Asymmetry in the Purchasing Power Parity in the Context of South Africa

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ABSTRACT
This paper investigated whether the purchasing power parity (PPP) hypothesis holds between South Africa and the United States of America and to determine if there is an asymmetry in the PPP from 1980 to 2020. A decomposition technique was applied to create key variables in which unit root tests such as ADF, PP, and the KPSS were employed. The results of all three tests found that the macro variables exhibited stationary behaviour, thus validating the PPP. Furthermore, by decomposing the variable into positive and negative components, the study reveals that the convergence to equilibrium is asymmetric. By showing this, we also confirmed the existence of asymmetry within the macro variables, which provides important implications for policymakers.

KEYWORDS: *asymmetry, exchange rate, purchasing power parity.*

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1. INTRODUCTION

Purchasing Power Parity (PPP) is one of the oldest and the most controversial economic doctrines. The PPP theory was coined in the early 1900's through a seminal work of Cassel (1916). The theory predicts that, in the long run, exchange rates between two countries will eventually converge such that the home and foreign currencies have the same buying power (Azali et al., 2001). There is no consensus on whether purchasing power parity holds; some scholars document evidence of this, while others refute such findings.

Overtime, studies have resulted in ambiguous findings on the validity of PPP, especially for South Africa. Some researchers found that it holds for South Africa, and others have found that it does not hold, which leaves us with the question of who is correct. Some reasons contributing towards the ambiguous findings could be attributed to the techniques employed when trying to validate the hypothesis. The South African economy was also subjected to numerous economic and political shocks overtime, which could also be the reason for the mixed findings.

Based on existing literature, there exist several reasons why this hypothesis's validity is important for policy making and the literature. One of the main reasons is that the PPP theory itself is seen as the exchange rate determination theory. Thus, the real effective exchange rate statistical properties, such as stationarity, are very important because if a unit root is found in

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the real exchange rate, then this means that, overtime, the time series could move to equilibrium (Cashin et al., 2004).

Another key reason around the importance of why the validity of the PPP theory is imperative is because many external and open macroeconomic policies throughout the world are based on this hypothesis. Therefore, a non-stationary real exchange rate, in the long-run, will place the macroeconomic theory into question (Narayan, 2005). The PPP hypothesis is also seen as an appropriate model for prediction that will allow policymakers to decide whether or not a country's exchange rates have been undervalued or overvalued (Narayan et al., 2009).

Therefore, the ability to empirically confirm the PPP hypothesis will introduce some vital implications toward the analysis of practical policies. Therefore, from a theoretical and an academic stance of view, the relationship between domestic and foreign price levels, monies, and real exchange rates in the long-run are assumed in monetary economics (Frenkel, 1978). The study differs from previous work because the analysis accounts for periods before and after the shocks, thereby providing a more consistent overview.

Thus, the study assesses whether the PPP holds for South Africa and whether it is asymmetric. This study is organised in the following sequence: Section two consists of a brief discussion of the literature review, which discusses the concepts related to the PPP and highlights the controversy surrounding this hypothesis where mixed findings are found in the literature. Then follows the methodology where data sources are used to conduct the study, results where the result analysis is discussed. Finally, the conclusion summarises the findings, recommendations, and limitations and suggests what should be the focus of future research on PPP.

2. LITERATURE REVIEW

The literature on PPP is replete with several conflicting studies, with others reporting that it does not hold while others report that it holds (Nzimande & Kohler, 2016; Taylor & Taylor, 2002). European studies often report that PPP holds, especially participating in the European Monetary System (EMS) (Fung & Lo, 1992). Fisher and Park (1991) and Artis and Nachane (1990), on the other hand, found no evidence that PPP hypothesis holds both for EMS and non-EMS countries.

These mixed findings raise the question of whether the PPP hypothesis would be an appropriate approximation long-run equilibrium for exchange rate. Mokoena (2007) and Murray and Papell (2005) uncertainty is one of the major contributors to the so-called PPP puzzle. These scholars point that the mean-reversion speed differ across studies. Others overestimate, while others underestimate the speed (D'Adano & Rovelli, 2015; Égert et al., 2006).

The price differences between international goods or the basket of goods in which these differences, as well as different weights used across countries, tend to be highly persistent or non-stationary (Taylor, 2001). Supporting the findings of the PPP puzzle, Rogoff (1996) argues that this puzzle arises because there are barriers to arbitrage and how one will be able to resolve the large amounts of the real exchange rates' short-run volatility with a very slow rate in which the shocks disappear. Over the years, extensive literature has contributed to a possible solution to this puzzle; however, we are still far from solving it.

For many years, the determination of exchange rates and many economic models have been built on the building blocks of the real exchange rates' concept of there being mean reversion in the long-run and the PPP hypothesis (Abuaf & Jorion, 1990). Based on empirical literature found favouring the validity of the PPP, what is known is that in order for the PPP hypothesis to persist and hold, the real exchange rate is required to show some mean reversion behaviour or evolve constantly over time (Bozoklu & Kutlu, 2012).

Favouring the findings of mean reversion, Mokoena (2007) extensively examined and tested the South African rand compared to other important currencies such as the dollar, pound, euro and yen, and in the bulk of the cases from the sample, mean reversion behaviour was found in the real exchange rates, thus inferring that the PPP hypothesis holds and is valid. However, when examining the PPP in a bilateral exchange rate series, Akinboade and Makina (2006) found that the PPP hypothesis failed to hold, mainly due to structural breaks.

Thus, the bilateral exchange rate series was not mean reverting. In addition to the reasonably important findings, Raihan et al. (2017) provided evidence which explained that recently, many countries' bilateral exchange rates have been exhibiting non-stationary behaviour and based on economic theory, this suggests that there will be an absence of mean-reverting behaviour in the long-run which will place the PPP hypothesis and theory under questioning and doubt, contributing to the mixed and controversial findings.

Overtime, there has been extensive research in which economists have used different kinds of cointegration approaches comprised of linear and stationary tests to test and validate the long-run PPP hypothesis and theory (Johansen & Juselius, 1990). What is known is that in order for the PPP hypothesis to hold, a long-run co-integrating relationship must exist, and if the real exchange rate is found to exhibit non-stationary behaviour, this will indicate that a long-run relationship does not exist amongst the local prices, other country's prices and also the nominal exchange rate, thus invalidating the PPP theory (Chang et al., 2006).

Empirical studies by Chang et al. (2010) found that a symmetric type of adjustment will not result in a co-integrating relationship and that asymmetric types of adjustment and behaviours are known to be associated with the validity of the PPP. Based on studies done by Holmes and Wang (2005) and Chang and Liu (2010), asymmetric adjustments were found in ten African as well as nine middle east countries.

Concurrently, Holmes and Wang (2006) and Liew (2004) affirmed the claim when they found that Asian countries also had asymmetrical responses, which implies that in the long-run, the PPP was found to be valid for all of these countries.

Overtime, the importance of the long-run PPP hypothesis and this economic doctrine contributing factors towards many economic models were commonly discussed (Dornbusch, 1985). Both Lothian (2016) and Mahdavi and Zhou (1994), for a lengthy period of time, have recognised the importance of the PPP hypothesis and that its calculations might be insightful when the factors which have an effect on the exchange rate are shadowed via large movements; thus, the PPP hypothesis as a long-run concept was found to be a very useful approximation.

Important evidence was discovered by Abuaf and Jorion (1990), in which for most of the models of the exchange rates, the long-run PPP will be invalidated if the random walk hypothesis holds, and in this study, the author presented unfavourable results towards the real

exchange rate of ten developed nations following a random walk, thus the PPP hypothesis held for all ten of these nations.

The PPP hypothesis consists of two versions that will be valid in the long-run: an absolute version and a relative version (Taylor & Taylor, 2002). The absolute version is found to hold and be valid when the PPP of a currency unit is equal between the local and foreign economies after the local currency is transformed into the foreign currency (Zhang, 2014).

The relative version consists of the current period exchange rate equilibrium ratio to the initial exchange rate equilibrium, which comprises the domestic country's prices relative to another country's prices. Ding and Kim (2017) and Officer (1978) found that it is more common to find tests consisting of the relative versions of the PPP, which is said to hold when inflation differences are cancelled out by the percentage adjustments in the exchange rates over time.

The United States of America (USA) is one of South Africa's major currency exchange partners (Ahwireng-Obeng & McGowan, 1998), and based on previous studies, the PPP hypothesis was found to be valid and held between economies that share similar characteristics. Therefore, the PPP hypothesis is very unlikely to hold between South Africa and other developed nations.

Surprisingly, Paul and Motlaleng (2007) found that the long-run price differentials influenced the rand and dollar currency, which means that the PPP hypothesis was valid. Similar findings were obtained by Muzindutsi et al. (2021), who found inflation differentials to be among the predictors of the South African exchange rate.

Supporting this evidence, but using a different approach, Phiri (2014) also found constructive proof favouring the PPP hypothesis holding between the South African rand and the US dollar, which also exhibited significant asymmetric PPP effects. However, conflicting evidence was found when Akinboade and Makina (2006) tested mean reversion without the consideration of structural breaks, which showed no support for the PPP hypothesis between the rand and the dollar currency.

Using a much larger pool consisting of 84 developed and developing nations, Alba and Papell (2007) found that the PPP hypothesis held true for Southern America and many European countries, though it failed to hold for Asian and African countries. Furthermore, strong evidence suggests that the PPP hypothesis holds for nations that are open to trade and possess low levels of inflation.

However, a series of mixed findings were discovered by Basso et al. (2017), who tested the validity of the PPP between 25developing Latin, African and Asian countries using the USA as a reference country. The author found that the PPP hypothesis failed to hold for almost all of the countries nationwide and attributed low trade levels as one of the contributing factors for the hypothesis not holding.

Since BRICS countries consist of emerging markets that are considered to be developing countries and are assumed to share similar characteristics, evidence in support of the PPP between these nations should be found. Supporting this notion, Chang et al. (2010), Chang et al. (2012), and Su et al. (2012), applying powerful techniques, found that the PPP hypothesis holds and is valid with asymmetric adjustments between all members of BRICS. Furthermore, Güris and Tirasoglu (2018) were able to validate the PPP hypothesis for two out of the five

countries, including South Africa. However, a study by Gyamfi (2017) found that there was persistence in the exchange rates as well as no co-integrating relationship between the relative prices and the nominal exchange rates for all members, thus rejecting the notion of the PPP holding for the BRICS members.

African countries have been found to possess much higher levels of inflation as opposed to nations of other regions, such as Europe and Asia (Yaya et al., 2019); thus, based on previous literature, there is some assurance that the PPP hypothesis will hold for the majority of African countries. Some reasons for the PPP hypothesis not holding between African countries and their main exchange currencies is possibly due to these countries not sharing similar characteristics, as well as possessing differences in preferences, technology, productivity, different economic structures, and different levels of inflation rates (Doğanlar et al., 2009).

Keeping those factors in mind, one might think of determining whether or not the PPP holds and is valid between African countries, which we would assume share similar technologies, preferences, and economic structures. Studies conducted by Kargbo (2003) and Kargbo (2006) using similar techniques tested the PPP hypothesis in 16 African countries and found favourable evidence towards the hypothesis holding. However, Chang et al. (2006), using a different approach, were also able to find that for most of the African countries, including South Africa, the PPP hypothesis was valid.

In support of the notion of the PPP hypothesis holding between high-inflation nations, Mahdavi and Zhou (1994) and Hoarau (2010) applied powerful techniques between high-inflation African countries, as well as between less developed and developing countries, and discovered strong results in favour of the PPP hypothesis holding when the real exchange rates exhibited reversion behaviours when a stable and constant trend was considered, thus finding overwhelming supporting evidence of the PPP holding in high inflation, less developed, or developing nations. In the literature, which consisted of tests between African countries, the PPP hypothesis was found to be valid for South Africa.

However, conflicting evidence not supporting the notion of the PPP holding for high-inflation rate nations was found by Bahmani-Oskooee et al. (2016a), who rejected the PPP hypothesis between all 20 African countries, and Rawlins (2013), who found very weak evidence of the PPP hypothesis when aiming to find out if the differentials in current inflation levels would explain the possible differences between the previous and current exchange rate levels for South Africa and other African countries. Thus, the continuous mixed findings of the PPP hypothesis contribute to the debates for and against its usefulness as an approximation, as well as whether inflation rates play a role in validating the PPP hypothesis.

Based on existing literature, such as by Davutyan and Pippenger (1985), it is said that errors in the PPP hypothesis are eliminated by technological and political shocks, which alter or change relative prices for non-tradable goods. South Africa is part of a number of emerging markets, but the country is unique from other emerging nations because of the country's political and technological shocks (Demirbag & Yaprak, 2015). Eager to find out if the PPP hypothesis of South Africa would be able to survive these shocks, Bahmani-Oskooee et al. (2016b) tested 11 emerging markets, including South Africa. Kahn and Parikh (1998), examining the currencies consisting of the South African rand against the US dollar and the rand against the British Pound, discovered that after allowing for structural breaks, the PPP

hypothesis held for all emerging markets; however, the PPP failed to hold for the South African rand and British Pound.

3. METHODOLOGY

The Purchasing Power Parity is a measure used to compare prices or exchange rates from different locations using a basket or a collection of goods. If PPP holds, it implies that in the long-run, the compared prices or the exchange rates will converge to equilibrium. The theory is essential for comparing living standards and productivity across countries.

This study revisits the PPP debate by examining whether it holds between the United States of America and South Africa. To this end, we use daily real exchange rate data between South Africa and the United States of America from 1980 to 2020. The data is collected from the Federal Reserve of St. Louis.

High-frequency data is important to use because it allows us to view the short-run effects and shocks on the exchange rate and not allow long-run fundamentals to cancel out these effects. Further, the use of high-frequency data in the analysis of exchange rates is advocated by Msomi and Ngalawa (2024), who argue that high-frequency data is more suitable for analysing exchange rate dynamics. The analysis is restricted between South Africa and the United States of America due to the consistent availability of the data.

Unlike previous studies, we follow Schorderet (2003) to decompose the data into positive and negative partial sums. This yields negative and positive exchange rate movements. It is extensively argued in the literature that the behaviour of exchange rates is asymmetric (Cheung et al., 2005; Msomi & Ngalawa, 2024). Therefore, in this study, in order to determine if depreciation or depreciation converges to the same equilibrium in this study, partial sums of exchange rates are created. The positive and negative values, respectively, represent the appreciation and depreciation of the rand against the dollar.

Secondly, we differenced the data and finally, utilised a technique proposed by Schorderet (2003), which consists of taking a time series and decomposing it into two parts, a negative component and a positive component. This author demonstrated that when beginning at a specific time series $\{D_t\}^T_{t=0}$ can be broken down into its initial values of the process.

$$\boldsymbol{D_t = D_0 + D_t^+ + D_t^-} \tag{1}$$

Where D_0 represents the values which arise at the beginning t
he time series

$$\boldsymbol{D_t^+ = \sum_{i=0}^{t-1} 1 \ \{\Delta D_{t-1} \geq 0\} \Delta D_{t-1}} \tag{2}$$

and

$$\boldsymbol{D_t^- = \sum_{i=0}^{t-1} 1 \ \{\Delta D_{t-1} < 0\} \Delta D_{t-1}} \tag{3}$$

$\{D_t^+\}^T_{t=1}$ and $\{D^-_t\}^T_{t=1}$ consist of the negative and positive collective economic shocks which define the levels of the prices at the beginning of the time period, which is represented by *t.* In the event of the brackets occurring, they will be represented by a value of one, which is the indicator function, and zero otherwise. Next, we will take into consideration the time series D_{1t} and D_{2t} and will also assume that both of these series are not co-integrated linearly with

each other; however, within each series itself, the existence of some kind of linear relationship is apparent and is represented by n_t such that,

$$n_t = \beta_0 D^+_{1t} + \beta_1 D^-_{1t} + \beta_2 D^+_{2t} + \beta_3 D^-_{3t} \quad (4)$$

The equation (4) above is comprised of a vector $\beta' = (\beta_0, \beta_1, \beta_2, \beta_3)$ with β_0 or $\beta_1 \neq 0$, β_2 or $\beta_3 \neq 0$, $\beta_0 \neq \beta_1$, $\beta_2 \neq \beta_3$ …and because this vector possesses a stationary distribution, an asymmetric co-integrating behaviour can exist in the time series. When the variables are decreasing or increasing, the relationship between those two variables will not be the same (Granger & Yoon, 2002).
Schorderet (2003) argues that in each time series from equation (4), if only one component exhibits a relationship that is co-integrating, then this could indicate the possibility of a co-integrating relationship which works in a single direction:

$$D^+_{1t} = \beta^+ D^+_{2t} + n_{1t} \quad \textbf{where } t = 1,\ldots,T \quad (5)$$

$$D^-_{1t} = \beta^- D^-_{2t} + n_{1t} \quad \textbf{where } t = 1,\ldots,T \quad (6)$$

According to West (1988), what is known is that the explanatory variable's mean will consist of some kind of linear trend; equation (4) has a normally asymptotically distribution and can be estimated using ordinary least squares (OLS). Additionally, common statistical inferences are valid, and this is the general condition application. Having now created my key variables (5) and (6). The study applied the above-mentioned unit root tests to investigate if they exhibit stationary or non-stationary behaviours.

We follow a large strand of the literature using unit root techniques to appraise the validity of Purchasing Power Parity (PPP) (see, for example, Nzimande & Kohler, 2016). Evidence of a unit root implies that PPP hypothesis does not hold—exchange rate does not converge to equilibrium.

The tests commonly used in investigating the behaviour of variables include the Augmented Dickey-Fuller (ADF), Phillips Perron (PP), and the Kwaitkowski Phillips Schmidt Shin (KPSS) (Phiri, 2014).

The Augmented Dickey-Fuller (ADF) test is a derivation of the standard Dickey and Fuller unit root test for stationary created by Dickey and Fuller (1979). This test consists of an extension of the original Dickey-Fuller tests through the inclusion of an extra lagged component of the dependent variables for the sole purpose of removing serial correlation. Thus, this procedure involves the continuous addition of lagged components of the dependent variable (q_{t-1}) to the existing model until autocorrelation is removed. The test can be illustrated as such: the variable

$$q_t = \beta_1 + \beta_2 q_t + \varepsilon_t \quad (7)$$

$$q_t = \beta_1 + \beta_2 q_t + \beta_3 q_{t-1} + \varepsilon_t \quad (8)$$

$$q_t = \beta_1 + \beta_2 q_t + \beta_3 q_{t-1} + \beta_4 q_{t-2} + \varepsilon_t \quad \textbf{(9)}$$

Now, taking the difference between time periods,

$$\Delta q_t = \lambda q_{t-1} + \beta_1 \Delta q_{t-1} + \varepsilon_t \quad (10)$$

$$\Delta q_t = \lambda q_{t-1} + \beta_1 \Delta q_{t-1} + \beta_2 \Delta q_{t-2} + \ldots\ldots + \beta_p \Delta q_{t-p} + \varepsilon_t \quad (11)$$

This process will continue until the point where autocorrelation is completely removed. A few assumptions of ordinary least square (OLS) should be noted, such as ε must be independent, there should be no heteroscedasticity, there should be no structural breaks, and the error term should be normally distributed. Utilising the ADF test for stationary will follow the same procedure as the simple Dickey-Fuller test. Stationarity is first checked at levels and then at the first difference.

The null hypothesis $\mathbf{H_0: \lambda = 0}$ for the ADF test is such that a unit root is present and that the trend of the series is non-stationary. A series that possesses a non-stationary trend indicates that the PPP does not hold. The alternative hypothesis $\mathbf{H_1: \lambda < 1}$ generally states that a unit root does not exist and that the time series is stationary, meaning that the PPP holds.

The next test consists of a Phillips-Perron (PP) unit root test, which builds on the ADF test and tests the null hypothesis of a time series for which the series is integrated into order one. The PP test is a derivation of the standard ADF unit root test, which is also utilised to investigate whether or not a unit root is present; however, it is used more in a general time series model. This unit root test works well with models that include drift components as well as trend components that are utilised in order to distinguish whether or not a time series is a unit root non-stationary or stationary time series. The null and alternative hypotheses are identical to the ADF unit root test in that the null hypothesis represents a non-stationary behaviour, and the alternative represents otherwise. Therefore, the regression which is used for the PP test is:

$$\Delta q_t = \beta Vt + \lambda y_{t-1} + \varepsilon_t \quad (12)$$

Here, εt could be heteroscedastic and is an I(0), which represents a time series which is stationary at levels before taking the first difference. The PP test is utilised in order to identify and correct any serial heteroscedasticity and correlation in the error term $\boldsymbol{\varepsilon_t}$ of the regression by changing the test statistic $\mathbf{t_{\lambda=0}}$ and $\boldsymbol{T\lambda\hat{}}$. The changed statistics are represented by $\boldsymbol{X_t}$ and $\boldsymbol{X_\lambda}$ which are given by:

$$X_t = \left(\frac{\alpha^2}{\pi^2}\right)^{\frac{1}{2}} . t_{\lambda=0} - \frac{1}{2}((\pi^2 - \alpha^2)/\pi^2)) \ . \ \left(\frac{T.\ SE(\hat{\lambda})}{\alpha^2}\right) \quad (13)$$

$$X_\lambda = T\hat{\lambda} - \frac{1}{2}\left(\frac{T^2 . SE(\hat{\lambda})}{\alpha^2}\right)(\pi^2 - \alpha^2) \quad (14)$$

The variance parameters' consistent estimates are represented by the terms π^2 *and* α^2

$$\alpha^2 = \lim_{T\to\infty} T^{-1} \sum_{t=1}^{T} E(u_t^2) \quad \textbf{(15)}$$

$$\pi^2 = \lim_{T\to\infty} \sum_{t=1}^{T} E(T^{-1} S_T^2) \quad (16)$$

Such that $S_T = \sum_{t=1}^{T} u_t$. The least squares residual sample variance $\hat{u_t}$ is a consistent estimate of α^2 and long-run variance estimate of u_t which uses $\hat{u_t}$ as a consistent estimate of

π^2. Therefore, the null hypothesis is such that $\lambda = 0$, the Phillips Perron X_t and X_λ statistics consist of the same asymptotic distributions just like the Augmented-Dickey-Fuller t-statistic and a bias statistic which is normalised. An advantage of utilising these tests is that they serve as a robustness test to forms of heteroscedasticity in the error term ε_t.

The final test, which is the Kwaitkowski-Phillis-Schmidt-Shin (KPSS), is somewhat different from the ADF and PP unit root tests. Firstly, the null hypothesis of the KPSS test is such that the time series is stationary. Therefore, this hypothesis is based on a time series that does not possess a unit root. The alternative hypothesis represents a time series which exhibits non-stationary behaviour and the presence of a unit root. Secondly, the absence of a unit root is not proof of stationarity but rather a trend of stationary behaviour. The KPSS test is derived from starting with the model below:

$$q_t = \beta V_t + \rho_t + \varepsilon_t \tag{17}$$

$$\varepsilon_t = \varepsilon_{t-1} + \mu_t, \mu_t \sim W N (0, \sigma_\mu^2) \tag{18}$$

Here, V_t includes deterministic components consisting only of a constant or a constant with the addition of a trend component. ε_t is **I(0)** and could possess heteroscedastic properties. The null hypothesis for this test is such that q_t is **I(0)** and is expressed as H_0: $\sigma_\mu^2 = 0$; this implies that ε_t is a constant. Therefore, the KPSS test statistic is a score statistic which tests $\sigma_\mu^2 = 0$ in contradiction of the alternative hypothesis, which is $\sigma_\mu^2 > 0$ and is derived by

$$KPSS = \left(\frac{T^{-2} \sum_{t=1}^{T} s_t^2}{\gamma^2}\right) \tag{19}$$

Thus, the stationary test is a right-tailed, one-sided test.
Over the years, the South African rand has undergone immense pressure from the dollar and has gradually depreciated overtime. The South African economy experienced numerous economic and political shocks, which contributed to the depreciating currency. The graph below graphically represents the exchange rate trend between the South African Rand and U.S. dollar between 1980 and 2020.

As shown in the figure below, the South African currency has gradually depreciated and has gotten weaker over time against the dollar (Figure 1). Therefore, it will be interesting to find out if the prices between these two countries will converge to an equilibrium in the long-run.

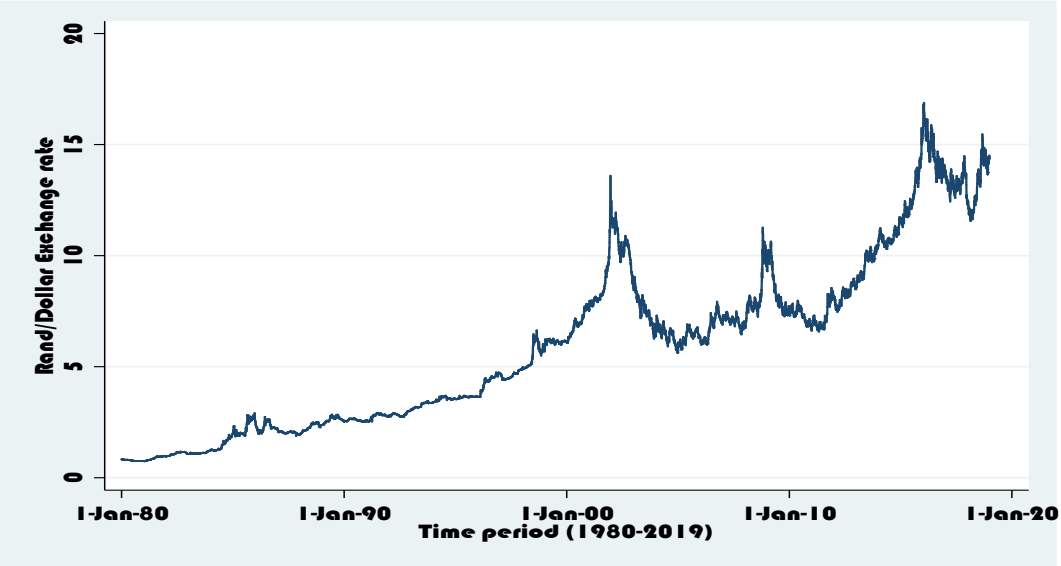

Figure 1. Rand/Dollar
Source: Authors' computation

Throughout the years, many economic and financial time series models have exhibited some kind of trending or non-stationary behaviour (Figure 1). Therefore, from a practical point of view, in order to have a good understanding of the relationship between two or more variables, some kind of stability must exist overtime in that relationship.

4. RESULTS

For all the unit root tests, *lnpve* represents the variable (D^{+}_{1t}), which is the log of the sum of the positive component created from the decomposition of the exchange rate with the addition of the change in the negative component. The *lnnve* represents the variable (D^{-}_{1t}), which is the log of the sum of the negative component created from the decomposition of the exchange rate with the addition of the change in the positive component.

Table 1. ADF Unit root test results

lnpve	-8,285441***(1)	-33,89676***(1)
lnpve	-15,99574***(2)	-33,89509***(2)
lnpve	-25,64698***(3)	-33,89346***(3)
lnnve	-5,89945***(1)	-29,56608***(1)
lnnve	-16,46731***(2)	-29,56469***(2)
lnnve	-19,71348***(3)	-29,56325***(2)

Notes: From the above Augmented Dickey-Fuller unit root test, (1) signifies the inclusion of just the main variable in the model. (2) signifies the inclusion of an intercept only in the model. (3) signifies the inclusion of an intercept and a trend component in the model. All values are significant at all levels. *** represents the null hypothesis being rejected at the 1% level of significance
Source: Authors' computation

The null hypothesis of a unit root is rejected in both the series at levels and the series in difference (Table 1). These results are also significant at the 1% level of significance. All results from the above table are stationary, meaning that, in the long-run, exchange rates will eventually reach an equilibrium; therefore, the prices in South African and United States

economies will converge (see Table 1). Therefore, the purchasing power parity does hold between South Africa and the US. Similarly, Nzimande and Kohler (2016) documented similar evidence. Although their analysis used a panel of African countries.

With regards to asymmetry, both results for each variable are stationary; however, their values differ from each other; therefore, this implies that asymmetric behaviour does exist between these variables (see Table 1), which agrees with the above literature in which multiple studies have found there to be a link between the PPP holding and the prices or exchange rates exhibiting asymmetric behaviour.

These results are consistent with Msomi and Ngalawa (2023, 2024), who showed that the exchange rate movement exhibits asymmetric behaviour. Further, Msomi and Ngalawa (2024) argue that one of the reasons for asymmetric response is that the exchange rate is affected by unobserved factors.

Table 2. PP Unit root test results

lnpve	-171,7703***(1)	-5214,813***(1)
lnpve	-122,8702***(2)	-5220,66***(2)
lnpve	-120,2717***(3)	-5233,554***(3)
lnnve	-167,663***(1)	-2542,361***(1)
lnnve	-119,9673***(2)	-2542,077***(2)
lnnve	-116,7258***(3)	-2542,959***(3)

Notes: from the above Phillips-Perron unit root test, (1) signifies the inclusion of just the main variable in the model. (2) signifies the inclusion of an intercept only in the model. (3) signifies the inclusion of an intercept and a trend component in the model. All values are significant at all levels. *** represents the null hypothesis being rejected at the 1% level of significance

Source: Authors' computation

Table 2 presents the results from the second unit root test applied, the PP unit root test. The results are similar to the ADF results with regard to the short-run and the long-run (Table 2). Both series appear to be stationary at both levels and at first difference. Although these values are large, they are significant at all levels (Table 2). Therefore, the null hypothesis for this unit root test is rejected for non-stationarity (Table 2). Thus, the PP test shows that the PPP holds in the short-run, which is different to what is seen in the ADF test.

These results may be plausible since, in the short-run, the exchange rate and prices of the domestic economy play a central role in the adjustment of PPP. Khan and Qayyun (2008) confirm this by showing that, in the long-run, PPP may be weak due to slow adjustment of the exchange rate and prices. These results show that there is a rapid adjustment to equilibrium in the short-run. Therefore, upon a deviation from equilibrium, it automatically triggers a rapid movement back to the steady state. Hence, the state of disequilibrium is always short-lived.

With regard to asymmetry, both variables appear to be stationary; however, they differ from each other by a small amount; therefore, asymmetric behaviour is apparent between these two variables.

Table 3. Kwaitkowsi Unit root test results

lnpve	1,972043	(1)	0,047116***(1)
lnpve	0,34116	(2)	0,044538***(2)
lnnve	3,070218	(1)	0,021253***(1)
lnnve	0,453607	(2)	0,018227***(2)

Notes: From the above Kwaitkowski-Phillips-Schmidt-Shin Unit root test, (1) signifies the inclusion of just an intercept component in the model. (2) signifies the inclusion of an intercept and trend component in the model. All statistics above are significant at all levels of significance. *** represents the failure to reject the null hypothesis at the 1% level of significance.

Source: authors' computation

From the above KPSS results (in Table 3), after undergoing tests in series at levels, the statistics appear to be greater than the critical values; therefore, we reject stationarity (Table 3). However, after testing the first difference, which is represented by the long-run, the statistics become much smaller than the critical values; therefore, for these values, we fail to reject the null hypothesis for stationarity.

Therefore, the statistics in the series at first difference are stationary, which means that the PPP does hold in the long-run. All statistics in the above KPSS table are significant at all levels of significance. Thus, based on this evidence, we can conclude that the two economies do converge in the long-run. Since the variables are I(1), it means that, in the long-run, PPP holds for both monies.

5. CONCLUSIONS

Like many other developing countries, South Africa was exposed to numerous political and economic shocks in the 1980s and in the 1990s. These shocks had severe consequences on South Africa's exchange rate and the country's macroeconomic policies. These experiences question the validity of the PPP theory and provide an opportunity to test whether or not this PPP theory holds within the South African context.

This study focused on the rand/dollar exchange rate with the main aim of identifying whether or not the PPP holds for South Africa. A decomposition technique was used not only to determine whether the PPP holds for South Africa, but also to investigate if there is some asymmetric behaviour of the Rand/Dollar exchange rate.

With regard to policy recommendations, what this means is that if the central bank plans on expanding the economy and implements strategies to reach a certain point, asymmetric behaviour suggests that if they had to undo all of those strategies or implement them in reverse, the economy will not necessarily end up back to its original position before the strategies were implemented. Therefore, shocks that affect monetary variables would undermine the exchange rate policy, leaving the economy at a worse level than the one before the policy adjustment.

In the study, for the KPSS, the null hypothesis is rejected at the level. Therefore, for future studies, it would be interesting to determine if the result would change if the sample could be extended by a longer period, thereby stretching the sample to earlier years. Furthermore, conducting the study for a country with the same technology, population growth, and productivity would be interesting.

The differences between South Africa and the United States of America are large in terms of the stated factors. Hence, evaluating the validity of PPP for countries with similar characteristics might produce interesting results. As a result, this would be a significant contribution to the literature. Therefore, the limitation of this study is that the stated factors between these two economies are different.

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