628894	0.0005	-0.701647	0.0000

Table 8. *Estimated ARDL model*

Variable	SA		USD	
	Coefficient	Probability	Coefficient	Probability
LNNER_PR(-1)	0.605229	0.0029	---	---
LNNER_PR(-2)	-0.234123	0.1876	---	---
LNNER_PD(-1)	---	---	0.589153	0.0009
LNNER_PD(-2)	---	---	-0.290800	0.0560
LNCPI_BOT	0.236154	0.7200	-1.787267	0.0957
LNCPI_BOT(-1)	1.238788	0.2332	0.587755	0.7213
LNCPI_BOT(-2)	-1.142106	0.0577	1.412744	0.1818
LNCPI_RSA	-0.356018	0.0054	---	---
LNCPI_USA	---	---	0.754787	0.0562
C	-0.076531	0.4343	-2.790562	0.0215
R-squared	0.754512		0.983318	
Adjusted R-squared	0.708483		0.980190	

S.E. of regression	0.066179		0.111403	
Sum squared resid	0.140147		0.397137	
Log likelihood	54.41958		34.10857	
F-statistic	16.39210		314.3669	
Prob(F-stat)	0.000000		0.000000	
DurbinWatson	2.098561		2.047926	

9ARDL bound cointegration tests

F-Bounds Test			Null Hypothesis: No levels relationship		
Variable	F-statistic	K	Significance	I(0)	I(1)
LNNER_PR	5.663651	2	10%	3.17	4.14
LNNER_PD	8.542638	2	5%	3.79	4.85
	Asymp n=1000		1%	5.15	6.36